



Project Final Report Form

Please complete this form including an Executive Summary and the Final project report and return by email to: research@sarf.org.uk
C/o FRM Ltd., Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire PH16 5NP, Scotland
Tel:/Fax: 01796 474473

Project Details

SARF Project ID Code: 005	
Project Title: Site Optimisation for Aquaculture Operations	
Project: Start date 20/1/05	End date 20/10/05
Name(s) and address(s) of contractor organisation(s): Hambrey Consulting Crancil Brae, Strathpeffer IV14 9AW Tel/fax 01997 420086 www.hambreyconsulting.co.uk john@hambreyconsulting.co.uk	
Contractor's Project Manager: Dr John Hambrey	
SARF Project Manager: Dr Mark James	
Total SARF Project costs £17,300+VAT	
Total approved project expenditure £17,300+VAT	Total actual project expenditure £17,021.50 + VAT
Total *approved staff input 49 days	Total *actual staff input 51.5 days
Is there any Intellectual Property arising from this project which is suitable for commercial exploitation (<i>This question requires a YES/NO answer only. All other details of any Intellectual Property must be included under the Scientific Report or in an accompanying Annex</i>).YES NO <input type="checkbox"/> <input checked="" type="checkbox"/>	
*Staff years of direct science effort	

NOTES

SARF aims to place the results of its completed research projects in the public domain wherever possible. The form is designed to capture the information on the results and outputs of SARF-funded research in a format that is easily publishable through the SARF website. This form must be completed for all SARF projects. A supplementary Final Financial Report Form must be completed where a project is paid on a monthly basis or against quarterly invoices. No Final Financial Report Form is required where payments are made at agreed milestone points.

- This form is in Word format and the boxes may be expanded or reduced, as appropriate.

ACCESS TO INFORMATION

The information collected on this form will be stored electronically and may be sent to any SARF Board Members, or to individual researchers or organisations outwith SARF for the purposes of reviewing the project. SARF may also disclose the information to any outside organisation acting as an agent authorised by SARF to process final research reports on its behalf. SARF intends to publish this form on its website, unless there are cogent reasons not to do so, which may be justified as being in line with exemptions under the Environmental Information (Scotland) Regulations or the Freedom of Information (Scotland) Act 2000. SARF may be required to release information, including personal data and commercial information, on request under the Environmental Information Regulations or the Freedom of Information Act 2000. However, SARF will not permit any unwarranted breach of confidentiality or act in contravention of its obligations under the Data Protection Act 1998.

It is SARF's intention to publish this form.

Please confirm your agreement for SARF to do so..... **YES NO**

(a) When preparing this and related report forms, contractors should bear in mind that SARF intends that they be made public. They should be written in a clear and concise manner and represent a full account of the research project which someone not closely associated with the project can follow. SARF recognises that in a small minority of cases there may be information, such as intellectual property or commercially confidential data, used in or generated by the research project, which should not be disclosed. In these cases, such information should be detailed in a separate annex (and clearly marked as "NOT TO BE PUBLISHED") so that the contents of the forms can be placed in the public domain. Where it is impossible to complete the Final Report without including references to any sensitive or confidential data, the information should be included and section (b) completed. NB: only in exceptional circumstances will SARF expect contractors to give a "No" answer. The principal reasons for withholding information should be in line with exemptions under the Environmental Information (Scotland) Regulations or the Freedom of Information (Scotland) Act 2000.

(b) If you have answered NO, please explain why the Final report should not be released into public domain

Scientific objectives

List the scientific objectives as set out in the contract. If necessary these can be expressed in abbreviated form. Indicate where amendments have been agreed with the SARF Project Manager, giving the date of amendment.

- 1) To develop an informed and objective review of the current status of knowledge, best practice and regulation regarding location and siting for aquaculture operation. This review will include lessons learnt from ongoing relocation programmes.
- 2) To identify the environmental, economic, social and legal issues - and associated criteria - that should be taken into account when assessing and selecting locations and sites for aquaculture development.
- 3) Taking account of existing and evolving decision making processes, to identify the ways in which the issues and criteria identified and developed in this research can be used effectively to deliver more informed decisions by both regulators and aquaculture enterprises.
- 4) To make specific recommendations for targeted cost effective research to underpin a defensible framework for coastal resource allocation with respect to aquaculture.

Milestones

List the milestones. It is the **responsibility of the contractor** to check fully that **all** milestones have been met and to provide a detailed explanation if this has not proved possible.

Milestone		Target Date	Milestone Met	
Number	Title		In Full	On Time
	Completion of review of current knowledge	31/03/2005	yes	yes
	Completion of identification of environmental, economic, social and legal aspects.	31/05/2005	yes	1 month late
	Working paper on decision making context and communication issues	30/6/2005	yes	yes
	Completion of recommendations	30/06/2005	yes	final recommendations delayed until feedback

Declaration

I declare that the information I have given in this form and in any associated documentation is correct to the best of my knowledge and belief.

Name: John Hambrey

Date:20/12/05

Position held: Director, Hambrey Consulting

Executive Summary

The executive summary must not exceed 2 sides in total of A4 (minimum font size 10) and should be understandable to the intelligent non-specialist. It should cover the main objectives, methods and research results, together with any other significant events and options for new work (the box below will expand to accommodate the Summary).

Executive Summary

Overall Objective

The broad objective of this research was to draw together existing information to define objective criteria for guiding the scale, location (and relocation) of aquaculture operations, as detailed in the SARF Open Call for Proposals published 17/9/04. The results should meet the collective needs of SARF members for guidance and information on this subject, enhance public understanding of site selection, assessment and approval for aquaculture, and encourage appropriate scientific research and development in aquaculture.

The research comprised desk based review, supplemented with interviews with fish and shellfish farmers from the West Coast of Scotland and Shetland.

Main findings

1. Site selection for aquaculture is not and cannot be an optimisation process. It is a “satisficing”¹ process in two main stages using two sets of criteria:
 - a) What is feasible and desirable? (“farmer” selection criteria);
 - b) What is acceptable and allowable? (sector management or “approval” criteria)
2. While “farmer” selection criteria are related directly or indirectly to financial viability and profitability, the “approval” criteria used by agencies and local government relate to the public good. In practice there is significant overlap between the two sets, especially in relation to water quality issues. *However, the priority and weighting afforded these criteria, and the standards or thresholds applied differ* depending on the decision making context in which they are applied, and according to the differing perspectives of the various stakeholders.
3. Approval criteria can in turn be classified as:
 - **“hard”** - relatively objective standards have been agreed, e.g. water quality;
 - **“soft”** - comprehensive guidance is available, but standards and thresholds are subjective and not widely agreed (e.g. landscape);
 - **“risk”** – agreed as important but associated with a high degree of ignorance and uncertainty (e.g. distance between farms and wild salmon runs)
 - **“public”** – criteria and standards applied through the public consultation process required for development consent (may include hard, soft and risk criteria, and existing user interests. Standards and thresholds depend on individual perspective)

¹ “Satisficing” is a business management term meaning that most businesses do not optimise – they seek to achieve a *satisfactory* outcome given the many opportunities and constraints.

4. Most “hard” criteria are well established through EU and national level guidance (especially water and sediment quality), and the procedures for approval in relation to most of these criteria are relatively clear. Farmers are usually able to select sites and submit proposals which meet these criteria.
5. Standards and thresholds relating to “soft” criteria and “risk” criteria are necessarily less well established, and while some guidance exists, there remains a substantial and well documented risk that sites will be selected by farmers, applications made, and subsequently rejected. This creates significant cost and uncertainty and is a disincentive to development. This uncertainty is compounded by the uncertainties related to “public criteria” since by definition agreed standards do not apply to these.
6. It is difficult to generate national level standards and thresholds in relation to soft and risk criteria, either because they are subjective and relate to trade-offs between different interests, or because the values associated with them are very locally specific. While there is useful national level guidance it is rightly less prescriptive than that associated with (for example) water and sediment quality.
7. There is now a need and opportunity for local government to address these issues more strategically, through the development of local marine plans, supported by thorough strategic environmental assessment and public consultation. This would allow for transparent and comprehensive application of the full range of criteria – and agreement on locally appropriate standards, thresholds and protocols - on a one-off or periodic basis, rather than in respect of individual site applications. This should reduce uncertainty and increase administrative efficiency.
8. There is also the opportunity to rationalise the very large number of “integrating” and “sustainable development” initiatives for the marine environment within such a framework, including fish farm site relocation initiatives.
9. Existing procedures to synthesise relevant information, clarify the trade-offs between all stakeholder interests, and facilitate agreement are weak. We need more efficient and representative consultation procedures, and clear communication of key issues and trade-offs between the various interests. A range of tools are available, including cost benefit analysis, multi-criteria decision analysis, and polling public opinion – all of which could greatly strengthen local strategic marine planning.
10. More specifically, standards and thresholds relating to farm location relative to wild salmonid populations are not well established and the science is complex and uncertain. Nonetheless agreed standards are needed urgently, and should be thrashed out on the basis of current knowledge and local circumstance in respect of each river/estuarine system. This in turn should be supported by and feed into local marine planning.

Further research and synthesis to support better siting

1. There is an urgent need to undertake an objective analysis of **the feasibility, costs and benefits of farming in more exposed sites**. This should be based primarily on existing knowledge and information, with detailed exploration of risk and investment issues given global price and market trends, and also the risks of escapes.
2. The implications of current research on the dispersion of sea lice and other disease organisms, and implications for siting of farms should be thoroughly reviewed and communicated in a useful form to the industry, local government and the agencies. In parallel with this we need **a thorough synthesis of existing knowledge of wild salmonid movements** (preferably in the form of an atlas) and where necessary further targeted research on these movements in support of local siting agreements and protocols.
3. It would also be useful to undertake research on the **potential economic impacts of farmed-wild salmon interactions**, and the economic trade-off in terms of jobs and income implicit in these impacts.
4. There is a widespread but largely unsupported presumption that fin-fish farming is bad for landscape and for tourism. We need thorough **research on actual visitor attitudes to fish farms in a range of situations and landscapes**, coupled with an analysis of the likely indirect economic impacts of fish farms on tourism.
5. Development of local strategic development plans will need to be based in part on an understanding of the environmental **carrying capacity of particular aquatic systems**. Again this research should be needs driven, and directly linked to the development of local strategic plans.
6. We have highlighted some weaknesses in local decision making with respect to siting of fish farms. We need more research on the value or otherwise of a variety of tools that can be used in support of **public consultation, multi-criteria decision making and trade-off analysis**.

Project Report to SARF

As a guide this report should be no longer than 20 sides of A4. This report is to provide SARF with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow SARF to publish details of the outputs. This short report to SARF does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication.

The report to SARF should include:

- the scientific objectives as set out in the contract;
- the extent to which the objectives set out in the contract have been met;
- details of methods used and the results obtained, including statistical analysis (if appropriate);
- a discussion of the results and their reliability;
- the main implications of the findings;
- possible future work; and any action resulting from the research (e.g. IP, Knowledge Transfer).

A comprehensive final project report addressing the sub-heads listed above is available separately. The following is a very brief summary but presented under the same section heads.

Scientific objectives

See above

The extent to which the objectives set out in the contract have been met

All the objectives have been addressed to the best of our ability within the time and resources available. Clearly many unresolved questions have arisen during the research and we have highlighted these in our discussions of future research needs.

Details of methods used and the results obtained, including statistical analysis (if appropriate)

This research involved:

- a) Desk based review, drawing on both peer reviewed and grey literature and data, and using both internet and library facilities
- b) Discussions with technical specialists – specifically from FRS Aberdeen and Pitlochry; the Institute of Aquaculture, University of Stirling
- c) In depth semi-structured interviews with fish farmers/fish farm managers
- d) Discussion with representatives of a small selection of other bodies with strong interests in aquaculture siting
- e) Circulation of a briefing note and solicitation of comments from members of the Scottish Executive Location-relocation Working Group
- f) In-house team workshop

It was not possible to undertake interviews with a complete representative sample of fish farmers. The sample selection was based on the following criteria:

- Broad geographic coverage from the Clyde and Argyll, the Northwest and Shetland
- Representation of both multi-national companies and small-medium scale independent Scottish based companies
- Availability and willingness to discuss site selection and approval issues

A complete list of consultees, and the checklists used to structure and guide the interviews are provided in the research report.

The internal workshop involved bringing the whole team together for

- a) An unstructured wide ranging discussion of impressions and issues arising from the review and from the interviews; and
- b) A structured analysis of criteria, indicators and their use, based around the development of a comprehensive matrix

A discussion of the results and their reliability

The results are wide ranging and complex and are presented in detail in the project report and summarised in the executive summary above.

Again these are presented in detail in the final report and summarised in the executive summary

Given the nature of the research – a review based on literature and interviews - the results depend to a large degree on the sample of interviews and our interpretation of these. This is closer to social science than physical science, and is necessarily partly subjective. We talked to more farmers than we did to government or government agency officials, and our sample of farmers was not (and could not have been) perfectly representative. It is arguable that some of our conclusions reflect these various biases. However, our own perspective and interpretation is effectively neutral, drawing on a wide range of perspective and opinion, and our own understanding of policy and decision making processes, to deliver research and policy relevant conclusions.

The main implications of the findings

The main implications of the findings are presented in detail in the final report and summarised in the executive summary. However it worth re-iterating two key conclusions of the work:

1. The many criteria of importance in relation to siting fish farms are more or less subjective, and decision making processes must be developed to address the subjective dimensions more thoroughly, consistently and efficiently through more strategic public consultation processes;
2. The bulk of further scientific research should be needs driven in support of more strategic local marine planning initiatives

Possible future work; and any action resulting from the research (e.g. IP, Knowledge Transfer).

References to published material

This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project (the box below will expand).

A set of working papers was developed based on literature review, interviews with farmers and technical specialists, and "in-house" brainstorming:

- Working Paper 1: Review of environmental considerations in site selection
- Working Paper 2: Review of regulation and economic, social and legal issues
- Final research report (overview and synthesis)

These can all be accessed on <http://www.hambreyconsulting.co.uk/reports-and-papers-g.asp>

The following are some key references used during the preparation of the final report. More comprehensive references and resources related to environmental issues can be found in working paper 1, and those relating to regulation and socio-economic issues can be found in working paper 2.

- AHJWG. 2004. Aquaculture Health Joint Working Group. Welfare and Husbandry. FRS website
- Berry C. & Davison A., 2001, Bitter Harvest A call for reform in Scottish aquaculture, for WWF
- Beveridge, M. 2004. Cage Aquaculture. Blackwell (Chapter 4, Site Selection).
- Chamberlain J., Fernandes T. F., Read P., Nickell T. D., Davies I. M. 2001. Impacts of biodeposits from suspended mussel (*Mytilus edulis* L.) culture on the surrounding surficial sediments. ICES Journal of Marine Science, 58: 411–416. 2001
- Clayton, Trish. 2002. Socio-economic profile of coastal communities in Ireland. University College Cork Directorate for Nature Management, 1999. Environmental objectives for Norwegian aquaculture, New environmental objectives for 1998-2000 - DN-rapport 1999-1b.
- Dunham, R.A., et al. 2001. Review of the status of aquaculture genetics. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthurs, Eds. Aquaculture in the Third Millennium. Technical proceedings of the Conference on Aquaculture in Third Millennium, Bangkok, Thailand, 20–25 February 2000. pp 137–166
- EC COM (2002)511 final Brussels. A strategy for the sustainable development of European aquaculture. 19.9.2002
- Gordon, J. & Northridge, S. (2002) Potential impacts of Acoustic Deterrent Devices on Scottish Marine Wildlife. Scottish Natural Heritage Commissioned Report F01AA404.
- Houlihan, D.F., Pierce, G.J., Theodossiou, I., Spencer, N.J., Mente, E., Dick, H.S., 2004. Aquaculture and coastal economic and social sustainability. Final Report to the European Commission's Directorate General for Research on Project Q5RS – 2000 – 31151.
- ICES, 2002, Working Group on Environmental Interactions of Mariculture, Mariculture Committee
- Johnsen, B.O., and Jensen, A.J. 1994. The spread of furunculosis in salmonids in Norwegian rivers. J. Fish Biol. 29:233-241.
- SAMS & Napier University, 2002, Review and Synthesis of the Environmental Impacts of Aquaculture, for Scottish Executive
- SEPA. 2003. Regulation and monitoring of marine fish farming in Scotland – a manual of procedures.
- SEPA 2000. Policy No. 40: Regulation and expansion of caged fish farming of salmon in Scotland;
- SEERAD 2003. Advice Note on Marine Fish Farming and the Environment
- Scottish Executive. 1999. Advice note: marine and fish farming and the environment.
- Shaw, Sylvie. Aquaculture: the Social Context. Australian Maritime College
- SNH. National Planning Policy Guideline 13. Marine aquaculture and the landscape – the siting and design of marine aquaculture developments in the landscape
- Westbrook, S. 2002. The economic impact of Marine Harvest in the Highlands of Scotland. for Marine Harvest.

Scottish Aquaculture Research Forum

Final research report

Site Optimisation for Aquaculture Operations

SARF Project Code SARF 005

SARF representative:

Dr Mark James

Contractors representative:

Dr John Hambrey

Contracting organisation:

Hambrey Consulting
Crancil Brae, Strathpeffer IV14 9AW
Tel/fax 01997 420086
www.hambreyconsulting.co.uk
john@hambreyconsulting.co.uk

Introduction

This research was funded by the Scottish Aquaculture Research Forum (www.sarf.org.uk) and undertaken between February and December 2005. It was undertaken in response to an open call for research proposals on site optimisation criteria issued by SARF toward the end of 2004.

It is primarily a desk review supplemented with understanding and analysis of issues developed through discussions with fish farmers in Scotland.

This final research report is supported by three working papers:

Working Paper No. 1: Review of environmental considerations

Working Paper No. 2: Review of regulation and economic, social and legal issues

Working Paper No. 3: Emerging conclusions – draft briefing paper for the Scottish Executive Location Relocation Working Group

The report is laid out in the format required by SARF.

Acknowledgement

We are indebted to the many fish farmers who took the time to talk to us and to SEPA, SNH, FRS, the Crown Estate, and Local Government who offered comment, advice and provided information.

Authors

The final report was compiled by John Hambrey and Tristan Southall. The research was undertaken by John Hambrey, Fiona Nimmo, Sue Evans, Tristan Southall and Trevor Telfer.

The opinions expressed here are those of the authors, and do not necessarily reflect those of the SARF board or any other organisation or interest group.

Contents

Introduction	2
Executive Summary	4
1 Scientific Objectives	6
2 Methods.....	6
3 Results	7
3.1 Interactions and criteria	7
3.2 Functional Types	14
3.3 Review of regulation and decision making procedures	22
4 Discussion	27
4.1 What are criteria for?	27
4.2 Using criteria more effectively	27
4.3 A map to guide development.....	27
4.4 Moving offshore	28
4.5 Shellfish Farming.....	28
4.6 Sustainable development	28
5 Conclusions and recommendations	29
5.1 Conclusions	29
5.2 Recommendations.....	30
6 Implications for future research	32
7 Extent to which objectives have been met	32
8 List of associated documents and publications	33
Annex 1: List of interviewees and consultees	34
Annex 2: Interview checklists	35
Annex 3: Summary of issues raised during interviews.....	37

Executive Summary

Overall Objective

The broad objective of this research was to draw together existing information to define objective criteria for guiding the scale, location (and relocation) of aquaculture operations, as detailed in the SARF Open Call for Proposals published 17/9/04. The results should meet the collective needs of SARF members for guidance and information on this subject, enhance public understanding of site selection, assessment and approval for aquaculture, and encourage appropriate scientific research and development in aquaculture.

The research comprised desk based review, supplemented with interviews with fish and shellfish farmers from the West Coast of Scotland and Shetland.

Main findings

1. Site selection for aquaculture is not and cannot be an optimisation process. It is a “satisficing”¹ process in two main stages using two sets of criteria:
 - a) What is feasible and desirable? (“farmer” selection criteria);
 - b) What is acceptable and allowable? (sector management or “approval” criteria)
2. While “farmer” selection criteria are related directly or indirectly to financial viability and profitability, the “approval” criteria used by agencies and local government relate to the public good. In practice there is significant overlap between the two sets, especially in relation to water quality issues. *However, the priority and weighting afforded these criteria, and the standards or thresholds applied differ* depending on the decision making context in which they are applied, and according to the differing perspectives of the various stakeholders.
3. Approval criteria can in turn be classified as:
 - “**hard**” - relatively objective standards have been agreed, e.g. water quality;
 - “**soft**” - comprehensive guidance is available, but standards and thresholds are subjective and not widely agreed (e.g. landscape);
 - “**risk**” – agreed as important but associated with a high degree of ignorance and uncertainty (e.g. distance between farms and wild salmon runs)
 - “**public**” – criteria and standards applied through the public consultation process required for development consent (may include hard, soft and risk criteria, and existing user interests. Standards and thresholds depend on individual perspective)
4. Most “hard” criteria are well established through EU and national level guidance (especially water and sediment quality), and the procedures for approval in relation to most of these criteria are relatively clear. Farmers are usually able to select sites and submit proposals which meet these criteria.
5. Standards and thresholds relating to “soft” criteria and “risk” criteria are necessarily less well established, and while some guidance exists, there remains a substantial and well documented risk that sites will be selected by farmers, applications made, and subsequently rejected. This creates significant cost and uncertainty and is a disincentive to development. This uncertainty is compounded by the uncertainties related to “public criteria” since by definition agreed standards do not apply to these.
6. It is difficult to generate national level standards and thresholds in relation to soft and risk criteria, either because they are subjective and relate to trade-offs between different interests, or because the values associated with them are very locally specific. While

¹ “Satisficing” is a business management term meaning that most businesses do not optimise – they seek to achieve a *satisfactory* outcome given the many opportunities and constraints.

there is useful national level guidance it is rightly less prescriptive than that associated with (for example) water and sediment quality.

7. There is now a need and opportunity for local government to address this problem more strategically, through the development of local marine plans, supported by thorough strategic environmental assessment and public consultation. This would allow for transparent and comprehensive application of the full range of criteria – and agreement on locally appropriate standards, thresholds and protocols - on a one-off or periodic basis, rather than in respect of individual site applications. This should reduce uncertainty and increase administrative efficiency.
8. There is also the opportunity to rationalise the very large number of “integrating” and “sustainable development” initiatives for the marine environment within such a framework, including fish farm site relocation initiatives.
9. Existing procedures to synthesise relevant information, clarify the trade-offs between all stakeholder interests, and facilitate agreement are weak. We need more efficient and representative consultation procedures, and clear communication of key issues and trade-offs between the various interests. A range of tools is available, including cost benefit analysis, multi-criteria decision analysis, and polling public opinion – all of which could greatly strengthen local strategic marine planning.
10. On a specific issue, standards and thresholds relating to farm location relative to wild salmonid populations are not well established and the science is complex and uncertain. Nonetheless agreed standards are needed urgently, and should be thrashed out on the basis of current knowledge and local circumstance in respect of each river/estuarine system. This in turn should be supported by and feed into local marine planning.

Further research and synthesis to support better siting

11. There is an urgent need to undertake an objective analysis of **the feasibility, costs and benefits of farming in more exposed sites**. This should be based primarily on existing knowledge and information, with detailed exploration of risk and investment issues given global price and market trends, and also the risks of escapes.
12. The implications of current research on the dispersion of sea lice and other disease organisms, and implications for siting of farms should be thoroughly reviewed and communicated in a useful form to the industry, local government and the agencies. In parallel with this we need **a thorough synthesis of existing knowledge of wild salmonid movements** (preferably in the form of an atlas) and where necessary further targeted research on these movements in support of local siting agreements and protocols.
13. It would also be useful to undertake research on the **potential economic impacts of farmed-wild salmon interactions**, and the economic trade-off in terms of jobs and income implicit in these impacts.
14. There is a widespread but largely unsupported presumption that fin-fish farming is bad for landscape and for tourism. We need thorough **research on actual visitor attitudes to fish farms in a range of situations and landscapes**, coupled with an analysis of the likely indirect economic impacts of fish farms on tourism.
15. Development of local strategic development plans will need to be based in part on an understanding of the environmental **carrying capacity of particular aquatic systems**. Again this research should be needs driven, and directly linked to the development of local strategic plans.
16. We have highlighted some weaknesses in local decision making with respect to siting of fish farms. We need more research on the value or otherwise of a variety of tools that can be used in support of **public consultation, multi-criteria decision making and trade-off analysis**.

1 Scientific Objectives

- 1) To develop an informed and objective review of the current status of knowledge, best practice and regulation regarding location and siting for aquaculture operation. This review will include lessons learnt from ongoing relocation programmes.
- 2) To identify the environmental, economic, social and legal issues - and associated criteria - that should be taken into account when assessing and selecting locations and sites for aquaculture development.
- 3) Taking account of existing and evolving decision making processes, to identify the ways in which the issues and criteria identified and developed in this research can be used effectively to deliver more informed decisions by both regulators and aquaculture enterprises.
- 4) To make specific recommendations for targeted cost effective research to underpin a defensible framework for coastal resource allocation with respect to aquaculture

2 Methods

This research involved:

- a) Desk based review, drawing on both peer reviewed and grey literature and data, and using both internet and library facilities
- b) Discussions with technical specialists – specifically from FRS Aberdeen and Pitlochry; the Institute of Aquaculture, University of Stirling
- c) In depth semi-structured interviews with fish farmers/fish farm managers
- d) Discussion with representatives of a small selection of other bodies with strong interests in aquaculture siting
- e) Circulation of a briefing note and solicitation of comments from members of the Scottish Executive Location-relocation Working Group
- f) In-house team workshop

It was not possible to undertake interviews with a complete representative sample of fish farmers. The sample selection was based on the following criteria:

- Broad geographic coverage from the Clyde and Argyll, the Northwest and Shetland
- Representation of both multi-national companies and small-medium scale independent Scottish based companies
- Availability and willingness to discuss site selection and approval issues

A complete list of consultees is presented in Annex 1. The checklists used to structure and guide the interviews are provided in Annex 2.

The internal workshop involved bringing the whole team together for

- a) An unstructured wide ranging discussion of impressions and issues arising from the review and from the interviews; and
- b) A structured analysis of criteria, indicators and their use, based around the development of a comprehensive matrix

3 Results

A set of working papers was developed based on literature review, interviews with farmers and technical specialists, and "in-house" brainstorming:

- Working Paper 1: Review of environmental considerations in site selection
- Working paper 2: Review of regulation and economic, social and legal issues
- Working paper 3: Emerging conclusions – draft briefing paper for the Scottish Executive Location Relocation Working Group

A summary of issues raised during interviews is presented in Annex 3.

The following represents a synthesis and overview of the research, drawing on the working papers and on confidential discussions.

3.1 Interactions and criteria

There are a number of key interactions between a fish farm and the community, landscape and environment which influence siting preferences and the likelihood of achieving development consent. Some of these issues have changed over the years as industry has developed and come under greater scrutiny. Scientific and socio-economic research has provided clarification and objective understanding of some of these interactions whilst others remain poorly understood, or are by their nature subjective.

3.1.1 Economic

Unless economically viable an industry is inherently unsustainable. It is therefore inevitable that applicants siting preferences are primarily influenced by economic considerations. For example, it makes economic sense for a business to expand near to an existing site, since personnel, boats, jetties, sheds and the like are already in place and the extra investment in fixed capital equipment is minimal. Infrastructure and availability of skilled/motivated staff were cited as key siting criteria by farmers. In general economic siting criteria used by farmers are simple and practical, and corresponding limits, thresholds or "optima" vary according to the nature and scale of the business (Table 1)

When evaluating applications for development consents for new farms or lease renewals Local Authorities already look at local social and economic implications, but the process is not transparent and there is not always consistency of approach or policy between the Scottish Local Authorities. Economic questions cited in deliberations over aquaculture development applications are often poorly understood and poorly documented. There is a need for guidelines which advise on the minimum level of social and economic analysis.

Relatively simple assessment can and should be undertaken, and some key criteria are presented in Table 2

There are however some more complex indirect effects which can and should be researched impartially. These include for example the possible positive or negative effects of fish farms on tourism with a knock on local economic impact.

3.1.2 Social

Aquaculture provides employment in remote areas where chances of alternative employment may be very limited. This improves the prospects of the community surviving as an economically active part of society with a range of age groups and a certain level of local services. This demographic aspect is important, as is the social benefits of work done by fish farm staff in the community². Their families keep schools and shops open and their money supports other local businesses. In recognition of this the FAO recommends that social impact assessments (SIAs) are undertaken at the same time as environmental impact statements (EIS)³. Indeed most guidelines on best practice EIA or SEA recommend that social impacts be included.

Most independent assessments of the social impacts of fish farm development have been positive^{4 5} particularly in terms of strengthening or maintaining a healthy demography, employment and skills range in relatively remote rural areas. Our own work in Shetland reinforced this view. Clearly, the importance of these criteria depends on the vulnerability of the communities, the nature of the local society and economy, and alternative opportunities. While a broad framework or check-list for social and economic assessment in relation to siting of aquaculture can be developed (and Tables 1 and 2 offer a basis for this), the relative importance of these criteria, or particular limits or thresholds, must be developed at local level.

3.1.3 Environmental

The location of a fish farm and the characteristics of its immediate environment plays an important role in determining its overall success. A “good” site will, all other things being equal, produce at less cost, is less prone to disease and is capable of stocking at a higher density without breaking the discharge consent conditions. In this sense many environmental criteria are supportive of sound business practice. But farms must also minimise impact on other resource users, the environment around them and wildlife.

There are several key interactions between aquaculture and the environment which cause the greatest concern, controversy and planning dispute. These can broadly be categorised as:

- Disease (including sealice)
- Genetic dilution (caused by escapees)
- Chemical leaching
- Nutrient enrichment (in excess of environment capacity)
- Wildlife

Most of these have objective and subjective dimensions, and some are characterised by a high degree of uncertainty and disputed risk levels. Some of this uncertainty may be reduced through further research; some may not – at least cost-effectively. Contradictory research evidence is a substantial problem for planners, and resort to a strict interpretation of the precautionary principle is sometimes the result.

² The economic impact of Marine Harvest in the Highlands of Scotland. S Westbrook for Marine Harvest. 2002.

³ Aquaculture: the Social Context. Dr Sylvie Shaw, Australian Maritime College.

⁴ A strategy for the sustainable development of European aquaculture. EC COM (2002)511 final Brussels 19.9.2002

⁵ Socio-economic profile of coastal communities in Ireland. Trish Clayton, University College Cork 2002

Disease

Most farmers are concerned not to be sited close to farms belonging to other companies. This concern relates in large part to the risk of disease transmission. This is normally dealt with by regulations which specify a minimum spacing between lease sites. Close liaison between neighbouring farms through management agreements and protocols have reduced the risk of disease transmission and cross-infection⁶. Some interviewees suggested that a one company one loch policy would be desirable.

There is also a risk of disease transmission between farmed and wild populations. In aquaculture the natural balance between disease organisms and hosts can be disturbed and organisms causing diseases may acquire artificially good conditions for growth and become a serious problem for both cultivated and wild populations⁷.

The lice can have direct negative impacts on sea trout which remain in loch and coastal waters throughout their period in the sea. Wild salmon may also be impacted although they remain in loch systems and coastal waters for a relatively short time⁸. This interaction between sealice and wild and farmed fish populations has also been implicated in the spread of infectious salmon anaemia (ISA). The spread of furunculosis between Norwegian farmed and wild salmon has also been well documented⁹.

Lice infestation has always been a significant economic and health problem for salmon culture and the Scottish industry has long recognised the value of an integrated approach to lice management and has developed procedures and agreements accordingly¹⁰.

At the present time the guidance on siting in relation to other farms is relatively specific, but guidance in relation to wild salmonid populations is very limited. At least 18km from an important river mouth is one "rule of thumb" currently in circulation. Another is quite simply to site well away from the head of sealochs, where sea lice tend to accumulate, and where wild salmonid runs are more concentrated. But there will undoubtedly be huge variations according to the nature of the wild run, and local hydrography.

Research is currently being undertaken by FRS Aberdeen on the dispersion of disease organisms, the proximity of farms, and the risks of disease spread. This should assist with improved guidance on appropriate distances between farms, and between farms and river mouths.

Genetic Dilution

Salmon that escape from farms interact with of wild populations. The number of fish escaping can be considerable with an estimated 731,000 from Scottish farms in severe storms in January 2005. Statistics indicate that the proportion of farmed fish

⁶ SEPA. 2003. Regulation and monitoring of marine fish farming in Scotland – a manual of procedures.

⁷ Directorate for Nature Management, 1999. Environmental objectives for Norwegian aquaculture, New environmental objectives for 1998-2000 - DN-rapport 1999-1b.

⁸ Directorate for Nature Management, 1999. Environmental objectives for Norwegian aquaculture, New environmental objectives for 1998-2000 - DN-rapport 1999-1b.

⁹ Johnsen, B.O., and Jensen, A.J. 1994. The spread of furunculosis in salmonids in Norwegian rivers. *J. Fish Biol.* 29:233-241.

¹⁰ See working paper 1 for more detail on the main elements of these schemes

in wild catches is about 1 % in Scotland¹¹. This interaction is complicated by the often non-native, or selected nature of the farmed strains.

Scientific research on the interactions between farmed escapees and wild populations is limited, and thorough research will be costly. However, three scenarios specific to genetic issues are likely¹²:

- Adding or reducing genetic diversity, and introducing novel genotypes.
- Replacement of wild populations.
- Co-existence of escapees with no interbreeding¹³.

Improved physical containment (netting, cage structure and mooring), improved husbandry practices during fish transfer and sorting are the principle solutions for reducing the numbers of escapees and some companies are developing techniques for escapee recovery.

The relationship between siting and the potential genetic impact of escaped fish is very poorly understood, and there is little specific guidance. This must be considered alongside the disease issue when developing guidance..

Chemicals

Therapeutic chemicals are used to treat a range of diseases and parasites. Until recently most of the product used in sea lice treatments was released into the water environment following bath treatment¹⁴. Although the advent of effective in-feed treatments has reduced the use of these, it is likely that their occasional use will continue as part of a range of techniques employed to reduce the rate of evolving lice resistance.

Particular concern surrounds some of the older bath treatment chemicals used which were developed for use in terrestrial agriculture, some of which were classified as toxic to aquatic organisms¹⁵.

The risk of recurring infestation can be strongly influenced by the siting of the cages and their proximity to each other. Poor dispersion sites are likely to require more sealice treatments. Sealice medicine discharge consents for these sites will also be more restrictive due to the waters limited ability to dilute, disperse and degrade the chemical before it exerts any toxic effects on the receiving ecosystem¹⁶.

Many farms use copper-based antifouling preparations on nets, in some cases with the addition of booster organic biocides. These give rise to new environmental concerns from the elevated concentrations of copper found in sediments around these farms, which may inhibit primary production in the surrounding waters.

Environmental capacity and carrying capacity

¹¹ ICES, 2002, Working Group on Environmental Interactions of Mariculture, Mariculture Committee

¹² Dunham, R.A., et al. 2001. Review of the status of aquaculture genetics. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthurs, Eds. Aquaculture in the Third Millenium. Technical proceedings of the Conference on Aquaculture in Third Millenium, Bangkok, Thailand, 20–25 February 2000. pp 137–166

¹³ See WP 1 and 4 for further detail

¹⁴ ICES, 2002, Working Group on Environmental Interactions of Mariculture, Mariculture Committee

¹⁵ Berry C. & Davison A., 2001, Bitter Harvest A call for reform in Scottish aquaculture, for WWF

¹⁶ SEPA. 2003. Regulation and monitoring of marine fish farming in Scotland – a manual of procedures

Environmental capacity describes an inherent property of the environment to assimilate or process waste from natural or anthropogenic activities. *Carrying capacity* is the amount of a given activity that can be accommodated within the environmental capacity of a defined area. While environmental capacity is determined by the ecological and physical characteristics of a particular area, carrying capacity is dependent of production technology and characteristics.

Sustainable marine fish farming requires that the levels of nutrient and chemical inputs are not allowed to exceed the environmental capacity of the surrounding aquatic environment. The environmental impact is dependent on the total production in a hydrographically distinct region which may be cumulative from many farms.

Environmental quality standards (EQS) have been established to ensure that concentrations remain well below the level at which adverse ecological effects are detectable¹⁷. Advice on these standards and the carrying capacities of marine locations can be obtained from SEPA, FRS and Dunstaffnage Marine Laboratory. In practice carrying capacity is highly dependent on water depth and water movement, and these in turn may be associated with exposure.

Nutrient Enrichment - Finfish farming

Nutrient enrichment occurs through the release of uneaten food - which varies according to husbandry techniques - and faeces, which varies according to food digestibility and fish health. Fish feed is extremely energy-rich, causing more organic enrichment than faeces on a weight for weight basis. The recent investment in feeding systems with feedback loops (eg pumps, dopler, camera, infra-red) has reduced feed losses in many well-run farms.

Particulate organic wastes from cage farms have a profound effect on the benthic environment beneath and immediately downstream of cages. In a Scottish study of benthic recovery, communities adjacent to the cages returned to near-normal 21–24 months after farming ceased. Fish farms only occupy a relatively small area of the Scottish coast and it is unlikely that effects of organic wastes on the seabed will be the environmental factor limiting increases in production. Although the present level of fish farming is having a small effect on the amount and growth rate of Scottish coastal phytoplankton this effect should not be a cause for concern except in a few, heavily-loaded sealochs¹⁸.

Guidance on nutrient enrichment issues and associated standards are well established as part of SEPA consent procedures. In practice these have been done on a site by site basis, and there is growing awareness of the need to address these issues – and especially those related to dissolved nutrients – on an area or hydrographic system basis.

Nutrient Enrichment - Shellfish farming

Despite the lack of supplementary food, shellfish farming produces substantial solid wastes comprising organic faeces, pseudo-faeces, shells, fallen fouling organisms and other detritus. Mussels also produce significant dissolved metabolic products such as ammonia, and reduce oxygen concentrations. A number of studies have

¹⁷ Scottish Executive. 1999. Advice note: marine and fish farming and the environment.

¹⁸ SAMS & Napier University, 2002, Review and Synthesis of the Environmental Impacts of Aquaculture, for Scottish Executive

shown that deposition beneath shellfish farms is sufficient to lead to localised organic enrichment and changes in local macrofaunal communities¹⁹.

In spite of this, the ability of a region to assimilate waste is rarely considered when determining its capacity for shellfish farming. Instead the focus of capacity determination is on availability of planktonic organisms to support a given biomass. There is a working assumption that farms extract nutrients from the system thus helping to reduce the impacts of nutrient inputs from other activities including finfish culture. Justification for shellfish farming even goes so far as claims that localised nutrient enrichment may enhance inshore fisheries as juvenile stages consume the associated harpacticoid copepods or annelids²⁰.

The impacts of waste from shellfish farming at different sites has hardly been considered to date, and represents an anomaly relative to the very high level of assessment and regulation relating to fin-fish farming

Sites with high environmental capacity

From a water quality perspective greater **depth** is an advantage, all else being equal. There will be greater dilution, wastes will be more widely dispersed, and accumulated sediments will be further away and more thinly spread. There is no particular minimum depth widely agreed, since this will depend very much on the current. However, greater depth is typically associated with higher mooring costs, and may be associated with higher access costs, and greater exposure.

Water movement is required to disperse wastes, bring in oxygen, and generally maintain water quality. In the case of bivalve mollusk culture it is required to bring in suspended food. Fish cages and other structures may serve as barriers to reduce water movement.

Greater water movement is better subject to the constraints of net sagging/stress, and in the extreme, stress on the fish themselves. Key criteria are mean current speed, and the 'zero' or quiescent period. SEPA guidance on maximum consented biomass is directly related to mean current speed.

Unfortunately deeper and better flushed sites are often more **exposed**, and exposure has had a major influence on the siting of cages, rafts and long-lines. As exposure increases, the required strength and cost of supporting structures tends to increase exponentially. More passive and flexible structures, and/or submerged structures offer a lower cost alternative, but may be associated with increased access/management costs and/or more difficult husbandry.

The higher costs associated with more exposed sites may be compensated by better water quality conditions, and reduced likelihood of conflict with other uses. However - and surprisingly given the high profile of the concept - there has been no thorough evaluation of the costs, benefits and risks associated with larger structures at more exposed sites.

Wildlife

¹⁹ Chamberlain J., Fernandes T. F., Read P., Nickell T. D., Davies I. M. 2001. Impacts of biodeposits from suspended mussel (*Mytilus edulis* L.) culture on the surrounding surficial sediments. ICES Journal of Marine Science, 58: 411–416. 2001

²⁰ ICES, 2002, Working Group on Environmental Interactions of Mariculture, Mariculture Committee

The interactions between predatory birds and mammals and aquaculture sites can result in serious stock losses. Conversely, predators may be drowned as a result of entanglement in anti-predator nets. It is in the industry's interest to locate sites away from areas of high predator concentration. The industry and nature conservation organisations have agreed codes of practice in relation to the interaction between fish farming and predatory wildlife.

The most significant predator-related problems for Scottish aquaculture facilities using sea pens involve interactions with **grey seals** (*Halichoerus grypus*) and **common seals** (*Phoca vitulina*).

Where present, farmers have three basic strategies to exclude seals:

- acoustic deterrent devices (ADDs) which emit high frequency sounds – but with mixed success;
- secondary predator nets – problematic for large cages
- maintaining the net tension to increase resistance

The legal shooting of a particular animal should only be considered after all reasonable attempts have been made to exclude seals from farms. This must comply with legislation as both common and grey seals are Annex II species under the Habitats Directive.

The use of acoustic deterrent devices (ADDs) may impact on the distribution and migration routes of cetaceans²¹. Cetaceans are much more sensitive to acoustic noise and a high pitched sound that might inconvenience a seal might cause pain to a cetacean. Thus, powerful acoustic deterrents may exclude cetaceans from a large area. Species likely to be of concern in Scottish waters include harbour porpoises; bottlenose dolphins, minke whales and common dolphins. Although Special Areas of Conservation have been proposed for some cetacean populations, their wide-ranging behaviour means that in general it is difficult to take them into account in siting decisions.

Many species of bird also interact with aquaculture sites in Scotland. **Eider ducks** (*Somateria mollissima*) in particular are the major predator of mussel farms and their distribution is a key factor in determining the location of a mussel farm. Birds are excluded by various methods including; nets, strings, gas guns and scarecrows. If these measures fail and predatory birds are causing serious stock damage, a SEERAD license to destroy them may be granted, although not for a number of protected species²².

It is estimated that some 90% of the UK **otter** (*Lutra lutra*) population is found in Scotland, often in coastal areas also occupied by aquaculture. Otters are both Annex IV and Annex II species and the government is required to establish SACs areas for their conservation. There is limited conflict between aquaculture facilities and otters which is not thought to be detrimental to the otters and the distribution of otters is not fundamental when considering aquaculture locations.

Overall then finfish farms should be sited away from high populations of seals, and shellfish farms away from high populations of eiders. Since this is fundamental to

²¹ Gordon, J. & Northridge, S. (2002) Potential impacts of Acoustic Deterrent Devices on Scottish Marine Wildlife. Scottish Natural Heritage Commissioned Report F01AA404.

²² AHJWG. 2004. Aquaculture Health Joint Working Group. Welfare and Husbandry. FRS website

business success, the key to better siting is better information on distribution rather than regulation.

3.1.4 Landscape

The interaction of aquaculture and the landscape is often categorised as an environmental impact. In this instance we list it under a separate heading, acknowledging that whilst landscape impacts should be kept to a minimum, it should be recognised that this is an issue heavily dependent upon personal perception and subjective assessments. Employing landscape architects to undertake detailed analysis of different cage designs and sites does not change this.

Three factors tend to make the physical development of marine fish farms contentious. The first is the close correspondence between the best fish farm development sites and those landscapes deemed to be of national or regional importance. The second is the introduction of development for the first time to areas that previously were almost totally undeveloped. The third is the industrial character of some fish farm installations, which may intrude upon surrounding areas²³. The recent proliferation of large concrete feed barges has added to this third point of contention.

There is no overall presumption against siting fish farms within National Scenic Areas, although landscape assessments are required in these areas, and guidance on design has been developed by SNH²⁴. In practice however, decisions on siting in relation to scenery will depend on objections by interest groups during the consultation phase, and the priorities of local government. As discussed above, the issue of possible costs to tourism is a common consideration, and at present is rather poorly informed.

3.2 Functional Types

In practice the above criteria are used in different ways by different stakeholders, and can be divided broadly into those used in site selection by farmers (Table 1) and those used to assess the desirability of fish farm development at particular sites or locations by responsible agencies and departments and the wider public (Table 2). A single table integrating both types of criteria is provided in working paper 4. Some additional criteria have been added, especially in relation to social and economic issues, for which existing guidance is limited.

We have also tried to identify for each criterion:

1. Indicators that may be associated with the criterion;
2. Standards (limits, thresholds, optima) that may be applied to the indicator or criterion;
3. The degree to which the criterion is scientifically measurable and any associated standards objective
4. Who makes decisions in relation to the criterion;
5. The need or otherwise for research
6. The need or otherwise for synthesis and mapping at local and national levels.

Overall it is notable that guidance and standards are limited to relatively few criteria, and these are in the main “hard” environmental criteria such as water and sediment quality. Very little guidance is available in relation to social and economic issues.

²³ Scottish Executive. 1999. Advice note: marine and fish farming and the environment.

²⁴ See Working Paper P1 for more detail

3.2.1 *Criteria used by farmers*

Farmer selection criteria are well established, and the same general criteria were found in the literature²⁵, although their relative importance is technology and company dependent. They include factors such as proximity and quality of infrastructure and workforce; suitable physical environment etc. The standards or thresholds applying to these criteria depend on the nature of the business, and in any case are flexible: if a site scores well on many criteria, a poor performance against one particular criterion may be deemed acceptable. Farmers undertake an informal, or occasionally formal trade-off analysis, in order to choose the best feasible site, taking account of all relevant criteria.

Many sites around Scotland meet farmer criteria. At the present time limitation is driven mainly through the sector management procedures.

Some argue (Beveridge pers. comm.) that farmers/farming companies may give inadequate weight to risk – for example in respect of wave damage at more exposed sites – relying on experience rather than detailed technical analysis, and minimising cost rather than minimising risk of damage and occasional loss. This is an example of a criterion relevant to both farmers (risk of stock loss) and sector managers (risks to wild stock associated with escapes), but where the relative weight accorded to the criterion may differ between the private and public interest.

3.2.2 *Criteria used in the assessment process*

Approval or “assessment” criteria can be classified as:

- “**hard**” - relatively objective standards have been agreed, e.g. water quality;
- “**soft**” - comprehensive guidance is available, but standards and thresholds are subjective and not widely agreed (e.g. landscape);
- “**risk**” – agreed as important but associated with a high degree of ignorance and uncertainty (e.g. distance between farms and wild salmon runs)
- “**public**” – criteria and standards applied through the public consultation process required for development consent (may include hard, soft and risk criteria, and existing user interests. Standards and thresholds depend on individual perspective)

Most “hard” criteria are well established through EU and national level guidance (especially water and sediment quality), and the procedures for approval in relation to most of these criteria are relatively clear. Farmers are usually able to select sites and submit proposals which meet these criteria.

Standards and thresholds relating to “soft” criteria and “risk” criteria are necessarily less well established, and while some guidance exists, there remains a substantial and well documented risk that sites will be selected by farmers, applications made, and subsequently rejected. This creates significant cost and uncertainty and is a disincentive to development. This uncertainty is compounded by the uncertainties related to “public criteria” since by definition agreed standards do not apply to these.

The way in which these various criteria are applied in practice is discussed in the next section.

²⁵ See for example Beveridge, M. 2004. Cage Aquaculture. Blackwell (Chapter 4, Site Selection).

Table 1. Farmer site selection criteria

criteria	indicators	Standard, threshold, or re-commendation	Object-ivity ²⁶	Who/how to decide?	Need for research	Need for synthesis and mapping at <i>local authority level</i>	Need for synthesis and mapping at <i>national level</i>	comment
<i>Infrastructure and costs</i>								<i>In SEERAD 2003</i>
existing (own) farms	Proximity (reasonably close for more efficient operations)		5	Farmer research and assessment		***	***	
farm services and supplies	proximity, quality		5	Farmer research and assessment	*	**		
roads	proximity, quality		5	Farmer research and assessment	*	*		
piers	proximity, quality		5	Farmer research and assessment	*	*		
Access to markets, processing and distribution facilities	proximity, quality		5	Farmer research and assessment	**	**	***	
labour force	proximity, quality, cost		5	Farmer research and assessment	**	*		
housing	proximity, quality		5	Farmer research and assessment	**	*		
finance	Availability; cost; conditions							
<i>Physical environment</i>								
Location relative to other farm companies	Distance (further is better – for disease, water quality, and public	Separate loch or hydrographic system	4					

²⁶ 5 – can be defined and agreed scientifically; 1 – highly subjective

	perception reasons (esp. shellfish and finfish farms)							
Water depth		30-50m (finfish cages); 10m for shell-fish	5	Farmer research and assessment				technology related
shelter	Wind, waves; fetch; microclimate	Complex. See for example Beveridge 2004 op cit	5	Farmer research and assessment		**		technology dependent; has implications for risk of escapes
water current	Flushing/water quality; cage stress; net collapse	>5cm/sec at bottom; <20cm/sec at surface Shellfish – sufficient supply of plankton Re-suspension speed of 9-10cm/sec	5	Farmer research and assessment	*	**		
high water quality	Locational guidelines categories; shellfish waters grading; distance from industrial discharge, agricultural and forestry run-off		5	Farmer research and assessment	*	**	**	
low toxin incidence (toxic plankton)	Historic records		4	Farmer research and assessment	**	**	***	
Biological environment								
biosecurity	distance from other fish farm companies; overall concentration of development		3	Farmer risk profile; national level guidance	***			
low fouling			4	Local guidance	**	***		
high food concentration (shellfish)			4	Pilots, local guidance	**	***		
minimal threat from predators (mainly seals, eiders, golden eye and shooter ducks)			3	Farmer research and assessment; local guidance	*	**		

Table 2: Sector Development and management criteria

criteria	indicators	Standard, threshold, or recommendation	Objectivity (5 – can be defined and agreed scientifically; 1 – highly subjective)	Who/how to decide?	Need for research	Need for synthesis and mapping at <i>local authority</i> level	Need for synthesis and mapping at <i>national level</i>	comment
Socio-economic								
Employment; demography	Number of jobs, jobs for young local people (direct and indirect); full time/part time/seasonality	Usually maximise	5	LA judgement	*			
Job quality/satisfaction	casual v contract; seasonality; subjective quality (shifts, distance, conditions, nature of work)		2	LA judgement	**			
Job safety								
Wage rates	Absolute; relative		5	LA judgement	**			
Employment sustainability/stability	relative		3	LA judgement	***			
Training and skills development	Absolute, relative		4		**			
Overall value added and multipliers	Local value added national value added; local and national type 1 and type 2 multipliers (induced & indirect)		4	LA judgement	**			

Community strengthening	Community use of facilities; aquaculture staff community participation		3	LA judgement	**				
Level of existing development			4	LA judgement				From NPPG 13 – priority to develop in developed coasts or brownfield sites	
Impacts on environment and other users/interests									
Location relative to designated areas	National scenic area (NSA); Special Area of Conservation (SAC); Special Protection Area (SPA); SSSI	Depends on designation	3 For most designations clear criteria within areas; but proximity issues largely subjective			Largely complete though easier access useful	***** Local dissemination maps needed		
Integrity of wild salmon and sea trout populations (disease, genetics)	Distance from river mouth; distance from migratory routes; concentration; escape prevention technology; exposure; distance from predator colonies/concentrations; disease management protocols	18km from important river mouth? (literature)	3	Overall EIA consultation and judgement (key role SNH)	***	*****	*****	SEERAD 2003 “genetic contamination”	
Shooting, scaring, disturbance of predators (mainly seals, eider, golden eye and scoter ducks)	Distance from colonies/aggregations; concentration; technology (ADDS etc)	Predator protection design recommendations	3	Overall EIA consultation and judgement (key role SNH)	*	***	**	SEERAD 2003 Conflicts with potential predator species (seal, otter, bird)	

Introduction of alien species		license	5	SEERAD				SEERAD 2003
Integrity of designated sites and other sites of particular interest or value	Distance; concentration; technology; waste and chemical management	No significant impact	2	Overall EIA consultation and judgement (key role SNH)	**	***	****	SEERAD Advice note 2003: designations (SAC, SPA, NSA, SSSI, NNR), marine consultation areas; direct/indirect impact on biodiversity covered by BAPs; NPPG 13: Attention to conservation and natural processes
Impact on water quality	concentration; technology; waste and chemical management; contribution to environmental capacity	SEPA water quality standards Water standards related to biodiversity interest	4	Overall EIA consultation and judgement (key role SNH); discharge consent (SEPA)	**	*****	***	SEERAD 2003: Impact on environmental quality and amenity of water body
Impact on landscape	Design; micro-location; concentration; character/quality of landscape affected including visual and aesthetic characteristics and individual landscape features; where farm will be seen from, and how it	Location, design and colour	2	Overall EIA consultation and judgement (key role SNH, tourism interests and general public);	***	*****	***	SEERAD 2003: Impact on character and quality of landscape and wild land Current research is rather academic. Greater need to understand ad weight perceptions of local and national

	will appear; who the viewers will be; acceptability of changes; remedial measures							interest groups and develop mechanisms for gaining consensus on landscape needs
Other users (e.g. fishermen, boat owners; fish farmers, shell-fish farmers; undersea cables)	Distance from navigation routes, anchorages, other farms, cables etc; waste and chemical management; noise and smell reduction		4	LA	**	*****		SEERAD 2003: "implications to fishing and recreation"
Shipping and recreation	Proximity to anchorages and navigation channels		3	LA in consultation with HM Coastguard, harbour authorities, leisure interests etc	**	*****		SEERAD 2003: "safe navigation"

3.3 Review of regulation and decision making procedures

The results of this work are presented in Working Paper No 2 and further developed in Working Paper No. 3. The results are based on literature review and discussions with farmers and regulatory specialists.

3.3.1 Basic procedures

Any site for aquaculture needs a *seabed lease* (from the Crown Estate Commissioners – Figure 1), a *discharge consent* from SEPA (Figure 2); and a *navigational consent* from the Scottish Executive Enterprise, Transport and Lifelong Learning Department).

In practice in order to gain a seabed lease a proposer must also obtain a *Development Consent* from a Local Authority under interim measures (in place since December 1998), or a Marine Works License in the case of Shetland.

Planning consents for any shore based facilities are also issued by the local authority under the Town and Country Planning (Scotland) Act 1997

Figure 1: Applying for a seabed lease

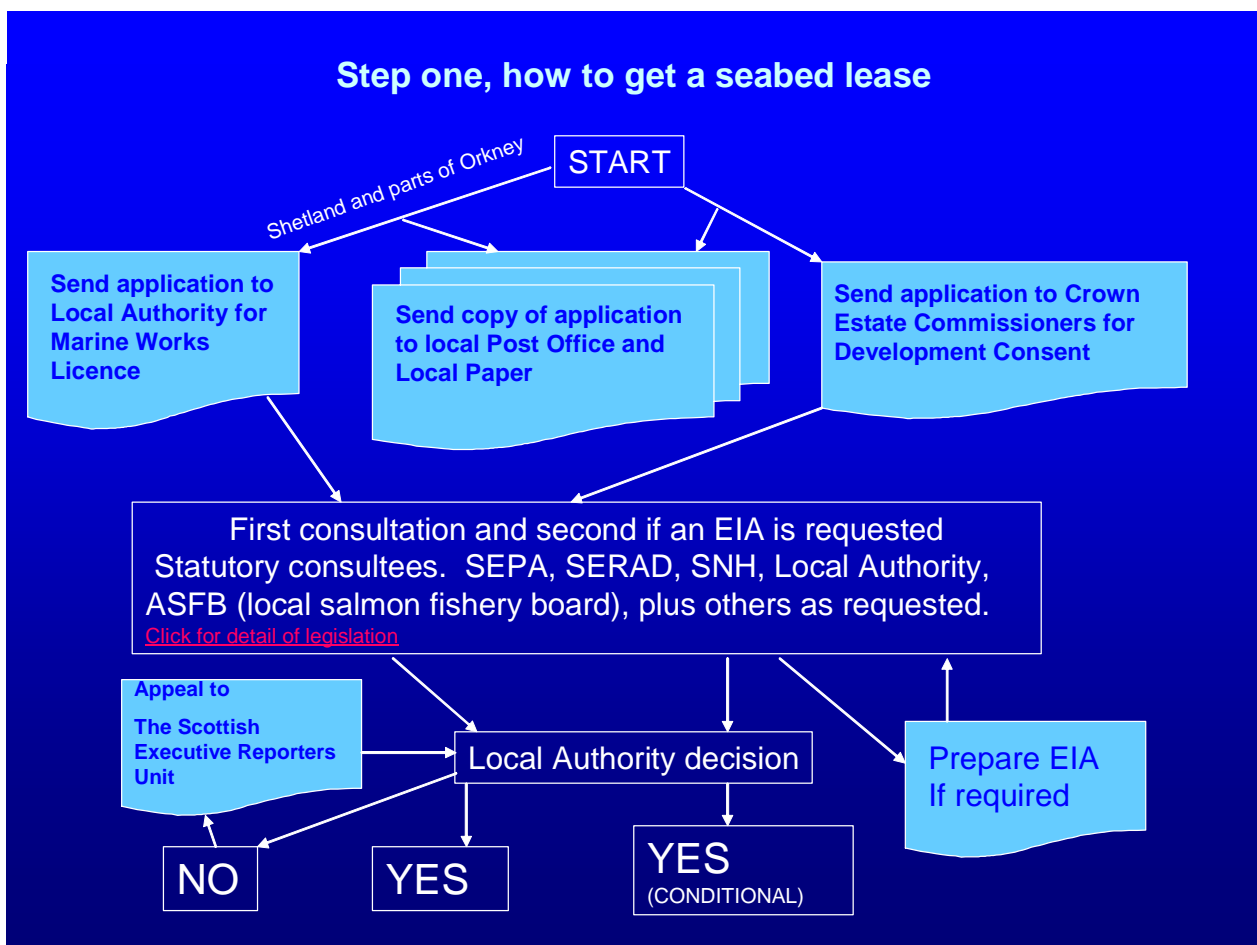
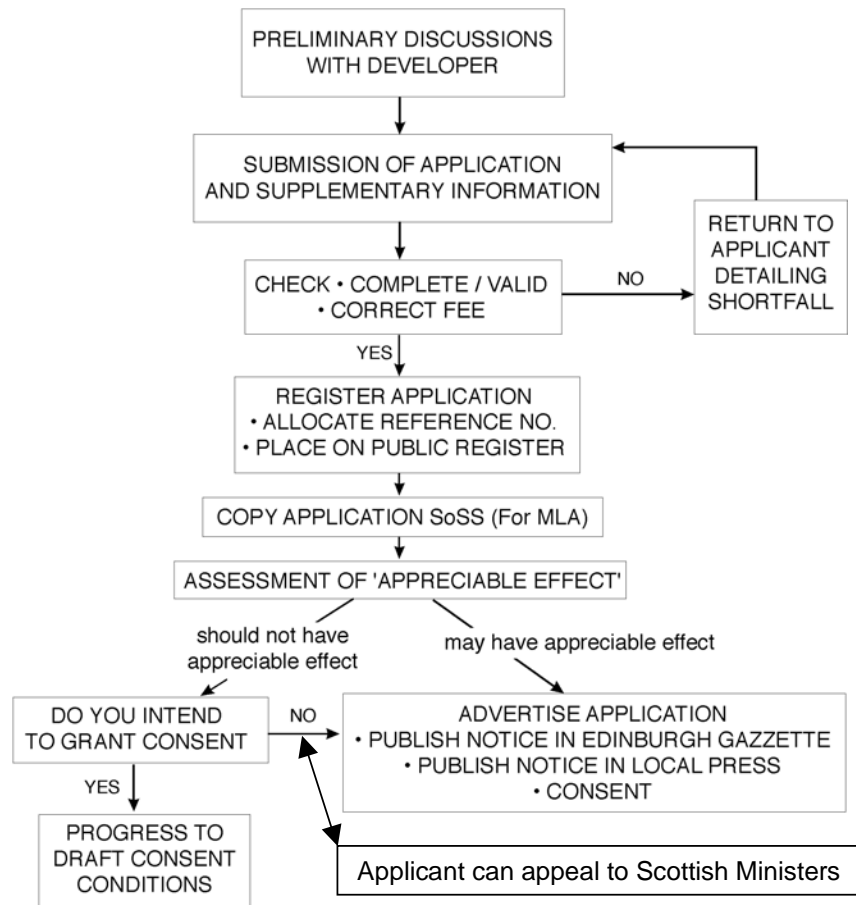


Figure 2: Application to SEPA for discharge consent



3.3.2 Guidance and criteria

Agency criteria and guidance

The criteria and associated guidance offered by various government agencies reflect the need to assess and manage the social, economic and environmental effects of fish farming. They reflect the interests of society as a whole, and in some cases the interests of the fish farming sector as a whole in the longer term, rather than the shorter term interests of individual farms (typically driven by the need for profitability over a 5-10 year period). While some of these criteria are similar to those used by the farmer, the rationale, relative weighting, and thresholds or standards may be different.

Clear standards and thresholds are clearly defined in relation to water quality, through the provisions of the Control of Pollution Act and the discharge consents procedure administered by SEPA. SEPA provides detailed guidance on the information required to obtain a discharge consent, including estimates of nutrient and chemical inputs, local bathymetric and hydrographic information, and information about the current biological characteristics of the site. The process is relatively clear

and transparent and farmers can take steps to ensure that sites will be acceptable in relation to these criteria.

In the case of biodiversity there is a presumption against development within SSSI (shore based facilities), Special areas of conservation (SAC) and special protection areas (SPA).

Additional higher level guidance is provided through the Locational Guidelines Category 1,2,3 system, the water quality grades A, B and C, and in other guidance documents²⁷.

The locational guidelines take into account a range of factors including (in very broad terms) environmental capacity and designations. There is a strong presumption against development in category 1 areas; and a lesser presumption against development in category 2 areas. Category 3 areas are more likely to support farms that meet the needs of discharge consents and do not infringe “hard” designations, but there is no presumption that a site will be approved in these areas.

National Scenic Areas and Areas of Great Landscape Value²⁸ represent a dilemma from the farmers’ perspective, since siting within these areas *may* reduce the chances of approval, but these areas are very extensive, covering many suitable areas for aquaculture development.

The Crown Estate itself has responsibility to manage the seabed within their ownership, and they can offer relatively straightforward guidance to potential developers on the nature and location of other seabed activities, such as communication cables and moorings.

Environmental Impact Assessment (EIA)

EIA is required as part of the process for considering applications for marine fish farm leases. The Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations 1999 implement this in the UK and automatically apply to proposed fish farm developments in sensitive areas, those that hold a biomass of 100 tonnes or more, or that cover an area in excess of 0.1 hectares. If an existing site expands by more than 100 tonnes biomass or 0.1 hectares surface area, another EIA is necessary.

The rationale for EIA typically emphasises the potential benefits to developers in terms of enhancing the likelihood of approval where best practice EIA procedures are followed. A key part of the process is to consider alternative sites and then to select and justify the “best practicable environmental option”, proposing mitigation measures as appropriate.

Some broad guidance on the criteria which should be addressed in EIA are provided in the 1999 regulations, and further guidance is provided in The Crown Estate EA Guidance Manual for Marine Fish farmers (see Appendix 5, WP 2). Annex 7 of this guidance manual lists “potential issues of concern”, and annex 9 lists “criteria for evaluating the possible significance of effects”. These include the standard EIA significance criteria, such as duration, reversibility, magnitude, area/extent, probability of occurrence, value and sensitivity of site and associated landscape,

²⁷ National Planning Policy Guideline 13; SEERAD Advice Note on marine Fish Farming and the Environment (2003); SEPA Policy No. 40: Regulation and expansion of caged fish farming of salmon in Scotland 2000; Marine aquaculture and the landscape – the siting and design of marine aquaculture developments in the landscape (SNH)

²⁸ Areas of Great Landscape Value - range of regional areas identified as being of scenic importance. Designated by Local Authorities and protected in Structure and Local Plans.

flora, fauna, other users/uses etc. In practice EIAs for fish farms tend to be strong on water quality issues – for which information is in any case needed for the discharge consent – and weaker in relation to wildlife, landscape, navigation and socio-economic issues. A problem in relation to social and economic impacts is one of scale and geography. Both positive and negative impacts can take place at local, national and international level, but they are largely addressed through a local objection process.

Part 2, schedule 2 of the 1999 regulations requires the developer to provide “data required to identify and assess the main effects which the development is likely to have on the environment”. In other words the emphasis is on *information* for the decision maker and its advisors/consultees; it is not *analysis* designed to facilitate the decision making process, and there is rarely if ever any kind of trade-off analysis between possible costs and benefits associated with the development. This is understandable – such an analysis would be widely regarded as biased. The problem at the present time is that there is no formal procedure for making an independent analysis of this kind.

The existing EIA procedures help to “take out” the worst sites, and especially those that would fail at the discharge consent stage. However they are costly and do not appear to significantly increase the overall chances of site application approval, which is determined primarily in relation to competing stakeholder interests.

3.3.3 The assessment of site/proposal performance in relation to criteria

The guidance on the application of assessment/approval criteria by the various consultees and decision makers is broad ranging and in some cases detailed. However, relatively few criteria are associated with specific thresholds, limits or “optimal” levels – except in relation to water quality. Assessment in relation to most criteria is qualitative. Furthermore, there is little guidance on the relative weight to be afforded different criteria – either by more specialist agencies such as SEPA and SNH, or by the decision makers in local authorities. Nor is there any guidance as to how to weight the views of different agencies or the wider public. There is no formal and neutral trade-off analysis which sets overall costs and benefits against each other. This means that while the process is complex and in many ways rigorous, the outcome is something of a lottery.

The assessment system has drawn criticism for involving up to 15 different authorities and four consent applications²⁹.

It is therefore worth examining the criteria which have been used to reject site applications, and to explore whether or not these rejections (and/or applications) could have been avoided.

3.3.4 Reasons for rejection of site applications

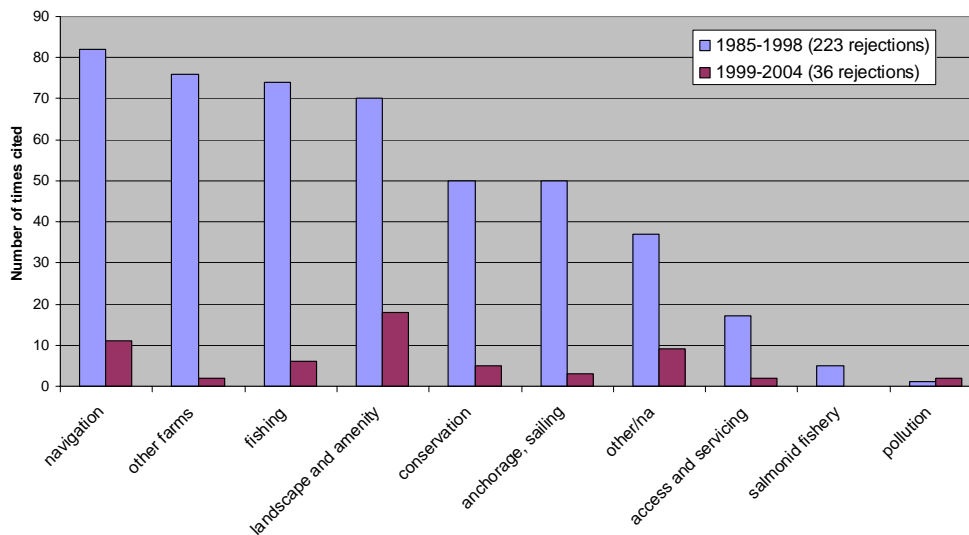
Applications for fish farm sites must be publicised, and local government has a duty to take account of any objections in making its recommendation to The Crown Estate, whether these come from statutory consultees, from representative organisations or from members of the public.

²⁹ Houlihan, D.F., Pierce, G.J., Theodossiou, I., Spencer, N.J., Mente, E., Dick, H.S., 2004. Aquaculture and coastal economic and social sustainability. Final Report to the European Commission's Directorate General for Research on Project Q5RS – 2000 – 31151.

This comment taken from the Special Report based on this AQCESS study, and reinforced by other commentators.

According to data provided by the Crown Estate, 259 (roughly 50%) of applications for fish farm sites (keeps, shellfish, salmon, undefined) were rejected between 1985 and August 2004. In most cases more than one reason was cited for rejection. We have analysed the number of instances in which a particular criterion was used to justify or part justify a rejection (Figure 3).

**Frequency of citation of different reasons
for rejection of fish farm site applications 1985-2004**



Note: the figure relating to salmonid fishery (rod and line and bag net) interests is probably an underestimate, since in many cases these would have been noted simply as fishing interests.

Disruption of navigation and/or anchorages is the most commonly cited reason for rejection (56%), followed by impacts on landscape/amenity (34%), impacts on fishing interests (31%), proximity to other farms (30%) and wildlife conservation (21%).

The graph breaks down the data to show the situation before and after the introduction of the interim measures in December 1998. The main difference seems to be the greater importance of landscape in recent years. In practice however, realistic comparison is difficult given the relatively small sample since 1999.

This indicates where efforts should be directed to clarify and simplify the site selection, assessment and approval process. It is surprising for example, that despite the importance of navigation and anchorages there is relatively little strategic guidance available. For purely physical-environmental reasons farmers will often select sites which are also important anchorages and navigation channels. Different users are competing for a scarce resource, and it is understandable that existing users are often afforded priority.

The chart also highlights the need for local authorities to develop clear policy and strategy relating to aquaculture and landscape: an issue which undoubtedly has substantial subjective dimensions, is open to controversy, and where priorities will differ substantially in different locations.

Issues of pollution do not figure significantly, as they are adequately dealt with through the EIA and discharge consent process.

4 Discussion

4.1 What are criteria for?

We need better guidance for the siting of fish farms, including agreed criteria, and where possible agreed standards relating to these criteria, for three main reasons:

- To ensure that fish farming develops successfully and sustainably in appropriate locations, generating maximum social and economic benefits, and minimising negative social and environmental impacts.
- To streamline the allocation and approval of sites in order to minimise delay and administrative cost.
- To enhance the likelihood that any application for a site is well informed and likely to be approved, thus minimising cost and risk to farmers and creating a positive environment for sustainable development.

In practice we have a huge range of criteria applied in very different ways by farmers themselves, responsible departments and agencies and the wider public. While some criteria and standards are well established and widely agreed (for example in relation to water quality) others are poorly understood or subjective, and national standards are likely to be impossible to set or agree.

4.2 Using criteria more effectively

There are two key issues relating to the utility and application of the criteria: the *scientific underpinning* of any assessment; and the *process* by which the interests and perspectives of the farmer, other user groups, and the wider public interest are *weighed and balanced in relation to particular criteria*. The latter is especially important since many criteria cannot be assessed according to scientifically determined standards – either because research cannot deliver the necessary precision; or because the criterion relates to a human value which varies according to perspective.

The classic way of dealing with the wider public interest is through public consultation. The problem with this is that farmers have little idea of the outcome, and increasingly anticipate a negative outcome. Guidelines *should* increase the chances for successful development in an appropriate location. In practice, even after following guidelines, farmers are now likely to be set back at the public consultation phase.

We therefore need focused research on key issues in support of transparent and predictable decision making procedures which can balance the social, economic and environmental costs and benefits of siting in particular locations. At present the local authorities have *de facto* responsibility for this, and this will become officially established once their new powers in relation to coastal management are put in place.

4.3 A map to guide development

There is widespread desire to have more locational guidance in map form so that developers could be reasonably sure of success in applications in certain locations. It is

unclear as to how far this is possible or cost effective at national level, although the development of such maps should be a key element in the development of local strategic plans.

A comprehensive map (or GIS) at national level should detail at minimum:

- Environmental Capacity (derived from existing FRS information)
- Designations (SPA / SAC / NSA / SSSI)
- Wild salmon and sea trout fisheries

Such a map could be further developed at local authority level as a key element in the development of marine strategic development plans, in particular for those areas which, after the above basic criteria have been considered, still offer the potential for development. These could include:

- Existing finfish and shellfish sites (both active and inactive)
- Areas of appropriate water (depth, current, exposure, salinity, temperature)
- Socio-economically appropriate areas (labour, expertise, access)
- Areas with appropriate infrastructure (road, communication, shore base)
- Areas adequately apart from other heavy industry.
- Important navigation routes
- Important inshore fisheries
- Popular marine recreation sites (including anchorages)

4.4 Moving offshore

Moving aquaculture to larger offshore sites to minimise coastal nutrient enrichment (especially in sea lochs) and interactions with wild fisheries has been suggested for many years. Unfortunately, the economics of offshore farming is very poorly researched, which is surprising given its high profile and the relatively low cost of such research. However, the perspective of most commercial operators is negative at the present time. Offshore farming would require very high levels of investment and/or high risk (unlikely when the industry is being squeezed); would be associated with reduced employment and reduced job quality; and would still raise navigational and landscape issues and concerns.

Less ambitious moves to sites closer to the mouths of sea lochs is viewed more favourably, though still requiring thorough economic assessment.

4.5 Shellfish Farming

Development applications for shellfish farms do not currently require an EIA and are not considered in the FRS water categories (although SEPA water quality categories apply). This anomaly appears to be based on the false assumption that there is little or no environmental impact from these farms. Given the rate of development within the shellfish sector and the likely increases in density and scale, it would seem appropriate to treat large shellfish farms in the same way as fin-fish farms.

4.6 Sustainable development

The Scottish Executive has signed up to a UK strategic framework for sustainable development, and is currently developing a new Scottish sustainable development strategy which will focus on key priorities. Three of these priorities are particularly applicable to the future of the aquaculture industry in Scotland:

- Sustainable consumption and production - achieving more with less, reducing environmental impacts, improving business competitiveness and breaking the link between economic growth and environmental damage.
- Natural resource protection and environmental enhancement - protecting and enhancing the environment to ensure a decent environment for everyone
- Sustainable communities - creating communities which embody the principles of sustainable development at the local level

The strategy will be underpinned by a commitment to environmental justice - tackling environmental inequalities and enabling people and communities to influence the decisions which affect their environments.

It is vital that guidelines for aquaculture and the implementation of these at Local Authority level should be guided by the Scottish Sustainable Development Strategy. In particular the equal emphasis on environmental considerations, community interests and local governance should be noted. The industry should similarly be guided by the strategy, in particular the commitment to '*break the link between economic growth and environmental damage*'.

In the current system it is easy to assume that sustainability will result if sufficient consultation is undertaken and issues resolved. There is a need for a substantial shift toward a clear statement of sustainable development strategy and a commitment to adhere to this in aquaculture development decisions.

5 Conclusions and recommendations

5.1 Conclusions

1. The criteria for optimal siting of fish farms from the producers perspective are relatively well established. Any standards or thresholds applied will depend upon the producers' situation, and the trade-offs against other criteria.
2. The criteria used for assessing sites in relation to water and sediment quality are relatively well developed, and the procedures for using these are well established and transparent in the form of discharge consent. Farmers can readily take them into account when selecting sites, and thereby minimise the chances of rejection.
3. Many site applications (approaching 50%) are turned down on grounds of navigation, landscape, fishing, and nature conservation interests. While some guidance is available on siting in relation to these criteria, either:
 - a. this is inadequate to ensure that conflicts of interest do not arise (this is the case with respect to wild fishery interests for example) or;
 - b. guidance is adequate but there are a limited number of suitable sites available, and many of these are likely to infringe these other interests (e.g. landscape and navigation interests).

4. This case by case approach is costly to the industry and costly to government and government agencies. It also creates an uncertain and unpredictable environment that undermines the competitiveness of the industry.
5. The current system gives significant weight to environmental criteria and to stakeholder interests. It places rather little weight – in terms of requirements for information and presentation – on the social and economic costs and benefits.
6. The constraints to more predictable and cost-effective procedures for site selection and approval are only in part related to lack of knowledge. Further research in relation to particular criteria will bring limited benefits without better procedures for applying, weighing and balancing the various criteria. We need to address the conflicts between fish farm sites and navigation, fishing, landscape and nature conservation interests more strategically. This has been well advanced at national level through locational guidelines and designations - although more research and guidance is still required in respect of siting relative to wild fisheries. The priority now is to build capacity for effective and sustainable decision making using agreed criteria at local level.
7. One of the greatest challenges for statutory regulators with responsibility for development consents lies in the weighting accorded to different parties (the developer, local people, NGOS/campaigners, agencies, visitors etc) during the public consultation process. These weightings are not always made explicit, and are often contentious. Furthermore, “passive” consultation inevitably leads to self selection – vociferous interest groups make their case effectively; the wider public do not. Public consultation needs to be addressed much more thoroughly, strategically, pro-actively and transparently.

5.2 Recommendations

Local strategic aquaculture development plans

1. Local government has great deal of experience in developing strategic plans at local level. These effectively zone certain areas where there is a presumption in favour of development, and others where there is a presumption in favour of other public interests. With the advent of local authority control of fish farm development there is the opportunity and the need to develop local strategic plans for aquaculture and other forms of marine development, in order to reduce uncertainty and conflict. There are several initiatives of this type already underway, and they should be pursued more widely.
2. Part of this process will be largely technical – only certain areas are physically suitable for aquaculture, and some areas are already “off-limits” because of other interests. The difficulties will arise in taking account of other users’ interests such as fisheries, and wider interests such as landscape and nature conservation. In many cases this cannot be resolved through the further development of clear national standards. In many cases these are not technical/scientific issues; they are highly subjective, and appropriate standards or acceptable thresholds will vary according to circumstance and perspective, and according to the weight accorded to different interests or

values by local decision makers. To develop rational strategy at local level will therefore require what amounts to a thorough *multi-criteria decision analysis*:

- agreement as far as possible on standards or thresholds in relation to particular criteria. This should immediately put certain locations “out of bounds”;
- thorough and objective assessment of the trade-offs between other criteria (e.g. lost amenity or anchorage value v. gained jobs);
- facilitation of agreement through consensus building and better more accessible information;
- if agreement cannot be reached, a transparent final decision making process drawing on a thorough trade-off analysis, and justification for the weight assigned to different interests or values.

Minimise duplication – broader strategic marine assessments and development plans

3. Taken together these measures would amount to strategic or area social and environmental assessment underpinning a strategic development plan. There is increasing demand for such studies as part of Water Framework Directive and improved marine management initiatives more generally, including the Sustainable Scotland Marine Environment Initiative. It is important that these activities are not duplicated for other activities such as wind power, tourism development, fisheries etc. Aquaculture development planning should simply be a part of enhanced planning in the marine environment more generally.

Area agreements relating to wild salmonids

4. More research may be useful to underpin guidance on location relative to wild salmonid fisheries (see section 6). However, the key to dealing with this issue will be to develop - or where appropriate strengthen existing fora - to agree strategy at the river catchment level. This process must integrate with local strategic development plans. Since this process may be contentious there must be established procedures to ensure resolution and the emergence of clear – if provisional - guidance and protocols within a specified time, which can then be incorporated in local strategic plans.

Sustainable development criteria

5. The most appropriate way of achieving compliance with the Scottish Sustainable Development Strategy will be for Local Authorities to develop specific sustainable development criteria and guiding principles and to give these explicit consideration in strategic aquaculture development plans and when issuing development consents. The task is not particularly difficult: the full range of criteria already used in the assessment of aquaculture (table 2) broadly conform with sustainability criteria as developed by the Scottish Executive and government agencies, although more explicit weight will need to be given to social and economic criteria.
6. Failure to address the need for a more predictable and positive development environment will seriously undermine the future of fish farming in Scotland.

6 Implications for future research

The main conclusion from this research is that strengthened decision making processes rather than further technical research should be afforded priority. However, ideally the two should go hand in hand, with research responding to the needs of the decision making process. As aquaculture planning becomes more locally accountable, so the underpinning research will need to be more practical, needs driven and situation focused. Nonetheless, we have identified some areas where further research is a priority:

There is an urgent need to undertake an objective analysis of **the feasibility, costs and benefits of farming in more exposed sites**. This should be based primarily on existing knowledge and information, with detailed exploration of risk and investment issues given global price and market trends, and also the risks of escapes.

The implications of current research on the dispersion of sea lice and other disease organisms, and implications for siting of farms will need to be thoroughly reviewed. In parallel with this we need **a thorough synthesis of existing knowledge of wild salmonid movements** and where necessary further targeted research on these movements in support of local siting agreements and protocols.

It would also be useful to undertake research on the **potential economic impacts of farmed-wild salmon interactions**, and the economic trade-off in terms of jobs and income implicit in these impacts.

There is a widespread but largely unsupported presumption that fin-fish farming is bad for landscape and for tourism. We need thorough **research on actual visitor attitudes to fish farms in a range of situations and landscapes**, coupled with an analysis of the likely indirect economic impacts of fish farms on tourism.

Development of local strategic development plans will need to be based in part on an understanding of the environmental **carrying capacity of particular aquatic systems**. Again this research should be needs driven, and directly linked to the development of local strategic plans.

We have highlighted the weakness and lack of transparency of local decision making with respect to siting of fish farms. We need more research on the value or otherwise of a variety of tools that can be used in support of **public consultation, multi-criteria decision making and trade-off analysis**.

7 Extent to which objectives have been met

The objectives of this research were as follows:

- 1) To develop an informed and objective review of the current status of knowledge, best practice and regulation regarding location and siting for aquaculture operation. This review will include lessons learnt from ongoing relocation programmes.
- 2) To identify the environmental, economic, social and legal issues - and associated criteria - that should be taken into account when assessing and selecting locations and sites for aquaculture development.
- 3) Taking account of existing and evolving decision making processes, to identify the ways in which the issues and criteria identified and developed in this research can be

used effectively to deliver more informed decisions by both regulators and aquaculture enterprises.

4) To make specific recommendations for targeted cost effective research to underpin a defensible framework for coastal resource allocation with respect to aquaculture

Objectives 1 and 2 have been met through the production of the working papers and are summarised in Tables 1 and 2. Objective 3 relates to the conclusions in this report, where we offer specific recommendations relating to decision making procedures, and note in particular that the key lies in better overall strategic assessment against multiple criteria and more thorough trade-off analysis. Section 7 specifically addresses objective 4 and offers concrete recommendations.

8 List of associated documents and publications

- Working Paper 1: Review of environmental considerations in site selection
- Working paper 2: Review of regulation and economic, social and legal issues
- Working paper 3: Overview and synthesis report
- Working paper 4: Emerging conclusions – briefing paper for the Scottish Executive location relocation working group
- Working paper 5 (confidential) Interview notes

Presentation to the Association of Scottish Shellfish Growers annual conference in Oban, 27th-28th October 2005: “Sites, markets and sustainability”.

Annex 1: List of interviewees and consultees

The following offered detailed practical information and perspective relating to site selection for aquaculture. In most cases interviews were conducted on site and face to face. 2 were conducted by telephone.

Fish farmers and fish farming interests

- Robin and Gilpin Bradley, Wester Ross Salmon
- David Sandison, Shetland salmon Farmers Association
- Independent fish farmer, retired, Shetland
- Independent salmon farmer in receivership, Shetland
- Independent salmon and mussel farmer
- Manager of Norwegian salmon company, Shetland
- Independent mussel farmer
- Alex Adrian - Technical Manager, Pan Fish, Argyll
- Ben Hadfield – Environmental and Technical Services Manager, Marine Harvest
- SARF Meeting – Scottish Sea Farms
- Sally Davies – Environmental and Technical Manager, Scottish Sea farms, Fortwilliam
- John Holmyard – previous owner and manager of Cadderlie Mussels Ltd

Other

- Peter Cunningham, Wester Ross Fisheries Trust
- James Mackay, Armadal salmon Fishing
- Colin Wishart, Highland Council Planning Department
- Martin Holmes, Coastal Zone Manager, Fisheries and Marine Resources, Shetland Islands Council
- Ruth Henderson, Seafood Shetland
- Andy Rosie, SEPA, Dingwall
- Paul Bancks, Crown Estate, Edinburgh (comment and data)

Technical specialists

The following were consulted with respect to specific technical issues, mainly relating to wild fisheries and disease issues

- Malcolm Beveridge, Director Pitlochry Fisheries Research Station
- Fisheries Research Services, Aberdeen: Trevor Hastings, Pauline Munro, Ron Stagg

Members of the Scottish Executive Location Relocation Working Group

A briefing paper was circulated to all members of the Working Group for comment and advice.

Annex 2: Interview checklists

Environmental issues

The following environmental / biological issues may influence optimal siting for aquaculture farms.

1. Disease interactions and treatments

- Disease interaction e.g. sea lice transfer from farmed to wild, farmed to farmed and wild to farmed.
- Disease treatments – bath or incorporated in feed? Is this synchronised with other farms in the area through Area Management Agreements etc?

2. Fish escapees

- Approximately how many fish escape per year? Reducing escapes.
- Should siting of aquaculture farms consider proximity to wild salmon / sea trout runs?
- Genetic interactions of farmed with wild.
- Ecological interactions

3. Proximity to wildlife

- Seals – haul out areas, use of acoustic deterrent devices (ADDs).
- Birds – cormorants, eider ducks (if shellfish farm).
- Otters –
- Cetaceans – use of ADDs.

4. Protected areas (link with above)

- Birds and habitats directive – Special Protection Area (SPA). Special Area of Conservation (SAC).
- National Scenic Areas.
- Marine Consultation Areas (NB these are not statutorily designated) and proximity to classic rich marine habitat.

5. Hydrography and physical interactions

- Depth – does deeper water permit higher levels of production per unit surface area?
- Current – relationship between current speed and maximum consented biomass.
- Topography/hydrography issues
- Smaller dispersed farms/sites versus larger better sited farms
- Following – moving sites around (reduces impact or spreads the impact?)
- Exposure – are offshore sites feasible? Trade off in terms of costs, access, product quality etc
- Physical – disturbances associated with lines, rafts and other structures.

6. Environmental capacity

- Nutrient loading
- More complex issues of cumulative impact (more farms; more fish; longer periods; local hydrography and environmental capacity)

Socio-economic issues

1. How did you learn to do this? (mentor/formal training/started as an employee/always been on boats/fished?)
2. Did you move here to do this, or did you live here before?
3. Is this where you/they first wanted to put the cages?
4. If no, where was your/their first choice, and why would it have been better for you?
5. Why couldn't you have the site you first wanted?
6. If yes, why here? (should pull out transport, anchorages, jetties, roads, proximity to house, good bit of water, shelter, tides etc)
7. Talk me through what you can remember about getting the permission you needed to start up.
8. What were the worst bits of this process? Where did you get stuck?
9. Did you get any help from anyone official?
10. Did you/they have the right number/kind of boats or did you have to buy one?
11. How far do you reckon you can travel in a day to feed fish? (Given reasonable conditions, boat speed/distance/time, whatever)
12. Do you have any help? Roughly how many people? Do you all do other things as well? (Don't ask for specifics, it is probably very unofficial).
13. If you, or your employees, gave this up, what would you all do instead? And would you have to move?
14. Do you know of any particular environmental problems with this site, or others nearby?
15. What would you tell someone who was starting up, and trying to decide on a good site?
16. Do you like this work? Why?
17. How do you see the future of the industry here?

Annex 3: Summary of issues raised during interviews

Detailed notes of all interviews were written up and used to inform our analysis. Some of this material is confidential and we are therefore unable to present it here. The following represents a concise summary of the key points made relating specifically to siting.

Socio-economic criteria and issues relating to site location

Based on interviews in Shetland

- Importance of a biologically suitable site for business viability
- Larger sites more economic
- Location of existing infrastructure as a primary consideration for site location
- Quality of life improved by site being close to house (self-employed farmers)
- Good level of job satisfaction among self-employed farmers (fin and shellfish), related to proximity to home, opportunity to use traditional skills, healthy lifestyle, satisfaction with product and level of business autonomy.
- Public consultation/objections regarding site location heavily dependent on nature of local society. Increasingly less traditional and not so dependent on, or familiar with sea-based local industry, so more likely to object on recreational/landscape grounds.
- Lack of any new sites at all increases difficulties regarding relocation and rationalisation to improve business viability.
- Location of nearby sites a real issue when they are owned by someone else; not a problem if owned by the same company.
- Work opportunities for local people viewed as important to family/community life.
- Importance of keen, motivated staff to business viability. Partly dependent on site location and nature of local community.
- Mussel farming viewed as an exciting “sunrise” industry, a new source of rural employment with fewer environmental issues than salmon farming has had.

Environmental and socio-economic site selection criteria and issues

Based on interviews with the environmental and / or technical managers of three large aquaculture companies, one medium scale Scottish Company, and one former owner and manager of a mussel farm operating in the West of Scotland. Unless otherwise stated, the issues raised are specific to finfish farming.

Physical conditions

- Optimum depth of water between ~30-50m which considers physical conditions such as water exchange, as well as economic implications such as length of moorings required.
- The depth of the actual nets or ropes (mussels) is dependant on the practicalities of maintaining nets / lines and harvesting.
- Deeper nets with a small surface area are more cost effective than nets with a large surface area.
- The depth of individual finfish farms varies per site in a range of approximately 6-16m with the majority in 10-12m.
- Current speeds of $>5 \text{ cms}^{-1}$ at the bottom and $<20 \text{ cms}^{-1}$ at the surface are optimal and dictate level of consented biomass and length of moorings required.

- Exposure has implications on the practicalities of working a site and mooring a site as well as increasing the level of associated risk.

Infrastructure

- It is more economically viable to locate a farm close to an existing site, since personnel, boats, jetties and other infrastructure are already in place.
- If there is no infrastructure present, it is important to assess whether the site has sufficient access for such infrastructure.

Environmental capacity

- Locate finfish farms with respect to locational guideline categories 1, 2, 3 (i.e. locate in areas of category 3).

Size of site

- It is preferable to expand current sites rather than create new ones due to problems associated with obtaining planning permission for new sites.
- Options for increasing site size include:
 - J Increase size of each individual cage, or increase number of cages
 - J Change cage orientation (to increase the size of biomass consented by SEPA)
 - J Change the modelling of the cage

Designations

- Difficult to secure planning permission for sites in National Scenic Areas and Special Areas of Conservation.
- Can mitigate certain factors such as visual impact by breaking up the cages to form a number of small cages rather than one large cage.
- Can use plastic instead of steel to reduce shimmer.

Proximity to other sites

- Advantageous to be situated close to an existing site owned by the same company due to the infrastructure, work force, known physical conditions.
- It is not favourable to be in close proximity of an existing site owned by a different company due to management implications.

Fish Escapes and Fish Disease

- The main problem associate with fish disease is farmed salmon infecting smolt with sea lice. There are two different sp. of lice, one is non-sp. specific and will infect mackerel, saithe, salmon etc, the other is salmonoid specific and this is the sp. that infects farmed salmon.
- Fish escapes may pass genetic characteristics to wild salmon. This is dependant on predation levels on the escaped fish, as well as its maturity.
- The impact of fish escapes and sea lice can be reduced by locating the farm away from a game river, or indeed any river mouth.
- The literature recommends locating a farm 18km away from the mouth of a river³⁰.

Proximity to wildlife

- It is in the best interests of a finfish farmer not to site a farm near seals or a known seal haul out area since they are potential predators of the fish.

³⁰ Personnel communication with Ben Hadfield, Marine Harvest

- Noise disturbance may be an issue if the site is located in close proximity to certain species of birds. However, these circumstances can be mitigated by ensuring disturbances are minimised such as not using generators, or not using noisy boats.
- Eider ducks can be a real problem for shellfish farms (particularly mussels) and potential sites should avoid locations where eider ducks are known to reside.
- Eider ducks can be in residence all year, or are seasonal dependant on area.
- Other duck species that predate mussels are golden eye ducks and shooter ducks.

Primary production, water quality & algal toxins (shellfish)

- When locating a shellfish farm it is important to ensure sufficient levels of primary production are present so that enough food is available.
- Shellfish farms are located with respect to water quality grading A, B, C (i.e. in areas graded A).
- Public perception does not favour siting a mussel farm in close proximity to a fish farm.
- Prior to siting a finfish farm it is crucial to gain knowledge on the algal toxin history of the area.
- Prior to siting a finfish farm it is important to determine the level of fouling organisms present.

Approval procedures

- Local Authority planning departments are the biggest single obstacle to the development of the aquaculture industry. Applications have become fraught with difficulties and delays since Local Authorities (effectively) took over from the Crown Estate.
- Guidelines can be followed, consents obtained, support from community councils secured and yet individuals, often not local, can sabotage aquaculture development projects with the loss of significant numbers of jobs.
- There is a need to rationalise public consultation and categorise and weight objections. Weighting should take account of residence in the area.
- There are valid concerns over impacts on wild salmon runs
- It would be useful to have a definitive map showing where they can or can't develop
- Regulation is threatening the industry, and companies will pull out.

Issues raised by other individuals and organisations

(biologist, Fisheries Trust; member of the Scottish Salmon net Association; Highland Council Planning Department)

- Concern relates mainly to sea-lice/disease impacts on wild salmonid stocks, especially migrating sea trout
- Scientific understanding is limited, but the precautionary approach should apply, and farmers should be required to demonstrate lack of impact rather than others being required to demonstrate impact
- Some evidence for a slow recovery in wild salmonid stocks; this may be attributable to effective use of "SLICE".
- 1 million escapes from West Coast salmon farms last year
- Local wild stocks probably resistant to genetic dilution

- Area management agreement with Marine Harvest seems to be working – signs of stock recovery
- Need dynamic GIS information on sea lice incidence to inform site selection and allow for effective preventive action
- In farmers' and fishermen's interests to have cages sited well away from the head of sea lochs where sea lice and migratory fish are concentrated
- There should be a moratorium on salmon farming
- There is a need for clearer guidelines – this would have reduced current conflicts between industry and Local Authorities over license renewals
- The existing site application/approval procedure is inefficient.
- Local authorities may lack the sectoral expertise needed to make overview judgements
- The industry is being squeezed, but public perception remains negative
- Local framework plans have received a broad welcome. A national framework would be far harder to achieve – inadequate focus and detail; variations in the level of fishery dependency; second home ownership; tourism; nature conservation
- Employment may become a less significant factor in favour of fish farming, as a significant proportion of employment benefits (processing etc) may fall outwith the farm's Local Authority
- Areas most suitable for aquaculture are often highly sensitive. Offshore technology should reduce conflict and should be promoted.
- Given technological developments, and the environmental sensitivity of most west coast sites, the embargo on development in the North and east should be re-examined.
- Very difficult to simplify/define the areas suitable for development, expansion, or relocation – other than general guidance to move away from the heads of sea lochs to closer to headlands and offshore islands.

Site Optimisation for Aquaculture Operations

WORKING PAPER 1

REVIEW OF ENVIRONMENTAL
CONSIDERATIONS IN SITE SELECTION

June 2005

Prepared for: Scottish Aquaculture Research Forum
Prepared by: Fiona Nimmo – Nautilus Consultants; Trevor Telfer,
Institute of Aquaculture, University of Stirling

Contents

Contents.....	1
1 Introduction.....	1
1.1 Context.....	1
1.2 Background.....	1
2 Hydrography.....	3
2.1 Depth.....	3
2.2 Currents.....	3
2.3 Exposure.....	4
3 Proximity to other farms.....	5
3.1 Disease interactions.....	5
3.2 Chemical interactions.....	5
3.3 Environmental capacity.....	5
3.4 Landscape.....	6
4 Proximity to wild salmonids.....	8
4.1 Wild and farmed fish interactions.....	8
4.2 Disease.....	10
4.3 Genetic.....	11
4.4 Ecological and behavioural impacts.....	13
5 Proximity to protected areas.....	14
5.1 Birds and habitats directives.....	14
5.2 Other designations.....	14
6 Proximity to wildlife.....	16
6.1 Seals.....	16
6.2 Birds.....	16
6.3 Otters.....	17
6.4 Cetaceans.....	17
6.5 Other wildlife.....	18
Annex 1: Separation distances for marine cage farms.....	19
Annex 2 References.....	20
Annex 3 Finfish and shellfish sites and sensitive natural heritage.....	22
Annex 4 Additional notes (socio-economic).....	29

1 Introduction

1.1 Context

The Strategic Framework for Scottish Aquaculture (Scottish Executive, 2003) emphasises the need for location and siting to take account of environmental capacity, the proximity of areas designated under the EU habitats Directive, the proximity of important habitat and major migratory routes for salmon and sea trout, and potential for exchange of sealice, disease, and ecological and genetic interactions. While scientific understanding of all these issues remains limited, there is a need to draw together and summarise relevant information and analysis, and to review existing criteria and protocols for location and siting.

This review forms part of Objective 1 of the project **Site Optimisation for Aquaculture Operations** for the Scottish Aquaculture Research Forum (SARF). The overall objectives for the project are:

- Objective 1** To develop an informed and objective review of the current status of knowledge, best practice and regulation regarding location and siting for aquaculture operation. This review will include lessons learnt from ongoing relocation programmes.
- Objective 2** To identify the environmental, economic, social and legal issues - and associated criteria - that should be taken into account when assessing and selecting locations and sites for aquaculture development.
- Objective 3** Taking account of existing and evolving decision making processes, to identify the ways in which the issues and criteria identified and developed in this research can be used effectively to deliver more informed decisions by both regulators and aquaculture enterprises.
- Objective 4** To make specific recommendations for targeted cost effective research to underpin a defensible framework for coastal resource allocation with respect to aquaculture.

1.2 Background

Aquaculture has grown to become a significant industry in Scotland over the last 30 years, with Scotland now a major international player in the farming of finfish and shellfish (Berry & Davison, 2001). The commercial production of salmon (in the finfish sector) and mussels (in the shellfish sector) currently dominate Scotland's aquaculture industry. There does, however, remain considerable interest in the commercial production of other species, including: anadromous salmonid species, such as the Arctic char, the brook trout and sea trout; and marine species including halibut, cod, turbot, lemon sole, lump sucker and haddock.

While aquaculture has grown in both scale and economic importance, its expansion has also been implicated in significant environmental problems and the degradation of areas of Scotland's inshore marine environment. Actual and potential impacts of salmon cage culture are illustrated in Figure 1.1.

At present, the overwhelming majority of farmed salmon in Scotland is grown in cages or pens, which are usually located in relatively sheltered sea areas such as bays or sea lochs. These cages are open to the wider marine environment - while designed to contain the fish, they also allow seawater to flow through (Berry & Davison, 2001). Compared with salmon farming, shellfish farming is thought to cause considerably less environmental impact since they are grown in the natural environment without need for therapeutic chemicals or supplementary food (Kaiser 2001).

The production demographic of salmon farming has changed considerably in the last decade, moving towards an ever-increasing reliance upon large-scale production facilities, with farm sites producing in excess of 1,000 tonnes annually growing rapidly. While a number of farms remain locally owned, an increasing majority of the industry appears to be controlled by foreign-owned multinational companies.

As the industry matures, there is a growing realisation that finfish aquaculture in Scotland is limited in the number of suitable production sites available for large-scale finfish farming (Berry & Davison, 2001). With increased tourism and urban uses, coupled with competition for aquaculture sites in environmentally complex coastal areas, it is understandable that there is a need to exploit the space differently (ICES, 2002). Furthermore, management practises such as synchronised fallowing, increase the pressure to license alternative sites. (Haya et al 2001).

Figure 1: Interactions between cage culture and the environment

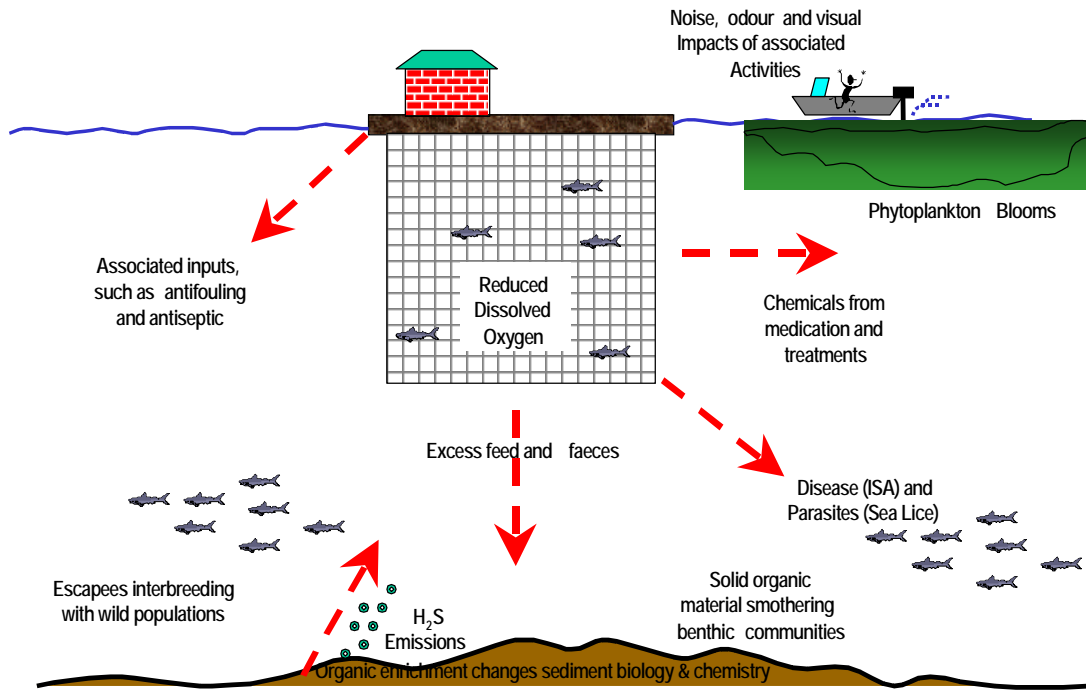


Figure 1.1 Actual and potential impacts of salmon cage culture (Hambrey & Southell, 2002)

2 Hydrography

From an aquaculture company's point of view, initial requirements when locating a new site include the physical properties of the water – the depth, the current, the exposure. Such hydrographical considerations are directly related to the variability in water-column chemistry (Alongi et al 2003) and as such have implications on the transport of dissolved inorganic and particulate nutrients.

2.1 Depth

Aquaculture sites in deeper water permit higher levels of production per unit surface area, are less susceptible to souring as a result of the accumulation of waste material, and generally have more stable salinities (Scottish Executive, 1999). As the time to settle through the water column is important for particle types, the depth of the water column also influences the distance particles deposit from the aquaculture farms. Deeper areas will result in particles taking even longer to settle and so will be advected a greater distance by the current (Cromey & White, 2004).

A restricting factor regarding depth is concerned with the length of the moorings, that are typically three times the depth of the site. This carries economic implications and also creates a larger obstruction in the water column.

2.2 Currents

Aquaculture cages are obstacles to water movements and currents, and can lead to a decrease in flushing if space is limited (Merceron et al 2002). Environmental impact arises from the physical disturbance associated with the lines, rafts and other structures – impacts that can only be evaluated on a site-by-site basis (ICES, 2002). Water currents often vary with depth and tide cycles. Strong currents, for example from tidal flushing, disperse waste material, bring in fresh, well-oxygenated water and, in the case of shellfish cultivation, provide fresh supplies of planktonic food (Scottish Executive, 1999).

The solids emanating from cage farms consist of a range of particle sizes and densities, with a range of settling velocities. The eventual site of deposition will depend on local bathymetry, water movement, and flocculation, however organic deposition is usually restricted to the immediate area of the cages, and so the local hydrography is fundamental in any decision making process. Furthermore, the development of farms in areas with poor dispersion will result in the imposition of more restrictive conditions by SEPA (SEPA, 2003).

Two main factors regarding currents, which have implications on the level of consented biomass, and should be considered when locating an aquaculture site are: the mean current speed and the 'zero' or quiescent period (SEPA, 2003):

Mean Current Speed

- greater than 10cm/s = strongly flushed,
- between 5 and 10cm/s = moderately flushed,
- between 3 and less than 5cm/s = weakly flushed,
- less than 3cm/s = quiescent.

Quiescent Period (this effectively includes all readings between 0 and 3cm/s. For mid- and bottom waters, the following percentage incidence of current speeds within the range 0-3cm/s may be used as a further indication of a site's hydrographic character).

- greater than 50% = highly quiescent,
- between 30 and 50% = moderately quiescent,
- less than 30% = slightly quiescent.

Table 1 shows a relationship between mean current speed and maximum consented biomass, produced by SEPA (2003) to be used as a guideline.

Table 1 Provisional guidelines for maximum consented biomass (SEPA, 2003)

mean speed (cm/s)	High risk site: no fallowing; fine sediments; enclosed waters; existing effects; 'sensitive' site.	Average risk site: no fallowing; no existing effect.	Low risk site: long fallowing; coarse sediments, no existing effects.
< 3	50 t	100 t	250 t
3 - >5	250 t	500 t	750 t
5 - 10	500 t	1000 t	1500 t
> 10	750 t	1500 t	2000 t

2.3 Exposure

Presently, aquaculture sites are generally located in sheltered or semi-sheltered sites in sea lochs and similar inlets. The more open coast has been considered too exposed for cages of normal design. In the past year, several small (100 tonnes) experimental sites have been established in exposed locations in Shetland (ICES, 2002). These sites use heavily weighted cone-shaped nets, with surface flotation collars. Preliminary observations indicate that these cages are resistant to the weather and wave conditions found at these more exposed conditions. If these cages prove economically successful, they could open considerable new areas of coastal waters to salmon cultivation.

A driving force towards moving to more exposed or even offshore sites is the increasing pressure on coastal habitats from many resource users, making site acquisition for mariculture development increasingly difficult. Furthermore, it is claimed that offshore operations mitigate environmental effects otherwise encountered inshore with units at identical scale. Open sea farming encounters very different hydrodynamics, providing much better water exchange within cages and also more improved and rapid dispersion of wastes (ICES, 2002).

Although cage and farm technologies are advancing, the economic implications and risks associated with siting a full-scale farm offshore prove to high for this to be considered a realistic option at this time.



3 Proximity to other farms

3.1 Disease interactions

There is a risk of disease transmission between farms, but this is normally dealt with by regulations which specify a minimum spacing between lease sites, and these regulations do not generally relate the spacing to the size of the farms. Oxygen uptake associated with fish respiration is another consideration, but because this is very localised it is often treated as a husbandry issue rather than a matter for regulation (ICES, 2002).

Management Agreements between neighbouring fish farms have been found to be useful in reducing the risk of disease transmission (SEPA, 2003). To minimise the risk of cross-infection and other adverse interactions between marine fish farms, close liaison between neighbouring operators is essential (Scottish Executive, 1999).

3.2 Chemical interactions

Therapeutic chemicals such as antibiotics are used to treat a range of diseases and parasites – chiefly sea lice – in farmed salmon. Applied as a bath treatment or incorporated in feed, quantities of these therapeutics eventually find their way into the wider marine environment. The type of chemicals used to treat sea lice is an issue, since the vast majority have been developed for use in terrestrial agriculture and are internationally classified as being toxic or extremely toxic to aquatic organisms (Berry & Davidson, 2001). The total quantity of chemical therapeutics entering the environment from sea lice control is proportional to the risk of infection or infestation (and re-infestation). The risk of recurring infestation can be strongly influenced by the siting of the cages and their proximity to each other. Poor dispersion sites can be more susceptible to a build up of sea lice requiring higher levels of chemical controls (SEPA, 2003).

In consenting the discharge of a medicine from a fish farm the main controlling factor is the ability of the surrounding waters to dilute, disperse and degrade the chemical before it exerts any toxic effects on the receiving ecosystem (SEPA, 2003).

Management practices include fallowing of sites to help control sea lice populations, preferably at the same time as neighbouring farms (synchronised fallowing) within a Management Agreement Area as part of a co-operative measure. Companies are also recommended to use as wide a range of licensed treatments as possible, in rotation, in order to reduce the risk of resistance within the lice populations (AHJWG, 2004).

The chemical interactions and associated management practices of farms located within the same loch / water system are not an issue when all the sites are owned by the same company since co-ordination of practices is easier. It is not as attractive to be located in close proximity to a site owned by a different company since management arrangements and agreements are required.

3.3 Environmental capacity

Sustainable marine fish farming requires that the levels of nutrient and chemical inputs are not allowed to exceed the carrying capacity of the surrounding aquatic environment. The environmental impact is more the effect on total production in the region (inlet, estuary, etc.) rather than that due to a single farm. This means that decisions about new licenses depend on how many sites and other sources of nutrification are in the region.

Environmental quality standards (EQS) have been established to ensure that concentrations remain well below the level at which adverse ecological effects are detectable (Scottish Executive, 1999). Advice on these standards and the carrying capacities of marine locations can be obtained from SEPA, FRS and Dunstaffnage Marine Laboratory.

3.3.1 Nutrient Enrichment - Finfish farming

Nutrient enrichment occurs through the release of uneaten food and waste from the fish. The amount of faeces and feed deposited will depend not only on the digestibility of the food, but also on a range of other environmental and husbandry factors such as temperature and disease status. It is now generally accepted that feed losses have been reduced to less than 5% in well-run farms (SAMS, 2002). This is important, as fish feed is extremely energy-rich, causing much greater organic enrichment than faeces on a weight for weight basis.

Particulate organic wastes from cage farms have a profound effect on the benthic environment and recovery, on cessation of farming, may take several years. However, severe effects are generally confined to the local area (a few hundred metres at most). In a Scottish study of benthic recovery, communities adjacent to the cages returned to near-normal (with respect to unimpacted stations) 21–24 months after farming ceased. Fish farms only occupy a relatively small area of the Scottish coast and it is unlikely that effects of organic wastes on the seabed will be the environmental factor limiting increases in production (SAMS, 2002).

3.3.2 Nutrient Enrichment - Shellfish farming

Despite the lack of supplementary food, shellfish farming will produce solid wastes comprising organic faeces, pseudo-faeces (particles rejected during filtering which are often bound in mucus) shells and other detritus. As this solid waste travels to the bottom sediments, a significant proportion is intercepted and consumed by animals on the farm. As a result, sedimentation reported in shellfish farms is usually considerably less than that for finfish farms (Berry & Davison, 2001). However, a number of studies have clearly shown that the sedimentation of faeces and pseudofaeces beneath mussel farms leads to organic enrichment and thus alters macrofaunal communities (ICES, 2002, Chamberlain *et al*/2001).

Shellfish farms produce much more limited local waste than finfish farms and the issue of carrying capacity revolves around establishing that there are sufficient planktonic organisms in the water to grow a given biomass without seriously depleting the resource (SAMS, 2002). Given that shellfish farms extracts nutrients from the marine system it is likely that cultivation, to some extent, helps reduce nutrient inputs from other activities including fish culture (SAMS, 2002). Furthermore, the transport of organic-rich sediment from mussel culture to coastal areas may enhance inshore fisheries. Juvenile stages may benefit first from these faunal changes, as they are able to consume harpacticoid copepods or annelids favoured by the organic enrichment (ICES, 2002).

3.4 Landscape

3.4.1 Aquaculture development

Three factors tend to make the physical development of marine fish farms contentious. The first is the close correspondence between the best fish farm development sites and those landscapes deemed to be of national or regional importance. The second is the introduction of development for the first time to areas that previously were almost totally undeveloped. The third is the industrial character of some fish farm installations, which may intrude upon surrounding areas (Scottish Executive, 1999).

For developments in sensitive sites landscape assessments are required and should describe:

- the character and quality of the landscape affected;
- the impact on visual and aesthetic characteristics;
- the impact on individual landscape features;
- where the fish farm will be seen from, and how it will appear;

- who the viewers will be;
- how acceptable the changes are likely to be; and
- any remedial measures which can be taken to reduce impact.

3.4.2 Visual Factors

Visibility is determined partly by local topography and vegetation, which can screen or expose a marine fish farm, and partly by public use and access. Distance and angle of view are also relevant. For example, tank farms and cage sites can be prominent in elevated panoramic views, whereas in distant low-level views topographic screening or camouflage effects may greatly reduce their visibility.

Choice of material can influence the visual impact of marine fish farm development. In general, light, bright and reflective materials draw the eye, whereas dark, subdued, matt colours do not because they resemble more closely the natural colours of land and water. Light conditions can also affect appearance. For instance, a cage site on open water, viewed from the north, will usually be seen in silhouette, against bright water, so that the use of light-coloured netting may be appropriate (Scottish Executive, 1999). The same site seen against the dark backdrop of the loch shore, could be obtrusive.



4 Proximity to wild salmonids

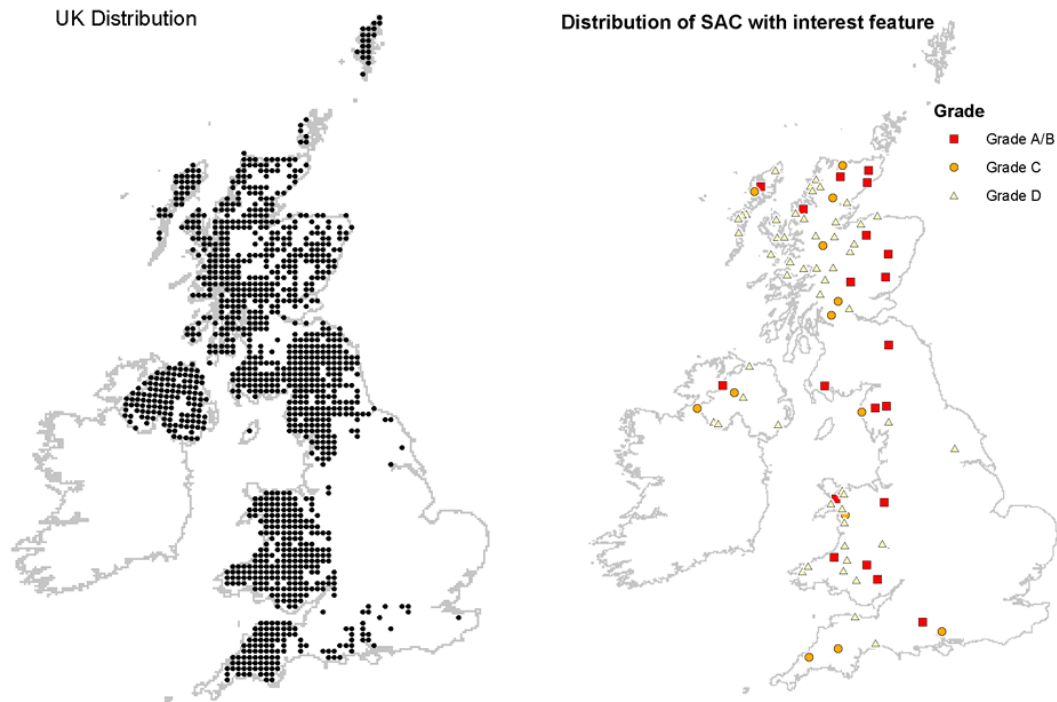


Fig. 2 Salmon UK distribution (JNCC, 2004a) Fig. 3 Distribution of UK salmon SACs (JNCC, 2004b)

The disease and genetic interactions of farmed salmon with wild salmon and sea trout are described in the following sections. In terms of where to locate an aquaculture site in respect of these issues, the best practise is to avoid areas directly adjacent to and in the vicinity of a river mouth.

4.1 Wild and farmed fish interactions

Considerable speculation has been given as to the impacts from farmed to wild fish, particularly through transmission of disease, and competition for resources or "genetic dilution" through interbreeding by escaped farmed fish. These three factors will be addressed here.

Firstly, let's put the situation in Scotland in terms of interaction between farmed and wild fish into context, before each of these factors is discussed in more detail. An extensive report by the WWF (WWF, 2001) – "The status of wild Atlantic salmon: a river by river assessment", showed that for rivers in 19 countries world wide Scottish rivers were either top or second in terms of health of their salmon populations. Overall it was found that in countries where wild salmon populations occur, 2,005 rivers were categorized as to status. Table 2 gives the results for the first four countries, and one of the worst counties (USA) for comparison, and the overall categorization for all categorized rivers.

Table 2 Breakdown of status of salmon populations in rivers by country. A representative number are given from 19 countries (WWF, 2001)

Pos	Country	No of salmon rivers	Status					
			Unknown	Healthy	Vulnerable	Endangered	Critical	Extinct
1	Iceland	103	0%	99%	0%	0%	0%	1%
2	Scotland	350	0%	63%	0%	37%	0%	0%
3	Norway	667	10%	47%	3%	23%	8%	9%
19	USA	50	0%	0%	0%	0%	16%	84%
	All	2005	-	43%	10%	20%	12%	15%

While it is understood that these values are relative and are cautionary, illustrating that there is potential threat to salmon populations, it does illustrate that this threat is apparently less in Scotland than many countries world wide. A considerable body of work has investigated the interactions between farmed and wild salmon, though this has often been in isolation of other environmental factors. For example, the WWF report highlights that fish farming has increased dramatically as wild salmon have declined therefore “clearly” there is a relationship. While this may be the case, farmed salmon are considered in isolation and may simply be one of a number of modifying factors rather than the single root cause. Many graphs have been shown given a relationship of increase in aquaculture/decrease in wild stocks (Hansen et al, 2003). These graphs rarely extend much beyond the 1950's when reliable records for salmon catches. However, it is also sometimes suggested that there is a periodic fluctuation in wild salmon stocks ,and while we are going through a decline at present there is little difference between this decline and ones that happened historically before the advent of aquaculture in Scotland.

Only Norway has official figures for escaped cultured salmon. In the period 1993 to 1999, the number given for escaped farmed salmon is approximately 2.63 million fish (Norwegian Directorate of Nature Management, 2000). However, it has been estimated that the actual number of escapes in Norway for 1999 alone is likely to be in excess of 5.7 million fish (WWF, 2001), as these cannot be accounted for by the industry. The production by Norway in 1999 was 360 000 tonnes (approx 90 million 4 kg fish), thus the approximately 6% escape rate in 1999, which is high. Since this time more rigorous controls on escapes through farm management and codes of practice (SQS, 2004) have been implemented, however there is still likely to be a considerable number of escapes. Evidence from the Norwegian fish farming industry indicates that losses from the cages can occur at any time after the fish are placed in the sea and at all life stages. Escaped fish are caught in fisheries and, when sexually mature, they enter fresh water to spawn (Hansen et al 1999).

In Scotland there is little data on salmon escapes, however, it has been estimated by environmentalists from catch figures that the catch ratio of farmed to wild salmon is more than 4:1 (FOE, 2000). The number of fish escaping from Scottish farms during January 2005 was estimated at 731,000 due to severe storms (WWF, 2005). The magnitude of escapes varies over time but typically escaped salmon may be greater in number than the estimated adult population of wild fish in farming areas (SAMS, 2002). Furthermore, statistics indicate that the proportion of farmed fish in wild catches is about 1 % in Scotland (ICES, 2002).

Some of these figures have been disputed by the salmon farming industry. Figures for catches of Scottish salmon have been collected since 1952. This has shown an increase between 1952 and 1970 to a maximum of 600 000 fish caught. This has been followed by a fluctuating decrease to 2002 where less than 100 000 fish were caught (FRS, 2003 in SNH, 2004). The decline has been sharper on the west coast than the east coast (SNH, 2004). Recent figures from the Scottish Executive show that there has been an increase in salmon catches by 77% in 2004 from 2003 (Scottish Executive, 2005). These figures are indicative but should be regarded critically as these

are as reported catch figures and not a true count of fish population. The increase in catch between 1952 and 1970 also suggest that these 40 year figures may be in themselves part of a longer term trend.

It is generally believed that escaped animals can account for a large proportion of some wild populations, causing potential risks to their fitness. Some of the problems caused by escaped salmon mixing with their wild counterparts have been reviewed by the Department of Fisheries and Oceans (Canada) (DFO, 1999), and are summarised below.

4.2 Disease

All organisms that cause disease are really a natural part of biological diversity. In the wild, interaction between these organisms and the host organisms is the result of evolutionary adaptation. In aquaculture farms, this natural balance could be disturbed, organisms causing diseases may acquire artificially good conditions for growth and become a serious problem for both cultivated fish, wild populations and the immediate surroundings (Directorate for Nature Management, 1999). Increased fish disease transfers may occur as a result of hatchery development (fish and shellfish), where broodstock are recruited from the wild, and juveniles or broodstock are moved between the hatchery and on-growing sites.

Diseases are known to spread between wild and caged salmon (McVicar, 1997). For example, the disease furunculosis was transferred from farmed fish to wild stocks through escaped animals in Norway. The disease originated in Atlantic salmon smolts imported from Scotland (Hastein and Linstadt, 1991). This highlights a further problem of salmon farming, with the introduction of non-local or exotic species, and their associated diseases, into new areas.

It is sometimes argued that large concentrations of farmed salmon result in higher incidence of pathogens in the coastal aquatic system, with negative impacts on wild stocks (Hambrey & Southall, 2002). The spread of furunculosis (probably from Scottish farmed salmon) in Norwegian farmed salmon and finally to Norwegian wild salmon has been well documented (Johnsen and Jensen, 1994). Fighting pathogens includes the use of both preventive/prophylactic and medicinal tools.

Sea Lice

Lice (an epizoid copepod crustacean) are now considered the main threat to farmed salmon in the North Atlantic area. Marine farms are prone to infestations picked up from wild stocks, and although these can be partly dealt with using chemical treatments, the greatest problem is caused by farm re-infection (McVicar, 1997). Sea lice can cause significant tissue damage and mortality to fish stocks, and can make them more susceptible to secondary infections via the lesions they cause on the skin

Originally, the problem was tackled site by site, company by company. Most large salmon producing countries now recognise the value of an integrated approach to lice management. The main features of strategies to reduce lice numbers include: regular monitoring of lice numbers; co-ordinated chemical treatments between farms sharing the same water body; single generation sites; fallowing of management areas to break lice cycles; and treatment of lice in the spring when lice numbers are low (SAMS, 2002, Butler *et al*/2001). Much of this interaction and co-ordination between fish farm operators are taken into account, in Scotland by Area Management Agreements between operators, local authorities and other representative groups within the relevant area. This is recommended by the Scottish Executive. Sealice treatment remains the single most common health-related issue in salmonid aquaculture. Almost all the product is released into the water environment as most treatments are done using baths (oral treatments are less efficient) (ICES, 2002).

The lice can have direct negative impacts on salmon and sea trout if present in sufficient numbers, and have been implicated in the spread of infectious salmon anaemia (ISA) which is deadly to farmed and wild salmon. Wild

salmon remain in loch systems and coastal waters for a relatively short time before migrating into the ocean, whereas sea trout remain in loch and coastal waters throughout their period in the sea (Directorate for Nature Management, 1999). Sea trout are therefore assumed to be more at risk of attacks by salmon lice during their adolescence.

It is widely recognised that farmed fish can contribute to lice prevalence in wild stocks, the extent of which, however, is still largely unknown (McVicar, 1997). Recent research by FRS (McKibben and Hay, 2002) suggests that the decline in sea trout catches in the Loch Torridon area was related to the presence of sea lice. It is clear from their work that the decline was linked to the reduced survival of the marine phase where sea trout tend to congregate near the shores of sea lochs. The study showed an inter-annual difference between the sea lice numbers on sea trout sampled taken in 2000 and 2001, with sea lice copepodids only being found in 2001 when gravid female sea lice were present on local fish farms. This is the first evidence in Scotland of a link between lice transmission between farmed and wild fish.

In response to the perceived threat on sea trout stocks from sea lice, the Animal Health Authority in Norway implemented the National Action Plan Against Salmon Lice (NA) in 1997 (Anon, 1999). Here legal limits for the maximum mean number of lice per farmed animal. A review of this strategy in 2005 (Heuch et al, 2005) showed that there was a significant downward trend in wild salmon smolts accompanied by lowered lice numbers within the plankton. In turn there was an apparent lower lice infestation in south-west fjords (Kalas and Urdal, 2004). More work is required for firm conclusions to be made.

Further work in Norway has shown that this work on cross infection may be complicated by a genetic disposition of certain wild salmon stock to be more prone to sea lice infection than others (Glover et al, 2004). This may mean that certain areas are under more threat from cross infection than others.

4.3 Genetic

Genetic selection and improvement are the major tools used to achieve the economic sustainability of the aquaculture sector (competing with other animal production sectors). However, less than 1 % of aquaculture production is based on genetically improved strains. Instead, its basis is the genetic variation of a single species, and selection within that variability to promote interesting / useful characters. Selection is primarily for body weight and growth (salmonids, trout), resistance to disease (Furunculosis and IPN in salmonids, sea lice in Atlantic salmon). More recently, flesh quality and yield indexes have been integrated into selection processes. Sometimes, undesired correlated responses may appear (e.g., decreased disease resistance when selecting for body weight) (ICES, 2002).

Farmed salmon are expected to have different genotypes to their wild counterparts, due to gradual selection for characteristics that make them suitable for farm culture. Farmed fish will generally be well adapted to a cage environment, but less well adapted to the natural environment. The extent of adaptation to cage culture depends on several factors, including:

- the origin of the farm stock,
- the number of breeding animals used to establish the farm stock,
- the number of generations in farm culture,
- the amount of both inadvertent and deliberate selection to enhance economically important traits, such as growth rate and colour.

Interbreeding of farmed fish with wild fish can alter the genetic make-up or lead to genetic dilution of wild stocks and have an adverse impact on their capacity for survival (Berry & Davison, 2001). The reproductive success of cultured salmon increases with the time the fish have lived in nature before maturing sexually; for cultured females released in nature at the smolt stage, reproductive success is similar to that of wild females. Offspring of cultured

salmon are more generally aggressive, more risk prone, and have a higher growth rate than wild offspring. Consequently, their survival rate in nature may be lower (Jonsson, 1997).. The nature and effects of wild / farmed salmon interbreeding on genetic fitness are still largely un-quantified, however, three scenarios are possible (Dunham *et al.*, 2002):

1. **Adding or reducing genetic diversity, and introducing novel genotypes.** Potential significant negative effects include increased vulnerability to environmental changes and decreased production and fitness of wild populations. In some cases (e.g., when over-fishing of wild stocks selects against size and reduces variability), artificial genetic diversity could increase fitness in endangered species.
2. **Replacement of wild populations.** The long-term survival of a population of escapees required to replace the wild population seems unlikely in the marine environment, given the available space, the discontinuous flow of accidental escapement, and the low survival rate of escapees. Very low occurrence of escaped Atlantic salmon has been reported in eastern Canada. Nevertheless, Atlantic salmon escapees in some rivers in Norway outnumber wild salmon and there is a risk of threatening wild populations even if escapees have a lower reproductive fitness.
3. **Co-existence of escapees with no interbreeding.** This is the case in Western Canada and Chile, where Atlantic salmon are breeding in small numbers. In Chile, where the numbers are much higher than in Western Canada, local fisheries are reported to control escapee expansion (Sotto *et al.*, 2001). The presence of escapees, however, may alter predation pressure on wild stocks, increase competition for feeding resources with wild conspecifics, affect reproductive behaviour (e.g., sterile fish minimizing reproductive features), transfer pathogens, or establish a new population in ecosystems outside their natural range.

A further impact on genetic characteristics stems from the spread of disease from farmed to wild stocks. Mortality among wild fish as a result of disease can reduce their population size, leading to the loss of genetic information. In turn, this could lead to the more frequent occurrence of undesirable traits among the population, and disrupt the evolutionary selective process.

ICES (2002) suggest the following measure for controlling or avoiding genetic impacts on local endemic populations:

1. improved physical containment for all life stages (e.g., improved netting and mooring, use of recirculation technology) (Youngson *et al.*, 2001);
2. improved husbandry practices during fish transfer and sorting (i.e., use of Code of Practice such as the one developed by NASCO and the International Salmon Farmers Association as well as the requirement for an escape contingency plan as part of the consenting of all new and modified farm developments in Canada and Scotland);
3. developing techniques for escapee recovery;
4. use of sterile fish (triploids); use local stock or population, particularly for new species; and
5. maintaining high numbers of wild fish in the production areas.

The Department of Fisheries and Oceans (Canada) (DFO, 1999) recommend the following measures to reduce potential impacts:

1. Improved containment of farmed salmon
2. Selective cage siting to reduce contact between wild and farmed stocks: Positioning of cages away from natural migratory routes, and location of smolt units and hatcheries in land locked fresh water bodies would help prevent interaction between escaped stocks and wild populations. Reduced contact between

- caged and wild fish would also lessen the extent of predation on wild fish by predators attracted to cage sites.
3. Use of local stocks to reduce the impact of altered genotypes in hybrid fish: However, all farmed fish, even of local origin, are likely to suffer some genetic changes after breeding in captivity, meaning this measure may not be very effective.
 4. Genetic containment or sterilization of farm stocks: The use of triploid fish, incapable of producing offspring, is currently the only commercially feasible method to prevent breeding. However, consumer concerns over genetically altered food may make such fish less marketable.
 5. Maintenance of high levels of farmed salmon health to reduce the likelihood of disease and lice transfer to wild fish.

In Norway, better netting and mooring, predator control, as well as improved fish handling practices, have decreased the number of escapees per tonne of fish produced from 4 to less than one from 1993 to 2000 (ICES, 2002).

4.4 Ecological and behavioural impacts

Escaped juvenile and adult fish that enter rivers to spawn increase the amount of competition between individuals in the wild for food, mates, and spawning sites. Escaped females can destroy eggs spawned by wild females through nest superimposition, and also have the potential to mate with wild males, resulting in hybrid offspring. Despite the fact that hybrid juveniles are likely to have lower inherent fitness than wild juveniles, they may have a competitive edge under certain conditions or at certain stages in their life cycle. Evidence from both North America and Europe suggests that fish culture can lead to genetic changes in certain fitness traits, such as increasing growth rate, changing aggressive behaviour, and reducing response to predation (DFO, 1999). These changes are likely to have some effect on the fitness of hybrid offspring, and could alter their competitive interactions with wild salmon. It therefore stands to reason that the higher the percentage of hybrid juveniles in a population, the lower the fitness of future generations.

Salmon cage positioning can also have behavioural and ecological implications for wild salmon. For example, positioning of cage sites along wild salmon migratory routes can lead to interactions between caged and wild fish, potentially altering the timing of migration. Contact could also lead to the spread of disease and parasites between farmed and wild salmon, and could bring wild stocks in to contact with high numbers of predators, such as seals and sea birds, attracted to the cage sites by high fish densities. Both could decrease the survival of wild salmon.

5 Proximity to protected areas

5.1 Birds and habitats directives

The **Habitats Directive** (92/43/EEC) and the **Wild Birds Directive** (79/409/EEC) concern the protection and conservation of natural habitats. SEPA is a “competent authority” with regard to all areas designated in Scotland under these directives, that is Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), collectively known as European sites. SEPA is also a “relevant authority” for European marine sites in Scotland, that is any SAC or SPA which extends below the mean low water mark of spring tides (SEPA, 2003).

The Habitats Directive provides protection for all cetaceans and otters, which are listed on Annex IV of the Directive and are thus classified as “animal and plant species of community interest in need of strict protection”. Article 12 of the habitats directive states that “Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV in their natural range”. Two sections of Article 12 are particularly relevant:

- a) which prohibits “deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration”; and,
- b) which prohibits “deterioration or destruction of breeding sites or resting places.”

Both species of seal, the otter, and two small cetaceans (the harbour porpoise and the bottlenose dolphin) are on Annex II of the Habitats Directive being species of community interest whose conservation requires the establishment of Special Areas of Conservation (SAC) (Gordon & Northridge, 2002).

For marine and terrestrial Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), particular arrangements must be applied in considering any proposals that might affect them. Any proposal, which is likely to have a significant effect on the interests for which the site was designated, must be subject to an appropriate assessment. If this assessment cannot demonstrate that the proposal will not adversely affect the integrity of the site it can only proceed in very exceptional circumstances (SEERAD, 2002). Table 1 lists the sensitivities concerned with natural heritage sites.

5.2 Other designations

Statutory designation of marine natural heritage does not cover a significant proportion of the Scottish marine environment and the absence of statutory designations in any area does not necessarily mean that the marine biology of the receiving waters is not of high quality. Designations are only examples of valuable habitats and many equally valuable areas are not covered by any designation. Available survey information may indicate the presence of habitats, communities or species known to be sensitive to organic enrichment or toxic substances (SEPA, 2003).

The Wildlife and Countryside Act 1981 makes provision for important marine habitats to be designated as Marine Nature Reserves (MNRs). There are no MNRs in Scotland at present. There are 29 Marine Consultation Areas (MCAs) in Scotland, which have been identified to assist bodies that consult SNH on marine conservation issues. While these contain marine habitats of particular quality and sensitivity, they do not have any statutory status (Scottish Executive, 1999).

Table 1: Natural Heritage Sensitivities (SEERAD, 2002)

Natural Heritage interest	Qualifying features	Sensitivity
Natura 2000 sites: Special Areas for Conservation (SACs) ¹ and Special Protection Areas (SPAs)	<p>Natura sites designated for habitats and species which could be sensitive to aquaculture:</p> <ul style="list-style-type: none"> • SACs with a marine element; • SACs that support salmon and/or freshwater pearl mussels (dependent upon salmonids for the early stage of their life cycle) as qualifying features; • Terrestrial SACs immediately adjacent to the marine environment and where otter is a qualifying interest. • SPAs which contain species that will have a direct interaction with the operational areas in the marine environment, and those supporting species in intertidal areas that could be disturbed by offshore activity or by shore based support activities, or affected by pollution. 	<p>SPAs and SACs form a network of protected areas designated under the Habitats Directive and Birds Directives. The Conservation (Natural Habitats &c.) Regulations 1994 require that where an authority concludes that a development proposal is likely to have a significant effect on a European site (even if the development is outwith the site), it must undertake an appropriate assessment of the implications for the conservation interests for which the area has been designated. For example, salmon cultivation beyond the mouth of cSACs with salmon and pearl mussel qualifying interests is likely to require an appropriate assessment of the likelihood of a significant effect upon them.</p>
landscape	National Scenic Areas	<p>NSAs identify areas where Scotland's scenery is of exceptional attractiveness, and where the need to safeguard the existing character and scenic qualities of the landscape assume a high priority. NSAs are a component of the key resource for tourism and thus form the basis for many local economies. Development within these areas should not compromise the objectives of the designation or the overall integrity of the area.</p>
non-Natura biodiversity	<p>Marine Consultation Areas, and other habitats and species identified in the Biodiversity Action Plan and known to be sensitive to aquaculture (maerl, Modiolus, sea fan anemone, seagrass, Limaria, serpulid reefs).</p>	<p>Marine Consultation Areas, although not statutorily designated, are of particular distinction in respect of the quality and sensitivity of their marine environment and where the scientific information available substantiates their nature conservation importance.</p> <p>Other sites identify where species and habitats have been recorded which are known to be sensitive to aquaculture and which are listed in the UK Biodiversity Action Plan. The precise distribution of these features is not certain: development close to mapped sites may also be sensitive.</p>

¹ For the purposes of this table, "SAC" should be taken to include "candidate" and "proposed" as well as "designated".

6 Proximity to wildlife

The interactions between predatory species and aquaculture sites can result in serious stock losses. Conversely, predatory birds and mammals are often drowned as a result of becoming entangled in anti-predator nets. The industry and nature conservation organisations have agreed codes of practice in relation to the interaction between fish farming and predatory wildlife (Scottish Executive, 1999).

6.1 Seals

The most significant predator-related problems for Scottish aquaculture facilities using sea pens involve interactions with grey seals (*Halichoerus grypus*) and common seals (*Phoca vitulina*) (SSGA, 1990). It is therefore in the aquaculture company's best interest to locate the site away from seal haul out areas.

Sites seem to vary as to the degree that seals present a problem and farmers have three basic strategies to exclude seals:

- 1) acoustic deterrent devices (ADDs) are transducers placed in the water and programmed to emit high powered sounds of a frequency that is unpleasant to the seals, thus excluding them from the immediate area;
- 2) the use of a second net designed to keep seals from gaining access to the fish net (not regularly used for large cages); and
- 3) maintaining the fish net at high tension thus preventing seals from being able to bite through to the fish.

Each of these measures is often supplemented with occasional shooting of "rogue" seals. The legal destruction of a particular animal should only be considered after all reasonable attempts have been made to exclude seals from farms and must comply with legislation (AHJWG, 2004).

Both common and grey seals are Annex II species under the Habitats Directive. With a substantial proportion of Europe's common seal population and the world's grey seal population breeding in its waters, the UK has an international role in conserving these species. The process of proposing and agreeing SACs for seals is underway and some of the candidate sites for both species are in areas that also have aquaculture installations. In these cases, issues surrounding the use of ADDs are likely to be considered in developing management plans (Gordon & Northridge, 2002). Grey seal breeding aggregations and some common seal haul out sites have been monitored with considerable precision by the Sea Mammal Research Unit, since the 1970s.

6.2 Birds

Many species of birds may interact with aquaculture sites in Scotland (SSGA, 1990). Eider ducks (*Somateria mollissima*) are the major predator of mussel farms (Gordon & Northridge, 2002) and their distribution is a key factor in determining the location of a mussel farm. Other duck species that predate on mussels include goldeneye and shooter ducks.

Birds are excluded using a number of methods including; deploying nets, strings, gas guns and by installing scarecrows. If properly applied measures fail to control the problem and predatory birds are causing serious stock loss or damage, or fear to the fish stock, a license to destroy them can be made to SEERAD. However, there are a number of protected species for which a license will not be granted (AHJWG, 2004).

6.3 Otters

Otters are both Annex IV and Annex II species and the government is required to establish SACs areas for their conservation (Gordon & Northridge, 2002). It is estimated that some 90% of the UK otter (*Lutra lutra*) population is found in Scotland, with a significant proportion of this number being found in coastal areas to the north and west of the country. Thus, there is potential overlap with Scottish aquaculture facilities. There are reports of some limited conflict between marine aquaculture facilities and otters (Ross, 1988), however this impact is not thought to be detrimental to the otters. The distribution of otters is therefore not fundamental when considering locations for new aquaculture sites.

6.4 Cetaceans

The use of acoustic deterrent devices (ADDs) used to deter seals may impact the distribution and migration routes of cetaceans. Cetaceans are much more sensitive to acoustic noise and a high pitched sound that might inconvenience a seal might cause pain to a cetacean. Thus, powerful acoustic deterrents may exclude cetaceans from a large area. Species likely to be of concern in Scottish waters include the following cetaceans.

Harbour porpoise (*Phocoena phocoena*)

Harbour porpoises are the most common inshore cetacean in UK waters and also regularly occur in many Scottish sea lochs. In addition to being Annex IV species, harbour porpoises are on Annex II of the Habitats Directive. That is, they are species for which member states are required to designate SACs to protect important habitat. So far, UK Government has identified no candidate SACs for harbour porpoise. However, several of the sites that have been proposed by NGOs are in Scotland and include areas with aquaculture sites (Gordon & Northridge, 2002).

Bottlenose dolphins (*Tursiops truncatus*)

Bottlenose dolphins are also an Annex II cetacean species in the Habitats Directive. Two SACs have already been proposed to provide protection for well-known resident populations of bottlenose dolphins: one in the Moray Firth and the other in Cardigan Bay. There is one salmon farm within the Moray Firth cSAC. On the west coast of Scotland bottlenose dolphins are seen throughout the Hebrides and well-known concentrations of this species are found off Islay and Barra. It seems likely that there will be considerable spatial overlap between fish farms and habitat used by this species on the west coast (Gordon & Northridge, 2002).

Minke whales (*Balaenoptera acutrorostra*)

Minke whales are found in all Scottish coastal waters. At least one seasonally resident group is known off Mull, and it seems likely that there may be other such groups along the west coast, and possibly elsewhere. The extent to which their distribution may overlap with fish farms is unclear (Gordon & Northridge, 2002).

Common dolphins (*Delphinus delphis*)

Common dolphins are mainly distributed to the south and west of Great Britain and Ireland, but during summer months common dolphins are frequently encountered in the Minches. Not usually associated with inshore waters, they are nevertheless frequently sighted from shore in some locations. Common dolphins, which feed mainly on pelagic schooling fishes, are probably less likely to interact with inshore fish farms than more predominantly coastal species (Gordon & Northridge, 2002).

6.5 Other wildlife

Phytoplankton

Many farms use copper-based antifouling preparations on nets, in some cases with the addition of booster organic biocides. These give rise to new environmental concerns from the elevated concentrations of copper found in sediments around these farms, and the potential for both the copper and booster compounds to inhibit primary production in the surrounding waters.

The present level of fish farming is having a small effect on the amount and growth rate of Scottish coastal phytoplankton but this effect should not be a cause for concern except in a few, heavily-loaded sealochs (SAMS, 2002).



Annex 1: Separation distances for marine cage farms

Table A.1 Indicative separation distances for marine cage fish farms (Scottish Executive, 1999)

Feature	Distance to finfish farm	Qualifications
Finfish farms	8 km	Closer siting may be possible between small-scale farms, and in large loch systems or open water
Shellfish farms	3 km	as above
Public viewpoints, tourist centres and popular tourist routes	1.5 km	Screening by buildings, landform or woodlands may permit closer siting.
Houses (other than those related to the development)	0.8 km	Attitudes of residents should be taken into account; closer siting may be acceptable in some areas.
Vulnerable wildlife	0.8 km	Assuming adequate anti-predator measures
Anchorage/approaches	0.5 km	Subject to the assessment of the DETR Marine Division
Fishing grounds/netting stations	0.5 km	Assuming specific productive areas in frequent use

Annex 2 References

- Alongi D.M., Chong V.C., Dixon P., Sasekumar A., Tirendi F., 2003. The influence of fish cage aquaculture on pelagic carbon flow and water chemistry in tidally dominated mangrove estuaries of peninsular Malaysia. *Marine Environmental Research* 55 (2003): 313 –333
- Alonso-Rodriguez R. & Paez-Osuna F. 2003. Nutrients, phytoplankton and harmful algal blooms in shrimp ponds: a review with special reference to the situation in the Gulf of California. *Aquaculture*; 219(1-4):317-336
- AHJWG. 2004. Aquaculture Health Joint Working Group. Welfare and Husbandry. FRS website.
- Berry C. & Davison A., 2001, Bitter Harvest A call for reform in Scottish aquaculture, for WWF
- British Columbia, 2003, Guide to the information requirements for marine finfish aquaculture applications
- Burka J. F., Hammell K. L., Horsberg T. E., Johnson G. R., Rainnie D. J. & Speare D. J. 1997. Drugs in salmonid aquaculture - A review. *Journal of Veterinary Pharmacology and Therapeutics*;20(5):333-349
- Butler J.R.A., Marshall S., Watt J., Kettlewhite A., Bull C., Bilsby M., Bilsby H., Ribbens J., Sinclair C.A., Stoddart R.C., Crompton D.W.T. 2001. Patterns of sea lice infestations on Scottish West Coast sea trout: survey results, 1997 – 2000. Association of West Coast Fisheries Trusts 2001
- Carroll M. L., Cochrane S., Fieler R., Velvin R. & White P. 2003. Organic enrichment of sediments from salmon farming in Norway: environmental factors, management practices, and monitoring techniques. *Aquaculture* 2003;226(1-4):165-180
- Chamberlain J., Fernandes T. F., Read P., Nickell T. D., Davies I. M. 2001. Impacts of biodeposits from suspended mussel (*Mytilus edulis* L.) culture on the surrounding surficial sediments. *ICES Journal of Marine Science*, 58: 411–416. 2001
- Cromey C. & White P. 2004. Potential farm management practices for the reduction of aquaculture impact. Newsletter 4. The Mermaid Project.
- Directorate for Nature Management, 1999. Environmental objectives for Norwegian aquaculture, New environmental objectives for 1998-2000 - DN-rapport 1999-1b.
- Dunham, R.A., et al. 2001. Review of the status of aquaculture genetics. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthurs, Eds. *Aquaculture in the Third Millenium*. Technical proceedings of the Conference on Aquaculture in Third Millenium, Bangkok, Thailand, 20–25 February 2000. pp 137–166.
- Gordon, J. & Northridge, S. (2002) Potential impacts of Acoustic Deterrent Devices on Scottish Marine Wildlife. Scottish Natural Heritage Commissioned Report F01AA404.
- Hambrey J. & Southall T., 2002, Environmental risk assessment and communication in coastal aquaculture – a background and discussion paper for GESAMP WG31
- Hansen L. P., Jacobsen J. A., Lund R. A. 1999. The incidence of escaped farmed Atlantic salmon, *Salmo salar* L., in the Faroese fishery and estimates of catches of wild salmon. *ICES Journal of Marine Science*, 56: 200–206. 1999
- Haya K., Burrige L. E., Chang B. D. 2001 Environmental impact of chemical wastes produced by the salmon aquaculture industry *ICES Journal of Marine Science*, 58: 492–496. 2001
- ICES, 2002, Working Group on Environmental Interactions of Mariculture, Mariculture Committee
- Jonsson B. 1997. A review of ecological and behavioural interactions between cultured and wild Atlantic salmon *ICES Journal of Marine Science*, 54: 1031-1039. 1997

- Johnsen, B.O., and Jensen, A.J. 1994. The spread of furunculosis in salmonids in Norwegian rivers. *J. Fish Biol.* 29:233-241.
- Kaiser, M.J. 2001. Ecological effects of shellfish cultivation. In: *Environmental Impacts of Aquaculture*. Sheffield Academic Press.
- Merceron M., Kempf M., Bentley D., Gaffet J.-D., Le Grand J., Lamort-Datin L. 2002 Environmental impact of a salmonid farm on a well flushed marine site: I. Current and water quality *J. Appl. Ichthyol.* 18 (2002), 40-50
- Ross A, 1988. *Controlling Nature's Predators on Fish Farms*. Ross-on-Wye: Marine Conservation Society; 96pp.
- SAMS & Napier University, 2002, *Review and Synthesis of the Environmental Impacts of Aquaculture*, for Scottish Executive
- Scottish Executive, 2003, *A Strategic Framework for Scottish Aquaculture*
- Scottish Executive. 1999. *Advice note: marine and fish farming and the environment*.
- SEERAD. 2002. *Locational guidelines for the authorisation of marine fish farms in Scottish Waters*.
- SEPA. 2003. *Regulation and monitoring of marine fish farming in Scotland – a manual of procedures*.
- Sotto, D., et al. 2001. Escaped salmon in the inner seas, southern Chile: facing ecological and social conflicts. *Ecological Applications*, 11: 1750–1762.
- SSGA, 1990. *Scottish Salmon Growers Association. Salmon farming and predatory wildlife: a code of practice*. Scottish Salmon Growers Association; 36pp.
- WWF. 2005. *Farmed salmon escape into Scottish rivers*. www.panda.org/news
- Youngson A. F., Dosdat A., Saroglia M. Jordan W. C. 2001 Genetic interactions between marine finfish species in European aquaculture and wild conspecifics *J. Appl. Ichthyol.* 17 (2001), 153- 162

Annex 3 Finfish and shellfish sites and sensitive natural heritage

The aquaculture industry in Scotland is primarily located on the western and northern coasts of Scotland where geographical and hydrographic conditions suit the species cultured².

The following maps illustrate the *active* salmon and shellfish aquaculture sites around Scotland and identify natural heritage interests in the marine environment, including where natural heritage interests on land could have implications for development in the marine environment. This information has mainly drawn on the following sources:

- SNH “Advising others – locational guidance for aquaculture, sensitivity of natural heritage to aquaculture” 2002³
- FRS “Scottish Shellfish Farm Production Survey 2002”⁴
- FRS “ Scottish Fish Farms Annual Production Survey 2002”⁵
- FRS “Management Area Maps – December 2003”⁶
- JNCC Special Areas of Conservation, Special Protection Areas, Sites of Special Scientific Interest⁷
- FRS “Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters: Category 1, 2 and 3 areas designated on the basis of FRS predictive models to estimate environmental sensitivity of sea lochs” 2005⁸

The Key for these maps is shown on the next page.

² A. R. Henderson & I. M. Davies (2000). Review of aquaculture, its regulation and monitoring in Scotland J. Appl. Ichthyol. 16(2000), 200-208.

³ Available at <http://www.snh.org.uk/strategy/sr-ac00.asp>

⁴ Pendrey D.J. & Fraser D.I. 2003 available at <http://www.scotland.gov.uk/Publications/2003/10/18408>

⁵ Stagg R.M & Smith R.J. 2003 available at <http://www.scotland.gov.uk/Publications/2003/10/18408>

⁶ Available at http://www.frs-scotland.gov.uk/FRS.Web/Uploads/Documents/Dec_Management_Area_maps.pdf

⁷ Available at <http://www.jncc.gov.uk/page-4>

⁸ Available at

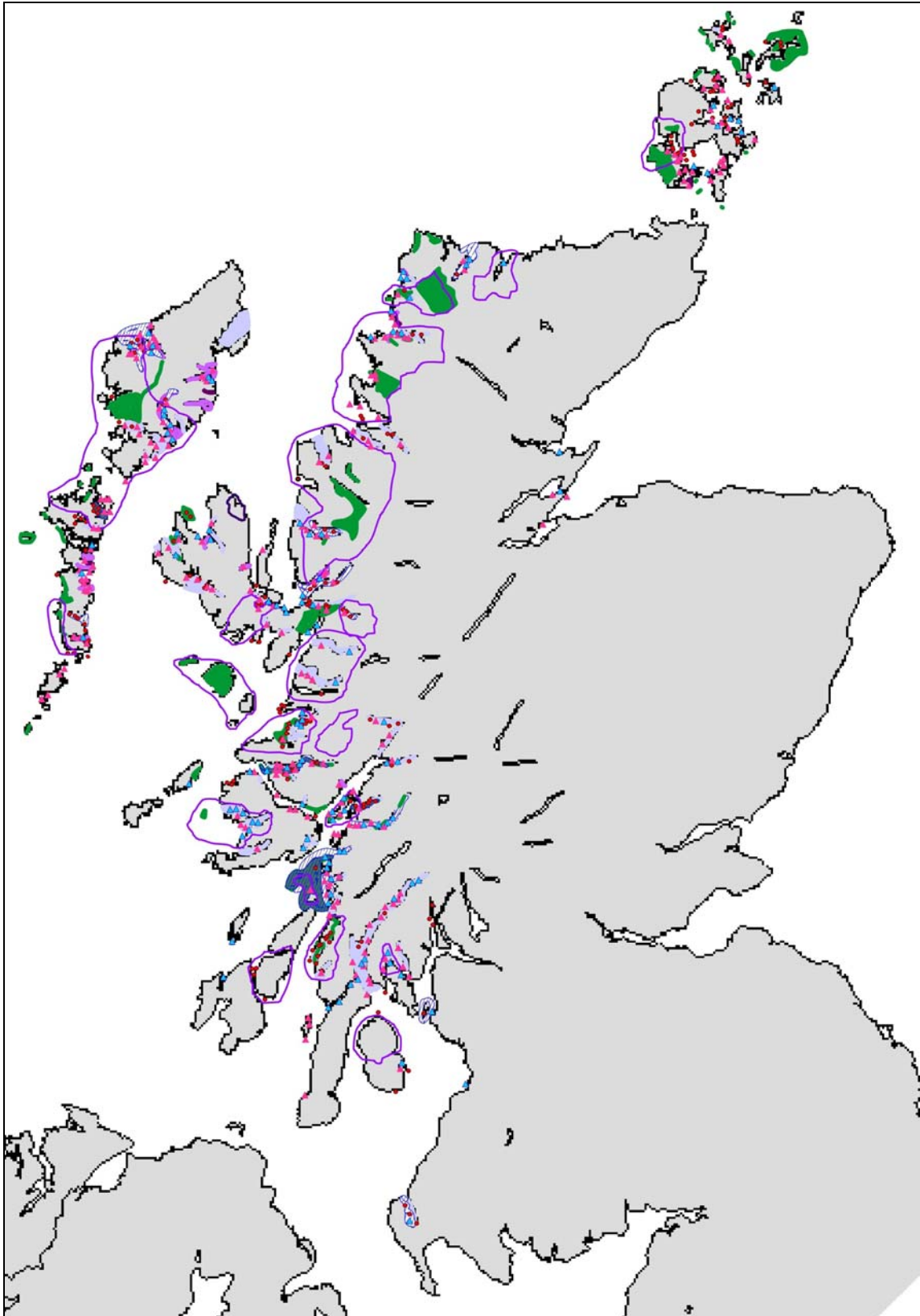
http://www.marlab.ac.uk/FRS.Web/Delivery/Information_Resources/information_resources_view_document.aspx?contentid=1416

-  **Finfish aquaculture sites**
-  **Shellfish aquaculture sites**
-  **Sensitive BAP species or habitats**
-  **Natura 2000 sites**
-  **National Scenic Areas**
-  **Marine Consultation Areas**

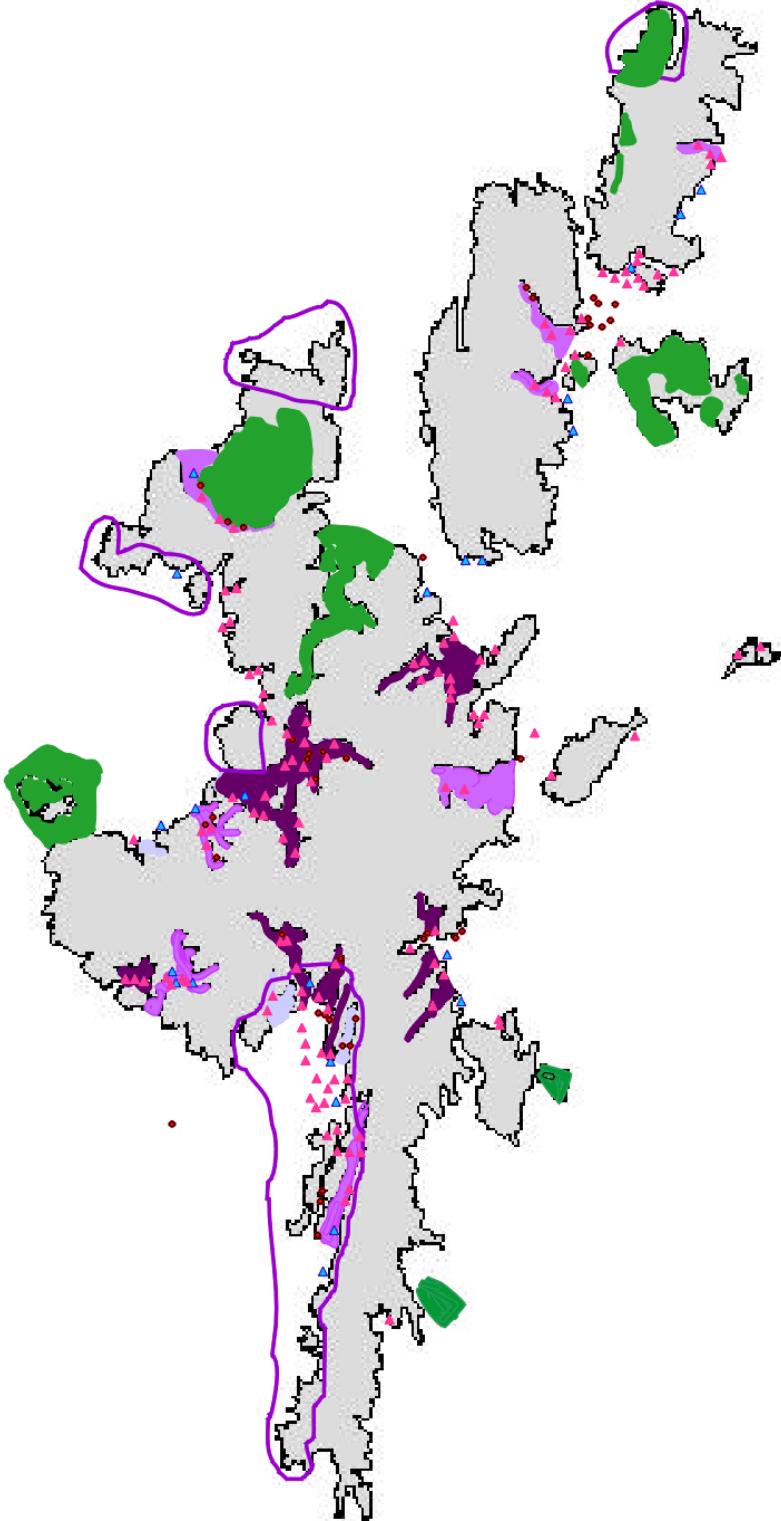
Locational Guideline Categories

-  **Category 1**
-  **Category 2**
-  **Category 3**

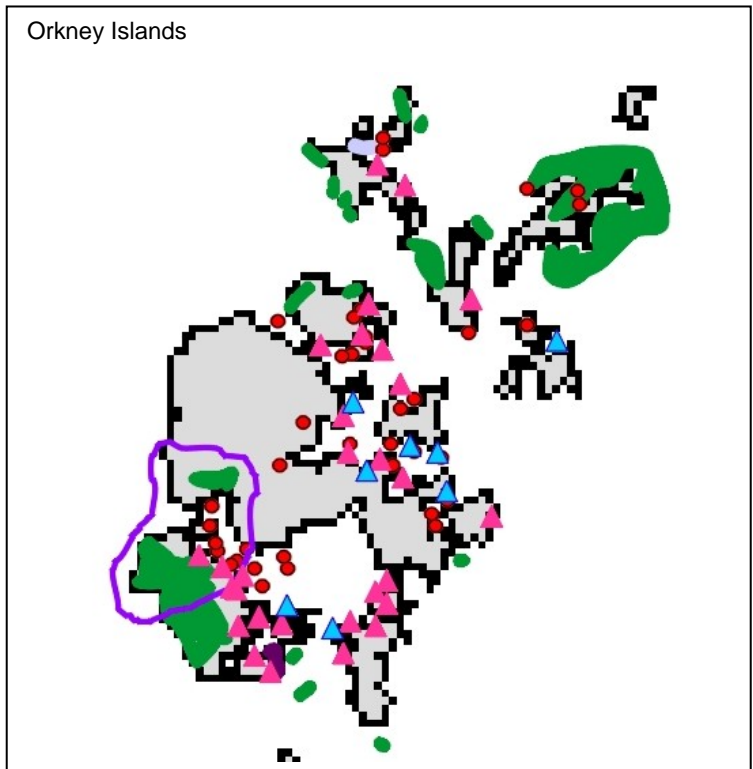
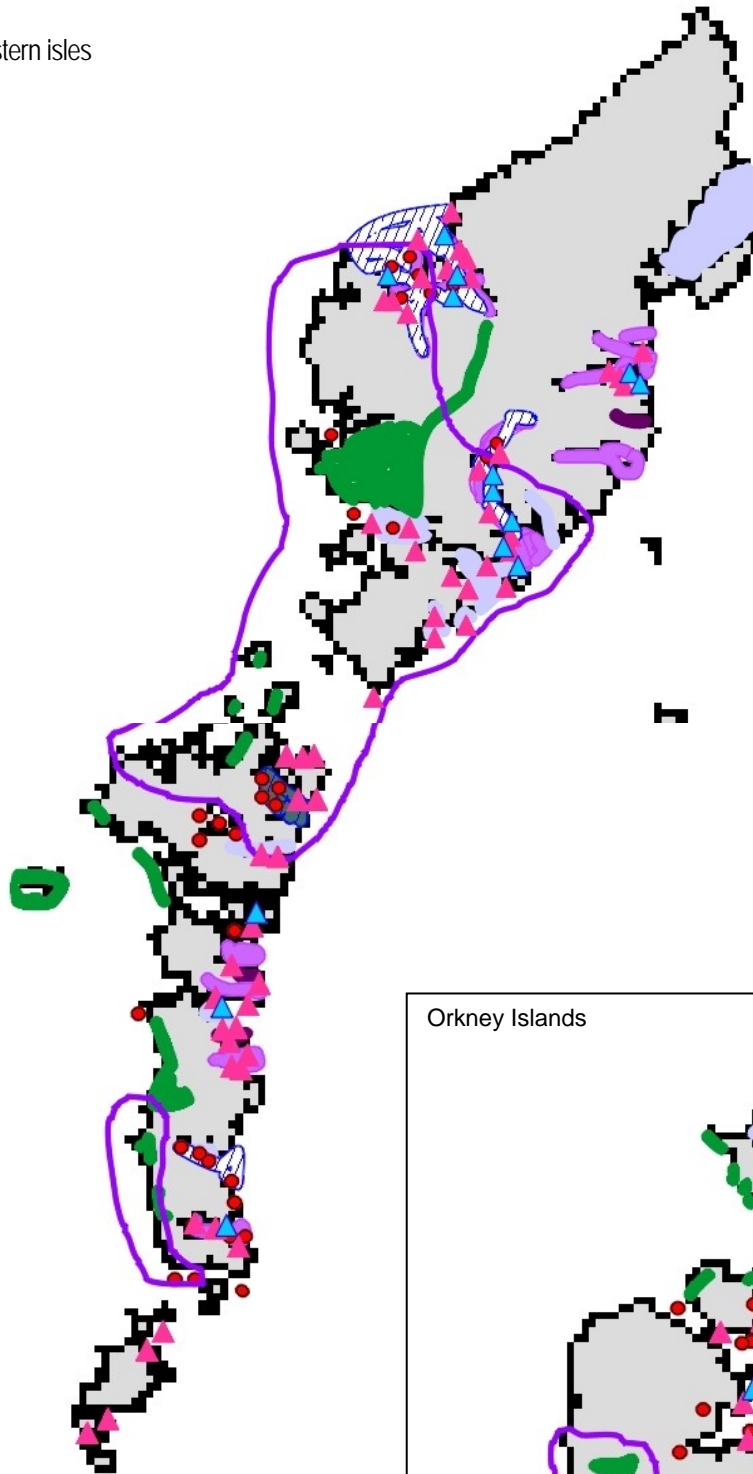
Whole of Scotland (minus Shetland)



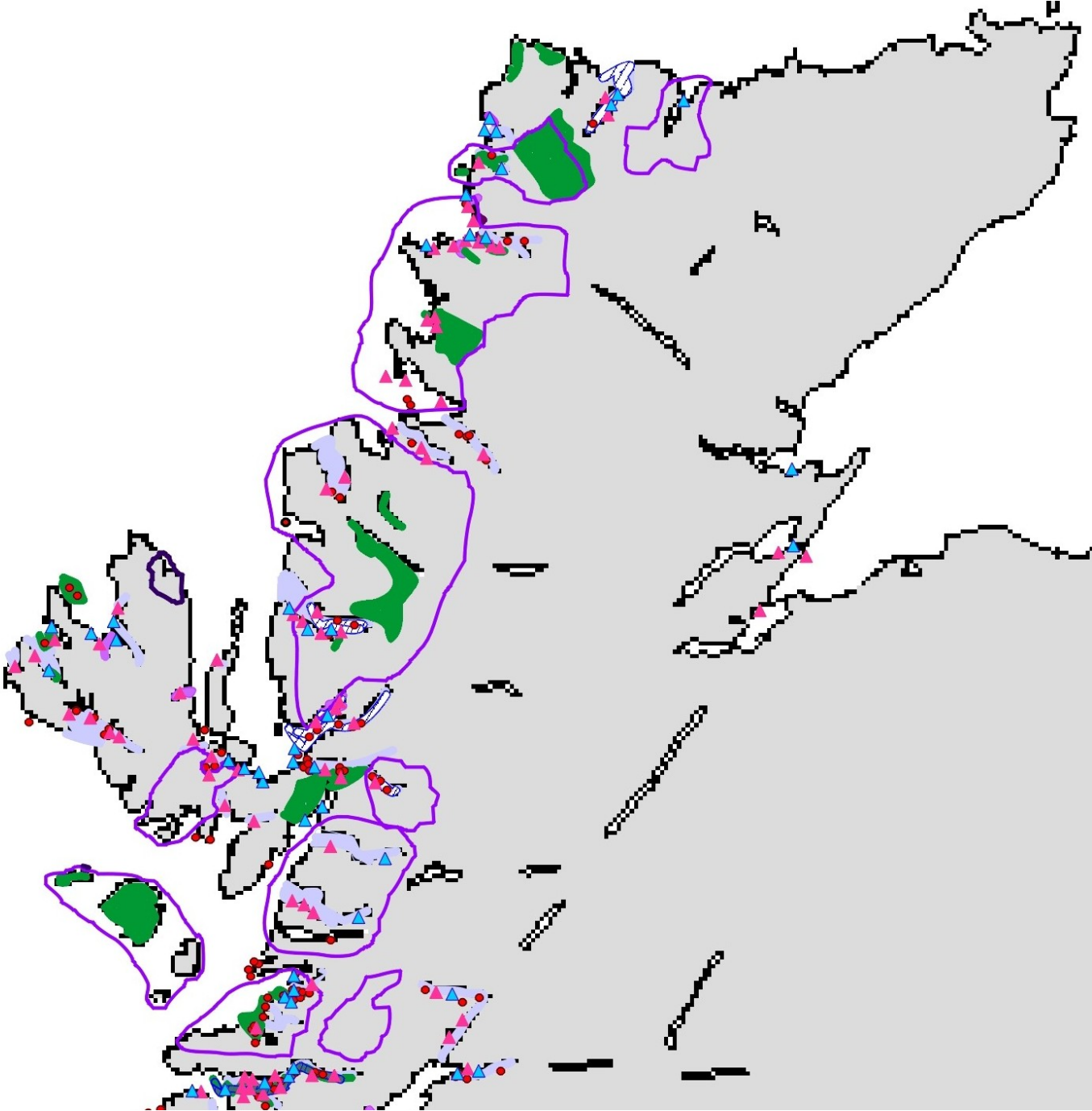
Shetland



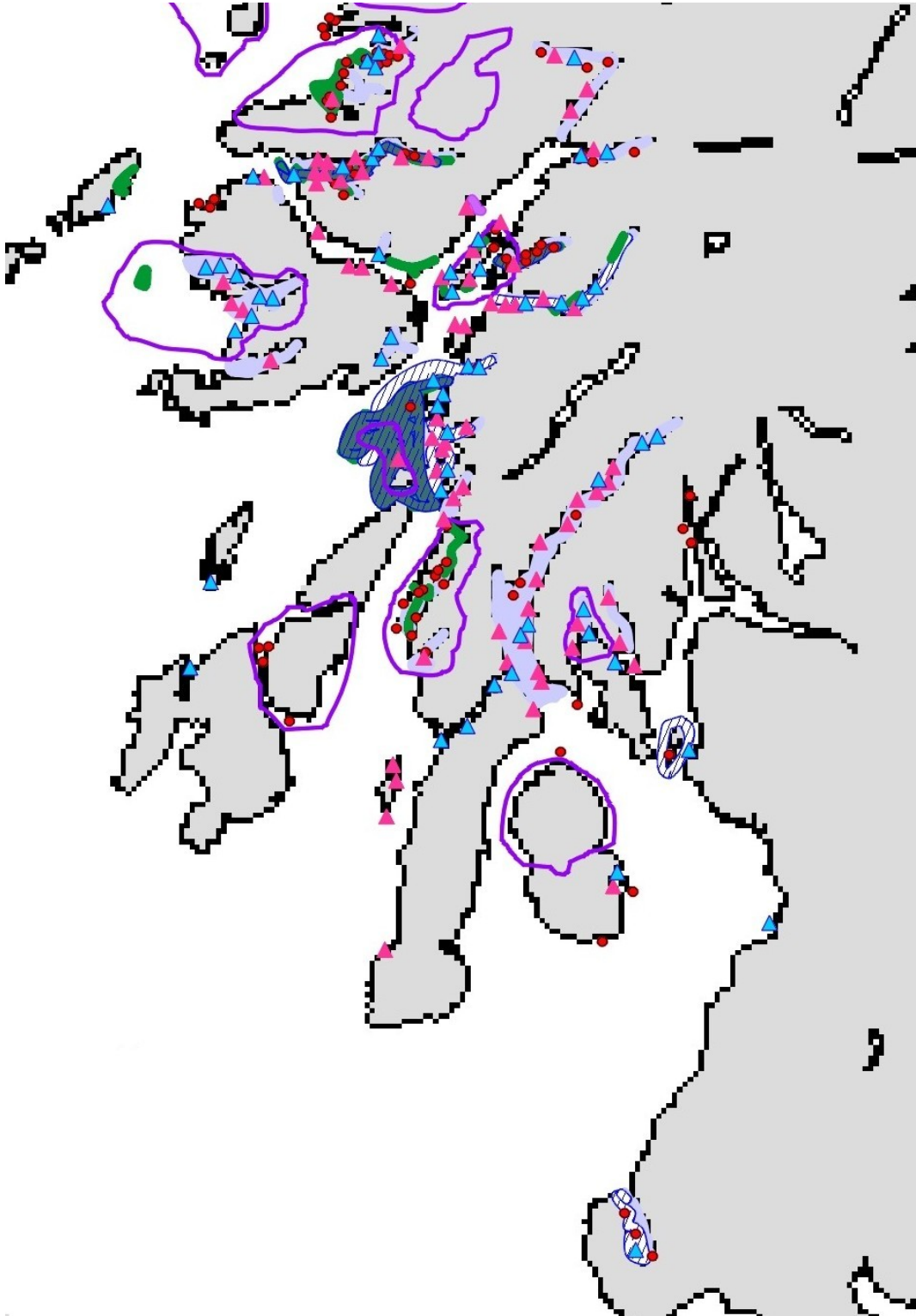
The western isles



North and north west coast Scotland



West coast of Scotland



Annex 4 Additional notes (socio-economic)

Proximity to human settlements (to be dealt with in WP 2)

Notes on landscape and visual impacts

- Both shellfish and finfish aquaculture can impact upon the landscape, due to the location of structures such as cages and buoys in the water, and the construction of support facilities on land adjacent to farms (Berry & Davisob, 2001).
- In some locations it will be appropriate to consider nutrient loading from aquaculture in the context of external factors such as agricultural run-off (Scottish Executive, 1999).

Notes on accommodation

- The availability of housing for employees is an important consideration, with suitable accommodation often being scarce in many parts of rural Scotland.
- Reasonable proximity between marine fish farming sites, service bases and staff accommodation is desirable on logistical grounds. The location of equipment and facilities within sight of occupied accommodation may be desirable for security reasons.
- Details of anticipated housing requirements and security considerations should be included within the initial development proposal.
- Planning permission for the development of onshore facilities does not imply that permission for a related housing development will automatically be forthcoming (Scottish Executive, 1999).

Proximity / ease of access to infrastructure

(To be dealt with in WP 2)

Notes on shorebases

- It is essential to ensure that adequate arrangements can be made for servicing offshore sites. Finfish farms in particular have substantial servicing requirements.
- Onshore sites are likely to be required as bases for servicing, purification, processing and maintenance operations and the storage of supplies and equipment.
- While it may be possible to locate some servicing facilities offshore, the location of huts or similar structures on offshore equipment is generally undesirable, as they are liable to be visually obtrusive. In all cases, appropriate arrangements require to be made for the safe disposal of dead and diseased fish and offal and for any waste-generating operations such as net cleaning.

Notes on roads

- The traffic generated by finfish farms can put considerable pressure on narrow rural roads and the consequential wear and tear has implications for the maintenance budgets of roads authorities.
- Planning permission for onshore facilities may be refused if the capacity of local roads is insufficient to accommodate service traffic. Ways in which such difficulties can be overcome where practicable include more transport of harvested fish by sea or rail rather than road (Scottish Executive, 1999).

Notes on land-based development

On land, marine fish farm structures include jetties, offices and stores, hatcheries, net drying and cleaning equipment, shore-based feeding systems and outdoor tanks. Good sites are often in hollows or enclosed bays, sheltered and screened by existing vegetation. It is recommended by the Scottish Executive (1999) to:

- avoid roadside development;
- avoid skyline sites, which can have an impact over a wide area, instead using hillsides and woodland as a backcloth;
- use redundant buildings; and
- avoid popular marine routes, such as regular ferry routes.

In addition, any direct damage to existing features of landscape interest such as woodlands, cliffs or beaches, should be avoided. Any new buildings should relate well to the landform - for example, they may lie parallel with the contours and be set into the hillside to reduce visibility from both land and water. Similarly, access roads, parking and working areas should be sensitively handled. Levelling and ground-modelling should be kept to a minimum.

Site Optimisation for Aquaculture Operations

WORKING PAPER 2

REVIEW OF REGULATION

and

IDENTIFICATION OF ECONOMIC, SOCIAL
AND LEGAL ISSUES

July 2005

Prepared for: Scottish Aquaculture Research Forum

Prepared by: Sue Evans – Research Services, for Hambrey
Consulting

Contents

Contents.....	1
Acknowledgements.....	2
1 Introduction.....	1
1.1 Context.....	1
2 Regulation of location and siting (Objective 1)	2
2.1 Overview	2
2.2 EIA.....	2
2.3 Consultations	3
2.4 Statutory Regulations	5
2.5 Key Issues	5
3 Economic, social and legal issues regarding siting (Objective 2).....	6
3.1 Overview	6
3.2 Economic viability for the individual business.....	7
3.3 Social and socio-economic issues.....	7
3.4 Legal issues	9
3.5 Key issues.....	9
4 Appendices	10
Appendix 1 – Procedure for applying for a seabed lease.....	11
Appendix 2 – SEPA framework for processing a discharge consent	12
Appendix 3 - Internal considerations by statutory consultees.....	13
Appendix 4: Criteria used by Local Authorities when considering a site application	15
Appendix 5. Criteria used in environmental impact assessment.....	16
Appendix 6: Summary of existing siting guidelines	18
Appendix 7: Summary of social and economic issues and criteria	22
Appendix 8: The use of economic multipliers to examine the socio-economic impacts of aquaculture.....	25

Acknowledgements

This work draws upon a draft of the paper "Decision-making in the Scottish Marine Environment" by Tristan Southall for Royal Haskoning/Scottish Executive, 2005. I am also grateful to Dr Graham Pierce for providing work from the Aberdeen University ACQESS report.

1 Introduction

1.1 Context

This review forms part of Objectives 1 and 2 of the project Site Optimisation for Aquaculture Operations for the Scottish Aquaculture Research Forum (SARF) and is complementary to the main Objective 1 Review (Nimmo 2005) which concentrated on the environmental aspects of location and siting. This paper reviews the operation of legislation relating to aquaculture siting in Scotland, examines relevant literature from Scotland and abroad and summarises key economic, social and legal issues relating to aquaculture siting.

The overall objectives for the project are:

Objective 1 To develop an informed and objective review of the current status of knowledge, best practice and regulation regarding location and siting for aquaculture operation. This review will include lessons learnt from ongoing relocation programmes.

Objective 2 To identify the environmental, economic, social and legal issues - and associated criteria - that should be taken into account when assessing and selecting locations and sites for aquaculture development.

Objective 3 Taking account of existing and evolving decision making processes, to identify the ways in which the issues and criteria identified and developed in this research can be used effectively to deliver more informed decisions by both regulators and aquaculture enterprises.

Objective 4 To make specific recommendations for targeted cost effective research to underpin a defensible framework for coastal resource allocation with respect to aquaculture.

2 Regulation of location and siting (Objective 1)

2.1 Overview

Any site for aquaculture, for shellfish or marine fin fish, needs:

i) A **seabed lease** from Crown Estate Commissioners, (CEC) See Appendix 1

For which one needs either - development consent, from the CEC via the Local Authority

OR (Shetland and parts of Orkney) - Marine Works Licence, directly from the Local Authority

AND

ii) A **discharge consent** from Scottish Environment Protection Agency. (SEPA) See Appendix 2

AND

iii) A **Navigational Consent** (CPA Section 34 1949 Licence) from the Scottish Executive Enterprise, Transport & Lifelong Learning Department. As the Development consent deals with issues of navigational safety through its process of statutory consultation, the navigational consent is not usually problematic.

Planning consents for shore base facilities (above the shore line) are issued by local authority, with reference to the Town & Country Planning (Scotland) Act 1997, just as any other planning application.

This system has drawn criticism for involving up to 15 different authorities and four consent applications¹. Essentially, various public bodies consider the application in the light of their own remit, which will include the likelihood that the development will conform with various regulations. Appendices 3 and 4 detail some of the issues taken into consideration by SEPA and SNH.

The seabed lease is issued by the Crown Estate, who will charge rent based upon production volumes, and informed by production costs and market values. The development consent which precedes the granting of the lease is currently issued by the Crown Estate but responsibility is to pass to Local Authorities², probably in 2006. In practice, CEC already follow the recommendations of Local Authorities. There is a right of appeal.

In Shetland, the Zetland County Council Act 1974 gives the Shetland Islands Council jurisdiction over the coastal waters and a marine works license is required for marine development. In the event that a works license is granted the Crown Estate would normally grant an accompanying seabed lease. In the Orkney Islands and parts of the Western Isles, Harbour Orders give similar powers to the Islands Councils in the areas covered by those orders.

2.2 EIA

The Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations 1999 automatically apply to proposed fish farm developments in sensitive areas, those that hold a biomass of 100 tonnes or more, or that cover an area in excess of 0.1 hectares. If an existing site expands by more than 100 tonnes biomass or 0.1 hectares surface area, another EIA is necessary. In practice EIAs for fish farms tend to be strong on water quality issues – for which information is in any case needed for the discharge consent – and weaker in relation to wildlife, landscape, navigation and socio-economic issues.

¹ Houlihan, D.F., Pierce, G.J., Theodossiou, I., Spencer, N.J., Mente, E., Dick, H.S., 2004. Aquaculture and coastal economic and social sustainability. Final Report to the European Commission's Directorate General for Research on Project Q5RS – 2000 – 31151.

This comment taken from the Special Report based on this AQCESS study, and reinforced by other commentators.

² In October 2004 The Scottish Executive published a consultation paper "Extending Planning Controls to Marine Fish Farming".

The rationale for EIA typically emphasises the potential benefits to developers in terms of enhancing the likelihood of approval where best practice EIA procedures are followed. A key part of the process is to consider alternative sites and then to select and justify the “best practicable environmental option”, proposing mitigation measures as appropriate.

Some broad guidance on the criteria which should be addressed in EIA are provided in the 1999 regulations (see Appendix 5). Further guidance is provided in The Crown Estate EA Guidance Manual for Marine Fish farmers. Annex 7 of this guidance lists “potential issues of concern”, and annex 9 lists “criteria for evaluating the possible significance of effects”. These include the standard EIA significance criteria, such as duration, reversibility, magnitude, area/extent, probability of occurrence, value and sensitivity of site and associated landscape, flora, fauna, other users/uses etc.

Part 2, schedule 2 of the 1999 regulations requires the developer to provide “data required to identify and assess the main effects which the development is likely to have on the environment”. In other words the emphasis is on *information* for the decision maker and its advisors/consultees; it is not *analysis* designed to facilitate the decision making process, and there is rarely if ever any kind of trade-off analysis between possible costs and benefits associated with the development. This is understandable – such an analysis would be widely regarded as biased. The problem at the present time is that there is no formal procedure for making an independent analysis of this kind.

The existing EIA procedures help to “take out” the worst sites, and especially those that would fail at the discharge consent stage. However they are costly and do not appear to significantly increase the overall chances of site application approval, which is determined primarily in relation to competing stakeholder interests.

2.3 Consultations

Statutory consultees are

SNH
SEPA
SE
District Salmon Fishery Board
Local Authority.

In addition to considering compliance with statutory regulation, detailed in Section 2.3, these bodies consider the application within their own remit and various forms of internal guidance. Any may request a full environmental statement, although the application will be usually be supported by some environmental data initially. Interested parties such as Northern Lighthouse Board, MCA, Royal Yachting Association, local fishermen's groups and neighbouring aquaculture facilities may also be consulted by either CEC or the local authority. Shellfish sites do not currently require an EIA.

SEPA is also required to have regard to the social and economic needs of any area, but particularly rural areas (where fish farming activities happen to be most concentrated), and staff must take account of this requirement when determining applications³. This is especially important where there may be a need to impose a restrictive condition. All public bodies are required to consider this, but it is most explicit in SEPA literature.

The responses of all consultation are also copied to the local authority who will take a decision based upon the consultations and respond to the Crown Estate. The local authority responds to the Crown Estate in one of 3 ways:

YES - Unqualified Favourable View (No formal expressions of concern – satisfied the proposal can proceed.)

³ SEPA guidelines Regulation and monitoring of marine cage fish farming in Scotland - a manual of procedures

YES BUT - Qualified Favourable View (One or more issues of concern – but LA is satisfied application can proceed, perhaps subject to certain conditions).

NO - Unfavourable View (Application should be refused – irrespective of whether statutory consultees have responded favourably).

The Crown Estate have informally undertaken to implement the local authority's recommendation. In the event of a favourable view the Crown Estate will prepare a lease for signature by the applicant, detailing the basic terms and conditions. In the event of an unfavourable view the applicant has a right of appeal, within 6 months of the date of notification, through the Scottish Executive Inquiry Reporters Unit. Since 1986 there have been over 1,000 applications with approximately 50% accepted and 50% rejected, withdrawn or amended.

2.4 Statutory Regulations

2.4.1 Applicable to a Seabed lease

Legislation	Considered by (statutory consultee)
Sea Fisheries (Shellfish Act) 1974	Scottish Executive (Fisheries Group)
Food & Environmental Protection Act 1985 – Part II – Deposits in the Sea	
Registration of Fish farming and Shellfish Farming Business Order 1985	
Sea Fisheries (Wildlife Conservation) Act 1992	
Diseases of Fish Acts 1937 &1983	Scottish Executive
Coast Protection Act 1949 (Part 2 Section 34).	Scottish Executive Transport Division
Conservation (Natural Habitats etc) (Amendment) Regulations 1997	Scottish Executive Wildlife and Habitats Division
The Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations 1999 (SI 1999 No. 367).	Crown Estate Commissioners
Nature conservation (Scotland) Act 2004 ?????	Scottish Natural Heritage
Town & Country Planning (Scotland Act) 1997	Local Authority
Environmental Impact Assessment (Scotland) Regulations 1999	
Zetland County Council Act 1974 & Orkney County Council Act 1974	

2.4.2 Applicable to Discharge Consent

Legislation	Statutory consultee
Environment Act 1995, Section 21, which identifies SEPA's pollution Control Functions under and by virtue of the: Control of Pollution Act 1974 under which: It is an offence for a person to cause or knowingly permit any trade effluent or sewage effluent into controlled waters	SEPA

2.5 Key Issues

- è The nature of Local Authority deliberations
 - Criteria for final decision
 - Relative weight given to different stakeholder opinions
 - Rigour and extent of consideration of formal social, economic and environmental information
- è The response of the system to the need for relocation
- è The ability of the process to take an overview of the sustainability of the site

3 Economic, social and legal issues regarding siting (Objective 2)

3.1 Overview

This review considers economic, social and legal siting issues at the local and regional level rather than at the global scale. There is a difference. On a global scale, the wisdom and sustainability of aquaculture has been questioned, but so could that of many industries.

One might expect a considerable international literature on the social and economic effects of aquaculture but this is not the case. Social and economic aspects of aquaculture are poorly understood and poorly documented, with the notable exception of parts of Ireland. Norway, Chile and Scotland are the worlds' three biggest farmed salmon producers and one might expect a body of literature there, but it is not obvious. For Norway, we could find nothing. In Chile regional commentators consider that Chile's competitive edge lies in low wages and in not internalising environmental and social costs⁴. Interestingly, there is little consideration of the social and economic benefits, although for these may exist.

Europe is little better, especially considering that the EC employs some 80,000 people in aquaculture, full and part time. The European commission themselves, not usually short on paperwork, concluded⁵ that "little information is available on the socio-economic impact of coastal aquaculture activities in Europe". They continue "However a recent study carried out in some Scottish areas⁶ shows that salmon farming development stopped the decline of the rural population (for the first time in the last century), and that young people found employment throughout the year, while other economic activities like tourism were only seasonal. Aquaculture, and in particular mollusc and cage culture, can be a part-time additional revenue for fishermen or an alternative for workers displaced from the fisheries sector, as marine aquaculture needs employees skilled in working in and from a boat."

The FAO recommends that not only should environmental impact statements (EIS) be undertaken, but also that social impact assessments (SIAs) should be conducted along with the EIS⁷. The practical Australians would also like a set of indicators to assess the social and economic aspects⁸. The lack of meaningful social and economic indicators makes it difficult to carry out this sensible "Triple Bottom Line"⁹ reporting on aquaculture siting, and therefore difficult to assess sustainability. All public bodies in Scotland have a duty to consider the sustainability of what they are doing, but quite how one is supposed to do this in the absence of some guidelines as to what is expected by way of social and economic analysis is not clear.

It may be that quite simple analysis is sufficient. In Scotland there is plenty of social and economic data available, although it is hard to disaggregate it to a small enough local level to say anything specific about individual sites, and one may need to go and ask questions. A rough approximation of the number of jobs that may be created in the local area (not at far flung processing sites), a feel for the level of economic activity, availability of employment, the demographic profile within the area and perhaps use of a multiplier to estimate the effect on the wider community may well be sufficient. During Local Authority deliberations in consultations leading to a decision on a seabed lease, one assumes that the Economic Development Unit of the Local Authority (or equivalent) does look at local social and economic implications, but the process is not transparent. Not all Local Authorities are well-versed in the issues, or have councillors who understand the implications of a NIMBY approach. Shetland Islands Council and Highland Council probably have the most experience. Certainly a Local Authority should be well placed to study the issue, but may not have prior experience of the industry

⁴ R Pizarro. Santiago Times. 11 July 2005

⁵ A strategy for the sustainable development of European aquaculture. EC COM (2002)511 final Brussels 19.9.2002

⁶ A strategy for the sustainable development of European aquaculture. EC COM (2002)511 final Brussels 19.9.2002

⁷ Aquaculture: the Social Context. Dr Sylvie Shaw, Australian Maritime College.

⁸ Assessment and Reporting of the Ecologically Sustainable Development of Australian Aquaculture – An Industry Perspective. Australian Department of Agriculture, Fisheries and Forestry. 2004.

⁹ The "Triple Bottom Line" approach simply means looking at the environmental, social and economic implications of a development or situation at the same time, and using all three parameters when considering what to do.

3.2 Economic viability for the individual business

Unless economically viable an industry is inherently unsustainable, and this applies firmly at the individual business level. Siting is not such an issue once farmers start to go out of business, except inasmuch as empty cages have as great a landscape effect as full ones, but no economic or social benefits. To a large extent, siting decisions as they affect individual business decisions are made by the applicant themselves before regulation kicks in. It makes economic sense for a business to expand near to an existing site, since personnel, boats, jetties, sheds and the like are already in place and the extra investment in fixed capital equipment is minimal. Availability of suitable jetties, roads, sheds and personnel is a primary criteria. Good road access helps with all aspects, including marketing. A longer journey to a site is more expensive in time, maintenance and diesel and is less than pleasant, if not downright dangerous, in bad weather. Having one or more people who work on the farm living within sight of the cages is a real advantage, although difficult to quantify financially. However, unless more sites are available there is little point in providing more infrastructure.

The precise location of the cages or mussel ropes matters in that a "good" site will, all other things being equal, produce at less cost, being less prone to disease and capable of stocking at a higher density without breaking the discharge consent conditions. A "poor" site will, again all other things being equal, cause a farmer to lose money before a good site will. In this sense many environmental criteria are perfectly supportive of sound business practice and not an issue.

Market price is crucial, as are production costs, and limited site availability is relevant here. Regardless of precise site location, lack of site availability limits expansion of farms and the development of new farms. Opportunities for deriving any benefits at all become seriously limited, and Scotland, with relatively high environmental regulation costs and fewer economies of scale, becomes less able to compete in what is becoming a global market. This has become an individual business problem. So serious has this become that the EC is considering special measures to protect the EC farmer (essentially the Scottish industry), to the chagrin of the Norwegians¹⁰.

Improvement of site availability may prove an effective way to enhance sustainability in the aquaculture industry and therefore communities. However, the principal of limited site availability is for good environmental reasons, and although the system is cumbersome it is clearly not in the best interest of the aquaculture industry to harm the environment upon which it relies¹¹. In practice, it may be possible to improve both the regulatory system and the technicalities of farming to the benefit of both farmers and environmental protection. Most of the difficulties are social, not technical or even environmental.

3.3 Social and socio-economic issues

Aquaculture provides employment in remote areas where chances of alternative employment may be very limited. This improves the chances of the community surviving as an economically active part of society with a range of age groups and a certain level of local services. This demographic aspect is important, as is the social benefits of work done by fish farm staff in the community. Fish farm staff are active, practical people who can be seriously useful as volunteer firemen and members of mountain rescue teams¹². Their families keep schools and shops open and their money supports other local businesses. They are permanent residents. Precise site location matters to them in that a good site is more likely to contribute to the survival of the business, and to the continuation of the economic and social benefits associated with it.

Ownership of the enterprise matters in some areas, and affects community perception of the industry. Aquaculture production is moving towards economies of scale, and multi-national takeovers are resented in some quarters, notably Shetland, but in other areas stakeholders consider such takeovers as a positive factor as they prevent the loss of farms in areas where people rely on the jobs¹³. Economies of scale could lead to better siting and relocation decisions. Multiple (very) independent owners within a voe or sea-loch can cause serious disagreements over seabed leases, discharge consents, relocation, lice treatment, mussels vs. salmon and many other issues. Our research on Shetland

¹⁰ <http://odin.dep.no/fkd/english/news/news/047011-070009/dok-bn.html>

¹¹ Hoolihan et al op cit.

¹² The economic impact of Marine Harvest in the Highlands of Scotland. S Westbrook for Marine Harvest. 2002.

¹³ Hoolihan et al 2004 op cit

found that local rivalries could stand in the way of what could have been a practical siting strategy for a locality. Co-operation is an obvious answer, but is not always a cultural tradition, the instinct for unhelpful territorial behaviour being very strong, particularly among men.

The social and economic dimension of fish farming in Ireland has been unusually well-studied. As part of the Aberdeen University Aqcess project¹⁴ two study sites, Bantry Bay in Co. Cork and the Dingle Peninsula in Co. Kerry were examined in depth. The aim of the project was to assess the sustainability of aquaculture in the area with respect to ecology/environment, socio-economics, community and institutions¹⁵. Shellfish farming predominates in both sites, population densities are below the national average and tourism is important. Bantry Bay is host to Irelands greatest concentration of rope mussel culture and also has some salmon farms. Mussel and oyster beds predominate on the dingle peninsula, with significantly less visual impact.

The study concluded that "The arrival of the aquaculture industry has introduced a new source of employment to the study sites. This has support from the community due to the employment given, however community members do not wish to see the traditional fishing activity pushed out to accommodate aquaculture (Synthesis interviews). They do appreciate that aquaculture provides an alternative source of employment, not only directly in the industry but also in the supporting industries." This report did not directly address siting issues, but did highlight the possible conflicts of interest inherent in an aquaculture industry operating in an area known for its landscape quality and very dependent on tourism. There was also concern over the number of mussel lines in Bantry Bay in that these pose a navigational difficulty, reducing the availability of the bay to swimmers, canoeists and other pleasure craft users.

The full report on the study¹⁶ detailed responses from a comprehensive survey of fish farmers. The main reasons individuals began working in the industry were family tradition, good income, lack of alternative employment, and lifestyle. The main reasons why aquaculture workers remain in the industry are lifestyle, lack of alternative employment and good income. The job characteristics rated most highly were earnings, working conditions, a way of life and independence. Detailed siting considerations appear to be an issue in the sense of landscape impact with regard to tourism, but simple practical measures (grey mussel barrels instead of blue ones) certainly help. Of more concern in the social and economic sense is the navigational difficulties that mussel lines pose, and this could be seen as a siting issue.

The tenor of the Irish report strongly implies that there are considerable social and economic advantages to the industry existing in the area at all, as the work provided is popular, there are few steady alternatives (although more than in some areas of Scotland) and the financial returns are worthwhile. The strong local sense of culture and community is obviously fostered (or at least not discouraged) by the presence of local jobs involving traditional skills. These findings were borne out by our work on Shetland, where enthusiasm for the work was striking. Aquaculture involves boats, mending everything, freedom from offices, a certain degree of autonomy and producing food. The salmon and mussel farmers we spoke to were extremely proud of their produce, and thoroughly enjoyed the work. Much better, said one farmer on Shetland, than hanging around Sullom Voe in a hard hat trying to look busy.

Key areas where siting can cause painful community conflict is over landscape impact, rubbish and navigation. Older members of the community in Shetland still remember when to get work meant going to sea, perhaps whaling in the South Atlantic, or taking some other job far from home. Fish farmers get to go home at night, and the older members of the society knew the value of this and liked to see fish farms. For newer members of the community, perhaps salaried or on a pension, with no memory of these times, a fish farm may seem a real blot on the landscape. Similarly with navigation, a local person will know where mussel ropes are but for a recreational yachtsman who visits occasionally they could be a serious problem. The impact on tourism is uncertain. Some tourists are apparently very interested in the farms, and the overall impression of the landscape is vary favourable, farms or not. It may be that their perception is coloured by how the subject is introduced, and by knowledge of local communities. Siting matters, as does some attempt at camouflage, proper facilities for cheap commercial rubbish disposal, proper buoyage, pilot information and a positive approach.

¹⁴ Houlihan et al 2004 op cit

¹⁵ AQCESS Work package 10 Synthesis. National Synthesis: Ireland. Trish Clayton & Valerie Cummins, University College Cork 2003

¹⁶ Socio-economic profile of coastal communities in Ireland. Trish Clayton, University College Cork 2002

3.4 Legal issues

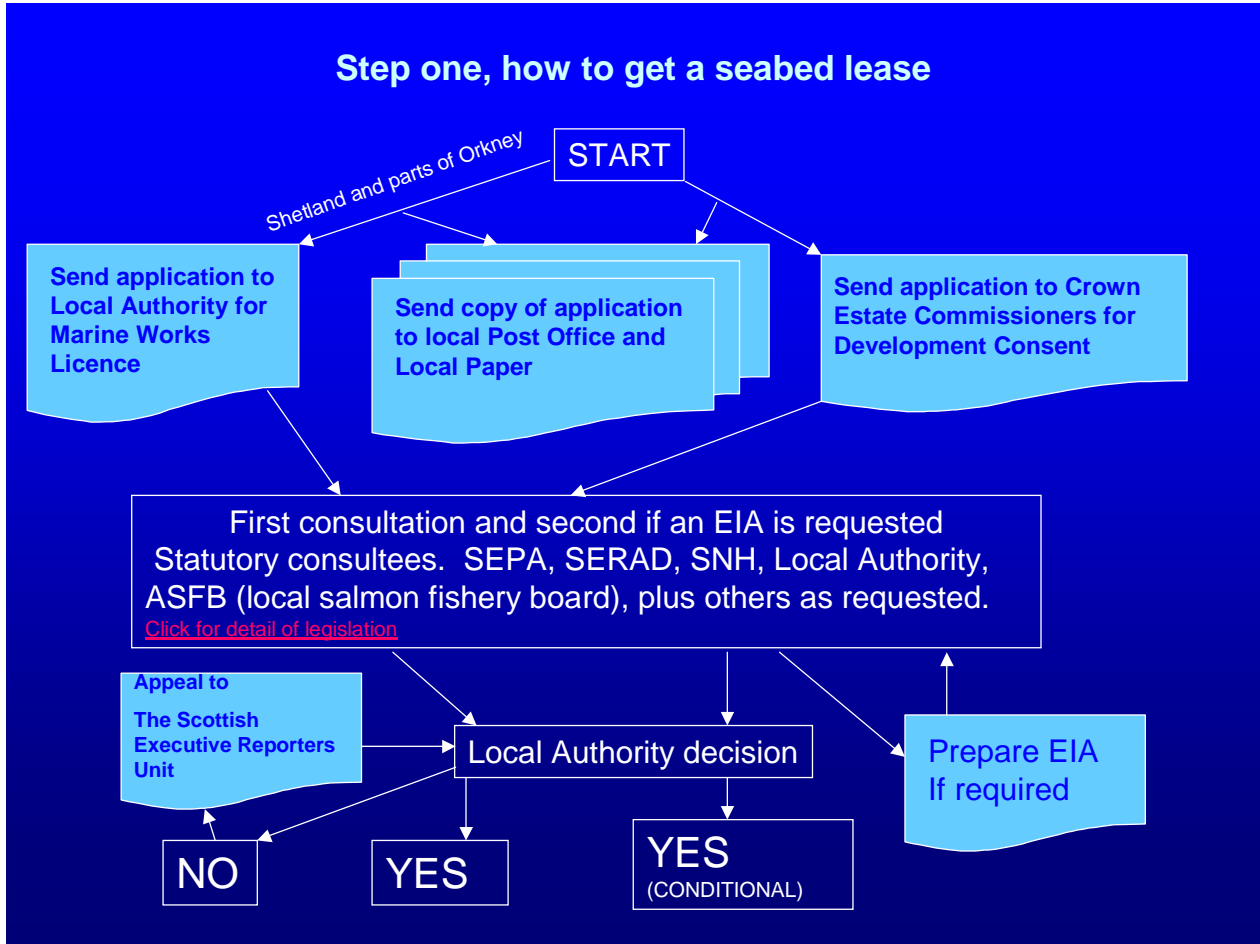
In Section 2, Regulation of location and siting, we have flagged up various aspects of the regulatory process that perhaps limit the potential to gain social and economic benefits, particularly the nature of Local Authority deliberations. Here the regulatory process engages, or should engage, with the relationship between the site and the local community, and hence with the social and economic aspects of the proposed development or relocation. As Local Authorities are taking a greater responsibility for siting decisions, this becomes a crucial point, and perhaps a legal issue. As matters stand at present, there is a clear and regulated consultation process during which various public bodies consider environmental issues in thorough detail, and adopt a standard internal procedure to do so. There is no such standard for consideration of the social and economic aspects, and there needs to be. Local authorities may need assistance, and a structure, within which to develop their experience in this area. Public objections, and perhaps even objections from local councillors, (unless they provide environmental information which can be properly considered by the appropriate body), need to be ranked in some kind of order according to the level of engagement of the objector with the local community. It also needs to be clear as to who constitutes the local community, or at least who thinks they do. Economically active people doing a manually tiring job are perhaps the least likely to go to public meetings, so these may not be an appropriate forum to catch the crucial viewpoints. Local Authorities are taking on a legal duty to consider the sustainability of an important industry without clear guidance as to how to do it, and sometimes without the necessary sectoral expertise.

3.5 Key issues

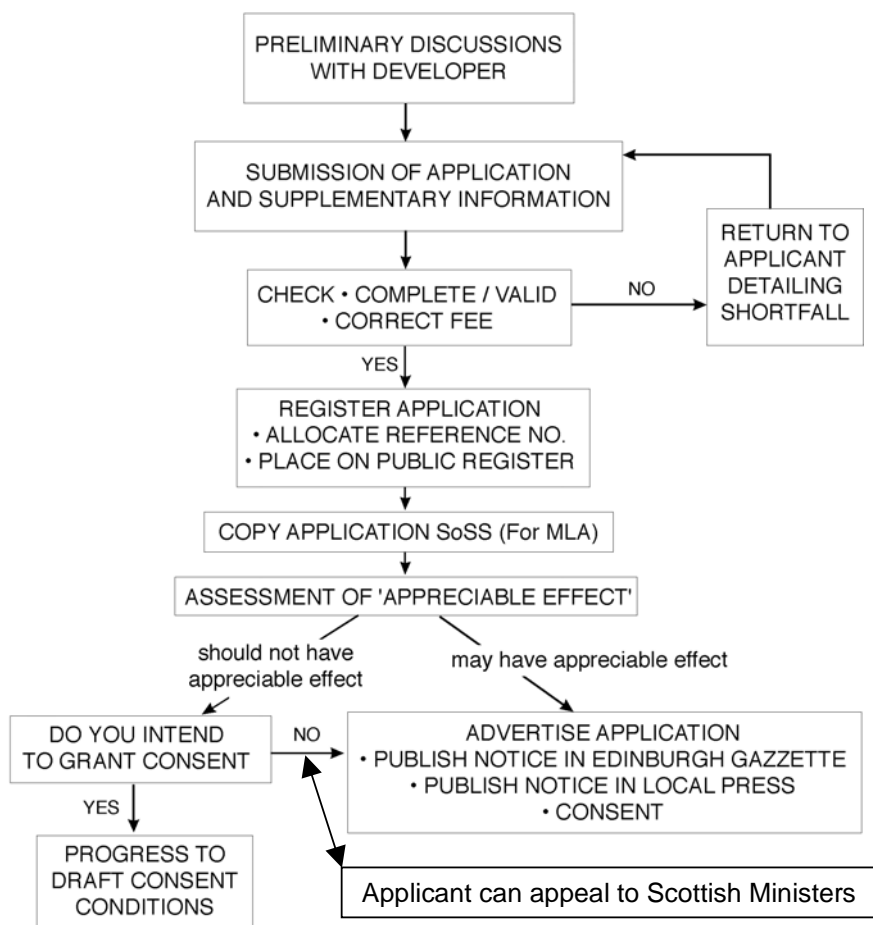
- è The social divisions reflected and entrenched by the present licensing system., particularly regarding landscape impact and navigational access.
- è The importance of a “good” site for business viability.
- è The lack of co-operation between farmers, leading to lower economic and social benefits than would result from planned siting and relocation in an area.
- è The lack of available sites, restricting the opportunities for any derived economic or social benefits.
- è The need to have a practical, transparent and robust framework to assessing the social and economic effect of development at particular sites.
- è The need for clear guidance as to where aquaculture is acceptable and where it is not, to allow for rationalisation and forward planning.

4 Appendices

Appendix 1 – Procedure for applying for a seabed lease.



Appendix 2 – SEPA framework for processing a discharge consent



To be included with the application:

- a written statement of application, duly signed and dated;
- the appropriate application fee;
- a map showing the location of the site and area licensed by the Crown Estate or covered by works license (including National Grid Reference), if already granted;
- a plan showing the cage locations within the site area (including NGR);
- plans and details of bathymetry;
- drawings showing the design of cages;
- details of production levels, including maximum biomass;
- details of the anticipated quantity of fish food, nitrogen and phosphorus content, and means of feeding;
- documentation on the use of medicines and chemicals not previously consented for use
- hydrographic survey data
- pre-development or ambient seabed characteristics and benthic biological survey data.

Appendix 3 - Internal considerations by statutory consultees

SEPA

- SEPA shall work with the fish farming industry, environmental agencies and other interested parties to contribute to the development of a thriving and sustainable fish farming industry in Scotland. This approach will be developed in the context of protecting and enhancing Scotland's environment in a manner that allows for a wide range of use and enjoyment of the countryside.
- SEPA strongly supports the fish farming industry's objectives of developing effective environmental management systems and, where appropriate, will assist in their development and promotion.
- In the longer term, SEPA will re-assess the appropriate level of regulation having taken into account the effectiveness of these management systems.
- SEPA will develop links with the regulatory agencies of other major marine fish farming states. The intention will be to promote a more internationally-consistent approach to the regulation of what is now a multi-national industry.
- SEPA considers that there is an inherently higher environmental risk associated with fish farming development within narrow, semi enclosed sea lochs and voes, which have relatively poor dispersion characteristics. Many farms in such areas have reached, or are close to reaching, their maximum sustainable size and their scope for further expansion is very limited.
- Accordingly, SEPA will favour the establishment, or expansion, of fish farm sites in more dispersive open-water and off-shore areas rather than those sites in enclosed areas.
- The increasing size of fish farm units justifies, and can support, more sophisticated pre-development environmental assessment, pollution control strategies and monitoring. SEPA will consider approaches to pollution control appropriate to the size and location of the farm, such as the collection and off-site disposal or on-site treatment of waste by the largest farms and/or those situated in sensitive areas.
- SEPA will actively promote a progressive reduction in the amount of waste lost to the environment per tonne of fish production.
- SEPA will identify any fish farming sites which have an unacceptable effect upon the environment, and take action to restore good environmental quality.
- SEPA welcomes comments on its actions and policies from interested parties (e.g. environmental groups, special interest groups). Accordingly, SEPA will seek to continue and improve its interactions with such groups.
- SEPA considers that certain industries which support fish farming, such as feed and pharmaceutical companies, and net and cage manufacturers, have an important role to play in the future development and environmental effects of fish farming. Accordingly, SEPA will seek to develop further its dialogue with the support industries in order to promote its strategic objectives.

SNH

When consulted on aquaculture applications, SNH takes into account the proximity to and potential impact on wildlife, habitats and landscape. The factors considered, in no order of priority, include :

- areas designated for natural heritage purposes, such as SSSIs, NNRs, SACs, SPAs and NSAs;
- species protected by legislation, including the Wildlife and Countryside Act 1981 and Habitats and Species Directive (Annexes II, IV and V);
- impact on general environmental quality and biodiversity;
- impact on natural heritage interest of pharmaceutical and other compounds used in aquaculture;
- possible conflicts with potential predator species arising from proximity to seal haul-out areas, and otter and fish-eating bird populations;

¹⁷ SEPA guidelines Regulation and monitoring of marine cage fish farming in Scotland - a manual of procedures

- the risk of introducing alien species and the likely consequences for wild animal and plant communities;
- the risk of genetic contamination of native stocks, particularly of Atlantic salmon;
- visual and landscape implications; and
- the potential impact on remote or wild land qualities



Appendix 4: Criteria used by Local Authorities when considering a site application

- National and regional guidance (incl. SNH)
- Designations
- Navigation
- Framework plans
- Local Plans
- Internal consultation
- Public consultation
- Community Council

These criteria inform the planning officer's view and is provided to the Council Committee to make the final decision

Appendix 5. Criteria used in environmental impact assessment

1. Criteria listed in The Crown Estate's "Environmental Assessment Guidance Manual for Marine Salmon farmers"

The following represents a summary of the main elements found in annexes 7 and 9 of the guidance:

Potential issues of concern

- Carrying capacity (nutrient dilution and dispersion capacity; landscape capacity)
- Visual amenity ("pleasantness in the COD); proximity to designated area
- Damage to marine and coastal habitats with their associated plant and animal species – seabed, seashore, seabird breeding colonies, seal haul outs – esp SAC, SCA or SSSI
- Sea fisheries
- Migratory salmon pops – population dynamics, fish movements
- Recreational use
- Heritage features (arch.; historic)
- Landbased activities
- Navigation
- Use of chemicals – regime, mitigation
- Socio-economic (housing demand; community (job creation), local business and social conditions)

Criteria for evaluating the possible significance of effects"

Effects:

- Duration
- Reversibility
- Magnitude
- Area/extent
- Probability of occurrence
- Potential for mitigation

Affected environment

- Site value
- Statutory designation
- Physical/ecological sensitivity
- People sensitivity
- Protected species
- Existing effect
- Environmental standards
- Conflict with land-use/spatial planning policy
- Conflict with environmental policy

Public awareness

- Level of public concern
- Level of political concern

Uncertainty

- Magnitude or significance of effects uncertain because of lack of knowledge?
- Methods to predict and evaluate uncertain effects?
- Can they be developed

2. SEPA Guidance on EIA (From the "Fish Farming Manual")

The "following factors are particularly relevant and will be a material consideration, along with national and local policy, when assessing individual proposals:

- Landscape and visual impact;
- Effect on recreation and tourism;
- Effect on fishing and navigation;
- Aspects of pollution, disease and carrying capacity;
- Nature conservation interests, including wild fish populations
- Access and infrastructure requirements, and
- Methods of operation (e.g. lighting impacts, noise etc)


"Decisions will require a balanced judgement"

Sound objections must be met with effective mitigation.

The EU Directive requires to describe the likely effects of projects on:

- People
- Flora and fauna
- Soil, water and air
- Climatic factors
- Material assets
- Architectural and archeological heritage
- The landscape
- Interactions between any of the above

3. Sensitive areas as defined in the 1999 Regulations (SI 1999 No 367)

- SSSI, NNR, SAC; SPA
 - Land to which subsection 3 of section 29 (nature conservation orders) of the W&C Act 1981) applies
 - National Park
 - UNESCO World heritage Site
 - Ramsar Sites
 - A scheduled ancient monument
 - A national heritage area (NH Scotland Act 1991)
 - A national scenic area (Town and Country Planning (Scotland) Act 1972)
- 

Appendix 6: Summary of existing siting guidelines

Interim Measure for the Authorisation of Marine Fish Farms in Scottish Waters (SERAD 2000).

This outlines the interim non-statutory regime for consideration of applications for fish farms in Scotland. This will be superseded when new primary legislation is drawn up passing aquaculture planning authority from the Crown Estates to Local Authorities.

It details the necessary documents and procedures for applicant, the roles of the statutory consultees and the process for 'Formulation of the Local Authority View'. It does not provide a clear decision-making framework, nor does it provide advice on siting of aquaculture operations.

National Planning Policy Guideline 13 – Coastal Planning (SO 1997)

This guideline provides statement of Government policy on nationally important land use and planning in coastal regions and is one of the key documents referred to by Local Authority planning departments when considering aquaculture development applications

Planning authorities must recognise the inter-relationship between onshore and offshore activities. For planning purposes, authorities should set out in local structure plans policies and priorities for the coast making a distinction between:

- Developed Coast
- Undeveloped Coast
- Isolated Coast

This categorisation is not a statutory designation, but is intended as a planning policy framework.

NNPG 13 also sets out overarching sustainable objectives for coastal planning which include:

- Precautionary principle
- Priority to develop in developed coasts, or brownfield
- Application of environmental bodies criteria
- Attention to conservation and natural processes

NPPG 13 also makes specific reference to aquaculture. This states that when responding to Crown Estates consultations the planning authority should:

“...acknowledge the potential benefits of marine aquaculture to the local economy while recognising that, on an isolated coast, new or expanded fish farms may be inappropriate. In other areas particularly where the tourism industry is based on high quality scenery and an unspoilt environment, special attention should be paid to the number of fish farms, their location in relation to each other and surrounding land mass.....”

Finally, NPPG 13 states that where there is potential for new or expanded fish farms planning authorities should prepare non-statutory framework plans to guide location. This is hoped will ensure the sustainable development of the industry and should be drawn up in close consultation with local community, the crown estates and SNH.

SEERAD Advice Note: Marine Fish Farming and the Environment (2003)

Provides background on the industry, details regulatory framework and roles of key consultees. This includes a list of key considerations for SNH when responding to fish farm applications:

- Designations (SAC, SPA, NSA, SSSI, NNR)
- Marine consultation areas – not designated but important
- Direct / indirect impact on biodiversity covered by BAPs
- Conflicts with potential predator species (seal, otter, bird)
- Risk of introduction of alien species
- Risk from genetic contamination
- Impact on character and qualities of landscape and wild land
- Impact of environmental quality and amenity of water body.

Also describes basic operational requirement (depth, shelter, temp, salinity etc), best practice advice and highlights particular environmental and servicing considerations which should be taken into account in determining the acceptability of development proposals.

- Individual and cumulative effects on water quality, ecology, landscape and visual amenity
- Infrastructure availability
- Implications (including socio-economic) to fishing and recreation
- Impact on other existing aquaculture
- Safe navigation

SEERAD Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters

The purpose of this Policy Advice Note (PAN) is to:

- Provide guidance on factors to be taken into account when considering proposals for new marine fish farms or modifications to existing fish farms
- Establish the national context for the preparation by planning authorities of non-statutory marine fish farming framework plans for guiding the location of future marine fish farms

This PAN is based on advice from SNH, FRS, CE – on existing farm size and location, other interested parties. In many areas this is a strongly worded advice note and also outlines the presumption against further development on the North and East coasts. The PAN states that:

“... Scottish Ministers consider it necessary to identify those areas which are likely to be particularly environmentally sensitive to new or expanded developments and in which stringent environmental sensitivities relating to both nutrient loading and the natural heritage should be fully addressed before consent might be given”.

This document introduces the proposed 3 categories for coastal waters (categorised by FRS) based on the level of nutrient loading and the associated benthic impact within each area arising from **existing** farm developments:

- Category 1: Further development only in exceptional circumstances
- Category 2: A new site wouldn't push area up to Category 1
- Category 3: Better prospects for satisfying nutrient loading and benthic impact requirements.

“there will be areas categorised as category 3, which maybe sensitive to enhances nutrient loading through aquaculture development but have not been specifically highlighted, as they do not currently contain significant aquaculture development”

The PAN note also details the role of EIAs, including what they should contain and identifies action required:

- More non-statutory framework plans and revision of old ones.
- Re-iterates what should be considered in assessment of applications.

SEPA Policy No. 40: Regulation and Expansion of caged fish farming of salmon in Scotland (2000).

This report refers in background to the implications of development toward large multi-national, centrally managed companies and points out that fish farmers are increasingly making applications for further production capacity at existing sites rather than establishment of new sites. Much of this is motivated by the perceived difficulties in obtaining licences for new sites.

The SEPA board state that:

“Real issues exist about the environment’s capacity to cope with the present and future husbandry practices but arguments put forward are becoming increasingly confrontational and emotive, resorting to “sound bites” and hard hitting media articles often with limited scientific credibility and this has the effect of limiting opportunities for constructive dialogue”.

And.....

“According to scientists at the Marine Lab, Aberdeen, the incidence of HABS does not match the distribution of fish farming activities. Over the wide area of the Minch and the Sea of the Hebrides fish farming is estimated to contribute less than 1% of the nitrogen input entering these inshore waters”.

Policy: SEPA will seek to adopt a broad and forward looking policy and will apply the same rigorous assessment to expansion of existing farms as the development of a virgin site. SEPA will act in accordance with the 1,2,3 category approach identified by FRS Aberdeen and advocated by the Scottish Executive.

- For category 1 areas (high risk of nutrient enhancement) there will be a presumption against granting discharge consents for new sites or increased biomass, except in exceptional circumstances.
- For category 2 areas (medium risk of nutrient enhancement) prospects for new developments will be limited and establishment or expansion must be linked to environmental benefits elsewhere in the same water body (almost like relative stability).
- Elsewhere SEPA will match maximum biomass with environments capacity to dilute or disperse. SEPA will reduce biomass limits and agree remedial action where waters have been downgraded and if necessary, revoke licences.

SNH: Marine Aquaculture & the Landscape – the siting and design of marine aquaculture developments in the landscape.

This is long, detailed and comprehensive stating what you can and can't have. If you should use metal, or plastic, paint your buoys orange or yellow etc, etc.

FRS: Location Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters.

Details Category 1, 2 and 3 areas designated on the basis of the FRS predictive models to estimate environmental sensitivity in sea lochs. This report stands in conjunction with the Scottish Executive Locational Guidelines.

The categorisation of waters for further aquaculture development by FRS into 1, 2 or 3 appears sensible, is supported by best available science and the concept of categorisation appears to be welcomed by the industry. The difficulty with this system is that it focuses on existing production levels, rather than assuming a 'clean slate'. This means that some waters may fall into category 3, by virtue of a lack of existing development – but development proposals may be blocked due to environmental sensitivity.



Appendix 7: Summary of social and economic issues and criteria

The underlying issues are sustainable prosperity ¹⁸ and the long-term viability of a vital and cohesive local society. This depends partly on:

- Population structure
- Economic activity rates/unemployment
- Housing availability
- Skills profile of community
- Community capacity/confidence

For any site, this background information is essential to set the following criteria in their proper local context.

Table 1 contains measurable criteria which provide a framework within which to discuss the contribution an aquaculture development will make to the local society and local economy. It is derived partly from our interviews, and partly from work done on measuring the social and economic implications of SNH activity ¹⁹.

Summary of socio-economic issues relating to site location, as raised during interviews

There was a good level of job satisfaction among self-employed farmers (fin and shellfish), related to proximity to home, opportunity to use traditional skills, healthy lifestyle, satisfaction with product and level of business autonomy. Mussel farming is viewed as an exciting "sunrise" industry, a new source of rural employment with fewer environmental issues than salmon farming has had.

Lack of any new sites at all increases difficulties regarding relocation and rationalisation to improve business viability. Location of nearby sites a real issue when they are owned by someone else; not a problem if owned by the same company.

Work opportunities for local people are viewed as important to family/community life.

Availability of keen, motivated staff is essential for business viability. This is partly dependent on site location and nature of local community.

Key criteria for the farmers:

- Importance of a biologically suitable site for business viability
- Larger sites more economic
- Location of existing infrastructure as a primary consideration for site location
- Quality of life improved by site being close to house (self-employed farmers)

Public consultation/objections regarding site location are heavily dependent on nature of local society. Increasingly less traditional and not so dependent on, or familiar with sea-based local industry, so more likely to object on recreational/landscape grounds.

Table 1 – social/economic criteria for site assessment.

¹⁸ Scottish sustainable development Indicators 1, 2 and 3. See appendix 1

¹⁹ Scoping study: Framework for measuring social, economic and environmental impacts of SNH activity and land designations SNH contract No. AB(04NC07)0405110 2004. John Hambrey, Keith Lawrence & Sue Evans

General Criteria	Suggested Criteria for assessing a particular site	Comment
Business viability	Biological suitability of site. This links directly with all economic and social criteria. Market prospects Management and marketing skills Labour availability	Direct impact on level of risk, job security and all other benefits accruing. Labour availability will partly depend on housing costs and transport.
Direct Employment	Full-time/part-time/seasonal/permanent/contract Travelling work team, associated with relatively distant processing plant or locally based? Wage/salary rate Job security, taking into account market stability, capital funding and management/technical expertise.	Nature of job (temp/permanent, FT/PT) linked to age and family situation of potential employees. consider carefully the location of the jobs.
Self employment	Number of employees, as above Risk profile for business, taking into account market stability, capital funding and management/technical expertise.	May increase community capacity and confidence BUT there may be insufficient inward investment to ride out dips in the market.
Induced and indirect effects	Employment and salaries generated by direct employees spending of their salaries/wages. (Induced) Employment generated by company spending on local supplies (Indirect).	Estimate using a published multiplier Consider the location of jobs generated.
Skills profile	Match of skills and qualifications required with those available locally Availability of in-house/on-site training Opportunity for exiled youngsters to return after higher education/skills training.	Retention of traditional skills may be particularly valuable in retaining a sense of community value. Attracting local people to return after training is a plus for long-term community viability
Age and family situation of potential employees	Affect on demographic structure of area Partial retention of young people in area through summer work/work teams.	Full time work essential for community stability, but part-time work also vital to families with children.
Non-monetary direct contribution to community	Potential for use of some company facilities by the local community Direct participation of aquaculture staff in local voluntary bodies	Share of jetty/shed with community organisations Staff participation in local fire service, rescue teams, youth clubs etc. (count this only if they would leave the area without this work)

Local Authority consideration of social and economic issues

In commenting on applications for seabed leases planning authorities should “acknowledge the potential benefits of marine aquaculture to the local economy”²⁰. Structure/local plans will have in-built consideration of such issues, and should provide social and economic data on coastal communities adjacent to aquaculture sites. In reality, the rigour of social and economic consideration could depend upon the relationship between the Economic Development Unit and the Planning Policy division of the Local Authority. There is no evidence yet of a transparent, standard format for assessing these issues, in spite of the hope expressed by the Scottish Executive that statutory planning controls would lead to “a more effective, transparent and democratically accountable system of regulation at the local level”.

²⁰ NPPG 13 – coastal planning

Indicators of sustainable development for Scotland

Full list of indicators + associated measure

Indicator 1:	Sustainable prosperity CO2/GDP
Indicator 2:	Work: people as a resource Unemployment rate
Indicator 3:	Population structure Proportion of population of working age
Indicator 4:	Waste production Municipal waste handling (tonnes)
Indicator 5:	Waste: recycling percentage of household waste recycled
Indicator 6:	Waste: landfilled tonnes of landfill
<u>Indicator 7:</u>	<u>Climate Change</u> greenhouse gases (DA by sector)
Indicator 8:	Air quality Air quality management areas
Indicator 9:	Water quality Length or river poor quality or seriously polluted
Indicator 10:	Biodiversity Percentage of BAP species and habitats stable or increasing
Indicator 11:	Sea fisheries Proportion of commercial stocks within safe biological limits
Indicator 12:	Energy consumed Electricity consumption
Indicator 13:	Energy: renewable Percentage of electricity generated from renewable resources
Indicator 14:	Travel distance Total vehicle kilometers
Indicator 15:	Travel: industry Freight intensity. Km-tonnes offfreight/GDP
Indicator 16:	Travel mode Percentage of journeys to work not using a car
Indicator 17:	Travel: accessibility Percentage of households within 6 mins of bus service
Indicator 18:	Home life Percentage of children living in workless households
Indicator 19:	Preparing for life % of 16-19yr olds who are not in training, education or employment
Indicator 20:	Fuel poverty Total number of households living in fuel poverty
Indicator 21:	Social concern Number of homeless people entitled to permanent accommodation
Indicator 22:	Crime Total number of crimes
Indicator 23:	Volunteering Percentage of people taking part in voluntary activities
Indicator 24:	Health Life expectancy

The use of economic multipliers to examine the socio-economic impacts of aquaculture.

Introduction

Economic multipliers bring alive tables of statistical data. They are a way of describing numerically the nature of the interdependence of various sectors of the economy. Multipliers are derived from input-output tables; real data about the flows of products, services and money in the (Scottish) economy for a given year. Multipliers can be used to predict the likely changes in output, employment and income resulting from a marginal²¹ change within one industry group. They enable us to quantify what we know intuitively; that a change in circumstances within an industry has a “ripple” effect in that it can effect the economic situation, and hence the society, in which that industry is based.

Used intelligently, multipliers add depth and reality to discussion about economic development and can be readily understood by the non-specialist. Tables of multipliers are publicly available to download on www.scotland.gov.uk/stats. It is important to understand exactly what they are measuring, and whether or not they can be sensibly used at a local level.

Derivation of multipliers

National multipliers are derived from Input-Output tables. The raw data for these tables comes from official sources such as the Scottish Annual Business Statistics, which are compiled using Office of National Statistics Annual Business Enquiry data. Other data sources include Scottish Executive Rural Affairs Department and various Scottish Executive surveys.

The basis data sources are the *supply table*, which gives the monetary value of the output of each industry for a given year, and the *domestic use matrix*, which indicates the inputs each industry has used to produce that output. These data can be presented as an *industry-by-industry use matrix*, which describes the purchases made by each industry from other sectors of the economy, thus indicating their level of interdependence.

To make practical use of this information it is transformed into a Leontief Inverse Matrix, which shows how much of each industry's output is required, in terms of direct and indirect requirements, to produce one unit of another given industry's output²². This is the change in the economy as a whole resulting from a marginal shift in the conditions pertaining in another industry, for example a change in the final demand for a commodity. At a more local level, a change in production levels in a local industry will have a ripple effect through the community, and this can also be described using multipliers as long as data is available that adequately describes the operation of industries at a local level.

Direct, indirect and induced impacts

The impacts of changes within an industry can be direct, indirect or induced, and can refer to production levels (output), employment or income. At the national level, multipliers exist for all these situations.

²¹ “Marginal” in economics means a small change, not enough to affect the basic structure of an industry but enough to have a measurable effect on some aspect of it. A large (non-marginal) change, such as the collapse of an entire industry, will affect economic behaviour so much that the real data used for the tables will be outdated and existing multipliers may be misleading.

²² *A2 Output, Employment and Income Multipliers, Scotland 1996*. Maria Melling and Lynn Graham, Scottish Economic Statistics 2000, Scottish Executive.

Direct impacts – changes that occur strictly within the industry under consideration, such as a change in output in response to a change in final demand, or an increase in the number of employees in response to a change originating within that industry.

Indirect impacts – changes within businesses and services that supply the original industry. For example, if the original business under consideration is a fish farm, and they reduce production, there will be an indirect impact on their suppliers who will provide less feed, potentially reducing their own output and levels of employment. Indirect impacts can be “upstream” e.g. feed producers, or “downstream” e.g. processors. This is the start of the “ripple” effect.

Induced effects – The combined effect of direct and indirect impacts on businesses not directly connected with that within which the original change occurred. The effects are due to consumer expenditure, which will change with employment and income levels. As an example, this could change the income levels of local shops. To continue the “ripple” analogy, this is where the ripple starts to deepen, and spread.

Types of multiplier

Multiplier information is so structured as to make it clear which type of impact is being described.

Type I multipliers. These consider only the direct and indirect impacts of a marginal change, i.e. those changes in output, employment and income that are confined to the industry under consideration and its supporting businesses, upstream (e.g. feed suppliers) and downstream (e.g. packing companies).

Type II multipliers. These consider all the impacts of a marginal change i.e. direct and indirect (as in Type I) plus the induced effects caused by impacts on consumer expenditure. Clearly, to look at the socio-economic effects of aquaculture siting, it is Type II multipliers that must be used.

Specifically, the most relevant multipliers²³ for our purposes are:

Type II employment multiplier. Measures the increase in total employment resulting from a unit increase in employment in one particular sector, i.e. the ratio of direct, indirect and induced employment changes to the direct employment change.

Type II income multiplier. The ratio of direct, indirect and induced income changes to the direct income change. i.e. for every unit change in wages in aquaculture what is the effect on income elsewhere?

It is also possible to calculate the employment and income effects throughout society as a whole resulting from changes in final demand (output) from a particular industry.

Employment coefficients may be relevant to local planning as they measure the amount of employment (measured in full-time equivalents, FTEs) required per unit output of each sector.

The practical use of multipliers

Once one is familiar with the difference between the two types of multiplier they are readily used, at least on a national scale. If we look at the latest multipliers (2001) available at the time of writing²⁴ we find that the Type I employment multiplier for fish farming is 2.591, and the Type II multiplier (larger, intuitively) is 2.857. This tells us that, in 2001, each job in the fish farming industry supported, in total, roughly two and a half jobs directly related to the industry, and nearly three jobs in the Scottish society as a whole. There are two important caveats:

²³ Definitions partly taken from Scottish Executive Statistics division website on www.scotland.gov.uk/topics/statistics/14713/460

²⁴ Available to download as an Excel file on <http://www.scotland.gov.uk/Resource/Doc/933/0007713.xls>

- 1) It is not possible to directly relate jobs supported to jobs that might be lost if employment in a sector were to decline. Employment may be found in other sectors of the economy and factors such as local work availability, skills profile and the overall health of the economy would affect the final figure.
- 2) Accurate local employment multipliers would need the generation of Input-Output tables for each area. Applying a national multiplier will overestimate aquaculture-generated employment in some areas and underestimate it in others²⁵.

Using multipliers at a local level.

Few studies have attempted to estimate Input-Output tables and multipliers for areas at a sub-Scotland level²⁶. Generally speaking, the larger the area, the bigger the multiplier as one includes more of the “ripple” effect originating from the original industry. Input-Output tables are available for the Shetland Isles²⁷, the Orkney Isles²⁸ and the Western Isles²⁹, but these are one-off studies, and not updated yearly as are the national multipliers. The study in the Western Isles found a Type II employment multiplier for fin-fish farming of 2.1³⁰ (1997), which is far lower than the comparable national multiplier of 3.423³¹. This indicates that much of the economic effect of the Western Isles fin-fish industry was not local³².

There are ways of attempting to estimate local multipliers short of running a full local business and household consumption survey, which is clearly an expensive and intrusive exercise. Caution must be exercised, as most non-survey methods of estimating single-region (local) multipliers will tend to over-estimate the local links involved. It may be possible to arrive at a reasonable estimate of local multipliers through spatial disaggregation of national, survey-based multipliers³³, but this is not a task for the novice.

How, and where, one obtains ready-made, recent local multipliers depends on the area in question, and is most variable. The first line of enquiry would be the Economic Development Unit, or equivalent, of the local authority.

Practical advice for the non-specialist.

Find out what sort of multiplier you are looking at.

To look at local issues, you need:

- a recent disaggregated national multiplier, or a survey-based local one, appropriate to the locality and to the industry
- a type II multiplier (includes ALL the ripple effect, or more of it than a type I)
- an employment or income multiplier, or both
- to remember that a multiplier will not, on it's own, tell you anything about long-term employment levels.

²⁵ The Regional Employment contribution of the Fisheries Sector to the Scottish Economy. Michael Thomson, Scottish Executive, Scottish Economic Report June 2002.

²⁶ Michael Thomson, 2002, *op cit*.

²⁷ An Input-Output Table and Model for the Shetland Isles, 1996/97, Gillespie, McGregor, Swales and Yin, Fraser of Allander Institute.

²⁸ An Input-Output Table and Model for the Orkney Isles, 1995, McGregor, Swales and Yin, Fraser of Allander Institute.

²⁹ Modelling the Western Isles Economy, 1999, Roberts, Thomson and Snowdon, MLURI/University of Aberdeen

³⁰ Note how much higher this is than the recent (2001) type II employment multiplier of 2.857. Perhaps due to changes in the structure of the industry, with more efficient feeding and processing reducing upstream and downstream effects of work in the primary industry.

³¹ National type II employment multiplier relates to 1998, the most comparable year available.

³² Caution required: the national figure includes shellfish farming, which may only be a small effect but the fact must be recognised before strict comparison may be made.

³³ Spatial interpolation and disaggregation of multipliers. Jan Oosterhaven in *Geographical Analysis* 1/1/2005

