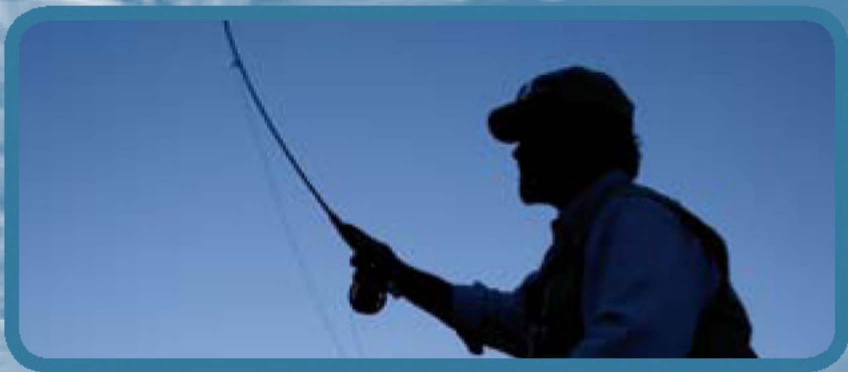
SCOTTISH EXECUTIVE

An Economic Evaluation of the Impact of the Salmon Parasite *Gyrodactylus salaris* (Gs) Should it be Introduced into Scotland

Published by
Scottish Executive
St Andrew’s House
Edinburgh

Produced for the Scottish Executive by
the University of Stirling

Report to the Scottish Executive Environment and Rural Affairs Department
Project No. SAQ/001/05

An Economic Evaluation of the Impact of the Salmon Parasite *Gyrodactylus salaris* (Gs) Should it be Introduced into Scotland

Final Report
October 2006

Institute of Aquaculture, University of Stirling
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Published by
Scottish Executive
St Andrew's House
Edinburgh

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A copy of this report can be downloaded from the following Internet address:

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Acknowledgements:

The authors would like to thank the following for their assistance in producing this report: M. Teters, Bill Jamieson for the maps of the Luce and Spey Catchments, Bob Laughton - Spey Fishery Trust, Jackie Graham - Galloway Fisheries Board, Mike Baird, Diane Burgess, Mike Allan, Margaret Dix, Margaret Mc Guinness - Scottish Water, Julie Frew, Roger Owen, David Pirie, Bruce Erisken and Derek Fraser – SEPA, Caroline Wall and Garnet Hooper, Environment Group, Institute of Aquaculture, Malcolm Dickson – Institute of Aquaculture, Tor Atle Mo and Asle Moen – VESO, Norway, Mike Dales - Scottish Canoe Association, Eric Verspoor, Charles Allan and Mike Myles – Fisheries Research Service, Richard Bates - Environmental Health Unit, EU Commission, Rob Murray – Howietoun Fishery, Paul Irving - Lakeland smolts, John Webster - Scottish Quality Salmon, Ramsay Handie - Snowie Disposal, Tracey Drysdale and Steve Duncan at SportScotland, Andrew Wallace – Association of Salmon Fisheries Boards, Alastair Stephen - Scottish and Southern Power, Stair Estate, Malt Distillers Association, and all the anglers who responded to the surveys.

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0 Executive Summary

0.1 Background

Gyrodactylus salaris (Gs) is a freshwater external ecto-parasite that infects Atlantic salmon (*Salmo salar*) and a number of other salmonid species. The aims of the study reported here were to estimate the economic consequences of the introduction of Gs into Scotland, and to identify the costs of prevention, eradication and containment.

Gs is one of many salmonid infecting gyrodactylid species, which belong to the Monogenea, a larger group of relatively simple, soft bodied flatworms that are, primarily, fish parasites. At less than 1 mm in length, Gs infests the skin, fins and gills where its attachment and grazing activity can lead to host death through salt and water imbalances.

Gs is thought to have been introduced into Norway during the 1970s on salmon smolts from Sweden when Norwegian hatcheries were unable to meet the demands of the growing salmon industry in Norway. The parasite subsequently spread from the initial hatcheries to other hatchery sites and rivers and by the mid-1980s it was estimated that Gs had been responsible for the loss of an estimated 300 tonnes of Norwegian Atlantic salmon.

Estimates of the economic benefits from maintaining Scotland's Gs free status or controlling its spread in the event of its introduction, and of the implicit policy costs are intended to inform the development of strategies to be deployed should an infestation be identified in Scotland.

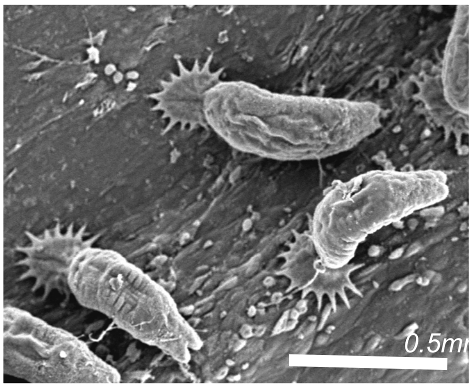

Figure 1: Gyrodactylus salaris *on Atlantic Salmon.*

It is generally assumed that the parasite would be introduced to a single location initially, with rapid infection of a single river system (catchment) a most likely consequence. It has also been assumed that if no action is taken to prevent transfer of Gs to other locations then, eventually, it could become established throughout Scotland leading to the potential decimation of wild salmon populations.

The parasite is most likely to spread from infected areas in water or on fish. Legislative controls exist to prevent fish movements from such areas abroad, and powers are currently being sought to prevent movements within the UK in the event of an outbreak. This study examines the cost of measures aimed at limiting the remaining possibility of transfer on wet clothing, angling and boating equipment.

In addition, there is a planned response to implement agreed emergency control measures to contain an infection following its detection. Subsequently, it might be possible to treat the water source using rotenone, a plant extract used extensively throughout Norway although not currently approved for use in the UK. This compound is used to remove the entire fish fauna from a river system, thereby removing any potential hosts for Gs. Salmonid

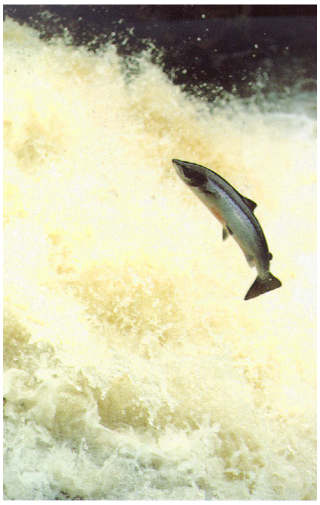

Figure 2: Wild salmon populations would be at serious risk if Gs were introduced into Scotland

populations then re-establish either as a consequence of salmon returning to spawn or as a result of restocking programmes. Aluminium sulphate, a more expensive alternative which is currently under trial, destroys the parasite but not the host fish. However, unlike rotenone, it may persist in the environment for long periods, depending on the specific conditions of the water and sediment chemistry.

Currently, the most appropriate strategy for containment or eradication of Gs is determined by catchment size and a range of physical and ecological factors. Thus, eradication is likely to be both technically feasible and economically justified for small, isolated river catchments, or even in larger catchments especially if the disease is caught early and can be confined to smaller downstream tributaries that can be segregated using dams. However, a less favourable cost-benefit relationship is likely for eradication if the parasite becomes established throughout very large catchments such as the Ness, Lomond and probably the Spey with complex systems of tributaries and deep lochs, particularly given current technology and scientific understanding. The Expected Value[1] of eradication could be lower than the costs, and a policy of containment may therefore be the favoured option on economic grounds. This forecast could change as technology advances.

0.2 The Economic Consequences of Gs Infestation throughout Scotland

Two key approaches have been used to evaluate economic consequences:

1) **Calculation of economic impact**
   Essentially, the change in national or regional income and employment after a change in circumstance.

2) **Calculation of the expected economic value**
   Specifically, the Net Economic Value, as a measure of individuals' wellbeing, as reflected in their Willingness To Pay after a change in circumstance.

The prevalence of Gs throughout Scotland would destroy salmon angling. The economic impacts, and the changes in economic value following the loss of salmon angling are summarised in Table I.

[1] Expected Value considers the possibility of a control measure not being 100% effective. It is found by multiplying a policy measure's economic benefits by the probability of the measure being successful. It would need to be calculated on a case-by-case basis.

Table I. Summary of Economic Effects if Gs Became Widespread in Scotland

Economic Impact		Net Economic Value Lost (£m)		
Total Salmon Angler Expenditure in Scotland Each Year (£m)	61.7		**Annual**	**Capitalised[2]**
Expenditure Lost to the Scottish Economy Each Year (£m)	44.8	Economic Rent	16.5	550.0
Lost Scottish Household Income Each Year (£m)	34.5	Consumers' Surplus	2.5	83.1
Lost Scottish Employment (FTE) Each Year	1,966	Net Economic Value	19.0	633.1

The key figures are losses of £34.5m of income to households, 1,966 full time equivalent jobs (FTEs) to the Scottish economy, and £633m Net Economic Value lost.

Figure 3: Spey Angler

Although in addition to salmon angling, salmon aquaculture could be seriously affected by Gs, effectively the economic impact of Gs in Scotland will be almost completely limited to the loss of angling. The argument for this forecast follows.

At one extreme, if, for instance, 50% of the hatchery/nursery sector had to close, there would be an estimated loss of some 150 FTEs with a reduction in local income of £2.5m. At a rough estimate, an additional £150m and around 2000 FTEs would be lost if 25% of the salmon farming (production and processing) sector closed in consequence. However, the industry could minimise such impacts if investment is made in biosecure hatcheries and nurseries.

Given the application of agreed containment strategies, the spread throughout the freshwater production sector, if it occurs, will be slow. The appearance of Gs would be an additional incentive[3] to accelerate the current trend towards increased use of tank-based smolt units, which utilise recirculated water supplies for environmental control, reduced pollution and increased biosecurity, making spread even less likely. Production based around mesh cages in freshwater lochs, which cannot be made biosecure, will utilise the new biosecure capacity. The cost of making the entire freshwater phase biosecure is estimated to be £30-£40m. Thus, unless a Gs outbreak occurs in the near future, or spreads extremely rapidly, the economic logic suggests that it is likely that the economic impact of Gs in Scotland will be almost completely limited to the loss of salmon angling. Consequently, Table I summarises the main economic effects from Gs infestation in terms of angling only.

[2] Annual values have been capitalised over an infinite time period. For a discussion of capitalisation used in this study, see Appendix 3 to the main report of 'An Economic Evaluation of the Impact of the Salmon Parasite *Gyrodactylus salaris* (Gs) Should it be Introduced into Scotland'.
[3] Other incentives might include production scale factors and constraints imposed through the implementation of the Water Framework Directive.

0.3 The Economic Costs and Benefits of Gs Policy Options

The Options

The benefits from successful Gs policy initiatives are the avoidance of the adverse economic consequences summarised in Table I. To evaluate the expected economic benefits of any specific strategy, it is necessary to estimate the probability that the strategy will be successful. This allows the calculation of Expected Value (defined above). Factors such as the biology of the parasite, current practices within the aquaculture and fisheries sectors, and the likely response of different stakeholders to possible policy measures have all been considered in the cost/benefit analysis.

Costs and benefits have been examined for the following policies:

1) **Prevention**
   Measures that potentially reduce the probability of Gs entry.

2) **Eradication**
   An eradication strategy might be possible if Gs reaches Scotland and infests a small river catchment (e.g. the River Luce in the south west). The strategy would have implementation costs, but would also generate economic benefits as the river recovers.

3) **Containment**
   Should Gs reach Scotland and it infests a large river catchment (e.g. the Spey in the North East) then it might be decided that eradication is not feasible on economic, political and/or legal4 grounds. However, a strategy of containment to protect the rest of Scotland from infestation might be appropriate. Such a containment policy might be either limited (Minimal Exclusion), focusing only on the greatest risk of Gs transfer, or it could involve the Total Exclusion of the public from the water.

4) **Other Measures**
   Initiatives that cannot properly be described as containment or eradication measures but which are essentially complementary to these strategic approaches.

Figure 4: Public information leaflets have already been widely distributed

Prevention

A strategy to prevent the entry of Gs into Scotland is expected to involve a programme of public education and promotion of responsible behaviour, backed up by the provision of necessary facilities (e.g. for the disinfection of small boats and angling equipment) at strategic locations such as ports. The total estimated cost of these measures (Table II.) is £6m, which is

[4] There are possible conflicts with both domestic and European law with respect to adverse effects of rotenone or aluminum sulphate (the chemical agents used) on protected species or purity of water used by distilleries, respectively.

small in comparison with both the Net Economic Value of £633m (approximately 1%) and the 1,966 FTE jobs at risk.

Table II. Costs of Measures to Prevent Gs Entry (£)

Action	Applicable Years	Annual Cost	Capitalised Cost
Publicity	All	156,100	5,151,300
Disinfection Equipment	1	66,000	66,000
Maintenance	All	20,000	660,000
Disinfectant	All	5,000	165,000
Total		**247,100**	**6,042,300**

Thus, on the basis of the Net Economic Value alone, a long-term reduction in the likelihood of transmission of 1% is all that would be necessary to justify these measures.

Eradication: The River Luce case study
The Luce is a small river in South West Scotland with no aquacultural activity. A loss of 600 angler days would follow if it became infected, with a direct economic impact of £12,500 in lost local income. However, overall, there would be a positive economic impact of eradication because the cost of this is put at around £550,000, with a labour bill of £166,000. During the process of river treatment, enhanced local employment prospects and raised incomes would be expected before a return to the *status quo*.

In contrast to those calculations of a positive economic impact, there is a pronounced loss of Net Economic Value associated with Economic Rents and Consumers' Surplus[5]. There is a clear benefit if this value can be regained by eradication. The economic costs and benefits of eradication relative to the value of containment are shown in Table III for rotenone and in Table IV for aluminium sulphate.

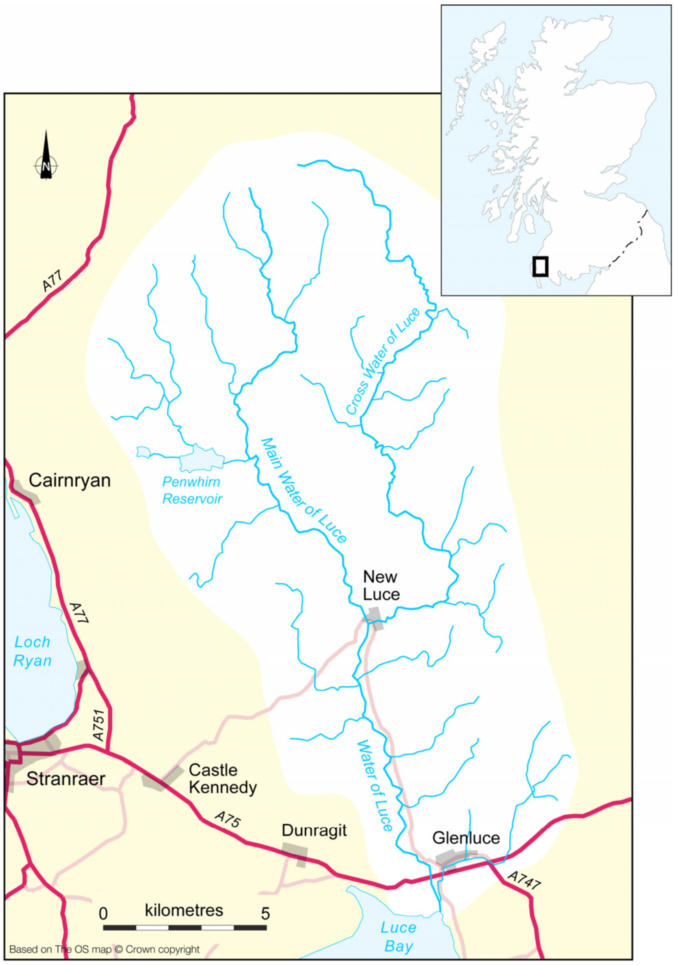

Figure 5: River Luce Catchment

[5] Economic Rent is e.g. anglers' payments for access to private recreational fisheries. Consumers' Surplus is the difference between what individuals (e.g. anglers) are willing to pay and what they are actually required to pay in the market place (their expenditure). See Sections 4.2 and 9 of the main report.

Table III. Costs and Benefits of Treatment with Rotenone (£)

COSTS				BENEFITS			
Element	**Applicable Year**	**Annual Cost**	**Present Value**	**Element**	**Applicable Years**	**Annual**	**Present Value**
Rotenone Treatment	1	676,620	713,609	Salmon Rents	11 to end	22,879	561,791
Sea Trout Rents	1 to 10	5,000	42,651	Salmon Consumers' Surplus	11 to end	1,266	31,087
Sea Trout Consumers' Surplus	1 to 10	1,000	8,530	**Sub-Total**			592,878
				Avoidance of Containment Costs	1 to End	50,000[6]	1,650,000
Total Cost			**764,790**	**Total Benefit**			**2,242,878**
Benefit-Cost			**1,478,087**	**Benefit/Cost Ratio**			**2.93**

Acting alone, both rotenone and Gs will eradicate salmon stocks. Hence, the cost of the temporary loss of salmon following rotenone treatment is not attributable to the chemical because eradication is a consequence of infection regardless of its use. The costs of rotenone are, therefore, restricted to treatment costs, and also to mortality of sea trout[7] (which would not occur in the absence of rotenone as Gs infection is not fatal in this species). The benefit of rotenone is re-establishment of the salmon population in about 10 years following treatment, and the consequent shortening of the containment period.

The analysis summarised in Table III clearly shows that the benefit of eradication by rotenone exceeds the benefits of containment alone, even if the potential benefits from removal of the transmission risk are ignored. The alternative treatment by aluminium sulphate[8], although more costly and labour intensive, has the major advantage of not being fatal to fish, so stocks will recover faster and angling can be resumed earlier.

Table IV. Costs and Benefits of Treatment with Aluminium Sulphate (£)

COSTS				BENEFITS			
Element	**Applicable Year**	**Annual Cost**	**Present Value**	**Element**	**Applicable Years**	**Annual**	**Present Value**
AlS Treatment	1	1,084,348	1,084,348	Salmon Rents	6 to end	22,879	650,221
				Salmon Consumers' Surplus	6 to end	1,266	35,980
				Sub-Total			**686,201**
				Avoidance of Containment Costs	6 to End	50,000	1,421,015
Total Cost			**1,084,348**	**Total Benefit**			**2,107,216**
Benefit-Cost			**1,362,430**	**Benefit/Cost Ratio**			**1.94**

[6] Best estimate derived from analysis of containment costs on the River Spey.
[7] It may be possible to catch and separately treat some fish prior to the eradication exercise, subsequently returning them so as to re-build stock sooner. The economics of this would depend on surviving stock densities and individual river characteristics
[8] In practice it is often necessary to use some rotenone in areas where the use of AlS is impractical

In this case again, the benefits of eradication exceed those of containment.

On the basis of the benefit/cost ratio, rotenone is the preferred treatment for the Luce. However, for a salmon river larger and/or more productive than the Luce, but for which eradication is still feasible, aluminium sulphate treatment could be judged economically more advantageous, given the more rapid resumption of angling. It is difficult to generalise. The judgement would depend on many factors, including economies of scale effects, and would have to be made for each individual river.

Containment: The River Spey case study

The Spey is a much larger and more complex river system, providing habitats for a number of vulnerable species. Aquaculture in the area, almost wholly for recreational purposes, is incorporated into the economic impact assessment of Gs on angling.

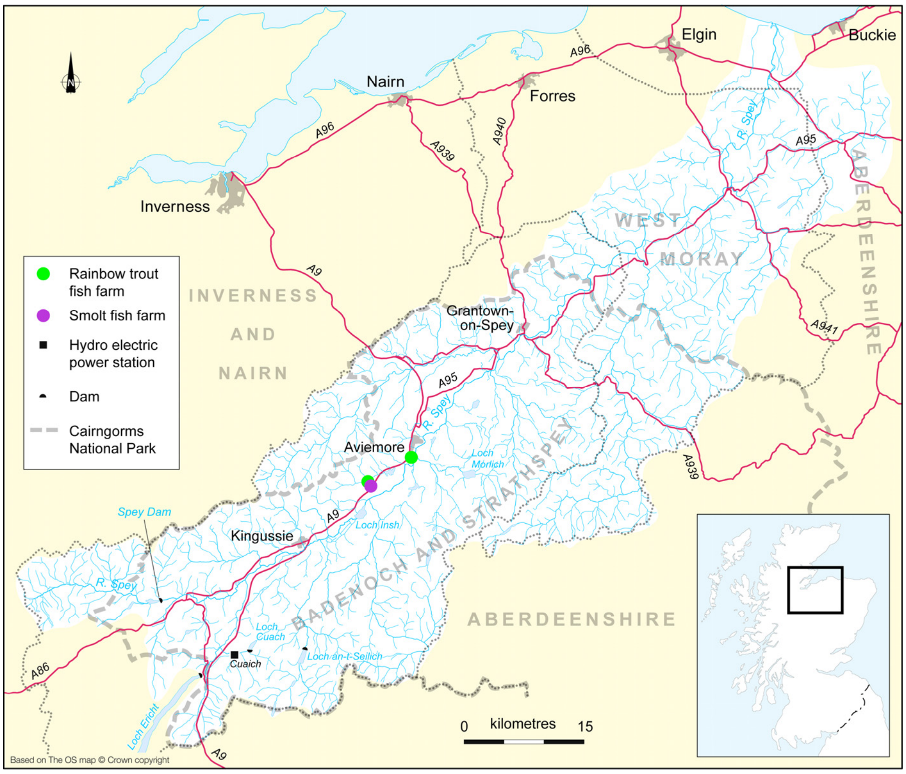

Figure 6: River Spey Catchment

In the event that it is considered that eradication is not feasible on economic, political, and/or legal grounds, the economic impact of Gs infection depends on the containment policies pursued, together with, since containment is not time limited, the period taken for economic recovery and the re-employment of those who lost their jobs. Two containment policies were examined:

- **Minimal Exclusion** where only transport of fish and 'water' are banned, and
- **Total Exclusion** where all activities (except water for cooling in distilleries) are banned.

Operational difficulties prevented exploration of policies involving partial exclusions.

Table V shows the economic impact of an infection and its containment locally and nationally. Table VI shows the relative costs of the Minimal and Total Exclusion schemes, where the costs to the groups affected by Total Exclusion are assessed by their estimated Net Economic Value.

Minimal Exclusion incorporates a pass scheme to ensure disinfection of all boats and equipment when they leave the area, which, along with the ban on fish movement, should virtually eliminate the possibility of Gs transfer. The scheme's running cost was found to be surprisingly small in the order of £175,000 per annum. In addition, the Minimal Exclusion policy does generate some FTEs in surveillance and in publicity.

Table V. Economic Impact of Containment Policies on Scotland and the Local Area

		Minimal		Total Exclusion	
		Income (£)	FTEs	Income (£)	FTEs
Scotland	Other Angling			305,000	19
	Other Recreation			250,000	15
	Total			**555,000**	**34**
Local	Water Sports			831,000	48
	Other Angling			664,000	40
	Other Recreation			500,000	30
	Less Containment	-100,000	-1	-250,000	-12
	Total	**-100,000**	**-1**	**1,745,000**	**106**

Total Exclusion has a more dramatic effect because it stops all angling and water sports. It would also affect the attractiveness of the area for the one million tourists who visit the Cairngorm National Park and lower Spey each year. A conservative estimate of the effect of the additional constraints on the local area is over £1.75m in income and 106 FTEs. The impact on Scotland as a whole is much less because most users would simply shift their activities to somewhere else in Scotland.

Table VI. Costs of Containment on the Spey (£)

	Minimal per Annum	Capitalised	Total Exclusion per Annum	Capitalised
Disinfection	75,000	2,500,000	0	0
Security	0	0	250,000	8,250,000
Publicity	100,000	3,308,000	100,000	3,308,000
Other Angling	0	0	180,026	5,940,864
Other Groups	0	0	725,670	23,947,110
Total	**175,000**	**5,808,000**	**1,255,696**	**41,445,974**

A containment policy's costs can be justified by the measure's reduction in the risk of spread of Gs to other rivers across Scotland with the loss of £633m Net Economic Value. Thus, if Minimal Exclusion reduces the risk of transmission by at least 0.91% it could be justified (the capitalised policy cost of £5.8m as a percentage of £633m). If Total Exclusion reduces the risk of transmission by at least 6.5% it could be justified (capitalised policy cost of £41.4m as a percentage of £633m).

Total Exclusion affects large numbers of other water users. Therefore, despite the very high value of salmon angling, in choosing the Total Exclusion policy over the Minimal Exclusion policy two conditions need to be considered:

a) In the event of Gs infecting a catchment there will be a risk of its spread to other rivers. Ideally, there should be evidence that the probability of transmission in the absence of any policy is high, estimated to be 6.5% or over.

b) The difference between the lowest risks that justify Minimal or Total Exclusions is 5.6%. Therefore, in choosing between the two policies, ideally there needs to be evidence that Total Exclusion reduces the risk of spread by 5.6% more than the risk reduction due to Minimal Exclusion.

Unfortunately, information on transmission probabilities is not currently available. It must be emphasised that catchments vary in other-user intensities and in physical characteristics. Each river system will need to be examined individually before a decision on the most appropriate scheme can be made.

Other Measures

The study looked at other measures that might be undertaken immediately, or possibly on first notification of infection within the UK, notably:

- Gene-banking and,
- Increased surveillance.

Gene-banking is the precautionary assembly of fish populations before Gs infestation (or any other potentially comparable event catastrophic to fish). The principal purpose of gene-banking is to enable re-establishment of natural populations native to specific rivers following successful eradication of Gs. Currently, there are no live fish gene-banks in the UK, and their establishment is both lengthy and costly.

A gene-bank accommodating a sample of 20 rivers would have a set-up cost of £16m, with a running cost of £1.2m per annum. This gives a total capitalised cost of £56m. There are over 380 salmon rivers in Scotland, so the cost of comprehensive gene-banking would be prohibitive. Further, given that rivers where eradication is likely to be successful are relatively small (the Luce, for instance), the chance of it being included in a limited gene-bank will be low. In addition, the value of re-instating salmon quickly in a small river attracting very few anglers will also be low.

Figure 7: A variety of methods are used for the diagnosis of Gs

Surveillance in the current programme involves sampling 226 sites annually (215 salmon or rainbow trout farms, and 11 rivers on a rolling system of 55 sites over five years). The implications of increasing surveillance to around 800 sites, including 385 rivers were examined. The total cost of the new regime would be £522,000 – an increase of £329,000 per annum. The capitalised cost would be £10.97m.

Surveillance has no value if the other precautionary measures succeed. In the event of failure, a value is generated where surveillance limits the spread of Gs from one river to the next. A value is also generated if surveillance allows the parasite to be confined and then eradicated within a section of a river system. If increased surveillance and early detection prevented spread, say from the River Findhorn to the Spey system, then it would have saved a system with an estimated capital value of £54.25m[9]. It is difficult to justify extra surveillance if the probability of Gs entry is very low after the suggested precautions have been taken. However, if Gs is detected in Scotland (or the UK), transmission probabilities will have increased, the Expected Value of surveillance will increase correspondingly, and additional surveillance might be economically justified.

Figure 8: Land-based salmon hatcheries and smolt units can be made biosecure using recirculated water systems

0.4 Conclusions

1) The criteria used in this study suggest that should the Scottish Executive take no action to prevent the spread of Gs, Scotland could lose £34.5m of annual household income, 1966 full-time equivalent jobs and a decrease in Net Economic Value, capitalised at £633m.

2) Aquaculture is not as likely to be seriously affected because of the incentive for, and ability of the commercial organisations involved to protect themselves.

3) The probability of Gs entering the UK could be reduced considerably by the provision of disinfection stations at ports, and by extensive publicity identifying the danger of the parasite. The cost of these measures is put at a capitalised value of £6m.

4) On entry of Gs into a river system, the appropriate eradication/containment policy is wholly dependent upon the biological and physical characteristics of the river:

    I. For a small river, eradication is likely to be preferred on economic grounds to long-term containment. If the salmon catch is relatively large, it is likely that, despite the increased cost, aluminium sulphate might be preferred to rotenone because salmon angling can be resumed earlier[10].

    II. If the river system is large and complex, such as the Tay, Spey or Ness, there may be more technical, legal and political obstacles[11] and the economic justification for eradication more uncertain. Further economic analysis of a clearly defined eradication plan in the largest systems is necessary in order to identify the conditions necessary for eradication to become appropriate.

[9] See Section 10.4 of the main report

[10] Although experience from Norway suggests that treatment with aluminium sulphate also requires the use of some rotenone to deal with Gs in the more inaccessible parts of the catchment.

[11] See also footnote 3. Large complex catchments are more likely to encompass protected areas (e.g. SSSI or SAC) or industrial abstractors such that the likelihood of legal objections increases with river length

5) In the Spey case study on containment, transmission probabilities were identified as a key factor in selecting between Minimal and Total Exclusion strategies. Transmission probabilities are influenced by the number of water sports-persons and visitors. The Total Exclusion strategy becomes more economically attractive with fewer users.

6) Further information in three areas would be useful for policy formulation:

   I. *Transmission probabilities and the factors affecting them,*

   II. *The relationship between river geography and the potential for Gs eradication,*

   III. *The uses made of rivers in Scotland.*

An Economic Evaluation of the Impact of the Salmon Parasite *Gyrodactylus salaris* (Gs) Should it be Introduced into Scotland

Main Report

1 Background, Aims and Overview

1.1 Introduction

The aims of the study were to estimate the economic consequences of the introduction of *Gyrodactylus salaris* (Gs) into Scotland, and to identify the costs of prevention, eradication and containment. Estimates of the economic benefits from maintaining Gs free status or controlling its spread, and of the implicit policy costs will inform the development of strategies to be deployed should an infestation be identified in Scotland.

There is no guarantee that prevention, eradication or containment measures will be 100% effective, and estimates of policy costs and benefits will have to reflect this. Our approach is to weight the policy **benefits** by the probability of the policy being successful. Where appropriate, therefore, we utilise the concept of **Expected Value**, which is found by multiplying a policy measure's economic benefits by the probability of the measure being successful.

It is generally assumed the disease would be introduced to a single location initially, with rapid infection of a single river system (catchment) a most likely consequence. On detection, the immediate response would probably be implementation of emergency control measures to limit its spread. The present options for subsequent chemical treatment are aluminium sulphate or rotenone.

Effectiveness of chemical treatment depends on the river size, and on a range of physical and ecological factors. Eradication is likely to be technically and economically justified for small, isolated river catchments, and appropriate, given delivery of an Expected Value that exceeds its costs. Given the volumes of water involved, eradication may be extremely difficult in larger catchments, such as the Lomond, Ness, Tay and, possibly, the Spey, which have complex systems of tributaries and lochs. A related problem is that populations of other salmonid species may act as hosts for Gs, and eradication may require the poisoning or removal of all fish populations. In effect, the Expected Value would be lower relative to the policy costs, and a policy of containment may therefore be the favoured option on economic grounds[12].

The ideal for this study, from a policy perspective, would be to generate an economic model with a two-stage approach. First, the costs of eradication for every individual catchment in Scotland would be identified and compared with the Expected Value of re-establishing Scotland's Gs free status. In this way, policy makers would have a list of the catchments where the Expected Value of the policy benefits exceeded eradication costs. The second stage would be to assess the costs and the respective Expected Values of alternative containment strategies that may be used in these catchments.

Unfortunately, economic data exist at this level for very few catchments, and, given the time constraints of the project, it would be infeasible to collect and analyse the required data.. A case study approach was therefore adopted. Taken together, the selected case studies are designed to identify the magnitude of policy costs and Expected Value analysis associated

[12] If eradication was technically impossible the Expected Value of the policy benefits would be zero.

with the key policy options of **prevention**, **eradication** and **containment**. Where possible we have used catchments for which good secondary data and economic analysis already exists.

An additional difficulty is that although we can estimate the policy costs and most of the benefits that would be realised, we do not know the true probability that a policy measure would be successful. Whilst fisheries science may identify theoretical transmission routes, there are no probabilities attached. Therefore, we cannot calculate the true Expected Value of policy benefits. Our approach has been to work towards identifying the **critical probability**. This is the probability that would make the estimated costs equal to the estimated Expected Value. Should a scientific judgement be made that the probability of successful prevention, eradication or containment exceeds the critical probability then the policy would be worth considering (because Expected Value would exceed cost).

1.2 The Four Case Studies.

The four case studies forming the core of the analysis of policy benefits and costs are: prevention, eradication, containment through minimal exclusion, and containment through total exclusion. The key characteristics of each are outlined below.

1.2.1 Prevention of the Introduction of Gs to Scotland

This section examines a number of **additional** actions that might be taken immediately to help prevent introduction of Gs to Scotland, and to minimise the impact if an outbreak occurs. The costs of resources devoted to such preventative action are identified. In the absence of Gs eradication throughout Europe, or genetic resistance to infection in UK stocks, some of these costs will be permanently incurred. The 'policy-on' benefits are the avoidance of the economic consequences of damage that might be associated with a widespread Gs infestation in Scotland.

1.2.2 Eradication: A Case Study of the River Luce

This section examines the contention that for small catchments which are relatively isolated – both physically, and in terms of human activity – the eradication costs could be less than the costs associated with widespread Gs infestation. The River Luce was selected as an exemplar of such a catchment. It also had the advantage of being owned by one estate that was willing to cooperate with the study. The case study estimates the costs of resources devoted to the eradication programme. These are not permanent costs as we can envisage a period when the policy would be 'off' following successful eradication of Gs. Although the eradication programme would destroy salmon angling on the Luce, the infestation itself would result in the same outcome. Thus, the (temporary) loss of salmon angling is not a cost that should be attributed to the eradication policy.

Again, avoidance of the economic consequences of damage that might be associated with a widespread Gs infestation in Scotland are the 'policy-on' benefits. Such benefits – extending beyond the 'policy on' period – would be permanent. An additional policy benefit is that the River Luce would recover, eventually. This benefit can be attributed to eradication, as the alternatives of 'no policy' or containment involve the permanent loss of wild salmon on the Luce.

1.2.3 Containment: A Case Study of the River Spey

It is likely to be more difficult to eradicate the parasite in large catchments. Whilst the use of more labour and chemicals increases the probability of successful eradication – and thus, the Expected Value – this is offset by the increase in costs associated with using more resources. To treat the entirety of large catchments, such as the Lomond, Ness and Spey with complex systems of tributaries and deep lochs would require the use of vast amounts of labour and chemicals. An alternative strategy of using barriers to prevent upstream migrations and then treating only the downstream sections is being investigated by SEERAD. This approach assumes that the parasite will eventually die out in upstream sections once it is denuded of migratory salmon. Whatever the approach, there would still be a possibility of failure to completely eradicate the parasite. In other words, for large complex systems, the expected value of eradication could be lower than the costs and a policy of containment may therefore be the favoured option on economic grounds. This case study therefore examines the economics of attempting to contain the parasite and prevent further spread.

In this context, it should be appreciated that a variety of containment strategies may be deployed. These range from extending control of obviously high risk activities, such as the movement of live fish, to the effective isolation of the catchment (obtained by total exclusion of all activity carrying any hypothetical risk of infestation transfer, however small). The combination of containment strategies is discussed in Section 3.9.2. It is concluded that the only feasible policies are minimal or total exclusion. We therefore consider only those two options.

1.2.3.1 Minimal Exclusion

Minimal containment combines the prevention of movements of potentially infected fish or water with an extensive publicity campaign that strongly encourages disinfection and/or thorough drying. The policy costs are the resources used in publicity campaigns and in disinfection, and these will be permanently incurred. There will be additional costs imposed on economic activity that is adversely affected by the restriction on the movement of fish or water. These additional costs may not be permanent if hatcheries can be relocated and/or their customers can source alternative supplies

The 'policy-on' economic benefit is the avoidance of the economic consequences of the damage that might be associated with a widespread Gs infestation in Scotland. Salmon angling within the catchment would be permanently lost. This is attributable to the infestation and not the containment policy.

1.2.3.2 Total Exclusion

Total exclusion effectively puts a cordon around the infected catchment, thus prohibiting access to the water, and ending all associated fishing and recreational activity. The policy costs are the resources used in enforcing the exclusion, and these will be permanently incurred. There are additional permanent costs (possibly substantial) associated with restrictions on all forms of water-based recreation within the catchment.

1.3 Structure of the Report

Sections 2 and 3 review the basic biology and distribution of Gs, its principal effects on salmon populations, and the current institutional arrangements for managing fish stock disease and parasitical infestation.

As already outlined, both the disease and the policy options have widespread and complex effects. For example, across Scotland there will be reductions in income and employment while individuals' quality of life will be compromised through a loss of recreational activity. Users of this study will need to fully appreciate how policy costs and benefits are defined and calculated, Sections 4 and 5 address such needs.

Section 6 quantifies the economic consequences of a widespread Gs infestation across Scotland. As already outlined, much of the 'policy on' economic benefit is the avoidance of such consequences. Sections 7 to 11 evaluate the costs and benefits of the policy options.

The study's conclusions are presented in Section 12.

2 The Parasite: Its Spread and Potential Impact

2.1 Introduction

Gyrodactylus salaris (Gs) is a freshwater ecto-parasite that infects Atlantic salmon and some other species of salmonids. It is one of many salmonid infecting gyrodactylid species, which belong to the Monogenea – a larger group of relatively simple, soft bodied flatworms that are, primarily, fish parasites. At less than 1 mm in length, Gs infests the skin, fins and gills where its grazing activity can lead to host death through salt and water imbalances.

Gs is thought to have been introduced into Norway during the 1970s on salmon smolts from Sweden when Norwegian hatcheries were unable to meet the demands of the growing salmon industry in Norway. The parasite subsequently spread from the initial hatcheries to other hatchery sites and rivers and by the mid-1980s it was estimated that Gs had been responsible for the loss of an estimated 300 tonnes of Norwegian Atlantic salmon.

Gs is supposed to be native in the Baltic states, and has been found on Baltic salmon in Sweden and Finland. The status of other Baltic states is still unknown. In Russia, the parasite has been found on Salmon in the White Sea. It has also been reported on rainbow trout in Denmark with mixed responses – some fish showing resistance and others susceptibility. Although cases of infection have been reported on rainbow trout in Spain, Portugal and France, such instances have not yet been verified. In 2005, northern Italy confirmed cases of Gs on rainbow trout using both molecular and morphological tests. Gs status in Iceland, Netherlands, Belgium, and in central European countries is still unknown.

A majority of introductions of Gs are through rainbow trout, with disease spreading by host to host contact. Most infection is of juveniles, with a lower burden of parasites on smaller fish. However, first feeding fry to broodstock may be affected.

Norwegian studies have shown that British salmon are also susceptible to Gs infection. Further research in Norway has shown the number of outward migrating smolts can be reduced by 98% in a five year period following introduction of the parasite (Johnsen and Jensen, 1991, Mo 1994).

2.2 *The Biology of* Gyrodactylus salaris

Gs is a resilient, long-lived parasite. It can survive for eight days at 19°C and 53 days at 2.5°C. It can live and reproduce in a range of salinities, supporting the theory that the parasite may be able to disperse through brackish water (Shinn *pers. com.* 2005). Gs successfully reproduces at 5 ppt. Only with increasing salinity above 7.5 ppt, does population growth slowly decline, with survival for only a few days at 20 ppt. The parasite can be revived from a saline environment, but only if returned to freshwater within eight hours.

A highly fecund parasite, Gs has an average birth-rate of two per parasite lifecycle at temperatures of 6.5-13°C. The daily death rate is low, with a daily population growth of 0.06-0.19 at 12°C. It can survive off its host for 5-6 days at low temperatures. Gs gives birth to live young. A daughter is born the same size as the mother, and, in a 'Russian dolls' effect, contains a future daughter developing within her.

Among salmonid species, Atlantic salmon is thought to be the most severely affected by the parasite, and research has revealed salmon in Scottish rivers are just as susceptible to infection as the Norwegian salmon. In addition, the parasite can survive and reproduce on a number of other salmonids, in declining order of susceptibility: rainbow trout, (*Oncorhynchus mykiss*); Arctic charr, (*Salvelinus alpinus*); North American brook trout, (*Salvelinus fontinalis*); grayling, (*Thymallus thymallus*); North American lake trout, (*Salvelinus namaycush*); and brown trout, (*Salmo trutta*). Gs can survive on migrating eels, but cannot reproduce on them. The parasite may be present on farmed fish, and go undetected for many years. Rainbow trout have been shown to carry the parasite without signs of clinical disease (World Organisation for Animal Health (OIE) 2003)

2.3 *The History of* Gyrodactylus salaris

Gyrodactylus salaris (Malberg) was discovered in 1957 on farmed *S. salar* (Baltic Stock) in the River Indalshaven, North Sweden. In the early 1970s, heavy mortalities of salmon parr in a hatchery in Norway were subsequently attributed to Gs. The situation in Norway continued to worsen, and by the late 1970s one river, the lakselva, presented 95% of salmon parr positive for Gs. Throughout the 1980s, the number of infected rivers rose sharply, with a total of 34 revealing the presence of Gs by 1989. In consequence, a Gs committee was set up in Norway, and the disease was made notifiable. Currently, Gs have been found in 41 Norwegian rivers and 41 fish farms.

Since 1981, attempts to treat 21 of the 41 rivers with rotenone have been made, and ten rivers are now considered Gs free. Rotenone is a natural product extracted from the derris plant. It is highly toxic, and kills all fish and many other aquatic organisms when introduced into a river system at an appropriate dose. The decision to treat in Norway was made to prevent spread of Gs to other river catchments. In addition, Norwegian rivers have low diversity and biomass. They are usually populated only by salmon and trout, with fish re-establishing within a number of years, and other fauna within a few months. Therefore, the overall negative impacts of treatment were deemed justifiable. Monitoring programmes have been put in place to examine re-establishing salmon parr for five years before the river can be given a Gs free status. Control of infections on Norwegian farms has been achieved by destocking, fallowing and disinfection with formalin.

2.4 Impact on Wild Fisheries

Some 380 rivers around Scotland contain salmon (NASCO 2005), The spawning populations of salmon in many Scottish rivers consist of multi-sea-winter fish. Many of these salmon are two-sea-winter fish, revealing a shorter time spent at sea than past populations.

In the large rivers, returning adult salmon are able to enter the river at anytime of year. It is possible for some early-running salmon to enter rivers more than a year before spawning. Grilse normally enter their rivers during summer and autumn, but some rivers do have early runs of grilse during May and June. Spring salmon, which enter the river before May 1st, are highly prized by fishermen.

The Statistical Bulletin on Salmon and Sea Trout Catches (Fisheries Research Services 2004) revealed the fishing effort for both salmon and sea trout to be higher in 2004 than the previous five year average. Over previous years there has been a decline in commercial effort and catch, possibly reflecting both the reduced numbers of commercial operators and a decline in the abundance of Atlantic salmon returning to Scotland.

In 2004, the total rod catch of sea trout was up 12% on the previous year, representing an 11% decrease on the five year average. The net and coble catch of sea trout for 2004 was down by 37% on the five year average, despite a slight increase in effort from 2003. The fixed engine catch of salmon and grilse was 20,758, the third lowest since records began in 1952.

Trends in rod catch since 1952 reveal variations between different populations. Catches of spring salmon have been in decline, showing an increase of grilse and little change in the number of summer salmon caught over the same time period. This overall long-term decline throughout Scotland appears to affect all populations of salmon, regardless of river type or location. However, there were increases in rod catches recorded for 2004, perhaps providing evidence of an increase in the number of fish entering freshwater. However, care should be taken to consider the trends over a number of previous years, rather than catch levels for the most recent years when inferring the status of stocks.

In circumstances where a Gs infestation did occur and there was no attempt to eradicate and/or contain it (the 'no policy' option), our working assumption is that, through time, Gs would become widespread throughout Scotland. It would lead to such extensive mortality that salmon angling in Scotland would not be viable in any of Scotland's 350 rivers. In practice, the speed at which the disease spreads will depend on a number of factors, including the characteristics of the initial catchment. Gs can infect species other than Atlantic salmon, though there is no discernable increase in their mortality. Therefore, the 'no policy' option will mean that, although anglers will no longer fish for salmon, other species such as rainbow trout, brown trout, coarse fish, grayling, and, in particular, sea trout will all be available. The economic consequences of this are estimated in later sections.

2.5 Salmonid Farming in Scotland

Over the last 30 years, the commercial salmon industry has been the most important economic development for those living in the Highlands and Islands area of Scotland, providing full-time equivalent jobs (FTEs) in production, processing, transport and other allied services. Production is in the region of 150,000 tonnes, and is worth around £300m at first sale value. Geographically, the industry is located in the more remote parts of Scotland and on the islands. The Shetlands, for example, produces 34% of the total, and the North West Highlands 28%. The most visible parts of the industry are the marine grow-out operations, which utilise floating cages moored in sea lochs. Here, salmon are grown on from a weight of around 70g to market size (usually between 3 and 5 kg). Before this, salmon are hatched and reared in freshwater systems involving several distinct stages. Firstly, broodstock may be returned from the sea to freshwater tanks or cages for breeding. Fertilised eggs (ova) from these broodstock are held in trays or troughs in flowing water until they hatch into aelvins. These continue to obtain nutrition from their yolk sacs until they start to feed and develop into fry. Early fry are usually transferred to larger tanks where they may be maintained until ready to go to seawater (i.e. become smolts at 50 to 100 g). Alternatively, they may be transferred to larger tanks, or more commonly, to cages in freshwater while they grow from a few grams in weight (often termed 'fingerlings' or 'parr' at this point) up to smolt stage. In nature, salmon will grow to smolt stage in either two or three years after hatching. In aquaculture, the combination of high quality diets, and manipulation of water temperatures and light regime (photoperiod) allows smolts to be produced between six months and one year from hatching.

In 2004, there were 48 companies actively engaged in producing freshwater stages of salmon (ova, fry and smolts), using 172 sites (out of a total of 276 registered sites). Very few sites will be completely integrated throughout the freshwater stages, so fish movements between sites will be common. It is assumed that virtually all freshwater salmon sites would be susceptible to Gs, and that large-scale mortalities could occur if a farm is infected. However, unlike the wild situation, in some circumstances it might be feasible to treat the fish using a formalin bath. This cannot be considered a long-term solution, however, as the use of formalin is under scrutiny, so its use in aquaculture may not be permitted in the future. There could also be serious issues regarding the required frequency of treatments and the consequent welfare considerations. Therefore, in practice, freshwater fish farms on infected rivers (or those using cages in freshwater) would be forced either to close or to invest in biosecure systems. These farms use a range of measures to protect stock from pathogens – most importantly, pathogen-free borehole water supplies, or finely filtered and sterilized surface water supplies, often combined with recirculated water systems that minimise intake requirements.

A small number of biosecure systems already exist. Their use is slowly expanding because recirculated systems allow a greater degree of control over environmental conditions and, hence, growth rates are faster. In 2004, there were 96 farms using tanks and raceways, and 76 using cages in freshwater. The number using biosecure tank-based systems is not recorded, but it is thought to be low as six (of which only 3-4 might produce smolts). Overall in 2004, around 44% of smolts were produced in cages, and 56% in tanks and raceways, but, probably, less than 5% of these were from biosecure systems.

If Gs were to infect a smolt site, it is possible that losses could be minimised through the use of formalin treatments, and that movement of fish to a sea site would be permitted. For hatcheries and intermediate freshwater sites that would normally move fish to another freshwater site, the viability of the fish stock would depend on prevailing movement restrictions. In the long term, infected sites might be regarded as unviable due to the extra cost of treatments and the likely movement restrictions.

Depending on the scale of an initial outbreak, it is possible the disease would cause a serious shortfall in smolt availability for the sea sites. This could have a serious impact on the grow-out and primary processing industries unless alternative supplies could be sourced, for example, from Ireland or Norway. Whilst any infestation would be very serious for affected farms, widespread infestation could have a devastating effect on the industry, given its current vulnerability. In the more likely scenario of the initial infestation being identified in one farm or one catchment, it is anticipated that there would be immediate emergency isolation of the infested area with destruction of all stock. The possibility exists of further transfer, but this will occur relatively slowly, catchment by catchment. Therefore, hatcheries will have a strong incentive to make themselves bio-secure. Thus, even if Gs continues to spread, destroying wild salmon populations as it goes, it will have only minimal effect on aquaculture in the long term.

2.6 Rainbow Trout Farming

Apart from salmon, the next most heavily cultured species is rainbow trout. Sold commercially as food fish, a proportion of those raised is used to restock ‘put and take’ sports fisheries. Restocking represents 14.7% of the market, with most production directed towards the table (85.3%). The total number of staff employed by the sector is 152 (FRS 2004).

The Scottish trout industry is highly dependent on imported ova. In 2004, trade in rainbow trout fingerlings continued with the majority being sourced within Scotland (FRS 2004). Other freshwater species cultured include the European eel and Arctic charr, which are both farmed to a much lesser extent.

Rainbow trout and Gs coexist without major mortality, which makes identification of infection and, hence eradication, harder. The problem is then largely the difficulties associated with Gs prevalent status.

2.7 Put-and-Take Fisheries

There are some 287 ‘put-and-take’ trout fisheries in Scotland (Walker 2002). These may be fished by private groups (usually syndicates), or in many cases are open to the public. Fishing intensity on such waters is much greater than on rivers and lochs relying on wild fish numbers. Stocks of fish are regularly replenished from farmed sources. The greatest proportion is rainbow trout, but many fisheries also stock brown trout, and some specialise in this species.

‘Put-and-take’ fisheries are often created in gravel pits or other water bodies with relatively limited water exchange with the wider catchment. There are ‘put-and-take’ fisheries for rainbow trout in all of Scotland’s major river catchments, including the major salmon rivers, Tay, Spey, Dee, Tweed, Esk and Don. Potentially, ‘put-and-take’ fisheries present a severe risk of disease transfer, given their reliance on introducing stock from (usually) multiple farms. Since Gs does not affect these populations they would be a potential reservoir for Gs. There are reports of rainbow trout being caught in almost all of the major salmon rivers and it is likely that these have escaped either from farms or from stocked fisheries that are connected by streams to the rivers.

2.8 Impact of Parasite Spread

The economic benefits and costs of any particular Gs policy measure are based on a comparison of the expected outcome of the measure(s) in place (the ‘policy on’ outcome) with what might happen if there was no policy intervention. This Section addresses the latter element of the comparison. Specifically, it considers the outcome for Scotland if there was Gs infestation, but no policy response from the Scottish Executive other than measures currently in line with the status of Gs as a notifiable fish disease. Please note, this Section does not address the **economic** consequences of the ‘policy off’ outcome; these are explored in Sections 5 and 6.

In undertaking this assessment, it is necessary to make simplifying and working assumptions. For example, little is known about the speed with which the infestation would spread through Scotland’s surface freshwater, especially in the absence of a policy response. Therefore, we have to rely on a comparative static approach that focuses on anticipated final outcomes, and one that largely neglects the intervening time period. Analytically, this is tantamount to assuming Gs spreads so rapidly that the process itself can be legitimately ignored allowing concentration on the hypothetical outcome of the parasite being fully established across the nation. This enables us to estimate the economic consequences of not having a Gs policy, and it establishes the baseline for comparison of the net benefits from the various policy options.

We also have to make assumptions about how individuals would adjust their behaviour if Gs became established in Scotland. Fortunately, we have survey data that tells us how anglers, and some participants in other water sports, would respond to the ‘policy off’ scenario (see Sections 5 and 6). Regrettably, there is no information on how some key private operators would respond, and, in its absence, it is necessary to make informed judgements on how commercial operators will adjust to Gs infestation. For example, in the presence of a Gs threat, independent hatcheries supplying the salmon aquaculture industry have a strong incentive to convert to biosecure production, or go out of business. Independent salmon grow-out companies might seek to purchase smolts from abroad if supplies from Scotland become limited due to closure, or prices rise above that of international suppliers. Independent vertically integrated companies could be faced with a more difficult decision as they might be giving up some surety of supply by closing their own freshwater facilities to rely on third parties, especially from other countries. However, the majority of Scottish salmon production is now in the ownership of a small number of vertically integrated Norwegian companies, which could decide to concentrate future investment in freshwater facilities in Norway if forced to close units in Scotland. However, this could create a new risk that they would be unable to supply their own grow-out farms in Scotland, should a different notifiable disease problem arise in Norway preventing export from there to Scotland. On balance therefore, we anticipate that the occurrence of GS in Scotland could result in increased imports of smolts, but over the longer-term there would be incentives for the industry to respond as it has in Norway and invest in biosecure facilities where appropriate.

3 Current Management, Control and Institutional Background

3.1 The Institutions

3.1.1 The Scottish Executive and SE Environmental and Rural Affairs Department

Ultimate responsibility for management and control of the parasite lies with the Scottish Executive (SE) and its Rural Affairs Department (SEERAD).

The SE is working on a contingency plan to try and limit the spread and impact of infection, if, or when it is introduced. The SE is seeking powers to certain primary actions in the event of an introduction, including:

- Placement of movement restrictions on fish, their viscera, eggs and food both to and from farms and wild catchments that are infected,
- Eradication of the parasite using chemical treatment,
- Imposition of standstills on water bodies,
- Erection of barriers or close fish passes,
- Demands for clearance of farms upstream of barriers,
- Mandatory disinfection of recreational gear, for example, angling and canoeing,
- Authorization of the disposal of dead or moribund stock.

3.1.2 Fisheries Research Service and the Fish Health Inspectorate

The Fish Health Inspectorate (FHI) of the Fisheries Research Service (FRS), Aberdeen plays an important role in the management of sustainable aquaculture and the protection of wild fish stocks in Scotland through research based regulation and legislation. Their main aim is to prevent the introduction and spread of fish and shellfish diseases. The group provide advice and a free diagnostic service to fish farmers, ghillies, district salmon fishery boards (DFSBs), fisheries trusts and other stakeholders. In addition to routine disease monitoring on fish farms and in wild catchments, the FHI is responsible for assessing applications for fish transport, health certification, veterinary medicines residue analysis and the collection of production data.

3.1.3 Fishery Boards

The management and day to day control of salmon and sea trout fisheries is carried out by the DSFBs. They are funded by a levy on the rights owners, and provide a range of services, notably, scientific and bailiffs. Bailiffs play a critical role when rivers become diseased, and additional funding is necessary when this occurs.

3.2 Notification and Movement Control

3.2.1 Reporting

The health of British freshwater fish stocks is protected under the Diseases of Fish Act 1937 and 1983, and a more recent European health regime. Under the EU regime, there are eight notifiable fish diseases. Annex A of Council Directive 91/67/EEC classifies notifiable fish diseases into three categories, each with its own set of restrictions. This classification functions to regulate disease control to ensure the safe movement of fish and the placement of aquaculture products on the market. The FHI is charged with implementing the regime in the UK on behalf of DEFRA and NAWAD. FHI is part of the FRS who, in turn, are responsible to SEERAD

The disease, gyrodactylosis, caused by Gs is notifiable under the regime, and it is categorised as a List III disease in the schedule, presented below.

List I Diseases
All diseases that are exotic to the EU, pose a serious threat to farmed and wild stocks where they occur, and for which there is no vaccination or treatment available. The health regime requires that all EU member states take immediate action to eradicate the disease. This includes:

- Infectious Salmon Anaemia (ISA)

List II Diseases
Diseases which have become established in parts of the EU, pose a serious problem to farmed stock, and for which there is no treatment or vaccination available. These include

- Viral Haemorrhagic Septicaemia (VHS)
- Infectious Haematopoietic Necrosis (IHN)

Presently IHN is exotic to Britain. Movements into Approved Zones or Farms can only take place from those areas of equivalent or higher health status. The regime requires that Member States take action to eradicate this disease in order to establish Approved Zones and Farms. At present, Great Britain is designated as 'an Approved Zone free from VHS', however a recent outbreak of the disease in North Yorkshire has suspended this status until it can be redefined to exclude the affected Ouse catchment area.

List III Diseases
Diseases which have become established in some EU Member States, and are posing a serious threat to aquaculture and, in some cases, wild stocks. Treatment and vaccinations may not be available for all. There are no community wide controls for List III diseases, but with agreement from the EU, national programmes can be established to contain or prevent the introduction of these diseases. These include:

- Gyrodactylosis (caused by *G. salaris*)
- Spring Viraemia of Carp (SVC)
- Bacterial Kidney Disease (BKD)
- Furunculosis (FC) in salmon
- Infectious Pancreatic Necrosis (IPN) in salmon

The diseases, FC and IPN are not currently controlled in Britain, according to the FRS.

3.2.2 Movement and Inspection

3.2.2.1 Imports
In developing government policy, a strong emphasis has been placed on controlling activities that increase the risk of an introduction. Primarily, the transport of eggs, gametes, live fish

and the use of live bait present the greatest risk of infection. In the past, no salmonid imports were allowed into the UK and Ireland without a licence. Following the establishment of the single European market in 1993, the movement of live salmonids from anywhere in the EU to the UK and Ireland is now permitted without a licence. However, movements are only allowed from EU Approved Zones and Farms.

The Approved Zones and Farms must have a high fish health status, which is equal to or higher than the areas they are exporting to. The inspection, sampling plans and diagnostic techniques required to achieve and maintain Approved Zone status are described by the Commission decision 2001/183/EC. To achieve Approved Zone status, all farms within a zone must have been inspected and have tested negative twice a year for two years. In a zone that has Approved Zone status and is trying to maintain freedom from disease, health inspection must be carried out once a year on all susceptible species.

All imports must follow pre-notification procedures, and must be accompanied with movement documents. Surface disinfection of eggs is required for all imports, along with disposal of containers and residual containers. Despite these restrictions, imports have increased and, hence, so too has the risk of an introduction.

3.2.2.2 Internal Controls

If the presence of Gs is confirmed, a restriction on all movements of fish will be implemented until disease surveys have investigated the distribution of the parasite. Once the distribution is known, movement restrictions will be placed on all infected areas, including fish farms. Fish in transit into or out of the catchment at the time the restrictions are imposed will probably be killed as a precautionary measure. The transport of fish for processing will be by licence with specific containment measures, and will only be authorised by the Disease Strategy Group (DSG). Catchments surrounding infected areas will be made buffer zones, and will have movement restrictions imposed to prevent the spread of infection.

3.3 Surveillance

In addition to restricted movement on imports, the SE currently has an annual surveillance programme monitoring fish farms and a small number of wild catchments for disease, in particular Gs.

The FHI carries out routine disease monitoring of Atlantic salmon and rainbow trout across Scotland on an annual basis, taking in both fish farm and wild catchment sites. The on-farm sampling programme operates in accordance with the mandatory EU surveillance programme, which screens for Gs but also includes other fish diseases. The main driving force of wild catchment surveillance is the monitoring of wild salmon stocks for signs of infection with Gs.

3.4 Diagnosis

There are over 400 gyrodactylid species, many of which are easy to distinguish. Gs can be more difficult to identify as it has close similarities to some other species, in particular, *Gyrodactylus thymali.* To facilitate diagnosis, the whole surface of the fish, including gills and mouth cavity, need to be examined under a dissecting microscope. Gs can be identified by examining the morphology and morphometry of hooks and bars in the opisthaptor (holdfast organ), and by DNA analysis. Screening, and presumptive and confirmatory diagnostic methods for the presence of Gs should be performed in accordance with the most recent World Organisation for Animal Health guidelines (OIE 2003).

3.5 Communication

Following lessons learned during the 2001 foot and mouth outbreak, the SE has designed a communication strategy to deal with future outbreaks of exotic disease (SE 2004).

When a suspected case is first reported, the Head of the Disease Strategy Group (HDSG) will brief the Minister and senior management, including the Chief Press Officer. MSPs/MPs with a constituency interest will also be alerted. Arrangements will be put in place in case disease is confirmed. The HDSG will appoint a Communications Coordinator who will be responsible for ensuring that all managers (HQ, Field and Laboratory) are made aware of policy and decisions that affect their role. Similarly, each manager must produce a regular report to the DSG on relevant actions within their unit (SE Gs Contingency Plan 2006).

3.6 Publicity

Regardless of the management policy implemented – prevention, eradication or containment – publicity will be required. It will be necessary to inform as many people as possible about the infection, and the precautionary measures that are required to prevent the spread of disease. Education and adequate explanation of intended actions to both politicians and locals might prevent or reduce any negative lobbying, particularly in relation to treatment with chemicals (Shave 2004).

Publicity may be achieved most easily by utilising the websites of involved governmental bodies, fisheries trusts and other stakeholders, specifically: (SEERAD); (FRS, which includes FHI); Scottish Environment Protection Agency (SEPA); State Veterinary Service (SVS); (DSFBs); Scottish Natural Heritage (SNH); Sport-Scotland; angling associations; Scottish Canoe Association (SCA); British Canoe Union (BCU); Royal Yacht Association (RYA); Scottish Rafting Association (SRA); Scottish Water; Visitscotland; local tourist boards and local government authorities in affected areas.

Advertisements will also be placed in national and/or local newspapers, and posters and leaflets distributed for use at relevant sites such as ports, service stations, hotels and fisheries.

3.7 Gene-banking

Worldwide, there is advocacy for *ex-situ* conservation of genetic resources as a result of declining wild stock. Initially, fish gene-banks were established to conserve marine species. Now, the conservation of freshwater species has been given similar importance (Harvey 1994). At present, there are no live fish gene-banks in the UK.

Scotland's Freshwater fish and Fisheries: Securing their future (SE 2001) is one example of the SE's commitment to Scotland's freshwater fish and fisheries. In addition to domestic concerns regarding the protection of Scotland's Atlantic salmon, the EU has signed both the Convention for the Conservation of North Atlantic Salmon (1982) and the Rio Convention on Biological Diversity (1992). Both of these conventions promote the conservation of wild salmon stocks as a component of national heritage, and as a resource to be commercially fished in the ocean.

The Norwegians established a salmon gene-banking programme in 1986 to protect Norwegian Atlantic salmon stock from acid rain, Gs, genetic contamination from farmed salmon, and water developments projects. In the initial stages, the bank contained only cryopreserved milt. Now, there are three live gene-banks (LGB), which utilise frozen milt and maintain several year classes.

The Directorate for Nature Management operates two of these, while *Statkraft* (the Norwegian state power system) operates the third. The LGBs are situated in Eidfjord (south western Norway), Haukvik (central Norway) and Bjerka (northern Norway). The LGBs supply eggs to local hatcheries, which produce fish for release, or the eggs are placed directly in the spawning habitat as eyed eggs (*Norwegian Gene-Bank Programme for Atlantic Salmon* 2005).

Initially, the fish to be banked need to be caught, and kept at a facility until sexually mature. Once mature, fish are stripped, and milt from one male is used to fertilise a number of female eggs. Fertilised eggs are placed in hatchery trays, and eggs from each female are kept separate. Throughout the growth cycle, families of the same stock are kept in separate tanks until they can be tagged or have their fins clipped. Families can then be put in the same tank. Once fish reach smolt stage, individual fish of each family are genetically tagged. Then, each generation is kept in separate rooms for two years, keeping each year class separate for four years (*The Norwegian Gene-bank Programme for Atlantic Salmon* 2005).

Throughout the rearing cycle, great emphasis is placed on keeping the fish disease free. All eggs need to be disinfected prior to export, and donor fish are routinely checked for diseases such as BKD, IHN and furunculosis. Water quality is vital for maintaining a disease free status. It is advisable to maintain an LGB away from known or high-risk infection areas.

3.8 Eradication

3.8.1 Rotenone

The natural piscicide, rotenone has been used as a treatment in over 20 Norwegian rivers to eradicate the fish and thereby the parasite. The decision to eradicate in Scotland will depend on the river system, and on whether or not the Scottish Executive authorise the licensing of appropriate chemicals. Currently, rotenone is not licensed for use in Britain, but ministers are seeking powers to authorise its use, if necessary. The administration of chemical soon after diagnosis is the key to successful eradication, and can greatly reduce the number of fish killed. Treatment may be administered while fish unaffected by the parasite are at sea. Therefore, little effect will be seen in the numbers of fish returning during subsequent years (Shave 2004). Rotenone kills fish and aquatic invertebrates as well as Gs. It has no effect on piscivorous birds, and it has low mammalian toxicity. There have been some concerns in relation to public health, and these issues are still being researched (Beinot *et al*., 2000).

In Norway, 27 rivers have been treated with rotenone, 21 of them successfully. The choice to treat each affected river has not only facilitated the recovery of lost stocks but has also generated enough public good will for further treatments – which, in turn, has provided political support and the appropriate funding required.

The more complex the river system – that is, the larger the main stem of river, drainage area and number of tributaries – the more difficult treatment can be. It follows that smaller, less complicated river catchments are easier to treat. A detailed assessment of the river system is required before a chemical treatment may be administered because all catchments are unique, varying in features, such as length, water flow and number of tributaries.

3.8.2 Aluminium Sulphate (AIS)

Aluminium Sulphate (AIS) is an alternative chemical that has been used to treat Norwegian rivers infected by Gs, but it is still in the experimental stages in Norway. Unlike rotenone, which kills off most aquatic vertebrates and invertebrates, AIS kills only the parasite. The idea of using AIS to eradicate Gs came from Norwegian acid rain research, and the observation that Gs numbers were lower in areas experiencing acid rain. Researchers at the University of Oslo, who have been investigating AIS use for treatment of Gs, have reported some encouraging findings. They found that water chemistry had to be just right, and that two or three treatments may be required. It has been shown that laboratory manipulation of water to induce acidic conditions with the addition of AIS can kill the parasite. The creation of conditions in which the parasite will not be able to survive is highly dependent on the timeframe and concentration in which dosing is provided. Repeated dosing with AIS over 14 days has been shown to be an effective treatment.

In Norway, there have been no objections to the use of AIS because it has the advantage of more selective action (targeting only the parasite). However, it should be noted that concerns have been raised regarding aluminium pollution, and its possible public health implications (see IPCS 1999, Hopkins 2006).

3.9 Long Term Containment

3.9.1 Means of Transmission

In the event that eradication is not possible, a containment policy would be applied to limit the spread of infection. The potential pathways for the introduction of Gs fall into three categories:

- importation of live fish and gametes,
- eviscerated fish carcasses,
- mechanical transmission through, for instance, equipment or water.

These risks were evaluated by Peeler *et al*. (2004), and are summarised in Table 3.1.

Table 3.1: Summary of Risk Assessment on Routes of Transmission of Gs

Route of Gs Transmission Between River Catchments	Probability that Event Will Result in Introduction	Probability that Introduction Results in Establishment	Combined Risk Assessment
Live rainbow trout or salmon movement (one consignment)	Very high	Very high	Extremely high
Movement of other species of live fish, including grayling and brown trout (one consignment)	High	High	High
Movement of salmon between rivers (one fish)	Moderate	High	Low
Farm equipment, staff and vehicles (one person or piece of equipment)	Low	Low	Low
Effluent from fish processing plants (100,000 l)	High	Low	Low
Angling equipment (belonging to one angler)	Low	Low	Very low
Canoe/boats etc.	Low	Low	Very low
Rainbow trout or salmon eggs (disinfected, one consignment)	Low	Low	Very low
Eel migration (one eel)	Low	Low to moderate	Extremely low
Piscivorous birds (one bird)	Extremely low	Extremely low	Negligible

Source: Adapted from Peeler *et al*. (2004)

This analysis illustrates that the priority for containment is the prevention of movements of live fish between catchments, with other routes assessed as lower risk. Therefore, a first priority for any containment policy is to stop all deliberate fish movements from infected to uninfected areas. Control over other routes of transmission is likely to be more difficult to implement, but it would add some additional security.

3.9.2 Containment Strategies Used in Scenarios

It is anticipated that if Gs is identified in Scotland, the initial regulatory response will be based on containment whilst the extent of the infestation is determined, and longer-term strategies can be evaluated. In the short term, the initial response is likely to be a complete and immediate ban on fish movements in Scotland, followed by a licensing of essential fish movements where risk is considered acceptable.

A key consideration is the extent to which long-term controls to reduce risk of transfer should be placed on other activities in an infected zone. The transfer of fish *en masse*, marked as very high and high-risk activities, would necessarily be banned. The three items marked as low risk in Table 3.1 involve the transfer of live salmon, vehicles and other equipment working at a diseased fish farm, and the dispersal of fish farm effluent. A minimal containment policy would also deal with these by banning the movement of any fish, instituting disinfection stations, and stopping the disposal of any untreated disinfected effluent into the water system from an infected farm.

The critical decisions relate to items marked as very low risk. Specifically, one option to be considered is a ban on all water sport and recreation activity, including angling, kayaking, boating, swimming and paddling (which we label as Total Exclusion). However, appropriate disinfection by steam or chemicals can virtually eradicate any possibility of transfer of Gs. In these circumstances, prevention of enjoyable, natural activities that generate significant economic activity might be regarded as unnecessary – provided that disinfection can be assured when equipment is transferred between infected and uninfected zones.

The assurance of disinfection is a function of incentives, policing and social behaviour; the strategies considered contain a mix of all three. Ideally, disinfection would occur on entry to a Gs free zone when an individual requires it, and the zone managers insist on it. Such an approach would require a system of disinfection stations and licensing for every catchment, and, clearly, this is not a practical proposition (unless Gs had spread so widely that there were very few Gs free zones). The only realistic alternative is disinfection when leaving an infected zone, where obvious incentives to carry it out are lacking.

A number of alternatives were considered. The first was based on the provision of a number of disinfection stations at all egress points. Anglers and boaters would be encouraged and expected to disinfect their equipment. Providing it was convenient, and the station was working, it was considered likely that the vast majority of users, but not all, would disinfect as part of agreed social behaviour.

Table 3.2 Containment Scenarios

	Minimal Restrictions	**Total Exclusion**
Fish farms in Infected Area	All outward fish movements banned	Farm closed and fish slaughtered
Angling	Angling allowed but anglers required to disinfect equipment and boots	All angling banned in infected water
Boating	Boaters required to disinfect boats before taking them to other waters	All boating banned in infected water
Swimming/Paddling	Publicity to emphasise importance of drying towels, costumes, flotation devices etc	All access to infected water banned
Water Abstraction	Risk assessment conducted – only water movement out of area e.g. to other catchments banned	Water abstraction limited to essential use
Fish Processing	Require licence to ensure adequate disinfection of fish waste	Ban processing of fish from infected areas
Vehicle Movements etc.	Install disinfection mats at fish farms	Close off access to high risk points

A second alternative – which we have utilised in the case study of the Spey – is based around a money deposit to take the equipment into the infected catchment. The deposit would be returned when an individual disinfects the equipment on exiting the catchment. It would be set at such a level that every user would seek and carry out disinfection. The details of this alternative (which we label Minimal Restrictions) are developed within the Spey case study in Section 10. Table 3.2 summarises the key overall features of the strategy.

In this study, it is assumed that a maximum containment strategy would be feasible and utilised on the River Luce (and other small catchments) prior to eradication. The economic effects of both a Minimal and a Total Exclusion strategy are examined for the Spey catchment.

4 Economic Framework for Assessing Policy Costs and Benefits

4.1 Introduction

The impact of Gs, as well as policy initiatives to prevent, control and/or eradicate an infestation will have consequences for many individuals who will gain and lose in a variety of complex ways. Therefore, in any economic evaluation, decisions need to be made about the scope and limitations of the evaluative process. Brown (1984) argues that the **held values** (value judgements) determine not only the boundaries of any evaluation, but also the logically appropriate uses of its findings. Historically, two kinds of economic evaluations have been applied to angling in the UK and elsewhere, each predicated on a different set of held values. This study seeks to assess the impact of Gs, and the policy response using both forms of evaluation.

One set of evaluations focuses on the **economic impact** of angling on local/regional economic activity; the remit of the project makes explicit reference to this form of evaluation. For example, a Tourist Board's concern may be with the effect of visiting anglers' spending on regional income and/or employment, and is thus likely to request an economic impact study. Studies which have addressed the economic impact of angling include: Cobham Resource Consultants (Anon 1983); Whelan and Marsh (1988); Mackay Consultants (Anon 1989); Dunn *et. al*. (1989); Radford *et. al*. (1991); Moon and Souter (1994); Radford *et. al.* (2004); and Riddington *et. al.* (2004).

Another set of held values define the scope and limitations of the Total Economic Value/Cost Benefit Analysis (TEV/CBA) framework. This type of study examines **economic value** and its sensitivity to changes in resource allocation. The primary focus is how changes in resource use affect the wellbeing of individuals as reflected in their willingness to pay (WTP) (see Hanley and Spash, 1993). As such, the evaluation process might be unconcerned about the differential impacts on the incomes of individual regions or sectors of the economy. Examples of this kind of evaluation of angling activity include: Willis and Garrod (1991 and 1999); Foundation for Water Research (Anon 1996); Davis and O'Neill (1992); Gibb Environment (1999); and Spurgeon *et. al*. (2001).

Section 4.2 deals with the theoretical framework of the TEV/CBA approach, and considers its relevance for Gs infestation. Section 4.3 outlines economic impact assessment.

4.2 TEV/CBA Framework and Gs Infestation

Fundamentally, this framework seeks to provide a monetary measure of society's preferences for alternative uses of its scarce resources, where society's preferences are taken as the aggregate of the individual preferences of its members. A key precept of this framework is that an individual's preferences for particular goods can be measured by Willingness To Pay (WTP), or, alternatively, their Willingness To Accept Compensation (WTA). WTP and WTA relate to two very similar concepts that articulate what is meant by a change in an individual's welfare.

Compensation Variation **(CV)** considers what is financially required to restore the individual to his/her original welfare position after a change in circumstances. Thus, the CV measure of welfare change is that financial transfer necessary following the change to leave the individual no better or worse off than before the change. A Gs infestation that leaves anglers worse off requires financial compensation to restore the original position[13]. Thus, the individual's WTA for infestation damages is the CV measure of the change in their well-being as they themselves would perceive it.

The *Equivalent Variation* (EqV) is a measure of the financial transfer needed before a change in circumstances that leaves an individual just as well off after the change. If Gs in fish decreases anglers' well-being, the EqV measure is the maximum amount the individual would be willing to pay to prevent the infestation occurring[14]. In this case, WTP to avoid infestation damages is the EqV measure of the change in their well-being as perceived by themselves.

CV and EqV are very similar. Theoretically, the minimum compensation required to induce willing acceptance of an undesirable change (i.e. WTA/CV) and the maximum willingness to pay to avoid it (i.e. WTP/EqV) should not differ by much (although in applied studies they do). The choice of which measure to use depends on the *status quo* and the existing structure of property rights. If property rights reside with angling, then perhaps WTA/CV is the appropriate basis for estimating the loss of welfare associated with Gs infestation.

Unfortunately, some methods of estimating WTA/CV suffer from respondents failing to appreciate that it is the **minimum** compensation that is being sought and not a level of compensation they would like to have. In the interests of credible estimates we seek to estimate WTP/EqV.

Following from the above, the **Gross Economic Value** (GEV) of allocating resources to produce something is given by the sum of individuals' WTP for it. Thus, the GEV of salmon angling (or paddling) is the aggregate WTP of anglers (or paddlers). Unfortunately, gross values ignore the resources used by anglers (or paddlers) in producing their recreational experiences. From society's perspective, these resources could have been used to produce something else for which there is a WTP. Therefore, there is an **Opportunity Cost**. The more relevant concept of **Net Economic Value** (NEV) is obtained by subtracting the Opportunity Cost of the resources used in production from GEV. In applied economic work, it is normal, and reasonable, to assume the market value of resources used (for example, energy, labour, raw materials) reflects society's opportunity costs. Thus, for anglers (or paddlers) the market value of their tackle, petrol, bait, equipment and so on, reflects society's Opportunity Cost.

With respect to policy costs**,** substantial amounts of real resources, (such as labour, chemicals and energy) may be deployed in initiatives to prevent, control and/or eradicate Gs. These could have been used to produce something else for which there is a WTP, and the policy therefore imposes an **economic cost**. Assuming the market value of the resources used reflects Opportunity Costs, the calculation of these particular economic costs is conceptually straightforward. A further dimension of the policy response to Gs is that other

[13] If the change made the individual better off, the CV measure is the amount the individual would have to pay / sacrifice to reduce his/her well-being to its (lower) original level.
[14] If the change made the individual better off, the EV measure is the minimum amount the individual would have to accept to willingly forego the beneficial change.

recreational uses of surface water (for example, paddling) may be curtailed. In measuring the full costs of Gs policy initiatives, the TEV/CBA framework should take into account the loss of NEV from paddle sports.

With respect to the economic costs of Gs infestation, the principal impact is fish mortality and, therefore, the destruction of salmon angling. It is important to appreciate that there is a loss of NEV associated with fish stock depletion, and a separate loss of NEV associated with the demise of salmon angling. They need to be discussed separately. The main economic benefit from Gs prevention, control and/or eradication is the preservation of the NEV from the fish stocks, as well as from angling activity.

The NEV associated with loss of salmon angling is discussed first. In doing so, we draw parallels with the NEV of other recreational activity. If other recreational activity (for example, paddling) is compromised by the Gs policy response, the associated reduction in the NEV could be a major component of the economic cost of Gs policy.

4.2.1 NEV of Angling Activity

4.2.1.1 Consumers' Surplus

As outlined, NEV is found by estimating WTP, and then subtracting the market value of the resources anglers (and/or paddlers) use, as reflected in their expenditure on tackle, petrol, bait and accommodation etc. The difference between what anglers (and/or paddlers) are willing to pay and what they are actually required to pay in the market place (their expenditure) is known as **Consumers' Surplus**. So, for non-priced angling (or paddle sports) a first approximation would be:

NEV = Anglers Consumers' Surplus (CSa)

Consumers' Surplus is important to anglers/paddlers, but it is not necessarily the only (or primary) reason for its calculation. Consumers' Surplus is estimated because, in the circumstances described above, it is the NEV to society of the activity.

4.2.1.2 Economic Rent

In Scotland, recreational fisheries are generally privately owned, with most owners of fishing rights charging anglers for access. The fishery is priced, and thus operates within a market. Therefore, unlike most paddlers, anglers have an additional item of expenditure in the form of the payment made to fishing rights owners. In effect, the owners appropriate part of the anglers' potential Consumers' Surplus. It can be argued that the payments anglers make to fishery owners for merely being allowed to access fishing sites have, in themselves, no resource allocation implications and, therefore, do not reflect Opportunity Costs. Such payments are known as **Economic Rent** (ER)**.** So, for a priced recreational fishery, NEV value comprises the remaining Csa, plus the ER accruing to fishery owners. Thus, we now have:

NEV = CSa + ER

Owners of fisheries possess the right to receive a net income flow by letting their fishing. Owners' rights to such an income flow – actual or potential, depending on choice to let or not – can be bought and sold in the market. The market value of fishing rights represents a capitalisation of the potential income from those rights. Additionally, the market value of fishing rights captures the status value, or 'psychic' income derived from the ownership of a fishery.

Given the considerable angler/paddler) expenditure on equipment, accommodation, food etc., there is the possibility of ER associated with the supply of these angling/paddling dependent goods and services. The market for angling equipment, by mail order and other means, is reasonably competitive, with little inelasticity in the supply of fixed or variable factors. It is reasonable to assume competition ensures low profit levels in the supply of angling goods and services, and therefore, only incidental amounts of producers' surplus/economic rent will be generated in this sector.

Salmon angling associated ER and CSa might be described as a 'direct consumptive user value'. However, it is conceivable there are other sources of value from the activity of fishing.[15] It is appropriate to consider all possible sources of NEV, and the potential significance of these. A discussion of such sources is presented in Appendix 2.

4.2.2 Estimation of NEV

Within the TEV/CBA framework, the main theoretical economic benefit from Gs prevention, control and/or eradication is the preservation of the NEV derived from both salmon stocks and salmon angling. Therefore, this needs to be estimated.

When markets exist, marginal WTP can be obtained from market data. The fundamental problem is WTP cannot be easily observed when no market or imperfect markets exist. However, a number of techniques are available. One set of techniques seeks to monetise individuals' strength of preference by observing behaviour in markets close to the non-priced amenity assets. These techniques include the travel cost method, discrete choice models, and hedonic pricing. Collectively these techniques may be labelled 'revealed preference techniques'. Another set of techniques utilises individuals' stated preference to determine WTP. These methods, such as contingent valuation and stated preference, depend on some form of direct contact through which individuals state their preference.

It should be noted that the values discussed in this section (and in Appendix 2) are intrinsically additive because they are based on a common assigned value (WTP) and constituency (society as a whole).

4.3 Economic Impact Assessment

4.3.1 Introduction

In the public domain the total expenditure of anglers, and the employment generated through the provision of angling services is often used for advocacy purposes. Unfortunately, in many instances the findings of an impact study are often cited and used inappropriately. This inappropriate use may be deliberate, but may also be simply misguided. Both culpable and innocent misuse is best tackled by ensuring that all sides are familiar with the scope and limitations of impact studies. It is therefore important initially to examine the relevance of angler's expenditure for resource allocation decisions.

[15] The term 'Consumptive' implies a reduction in resource stocks. Fish stocks are renewable, and provided harvest rates are less than the growth rate of the stock the biomass can remain undiminished. Also many fisheries practice catch and release. Angling, of itself, does imply reductions in fish stocks.

It must be emphasised that there is no necessary link between total anglers' expenditure (on fishing rents and permits, accommodation, travel, meals etc.) and the NEV of angling (or paddling), as described above. Should Scottish salmon fisheries became more inaccessible, through road closures, for instance, and anglers' travel expenditure increased, then CSa would decrease. In simple terms, anglers would be paying more, and society's NEV would decrease, because more of society's scarce resources (such as fuel) would now be used by anglers to produce the same recreational experiences. Nevertheless, given the axiom that anglers do not make actual payments greater than their willingness to pay, total anglers' expenditure can be regarded as indicating the lower boundary of GEV.

Anglers' expenditure, of course, may be relevant as a measure of some concept of value other than NEV. In the media, for example, the **value** of an industry is often quoted as the annual total of consumers' spending on its products. Such Figures, however, are really only a measure of *size,* and they do not relate meaningfully to any specific concept of value. Even then, they are total Figures and are, therefore, not very helpful to decision makers. The devotion of even more resources to an industry cannot be justified simply because that industry is already large. It should also be reiterated that expenditure totals are gross measures, and so ignore what is foregone in producing the particular goods rather than some other.

4.3.2 Changes in National and Regional Expenditure

The impact on incomes and employment of changes in anglers' expenditure does, however, warrant consideration, although care is needed in generalising about such impacts.

In assessing the economic impact of angler expenditure, one is effectively seeking to answer the implicit question "What would happen (to income and employment) in region 'X' if angling for 'Y' ceased to exist?" Two key issues arise:

- What would anglers do if angling for 'Y' ceased in region 'X'? How much of their expenditure would be diverted outside region 'X'? (Anglers' Substitution Possibilities)
- What would be the impact on income and employment within region 'X' of the reduction in angler expenditure? (Multiplier Effects)

4.3.3 Anglers' Substitution Possibilities

Anglers will respond in different ways to the loss of a particular type of fishing in a region. Some anglers will spend as much on alternative activities within region. Were all anglers to respond in this way, the cessation of angling for a given fishery type would have little impact on regional income and employment. Alternatively, if anglers diverted their expenditure outside the region, one can argue that angling's contribution to regional income and employment is significant. Practitioners often make the simplifying assumptions that visitors have better substitutes outside the region, whereas local residents have better substitutes within it (see Fisheries Resources Management, 2000). This implies that a region would lose all visitor angler spending, and retain all local angler spending. Thus, researchers employing these assumptions only need to quantify visitor spending.

Obviously, the above assumptions are somewhat crude. The actual substitution possibilities are not always evident, and may only be properly revealed by the anglers themselves. Moreover, substitution possibilities will vary with the size of the region. The smaller the region, for instance, the fewer substitutes there are within it.

4.3.4 Multipliers

The full effect of expenditure diverted by visiting anglers on regional income is typically greater than the magnitude of that expenditure. It comprises direct, indirect and induced effects.

The direct effect is simply the increase in local incomes (wages and self-employment income) and any increase in locally sourced inputs (i.e. additional local output) that arise from the initial angler expenditure. Notice that some expenditures have a minimal initial local impact. For example, only some 5% of spending on petrol in, say, the Borders has a direct effect locally as 95% 'bounces off' through the purchasing of inputs from outside. In contrast, accommodation spending, after VAT has been removed, has a direct effect on the size of the hospitality industry. The composition of angler expenditure is thus important in determining the magnitude of the initial direct effect.

There are indirect effects arising from the direct effect. Specifically, the local impact of producing these additional locally sourced inputs is known as the first round indirect effect. This effect manifests itself in further increase in local incomes (wages and income from self-employment) and further demands by firms for locally produced inputs. The local effect of producing more local inputs creates further rounds of successively smaller indirect effects. The combined impact of the direct effect, and all the rounds of indirect effects are modelled by what is termed 'Type I' multiplier analysis. Among other things, this analysis would calculate the total local output dependent on the fishery, and the total increase in local household income.

Both the direct effect, and every round of indirect effects increases household incomes (wages and income from self employment) and in each spending round a proportion of these are spent on locally produced goods, creating further local income and local output. This is the induced effect**.** 'Type II' multiplier analysis incorporates these induced effects into the analysis, enabling estimation of the corresponding Type II total output effects and the Type II total income effect (termed Type II gross value added).

4.3.5 Employment

Once the (Type I and/or Type II) local incomes or output impacts are calculated, (Type I and/or Type II) local employment can be estimated through known relationships between output and employment, or total wages and employment.

4.3.6 Modelling the Local Economy

The regional impact of angler expenditure will depend on such things as inter-firm linkages within the regional economy, taxation policy, and the proportion of local income normally spent within the region. An important characteristic is the absorption rate – the propensity to purchase locally produced goods. A heavy and homogeneous product, such as building materials, would have a high level of absorption in the local economy, and would be sourced as close to the area as possible if not available locally. In contrast, the 'absorption rate' in financial services would be low relative to cement. These parameters themselves will be dependent on the size of the region. Specifically, the smaller the area, the less likely local business and retailers will purchase locally produced supplies (weak indirect effects). Also, the smaller the area, the less likely local households will purchase locally produced goods (weak induced effects), and a large proportion of the expenditure, notably income tax, employee national insurance and mortgage payments will flow outside the region. Conversely, for large areas, such as Scotland or the UK as a whole, the majority of goods will be sourced within the economy, and the multiplier will be relatively large.

However, it should be noted that the substitution effect increases as the boundaries expand. This is because the larger the region, the more likely one will be able to find substitutes within it. Thus, the larger the region, the greater will be the probability that expenditure Figures will need to be adjusted to capture substitution effects.

4.3.7 Use of Results

It is important to realise that this impact study records the current position. The results presented need to be used sensitively in analysing the effect of changes in the current position. A doubling of the returning salmon stock, for example, will not result in a doubling of the economic impact of salmon angling. Thus, whilst it is interesting to quote that a rod caught salmon currently generates, on average, £x in local income, the causal chain between salmon stocks and output, income and employment is complex and not linear. Given this, crude averages need to be used with care.

As outlined, the current size of the economic impact cannot be directly used as an argument for additional resources to be devoted to it. What is important is the magnitude of change that additional resources will induce, not the overall size.

5 The Economic Impact of Widespread GS Infestation

5.1 Introduction

Given the 'no policy' option – no eradication and/or containment measures after Gs introduction – it is assumed the parasite would become widespread throughout Scotland. Potential loss of income and employment could follow through effects on:

- Salmon angling,
- Salmon aquaculture,
- Trade in live salmon products,
- The trout industry,
- Other salmonids,
- 'Put and take' fisheries.

These potential impacts are discussed in turn below.

5.2 Salmon Angling

Some 380 rivers around Scotland contain salmon (Section 2.4). Their geographical characteristics provide an ideal playground for both anglers and water sports enthusiasts.

The great rivers – Tweed, Forth, Tay, Dee, and Spey – flow eastwards over substantial distances. The Clyde, an exception, owes its westerly flow to glacial scouring of the Clyde Basin. More typically, the west coast is characterised by long lochs and short, steep rivers. In several instances, long, deep freshwater lochs have developed following blockage of sea lochs by glacial moraine (for example, Lochs Lomond, Shiel, and Awe). In the central highlands, glaciation has led to sizeable lochs as part of the river system (for example, Loch Tay). Lastly, abundant rainfall keeps the major rivers full[16].

The working assumption of the 'no policy' option is that extensive mortality over time would make Atlantic salmon angling unviable in all 380 rivers. However, although Gs can infest other species, because there is no discernable increase in their mortality, then rainbow trout, brown trout, coarse fish, grayling, and, in particular, sea trout would all still be available, (Section 2.4).

In consequence, current salmon angler expenditure would switch to both angling and non-angling substitute activities. Such expenditure switching would result in loss of income and employment in some regions, with gains elsewhere. Hence, the research needs to identify current angler expenditure, the substitution effects, and the eventual impacts on income and employment (discussed in detail in Section 4).

Detailed information on the level of Scottish angling activity and its economic impact is provided by Radford *et al.* (2004). Fortunately, the study provides a basis for estimation of the impact of Gs on Scottish income and employment. Its key features and findings are

[16] Shorter West Coast rivers with rapid run-off characteristics are more variable.

presented below, together with our amendments to reflect the consequences of a widespread Gs infestation.

5.2.1 Radford et al. (2004)

The study assessed the economic contribution of four types of angling (salmon and sea trout, brown trout, rainbow trout and coarse) to the main Scottish regions[17]. Total angler days, average expenditure per day, and total expenditure across all forms of coarse and game angling in Scotland are summarised in Table 5.1. Anglers are also separately identified as: local from within a region, visitors to a region from elsewhere in Scotland, and visitors from outside Scotland.

Table 5.1 Angler Days and Expenditure in Scotland

Species	Origin of Anglers	Angler Days	Spend Per Day (£)	Expenditure (£)
Salmon and Sea Trout	Local	212,441	80	16,959,273
	Elsewhere in Scotland	76,395	101	7,748,359
	Outside Scotland	256,212	190	48,780,861
	Total	545,048	135	73,488,493

Source: Radford *et al.* (2004)

A total of 545,048 salmon and sea trout angler days accounted for an expenditure of £73.49m. The models of regional economies[18] used by Radford *et al*. can provide estimates, at both National and Regional levels, of the impact of angler expenditure should a fishery type cease to exist **in a particular region**. Given this, the Radford substitution analysis examined angler response to closure of a fishery type in a region.

The Radford survey did not allow generation of data on angler reactions to the closure of a complete fishery type, nor to closure of all fisheries, across the **whole of Scotland**. Therefore, estimation of such Scottish level impacts had to rely on assumptions about, and distinctions between, locals and visitors to Scotland.

In Table 5.2, the first row illustrates what might happen if:

- All salmon and sea trout visiting anglers stopped coming to Scotland because they cannot fish their desired region/fishery combination,
- All Scottish salmon and sea trout anglers continue to fish elsewhere in Scotland.

Loss of salmon and sea trout angling would lead to a reduction of £36.2m of Scottish household income through combined impact of the direct, indirect and induced effects (Table 5.2).

[17] The regions were Dumfries and Galloway, Borders, Central, Orkney and Shetland, Western Isles, North East, Highlands

[18] Developed by *CogentSI Ltd, Killylung, Dumfries, DG2 0RL, Scotland* for the Radford (2004) study for the seven regions outlined in the footnote above.

Table 5.2 Scottish Income Lost (£'000)

Visitors Only Lost	36,212
Visitors Plus 50% Scottish Travellers	44,893

Source: Radford *et al.* (2004)

However, it is perhaps unreasonable to assume all Scottish anglers would continue to fish in Scotland. Thus, the second row of Table 5.2 illustrates what might happen if:

- All visitors stop coming to Scotland because they cannot fish their desired region/fishery combination,
- 50% of Scottish anglers who travel to other Scottish regions will fish outside Scotland, and their expenditure will be lost.

This gives a total impact on income in Scotland of £44.9m from the loss of salmon and sea trout angling.

Table 5.3 gives the impact on employment, measured in Full Time Equivalents (FTE), under the same assumptions.

Table 5.3 Impact on Scottish Employment (FTE)

Visitors Only Lost	2,033
Visitors Plus 50% Scottish Travellers	2,200

Source: Radford *et al.* (2004)

Given the assumptions on loss of visitors and Scottish travellers outlined above, the best estimate of the potential loss of FTEs associated with coarse and game angling is between 2,449 and 2,786, with salmon and sea trout angling accounting for between 2000 and 2,200. For reasons outlined below, the Radford estimates represent the upper boundary of the economic impact of Gs.

5.2.2 Required Amendments to the Radford Estimates

For the purposes of our analysis, the Radford study presents two problems:

(i) Estimates of the impact on output, income and employment relate to both salmon and sea trout, and thus over-estimate the impact of Gs, which causes losses only to salmon. Therefore some additional primary data from anglers were needed to identify the number of angler days devoted to sea trout, and the extent to which expenditure patterns differ between salmon and sea trout.

In addition, the substitution analysis did not allow for the possibility of salmon anglers switching to sea trout with the demise of salmon angling. Given that some anglers would switch to sea trout in Scotland, the Scottish economy would lose less expenditure, output, income and FTEs. Therefore, additional primary data were needed to assess the substitution possibilities specific to the Gs scenario.

The WTP survey of anglers (reported in Section 6) provided the opportunity to generate data on the proportion of salmon days within the total salmon and sea trout days estimated in the Radford study. The same survey addressed the response of anglers if salmon fishing across the whole of Scotland was lost through Gs infestation. Thus, it was possible to avoid making assumptions about the Scottish level substitutions outlined in Section 5.2 above. Specifically, we could allow for the possibility that salmon anglers (both Scottish and visitors) would switch to sea trout fishing in Scotland.

5.2.3 Economic Impact of Lost Salmon Angling

The effect of subtracting sea trout fishing from the salmon and sea trout estimates recorded by Radford *et al*. is shown in Table 5.4. The number of angler days is reduced to 85.7% of the previous total while expenditure is reduced to 89.1%.

Table 5.4 Amended Angler Days and Expenditure

	Spend Per Day (£)	Percent of Days	Percent of Expenditure	Expenditure (£m)
Salmon	158.50	85.7%	89.1%	61.65
Sea Trout	71.49	14.3%	10.9%	11.84
Total	135.00	100.0%	100.0%	73.49

The implications of these adjustments for household income and employment, measured in FTEs, are given in Table 5.5.

Table 5.5 Estimated Lost Income and Employment (before substitution)

	Income (£m)	Employment (FTE)
Salmon	47.7	2,723
Sea Trout	5.9	335
Total	53.6	3,058

The WTP survey asked anglers about their intended substitute activity should Gs eradicate salmon throughout Scotland but leave sea trout populations largely unaffected. As explained above, we dispense with the assumptions required in the Radford study. The responses are summarised in Table 5.6. Assuming visitors will undertake their other activities outside Scotland whereas Scots will undertake theirs within Scotland, we would lose 70% of visitor days and 14.63% of Scottish Visitor Days.

Table 5.6 Substitute Activities

	Visiting Anglers (%)	Scottish Anglers (%)
Fished for Sea Trout in Scotland	10.00	23.58
Fished Outside of Scotland	10.00	14.63
Fished for Other Species in Scotland	20.00	45.53
Engaged in Other Activities	60.00	16.26
Total	100	100

Details of substitute days not lost are given in Table 5.7.

Table 5.7 Substitution Effects

Substitute Activity Retaining Expenditure	Number of Days	Spend per Day (£)	Expenditure Retained (£)
Scottish Anglers Fishing for Sea Trout	48,594	45.32	2,202,289
Visitors Fishing for Sea Trout	20,986	118.12	2,478,913
Scottish Anglers Fishing for Other Species	41,973	116.24	4,879,084
Visitors Fishing other Species	93,837	39.73	3,728,413
Scottish Anglers Engaging in Other Activity			3,595,800
Total	20,5390	84.26	16,884,500

The estimation of the £3.595m expenditure by Scottish anglers engaging in other activity is as follows:

From Table 5.1, Scottish anglers' spending on salmon and sea trout is £24.707m (£16.959m by locals and £7.748m by other Scots). Of this, 89.1%[19] (£22.114m) is on salmon angling (see Table 5.4). Based on Table 5.6, we draw the inference that 16.26% (£3.595m) of this £22.114m will be retained in Scotland.

Expenditure-income and expenditure-employment relationships of substitute activities are assumed to be similar to those for salmon angling.

Table 5.8 Estimated Lost Expenditure, Income and Employment (after substitution)

	Expenditure (£m)	Expenditure Retained (£m)	Expenditure Lost (£m)	Lost Income (£m)	Lost Employment (FTE)
Salmon	61.65	16.88	44.77	34.45	1,966

The best estimate of the impact of the demise of salmon angling on the Scottish economy is that, after allowing for substitution, we would lose 1,966 FTEs and an added value (income) of some £34.5m.

[19] The unrounded figure used in the calculation is 89.50345%

5.3 Economic Impact on Salmon Aquaculture

The direct impact of widespread Gs infestation would be on the freshwater producers of salmon ova, fry and smolts (discussed in Section 2.5). Most of the current production sites (276 registered, 183 active and 172 commercially producing) would be vulnerable to Gs infestation if their supply rivers were infected. Formalin treatments could mitigate direct losses. However, movement restrictions and continual re-infection through untreated water supply would most likely close them down.

In 2004, of a total of 319 staff employed in freshwater salmon production (FRS, 2005), 259 were full time and 60 part time. Production of ova in 2004 was almost 129m (worth at least £6.5m), whilst smolt production was just under 40m (worth at least £28m). The direct impact of Gs on the industry would depend on the geographic extent of infestation and, if localised, the key areas affected. The most sensitive region would be North West Scotland, followed by West of Scotland, and then the Western Isles (Figure 5.1)

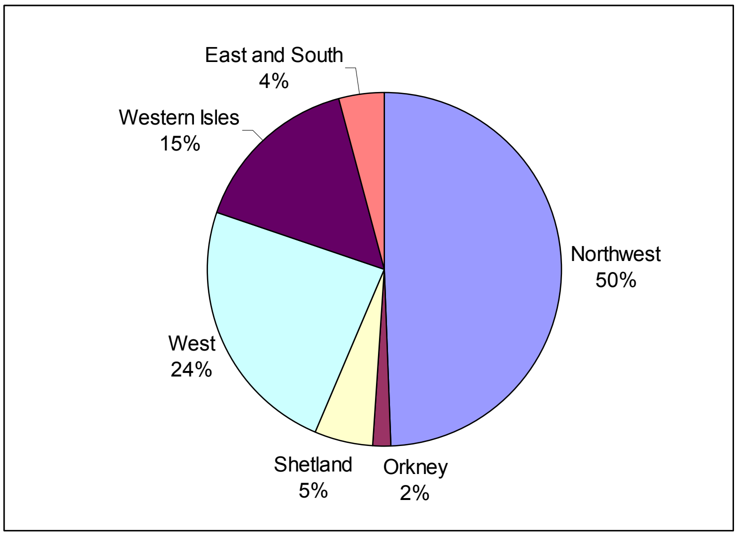

Figure 5.1 Geographic Distribution of Scottish Salmon Smolt Production
(Source: FRS 2005)

Trade between companies incurs a risk of disease transfer, but also provides some resilience against localised losses. Around 44% of the ova laid down to hatch are from companies' own broodstock; 28% are purchased from other ova producers in the UK; and 27% are from overseas (the remaining 1% from wild broodstock are usually hatched as a contribution to local salmon enhancement schemes).

Given only about 5% of production is currently considered biosecure, the vast majority of current freshwater production systems would be vulnerable if Gs infestation became widespread relatively suddenly. A more limited Gs distribution would present a worst case scenario in which, perhaps, up to 50% of the freshwater production sites would have to close.

The impact of a 50% closure of freshwater salmon facilities would be:

- Approximately 160 direct job losses,
- Approximately £14-20m in lost smolt production,
- Potential knock-on effect of a 25% reduction in salmon production. This would represent a combined loss of around £150m in primary production and processing, and the loss of around 2000 FTEs.

However, reduced production would be mitigated if smolts could be imported from Ireland or perhaps Norway. The rate of investment in biosecure production facilities by the industry would also be ameliorative.

In Scotland, the long-term economic impact of widespread infestation on salmon aquaculture would mainly be determined by the number of biosecure units, and also by their ability to expand production to substitute the stock from units destroyed by Gs.

The worst case scenario could mean not only closure of 50% of nurseries, but also a substantial number of marginal fish farms unable to obtain smolts at a price essential for a viable enterprise. In this event, all the associated local expenditure and its multiplier effects would need to be evaluated.

However, the capital intensity of smolt production, and the economic benefits of biosecure systems suggest that, with encouragement, the whole industry could become biosecure. This in turn would provide security for the seawater farms. Depending on the size of each unit, the estimated cost for developing biosecure tank-based production units for 40m smolts is between £30 and £40m, assuming some re-use can be made of existing facilities. Therefore, we have not evaluated the impact further – although we note that it would encourage further consolidation within the industry, as the more marginal companies would be less likely to find the necessary funds for investment.

5.4 Economic Impact on Exports of Live Salmon Products

Loss of Gs free status would prevent the export of live fish products outside Scotland, except to other infected regions. Whilst young salmon (fry or parr) are often moved between freshwater hatchery facilities, it is uncommon for them to be traded internationally, and no such trade is recorded in the FRS Figures. Similarly, FRS do not record any exports of salmon smolts, which, in any case, would be from fresh to saltwater and therefore of less concern.

The salmon industry exported 5.9m ova in 2004 – an increase of 3.7m over 2003 (FRS, 2004). The value of this trade is estimated to be in the region of £400,000 - £450,000. Chile is likely to have been the major importer, but some may have gone to Ireland and possibly other countries. It is likely that only two or three companies are significant exporters of ova. The fact that Scotland is a net importer of ova (by around 11m in 2004) suggests Scottish purchasers may be able to find alternative sellers.

Overall, therefore, if the whole of Scotland was designated an infected zone, the impact would be relatively small. Should only parts of the West Coast, or Western Isles be designated as infected the impact could be greater, affecting the significant movement of ova between different regions – particularly between Shetland, Mainland, and Western Isles.

However, providing smolt movements (from freshwater to seawater) were not restricted, the impact on industry should not be severe.

5.5 The Trout Industry

5.5.1 Potential Loss of Export Markets for Live Fish

The Scottish trout industry is considerably more reliant on imported ova than the salmon industry. It used 31.6m imported ova in 2004 compared with only 0.6m from within the UK. Therefore, a ban on trout ova exports might be expected to have minimal effect.

Trade in trout fry and fingerlings is considerable, involving purchases from, and sales to England, Wales and Northern Ireland. Overall, Scotland is marginally a net importer – in 2004, 20.75m were purchased compared with 19.17m sold. Thus it is suggested Scottish producers may be able to concentrate on home markets if export opportunities were denied. However, this inference is somewhat simplistic because a variety of trout fry and fingerlings are produced (species, sizes, single-sex, diploid, triploid and coloured varieties etc.). In practice, if Scotland could continue to import fry and fingerlings from other regions of the UK, but was unable to export, then a small number of specialist hatchery companies and some growers of restocking fish may be severely affected. However, the FRS and CEFAS[20] statistics are not sufficiently disaggregated to evaluate this impact.

5.5.2 Impact of the Disease on Production

Around 17% of rainbow trout production in Scotland is in seawater cages. The remainder in freshwater uses cages, ponds, tanks and raceways. Few, if any, of these facilities are biosecure and would, therefore, be susceptible to some degree.

FRS records for 2004 show 38 companies produced rainbow trout from 62 sites. Further, a total of 6,353 tonnes of table trout was produced, and 936 tonnes of rainbow trout sold for restocking in 2004 (worth approximately £2m). In FRS statistics, brown trout production for restocking is aggregated with brown and sea trout production for the table, giving some 167 tonnes in 2004, and involving 29 companies at 45 sites. The overlap between rainbow trout and brown trout producers is not clear. A minimum of 152 FTEs is involved in trout production (115 full-time and 37 part-time farming rainbow trout), with perhaps a further 50 involved in brown/sea trout farming.

Data from other countries suggest that brown trout are little affected by Gs. Rainbow trout may be somewhat more susceptible in certain circumstances but, overall, it appears unlikely many trout farms would suffer significant mortalities from Gs. Other impacts would follow any movement controls that might be implemented.

5.6 Other salmonids

In 2004, five companies farmed Arctic Charr at a total of eight sites, with a production of 3.25 tonnes (FRS, 2005). The industry appears to be self-sufficient in ova, and is unlikely to have significant exports.

[20] Centre for Environment, Fisheries & Aquaculture Science

5.7 *Put and Take Fisheries*

There are around 287 put-and-take trout fisheries in Scotland (Walker 2002). They are often created in gravel pits, or other water bodies with relatively limited water exchange with the wider catchment, and, generally, are not allowed in river systems with valuable wild salmonid populations. Whilst rainbow trout are not adversely affected by Gs, restrictions may have an impact if the parasite was found in or near the fisheries. However, should Gs be widespread throughout Scotland, no purpose would be served by imposing such restrictions, and 'put-and-take' trout fisheries would remain unaffected.

5.8 *Overview of the Economic Impact on Scotland of Gs*

A summary of the discussion in Section 5 is presented in Table 5.9.

Table 5.9 Overview of Impacts

Activity	Best Case Scenario	Worst Case Scenario
Salmon Angling	Destroyed	Destroyed
Other Angling	Slight Increase	Slight Increase
Smolt Production	All Units Biosecure	50-95% Destroyed
Farmed Salmon Production	None	Marginal Units Affected
Export of Live Salmon Products	Minimal Effect	Minimal Effect
Trout Exports	Net Importer (Minimal Effect)	Net Importer (Minimal Effect)
Trout & Charr Production	Minimal	Minimal
Put and Take Fisheries	Minimal	Minimal

Given appropriate precautions, it would appear the effects of Gs can be limited to salmon angling. However, the economic impact of losing salmon angling would be substantial, with an **annual loss of household income of £34.5m and a loss of 1966 FTEs**.

6 The Loss of *Net Economic Value* from Widespread Gs Infestation

6.1 Introduction

Where Gs infection did occur and there was no attempt to eradicate and/or contain it (the 'policy off' option), the resulting widespread infestation would wipe out Scottish salmon stocks and salmon angling in Scotland. This section considers the impact on Net Economic Value (NEV) of this scenario.

As outlined in Section 4, the NEV arising from salmon angling can be estimated from the following sum:

Economic Rent (ER) + Consumers' Surplus of anglers (CSa) + Existence Value of angling (EVa) + Bequest Value of angling (BVa) + Option Value of Angling (OVa).

A capitalised value for ER can be obtained from the market value of fishing rights. If CSa is estimated through contingent valuation (see below), this procedure captures the EVa, BVa and OVa of the anglers. This process would not capture the Eva, BVa and OVa of the non-angling general public. The estimation of general public values would involve a research effort beyond the scope of this study. The NEV associated with fish stocks involves the following summation:

Passive Use Value of stocks (PUVs) + Passive Indirect Use Value of stocks (PIUVs) + Existence Value of passive use (EVpu) + Bequest Value of passive use (BVpu) + Option Value of passive use (OVpu) + Existence Value of stocks (EVs)[21].

It is probably the case that EVs is the only dimension of fish stocks' NEV that is worth estimating. This would involve an extensive survey of the general public, and is also beyond the scope of this study. As a result of being unable to survey the general public, our estimates of lost NEV attributable to Gs are an underestimate of the true loss. It is undoubtedly the case that the general public in Scotland would not be indifferent to the loss of salmon stocks as other research work in this area confirms.

Given the above discussion, this project seeks to estimate the components of NEV outlined below.

(i) Economic Rent (ER)
(ii) Consumers Surplus of anglers (CSa)
(iii) anglers' Existence Value of angling (aEVa)
(iv) anglers' Bequest Value of angling (aBVa)
(v) anglers Option Value of angling (aOVa)
(vi) anglers Existence Value of stocks (aEVs)

The estimation of Economic Rent is a relatively simple process that provides very significant insights into the magnitude of NEV that could be lost through a widespread Gs infestation.

[21] See Appendix 2 for a discussion of use value, passive use value, existence value, bequest value and option value as they apply to angling and fish stocks.

The estimation of anglers' WTP for (CSa, aEVa, aBVa, aOVa, aEVs) is much more problematic. We employ the Contingent Valuation Method (CVM), which provides an estimate of the sum (CSa, aEVa, aBVa, aOVa and aEVs). We also seek to estimate CSa through the use of the Travel Cost Method (TCM).

6.2 Estimation of Lost Economic Rent

Economic Rent is part of the TEV captured by the resource owners who own the right to receive a net income flow by letting their fishing (outlined in Section 4). Whether or not owners choose to let their fishing, an actual or potential income flow is available to them, and the rights to this flow can be bought and sold in the market. The market value of fishing rights represents a capitalisation of the potential net income from those rights. Given this, there are two routes to estimating the Economic Rent. We can obtain a capitalised value from observing the sale of salmon and sea trout fishing rights in the open market. Alternatively, we can estimate owners' net income flow by analysing angler expenditure on fishing permits. These two methods are presented below.

6.2.1 Telephone Survey of Estate Agents

The first approach is by examining the capitalised value when sold. A 'rule of thumb' is that the value of a fishery in any current year is the product of the average catch over the previous five years and a value per fish. Theoretically, each individual fishery would have a per salmon value that reflected the particular characteristics of the fishery, such as scenic quality, reputation, number of named pools, number of rods access etc. For each of the three scenarios, we sought to calculate the market value by multiplying the five year catch of salmon and sea trout by an appropriate per capita value. Catch statistics are readily available, and are believed to be reasonably reliable. The per capita value is less reliable, and is not available from easily accessed secondary sources. With a limited number of very different estates coming on to the market, it is not possible to obtain enough information from tracking sales of fishing rights to make reliable generalisations about market values.

A telephone survey was undertaken of all land and estate agents who advise on sporting estate valuations. Agents from *Savills*, *Bidwells*, *Smith Gore,* and *Strutt and Parker* were contacted. They provided very consistent information. All agents stated that a figure of £2,000 to £3,000 per fish would be a low value, perhaps appropriate for a small West Coast river that fished for a couple of months at the back end of the season. At the other end of the scale, the best fisheries on, say, the Spey could command £8,000 to £10,000 per fish. For Scotland as a whole, it was considered £5,000 to £5,500 per fish would represent a suitable mean value. All agents emphasised that this was a generalisation, and the Standard Error of estimates predicated on these values could be relatively large. Sea trout capital values would be a quarter to one third of salmon values.

Salmon and sea trout catches for 2004 are given in the Table 6.1.

Given the catches in the table, and applying the value of £5,500 per salmon, the capital value of Scotland's salmon fisheries is **£511.05m**. Applying a per capita sea trout value of £1650 would add a further **£42.67m**, producing a total value for Scottish salmon and sea trout fishing rights of **£553.72m.**

Table 6.1 Scotland Salmon, Grilse and Sea Trout Catches 2004

	Salmon	Grilse	Salmon and Grilse	Sea Trout
Retained	28,555	18,114	46,669	15,596
Released	31,068	15,181	46,249	10,264
Total	59,623	33,295	92,918	25,860

To convert a capitalised value into an equivalent annual flow, we need to identify an expected real rate of return. Salmon fishing rights provide a relatively low net annual income flow to the owners. The annual income flow represents about 3% of the capital value. Indeed, the current real interest rate for 'cachet' property is around 3% (3.5% is the real mortgage rate for householders). Using the 3% rate of return, an annual flow over infinite time is converted to a capital value by multiplying by a factor of 33. Similarly, we convert a capital value to an annual value by dividing by 33[22]. Table 6.2 presents our estimate of annual and capitalised Economic Rent as estimated from market data.

Table 6.2 Capital and Annual Value of Economic Rent from Market Data

Economic Rent	Salmon (£)	Sea Trout (£)	Total (£)
Capital Value	511.05m	42.67m	553.72m
Annual Value	15.49m	1.29m	16.78m

6.2.2 The Rents Per Day Paid by Anglers

The second approach is to utilise data from Radford *et al.* (2004) concerning the average total rents anglers pay (as part of their expenditure). We also have details from a survey of owners, of the percentage distribution of the total rent to different end points (such as VAT, wages and maintenance).

In 2004, the average total daily permit charge was £91.00, and the owner retained just less than 40% of this. The remainder was spent on VAT, wages and maintenance. Combining the two, we obtain an economic rent of **£36 per angler day**. If we multiply this by 545,048 salmon angler days (see Table 5.1), the annual flow would be **£19.62m**. Assuming the 3% return, this would capitalise to **£647.46m.** This is reasonably close to the capital value estimated from the survey of agents (£553.72m). Table 6.3 has been constructed with the assumption that the relative contributions of salmon and sea trout are similar to those revealed in the market for fishing rights

The two different approaches have given us figures for the capitalised value of economic rent of **£511.05m** and **£597.57m**, respectively. From this, we will take **£550m** to be our estimate of the capitalized value of Economic Rent. This translates into an annual flow value of **£16.5m**.

[22] Appendix 3 provides a discussion of the justification of this.

Table 6.3 Capital and Annual Value of Economic Rent from Angler Expenditure Data

Economic Rent	Salmon (£)	Sea Trout (£)	Total (£)
Capital Value	597.57m	49.89m	647.46m
Annual Value	18.11m	1.51m	19.62m

6.2.3 The Pricing of Labour in NEV Calculations: A Note

Angling provides a significant number of skilled FTEs in an environmentally friendly and sustainable industry. It would appear obvious that these FTEs are important to the local community, and the community will be worse off if they are lost. Economic impact analysis, as outlined in Section 4, seeks to assess these local effects. In this Section, we are concerned with the treatment of labour within the TEV/CBA framework, which, as explained earlier, is predicated on a different set of value judgements.

The treatment of labour in NEV calculations is not always straightforward. Society's NEV derived from salmon angling is the anglers' WTP for all aspects of the whole recreational experience (from planning the trip through to reflection) minus the Opportunity Cost of all the resources they use (ghillies' services, food and drink purchased, travel accommodation etc.). Normally, we use the market value of the resources used (in particular wages) to represent Opportunity Cost. It is distinctly possible that wages exceed the Opportunity Cost, and that significant training activity (often undertaken at considerable cost by local enterprise companies) would be required before an individual is able to produce work of equivalent value. The evidence suggests that re-employment is not instantaneous (see for example, Boheim & Taylor 2000) and, indeed, some who lose their FTEs would never work again. In Appendix 4, we have analysed these issues and present estimates of the extent to which we may have over-estimated Opportunity Cost (i.e. under-estimated the economic rent component of NEV).

6.3 Estimation of Consumers' Surplus

This is the most difficult aspect of the estimation of the loss in NEV, and the literature highlights problems with any method that is used to estimate Consumers' Surplus. Given this, we employed two techniques to provide a measure of reassurance with respect to the order of magnitude of Consumers' Surplus. The first method was based on utilising data generated by previous studies (Radford, *et al*., 2004 and Riddington, *et al*., 2004). This data was used in an application of TCM to estimate a demand function. From this demand function, we estimated Consumers' Surplus. A second set of estimates was derived from a contingent valuation exercise based on postal and telephone surveys of anglers.

It should be noted that we know neither the total number of anglers fishing in individual rivers/catchments/regions nor, indeed, in Scotland as a whole. Therefore, there is little point in seeking to estimate Consumers' Surplus per angler. The only scaling factor available is the number of angler days, as reported in Radford *et al*. (2004). Accordingly, both techniques seek to estimate Consumers' Surplus per angler day.

6.3.1 The Contingent Valuation Method

The contingent valuation method (CVM) is used extensively to estimate changes in NEV, and can be used to estimate change in both use and non-use components of NEV. It is called 'contingent' valuation because individuals are asked to state their WTP, **contingent** on a specific change occurring. The fact that CVM is based on what people say they would do means that it can be applied to a great variety of situations. However, it is controversial since it is not based on what people are observed to do. Indeed, some economists doubt the validity of CVM estimates, and policy-makers can be reluctant to accept the results of CVM studies.

Estimates derived from CVM surveys are often highly sensitive to what people believe they are being asked to value, as well as the context that is described in the survey. Thus, it is essential to clearly define the services and the context, and to demonstrate that respondents are actually stating their WTP for these when they answer the valuation questions. Contingent valuation questions must focus on a clearly defined change in environmental quality, and a context that is clearly specified and understood by survey respondents. CVM also assumes that people will reveal their preferences in the contingent market just as they would in a real market. However, the general public are unfamiliar with placing values on environmental goods and services, and may not have an adequate basis for stating their true WTP. Some researchers also argue that there is a fundamental difference in the way that people make hypothetical decisions relative to the way they make actual decisions. For example, respondents may fail to take questions seriously because they will not actually be required to pay the stated amount, and may declare unrealistically high WTP values if they believe they will not actually have to pay.

Given the above, CVM is probably most controversial when seeking to assess the non-use WTP (for example, Existence Value) of the general public for a change in an unfamiliar environmental asset in situations where they believe they will not be required to pay. In this type of situation, the survey instrument (mail, telephone or personal interview) has to bear the burden of describing the asset itself and the contingent change. Some individuals may need information on the location and characteristics of the site, the uniqueness of species, whether the species exists elsewhere and so on. In some cases, visual aids such as colour photographs may be presented to help the general public understand the conditions of the scenario that they are being asked to value. If, for example, the context was a proposed afforestation scheme that would compromise salmon stocks, the researchers would also want to learn about peoples' knowledge of forestation, and whether this is a controversial issue for them. If people are opposed to an afforestation development, they may answer the valuation questions with this in mind, rather than expressing their value of salmon stocks.

At the tendering stage, it was agreed the study could not embrace any of the general public WTP relating to salmon angling or salmon stocks. This resulting exclusive focus on the WTP of anglers relieves many of the usual pressures on the CVM survey. This is because we are dealing with a population of users who can easily appreciate the loss they would experience if they were deprived of their sport. Moreover, the Gs problem is well known and understood within the angling community at large. It should also be appreciated that anglers regularly pay for their angling, and are, therefore, highly experienced in assessing the trade-off between their WTP and the pleasure they obtain from angling. Given their purchasing experience, their stated WTP is, therefore, more likely to reflect their true WTP. Additionally, there is a possibility that a levy could be imposed on anglers to help defray the costs of Gs prevention, containment and/or eradication.

Therefore, in many respects, our efforts to estimate the anglers' Consumers' Surplus should be less problematic than other applications of CVM. In any instance, a CVM survey must be properly designed, pre-tested and implemented in order to provide meaningful results. The basic characteristics of the CVM elements of the study are described below.

6.3.1.1 The Anglers' Postal Survey

A web-based survey that is completed on-line is the only survey instrument able to generate the required number of observations. There are practical reasons for reliance on a Web survey. In Scotland, we do not have access to anglers' names, address and/or telephone numbers and this precludes extensive postal or telephone survey work. Budget and time constraints did not allow for river bank face to face interviews. In addition, we were hoping to obtain responses from specific areas (the Luce and the Spey) to enable estimation of the costs of containment and eradication measures. Unfortunately, the on-line questionnaire does not enable reliable targeting of such particular regions. However, local contacts in these areas agreed to distribute a postal version of the questionnaire. The postal survey has two functions:

a) testing of the CVM questions relating to CSa, and
b) the provision of information on anglers CSa on the Spey and the Luce.

The Spey questionnaire was mailed first, and the Luce mailing was held back in the event of changes being required (which, in turn, would need to be re-tested).

6.3.1.2 The Anglers' Postal Questionnaire[23]

Part (a) of the questionnaire establishes individuals' substitution possibilities in the event of Gs infestations, both with respect to Gs infestation in Spey and Luce areas, and Scotland as a whole. Part (b) establishes the individual's actual daily expenditure on salmon angling. Again a distinction is made between spending in the local area and spending across the whole of Scotland. By the end of part (b), respondents will be aware of the consequences of Gs infestation, will have reflected on their substitution possibilities, and will have been reminded of their daily spending on salmon angling.

Part (c) then seeks to establish angler's residual consumer surplus though a contingent valuation scenario. Respondents were invited initially to consider whether they would, in principle, be willing to pay any amount, however small. Those anglers declaring that they were unwilling, in principle, to contribute anything were directed to a question that seeks to establish whether these were genuine zero WTP bids, or were protest/irrational responses[24]. Those declaring a WTP in principle were presented with a question designed to encourage them to reflect on CSa, aEVa, aBVa, aOVa, EVs. They were then presented with the contingent valuation scenarios.

6.3.1.3 The Telephone Survey

Respondents were requested to provide telephone details to enable us to conduct follow up interviews to check, as far as possible, that their declared WTP reflected their true valuation.

[23] Copies of the questionnaires for the Spey and the Luce can be found in Appendices 6 and 7 respectively.
[24] See Appendices 6 and 7 for further details.

In some circumstances, it was necessary to question respondents whose responses were seemingly irrational.

Two particular problems were investigated. Firstly, some respondents declared a WTP to prevent an infestation of the Spey that was greater than their WTP to prevent an infestation across the whole of Scotland including the Spey. This is clearly irrational, and required investigation. Secondly, some respondents declared a WTP for the Spey that was identical to their WTP to preserve the whole of Scotland. This is rational for anglers who only fish the Spey, but not for anglers who fish the Spey and elsewhere. Similarly, anglers who declare they would fish for salmon elsewhere if Spey salmon angling ceased to exist should declare a higher WTP to protect the whole of Scotland (i.e. the Spey and their substitute salmon angling) than just the River Spey. It appears that the ordering of questions was the main problem, with respondents implicitly assuming the Scottish WTP was **in addition** to what they would be WTP for the Spey.

In the Luce questionnaire, the ordering was changed with the 'all Scotland' scenario being presented first and then the Luce infestation. This seems to have corrected the problem, and telephone follow up of the Luce responses confirmed this.

6.3.1.4 Consumers' Surplus Per Day: the Spey and the Luce

Table 6.4 below presents the results from the mail and telephone follow up of Spey and Luce anglers. Given the magnitude of angler spending and economic rent per day of over £30, these values are less than anticipated. There are a number of reasons for this. First, we may have failed to appreciate the extent to which fishery owners have been able to capture much of the anglers' Consumers' Surplus through discriminatory pricing. Second, at the initial stage of the study, the reliability of estimates may have been compromised through the relatively small numbers of respondents.

Table 6.4 Consumers' Surplus (CS) Per Day (Spey and Luce anglers)

	Respondents	CS for Spey or Luce Salmon Angling (£)	CS for all Scotland's Salmon Fisheries (£)
Spey	37	8.89	10.77
Luce	18	2.11	2.56

Apart from the relatively low magnitudes, the responses are not irrational in the sense that anglers are WTP more to preserve salmon angling across the whole of Scotland than to preserve salmon angling on just the Luce, or just the Spey.

6.3.1.5 Web-Based Questionnaire and Telephone Follow Up

As stated above, the mail surveys were aimed at providing information specific to the Spey and the Luce, as well as information on WTP to preserve Scotland's Gs free status. A web-based questionnaire was developed using SNAP software[25] and loaded to a server in Glasgow Caledonian University. The hot link to the questionnaire was disseminated through

[25] Snap Survey Software is a powerful, intuitive Windows-based program for questionnaire design, publishing, data collection and analysis and supports all survey modes (Web, E-mail, Paper, Kiosk, Phone, PDA, Scanning, Tablet PC).

angling clubs and angling web sites. The questionnaire itself was identical in almost all respects to the paper versions used on the Spey and the Luce.

After removal of protest votes, a total of 95 useable responses were received from the web-based questionnaire. This is a disappointing response, and in the circumstances may compromise the reliability of the estimates derived. A further, and possibly related issue, is that preliminary analysis revealed anglers' declared WTP to be lower than expected, though these were generally confirming the orders of magnitude revealed on the Spey and the Luce. It was decided to use the telephone follow up stage to ensure that anglers were aware of the relatively low values declared for Consumers' Surplus. Anglers were first asked to confirm their WTP. They were then informed of their WTP as a percentage of their total spending, and then asked to confirm that they were content with the relative magnitudes. Very few of the anglers wanted to increase their declared WTP, and those who did made only marginal adjustments. Thus, while there are relatively few responses, there is consistency between survey instruments, and the individuals stated values appear to be robust when subject to further investigation.

Combining the responses from all survey instruments, we obtained Table 6.5, which provides estimates of the Consumers' Surplus for the whole of Scotland. Separate estimates are produced for Scottish anglers (£4.39 per day) and anglers visiting Scotland (£6.41 per day). In Section 5.2.3, it was estimated that of the 545,048 salmon and sea trout angler days, 467,106 were salmon angler days.

Table 6.5 Annual and Capitalised Consumer Surplus for Scotland

	CS per Day (£)	Annual Angler Days	Annual CS (£)	Capitalised CS (£m)
Visitor	6.41	219,574	1,407,469	46.92
Scot	4.39	247,532	1,086,665	36.22
Total	5.34	467,106	**2.49m**	**83.14**

In conclusion, the total number of salmon (as opposed to salmonid) angler days is estimated to be 467,106 giving a total surplus of **£2.49m per annum**. The associated capital value is **£83.14m.**

6.3.2 The Travel Cost Method (TCM)[26]

Estimates of the demand function for salmon angling were obtained using data from Radford (2004). Table 6.6 shows the resulting Consumers' Surplus using the TCM for Scotland as a whole, the Spey catchment and the Luce, together with the implied mean consumer surplus per day.

These figures derive from an estimation procedure, which does not take into account the existence of substitute fishing being available to anglers. Using this version of TCM, it is necessary to subtract the Consumers' Surplus associated with the next best alternative, from the estimated Consumers' Surplus. Unfortunately, data was not available to complete this stage of the process and the estimates in above table should be regarded as the upper

[26] Appendix 5 outlines the TCM method, the estimation process and results.

boundary of Consumers' Surplus. Throughout this study we rely on the more conservative estimates generated by the CVM.

Table 6.6 Travel Cost Method Estimates of (Gross) Consumer Surplus (CS)

	Price (£)	Days p.a.	Annual CS (£)	Mean CS Per Day (£)
Scotland	136.43	598,452	13,674,628	22.85
Spey	265.11	40,543	1,796,113	44.40
Luce	35.83	600	6,210	10.35

6.4 Summary of the NEV Lost Through Widespread Gs Infestation

In Section 6.2.2, it was estimated that Economic Rent is **£16.5m** as an annual flow, and **£550m** as a capital value[27]. In Section 6.3, Consumers' Surplus was estimated at **£2.49m** as an annual flow, and **£83.14m** as a capital value. These figures are contained in the Table 6.7.

Table 6.7 Summary of NEV Value Lost Through Widespread Gs Infestation

	Annual (£m)	Capitalised (£m)
Economic Rent	16.5	550
Consumers' Surplus	2.49	83.14
Net Economic Value	18.99	633.14

Combining these figures, we estimate that 86.87% of the total NEV of salmon angling in Scotland is comprised of Economic Rent, and 13.13% of anglers' Consumers' Surplus. The latter is a smaller proportion of NEV than was anticipated. It is reassuring that responses were consistent across the postal, telephone and web-based survey instruments. Indeed, even when respondents were informed about the small ratio of their Consumers' Surplus to their total expenditure, they confirmed their initial WTP rather than accept the invitation to amend. We might tentatively conclude that proprietors' pricing strategies are able to capture much of the potential Consumers' Surplus from salmon angling.

[27] There may also be some underestimation of NEV through over-estimation of the opportunity cost of labour (see Appendix 4)

7 The Economic Costs and Benefits of Additional Policies to Preserve Gs Free Status in Scotland

The economic benefits of preserving Scotland's Gs free status are that we avoid the loss of income and employment (see Section 5) and the loss of Net Economic Value (NEV) (see Section 6) that would accompany a widespread Gs infestation. It follows that these are the benefits that can be attached to the 'prevention policy'. They are summarised in Section 7.1. The remainder of Section 7 considers the costs that might be encountered immediately with additional action to help ensure the Gs free status of Scotland.

7.1 The Policy Benefits from Maintaining GS Free Status

Table 7.1 presents the policy benefits assuming that Scotland successfully maintains its disease free status. It is important to note that these benefits are based on two implicit assumptions. The first is that without these policy measures Scotland would, with complete certainly, become infested. We cannot be sure of this and, in theory, the 'policy on' benefits in Table 7.1 should be weighted by the probability that, without intervention, Scotland would become infested. This probability is unknown and we are assuming 100% probability of infestation in the absence of intervention. The second asumption is that the measures deployed will be 100% effective against any prospective Gs infestation. In reality they might not be, and the 'policy on' benefits should also be weighted by the probability of the policy being successful. This probability is also unknown and we are assuming policy instruments are 100% effective. In summary, the policy benefits in Table 7.1 relate to a situation where completely effective policy measures are deployed against an adverse impact which will otherwise certainly occur.

Table 7.1 Summary of the Economic Benefits from Maintaining Gs Free Status

Economic Impact Avoided		**Net Economic Value Preserved (£m)**		
Total Salmon Angler Expenditure in Scotland (£m)	61.7		**Annual**	**Capitalised**
Expenditure Lost to the Scottish Economy (£m)	44.8	Economic Rent	16.5	550.0
Lost Scottish Household Income (£m)	34.5	Consumers' Surplus	2.5	83.1
Lost Scottish Employment (FTE)	1,966	Net Economic Value	19.0	633.1

7.2 Costs of Publicity and Disinfection

To prevent an introduction of Gs into Scotland, the general public, especially water users, will need to be informed about the parasite and its impact. This can be achieved by widespread publicity, targeting both water users in Britain and those returning from abroad. The campaign will need to send out a clear and concise message, providing instructions on how to prevent the spread of the parasite.

Initially, all groups who need to be informed will have been identified during the development of a communication strategy, which will include the maintenance of a database containing all the relevant stakeholders. Advertisements on websites of fishery trusts, angling clubs, canoeing clubs, tourist boards, and hostels and hotels will be required to raise awareness, and will need to be accompanied by widespread distribution of leaflets. Posters and leaflets will need to be provided to all ferry ports and airports, and posters placed at all main access points to the rivers, and at links between catchments. Basic publicity costs are shown in Table 7.2.

Table 7.2 Cost for Basic Public Awareness Campaign

Type	Number	Cost (£)
Print, Design and Supply		
A4 Full Colour, 2 Sided Leaflets	3,000,000	
A2 180gsm posters, Full Colour	12,000	
A2 250gsm posters, Full Colour	3,000	
		57,000
Distribution		
Leaflets		18,000
Posters		23,100
Sub Total		**98,100**
Three Month Advertisement[28]		**58,000**
Total Publicity Cost		**156,100 (+VAT)**

7.3 Disinfection

It is estimated that several hundred paddlers (sea-kayakers and river paddlers) travel through Newcastle or Harwich to Norway each year, with most of the traffic in the summer months. Whilst Norway is the most popular Scandinavian country for canoeing, some paddlers may travel by ferry to Sweden and Finland. A few will travel by plane and hire equipment over there, but most like to take their own boat. In total, there are approximately 2,000 British people canoeing in Scandinavia each year. This is a rough estimate, and there are probably similar numbers going for other forms of water-sports, such as sailing, diving or simply swimming in the outdoors whilst on another form of holiday (Mike Dales *pers. Comm.* 2006*).*

To minimise the risk of an introduction of Gs from countries visited that may be infected, it is suggested that disinfection stations be provided at ferry ports in Britain. Certain ferry ports may deal with more traffic carrying a higher risk of parasite introduction (e.g. canoeists from Scandinavia). Therefore, more than one disinfection station may be required at these ports.

[28] Advertisements in local and national newspapers will be required. 75 quarter page adverts to regional (Scottish) press and 40 quarter pages in national press – press coverage to run over a 3 month period with editorial coverage arranged free of charge. Costs will run at £58,000 approx.+ VAT.

Notices at each station would provide clear instructions to all users of the disinfection process, including the time it will take. To increase efficiency and reduce delays, it may be worthwhile to warn people on outward journeys about what will be required of them on their return. This advice could be incorporated in the general publicity campaign. Table 7.3 shows the costs to provide, install and maintain disinfectant pressure washers at 20 ferry ports.

Table 7.3 Costs to Provide 20 Disinfection Stations at Major Ferry Ports

Equipment	Cost (£)
Pressure Washers/tamper proofed	20,000
Disinfection per annum (Virkon®)	5,000
Installation	40,000
Maintenance per annum	20,000
Instruction notices	6,000
Total	**91,000**

8 Economic Cost and Benefit of Measures to Mitigate the Effects of a Gs Outbreak

There are four initiatives that cannot properly be described as preventative, containment or eradication measures but which are essentially complementary to these strategic approaches. These are:

- Surveillance
- Gene-banking
- Fish Farm Biosecurity
- Catchment Biosecurity

In this Section, the costs and benefits of these measures are considered. Whilst the costs are conceptually easy to estimate as they involve the commitment of identifiable quantities of resources that can be priced, the benefits are conceptually, and often practically difficult to estimate.

8.1 Increased Surveillance

8.1.1 Costs of Increased Surveillance

On-farm sampling takes in 172 salmon and 43 rainbow trout farms, some of which may only operate as hatcheries. The wild catchment survey samples from 11 sites, operating a rolling system of 55 sites over five years. When required, there are ten full-time fish health inspectors from the FHI, who will work full-time on surveillance. The costs of annual Gs surveillance in Scotland, including on-farm surveillance, sampling carried out on wild fish, and costs incurred in laboratory analysis are shown in Table 8.1.

The on-farm surveillance covers a range of fish diseases. Most of this sampling time is taken up with other work, so specific costs for Gs work are not available. Most of the costs shown are taken up by wild catchment monitoring for Gs.

Table 8.1 Present Costs of Per Annum Gs and Other Fish Disease Surveillance Monitoring Across Scotland (£)

	Salmon	Trout	Wild sites	Total
No. of Sites	172	43	11	226
Cost of Sampling[29]				62,600
Staff Costs[30]				130,500
Total				**193,100**

[29] Total sampling costs for the three areas, on-farm, wild catchment, and laboratory analysis are £62,600. This cost includes sampling work with regard to Gs work, but does not include work with regard to contingency planning or epidemiological analysis.
[30] Seven Inspectors' Full Economic Cost for 2005/06 is £72,850, and three inspectors whose FEC for 2005/06 is £57,719.

Table 8.2 assumes that there are 800 sites to be sampled across Scotland. This includes wild catchments, 172 salmon farms, and 43 trout farms and trout 'put and take' fisheries.

Table 8.2 Extended Per Annum Gs surveillance Monitoring Across Scotland (£)

Cost of Sampling	Transport Cost	Laboratory Costs	Total Cost
130,000	32,000	360,000	522,000

The average transport distances are 100 miles. Given ten inspectors sampling two sites per day at £325 per day, sampling would take a total of 40 days, generating costs of £162,000. Laboratory costs, including molecular techniques on each sample/replicate, would be £360,000, generating a total Gs surveillance cost of £522,000 per annum.

8.1.2 The Benefits of Increased Surveillance

The benefits from enhanced surveillance are conditional on circumstances, and we can only speculate on the factors that influence the magnitude of these benefits. We consider a number of scenarios.

8.1.2.1 Gs Free

Theoretically, if Scotland was known to be Gs free, and preventative measures were known to be 100% effective, there would be no benefit from enhanced surveillance. The reality is that we cannot prove Scotland is Gs free, and we have little knowledge of the efficacy of current or future preventative measures. Given the potential economic consequences of Gs (see Sections 5 and 6), there may be a role for surveillance.

In the absence of enhanced surveillance, and if Gs is allowed to establish itself throughout a region, eradication may not be feasible. Depending on the location of initial infestation, early detection is, therefore, probably a pre-condition for feasible eradication. It can then be argued that the difference between eradication and containment costs is the principal benefit from enhanced surveillance successfully identifying an initial infestation. It is instructive to consider some of the factors that might influence the likely magnitude of the cost differences between eradication and containment, notably:

1) The costs of successful eradication are one-off costs. Unlike containment costs, they are not permanently incurred.
2) Successful eradication leads, through time, to the re-establishment of the river itself (with gene-banking). With containment, the river's salmon angling is lost, and other water-based recreational activity is compromised, permanently.
3) Successful eradication of an initial infestation re-establishes Scotland's Gs free status.

Of course, if the above benefits were estimated, they would need to be weighted by the probability that surveillance would successfully identify the initial infestation. In addition, successful identification would have to occur in a catchment where eradication was considered a realistic prospect.

8.1.2.2 Gs Fully Established Throughout Scotland

At the other extreme, there are no benefits of surveillance, even from routine monitoring, if Gs is fully established in all catchments. This is because it would only confirm current knowledge, and there is no policy response that would be informed by such surveillance.

8.1.2.3 Containment of Gs

In the more likely scenario, where we are seeking to contain a Gs infestation (the Spey scenario), there is no role for surveillance within the contained catchment. The purpose of surveillance is to increase the probability of early detection of Gs outside the catchment. This early detection might allow the new containment areas to be geographically smaller than would otherwise be the case. The benefits of surveillance in this scenario are the cost savings from containing Gs to smaller areas. Savings would be made on disinfection and policing, and there would be less restriction on angling and other water-based recreational activity. Once again, we need to weight these benefits by the probability that enhanced surveillance would successfully identify the new infestation.

8.2 Precautionary Gene-Banking (G-b)

8.2.1 Cost of Precautionary Gene-Banking

Setting up gene-banks is an expensive and lengthy process. An estimated 300-400 fish are required to provide enough genetic material to store one stock. Before this, extensive background research is needed to establish the structure of the populations in relation to individual river systems. It is estimated that it takes 2-3 years for two people to investigate one river for population structure, at a cost of £200,000 to £300,000 (Eric Verspoor *pers. com*. 2006).

Information derived from Norwegian reports suggests that setting up a gene-bank facility costs approximately £10m, with operating costs of £1.2m per year (Eric Verspoor *pers. com*. 2006). £10m spent on one gene-bank may conserve populations from as many as 20 catchments, and would not be set up to serve a single catchment. Therefore, population structure studies would need to be carried out for all the catchments to be banked (Table 8.3).

Table 8.3 Total Cost of Gene-banking of Salmon Populations for Re-introduction Post Treatment (£m)

Gene-banking	Cost	Capitalised
Population Structure – 20 Rivers	6.0	6.0
Setting up Costs of Biosecure Unit	10.0	10.0
Operation Costs per Annum	1.2	40.0
Total	**17.2**	**56.0**

For comparative purposes, costs for setting up a selective breeding facility are shown in Table 8.4 (Stirling Aquaculture Estimates[31]). This farm would have a starting number of 40m eggs, aiming to produce 3-4m smolts.

Table 8.4 Approximate Costs to Set-up a Biosecure Salmon Hatchery for Selective Breeding

Setting up costs	Cost (£)
Hatchery	500,000
Family unit	500,000
Broodstock Unit	2,000,000
Smolt Production Unit	5,000,000

8.2.2 Benefits of Precautionary Gene-Banking

Gene-banking is the precautionary assembly of fish populations before Gs infestation, or any other comparable event potentially catastrophic to fish. The purpose of the bank is to ensure the gene pool is preserved. This is different from pre-treatment fish capture, where surviving fish are removed, cleaned of the parasite and kept for re-entry on the catchment once the parasite is eradicated. We consider three scenarios. As with surveillance, the benefits of G-b are difficult to quantify.

8.2.2.1 Gs Free

Theoretically, if Scotland was known to be Gs free, and preventative measures were known to be 100% effective, there would be no benefit from the precaution of G-b . As discussed above, we cannot prove that Scotland is Gs free, and we have little knowledge of the efficacy of current or future preventative measures. A strong case for **precautionary G-b** can be made if we assume that initial Gs infestation would be undetected and would spread almost instantaneously throughout Scotland. The benefit of precautionary G-b is there would be some prospect of re-establishing sustainable salmon stocks through eradication and re-stocking. However, this is only a benefit to the extent that eradication and re-stocking delivers sustainable fish populations more quickly and /or effectively than natural selection.

The reality is somewhat different, because:

- Surveillance might be in place,
- The parasite may spread relatively slowly,
- The parasite may become isolated if the initial infestation were on, say, the Western Isles,
- Containment measures might be effective.

These factors would reduce the need to engage in precautionary G-b, as we would have some warning of the imperative to G-b. If the spread of infection is relatively slow, one could postpone G-b until Gs is actually detected. In this scenario, there are greater benefits from precautionary G-b if natural stocks and habitats are likely to be quickly compromised by Gs,

[31] Derived from an unpublished study conducted for commercial purposes

effectively rendering G-b impossible. The benefits of G-b in this scenario depend on the balance of probabilities.

8.2.2.2 Gs Established Throughout Scotland

There would probably be little point in G-b, because there would be no safe natural environment to which the banked fish could be returned. Besides, experience from Norway suggests that around 5% of the natural stock would survive infestation and maintain a gene pool that would be Gs tolerant.

8.2.2.3 Gs Infestation Detected

The principal purpose of G-b is eventually to be able to re-establish natural populations. A precondition is successful eradication of Gs. Complete eradication of the parasite delivers Gs free status to Scotland and, as outlined in Sections 5 and 6, there are very considerable benefits from eradication. In contrast, the benefits from using the gene bank to re-establish salmon populations in a previously infected river produces benefits that relate only to that particular river. If the river in question is small (for example, the Luce), there are very few anglers, and the benefit flow could be small in relation to G-b costs. Alternatively, for a large complex catchment (for example, the Lomond, Ness, Tay or Spey) eradication may be unfeasible. In this case, there would be little point in gene banking stock from such a catchment. Additionally, it should be noted that the incremental contribution from G-b would be reduced if, over the long term, a sustainable Gs resistant population might be established naturally.

8.3 Biosecurity of Fish Farms

Biosecurity on fish farms involves the exclusion of disease-causing organisms from the environment. Measures to prevent spread of infection may involve internal or external barriers:

- Internal Barriers prevent the spread of disease within the fish farm,
- External Barriers prevent the spread of disease onto and off the fish farm.

In Norway, water for use in salmon hatcheries must be sourced from areas where anadromous[32] fish are absent. Additional external barriers in use on rainbow trout operations in Norway include:

- Water intake must be above the level where anadromous fish are found, or the inflow must be treated with UV light or ozone,
- Outflow must be into seawater or filtered through a 40 micron mesh,
- Hatcheries can only supply seawater production units within the same epidemiological zone or freshwater sites in the same catchment,
- On-growing units must be fallowed annually.

In 2004 in Scotland, there were 96 farms using tanks and raceways and 76 using cages in freshwater. The number using biosecure tank-based systems is not recorded but is thought to be low as six, of which three or four might produce smolts. Overall, around 44% of smolts were produced in cages in 2004, and 56% in tanks and raceways but, probably, less than 5%

[32] Anadromous fish enter rivers from the sea to spawn.

of these were from biosecure systems. The commercial requirement to become biosecure will lead to extensive rationalisation of production. The capital cost of biosecure plant per million smolt capacity is in the region of £0.75m to £1m. This would suggest a capital cost of between £30m and £40m to satisfy demand.

Internal biosecurity measures to exclude disease causing organisms may include disinfection. The correct selection and use of disinfectants is important. Three factors to be considered when choosing a disinfectant for fish farm biosecurity are: proven efficacy; environmental impact; and user safety. Virkon was chosen as the disinfectant for use in this study. Disinfection measures required in hatchery/broodstock facilities and freshwater production sites centre on identifying critical control points for the entry and spread of infection, followed by the implementation of the appropriate biosecurity measure[33].

Estimated costs to improve biosecurity by providing on-going disinfection on fish farms, including the costs of equipment, are **£5-10,000** per annum. The cost of equipment and disinfection will depend on the size and productivity of the operation. In addition, weather conditions will affect how long disinfectant and equipment lasts.

8.4 Catchment Bio-security (CBs)

A number of catchments have been linked, normally for hydro-electric purposes. The benefit of CBs is the avoidance of the Gs damage that would occur should the parasite use these links to migrate across catchments. It would be appropriate at this stage to identify all the catchments' links, and to assess the costs of making them biosecure. We analysed the links between the Spey, Tay and Spean catchments, and this is discussed in Section 10.5.

[33] See Appendix 11

9 The Costs and Benefits of Eradication: The River Luce

9.1 Introduction

The River Luce system is approximately 100 km long, and drains from the Galloway uplands to Luce Bay. Whilst the neighbouring Cree and Bladnoch sub-catchments are dominated by conifer plantations, the Luce catchment is predominantly moorland. The Water of Luce is formed by the joining of the Cross Water of Luce and the Main Water of Luce. The Main Water is now dammed to form Penwhirn Reservoir, and salmon angling has suffered from the damming. Sea trout runs have also deteriorated (Stair Estates 2006). The Luce has no underlying environmental designation or conservation management, although the Luce Bay and sands is a large and diverse coastal system with Designated Special Area of Conservation status (SAC).

9.1.1 Angling Activity

Penwhirn Reservoir has some brown trout, and is a fly-only fishery. The Stair estates privately own the entire river, with Lord Stair retaining a significant proportion of the salmon angling. On some of the retained water (below Cross Water at New Luce), day rods are available. Four syndicates occupy much of the rest of the river. Stair Estates estimate a total of 40 salmon and sea trout anglers fish the river. The estimate of salmon angler days is 600. A small number of local sea trout anglers fish the lower reaches quite intensively.

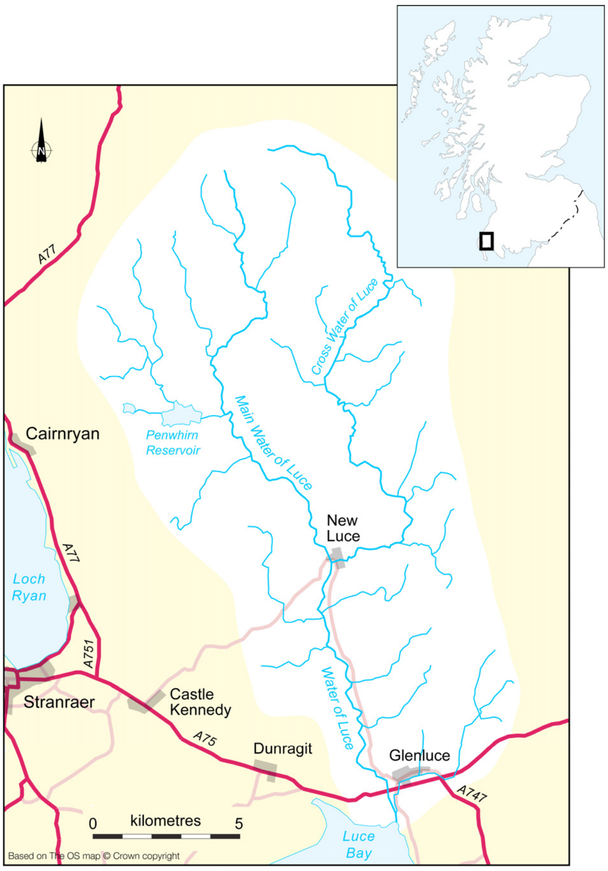

Figure 9.1 Location and Extent of the River Luce Catchment

9.1.2 *Estimated Economic Rent and Consumers' Surplus on the Luce*

The 2004 catch statistics for the Luce are given in Table 9.1.

Table 9.1 Luce Salmon, Grilse and Sea Trout Catches 2004

	Salmon	Grilse	Salmon and Grilse	Sea Trout
Retained	89	49	138	55
Released	8	5	13	55
Total	97	54	151	110

Applying the value of £5,000 per salmon, the capital value of the Luce, in terms of its salmon catch, is £755,000, which equates to an annual economic rent of £22,879. With respect to sea trout, if we assume £1,500 per sea trout, there is £165,000 in capital value, which is equivalent to an annual economic rent of £5,000

Salmon anglers' Consumers' Surplus (see Section 6) was estimated at £2.11 per day (with a daily expenditure of £35.83 per day). Given a total of 600 salmon angler days, annual Consumers' Surplus is only £1,266. This would produce a capitalised value of £42,000. Gs infestation in the Luce would result in a loss of capital value of the salmon fishing rights amounting to £755,000 (£22,879 annually). In addition, there would be a loss of anglers' Consumers' Surplus with a capitalised value of £42,000, yielding an aggregate capitalised loss of NEV of £0.797m.

9.2 *Cost of Eradication*[34]

In this section, we attempt to identify the costs should Gs enter the River Luce system. The Luce was chosen because it is an example of a small self-contained system with limited use by anglers, no use by aquaculture, and no obvious ecological constraints. Therefore, it is believed that eradication would be a feasible and a relatively effective option in the event of an introduction. However, the issue of the River Luce's status as a SAC would need to be considered in relation to licensing chemical treatments. The cost of treatment includes baseline water-quality analysis prior to treatment, making both biological and chemical assessments. Mapping of the area is costed, as are the planning time of treatment and the purchase of equipment. Direct treatment costs include labour and chemical.

9.2.1 *Total Cost of Treatment with Rotenone*

The estimated costs for treating the River Luce using rotenone are presented in Table 9.2. As discussed previously, this would be intended to kill all the fish in the river.

[34] See Appendix 13 for a detailed discussion of rotenone and AlS treatment costs

Table 9.2 Total Cost of Treatment with Rotenone

Treatment	Cost (£)
Pre-treatment Surveys	30,960
Planning	17,817.50
Mapping	21,381
Equipment	123,764.56
Crew	120,236.40
Dye Tracer Study	60,369.80
Rotenone	58,000
Disposal (per 500 MT)	39,500
Publicity	90,700
Repeat Treatment	58,000
Follow-up Biological/Chemical Surveys x 3	92,880
Total	**713,609**

The costs of precautionary gene-banking to conserve different populations of salmon (so they may be reintroduced once treatment has been carried out, and the parasite eradicated) was discussed in Section 8.3. If the Luce were incorporated in such a scheme, its share of the year 1 establishment cost would be £0.86m. Its share of the total capitalised cost would be £2.8m (Costs from Table 8.3 divided by 20). Given the net economic value of £0.97m of the Luce, it would be difficult to justify gene banking.

If the river were not covered by a gene-banking scheme, consideration might also be given to removing and separately treating at least a proportion of the fish prior to the main river treatment and returning them afterwards. The options here would include:

- Building a special biosecure holding unit in Scotland;
- Constructing a temporary fish holding facility on the river bank utilising portable tanks, pumps, treatment equipment and generators;
- Short-term use of transport tanks and well boats (for smolts and adult fish)

Fish would either need to be captured during a separate operation prior to the main treatment, or a more limited fish capture might be attempted during the treatment operation itself. Table 9.3 indicates the likely cost of different options for fish removal and treatment operations. It is important to note that investment in dedicated holding facilities (temporary or permanent) would probably only be justified if required for multiple rivers, or for use in a very large catchment. For the purpose of this case study it has been assumed that no fish recovery and treatment would be attempted. This is in order to provide a clear comparison with the Aluminium Sulphate option described below[35]. However, it is an option that should be considered if an outbreak occurs and rotenone is selected as the treatment.

[35] The higher cost of the treatment and the shortening of the recovery time would make the scenario very similar to the AlS case with respect to economic analysis.

Table 9.3 Cost of Fish Removal, Separate Treatment and Re-introduction after Parasite Eradication - Options for the Luce

Activity	Units	Unit cost	Number Required	Total Cost (£'000)
Capture options				
(a) Prior Fish capture (electrofishing and netting)	Team of 6 with boat, transport and equipment	£2000/km	85†	170
(b) Limited netting at time of treatment (use existing team with additional equipment)	Approx. additional cost per treated km	£500	85†	42.5
Holding and treatment options				
(a) Well boat (hire)	Per well boat	£5000/day	20	100
(b) Temporary bank-side tanks (purchase & install)	Per holding unit (reusable)	£250,000	1	250*
(c) Permanent unit	Per facility	£1.5 million	1	1,500*
Direct operating cost for temporary or permanent facility (staff, power etc.)	Per day	£1,000	20	20
Additional transport (e.g. return of fish from holding facility)	Transporter/day (approx. 1.5 – 2 tonnes capacity)	£500	5	2.5

*This is the capital cost for the facility.
†It is assumed that fish are only removed from 85% of the river length.

9.2.2 Treatment with AlS

The estimated costs of treating the River Luce with aluminium sulphate are presented in Table 9.4. It is noted that some parts of the river might still need to be treated with rotenone (based on experience from Norway). However, since this would influence some costs upwards and others downwards, the overall impact is considered to be within the margin of error of these estimates.

Table 9.4 The Cost of AIS Treatment on a 100 km Water Course

AIS Treatment	Cost (£)
Pre-treatment Surveys	30,960
Planning	17,817.50
Mapping	21,381
Equipment	508,840
Crew	104,689.30
AIS	236,600
Disposal (per 500 MT)	39,400
Between Treatment - Chemical Analysis	3,000
Publicity	90,700
Follow-up Surveys x 1	30,960
Total	**1,084,348**

9.2.3 Economic Impact of Eradication

Luce anglers had a mean expenditure of £35.83 per day, and an estimated total number of angler days of 600. Angler expenditure is only £21,500. Since most of this expenditure will be transferred within Scotland and, at a local level, will be exceeded by expenditure to contain or eradicate Gs, the impact is essentially insignificant, and will not be considered further.

If Gs infestation occurs, then action will be taken to prevent the substantial loss of NEV, income and FTEs that would accompany widespread Gs occurrence. These benefits are outlined in Table 7.1, and again here in the Table 9.5.

Table 9.5 Summary of the Economic Benefits from Eradication of Gs

Adverse Economic Impact		Net Economic Value Preserved (£m)		
Total Salmon Angler Expenditure in Scotland (£m)	61.7		**Annual**	**Capitalised**
Expenditure Lost to the Scottish Economy (£m)	44.8	Economic Rent	16.5	550.0
Lost Scottish Household Income (£m)	34.5	Consumers' Surplus	2.5	83.1
Lost Scottish Employment (FTE)	1,966	Net Economic Value	19.0	633.1

Given the size of these losses, the minimum reaction would be containment, as specified in the draft action plan (see Section 3.1). Theoretically, this could continue indefinitely. We estimate that at least one bailiff would be required and, given transport and materials, we assume a cost of £50,000 per annum, which is £1.65m capitalised. The benefit is the reduction in likelihood of transmission multiplied by NEV. Assuming this is close to 100%, we get a benefit from containment in excess of £600m.

There are three major benefits of eradication over containment. Firstly, with rotenone treatment, the benefits summarised in Table 9.6 would be obtained, but there would be no risk whatsoever of transmission to the rest of Scotland. The eradication of transmission risk is a benefit properly attributable to rotenone. Unfortunately, we are unable to estimate the magnitude of transmission risk. Secondly, there would be a shortening of the containment and hence a reduction in costs. Thirdly, after a period of about 10 years, salmon fishing would be recovered. In summary, the benefits of rotenone are the elimination of transmission risk (unknown), the recovery of the salmon population after about 10 years (with a capital value of £592,878), and the saving on containment costs (with a capital value of £1,650,000).

It should be noted that that whilst rotenone will initially eradicate salmon stocks, the parasite would also have this impact. Consequently, the (temporary) loss of salmon is not a cost attributable to rotenone. The costs of rotenone are therefore restricted to treatment costs and to sea trout mortality (which would not occur in the absence of rotenone). The capital value of treatment costs is estimated to be £713,609. The annual loss of the Economic Rent associated with the sea trout fishery, was estimated to be £5000 per annum. In addition, there would be a loss of anglers' Consumer Surplus associated with sea trout fishing. The annualised value for the sea trout Economic Rent is only £5000, and, if we make allowance for anglers' Consumer Surplus, £6000 would be a reasonable estimate of the annual sea trout cost.

The economic costs and benefits associated with rotenone treatment are given in Table 9.6.

Table 9.6 Costs and Benefits of Treatment with Rotenone

COSTS				BENEFITS			
Element	**Applicable Year**	**Annual Cost (£)**	**Present Value (£)**	**Element**	**Applicable Years**	**Annual (£)**	**Present Value (£)**
Rotenone Treatment	1	676,620	713,609	Salmon Rents	11 to end	22,879	561,791
Sea Trout Rents	1 to 10	5,000	42,651	Salmon CS	11 to end	1,266	31,087
Sea Trout C.S.	1 to 10	1,000	8,530	**Sub-Total**			592,878
				Avoidance of Containment Costs	1 to End	50,000	1,650,000
Total Cost			**764,790**	**Total Benefit**			**2,242,878**
Benefit-Cost			**1,478,087**	**Benefit/Cost Ratio**			**2.93**

The table clearly shows that benefits of eradication by rotenone exceed the benefits of containment, even if the benefits from removal of the transmission risk are ignored. However, there is the alternative of treatment by AIS, which has the major advantage that fishing can be retained. The costs and benefits of this option are given in Table 9.7.

Compared to rotenone, there are higher treatment costs but no loss of sea trout angling and, on the assumption that AIS is effective, there is no loss of salmon rents or Consumers' Surplus associated with Gs infestation. This option has a similar benefit to cost difference, but a significantly inferior benefit to cost ratio. However, a larger more productive salmon river might suggest that AIS treatment was economically more advantageous, but this would depend on many factors, and it is difficult to generalise. Since relatively few salmon anglers use the Luce, the benefits from gene-banking in the form of re-establishing the salmon fishery are only £0.797m. This ignores the general public's valuation of salmon stocks in the River Luce. These values could be significant, and we can only speculate whether they would be high enough to justify gene-banking.

Table 9.7 Costs and Benefits of Treatment with Aluminium Sulphate

COSTS				BENEFITS			
Element	**Applicable Year**	**Annual Cost (£)**	**Present Value (£)**	**Element**	**Applicable Years**	**Annual (£)**	**Present Value (£)**
AIS Treatment	1	1,084,348	1,084,348	Salmon Rents	1 to end	22,879	755,000
				Salmon CS	1 to end	1,266	41,778
				Sub-Total			**796,778**
				Avoidance of Containment Costs	1 to end	50,000	1,650,000
Total Cost			**1,084,348**	**Total Benefit**			**2,446,778**
Benefit-Cost			**1,362,430**	**Benefit/Cost Ratio**			**2.26**

10 The Operating Costs of Alternative Containment Policies: The River Spey

10.1 Introduction

The economic analysis of a policy of containing Gs within a catchment focuses on the River Spey. This Section, after an outline of the river's key features, explains two alternative containment schemes, and provides a summary of their operating costs.

10.2 Physical Attributes

The River Spey is one of the great rivers of Scotland, running northeast for just over 100 miles from the Highlands to the North Sea. The main stem is navigable by canoe for 124 km from Spey Dam, without impediments, such as blockages or waterfalls etc. The river has an extensive network of tributaries, notably the River Avon, which runs for some 40 km (24 km easily navigable). Other tributaries include the Truim, Calder, Tromie, Feshie, Nethy, Einich, Fiddich, Luineag and Dulain, most of which provide both angling and whitewater kayaking. The catchment also hosts a large number of freshwater lochs[36].

Figure 10.1 presents a map of the catchment, together with economic and political boundaries. One important feature is that approximately half of the Cairngorm National Park is in the catchment, and some two thirds of the catchment is in the National Park.

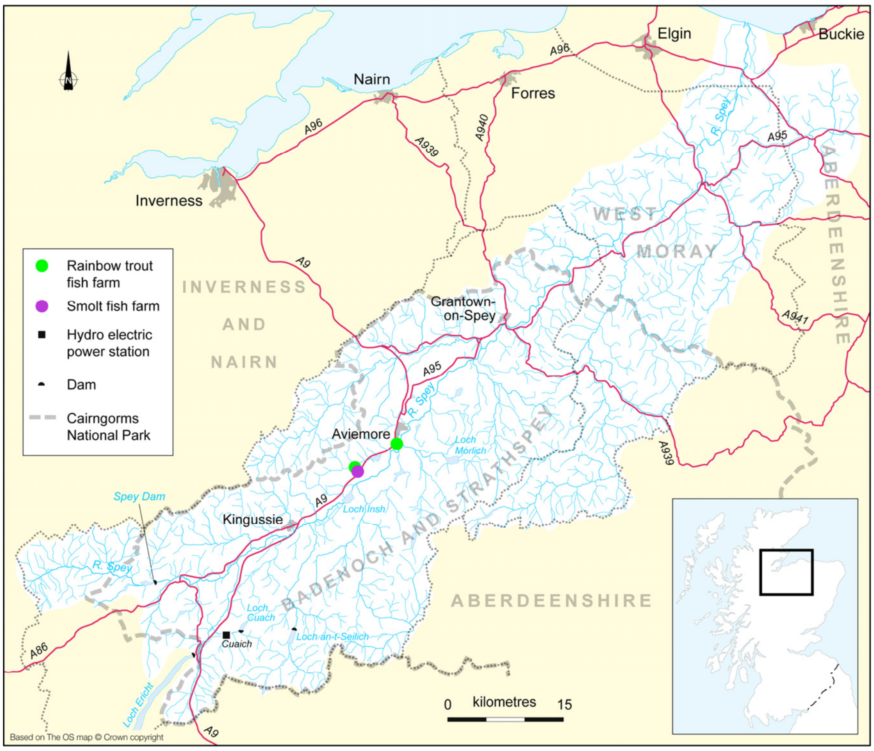

Figure 10.1 Location and Extent of the Spey Catchment

[36] Appendix 8 provides a list of 41 lochs and lochans in the catchment, of which six exceed 100 hectares (1 km^2) in area.

10.3 Species Diversity

The catchment is also extremely important as a location for endangered species. Three SAC species are identified: the salmon (*Salmo salar*); sea lamprey (*Petromyzon marinus*); and freshwater pearl mussel (*Margaritifera margaritifera*). In addition, the osprey (*Pandion haliaetus*) nests on Loch Garten, and feeds on the river and surrounding lochs, whilst the otter (*Lutra lutra*) is found in the Insh Marshes. The peregrine falcon (*Falco peregrinus*) nests close to Craigellachie. There are three national nature reserves: Insch Marches; Abernethy (including Loch Garten); and Craigellachie.

10.4 Angling Activity

The Spey is one of the four great salmon angling rivers of Scotland, and has a world famous reputation. Table 10.1 provides estimates of the salmon catch, and Table 10.2 estimates of the angling activity in our chosen metric, activity days.

Table 10.1 Spey Catchment Salmon and Sea Trout Catch 1998-2004

Year	Salmon & Grilse Released	Salmon & Grilse Retained	Total Salmon Catch	Sea Trout Released	Sea Trout Retained	Total Sea Trout Catch	Total S & ST Catch
1998	419	8,335	8,754	56	3936	3992	12,746
1999	561	5,820	6,381	220	2,901	3,121	9,502
2000	1,376	7,392	8,768	398	3,564	3,962	12,730
2001	1,724	6,038	7,762	317	3,136	3,453	11,215
2002	1,953	4,375	6,328	397	3,936	4,333	10,661
2003	4,272	2,166	6,438	443	2,930	3,373	9,811
2004	6,616	3,248	9,864	689	2,255	2,944	12,808

Source: Fisheries Research Service

Table 10.2 All Species Angler Days by Key Origins

Home Region	Salmon & Sea Trout	Brown Trout	Rainbow Trout	Coarse Fish	All
MSBE[37]	6,386	1,910	1,871	300	10,467
Rest of Highlands	2,319	539	1,613	253	4,724
Rest of Scotland	5,486	1,023	1,660	350	8,519
Outside Scotland	26,353	1,342	3,042	299	31,037
ALL	40,543	4,815	8,186	1,202	54,746

Source: Riddington *et al*. (2004)

Visitor numbers are of critical importance to the local economy, as is their high spending. Details are shown in Table 10.3.

[37] Figures relate to the old *Moray, Badenoch and Strathspey Enterprise (MSBE)* area.

Table 10.3 Expenditure by Anglers by Species and Home Location

Home Region	Salmon & Sea Trout (£)	Brown Trout (£)	Rainbow Trout (£)	Coarse Fish (£)	All (£)
MBSE	782,290	66,559	49,263	11,219	909,332
Rest of Highlands	264,072	39,681	66,004	9,552	379,309
Rest of Scotland	1,688,223	84,129	81,622	13,237	1,867,211
Outside Scotland	8,013,932	170,361	475,404	11,724	8,671,421
ALL	10,748,517	360,731	672,293	45,732	11,827,273

However, these expenditure Figures are potentially misleading, because:

- Anglers may divert their expenditure to other species, or other regions in Scotland,
- Only a fraction is absorbed in the local economy,
- That which is absorbed has multiplier effects within the economy.

Section 4.3 detailed the way in which the expenditure assessment becomes an economic impact analysis.

Calculation of the NEV of salmon angling involves the assessment of Consumers' Surplus and Economic Rent (the balance between charges made by the owners, and the opportunity costs of resources used).

The catch statistics for the Spey are given Table 10.1, and, applying the value of £5,500 per salmon, it is estimated that the capital value of the Spey is conservatively estimated at £54.25m. A further £4,86m could be added for the sea trout fisheries contribution to its capital value.

On the Spey, using the rent per day approach gives an estimated value of £1,459,548. The capitalised value approach converted to an annual sum gives an estimate of £1,476,500 per annum (salmon & sea trout) or £1,448,550 per annum (salmon only).

10.5 Water Sports Activity

As might be expected, there is a considerable volume of water sport activity centred on the nine outdoor centres found in the region. Table 10.4 summarises this activity, together with information on how it was collated. It should be emphasised that the Spey catchment is the only area of Scotland with any information of this type.

Table 10.4 Number of Activity Days in Spey Catchment Area

Location		Spey Descent[38]	Centres[39]	Other[40] Day	Total
Loch Morlich:	Sail		3,049	1,139	4,188
	Paddle		8,630	1,534	10,164
Loch Insch:	Sail		6,980	100	7,080
	Paddle		8,816	100	8,916
Upper Spey to Aviemore		390	700	300	1,390
Middle Spey to Ballindalloch		430	1396	1404	3230
Middle Spey to Craigellachie		430	40	250	720
Lower Spey to Spey Bay		394	40	223	657
Total for Main Stem (Spey)		**1,644**	**2,176**	**2,177**	**5,997**
Rivers Avon & Feshie			32	250	282
Total		**1,644**	**29,683**	**5,300**	**36,627**

Source: Riddington *et al*. (2004)

Table 10.5 provides estimates of the expenditure of this level of activity in the local area.

Table 10.5 Estimated Expenditure by Category and Water-Sports Type (£)

	Centres	Descent[41]	Day	Total
Accommodation (incl. Campsites)	194,426	11,659	0	206,085
Meals	220,281	11,303	21,455	253,040
Drinks	154,109	10,230	17,623	181,962
Food and Drink (Retail)	133,951	11,288	20,384	165,623
Equipment Rental & Guides	344,299	2,019	1,831	348,149
Petrol & Fuel	90,567	21,004	67,394	178,964
Trip Fees	323,118	8,105	12,186	343,409
Total per day	1,460,751	75,608	140,874	1,677,232

In Section 11.2.2, we examine the economic impact of this activity, and the economic and welfare impact if containment measures aimed at controlling the spread of Gs end water sports activity in the catchment.

[38] Activity days by paddlers descending the Spey
[39] Activity days recorded at water sports centres
[40] Activity days recorded by observers, such as ghillies
[41] Includes independent paddlers staying overnight in area

10.6 Water Abstraction

In Scotland, the main uses of abstracted water are energy generation, dissipation of heat (cooling), and domestic and industrial water supply. Volumes of water abstracted by major industrial sectors are presented in Table 10.6. The main impounders abstract water for energy generation, using hydropower and water that is stored in reservoirs. Of clean water used by Scottish households, 90% is discharged to main sewers. Non-consumptive users abstract water and return it to the river in a different form, including water used for cooling by the distilling industry. Sewage and the disposal of refuse are the most significant point source polluters of water, followed by the fish farming and manufacturing industries (Scottish Environmental Protection Agency 2003).

Table 10.6 The Volume of Water Abstracted Per Sector in Scotland Per Annum

Sector	Water Abstraction Plus Mains Water per Annum ('000m^3)
Fish Farming	1,617
Scottish Water	926,000
Malt Whisky Distilling	76,000
Paper Manufacturing	83,000
Chemical Industry	29,000
Food Processing	12,300

In terms of the Spey, Scottish Water abstracts approximately 20m litres per day from the main water treatment works for the area. This supplies 60,000 customers, including major food producers, such as *Walkers' Shortbread* and *Baxters* of Speyside. In addition, sites such as the RAF bases in Lossiemouth and Kinloss abstract in the region of 1m litres of water per day.

Treated abstracted water will have Gs removed through the normal treatment process, and there should be no risk of transmission from this source. Water abstracted directly by farmers and households does constitute a risk if water is transported outside the catchment within five to six days of abstraction. We have assumed that, with education, this constitutes a minimal risk.

10.6.1 Distilleries

Whisky distilling is the main industrial use of water on the river Spey. There are 33 malt distilleries and three dark grain facilities. All of these operations secure their water supply from private sources, and they also abstract from the river for cooling purposes. Of the water used for distilling,10% is abstracted from natural springs and burns. The remaining 90% is used for cooling, which is returned to the catchment at a slightly higher temperature. In an area like the Spey where there is a large concentration of distilleries, the same water may be used for cooling in a number of distilleries on its passage downstream.

There should be no reason for refusal of water abstraction for cooling, even in a total exclusion case, because the system appears to be almost completely closed. However, it may be decided to treat certain sections of the Spey watercourse to eradicate Gs. In this case, water abstraction would have to be curtailed. In an area like the Spey where there is a large number of distilleries closely situated, the same water may be used for cooling in a number of distilleries on its passage downstream. This could have implications for greater losses if a number of distilleries in the same area had to close (Figure 10.2). Confidential information from one of the distilleries suggests they employ around ten people directly with a multiplier of five for the support industry. The loss of income from prevented production would be in the region of £1.8m per year.

Table 10.7 Malt Whisky Distilling Industry Abstraction Volumes from the River Spey Catchment

No. of Distilleries	Total Flow (m^3 per Annum)	Water Abstracted for Mashing (m^3 per Annum)	Water Borrowed for Cooling (m^3 per Annum)
36	2020m	1.81m	27.15m

Source: Scottish Parliament

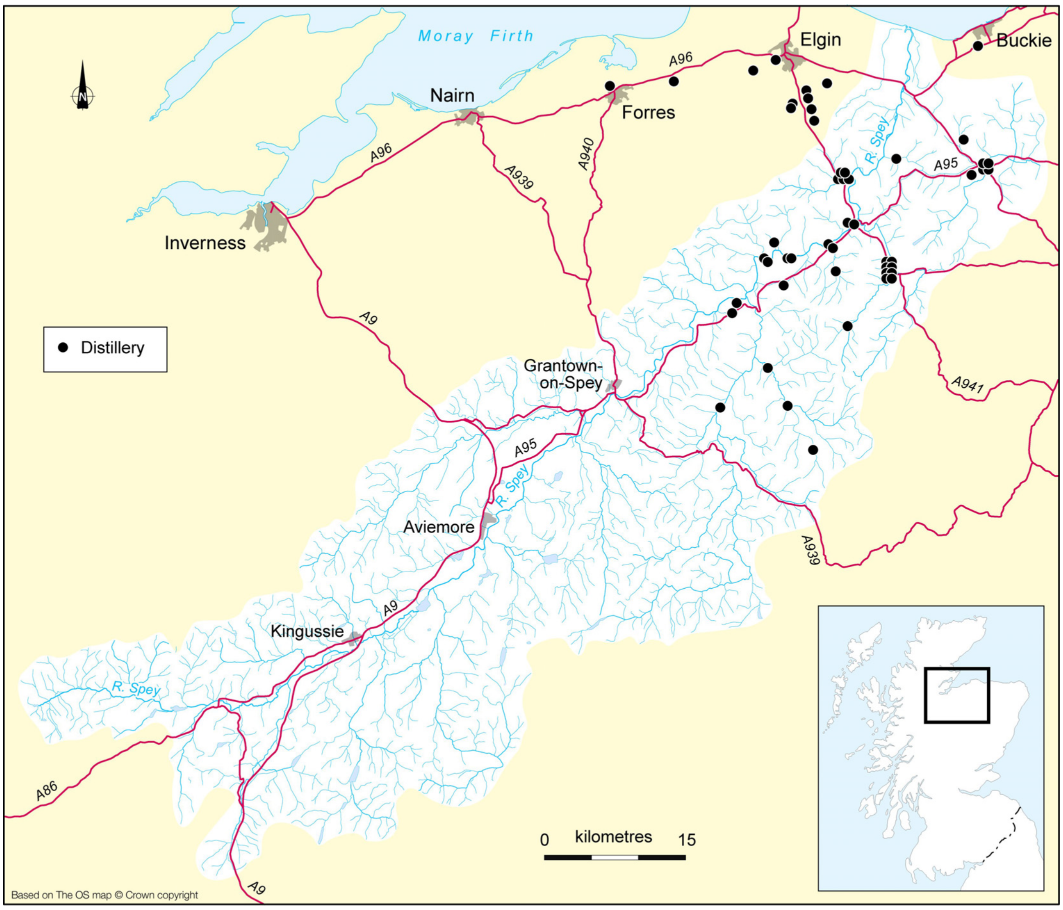

Figure 10.2 Location of Distilleries in the Spey Catchment

10.6.2 Hydro-Electricity Schemes

The River Spey catchment is used at a number of points to provide water for the generation of hydro-power via diversion to neighbouring catchments. There are two main schemes in operation in the upper catchment. *Scottish & Southern Energy plc* diverts water from the catchments of the rivers Tromie and Truim to Loch Ericht (Tummel/Tay catchment). Water is drawn from the Upper Tromie at Loch an t-Seilach, which has been enlarged by damming. It is then piped to Loch Cuaich, which stands at the head of the River Cuaich. Water passes from Loch Cuaich through the power station, on an aqueduct across the Truim, and through a short tunnel into the Ericht and the Tay catchment. In normal conditions no water passes down the old Cuaich water course into the Spey. Infected salmon could however pass up the Tromie into the Loch. Further, although all pipes are screened, unattached parasites (and even on occasions very small smolts) could be washed down into the Tay system. There is also a weir on the Truim above Dalwhinnie that diverts water into Loch Ericht. Again, it is possible for salmon to pass upstream of the weir, and consequently pass the infection into the Tay system.

Alcan Smelting & Power UK diverts water from the River Spey (at Spey Dam), and from the River Mashie to the River Pattack (Loch Laggan/Spean catchment) for hydro-power generation at Fort William. A sizeable flow occurs down the old watercourse, and a fish ladder has been provided to allow salmon access to their traditional spawning grounds. No abstraction occurs if the flow falls below a minimum level, and then all the water is passed to the river. Freshets (controlled rushes of water) are released for 22 days from the Spey Dam to the river specifically to provide an aspect of the hydrological regime necessary for the migration of salmonids in the River Spey (SCMP 2003).

Significant numbers of fish do pass upstream of the dam. Consequently, although the pipe from the Spey dam is screened, there is a significant risk of transferring Gs into the Laggan/Spean catchment along this route. However, on the Spey and its tributaries, preventing fish movement past these diverting dams and weirs is relatively easy and cheap – put at between £10,000 and £20,000 (Spey Fishery Board 2006 *pers. comm.*). It would seem to be a sensible precaution to identify all such catchment links and ensure that prevention in all cases is as easy.

10.7 Other Water Using Activity

Two other activities are potentially affected by efforts to combat or contain Gs; aquaculture and non-specifically water based leisure. The physical geography of the Spey has ruled out eradication as an option, assuming those abstracting water directly for water supply or for irrigation should be unaffected as they offer no transmission threat.

Aquaculture comprises estate and fishery trust salmon hatcheries for promotion of salmon volumes, and rainbow trout farms for local recreational use or local consumption. Closure of fish farms and hatcheries are covered under angling. The economic impact of restrictions on movement of fish outside the area would appear to be minimal.

The greatest problem is the closure of all water to tourists for swimming, paddling, splashing and so on. Given the size and complexity of the system, it is clearly impossible to impose complete closure. Unless there was a ban on wild camping, then utilisation of water from remote mountain lochs and burns would continue. It is likely that restrictions would be concentrated on popular spots such as the beaches around Loch Morlich, Loch Insch, Loch an Eilan, together with riverside locations at Aviemore, Aberlour, Fochabers and Spey Bay.

Data is lacking on numbers affected and the alternative choices they would make if restrictions were imposed. Consequently, it is problematic to estimate the welfare losses or economic impact of such restrictions. It is worth noting, however, that the Glenmore Campsite adjoining Loch Morlich has 220 pitches, which would imply a capacity of between 500 and 1000 people. Table 10.8 gives the monthly occupancy. Taking a conservative average of 2.5 persons per unit gives 75,000 bed-nights at the site for the year. Typically for outdoor activity holidays, we find spending of around £40 per activity day which gives £3m a year for these campers alone.

Table 10.8 Glenmore Campsite Monthly Occupancy

Month	Units occupied
Jan	576
Feb	817
Mar	413
Apr	1653
May	1965
Jun	1931
Jul	6637
Aug	4087
Sep	5647
Oct	6473
Nov	Closed
Dec	Closed
Total	**30199**

Source: Forestry Commission

In addition, it is estimated there are over 250,000 visitors to the Rothiemurcus Estate per annum using paths that surround Loch Morlich and Loch an Eilan, and 750,000 visits to the area in some form (Mather, 2000). Should access to the water be forbidden, the number that would not camp or walk in the area is clearly critical, and it is discussed later. However, if only 20% were deterred from the Spey area, the loss in terms of expenditure could well approach £1m.

10.8 Alternative Containment Measures

10.8.1 The Minimal Scheme

As discussed in section 3.9.2, there are considerable practical problems associated with schemes that allow water activity. Initially, a completely voluntary scheme was considered, with disinfection immediately upon exit to minimise inconvenience and maximise uptake. This required up to 30 disinfection stations with necessary power and water supplies, and regular inspection to ensure no breakdowns or vandalism. Eventually, it was concluded that such a scheme would be both expensive to run and potentially insecure if the disinfection system had broken down.

The selected alternative Pass scheme is utilised, and it is costed in this section. The major threat of transmission is the visitor who leaves the catchment, and moves, with equipment still wet and without disinfecting it, to an adjacent catchment such as the Findhorn or Dee. The following scheme seeks to ensure that disinfection occurs:

- Throughout the catchment there are a series of disinfection stations, termed Pass Management Units (PMUs). These will be located at water sports centres, outdoor centres, boat and angling clubs and strategic manned sites, such as garages and visitor centres throughout the catchment.
- All visitors using the water must have a DAY PASS dated for the day of use. To obtain the pass they must provide a sizeable but returnable deposit of the order of £100. Passes can be obtained at the PMUs or (more normally) via the internet from the Pass Management Centre (PMC). In general, the deposit will be in the form of a debit or credit card number, which will be held centrally at the PMC. Cash deposits may be made at a PMU but can only be reclaimed at the same PMU.
- Penalties, involving the confiscation of equipment, will be implemented against any individual using equipment that does not have a correctly dated pass.
- An ANNUAL PASS can be obtained for equipment belonging to a PMU (e.g. a water sports centre) that rarely, if ever, leaves the catchment. This pass is issued with the requirement that the PMC is notified if the equipment is taken from the catchment and a certificate of disinfection obtained. Failure to do either will cause the loss of PMU status and the availability of an annual pass, a significant incentive. Equipment with annual passes will be clearly marked, and will include a warning that a disinfection certificate is required if used outside the catchment.
- There is a choice about the treatment of locals who regularly use the water but also take their equipment out of the catchment. On the one hand, a day pass and disinfection could be required for every day of use. This could be very inconvenient and unnecessary if the equipment is not leaving the catchment. The possibility of it being ignored remains, with the consequential risks and costs. The alternative is to encourage locals to become attached to a PMU, with the PMU applying for an Annual Pass for the equipment. In effect, the PMU is risking its own status on the individual, and consequently will not apply unless they have trust in that individual. They will also exert considerable collective pressure on that individual to conform.

The model is summarised in Box 10.1

The alternative containment strategy seeks to exclude all users from the watercourse. The next section considers the costs and benefits of:

- The Minimal scheme that prevents the movement of infected fish or water, and couples that with an extensive publicity campaign, together with a Pass scheme to ensure disinfection.
- The Total Exclusion scheme that effectively puts a cordon around the infected catchment and prohibits access to the water. The effect is the ending of all fishing and recreational activity associated with the water.

Box 10.1 A Model of an Infected River Pass Scheme

Infected River Pass Scheme

A Pass Management Centre (PMC) that:

- Establishes a number of Pass Management Units conveniently located in the catchment,
- Issues Annual Passes for boats (canoes, kayaks and dinghies) associated with Pass Management Units (PMUs),
- Issues Day Passes for boats on receipt of a large deposit via the Internet.

A number of PMUs (around 20) based around water sport providers, clubs or garages, and with disinfection facilities on site will:

- Issue Day Passes for boats on receipt of a large deposit,
- Return/cancel the deposit after a Day Pass has been returned and the boat disinfected.

Boats with clearly identified Annual Passes cannot leave the catchment unless they carry a valid disinfection certificate issued by a PMU. The PMU will notify the PMC of any boat with an annual pass that has left the catchment.

Local users who would like an Annual Pass must be a member of a PMU.

10.9 Cost of Containment

Two types of containment policy for the Spey are suggested, Minimal Exclusion and Total Exclusion. For both strategies communication, disinfection, surveillance and publicity costs may be generated. These costs will vary due to the disparity in the range of both policies.

10.9.1 Minimal Policy

Beyond the movement of infected fish, the movement of water or wet items is the most likely source of transfer. The Minimal policy would allow wet equipment to leave the river environment. Ensuring that any parasites in the water cannot reproduce is central to the reduction of risk. The most effective method, because of the shape and type of equipment, would appear to be a pressure spray of the type associated with power washers. A high powered jet would reach the darkest recesses of canoes and dinghies, and cover less complex items such as rods, Wellington boots or boat trailers quickly and effectively. It is also suggested that mats be used at any infected farms, and on the two slipways believed to exist at Loch Insch and Loch Morlich.

Around 20 disinfection stations will be required at a total cost of less than £20,000. Disinfectant[42] costs, at around 10p per boat, will be small as disinfection will only apply to

[42] The costs here relate to the chemical Virkon but research is currently underway comparing effectiveness and environmental friendliness of steam and alternative chemicals.

boats leaving the catchment. Table 10.4 indicates somewhere between 5 -10,000 trips, which gives a cost of £500 - £1000 per annum.

Labour will be required to maintain the sprays and baths, but it is expected that this, along with the Pass scheme, will be managed by the PMUs for a relatively small gratuity. The scheme will require a full time employee at the PMC.

The Pass scheme is expected to cost £25,000 for the sprays, mats and installation, and to have annual operation costs of £75,000.

10.9.2 Total Exclusion Policy

Disinfection is required whenever a ‘wet’ item leaves the catchment. The Total Exclusion policy should prevent any item becoming wet and consequently there should be no need for disinfection.

10.9.3 Education and Publicity Costs

An effective containment policy depends on as many people as possible being made aware of the situation and what they can do to prevent the spread of the parasite. Initially, all groups that need to be informed will have been identified during the development of a communication strategy. This will include maintenance of a database containing all relevant stakeholders. Advertisements on the Spey Fishery Trust website will be required, accompanied by distribution of leaflets. At present, the trust does not hold a database of all anglers so it would be impossible to reach all of them.

Allowing for transport and VAT, where applicable, we estimate that adequate publicity should cost in the order of £100,000 per annum (Table 10.9). In addition, a series of warning signs will be required forbidding angling or boating (without a pass in the case of the Minimal option) and providing information on the nearest disinfection point. We estimate 20 signs will be required at a total capital cost of £8,000.

Although the content of the publicity will differ between Minimal and Total Exclusion policies, the level of publicity will be similar.

Table 10.9 Publicity Cost for Print Design and Distribution of A4 2 Sided Leaflets, A2 Size Posters and a Three Month Advertisement

Type	Number	Cost (£)
Print, Design and Supply		
A4 Full Colour, 2 Sided Leaflets	1 m	
A2 180gsm posters, Full Colour	4,000	
A2 250gsm posters, Full Colour	1,000	
		19,000
Distribution		
Leaflets		6,000
Posters		7,700
Sub Total		**13,700**
Three month advertisement[43]		**58,000**
Total Publicity Cost		**90,700 (+ VAT)**

10.9.4 Security Costs

10.9.4.1 Minimal Exclusion

The Minimal Exclusion policy is based on the pass system discussed above. The river itself does not need to be made secure, although the water bailiffs currently operating to minimise salmon poaching will be required to check passes.

10.9.4.2 Total Exclusion

Total Exclusion requires high surveillance plus, potentially, work on fences and blockades to prevent access to the water. One problem is that containment is effectively endless. Whilst people will respect emergency closure, permanent closure of a huge recreational asset spread over 125 miles would be contentious. Too stringent an application might generate problems of deliberate trespass. Fencing Loch Morlich and Lochan an Eilan, for example, would be both extremely expensive and extremely contentious. Table 10.10 provides indications of cost.

Table 10.10 The Cost of Chain Link Fencing

Fencing	Price per mile (£ incl. VAT)	Loch Morlich Circum. (mi)	Cost (£)
1400mm	45,142	3.1	139,940
1800mm	53,574	3.1	166,079

[43] Advertisements in local and national newspapers will be required. 75 quarter page adverts to regional (Scottish) press and 40 quarter pages in national press – press coverage to run over a 3 month period with editorial coverage arranged free of charge. Costs will run at. £58,000 approx + VAT.

Expenditure of £150,000 to keep individuals away from a loch central to a national park might be difficult for the public to accept. To fence off the river would cost in the order of £25m and is not considered further.

Given that physical solutions are limited, the alternative would appear to be publicity coupled with extensive policing. A high level of security for the size of the system would require a minimum number of security personnel of the order of 12, giving a cost of around £250,000 per annum. It is recognised that in early years lower numbers might not seriously increase risk if they are associated with an effective reporting system by locals when anglers or boaters are seen. It is hypothesised, however, that over decades with little obvious risk, Total Exclusion would become harder to police and there is more danger of deliberate trespass.

10.9.5 Enforcement Costs

As part of the containment strategy, there would need to be a series of by-laws and, eventually, prosecutions for those that infringed them. The nature and number, and hence cost, of such cases are unknowable. However, since the potential number under each policy is not likely to differ, the costs are not considered further.

10.9.6 Summary of Operating Costs of Containment

Table 10.11 summarises the operating costs of the two containment strategies. However, there are also indirect costs on others who currently use the river. These are discussed in the next section.

Table 10.11 Operational Costs of Alternative Containment Options (£)

	Minimal Per Annum	Capitalised	Total Exclusion per annum	Capitalised
Disinfection	75,000	2,500,000	0	0
Security	0	0	250,000	8,250,000
Publicity	100,000	3,308,000	100,000	3,308,000
Total	175,000	5,808,000	350,000	11,558,000

11 The Economic Costs and Benefits of Containment Policies

11.1 Introduction

In addition to the operating costs outlined in Section 10, the economic consequences of alternative containment schemes embrace economic impacts (on income and employment) as well as changes in Net Economic Value (NEV). This section commences with a description of the economic consequences of a Gs infestation in the Spey, and then evaluates alternative containment policies from both an economic impact and a NEV perspective.

11.2 Economic Consequences of GS Infestation

With respect to NEV, the previous section reported that salmon fisheries had a capital value of £54.25m. The total number of salmon angler days on the Spey is 40,543 (Table 11.1), and Consumers' Surplus per day was estimated to be £8.89 (Table 6.4). This gives an annual Consumers' Surplus of £360,427, which would generate a capitalised value of £12m. Assuming Gs infestation would devastate salmon angling, the capitalised loss of NEV is estimated to be £66.25m

With respect to the economic impact of GS infestation, Section 10 reported that salmonid fisherman spent some £10.8m in the area. After appropriate deductions for tax and import effects, and allowance for indirect and induced effects, that is estimated to result in £6.4m income in the locality, associated with 401 FTEs. These Figures need to be modified in two ways:

- Allowance for sea trout as opposed to salmon anglers,
- Allowance for expenditure that will remain in the region through anglers switching to other species, or spending on some other activity within the region.

Table 11.1 Economic Impact of Salmonid Angling in Spey Catchment

Origin of Anglers	Angler Days	Spend Per Day (£)	Total Angler Expenditure (£)	Direct Effect (£)	Spey Income (£)	Total MBSE FTEs
Local	6,386	123	782,290	508,577	450,217	13
Highlands	2,319	114	264,072	196,643	164,521	13
Scotland	5,486	308	1,688,223	1,103,615	1,051,789	74
R. World	26,353	304	8,013,932	5,841,334	4,686,736	301
Total	40,543	228	10,748,517	7,650,169	6,353,263	401

Source: Riddington *et al.* (2004)

The survey of Spey anglers in Section 6 found that 85.8% of the salmonid anglers were fishing for salmon, and that the mean spend was £250, rather than £228. Assuming the distribution of anglers and spend are similar, the impact for salmon alone is 94% of that for the salmonids.

The survey also covered the likely switching behaviour. This is summarised in the Table 11.2.

Table 11.2 Substitution Patterns (%)

	Locals	Visitors	Weighted by Angler Days
Retained in Catchment	21.4	4.3	10.3
Lost to Catchment	78.6	95.7	89.7
Retained in Scotland	57.1	65.2	62.4
Lost to Scotland	21.4	30.4	28.3

Source: Riddington *et al.* (2004)

Combining these factors, the impact of Gs infestation of the Spey to the local area would be a reduction of local income of **£5,359,652 and 338 FTEs lost**.

Because of transfers to other rivers in Scotland (or simply to other activities in Scotland), the nation as a whole would expect to lose less income. However, there are larger multiplier effects at the Scottish level (a Type II employment multiplier of 1.294 compared to 1.23), which will inflate the losses. Taken together, these suggest a drop in Scottish income of £2,365,235, and some 149 FTEs lost.

11.3 Economic Impact of Minimal Containment

Minimal Containment, which is essentially a disinfection policy enforced through a system of penalties for non-compliance, does not restrict angling or any other activity. Apart from some unquantifiable inconvenience costs, the Minimal Containment policy will have no impact on other forms of angling or water-based activity. Neither the local region, nor Scotland as a whole will suffer any addition economic impact effects as a result of this policy.

11.4 Economic Impact of Total Exclusion

In contract to Minimal Containment, a policy of Total Exclusion will have consequences for angling for species other than salmon, water sports and other leisure activities that indirectly use rivers and lochs in the catchment. These are discussed below.

11.4.1 Non-Salmon Angling

The Total Exclusion policy aims to stop all public access to the water. If no angling is allowed, the gross impact, before allowing for substitution (including that for salmon which will, in any case, have disappeared), is shown in Table 11.3.

The additional impact of ending non-salmon angling is the effect of expenditure on sea trout (£376,405), brown trout (£360,731), rainbow trout (£672,549) and coarse fish (£45,732), totalling some £1,455,416. This has an estimated gross impact of **£847,208 on incomes, along with 52 FTEs lost.**

Table 11.3 Economic Impact of All Angling on the Spey

Species	Origin of Anglers	Angler Days	Spend Per Day (£)	Total Angler Expenditure(£)	Income (£)	Total FTEs
Salmon And Sea Trout	Local	6,386	123	782,290	450,217	13
	Highlands	2,319	114	264,072	164,521	13
	Scotland	5,486	308	1,688,223	1,051,789	74
	R. World	26,353	304	8,013,932	4,686,736	301
	TOTAL	**40,543**	**228**	**10,748,517**	**6,353,263**	**401**
Brown Trout	Local	1,910	35	66,559	31,879	3
	Highlands	539	74	39,681	18,997	1
	Scotland	1,023	82	84,129	40,277	2
	R. World	1,342	127	170,361	89,458	5
	TOTAL	**4,815**	**72**	**360,731**	**180,611**	**10**
Rainbow Trout	Local	1,871	26	49,275	23,878	1
	Highlands	1,613	41	66,046	27,560	0
	Scotland	1,660	49	81,606	34,053	2
	R. World	3,042	156	475,622	241,781	4
	TOTAL	**8,186**	**52**	**672,549**	**327,273**	**7**
Coarse Fish	Local	300	38	11,219	5,450	0
	Highlands	253	38	9,552	4,640	0
	Scotland	350	39	13,237	6,431	1
	R. World	299	39	11,724	7,216	0
	TOTAL	**1,202**	**39**	**45,732**	**23,737**	**2**
TOTAL	Local	10,467	97	909,343	511,424	16
	Highlands	4,724	89	379,351	215,719	14
	Scotland	8,519	235	1,867,195	1,132,550	79
	R. World	31,036	285	8,671,639	5,025,191	310
	TOTAL	**54,746**	**193**	**11,827,528**	**6,884,884**	**419**

Source: Riddington *et al.* (2004)

Some of this expenditure will remain within the local economy. Riddington *et al*. (2004) suggest 16%, for brown trout, 27% for rainbow trout, and 16% for coarse fishing. Overall, the economic impact is an additional income reduction of **£664,181 and 40 FTEs**.

At the Scottish level, some 36% of the activity days come from outside Scotland. A number of these will remain in Scotland, and some Scots will leave, but our best estimate of the impact at Scottish level is simply the impact of these visitors. Our best estimate of the effect on Scotland of closing all angling on the Spey is an additional **£305,000 and 19 FTEs lost**.

11.4.2 Water Sports

The gross economic impact for water sports is shown in Table 11.4.

Table 11.4 Economic Impact of Water Sports (No Substitution)

Type	Activity Days	Spend Per Day (£)	Spey Expenditure (£)	Income (£)	FTEs
Centres	38,190[44]	38.25	1,460,751	859,504	49
Descent	1,644	45.99	75,608	34,490	2
Day	5,300	26.58	140,874	44,569	3
Total	45,134	37.16	1,677,232	938,563	54

Source: Riddington *et al.* (2004)

However, as with angling some of the local expenditure will remain in the short term, and virtually all will remain at the Scottish level. Riddington *et al*. (2004) estimate that, after substitution, the net impact will be **£831,985 and 48 FTEs lost**.

11.4.3 Other Activities

Other leisure activities utilise the lochs and rivers indirectly (Section 10.6). We are not, however, in a position to accurately estimate these. In Section 10.6, it is suggested that a moderate 20% of the tourist spend might leave the area, which amounts to £1m. Application of similar ratios to those used for water sports leads, in the local area, to a fall in income of **£500,000 and 30 FTEs lost**. To obtain a figure for Scotland it has been assumed that half of this impact will apply.

11.4.4 Summary of Impact of Total Exclusion

The closure of the Spey catchment to users will affect non-salmon anglers, water sportspersons and tourists. This impact is summarised in Table 11.5

Table 11.5 Economic Impact of Total Exclusion Policy

	Local		Scotland	
	Income (£)	FTEs	Income (£)	FTEs
Water Sports	831,985	48	0	0
Angling	664,181	40	305,000	19
Other Recreation	500,000	30	250,000	15
Total	1,996,066	118	555,000	34

Our research suggests that the total economic impact on the local economy would approach £2m, with 118 associated FTEs lost. For Scotland as a whole, some £0.5m and 34 FTEs would be lost. The operational costs of containment policies generates local income (£250,00) and jobs (12 FTEs) to patrol the Spey and enforce the Total Exclusion policy. Similarly, the Minimal Exclusion policy would generate local income (£100,000), and would

[44] Includes gorge walking/burn running.

probably create one FTE locally. At the level of Scotland as a whole there would be no net impact arising from the operating costs.

11.5 Loss of NEV from Containment Policies

11.5.1 Introduction

The costs of operating alternative containment policies are discussed in Section 10.8. In this section we also look at the cost to other groups. Specifically, we estimate the change in NEV as a result of this policy. It is important to note that there is no loss of NEV to salmon anglers from either containment policies. The loss of NEV occurred as a result of a natural phenomenon, and the failure of a policy designed to prevent entry to Gs to Scotland in particular.

11.5.2 Loss of NEV with Minimal Containment

The Minimal Containment policy should have little effect on other groups. There may be some small time delays at disinfection stations, but angling for other species would continue as before – as would water sports and recreational use of the water edge.

11.5.3 Loss of NEV from Total Exclusion

As discussed in section 11.4, a Total Exclusion policy imposes costs on non-salmon anglers. The next sections try to estimate the loss of value.

11.5.3.1 Other Anglers

The numbers currently involved in salmonid angling are given in Table 11.1. The ratio of salmon to sea trout days allows us to calculate the number of days for sea trout currently being undertaken. However, if salmon angling ceases the survey of anglers reported in Section 5 indicates the proportions that would shift to angling for sea trout and other species in the catchment. Together, these provide an estimate of the number of angler days that would be affected, and is summarised in Table 11.6.

Table 11.6 Angler Days Lost as a Result of Total Exclusion Policy

	Now	Additional	Total
Sea Trout	5,758	623	6,381
Other	14,203	1,919	16,122
Total	19,961	2,542	22,503

The Consumers' Surplus associated with other forms of angling has not been directly surveyed. For this exercise, it has been assumed the surplus on all forms of angling are similar, and a value of £8 per angler day[45] has been applied to the 22,500 anglers affected. This gives a cost of £186,026

11.5.3.2 Water Sports and Other Leisure

No data is available to provide estimates of the change in NEV, and it was outside the scope of this study to obtain direct estimates. Riddington (2006) used data gathered from the river

[45] Table 6.4

survey to estimate the value of natural characteristics such as flow rate to the individual kayaker. The approach is very similar to the Travel Cost Method, and one output from the study was an estimate of a mean Consumers' Surplus to a kayaker on the Spey of £22.66. A number of problems then arise. Firstly, to calculate the net change in NEV, we need the Consumers' Surplus of the next best alternative. Given the quality and number of the alternatives available, the loss of welfare may be quite small. Secondly, the survey relates to kayakers on the river whilst the majority of water sports take place on Loch Morlich and Loch Insch, often with young people. Whilst we might expect the surplus for this group to be lower, good alternatives close to, but outside, the catchment are limited. In these circumstances the net change in welfare might be similar to that of general kayakers.

The loss of welfare to other leisure groups camping or walking in the catchment could approach £1m, simply because of the very large numbers involved (Section 10). For this study, failure to include a cost for these groups might significantly distort the assessment. As an exercise, therefore, we have identified three levels of 'costs' to these users. The hypothesised values are given in Table 11.7.

Table 11.7 Loss of NEV from Total Exclusion Policy for Other Recreational Users (£)

	Surplus (Kayakers) per Activity Day	Surplus (Kayakers)	Other Users	Total
Low	2.50	112,835	250,000	362,835
Medium	5.00	225,670	500,000	725,670
High	10.00	451,340	1,000,000	1,451,340

A critical feature of a closure policy is that it will be in place for the foreseeable future because Gs has not been eradicated and would continue to pose a threat to other salmon rivers. Thus, the actual costs of high surveillance, disinfection, fencing etc will continue, as will the costs to those deprived of access to the water. It is, therefore, appropriate to capitalise these costs which are summarised in Table 11.8.

Table 11.8 Total NEV Costs of Containment on Spey (£)

	Minimal Per Annum	Capitalised	Total Exclusion per annum	Capitalised
Disinfection	75,000	2,500,000[46]	0	0
Security	0	0	250,000	8,250,000
Publicity	100,000	3,308,000[47]	100,000	3,308,000
Other Angling	0	0	180,026	5,940,864
Other Groups	0	0	725,670	23,947,110
Total	175,000	5,808,000	1,255,696	41,445,974

[46] Includes initial capital cost of £25,000
[47] Includes initial capital cost of £8,000

11.6 Conclusion on Containment Policy

Without salmon the value of the river as an angling amenity, closed or open, to salmon anglers is zero. The objective of closure is to retain the value of salmon fishing in the rest of Scotland (summarised in Table 7.1). Clearly, if it does not achieve that objective then the Expected Value of the policies is zero. Table 11.9 provides a summary of the economic impacts at local and Scottish level, and of the NEV of applying a Total Exclusion policy.

Table 11.9 Summary Table Showing Local and Scottish Wide Impact and NEV of Applying a Total Exclusion Policy

	Local		Scotland			NEV	
	Income (£)	FTEs	Income(£)	FTEs		Annual (£)	Total (£)
Other Angling	664,189	40	305,000	19	Operations[48]	350,000	11,558,000
Water Sports	831,695	48	0	0	Anglers	180,026	5,940,864
Other Recreation	500,000	30	250,000	15	Others	725,670	23,947,110
Total	1,995,884	118	555,000	34	Total NEV	1,255,696	41,445,974

The benefit of preventing Gs entering the rest of the system approaches the £633m value of the whole system. If the movement of water or fish from the infected catchment is stopped the risk of transfer drops to very low, and the most important transmission mechanism becomes equipment used for angling and boating. The risk from this source can be virtually eliminated by the use of disinfection. We have sought to design an indicative scheme that should ensure a high level of disinfection through appropriate incentives and penalties. The cost is surprisingly small at £175,000 per annum.

Given the £633m of lost NEV that would accompany widespread Gs infestation, we can assess the reduction in risk associated with a policy necessary to justify the cost. As an example, a 1% reduction in risk would be valued at £6.33m. Similarly, if the risk is very small then large sums are not justified to prevent that risk. Table 11.10 looks at the cost of the two policies and the reduction in risk necessary to justify them.

Table 11.10 Costs of Containment Policies and the Risk Reductions Required for Justification

Policy	Capitalised Cost (£m)	Reduction in Risk Required (%)
Minimal	5.8	0.91
Total Exclusion	41.4	6.54
Difference	35.6	5.6

If the initial risk is less than 5.6% then Total Exclusion as a policy cannot be justified over Minimal.

[48] Disinfection, Security & Publicity

The key elements of this rather technical analysis can be more simply expressed. Total Exclusion affects large numbers of other water users. Therefore, despite the very high value of salmon angling, in choosing the Total Exclusion policy over the Minimal Exclusion policy two conditions need to be considered:

a) In the event of Gs infecting a catchment there will be a risk of its spread to other rivers. Ideally, there should be evidence that that probability of transmission in the absence of any policy is high, estimated to be 6.5% or over.

b) The difference between the lowest risks that justify Minimal or Total Exclusions is 5.6%. Therefore, in choosing between the two policies, ideally there needs to be evidence that Total Exclusion reduces the risk of spread by 5.6% more than the risk reduction due to Minimal Exclusion.

It must be emphasised that catchments vary in other-user intensities and in physical characteristics. Each system will need to be examined individually before a decision on the most appropriate scheme can be made.

12 Summary and Conclusions

12.1 Introduction

The *Economic Evaluation of the Impact of the Salmon Parasite Gs should it be introduced in Scotland* commences with an assessment of the consequences of widespread Gs infestation across the nation. This is the worst case scenario which would only happen in the absence of intervention to deal with Gs. It represents the baseline against which the costs and benefits of policy initiatives are assessed.

Three forms of policy intervention were investigated, based on the following measures:

1) **Prevention** The maintenance of Gs free status in Scotland.
2) **Eradication** The re-establishment of Gs free status.
3) **Containment** The restriction of the spread of Gs.

The study has used two approaches to evaluate the economic consequences:

1) Calculation of the economic value, and in particular, the Net Economic Value (NEV), as a measure of the change in individuals' wellbeing, as reflected in their willingness to pay (WTP).
2) Essentially, the change in national or regional income and employment after a change in circumstance.

12.2 Policy Off: Widespread Gs Infestation in Scotland

Widespread infestation of Gs in Scotland would destroy salmon angling. Salt water aquaculture activities would be unaffected, provided the supply of smolts can be maintained. Commercial self-interest would lead to the development of biosecure hatcheries to provide smolts, or that they could be imported from elsewhere, for example Norway or Ireland.

The economic consequences associated with the loss of salmon angling are given in Table 12.1 (see Table 7.1)

Table 12.1 Summary of the Economic Consequences of Widespread Gs in Scotland

Adverse Economic Impact		Net Economic Value Lost (£m)		
Total Salmon Angler Expenditure in Scotland Each Year (£m)	61.7		**Annual**	**Capitalised**
Expenditure Lost to the Scottish Economy Each Year (£m)	44.8	Economic Rent	16.5	550.0
Lost Scottish Household Income Each Year (£m)	34.5	Consumers' Surplus	2.5	83.1
Lost Scottish Employment (FTE) Each Year	1,966	Net Economic Value	19.0	633.1

12.3 Prevention

Table 12.2 presents a summary of the costs of two measures, publicity and disinfection at ports (see Tables 7.2 and 7.3).

Table 12.2 Summary of Measures to Prevent Gs Entry

Action	Applicable Years	Annual Cost (£)	Capitalised Cost (£)
Publicity	All	156,100	5,151,300
Disinfection Equipment[49]	1	66,000	66,000
Maintenance	All	20,000	660,000
Disinfectant	All	5,000	165,000
Total		247,100	6,042,300

The cost of improved protection measures is small in comparison with the value protected.

12.4 Eradication: The Luce

The Luce was chosen as an exemplar of a situation in which eradication was clearly feasible (Section 9). In the Luce, there were just over 600 anglers days with a total directly related expenditure of £21,500. On the Luce, Gs has no implications for aquaculture.

There are three potential treatment options:

1) containment (estimated capitalised cost £1.65m[50]),
2) eradication by rotenone,
3) eradication by aluminium sulphate (AlS).

The costs and benefits of both eradication methods are summarised in Tables 12.3 and 12.4 (as Tables 9.6 and 9.7). The benefits in these tables exclude the benefit of removing the transmission risk associated with the containment policy. For example, with a 1% probability of Gs on the Luce being transferred within the policy's duration, even with containment measures in place, then there is an additional expected economic value of £6.33m (0.1 x £633m) attributable to eradication.

Table 12.3 clearly shows the benefits of eradication by rotenone exceed the benefits of containment, even if we ignore the benefits from removal of the transmission risk. The costs and benefits of AlS treatment are given in Table 12.4.

For the Luce, treatment with rotenone would appear to be the preferred option on economic grounds. However, a larger more productive salmon river might suggest that AlS treatment

[49] Includes equipment, set-up and instruction notices
[50] Based on estimated annual cost of £50,000

was economically more advantageous, but this would depend on many factors, and it is difficult to generalise.

Table 12.3 Costs and Benefits of Treatment with Rotenone

COSTS				**BENEFITS**			
Element	**Applicable Year**	**Annual Cost (£)**	**Present Value (£)**	**Element**	**Applicable Years**	**Annual (£)**	**Present Value (£)**
Rotenone Treatment	1	676,620	713,609	Salmon Rents	11 to end	22,879	561,791
Sea Trout Rents	1 to 10	5,000	42,651	Salmon CS	11 to end	1,266	31,087
Sea Trout C.S.	1 to 10	1,000	8,530	**Sub-Total**			592,878
				Avoidance of Containment Costs	1 to End	50,000	1,650,000
Total Cost			**764,790**	**Total Benefit**			**2,242,878**
Benefit-Cost			**1,478,087**	**Benefit/Cost Ratio**			**2.93**

Table 12.4 Costs and Benefits of Treatment with Aluminium Sulphate

COSTS				**BENEFITS**			
Element	**Applicable Year**	**Annual Cost (£)**	**Present Value (£)**	**Element**	**Applicable Years**	**Annual (£)**	**Present Value (£)**
AIS Treatment	1	1,084,348	1,084,348	Salmon Rents	1 to end	22,879	755,000
				Salmon CS	1 to end	1,266	41,778
				Sub-Total			**796,778**
				Avoidance of Containment Costs	1 to End	50,000	1,650,000
Total Cost			**1,084,348**	**Total Benefit**			**2,446,778**
Benefit-Cost			**1,362,430**	**Benefit/Cost Ratio**			**2.26**

12.5 Containment Policy: The Spey

The Spey is a much more complex river system with a number of vulnerable protected species. This report considered the options for containment if the decision was taken that treatment would not be feasible on economic, political, and or legal grounds. Two containment policies were examined:

- Minimal Exclusion, where only the transport of fish and 'water' is banned, and
- Total Exclusion, where public access to the water is banned.

Table 12.5 combines the information on Economic Impact of the loss of salmon on the Spey (Tables 11.1 and 11.2), the Economic Impact on other users of the Total Exclusion containment policy (Sections 11.2.4.), and the expenditure (and jobs) associated with the alternative containment policies (sections 10.7.1 and 10.8.4). Implementing the policy does, however, generate jobs, for example, those involved in running the disinfection pass system, and the security officials needed to patrol the Spey to ensure there is no usage.

Table 12.5 Economic Impact of Containment Policies on Scotland and the Local Area

		Minimal		Total Exclusion	
		Income (£)	**FTEs**	**Income (£)**	**FTEs**
Scotland	Other Angling			305,000	19
	Other Recreation			250,000	15
	Total			**555,000**	**34**
Local	Water Sports			831,000	48
	Other Angling			664,000	40
	Other Recreation			500,000	30
	Less Containment	-100,000	-1	-250,000	-12
	Total	**-100,000**	**-1**	**1,745,000**	**106**

Under the Minimal Exclusion policy it was estimated that there would be a net gain of £100,000 and one FTE in the local MBSE[51] area. For Scotland as a whole, there would be no impact on income and employment.

The Total Exclusion policy has a greater effect because it stops all angling, all water sports and will also affect the attractiveness of the area for the 1m tourists who visit the Cairngorm National Park and lower Spey. We estimate that the effect of Total Exclusion on MBSE would be £1.75m and 106 FTEs. The impact on Scotland as a whole is much lower because most users will simply shift their activities to somewhere else in Scotland, or, in the case of the FTEs created to run the policy, will be transferred from elsewhere in Scotland.

The income and employment loss for Scotland would be £0.55m and 34 FTEs.

The implications for NEV of containment policies are summarised in Table 12.6.

The benefit from preventing Gs spreading to the rest of Scotland is £579m (NEV of £633m for Scotland as a whole, minus the £54m NEV lost on the Spey). When the movement of water or fish from an infected catchment is stopped, the risk of transfer drops to very low. In this case, the most important transmission mechanism becomes equipment used for angling and boating. Potentially, the risk from this source can be virtually eliminated by the use of disinfection. We have sought to design an indicative scheme that should ensure a high level

[51] The former Moray, Badenoch and Strathspey Enterprise Area, which is broadly contiguous with the Spey catchment

of disinfection through appropriate incentives and penalties. The cost is surprisingly small at £175,000 per annum.

Table 12.6 Total NEV Costs of Containment on Spey (£)

	Minimal per Annum	Capitalised	Total Exclusion per Annum	Capitalised
Disinfection	75,000	2,500,000	0	0
Security	0	0	250,000	8,250,000
Publicity	100,000	3,308,000	100,000	3,308,000
Other Angling	0	0	180,026	5,940,864
Other Groups	0	0	725,670	23,947,110
Total	175,000	5,808,000	1,255,696	41,445,974

Total Exclusion affects large numbers of other water users. Therefore, despite the very high value of salmon angling, in choosing the Total Exclusion policy over the Minimal Exclusion policy two conditions need to be considered:

a) In the event of Gs infecting a catchment there will be a risk of it's spread to other rivers. Ideally, there should be evidence that that probability of transmission in the absence of any policy is high, estimated to be 6.5% or over.

b) The difference between the lowest risks that justify Minimal or Total Exclusions is 5.6%. Therefore, in choosing between the two policies, ideally there needs to be evidence that Total Exclusion reduces the risk of spread by 5.6% more than the risk reduction due to Minimal Exclusion.

Unfortunately, information on transmission probabilities is not currently available. It must be re-emphasised that each catchment will have different ,other user, intensities and physical characteristics, and each river system will need to be examined individually before a decision on the most appropriate scheme can be made.

12.6 Other Measures

Finally, there are four initiatives that cannot properly be described as containment or eradication measures; they are essentially complementary to these strategic approaches, in the event of Gs being identified in Scotland. These are:

- Increased surveillance,
- Gene-banking,
- Fish farm biosecurity,
- Catchment biosecurity.

Of these, catchment biosecurity would appear to offer the highest likelihood of a high expected economic benefit/cost ratio, and it might be appropriate to consider identification of all catchment links.

Table 12.7 Costs of Other Measures (£)

Action	Applicable Years	Set-up Costs Plus One Year Costs	Capitalised Cost
Hatchery Biosecurity[52]	1	30,000,000	30,000,000
Increased Surveillance	all	522,000	13,711,500
Gene-banking	all	17,200,000	56,000,000
Catchment Biosecurity	1	100,000	100,000

52 This is a very rough estimate. Detailed survey of each potential crossing point and the necessary measures that need to be undertaken is required. However, it is currently thought that work required is very limited.

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Appendix 1. Salmon Life Cycle and Glossary

In this report a variety of names are used for the salmon at each stage of its life cycle. This section is intended to provide a glossary for the non-specialist.

Salmon typically spawn in rapidly flowing, clear streams with gravel and rocks in the bottom. Before mating, one parent excavates a nest, or redd, for the eggs. The female deposits eggs (**ova**) in the nest and the male releases sperm, or **milt**, over the eggs to fertilize them. The female then stirs up the stream bottom so that earth and stones cover the eggs and protect them. During the migrations and nest-building activity that precede mating, neither the females nor the males consume food.

The eggs hatch in two weeks to six months, depending on the species and the water temperature. The newly hatched young, called **alevins**, remain buried in the nest, living on nutrients absorbed from a yolk sac attached to the abdomen. When all the yolk has been absorbed, the young salmon, then called **fry or fingerlings**, emerge from the gravel to seek food. Their diet consists of microscopic plants and small animals, such as insects.

As the fry feed and grow larger, dark vertical bars appear along their sides. At this stage they are referred to as **parr or brandlings**. The amount of time the young salmon spend in fresh water depends on the species. Eventually the young salmon turn bright silver and, in the case of seagoing forms, descend to the sea. At this stage they are called **smolts**. When they are fully grown and have reached sexual maturity, the salmon begin the migration back to fresh water to reproduce. Different species of salmon spend different amounts of time in salt water before migrating back to their birth stream to spawn. Those returning after 18 months (i.e. one summer at sea) are relatively small and are known as **grilse.** Fish may spend up to six years at sea before returning to spawn. After forcing a way upstream, spawning and going without food for several months the fish either dies or returns to the sea. The mature fish, now in very poor condition, is known as a k**elt** and is never retained by the angler. It may recover in the ocean to repeat the trip up river to spawn again.

Salmon farming involves a freshwater stage to produce smolts, and a seawater stage to grow the salmon to a size ready for production. The freshwater stage may involve two or more sites; a hatchery close to a productive river and a nursery for growth of fry or parr to smolt stage, which may be located closer to the eventual seawater farm.

Appendix 2. Other Sources of Net Economic Value of Angling and Fish Stocks

A2.1 Net Economic Value of Angling

A2.1.1 Existence and Bequest Value of Angling (EVa & BVa).

In addition to consumers' surplus, some individuals in society may derive an existence value from knowing that the angling activity exists and is enjoyed by others. In other words, they would be willing to pay something to preserve the activity for the enjoyment of their contemporaries. This is existence value of angling (EVa)

Some individuals may derive some satisfaction from knowing that future generations will be able to participate in the activity and are even willing to pay something to ensure future generations' participation. This is the bequest value of angling (BVa)

The common feature of BVa and EVa is that they derive from the individual's appreciation of a consumptive use of a natural resource by others. These are passive or non-use values, but relate to a consumptive use value. Essentially, if they exist, they arise from the altruism of individuals. If a sizeable proportion of the non-angling public has some vicarious concern for anglers, then EVa and BVa might be significant, but this is unlikely. Indeed, the non-angling public is just as likely to view angling as an undesirable activity because of its impacts on fish welfare. In contrast an angler may have an altruistic concern for fellow anglers that manifests itself in a willingness to pay (WTP) so that others, now and in the future, may participate. Our view is that there may be EVa and BVa, but only within the angling population. Similar existence and bequest values could exist for paddle sports.

A2.1.2 Option Values of Angling OVa.

EVa and BVa reflect circumstances where the individuals are sure of their income, preferences (both now and in the future), and the availability of the natural resource when they (and others) wish to use it. If there is uncertainty, say, about the future availability of an activity. and if we assume that individuals show 'risk-aversion', then there is the possibility of another category of value.[53] If we presume that anglers would be prepared to pay a premium to avoid risk, then this gives rise to their option value.

A2.1.3 Total NEV of Angling

In conclusion, the NEV of angling is as follows:

$$\text{NEV of Angling} = CSa + ER + EVa + BVa + OVa$$

A2.1.4 Net Economic Value of Fish Stocks

Wildlife and amenity assets e.g. (fish stocks) give rise to a range of non-consumptive or passive economic values (as distinct from consumptive uses such as angling).

[53] Risk-averse individuals would, for example, prefer a certain outcome of £100 to a gamble having the same aggregate outcome (e.g. a 50% chance of £50 and a 50% chance of £150).

A2.1.5 Passive User Values (PUVs)

Activities such as wildlife photography are non-consumptive, but are still based on direct contact with natural resources. Participants in these activities have a WTP. Many species may be observed at particular locations at certain points in time, and riverside walking may be enhanced simply by the prospect that fish may be seen.

A2.1.6 Passive Indirect User Value (PIUVs)

Through reading about wildlife or watching TV nature programmes, an individual may derive enjoyment from a resource without direct contact. Again, WTP is the appropriate measure, but will not be significant for fish stocks in any given surface water area in the UK.

A2.1.7 Existence and Bequest Value of Passive Direct and Indirect Use of Fish Stocks (EVpu & BVpu)

Some individuals in society may derive an ‘existence value' from knowing that the stock is enjoyed by others. In other words, they would be willing to pay something to preserve the passive enjoyment of their contemporaries. This is the Existence Value of passive direct and indirect use of stocks (EVpu).

Some individuals may derive some satisfaction from knowing that future generations will be able passively to enjoy fish stocks, and are even willing to pay something to ensure future generations’ participation. This is the Bequest Value of passive direct and indirect use of stocks (BVpu).

The common feature of BVpu and EVpu is that they derive from the individual's appreciation of a passive use of a natural resource by others. These are passive values and relate to passive use values. Essentially, if they exist, they arise from the altruism of individuals.

A2.1.8 Option Value of Passive Direct and Indirect Use of Fish Stocks (OVpu)

Individuals may have a WTP to preserve the option of passive encounters with the stock. If PUV and PIUV are insignificant then so is OVs . Conceivably there could be bequest and existence values associated with passive use (and indirect use) of fish stock, but this is unlikely.

A2.1.9 Existence Value of Fish Stocks (EVs).

People may derive an 'existence value' from simply knowing that the natural resource exists. This represents a vicarious concern for the stock itself, and is a non-use value of the stock. EVs does not relate to any use, now or in the future, of the stock, but arises out of a sympathy for the right of the species to continue to exist. In Scotland there may be significant

WTP to preserve the Atlantic salmon species, given that it has almost emblematic status. EVs could be relevant for both the angling population and the general public.

A2.1.10 Total NEV of Fish Stocks

Theoretically, the NEV of fish stocks is given by:

NEV of Fish Stocks = PUVs + PIUVs + EVpu + BVpu + OVpu + EVs

In our judgement, only EVs has any potential relevance. However, its estimation would require a very extensive research effort

Appendix 3. The Relationship Between Annual and Capital Value

Values in the present and future are not simply aggregated. The value of £10 now is worth more that £10 next year because if £10 had been placed in a bank at 5% interest then next year it would be worth £10.50. Conversely, £10.50 next year is worth £10 now. Any value in the future can be given a Present Value (PV) by discounting at an appropriate discount rate. For example a value V_5 obtained in five years time has a Present Day Value of $V_5/(1+r)^5$. The aggregation of the PVs from a flow of values into the future is known as the Capital Value. If investment is required then we subtract the discounted current and future payments and the capital value is then known as the Net Present Value (NPV).

It is important to note that all assessments are undertaken using real values i.e. values at constant prices.

Resources in the environment have two characteristics. Firstly, there is no reason to suppose that the value of a service provided by a natural resource (e.g. a mountain walk or salmon angling) will change on a year to year basis. Secondly, because there is little risk that this value will not be realised, then the discount rate will be low, typically about 3% in real terms.

Suppose the annual value from the resource is V. Then the capital value is:

$$CV = V/(1+r)^0 + V/(1+r)^1 + V/(1+r)^2 + \ldots + V/(1+r)^n + \ldots\ldots\ldots$$
$$= V^*(1 + k + k^2 + k^3 + \ldots\ldots\ldots\ldots + k^n + \ldots\ldots\ldots) \text{ where } k = 1/(1+r)$$

The sum of an infinite series $1 + k + k^2 + k^3 + \ldots\ldots\ldots + k^n + \ldots\ldots = 1/(1-k)$.

Substituting k = 1/(1+r) gives CV = V* (1+r)/r = V*(1+1/r). If the flow is assumed to start in period 1 then CV = V*(1/r)

Thus if r =0.03 then CV = either V*(1+1/0.03) = V*34.333. (or V* 33.3. if all the values are in the future).

This simple relationship allows a capital value (such as the price of angling rights) to be recognised as an annual value flow V= CV*0.03 or an annual flow of say consumer surplus or rent capitalised (CV =V*33.3)

Appendix 4. Opportunity Costs and the Correct Pricing of Labour

Angling provides a significant number of skilled full time equivalent jobs (FTEs) in an environmentally friendly sustainable industry. It would appear almost obvious that these FTEs are important to the local community, and the community will be worse off if they are lost. Economic impact analysis seeks to assess these local effects. This section concerns the treatment of labour within the Total Economic Value/Cost Benefit Analysis (TEV/CBA) framework, which is predicated on a different set of value judgements.

The treatment of labour in Net Economic Value (NEV) calculations is not straightforward. Society's NEV derived from salmon angling is the anglers' willingness to pay (WTP) for all aspects of the whole recreational experience (from planning the trip through to reflection) minus the Opportunity Cost of all the resources they use (ghillie services, food and drink purchased, travel, accommodation etc). Normally, we use the market value of the resources used (in particular wages) to represent opportunity cost. However, if labour would otherwise be unemployed, wage rates do not represent society's opportunity cost.

The wage is composed of two elements: the transfer value, which is the value of the resource if employed in the next best activity: and the economic rent, which is the value generated by the specific skills of the individual in that job. If we assume that most of the wage is the transfer value, i.e. the opportunity cost, and that FTEs will quickly be found, then it is reasonable to price labour at the market rate. The standard approach to employment is based around the assumption that in a changing economy we would expect some frictional unemployment. This is how the Treasury usually justifies labour being priced at its market rate.

Our view is that these assumptions are too extreme. Firstly, it is believed that in many cases the wages exceed the opportunity cost and that significant training activity (often undertaken at considerable cost by local enterprise companies) would be required before an individual is able to produce work of equivalent value. Secondly, the evidence suggests (see for example Boheim & Taylor, 2000) that re-employment is not instantaneous, and, indeed, some will never work again. Indeed, for our typical male employee in full time work Table A4.1 shows a worrying 28% are not re-employed within 2 years.

Table A4.1 Unemployment Duration by Gender and Destination State (Surviving Percent)

Destination state	Duration (months)									
	1	2	3	4	5	6	9	12	18	24
Men										
All states	92	80	66	58	50	44	30	24	16	12
Full-time employment	94	84	75	69	62	57	45	40	33	28
Any employment	93	82	70	63	56	50	38	32	24	20
Women										
All states	86	70	56	46	39	32	21	14	9	7
Full-time employment	91	83	74	68	62	57	48	41	34	33
Any employment	88	76	64	56	49	41	29	23	17	14

Source: Boheim & Taylor (2000)

The likelihood of leaving a given state (in this case unemployment) is known as the Hazard Rate and the corresponding function, the Hazard function. The data and a fitted function are shown in Figure A4.1. This suggests that we might expect some 30% of our workforce not to regain employment, and to progress to leave the labour market through retirement, ill health or migration.

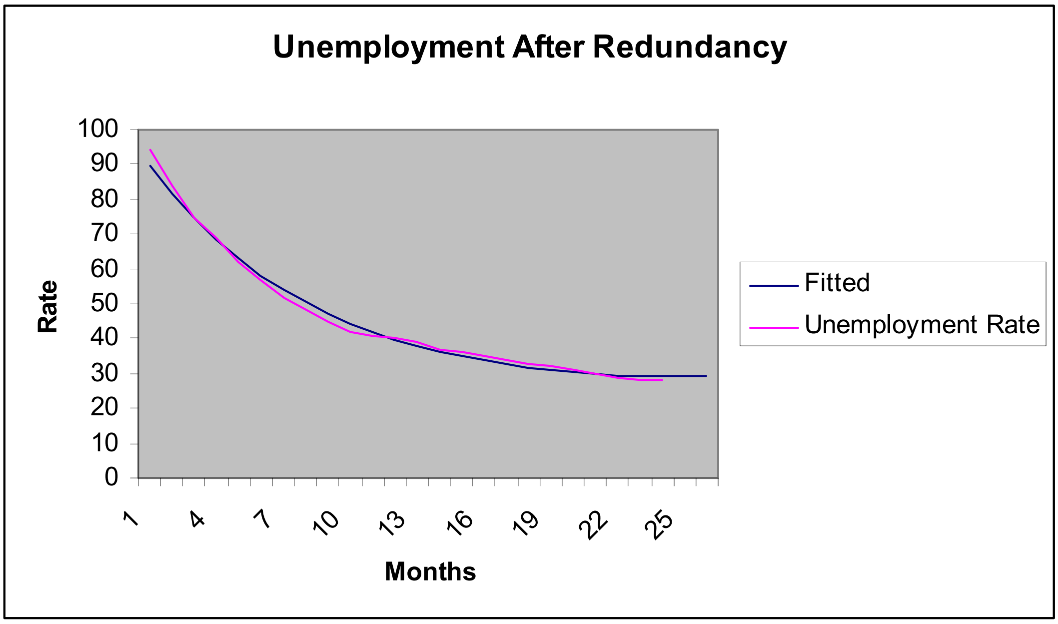

Figure A4.1 Unemployment After Redundancy

The economic impact analysis provides a snapshot of the situation after a change, in this case the termination of salmon angling. In the Scottish closure scenario this found 2,212 FTEs lost with an associated income of £38.7m, with equivalent impact on Scotland of a Spey infestation of £2.37m and 149 FTEs. However, this assumes that expenditure will be immediately transferred to other activities in the region. Without this assumption, the number made unemployed is 2723 with a gross income of £47.7m. These figures incorporate those directly involved in generating the angling experience, those indirectly involved, and those who are in FTEs because of the health of the local economy (the induced demand). Only the wages of those directly and indirectly involved can be regarded as resource costs; thus the number directly or indirectly losing their FTEs is 2206 with a wage bill of £36.6m.[54]

In the first year, 60% of those laid off are re-employed. Some of these (30%) move into industries associated with the substitute expenditure (e.g. sea trout or other angling) with the balance taking up new or released FTEs. At the end of year 1, 40% of those who lose their FTEs are not in employment. For year 2, we estimate this falls to 30%. Since employment life is constrained, and it is the older workers who are most immobile, we assume a maximum period of ten years unemployment before retirement or re-employment with the balance falling linearly to zero at the end of year 10.

[54] Indirect labour has been included because it is essential to the angling experience, and differences are definitional. For example, an estate with in-house river maintenance or catering would have all workers classified as direct whereas sub-contracting these services would identify them as indirect. There was some debate about the opportunity cost of the individual supplying goods and services to those made unemployed who consequently as a result also become unemployed. As we are unable to evaluate the benefit associated with induced purchases it seemed unreasonable to make allowances for opportunity costs associated with them, and they have not been included in the calculus.

However, even if labour remains unemployed, the recreation activity enjoyed by those unemployed is an opportunity cost of employment. The value of recreation is normally assumed to be about one third of the wage (e.g. in transport studies, the value of leisure time is assumed to be one third that of work time). Thus, we can calculate the overestimation of opportunity cost by taking 66.6% of the wage applied in the first year to 40% of those made redundant, and in the next 9 years to 30% declining annually to zero of those made redundant. The over-estimation in future years is discounted in the normal way to give a present value. This is summarised in table A4.2

Table A4.2 The Overestimation in Future Years for Scotland, Spey Local Effect and Spey Scotland Wide

	FTEs	Income (£m)	Over Estimate Year 1 (£m)	Over Estimate Year 2 (£m)	Present Value (£m)
Scotland	2206	36.60	9.76	7.32	40.16
Spey Local Effect	338	5.36	1.43	1.07	9.49
Spey Scotland Wide	149	2.37	0.63	0.47	4.20

The overestimation of opportunity cost in Scotland (or the Spey area) is dependent upon the speed of the return to full employment. Initially, labour is employed to meet expanding expenditure in other areas as salmon anglers spend their money elsewhere. Later, unemployment declines as entrepreneurs move in to make use of the disused infrastructure (e.g. empty hotels) and unemployed labour. Our forecast assumes a 'normal' rate of recovery. This rate can be accelerated by concentrated action by local enterprise companies but, in this case, the activity is so widely distributed that concentrated efforts are unlikely to generate positive returns. Conversely, in a period of economic recession the recovery rates are likely to be high.

In summary, under normal conditions, **the overestimation of opportunity cost**, due to a loss of salmon angling resulting from persistent unemployment, is estimated to have a present value (capital) of **£40m** for Scotland, and £2m for Scotland if there is infestation limited to the Spey.

Appendix 5. Estimation of Consumer Surplus by Travel Cost Method

A5.1 Introduction

Consumer surplus represents the aggregation of the prices individuals would have paid less the price actually paid. Diagrammatically it is the area ABC in Figure A5.1.

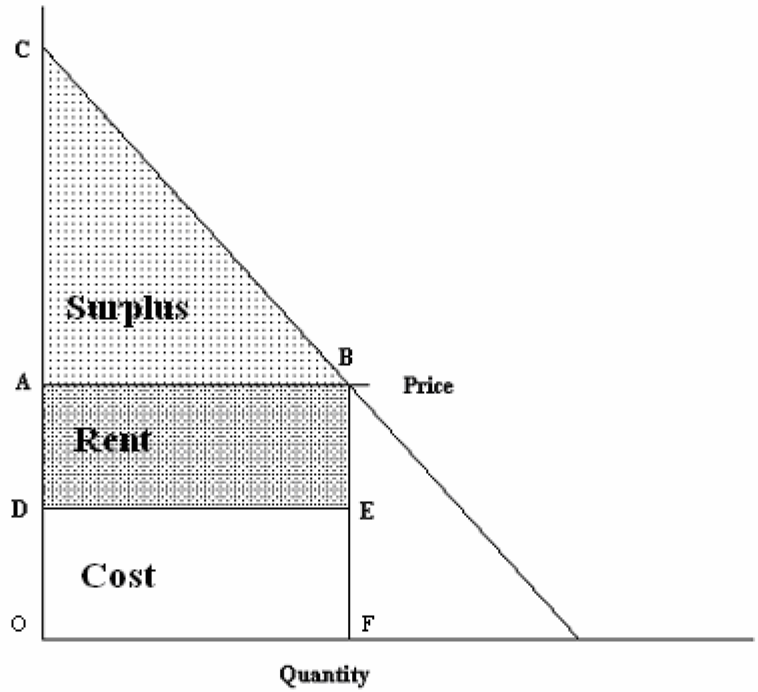

Figure A5.1 Demand, Rent and Surplus

To establish this area, we need to identify the relationship between the price and the quantity, the Demand curve.

If the cost of providing the fishing is given by DEFO, the economic rent is represented by ADEB and the Value by the combined area CBED.

A5.2 The Data

Data to establish a demand curve can be obtained by observing changes in demand and changes in the factors that determine it over time, over space or over time and space. For a study of Scottish Angling for SEERAD (Radford *et al*., 2004) data had been obtained from a census of suppliers on the total number of activity days individuals from six areas of Scotland (Dumfries and Galloway, Borders, Central, Highland, North East Scotland, Western Isles and Orkney & Shetland) and five other areas (Northern England, Ireland, Rest of UK, Mainland Europe and North America) spent fishing in the six Scottish Areas.

The price of a product to the consumer is always problematic. Travel Cost Method (TCM) developed from trying to establish the value of recreational sites such as forests where the only cost was the cost of transport to and from the site. By examining distances and assuming a linear relationship between distance and generalised cost (which includes direct costs such as petrol, indirect coats such as depreciation plus the value of time) we obtain a typical price for utilising the service. We considered such an approach but in practice this would have failed because:

1) It would fail to include other direct costs of angling specifically rent.
2) Travel was multimode, the mode mix was unknown, and, particularly for air, the 'cost' of a typical journey was unknown.
3) For overnight stays the travel cost had to be split over the number of days but an accommodation cost was essential.

The alternative was to consider the daily cost of the holiday. For the SEERAD study the expenditure of a large sample (3000) of individuals from the 11 home areas in the six fishing regions had been obtained which provided an 'average price' paid by individuals. Some 57 combinations were identified which, with the total flows to Scotland from the 11 home areas, provided 68 data points relating activity days and prices paid.

Demand is not, however, simply a function of price. Clearly *ceteris paribus* we would expect a large home area to have more anglers at a location than a small area. Indeed on *a priori* grounds we might expect the numbers to be directly proportionate to the populations. Population of the home area must therefore enter the demand function.

A third critical factor is the supply of angling, both volume and quality in the fishing region. Large numbers of fish in a large number of rivers will attract more angling. To capture these inter-regional differences, a series of dummy variables were used.

A final factor that was considered is the nature of the home location. Although angling has massive appeal for all classes and locations, it is still a 'country sport' and we might expect the participation rate to be far higher in rural areas than in urban.

A5.3 Specification

The general functional form considered is:
$Q_{ij} = f(P_{ij}, N_j, D_i, R)$ where
Q_{ij} = The number of activity days in region i undertaken by anglers from location j
P_{ij} = The average expenditure in region i by anglers from location j
N_j = The population of j
Di are the six dummies (representing the supply characteristics of a region)
For example D1 = 1 if region i is Borders, else = 0
R = 1 if location j is rural, else = 0

The interaction of these variables is a matter of some debate. On logical grounds it is often argued that demand specifications ought to be multiplicative (or Log-Log) since if there were no home population there would be no demand, whatever the price. There is also some evidence from psychological studies that the rate of change of response is directly proportionate to the rate of change of stimulus i.e. over the normal range the elasticity is constant. Normally the dummies are added to the log-log giving
$\text{Log}(Q_{ij}) = \alpha + \beta \log(P_{ij}) + \gamma \log(N_j) + \Sigma\delta_\iota{*}Di + \kappa{*}R + \varepsilon_{ij}$
Where $\alpha, \beta, \gamma, \delta_1, \delta_2, ...\delta_6$ and κ are constants to be estimated and ε_{ij} is a stochastic term representing all the factors not considered and assumed to be $N(0,\sigma^2)$. In multiplicative form an equivalent is

$$Q_{ij} = A * P_{ij}^{\beta} * N_j^{\gamma} * \Delta_i^{\delta i} * \Psi^{\kappa} * \Phi_{ij}$$

Where $A = e^{\alpha}$ $\Delta\, and\, \Psi = e\ or\ 0$ and $\Phi \sim \text{lognormal}(1, e^{\sigma})$
This may be contrasted with a linear function
$Q_{ij} = \alpha + \beta\ P_{ij} + \gamma\ N_j + \Sigma\delta_i{*}Di + \kappa{*}R + \varepsilon_{ij}$

One difficulty, which is particularly important when trying to assess value, is that the log-log specification implies that for some individual there is no price that would stop purchase and that for this individual the consumer surplus is infinite. Consequently the value is infinite for the whole population. Effectively, we know that some individuals will reject all sums offered in compensation (infinite willingness to accept) but every individual is bounded by income (limited willingness to pay). This divergence is a fundamental problem in theory. One alternative reflecting the WTP proposition is a multiplicative model of the form:

$$Q_{ij} = \mathrm{A} * P_{ij}^{\ \beta} * N_j^{\gamma} * d_i D_i \ * \kappa R \ \ + \nu + \varepsilon_{ij}$$

The parameter ν “shifts” the function as in Figure A5.2 and in order for consumer surplus to be estimable must be less than zero.

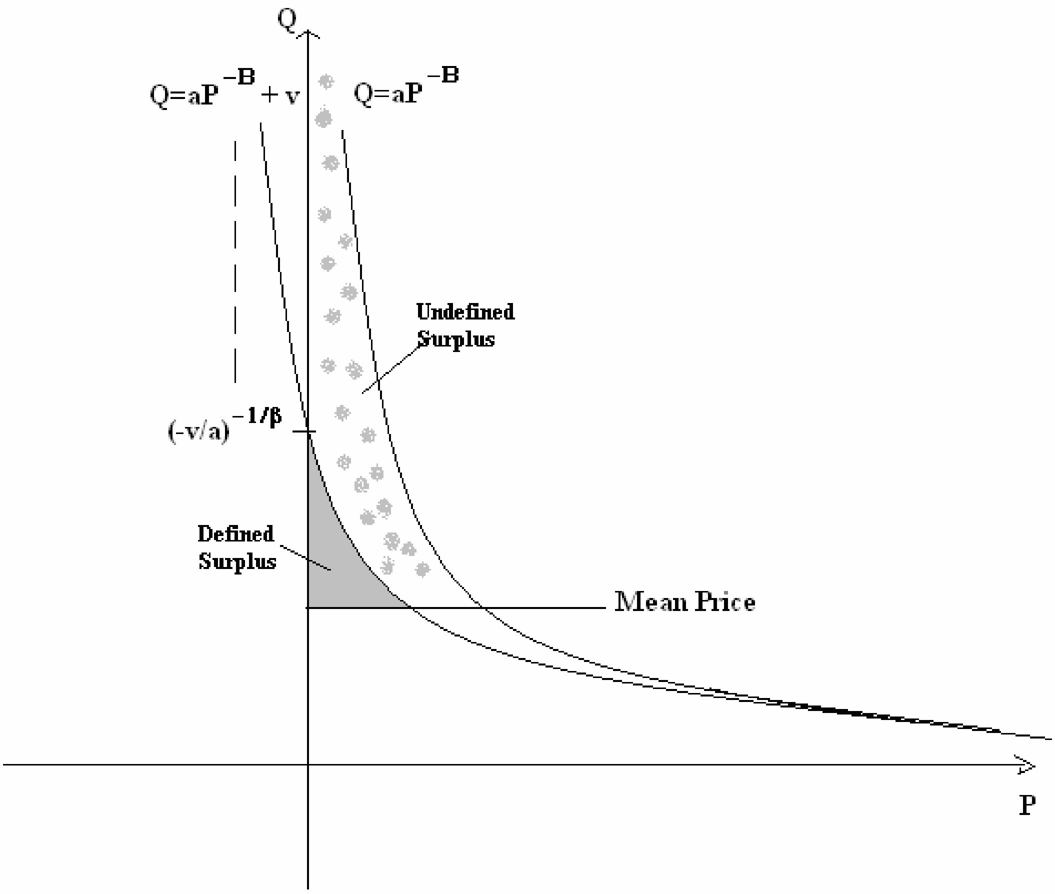

Figure A5.2 Surplus from ‘shifted’ demand and simple demand curves

Finally, it can be argued that *ceteris paribus* the number of activity days should be directly proportionate to the number of people in a region. This hypothesis can be incorporated either via a constraint on the parameter γ or by simply using the activity days per capita as the dependent variable.

A final set of models tried to identify the ‘value’ of salmon angling over other species using a choice modelling framework. In general, the proportion of individuals from location j choosing salmon over other species at location i is a function in the difference in utility between fishing for salmon and other species. The utility in turn is made up of the value of salmon/other fishing (with quality represented by a dummy on the location) less the cost of that fishing. The simplest such model estimated was a Logit of the form:

$\Pr ob\left(\frac{Salmon}{Other}\right)_{ij} = \frac{e^{V_{ij}}}{1+e^{V_{ij}}}$ where $V_{ij} = \alpha + \beta D_i + \gamma P_{ij} + \varepsilon_{ij}$

A precondition of this approach is that the individuals involved in the choice have similar characteristics and regard the choices as substitutes

A5.4 Estimation Procedures

A5.4.1 Heteroscedastcity and Weighted Least Squares

Estimation procedures reflect the specification of the model and the assumptions made about the stochastic term (and any prior values placed on the parameters and their distributions). The 'normal' approach assumes non-informative priors and a stochastic term that is zero mean independent normally distributed with constant variance. In cross sectional studies for linear models the assumption of constant variance is often inappropriate as expected errors may well reflect the size of the dependent term. For example, in this case, the potential error in flows that measure tens of thousand activity days is likely to be far larger than in those flows that are measured in hundreds. In the multiplicative model the stochastic term is the proportionate error and can thus be assumed to be constant.

Even for the multiplicative model, however, there is another potential source of heteroscedasticity (unequal variance). Estimates of the mean expenditure of a group are drawn from samples of very different size, and hence have significantly different variances. It is reasonable to hypothesise that these 'error in variable' estimates will generate proportionate errors in the stochastic term.

Estimation when heteroscedasticity is assumed, is normally via weighted least squares with the weights being proportionate to the generating factor (population size and/or standard deviation of estimate).

Normal regression techniques, whether weighted or otherwise, normally involve a linear model. For the multiplicative specification this assumes the log transformation of all variables and weights. For the final suggested specification, however, linearization is not possible. Non-linear least squares is identical to 'normal' regression in that it searches for the parameter set that minimises the sum of squares of the stochastic term.

A5.4.2 Sample Selection Bias

A second fundamental problem is the assumption that the characteristics of those involved are similar over the range of expenditures. However, in reality those most able to pay tend to gravitate to the most expensive locations; income will be a factor in the demand. Failure to take income into effect will bias the elasticity downward. Data on incomes of individuals at different levels of expenditure, however, were not available. One examined solution was to assume that the expenditure itself was a proxy for income, and an attempt was made to estimate a model that both shifts the curve down (to reflect the bias) and cuts the axis as in Figure A5.3 below.

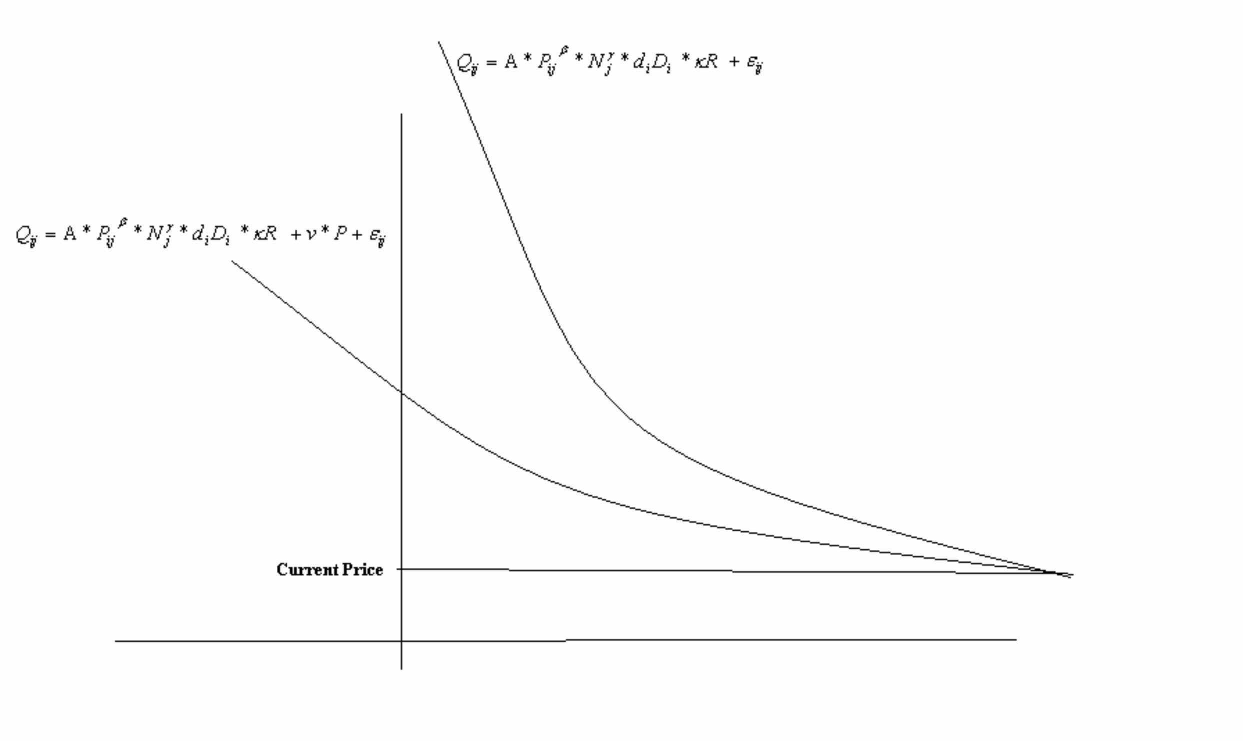

Figure A5.3 Model adjusted for sample selection bias

This has the form:

$$Q_{ij} = A * P_{ij}^{\beta} * N_j^{\gamma} * d_i D_i * \kappa R + \nu * P + \varepsilon_{ij}$$

Unfortunately this specification proved so unstable that no solution could be found.

A5.4.3 Specification Selection

Criteria for selection combine economic logic, economic sense of the resulting parameters, economic sense of any forecasts and statistical criteria such as the fit of the model to the data and the significance of a parameter estimate. On purely economic grounds we might expect the shifted multiplicative model estimated using non-linear least squares. Although estimates of the elasticity seemed sensible, estimates of the key shift parameter were computationally unstable being highly dependent upon start values. In addition, all models generated an extremely large estimate of the price for zero output and a resultant unacceptable estimate of value.

The choice models similarly proved unacceptable; it appears that for too many visitors fishing for other species is not a substitute for salmon fishing.

The model eventually selected was a simple multiplicative model of angling days *per capita* related to the expenditure, fishing quality (location dummy) and rural nature of home area estimated in log-log form with weights given by the log of the standard deviation of the estimate of mean expenditure of the group. The results are given in Table 1 below. In summary, these show a good fit to the data (Adjusted R^2 = 62.4%), significant parameters for all selected variables and a high price elasticity of -3.55. As a crude check this implies a mean willingness to pay of around £80. Adjustments for sample selection bias are discussed in the next section along with details of the estimation of the change in welfare.

Table A5.1 Regression Estimates of Simple Log-Log Model

Ordinary least squares regression Weighting variable = LOGW
Dep. var. = LOGPERCA Mean= .6476083606 , S.D.= 2.824948666
Model size: Observations = 69, Parameters = 9, Deg.Fr.= 60
Residuals: Sum of squares= 179.8583975 , Std.Dev.= 1.73137
Fit: R-squared= .668563, Adjusted R-squared = .62437
Model test: F[8, 60] = 15.13, Prob value = .00000
Diagnostic: Log-L = -131.4034, Restricted(b=0) Log-L = -169.5024
LogAmemiyaPrCrt.= 1.220, Akaike Info. Crt.= 4.070
Model does not contain ONE. R-squared and F can be negative!
Autocorrel: Durbin-Watson Statistic = 2.32320, Rho = -.16160

Variable	Coefficient	Standard Error	t-ratio	P[T>t]	Mean of X
LOGP	-3.548602060	.56680228	-6.261	.0000	4.8299177
DUMFRIES	15.08350234	2.7026521	5.581	.0000	.10242658
BORDERS	16.41252912	2.9619996	5.541	.0000	.13948946
WI	14.96933169	2.7378461	5.468	.0000	.12444449
HIGH	18.24918888	3.0893061	5.907	.0000	.19313628
NE	17.17260319	2.9567749	5.808	.0000	.17322183
CENTRAL	13.01445142	2.5502415	5.103	.0000	. 80143332E-01
SCOTLAND	18.78200277	2.9540196	6.358	.0000	.18713803
RURAL	2.098141586	.46260765	4.535	.0000	.49223952

A5.5 Estimation of Gross Surplus

Figure A5.4 below identifies an 'ideal type', with a common price elasticity but adjusted for selection bias that generates a finite surplus. The *ad hoc* method here is to fit a linear model at current values P_c, Q_c with an elasticity derived from the multiplicative model as shown in Figure 3. The slope of the linear model, P= a+**bQ,** is given by $1/b*P_c/Q_c$ and the surplus given, in the normal manner, by $0.5*b*Q_c^2 = 0.5/\beta*P_c*Q_c$ [55].

[55] P=a+bQ. Intersection is where Q=0 ie P = a. Area of triangle = $0.5*(a-P_c)*Q_c = 0.5*(a-(a+bQ_c))*Q_c=0.5*b*Q_c^2$
Elasticity = $\beta = (\delta Q/\delta P)*(P_c/Q_c) = (1/b)*(P_c/Q_c)$ ie $b = (1/\beta)*(P_c/Q_c)$

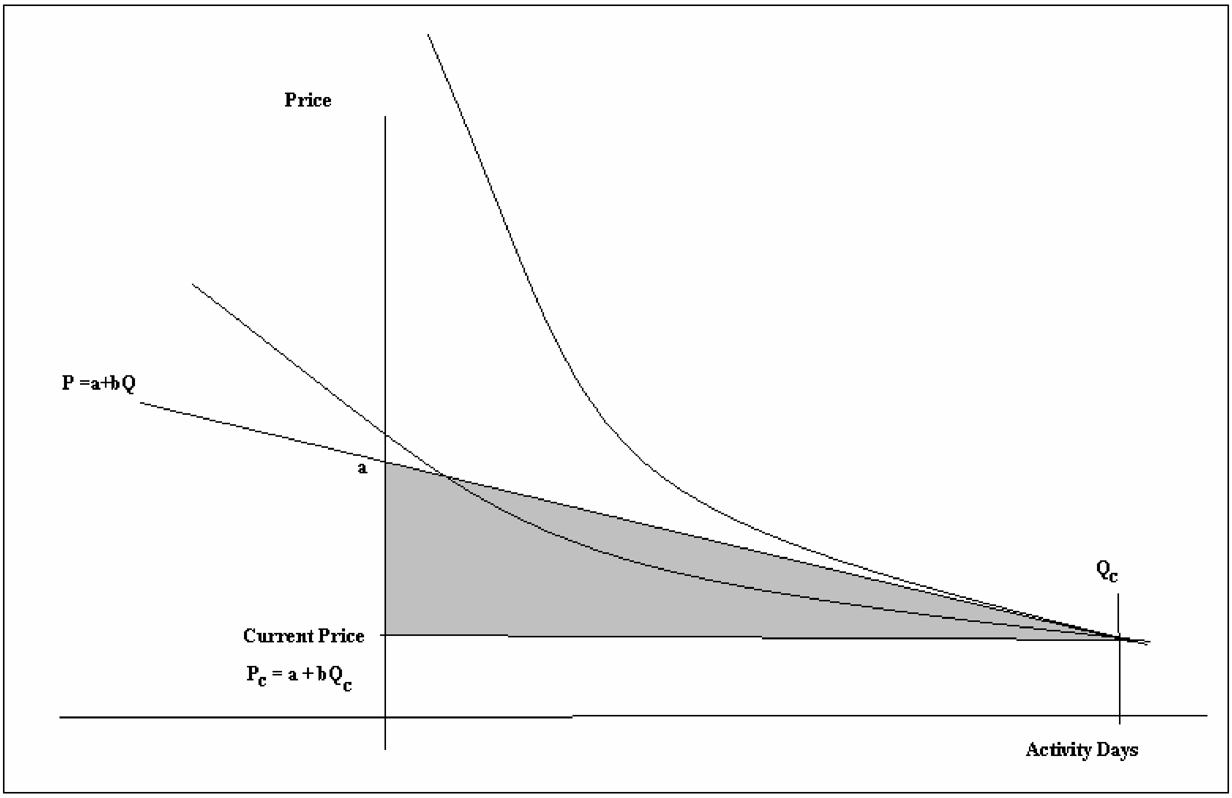

Figure A5.4 Comparison of Multiplicative, Adjusted Multiplicative and Linear Models

Table A5.2 shows the estimated consumer surplus for salmon in Scotland as a whole, the Spey catchment and the Luce, together with the implied mean willingness to pay **if there are no substitutes available.**

Table A5.2 Travel Cost Method Estimates of (Gross) Consumer Surplus (CS)

	Price (£)	Days p.a.	Annual CS (£)	Mean CS per day (£)
Scotland	136.43	598,452	13,674,628	22.85
Spey	265.11	40,543	1,796,113	44.40
Luce	35.83	600	6,210	10.35

It should be noted that these Figures derive from an estimation procedure, which does not take into account the existence of substitute fishing being available to anglers. The above table, therefore, relates to estimates of gross consumers' surplus since there is no allowance for substitution. Below we speculate on the net loss in consumers' surplus associated with the termination of salmon angling.

A5.6 Net Economic Value using TCM

An individual makes a choice with the aim of maximising consumers' surplus. For example, consider identical quality angling offered by two different fisheries, one priced at £25 and one at £35 per day. An angler with a WTP of £40 per day chooses the cheaper fishery because it provides him with a surplus of £15. If the cheaper fishery closes, he will purchase his angling from the alternative fishery at a cost of £35. His surplus will now only be £5. The angler's loss is the difference in the surpluses i.e. £10.

Using this version of the TCM to calculate the welfare loss from closure of a fishery, it is necessary to subtract from the consumer surplus associated with the chosen fishery, the consumer surplus associated with the next best alternative.

In Scottish terms, if a Spey angler switches to the Findhorn then there is an increase in the value of the Findhorn, but less than the decrease in the value of the Spey and overall for Scottish rivers a slight fall. However, if the Spey angler goes outside of Scotland, the value of Scottish rivers will fall by the whole of the surplus. If the Spey angler does another activity in Scotland then the value of fishing will fall by the entire surplus, but the value of other activities will rise by some unknown proportion of this fall.

We have no direct way of identifying what percentage of the value on average is lost when anglers transfer to other species or activities. However, we do have an estimate of the welfare loss if a Spey salmon angler is forced to fish for salmon elsewhere in Scotland. This would be the difference between the mean WTP for the Spey and the mean WTP for Scotland as a whole i.e. **the TCM estimate of the consumer surplus for the Spey is £21.55**. By comparison, Section 6.3.1.4 indicates a stated WTP for the Spey of £10.77, significantly lower but not of a different order of magnitude.

Appendix 6. River Spey Angler Questionnaire

CaledonianBusinessSchool

GLASGOW CALEDONIAN UNIVERSITY

Gyrodactylus salaris Study: Spey Angler Survey

Dear Spey Angler

Gyrodactylus salaris (GS) is a serious parasite of salmon in freshwater. It is widely distributed in Europe and if introduced to Scotland it has the potential to eliminate most of the Atlantic salmon in our rivers. The Scottish Executive is funding this study which seeks to assess the economic consequences in Scotland were GS to be introduced. The study will also estimate the cost of maintaining Scotland's current disease free status, as well as the costs of eradication and containment. This information will help shape advice to Ministers.

Economists from Glasgow Caledonian University and experts in parisitology, fisheries management and epidemiology from the University of Stirling are undertaking the study jointly. The scientists from Stirling University are primarily concerned with eradication and containment strategies and as leader of the team of economists, I am writing to you in connection with the economic consequences were GS to get into our rivers.

One of the scenarios we are investigating is an infestation restricted to, but widespread across the Spey catchment. In this scenario, the combined effect of fish mortality and the containment measures associated with GS infestation could lead to the cessation of salmon angling within the Spey catchment. In this context, you should note that in 2004 we published a study on the economic impact of paddle sport and angling in the Spey catchment[1] and a separate broader study on the economic impact of game and coarse angling in Scotland.[2] From this work we have a reasonable knowledge of the potential consequences for incomes and jobs of reductions in angler numbers. Unfortunately, there are a few key gaps in our knowledge, particularly relating to how the loss of salmon angling would impact on individual anglers themselves.

The River Spey Anglers Association has very kindly agreed to distribute this questionnaire which I hope you will be willing to complete. Please only complete this questionnaire if you have fished for freshwater species within Scotland in the ***last three years***. We also would like to talk to you on a personal basis about salmon angling and GS infestation. At the end of the questionnaire we have therefore requested telephone contact details. If you are unwilling to complete the questionnaire in its entirety, we still hope you might provide telephone details. Under the Data Protection Act all replies and telephone details will of course be treated in the strictest confidence. Moreover, results will be presented in a summary format and it will not be possible to identify individuals.

Please return the questionnaire in the enclosed envelope. The closing date is December 31st 2005. If you have any queries please do not hesitate to contact me.

Alan Radford
Senior Lecturer
Caledonian Business School
Glasgow Caledonian University
Cowcaddens Road
Glasgow G4 OBA

[1] Produced for the Spey Catchment Steering Group. A full report and a summary report in PDF format are available from http://www.snh.org.uk/scottish/ehighland/spey-economics.asp.
[2] Produced for the Scottish Executive Environment and Rural Affairs Department. The research report is available in PDF format from http://www.scotland.gov.uk/library5/environment/eigc-00.asp

PART A YOUR ANGLING DETAILS

Q1) Please indicate where you normally live: (Tick One Box)

A) Within the Spey Catchment	☐	**C) Rest of the UK**	☐	**E) North America**	☐
B) Elsewhere in Scotland	☐	**D) Mainland Europe**	☐	**F) Elsewhere**	☐

Q2) For each species below, please indicate **how many days in total** you fished, both within Scotland and within the Spey Catchment during a **typical season** in the last 3 years.

- Please count a part of a day as one full day. On days when you were fishing for more than one species (e.g. salmon and sea trout), allocate these days to the species you were primarily seeking to catch.

	Salmon	**Sea Trout**	**Brown Trout**	**Coarse**	**Rainbow Trout**
Scotland:	Days	Days	Days	Days	Days
Spey Catchment:	Days	Days	Days	Days	Days

If you did not fish for <u>salmon</u> either in the Spey catchment or Scotland or, please go to Q (8).

Q3) For each of the two areas (Scotland and the Spey Catchment) please indicate the % of fishing days in (Q2) where fishing was the **main purpose** for being in the area. Fishing would not be the main purpose if you normally live in the area or you fished for a day whilst on a family holiday.

	Salmon	**Sea Trout**	**Brown Trout**	**Coarse**	**Rainbow Trout**
Scotland:	%	%	%	%	%
Spey Catchment:	%	%	%	%	%

Only answer the following question if you fished for salmon in the Spey Catchment

Q4) If, because of GS infestation, salmon angling was not available **in the Spey catchment but was still available elsewhere in Scotland,** indicate what you principally would have done instead of your Spey salmon angling. (**Please tick the most appropriate box)**

Spey Catchment Residents:		**Visitors to the Spey Catchment:**	
Fished instead for **sea trout** somewhere **within** the Spey catchment	☐	Fished instead for **sea trout** somewhere within the Spey Catchment.	☐
Fished instead for species other than salmon and sea trout somewhere **within** the Spey Catchment	☐	Fished instead for species other than salmon and sea trout somewhere **within** the Spey Catchment.	☐
Fished **outside** of the Spey Catchment but within Scotland	☐	Fished **outside** the Spey Catchment but within Scotland	☐
Fished **outside Scotland**	☐	Would not have fished but **still visited** Scotland	☐
Would **not have fished** at all	☐	Would **not have visited** Scotland	☐

Q5) If, because of GS infestation, salmon angling was not available **anywhere in Scotland,** indicate what you principally **would have done** instead of your salmon angling in Scotland. (**Please tick the most appropriate box)**

Scottish Residents:		**Visitors to Scotland:**	
Fished instead for **sea trout** somewhere **within** Scotland	☐	Fished instead for **sea trout** somewhere within Scotland	☐
Fished instead for species other than salmon and sea trout **within** Scotland	☐	Fished instead for species other than salmon and sea trout **within** Scotland	☐
Fished **outside** of Scotland	☐	Would not have fished but **still visited** Scotland	☐
Would **not have fished** at all	☐	Would **not have visited** Scotland	☐

PART B YOUR DAILY SALMON ANGLING EXPENDITURE:

Please answer the following question if you fished for salmon in the Spey Catchment

Q6) Please estimate your typical daily expenditure in Scotland whilst on salmon angling trips **to the Spey Catchment.** Include **all** your expenditure on such Spey trips, even if it covered more than one person, including daily accommodation costs. We would be very grateful if you could record your **daily** expenditure using the subdivisions below

Accommodation per day	£ :	Fishing clothes and footwear	£ :
Meals/drinks served to you	£ :	Hire of tackle and boats	£ :
Food and drinks from shops	£ :	Ghillie hire and tips	£ :
Public transport and vehicle hire	£ :	Bait	£ :
Petrol, diesel etc. purchased	£ :	Fishing rents, licences, syndicate fees, permits.	£ :
Tackle	£ :	Fishing club fees	£ :
Other goods including gifts and souvenirs	£ :	Other (please specify)	£ :

*Please answer the following question if you made any **salmon** angling trips to **Scottish** locations **outside** the Spey Catchment*

Q7) Please estimate your typical daily expenditure in Scotland whilst on salmon angling trips **to Scottish salmon fisheries outside the Spey Catchment.** Include **all** your expenditure on such trips, even if it covered more than one person, including daily accommodation costs. We would be very grateful if you could record your **daily** expenditure using the subdivisions below.

Accommodation per day	£ :	Fishing clothes and footwear	£ :
Meals/drinks served to you	£ :	Hire of tackle and boats	£ :
Food and drinks from shops	£ :	Ghillie hire and tips	£ :
Public transport and vehicle hire	£ :	Bait	£ :
Petrol, diesel etc. purchased	£ :	Fishing rents, licences, syndicate fees, permits.	£ :
Tackle	£ :	Fishing club fees	£ :
Other goods including gifts and souvenirs	£ :	Other (please specify)	£ :

PART C GS INFESTATION: THE SPEY CATCHMENT SCENARIO:

Q8) ***The combined effect of fish mortality and the containment measures associated with a widespread GS infestation would lead to the cessation of all salmon angling within the are infected. Other forms of angling within the area, such as sea trout, brown trout, rainbow trout and coarse angling, would be unaffected.***

We would like you to imagine a scenario, where the Spey catchment alone becomes infected, and because of robust and successful GS containment measures, it would still be possible to fish for salmon elsewhere in Scotland, as well as other species within the Spey catchment.

In principle, would you be willing to pay an amount, **however small**, to **prevent** the above scenario of a widespread GS infestation of the Spey Catchment?

Yes ☐ **No** ☐ **If 'no' Go to question (11)**

Q9) Please tick **ANY** of the following reasons that you feel have any relevance to your willingness to contribute an amount.

Tick any relevant box(es)

Because of my enjoyment of my salmon angling on the Spey	☐
Because I wish other people and future generations to enjoy Spey salmon angling	☐
Because just knowing salmon exist in the Spey is important to me	☐
Because other people and future generations might derive benefit from just knowing salmon exist in the Spey	☐
Other (please specify)	☐

10) What is the **maximum** amount you would be willing to pay **per fishing day** into a fund to prevent the above scenario of a widespread GS infestation of the Spey catchment? This (hypothetical) payment would take the form of a daily riverbank charge, which would be additional to angling permits, fees, licences etc.

> **Before answering, remember it would still be possible to fish for salmon elsewhere in Scotland, as well as other species, such as sea trout, within the Spey catchment**

The **maximum amount** I would be willing to pay per day (or part day) is:

£0.10	☐	£5	☐	£35	☐	£65	☐	£95	☐	£400	☐
£0.25	☐	£10	☐	£40	☐	£70	☐	£100	☐	£500	☐
£0.50	☐	£15	☐	£45	☐	£75	☐	£150	☐	£600	☐
£0.75	☐	£20	☐	£50	☐	£80	☐	£200	☐	£700	☐
£1	☐	£25	☐	£55	☐	£85	☐	£250	☐	£800	☐
£2	☐	£30	☐	£60	☐	£90	☐	£300	☐	£900	☐

Other (please specify) £_______ **After completion go to Q(12)**

11) Please tick **ANY** of the following statements that you feel have any relevance to your unwillingness to contribute any amount.

Tick any relevant box(es)

I cannot afford to contribute an amount, however small	☐
Salmon angling on the Spey is relatively unimportant to me	☐
I have no concern about other people and future generations' enjoyment of Spey salmon angling	☐
Just knowing salmon exist in the Spey is unimportant to me	☐
The benefit other people and future generations derive from just knowing salmon exist in the Spey is unimportant to me	☐
Others should pay	☐
Other (please specify)	☐

PART D GS INFESTATION: THE WHOLE OF SCOTLAND SCENARIO:

Q12) We would like you to imagine a scenario where the **whole of Scotland** becomes infected and it would not be possible to fish for salmon anywhere in Scotland, though you could fish for other species.

In principle, would you be willing to pay an amount, **however small**, to prevent the above scenario of a widespread GS infestation across the whole of Scotland?

Yes ☐ **No** ☐ **If 'no' Go to question (15)**

Q13) Please tick **ANY** of the following reasons that you feel are relevant to your willingness to contribute an amount.

Tick all relevant box(es)

Because of my enjoyment of my salmon angling in Scotland	☐
Because I wish other people and future generations to enjoy Scottish salmon angling	☐
Because just knowing salmon exist Scotland is important to me	☐
Because other people and future generations might derive benefit from just knowing salmon exist in Scottish rivers	☐
Other (please specify)	☐

14) What is the **maximum** amount you would be willing to pay **per fishing day** into a fund to prevent the above scenario of GS infestation across the whole of Scotland? This (hypothetical) payment would take the form of a daily riverbank charge, which would be additional to angling permits, fees, licences.

> **Before answering remember it would still be possible to fish for salmon outside Scotland, as well as other species within Scotland.**

The **maximum amount** I would be willing to pay per day (or part day) is:

£0.10	☐	£5	☐	£35	☐	£65	☐	£95	☐	£400	☐
£0.25	☐	£10	☐	£40	☐	£70	☐	£100	☐	£500	☐
£0.50	☐	£15	☐	£45	☐	£75	☐	£150	☐	£600	☐
£0.75	☐	£20	☐	£50	☐	£80	☐	£200	☐	£700	☐
£1	☐	£25	☐	£55	☐	£85	☐	£250	☐	£800	☐
£2	☐	£30	☐	£60	☐	£90	☐	£300	☐	£900	☐

Other (please specify) £_______ **After completion go to Q(16)**

Q15) Please tick **ANY** of the following statements that you feel are relevant to your unwillingness to contribute any amount.

Tick all relevant box(es)

I cannot afford to contribute an amount, however small	☐
Salmon angling in Scotland is relatively unimportant to me	☐
I have no concern about other people and future generations' enjoyment of Scottish salmon angling	☐
Just knowing salmon exist in the Spey is unimportant to me	☐
The benefit other people and future generations derive from just knowing salmon exist in the Spey is unimportant to me	☐
Others should pay	☐
Other (please specify)	☐

16) **We would like to talk to you on a personal basis about salmon angling and GS infestation. This would take only a few minutes of your time and if you are willing we would be very grateful if you could provide telephone contact details. These will be treated in the strictest confidence and destroyed on the completion of the project**.

Telephone number(s) ________________________________

Please return the questionnaire in the enclosed pre-paid envelope.

Thank very much you for your cooperation.

Appendix 7. River Luce Angler Survey

Gyrodactylus salaris Study: River Luce Angler Survey

Dear Luce Angler

Gyrodactylus salaris (GS) is a serious parasite of salmon in freshwater. It is widely distributed in Europe and if introduced to Scotland it has the potential to eliminate most of the Atlantic salmon in our rivers. The Scottish Executive is funding this study which seeks to assess the economic consequences in Scotland were GS to be introduced. The study will also estimate the cost of maintaining Scotland's current disease free status, as well as the costs of eradication and containment. This information will help shape advice to Ministers.

Economists from Glasgow Caledonian University and experts in parisitology, fisheries management and epidemiology from the University of Stirling are undertaking the study jointly. The scientists from Stirling University are primarily concerned with eradication and containment strategies and as leader of the team of economists, I am writing to you in connection with the economic consequences were GS to get into our rivers.

One of the scenarios we are working on is a GS infestation that was restricted to a small system such as the Luce. In this scenario we are assuming that the preferred option would be eradication of the parasite by chemical treatment of the whole system. Whilst this would prevent the parasite spreading to the rest of Scotland, all angling within the Luce would be wiped out. We are assuming this would be permanent, though in practice it might be possible for the river to be stocked at some time in the future. In this context, you should note that in 2004 we published a study on the economic impact of game and coarse angling in Scotland.[1] From this work we have a reasonable knowledge of the potential consequences for incomes and jobs of reductions in angler numbers. Unfortunately, there are a few key gaps in our knowledge, particularly relating to how the loss of salmon angling would impact on individual anglers such as yourself.

The Stair Estate has very kindly agreed to assist in the distribution of this questionnaire, which I hope you will be willing to complete. Please only complete this questionnaire if you have fished for freshwater species within Scotland in the ***last three years***. We also would like to talk to you on a personal basis about salmon angling and GS infestation. At the end of the questionnaire we have therefore requested telephone contact details. If you are unwilling to complete the questionnaire in its entirety, we still hope you might provide telephone details. Under the Data Protection Act all replies and telephone details will of course be treated in the strictest confidence. Moreover, results will be presented in a summary format and it will not be possible to identify individuals.

Please return the questionnaire in the enclosed envelope. The closing date is January 20th 2006. If you have any queries please do not hesitate to contact me.

Alan Radford
Senior Lecturer
Caledonian Business School
Glasgow Caledonian University
Cowcaddens Road
Glasgow G4 OBA

[1] Produced for the Scottish Executive Environment and Rural Affairs Department. The research report is available in PDF format from http://www.scotland.gov.uk/library5/environment/eigc-00.asp

PART A YOUR ANGLING DETAILS

Q1) Please indicate where you normally live: (Tick One Box)

A) Dumfries and Galloway	☐	**C) Rest of the UK**	☐	**E) North America**	☐
B) Elsewhere in Scotland	☐	**D) Mainland Europe**	☐	**F) Elsewhere**	☐

Q2) For each species below, please indicate **how many days in total** you fished, both within Scotland and on the river Luce system during a **typical season** in the last 3 years.

- Please count a part of a day as one full day. On days when you were fishing for more than one species (e.g. salmon and sea trout), allocate these days to the species you were primarily seeking to catch.

	Salmon	Sea Trout	Brown Trout	Coarse	Rainbow Trout
Scotland:	Days	Days	Days	Days	Days
Luce System:	Days	Days	Days	Days	Days

Only answer the following question if you fished in the Luce system for ANY SPECIES

Q3) If, because of GS eradication measures no angling of any kind was available **in the Luce system** indicate what you principally would have done instead of your angling on the Luce. (**Please tick the most appropriate box)**

Dumfries and Galloway Residents:

Fished instead somewhere else **within** Dumfries and Galloway	☐
Fished **outside** Dumfries and Galloway but within Scotland	☐
Fished **outside Scotland**	☐
Would **not have fished** at all	☐

Visitors to Dumfries and Galloway:

Fished instead somewhere else **within** Dumfries and Galloway	☐
Fished **outside** Dumfries and Galloway but within Scotland	☐
Would not have fished but **still visited** Scotland	☐
Would **not have visited** Scotland	☐

Only answer the following question if you fished FOR SALMON anywhere in Scotland (including the Luce)

Q4) If, because of GS infestation, salmon angling was not available **anywhere in Scotland,** indicate what you principally **would have done** instead of your salmon angling in Scotland. (**Please tick the most appropriate box)**

Scottish Residents:

Fished instead for **sea trout** somewhere **within** Scotland	☐
Fished instead for species other than salmon and sea trout **within** Scotland	☐
Fished **outside** of Scotland	☐
Would **not have fished** at all	☐

Visitors to Scotland:

Fished instead for **sea trout** somewhere within Scotland	☐
Fished instead for species other than salmon and sea trout **within** Scotland	☐
Would not have fished but **still visited** Scotland	☐
Would **not have visited** Scotland	☐

PART B YOUR DAILY SALMON ANGLING EXPENDITURE:

Please answer the following question if you fished for salmon in the Luce system

Q5) Please estimate your typical daily expenditure in Scotland whilst on salmon angling trips **to the Luce system.** Include **all** your expenditure on such Luce trips, even if it covered more than one person, including daily accommodation costs. We would be very grateful if you could record your **daily** expenditure using the subdivisions below

Accommodation per day	£ :	Fishing clothes and footwear	£ :
Meals/drinks served to you	£ :	Hire of tackle and boats	£ :
Food and drinks from shops	£ :	Ghillie hire and tips	£ :
Public transport and vehicle hire	£ :	Fishing rents, licences, syndicate fees, permits	£ :
Petrol, diesel etc. purchased	£ :	Fishing club fees	£ :
Tackle	£ :	Other goods including gifts and souvenirs	£ :
Other (please specify) :			£ :

*Please answer the following question if you made any **SALMON** angling trips to **Scottish** locations **outsid**e the Luce system*

Q6) Please estimate your typical daily expenditure in Scotland whilst on salmon angling trips **to Scottish salmon fisheries outside the Luce system.** Include **all** your expenditure on such trips, even if it covered more than one person, including daily accommodation costs. We would be very grateful if you could record your **daily** expenditure using the subdivisions below.

Accommodation per day	£ :	Fishing clothes and footwear	£ :
Meals/drinks served to you	£ :	Hire of tackle and boats	£ :
Food and drinks from shops	£ :	Ghillie hire and tips	£ :
Public transport and vehicle hire	£ :	Fishing rents, licences, syndicate fees, permits	£ :
Petrol, diesel etc. purchased	£ :	Fishing club fees	£ :
Tackle	£ :	Other goods including gifts and souvenirs	£ :
Other (please specify) :			£ :

PART C GS INFESTATION: THE WHOLE OF SCOTLAND SCENARIO:

Q7) We would like you to imagine a scenario where the **whole of Scotland** becomes infected with GS and eradication is not feasible. In this scenario the combined effect of fish mortality and containment measures would lead to the cessation of **all salmon angling** within the whole of Scotland. Other forms of angling within Scotland such as sea trout, brown trout, rainbow trout an coarse angling, would be unaffected.

In principle, would you be willing to pay an amount, **however small**, to prevent the above scenario of a widespread GS infestation across the whole of Scotland?

Yes ☐ **No** ☐ **If 'no' Go to question (10)**

Q12) Please tick **ANY** of the following reasons that you feel have any relevance to your willingness to contribute an amount.

Tick any relevant box(es)

- Because of my enjoyment of my angling on the Luce ☐
- Because I wish other people and future generations to enjoy Luce angling ☐
- Because just knowing fish exist in the Luce is important to me ☐
- Because other people and future generations might derive benefit from just knowing fish exist in the Luce ☐
- Other (please specify) ☐

Q13) What is the **maximum** amount you would be willing to pay **per fishing day** into a fund to prevent the above scenario of a GS infestation and subsequent permanent cessation of all angling in the Luce system? This (hypothetical) payment would take the form of a daily riverbank charge, which would be additional to angling permits, fees, licences etc.

Before answering, remember it would still be possible to fish elsewhere in Scotland.

The **maximum amount** I would be willing to pay per day (or part day) is:

£0.10	☐	£5	☐	£35	☐	£65	☐	£95	☐	£400	☐
£0.25	☐	£10	☐	£40	☐	£70	☐	£100	☐	£500	☐
£0.50	☐	£15	☐	£45	☐	£75	☐	£150	☐	£600	☐
£0.75	☐	£20	☐	£50	☐	£80	☐	£200	☐	£700	☐
£1	☐	£25	☐	£55	☐	£85	☐	£250	☐	£800	☐
£2	☐	£30	☐	£60	☐	£90	☐	£300	☐	£900	☐

Other (please specify) £_______ **After completion go to Q(15)**

Q14) Please tick **ANY** of the following statements that you feel have any relevance to your unwillingness to contribute any amount.

Tick any relevant box(es)

- I cannot afford to contribute an amount, however small ☐
- Angling on the Luce is relatively unimportant to me ☐
- I have no concern about other people and future generations' enjoyment of angling on the Luce ☐
- Just knowing fish exist in the Luce is unimportant to me ☐
- The benefit other people and future generations derive from just knowing fish exist in the Luce is unimportant to me ☐
- Others should pay ☐
- Other (please specify) ☐

Q15) **We would like to talk to you on a personal basis about salmon angling and GS infestation. This would take only a few minutes of your time and if you are willing we would be very grateful if you could provide telephone contact details. These will be treated in the strictest confidence and destroyed on the completion of the project.**

Telephone number(s) ___________________________________

Please return the questionnaire in the enclosed pre-paid envelope.

Thank very much you for your cooperation.

Appendix 8. Non Salmon Fisheries in the Spey Catchment

Table A8.1 Non Salmonid Fisheries in the Spey Catchment

Brown Trout	Coarse Fish	Rainbow Trout
Loch a'Gharbh-choire	**Loch Alvie**	Avielochan
Loch Alvie	**Loch Insh**	Craggan Fishery
Loch Beag	**Loch Morlich**	Glen of Rothes Trout Fishery
Loch Dallas	Loch Beag	Inverlochy Trout Fishery
Loch Garten (RSPB)	Loch Pityoulish	Rothiemurchus Fishery
Loch Gynack	**Spey Dam**	
Loch Insh		
Loch Mallachie		
Loch Morlich		
Loch Pityoulish		
Loch Vaa		
Lochan an t-Sluie		
Lochan Dubh		
Lochan Geal		
Lochan na Beinne		
Lochan nam Bo		
Uath Lochan		
Loch an t-Seilach		
Loch Coire an Lochain		
Loch Einich		
Loch Etteridge		
Loch Mhic Ghille-chaoil		
Loch na Cnapan		
Loch na Stuirteag		
Lochan an Dabhaich		
Lochan Beanaidh		
Lochan Dubh		
Lochan Odhar		
Lochan Uaine		
Park Loch		
Phones Loch		
Loch Avon		
Loch an Eilan		
Spey Dam		

Lochs over 100 hectares are shown in bold

Appendix 9. Access Points in Spey Catchment

A9.1 Main Access Points by Road to the River Spey

Table A9.1 Main Access Points to the River Spey

	Main Roads
1	A9 From Slocht Summit in North, from Drummochter Summit in South
2	A86 at Laggan
3	A939 at Grantown in Nrth and Lecht Ski Area in South
4	A941 at Dufftown
5	A920 at Dufftown
6	A941 at Rothes
7	B9010 at Knockando
8	B9103 at Mulben from East and at Orton from Nrth
9	A96 at Fochabers
10	A98 at Fochabers
11	B9104 Spey Bay Road
12	A number of other minor roads also can access the Spey.

A9.2 Kayak Access Points

Access points variously recommended / agreed / traditional use.

The Scottish Land Reform Act (2003) allows for reasonable and responsible pedestrian/canoe access anywhere along the river, which is not over an area of curtilage and causes no damage to property or crops.

- Laggan Bridge – either bank by bridge
- Newtonmore – right bank, below road bridge (left bank only if resident on Speybridge Campsite).
- Kingussie – right bank, below road bridge at Ruthven (use gate on upstream side of the road.)
- Loch Insh – water-sports centre site at north-east corner of the Loch.
- Kincraig – right bank below bridge (park in large lay-by opposite church; access 100m downstream, over rough track running parallel with the road).
- Aviemore – left bank below road bridge, just above or below the footbridge.
- Boat of Garten – left bank downstream of road bridge.
- Broomhill Bridge – left bank by road bridge.
- Grantown on Spey – left bank, 450 metres approx. above bridge (by parking areas).
- Cromdale – right bank below road bridge, by the church.
- Dellefure Burn – (GR.085316) left bank (limited parking space).
- Advie Bridge – (GR.120354) park on verge, river-left, opposite five bar gate.
- Delneigh Pool – (GR138353) 1 mile downstream of Advie Bridge; access via signposted track (half mile approx. downstream of bridge); follow track in downstream

direction, passing maintenance area/sheds to your right, until reaching the ample parking and turning area by the water's edge, well away from the road.

- Ballindalloch (1) – (GR.158369) left bank, in the trees, some 750m downstream of where road comes within 15 metres of the river; look out for entrance to the small vehicle track leading to the riverside (this continues to be one of the most frequently used access points on the Spey, so please minimise erosion and numbers of vehicles left parked at this area.)
- Ballindalloch (2) – (GR.168368) left bank below railway bridge; for use by those camping at the small Speyside Way campsite, by the old station (disused railway line is part of the Speyside Way long distance footpath); parking in the small area by the old Ballindalloch Station.
- Blacksboat Bridge – left bank just upstream of bridge (this point is available only to paddlers who propose to camp at Blacksboat Railway Station and have in advance contacted Ballindalloch Estate Office Tel. 01807 500205/fax. 01807 500210); please park, launch and land with care and consideration at all locations.
- Knockando – (GR.195415) left bank below Tamdhu distillery (ample vehicle parking by the old station, but please do not block emergency and maintenance access to Speyside Way between the platforms)
- Carron – left bank by road bridge.
- Aberlour – right bank above Victoria footbridge.
- Craigellachie (1) – right bank between the old Telford bridge and the new road bridge; carpark adjacent.
- Craigellachie (2) – if using the Boat o'Fiddich Park campsite; right bank above the confluence of the Fiddich Water some 500m below the road bridge; for vehicles, please use the car park, across the road, in the Fiddich Park (toilets are also located in the Fiddich Park); following a change of ownership away from the Speyside Ranger Service, exact formal camping arrangements at this location still being negotiated (2005).
- Boat o' Brig – left bank, above or below bridge
- Fochabers – right bank below road bridge.
- Spey Mouth – right bank by buildings and vehicle parking (Tugnet).

The above constitutes a list of traditionally recognised, long used access points with, for the most part, the full agreement of the land/estate owners. However, The Land Reform Act (Scotland) facilitates reasonable access at any point that can be reached by foot, without damage to property.

Appendix 10. The Rannoch Power System

Tummel Hydro-Electric Power Scheme

Pitlochry Power Station

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The Tummel Valley is well suited to a hydro-electric scheme, representing a large catchment with heavy rainfall. Its potential was recognised by the Grampian Electricity Supply Company who built power stations at Rannoch and Tummel Bridge in the 1930's. Today there are nine stations located between Pitlochry in the east, Dalwhinnie in the north and Rannoch Moor in the west.
To the north, the 2.5 megawatt (MW) Cuaich Power Station in Glen Truim discharges into Loch Ericht, the largest reservoir in the scheme, where the 2.2 MW Ericht station is fed from Loch Garry in the mountains above. From Loch Ericht, the water passes down through the 45 MW Rannoch station, on the northern shore of Loch Rannoch.
In the west the Gaur Dam feeds the 6.4 MW station on the River Gaur, which flows into Loch Rannoch. Gaur was the first power station in Scotland to be automated (1953). From Loch Rannoch water flows down to Dunalastair Reservoir, the 34 MW Tummel Bridge station (built in 1935 and control centre for the scheme) then into Loch Tummel. The 75 MW Errochty station, the largest in the scheme, is fed by tunnel from Loch Errochty to the north. Stone from the 10 km long tunnel is used to face the power station. Water from Loch Tummel is conveyed by tunnel, represented for tourists by the nearby Clunie Arch, to the 61.2 MW Clunie station, at the confluence of the Rivers Garry and Tummel, just south of Killiecrankie, before flowing into the small man-made Loch Faskally.
Loch Faskally, the last reservoir in the scheme, is held behind the Pitlochry Dam. The dam, its 15 MW power station and particularly its fish-ladder, which allows salmon to pass upriver to spawn, attract approximately 500,000 tourists each year. Water reaching Pitlochry may have passed through five stations generating a total 245 MW of power. The scheme is run by the privatised Scottish & Southern Energy Plc (previously Scottish Hydro-Electric), headquartered in Perth, with an annual turnover of £2.3 billion.

Appendix 11. Disinfection at Fish Farms

The disinfectant chosen for use in this study is Virkon®. It has been tested and has proven efficacy amongst a wide variety of pathogens of particular importance to the aquaculture industry. It has also been used in Norway to protect against Gs infestation (Shave 2004). Virkon® consists mainly of organic salts, which decompose into benign by-products. At a 1% dilution, Virkon® decomposes and or/biodegrades to a by-product that is comparatively harmless. Virkon® shows low toxicity to earthworms and anaerobic sludge and analysis of,biological oxygen demand (BOD) of stream effluents has shown no adverse effects. This indicates that,sewage treatment plants will not be negatively impacted upon as a result of its use. However, there are some concerns arising from toxicity to freshwater organisms.

No occupational hazards are specified in relation to its use. According to requirements laid down by Health and Safety Executive Guidance, it has been classed as a non-irritant to skin and eyes at 1% dilution.

Table A11.1 Bio-security Measures to be Taken in Hatchery/Broodstock Facilities, Freshwater Production Sites and Processing Plants

Critical Control Point	Dilution Rate	Application Rate	Frequency
Vehicles	Virkon® 1/100	All vehicles should pass over a disinfectant mat on entry and departure to/from the farm	On Arrival
Personnel			
Footdips/mats	Virkon® 1/100	Place footdips at the entry to all piers and cages	On passing through area
Skin hygiene	Handsanitisers	Hands should be washed between areas with disinfectant soap	On passing through area
Protective clothing	Virkon® 1/100	Rinse with clean water and immerse for 10 min in disinfectant	After each use
Equipment			
Transport tanks & equipment	Virkon® 1/200	Visibly Clean	After each period of use
Carry bins, hand nets, weighing equipment	Virkon® 1/200	Visibly clean	After each period of use
Dip nets & tank brushes	Virkon® 1/200	Immerse	Daily use
Grading equipment	Virkon® 1/200	Clean with Biosolve and then disinfect	Daily use
Tanks	Virkon® 1/200	Clean with Biosolve and then disinfect	When empty
Diving Equipment	Virkon® 1/100	Clean with water and then immerse for 10 min	After each use
Waste Disposal Areas			
Waste disposal areas and bins	Virkon® 1/200	Rinse with clean water and immerse in Virkon® for 10 min and allow to dry	Daily
Biosecurity Barriers			
Paths and roadways	Virkon® 1/200	Brush or rake and then disinfect	Weekly basis

Adapted from *Dupont Animal Health Solutions* (2006)

Appendix 12. Other Costs

A12.1 Cost of Hydrochemical Analysis

Table A12.1 Cost of Hydrochemical Analysis in Scottish Rivers

Hydrochemical Analysis	SEPA Cost (£)	Private Consultants(£)
pH		7.00
Conductivity	Fixed	7.00
Alkalinity		7.00
Hardness	Fixed	12.84
Biological oxygen demand		18.19
Suspended solids	Fixed	15.00
Total	**50**	

A12.2 Cost of Disposal

The Animal Waste Directive 90/667/EEC controls the disposal of mortalities and processing waste. Table A12.2 demonstrates the costs to transport and incinerate mortalities as a result of chemical treatment in the River Luce. The Animal By-products Order (1999), which implements the Animal Waste Directive 90/667/EEC, controls the disposal of mortalities and processing waste. The Directive lays down rules for "disposal and processing of animal waste, for it's placing on the market and for the prevention of pathogens in feed stuffs of animal or fish origin. Fish are included in the definition of animal, and animal products are defined as: 'animal carcasses or parts of animal carcasses, or products of animal origin which are not intended for human consumption.'"

The Order divides animal by-products into high and low risk categories.

In the case of Atlantic salmon infected with Gs, dead fish requiring disposal will fall into a high risk category:

- 'Fish which show signs of clinical disease communicable to man or fish' (Article 3.1 (f))
- 'Fish which are killed in the context of control of disease measures (other than those slaughtered for human consumption)' (Article 3.1 (d)).

.

Table A12.2 Cost of Carcass Disposal, Including Incineration and Transport Costs (tonnes)

Disposal	Cost (£) (per t)	Cost (£) (Per 25t)
Incineration	45	1125
Transport	34	850
Total (per 25t)		1975
Total (per 200t)		15,800
Total (per 500t)		39,500

Snowie Disposal Group of Companies (2005)

Appendix 13. Cost of Eradication

A13.1 Cost of Treatment with Rotenone

Annually, the Scottish Environmental Protection Agency (SEPA) carries out both biological and chemical analysis in order to monitor water quality in all Scottish rivers. This data could be used as baseline water quality analysis prior to treatment in the event of an introduction.

13.1.1 Biological Assessment

Macroinvertebrate (e.g. mayflies, water beetles, aquatic worms) sampling takes place twice yearly. Fish, macrophyte and phytobenthos sampling takes place once every 3-6 years. In the case of a pre-treatment survey, all of the above biological assessments would need to be made. In the short term, treatment of any river system with rotenone will take out virtually all of the vertebrate and invertebrate biota. Therefore, it is essential to have baseline biological assessments to facilitate monitoring of efficacy of treatment, and recovery monitoring of the river system post treatment. Table A13.1 shows the cost of biological assessment in Scottish rivers that includes an average labour cost for an Ecologist working for SEPA. This incorporates an overhead factor for external costing purposes (i.e. if they had been contracted to do it for an external client). The costs also include the sampling, and the analysis and reporting of data.

Table A13.1 Total Cost of SEPA's Pre-treatment Biological Assessment Covering 100km of River

Sample Types	Sample No.	Cost (£)
Macroinvertebrates (per sample, family level analysis)	60	5,031
Phytobenthos (per sample)	60	12,771
Macrophytes (per survey)	20	6,192
Fish (per survey)	20	4,128
Total		**28,122 + VAT**

Undertaken by private consultants, macroinvertebrate and phytobenthos sampling and analysis is carried out by a single ecologist, whereas both macrophyte and fish surveys require a team of three ecologists (Table A13.2). The additional costs of survey teams, including field work and travel, are built into the estimates below. Sampling would be carried out every 5 km of river over a total of 100km.

Table A13.2 Total Cost of Pre-treatment Biological Assessment made by Private Consultants over 100km of River (£)

Private Consultants	Cost for 20 surveys
Macroinvertebrates	
Macrophytes	
Phytobenthos	
Total	**17,960**
Fish	10,000
Total cost	**27,960 + VAT**

A13.1.2 Chemical Assessment

SEPA has extensive data on pH in Scottish rivers because it is one (of a number) of the primary chemical parameters it monitors 6-12 times per year at upwards of 3,000 sites. Aluminium and dissolved organic carbon are more specialised parameters, and SEPA carries out monitoring for these at 100 sites across Scotland, 12 times per year.

Table A13.3 shows the costs for hydrochemical analysis prior to treatment with rotenone. SEPA does not have costs for individual parameters because it tends to operate in suites of analysis. The costs do not include sampling, and assume that the sample can be dealt with in large batches to maximise the use of equipment. Routine water quality parameters include BOD, alkalinity, suspended solids, conductivity, pH and hardness. The costs generated are per sample.

A pre-treatment survey of water chemistry on the River Luce would need to be carried out prior to the administration of rotenone treatment. Samples would be taken from the river and its tributaries at 5 km intervals over a 100 km area.

Table A13.3 Cost of Pre-treatment Assessment of Water Chemistry over 100km of River

	SEPA		Private Consultants	
Sample Types	**Sample No.**	**Cost (£)**	**Sample No.**	**Cost (£)**
pH			60	420
Conductivity	**One cost for all parameters**	**£50 per sample**	60	420
Alkalinity			60	420
Hardness			60	770.40
Biological Oxygen Demand			60	1,091.40
Suspended solids			60	900
Total		**3,000 + VAT**		**4,021.80 + VAT**

A13.1.3 Mapping of Treatment Area

The area where infection is located would need to be mapped to facilitate eradication. Each location would be allocated an identification number and a description, with recommended treatment for that location documented. Costs include the number of hours it would take one person to map a 100 km river course with two tributaries (Table A13.4).

Table A13.4 Costs for One Person to Map a 100 km River System

Km/day/ person	Hours/ day	Total length (Km)	No. days necessary	Hours	Cost/hour (£)	Total cost (£)
4	12	100	25	300	71.27	**21,381 +VAT**

A13.1.4 Planning of Treatment

Planning of treatment would include treatment design, and obtaining the necessary equipment to administer the prescribed chemical. It would also include the hiring and organisation of the appropriate staff, accommodation and transport etc.

Table A13.5 Planning Costs Prior to Administration of Chemical Treatment for Gs

Hours	Cost/hour (£)	Total cost (£)
250	71.27	**17,817.50 +VAT**

A13.1.5 Equipment

Table A13.6 shows the cost of equipment used in Norway. The specific equipment required in Scotland may differ according to the type of river system, hydrography etc. For example, a boat with a pump is required where there is a lot of stone and gravel on the river bed.

Table A13.6 Equipment Necessary for the Administration of the Chemical Treatment Rotenone

Equipment	No. required	Cost each (£)	Total cost (£)
Application Equipment	20	2934.72	58,694.40
Boat with Pump	15	2515.47	37,732.05
Large Drip Barrels	25	251.55	6,288.75
Small Drip Barrels	50	83.85	4,192.50
Other Equipment			16,856.86
Total			**123,764.56 + VAT**

A13.1.6 Dye Tracer Study

Prior to treatment it is often necessary to simulate the treatment using the dye rhodamin. This can be done in the main stream and the larger tributaries, applying the dye the same way as rotenone. The dye tracer study gives information on velocity, and checks to ensure the application permeates through the watercourse.

Table A13.7 Cost of Crew to Administer Dye Tracer Study

Dye tracer study	No. persons required	Cost/day (£)	Cost/hour (£)	No. days/hours	Total Cost (£)
Applications	30	125.77		2	7,546.20
Collecting Results	40	125.77		2	10,061.60
Technical Assistance	6		71.27	60	25,657.20
Operations Leaders	4		71.27	60	17,104.80
Total	**80**				**60,369.80 + VAT**

A13.1.7 Basic Treatment

The costs of labour to administer a chemical treatment of rotenone are shown in Table A13.8. At least two applications of rotenone are required to treat infected areas.

Table A13.8 Labour Costs to Administer a Chemical Treatment of Rotenone to a River

Treatment	No. persons required	Cost/day (£)	Cost/hour (£)	No. days	Total Cost (£)
Main Applications	30	125.77		2	7546.20
Boat	60	125.77		2	15,092.40
Drip Barrels	12	125.77		2	3,018.48
Treatment of Brooks	24	125.77		2	6036.96
Picking up Dead Fish	80	125.77		2	20,123.2
Technical Assistance	8		71.27	60	34,209.6
Operations Leaders	8		71.27	60	34,209.6
Total	**222**				**120,236.40**

A13.1.8 Provision for water abstraction

There are no hydro-electric schemes on the Luce river system and so interruption or disinfection of tunnels would not be required. Most farmers abstracting water are doing so from borehole sources and not directly from the river. However, water abstraction in the area may need to be interrupted for the duration of treatment, particularly in the case of rotenone as some public health issues have been raised in relation to its use (Bienot *et. al*. 2000). Treatment is carried out over a period of days. The chemical needs to degrade, and disposal of dead fish needs to be carried out before the water quality can return to normal. In Norway, it is recommended that water be not used for drinking or swimming for 24 hours after the end of treatment. In normal conditions, rotenone will not be detected in water after 2-3 days. Farmers are allowed to use water treated with rotenone for their stock as long as their animals are not producing milk. However, where possible if the water source can be switched this is recommended.

Follow-up studies would be integrated into routine biological and chemical analysis, depending on the treatment used. In the case of Aluminium Sulphate, Al and dissolved organic carbon (DOC) would need to be monitored. Costs for follow up-studies would be based on pre-treatment survey costs. In the case of rotenone treatment, invertebrate fauna appear to recover within three months, with fish taking longer (upwards of five years).

A13.2 Treatment with Aluminium Sulphate

Treatment with aluminium sulphate would require the same pre-treatment survey, followed by mapping, planning and the purchase of equipment. The Al method is pH dependent and the method is based on obtaining specific water chemistry by adding acid aluminium sulphate (AlS). Therefore, the volume of AlS necessary to eradicate the parasite, without affecting the fish (and other organisms), is water chemistry dependent.

The costs will be illustrated by AlS treatment of a 5 km river system. The main river has a water flow of about 10 $m^3 sec^{-1}$ and an alkalinity of 50 meq/l. To treat this river section, about 5 m^3 AlS a day would be needed. Treatment lasting for 14 days is thought to be enough to eradicate the parasite. The total volume of AlS needed would be 70 m^3. AlS treatment in Norway costs 2000 Norwegian Kroner (NOK) (£169) per m^3 of AlS. Thus, the chemical costs for this river section would be about 140,000 NOK (£11,830). Two dosing units to add 5m^3 AlS a day (to prevent supplying one unit every second day) would be required. One unit consists of an isolated container (20 feet), containing a fibre glass tank (10m^3), a pump and a program unit. The price for a complete unit is approximately 150,000 NOK (£12,721). In Norway, 4-5 people are employed from two different institutions to carry out most of the AlS treatment work. Planning and mapping is very time consuming but varies according to the size and complexity of the water course. During the 14 day treatment, approximately 20 people are involved. Water chemistry analysis is performed by the group in the field laboratories.

Treatment with AlS requires specific hydrochemical conditions including pH, temperature and DOC. There is a possibility that Gs may not be able to reproduce or survive on salmon or other host species as a result of local water conditions, e.g. local aluminium concentrations.. Further research will be required investigating parasite behaviour in Scottish water to establish necessary water conditions for Gs reproduction and survival on salmon and other host species, e.g. brown trout, charr and grayling. There is a possibility that Gs may not be able to reproduce or survive on salmon or other host species as a result of local water conditions, e.g. local aluminium concentrations. As treatment with AlS lasts two weeks, water abstraction from the catchment may need to be limited for a number of weeks. In Norway, the concentration of Al used during treatment is below 200ug Al l^{-1}, which is the limit stipulated by the EU Water Directive (98/83/EF). The Norwegians cite no public health risk in relation to long-term exposure to AlS when the dose used is below this limit.

Costs are summarised in Tables A13.9, A13.10 and A13.11.

Table A13.9 Cost of Water Chemistry Analysis Pre-AIS Treatment

	SEPA		Private Consultants	
Sample Types	**Sample No.**	**Cost (£)**	**Sample No.**	**Cost (£)**
Aluminium	60		60	961
pH	60		60	420
Alkalinity	60		60	420
Temperature	60		60	Included
DOC	60		60	1000
Total		**3000**		**2800**

Table A13.10 The Cost of Treating a 100km Main Stem With AIS

River Length	River flow	Alkalinity	Duration	AIS per day	Total AIS	AIS Cost	Administration	Total cost
(km)	(m^3/sec)	(µeq/L)	(days)	(m^3)	(m^3)	(£)	Unit (£)	(£)
5	10	50	14	5	70	11,830	1 unit 12,721 40 units	24,551
100	10	50	14	5	1,400	236,600	508,840	**745,440**

Table A13.11 The Cost of Crew to Administer a 14 Day Treatment of AIS to a 100km Watercourse

Crew	No. required	No. Days	Cost (£)	Cost (£)
	15	14	125.77 (per day)	26,411.70
	5	10	71.77 (per hour)	43,062
Disposal	20	14	125.77(per day)	35,215.60
Total cost (£)				**104,689.30**

Appendix 14. Topics for Further Research

A14.1. Usage of Scottish Lochs, Rivers and Canals

The research on the potential impact of Gs and possible containment policies has highlighted a dearth of knowledge on the use made of the lochs, rivers and canals of Scotland. A total or partial exclusion policy in any catchment would affect all water users, including those who simply like to splash at the edge of a campsite. The real problem for the policy maker is that, with the notable exception of the Spey, almost nothing is known about the numbers involved.

The Gs work has suggested that for the Spey, because of its importance to both on and off water recreation, the Total Exclusion policy would be economically and probably socially undesirable. We can hazard a guess that the same would be true for the Clyde/Lomond system and, apocryphally, for the Tay. However, other major systems, the Tweed, Don, Dee and Forth, may or may not have significant numbers of other users. It is simply unknown.

The potential variance is so large that every major system would need to be surveyed over a large number of days. The Spey survey utilised riverside enumerators backed up by card responses (full details are given in Riddington *et al.* (2004)). In addition, a census of all major suppliers was undertaken. This is a very major task but we would recommend it is undertaken as a matter of urgency for the major rivers, possibly on a rolling programme. Whilst the data will inevitably become dated, given the lack of knowledge of even the order of magnitude (10, 100, 1000 or 10,000 on the Dee?) this would be a huge improvement.

A14.2 Economic Value and Impact of Water Sports

In our experience the variance in patterns of expenditure with non-motor craft is relatively small. We have not, however, previously encountered high spend categories such as the large motor cruising craft found on Loch Lomond. The economic impact of a ban of such craft might be highly significant. We would, therefore, argue that as soon as the numbers have been established research into the impact should quickly follow (or should be conducted alongside the work).

Surveying expenditure can easily be coupled with willingness to pay assessments, and would be needed for effective policy making.

A14.3 Camping and Other Leisure

It may be argued that any waterside facility, be it beach, car park, footpath, pub, slipway, campsite, caravan park and so on, would be affected by an exclusion zone on a river. We would advocate the construction of a database for each river detailing *inter alia* public facilities, and the number and size of riverside camping and caravanning sites. We would expect this to be undertaken by local organisations (Tourist Board, local authorities) and both linked within Scotland and referenced to an agreed geographic information system(GIS).

The level of involvement in and importance of the water is a task of great complexity requiring very extensive survey work. We do not regard this as being a high priority for research.

The emphasis to date of river surveys has been on the flora and fauna found. A systematic survey of human uses would appear to us to be as important.

A14.4 Conclusion

Rough estimates of the economic value of water usage, and of a Gs containment strategy's impact can be made if the numbers involved in water related activities are known. Currently, however, we know almost nothing about the numbers involved. This basic research is urgent and essential.

Published by
Scottish Executive
St Andrew's House
Edinburgh

Produced for the Scottish Executive by the University of Stirling

Published by the University of Stirling

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