SCOTTISH NATURAL HERITAGE

COMMISSIONED REPORT

Commissioned Report No. 043

Assessment of sea lamprey distribution and abundance in the River Spey: Phase III

(ROAME No. F02AC604)

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Summary

Assessment of sea lamprey distribution and abundance in the River Spey: Phase III

Commissioned Report No. 043 (ROAME No. F02AC604)
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Background

A walk survey of the River Spey was conducted during summer 2002 to identify potential areas of lamprey habitat. These were then classified into optimal and sub-optimal habitat. In total 158 potential areas were identified, 59 of optimal habitat and 99 of sub-optimal habitat.

An electro-fishing survey was then conducted at 28 sites (23 optimal habitat and five sub-optimal habitat) using pulsed DC. Timed fishings were conducted at each site providing Catch Per Unit Effort (CPUE) data. In addition, an estimate of the area fished was also recorded allowing density to be calculated.

Main findings

- Sea lamprey (*Petromyzon marinus*) ammocoetes were scarce, only seven were caught at six survey sites. CPUE (fish.min^{-1}) for *Petromyzon* ammocoetes ranged from 0.1–0.2 fish.min^{-1} and similarly estimated densities of sea lampreys were low, ranging from 0.1–0.3m^{-2}. All the *Petromyzon* ammocoetes were non-transfomers and were captured in optimal habitat areas. Lengths ranged from 55–105mm but little can be determined regarding their distribution in the lower Spey.
- *Lampetra* sp. ammocoetes were widely distributed and captured at 23 sites, in both optimal and sub-optimal habitats. They were abundant in many areas and, where present, CPUE for non-transformers ranged from 0.67–12.67 fish.min^{-1}. Estimated densities of *Lampetra* ammocoetes ranged from 1.9–38m^{-2}.
- Transforming *Lampetra* species were recorded at eight locations. In general catches were limited to between one and four transformers although one site produced 12, and estimated densities ranged from 0.1–0.8m^{-2}. Lengths of *Lampetra* transformers ranged from 97–145mm.

The present survey is similar to previous Spey surveys indicating that *Petromyzon marinus* junveniles are poorly distributed and present in low densities. *Lampetra* sp. is more widely distributed and generally more abundant.

Key areas of optimal habitat are identified; these should be carefully managed to ensure that if an increase in the returns of adult *Petromyzon marinus* occurs there are suitable areas of optimal habitat available for their offspring.

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1 INTRODUCTION

Three species of lampreys are found in the Spey, the sea lamprey (*Petromyzon marinus*), the river lamprey (*Lampetra fluviatilis*) and brook lamprey (*Lampetra planeri*). All three lamprey species spawn in fresh water in spring or early summer and this is followed by a larval phase (ammocoetes) spent in suitable silt beds in streams and rivers. The ammocoetes can spend several years in these silt beds, feeding on organic detritus and eventually begin to transform into adults from late summer onwards. The transformation into the adult stage is characterised by the development of functional eyes and the mouth changes into a fully formed sucker (Gardiner 2003). Lampreys at this stage of development are referred to as 'transformers'.

After transformation, the river and sea lampreys migrate to sea, where they use their suckers to attach to other fish. After several years the adults return to fresh water to spawn. Sea lampreys are the larger of the two species reaching lengths of up to 100cm. River lampreys generally reach lengths of 30–40cm. Brook lampreys differ in that they remain in fresh water and do not feed as adults. They spawn in the spring and are considerably smaller, only attaining lengths of 15–20cm. For a useful review of their life histories see Johns (2002).

The mainstem of the river Spey is a Special Area of Conservation (SAC) for sea lamprey (*P. marinus*), Atlantic salmon (*Salmo salar*), otters (*Lutra lutra*) and the freshwater pearl mussel (*Margaritifera margaritifera*). The latter three species have received considerable attention in recent years but less is known about the distribution and ecology of the sea lamprey within the Spey. Some studies have been completed (Gardiner *et al.* 1995; APEM 2001a, 2001b, 2002a) and provide initial information on the distribution of the sea lamprey in the river. However, to date a thorough survey of the lower half of the mainstem from Grantown to the mouth has not been completed.

The present study aims to locate suitable habitat areas for lampreys in the lower River Spey (mouth to Grantown), to conduct an electro-fishing survey of a range of these areas and determine sea lamprey distribution. Habitat areas where sea lamprey ammocoetes were identified would also be more intensively surveyed to determine population densities. The results of this study complement those of an earlier survey that examined the distribution of sea lampreys upstream from Grantown (APEM 2002a).

2 METHODS

2.1 Walk survey

A River Corridor Survey of the mainstem Spey was conducted in 1994 (Cobham Resource Consultants 1994). Within this survey the mainstem was divided into 500m sections and coded appropriately. These sections were used as a template for the current survey.

Optimal lamprey habitat can be readily identified and generally consists of an area of shallow (<50cm) slow flowing water (Malmqvist 1980), containing several square metres of silt/sand substrate which also includes organic material/debris (Potter *et al.* 1986). A continuous supply of well-oxygenated water is also important. Backwaters or back channel areas adjoining the mainstem are generally good rearing areas. However, suitable accumulations of silt/sand and organic material can also be deposited behind fishing croys and in slower flowing areas of the mainstem to provide suitable habitat.

To allow comparison with previous lamprey surveys on the Spey and elsewhere a simple two point key for characterising lamprey habitat (Table 1) was employed during the current survey (from APEM 2002b).

Table 1 Definitions for lamprey ammocoete habitat used in walk survey of the lower River Spey

Habitat Type	Definition
Optimal	Stable cover of sand/silt/organic material >=2m^2 with depth >=15cm Low water velocity Clear connection to mainstem
Sub-optimal	Shallow patchy cover of sand/silt/organic material >2m^2

The survey was conducted by walking both banks of the mainstem wherever possible and recording the location of each area of suitable lamprey habitat. The OS co-ordinates for each site were recorded along with a brief description of the site. When available, hand-held GPS (Garmin Etrex) were used to provide location coordinates. If the GPS was not available, co-ordinates were determined from a 1:25,000 OS map. In general most areas of suitable habitat occupied a clearly defined backwater channel and point co-ordinates were recorded along with a visual estimate of the suitable area. Data were then compiled into an Excel spreadsheet (Appendix 1).

2.2 Ammocoete identification

Gardiner (2003) indicates that the ammocoetes of river and/or brook lamprey are likely to dominate any samples taken in the UK and previous samples of lamprey populations in the Spey concurred with this statement (Gardiner *et al.* 1995; APEM 2002a).

Potter and Osborne (1975) indicated that sea lamprey ammocoetes could be distinguished from those of river or brook lamprey by the different pigmentation patterns and morphology. Using these and other characters, Gardiner (2003) provides a very useful key for the identification of ammocoetes in the wild.

In sea lamprey ammocoetes, the entire oral hood is pigmented, although the intensity diminishes towards the lower edge of the upper lip. In the river and brook lamprey, the pigmentation does not extend as far as the edge of the upper lip and appears transparent.

In sea lamprey, pigment is spread from the body into the caudal fin, and second dorsal fin, in contrast to river and brook lamprey, where it is generally limited to a thin strand along the base of the fin. Differences in caudal fin shape are also present. Trunk myomere counts can also be used with the counts ranging from 69–75 in sea lamprey, but only 57–66 in river and brook lamprey. Surveyors undertaking the current project were all trained to identify lamprey ammocoetes by Ross Gardiner (Fisheries Research Services, Freshwater Laboratory).

Headband magnifiers (x2) and a white measuring board to aid identification were also used (Gardiner 2003). All captured lamprey ammocoetes were identified and measured. Any transformers were also recorded and measured. A weak solution of benzocaine was used to pacify the lampreys during the process. After identification and measurement the lampreys were allowed to recover and returned at their point of capture.

2.3 Electro-fishing survey

APEM (2002a) outlined two techniques for electro-fishing surveys of lamprey. The semi-quantitative technique involves one minute electro-fishing in a circular pattern around the anode operator. Any lamprey ammocoetes attracted to the current are then captured using dip nets. Pulsed DC current is used at a minimum of 100V. Fishing is conducted by energising the anode for 15 s and then switching it off for 5 s. This pattern is repeated until a full minute's fishing time is completed.

APEM (2002a) also outlined a quantitative technique. This involves the placement a vertical walled quadrat of $1m^2$ over the lamprey habitat. The area within is then electro-fished with 100V pulsed DC current in 15 s bursts with a 5 s gap between bursts. The quadrat is fished in this manner for 2 min. This process is then repeated after resting the area for approximately 15 min. Between three and five runs are typically completed.

These methodologies were utilised in the current survey with some minor adaptations. Drawing on previous electro-fishing experiences in the mainstem Spey for salmonids, voltages were increased to between 150 and 250V for both methods. During the semi-quantitative survey 1 min was found to be too short a time period to draw out the lampreys, net them and transfer them to a holding bucket so the fishing time was extended to 3 min. An estimate of the area fished during the timed electro-fishing was also recorded and this was used to give an estimated density for the site. This allows comparison with previous studies on the Spey and with other rivers.

When quantitative surveying was undertaken at one site, lamprey ammocoete population densities were estimated using the Zippin (1958) depletion model.

3 RESULTS

3.1 Walk survey

The walk survey was completed during August and September 2002. As far as possible both banks were walked although in some areas access was difficult. Where access was not possible and a suitable backwater was observed from the opposite bank it was recorded and on several occasions ghillies were able to provide information and advice regarding the suitability of these areas for lamprey ammocoetes.

The survey area extended from the A95 road bridge in Grantown on Spey downstream to the viaduct near Tugnet. Spot checks were also carried out downstream from the viaduct to the mouth.

The area covered in the walk survey is summarised in Table 2. In general the left bank (looking downstream) of the mainstem was the more readily accessible with only two RCS sections not examined (S125 and S126). A number of areas along the right bank, most notably at Knockando, Rothes, Delfur and from Boat o'Brig to Fochabers are very difficult to survey due mainly to the presence of high cliffs and, in some stretches, dense forestry.

Table 2 Summary of river corridor sections surveyed for lamprey habitat during August/September 2002

River Corridor Sections (RCS)	Location	River Banks surveyed	Notes
S148 to S131	A95 Road Bridge Grantown on Spey to Pollowick Pool, Castle Grant	Left and right	
S130 to S127	Pollowick Pool to Dellifure Burn	Left only	Access to right bank difficult, thick forest
S126 to S125	Dellifure Burn to Tulchan Beat A Hut	None	Access difficult
S124 to S90	Tulchan A Hut to Knockando (Stoney Island)	Left and right	
S89 to S81	Stoney Island to Laggan	Left only	Access difficult on right due to cliff and forestry
S80 to S48	Laggan to Lower Arndilly	Left and right	
S47 to S13	Rothes to Fochabers Bridge	Left only	Access along right bank very difficult, cliffs and forestry
S13 to S2	Fochabers Bridge to Viaduct	Left and right	

Using the two-point scale (Table 1) for suitable lamprey habitat 158 potential areas were recorded. These are summarised in Table 3 and Appendix 1 contains full grid references and location details.

Table 3 Summary of suitable lamprey habitat areas recorded during walk survey from Grantown to Spey Viaduct, during 2002

Habitat Type	Number of Sites
Optimal	59 (37%)
Sub-Optimal	99 (63%)
Total	**158**

Suitable habitat was generally found in backwaters and old river channels. However, suitable deposits along the bank side, in slow flowing areas, on the inside of river bends and, on occasion, behind fishing croys were also identified.

Some areas of extensive deposits, >100m^2 were recorded and these are presented in Table 4. These 11 sites represent the largest suitable areas on the lower Spey and the most stable. For longer term monitoring purposes these areas may well offer suitable sites that can be re-visited routinely. Two of the 11 areas were not electro-fished. The other nine areas were electro-fished and details of all the sites are presented in Table 4.

Table 4 Suitable areas of lamprey habitat greater than 100m^2 in the lower Spey 2002

Easting Northing	Description/Location	Estimated Area	Electro-fishing Site Code
334370 862998	Extensive Backwater beside Essil Pool	600–1000m^2	L005L1
334150 859680	Backwater, 300m downstream from Fochabers Bridge on right bank	100m^2	L012R1
333221 855722	Backwater beside Lord March Pool, Brae Water Beat 3	>100m^2	L022L1
333275 856843	Backwater at lower end of Aultdearg Pool, Brae water Beat 3	>100m^2	No EF Survey
331750 852500	Backwater at Upper end of Orton Beat	>100m^2	No EF Survey
333221 850851	Large backwater at upstream end of Sourden pool, Delfur	800m^2	L042L1
324800 842900	Extensive sand/silt deposit in Pike Hole, Wester Elchies	>100m^2	L070L1
323822 841734	Backwater at Horse Hole, Delagyle	150m^2	L73R1
317972 837878	Backwater approx 500m upstream from Blacksboat Bridge, Pitchroy	500m^2	L97L1
316300 836882	Backwater downstream from March Pool, Ballindalloch	800m^2	L103L1
331750 852500	Backwater 1km downstream from Cromdale Church, Castle Grant Beat 2	150m^2	L136R1

3.2 Identification training day results

Lamprey ammocoetes were collected from two locations on the Spey using electro-fishing equipment for identification training purposes. No measure of the area fished or the time taken was recorded; however, details of the catch at each site are included in Table 5. The majority of the lampreys captured were *Lampetra* ammocoetes (277). In addition 12 *Lampetra* transformers were captured and three *Petromyzon* ammocoetes were identified in the samples.

Table 5 Lamprey ammocoetes collected during identification training on 26th August 2002 with Ross Gardiner (FRS Freshwater Laboratory)

Location	Easting Northing	*Lampetra*		*Petromyzon*	
		Ammocoetes	Transformers	Ammocoetes	Lengths (mm)
Lord March, Brae Water	333221 855722	181	12	3	60, 68, 80
Upper Craigellachie Beat	327600 843788	96	0	0	

3.3 Semi-quantitative electro-fishing results

Having identified suitable habitat areas electro-fishing commenced in September 2002. A semi-quantitative electro-fishing survey was carried out at 28 sites along the length of the mainstem encompassing a range of habitat types from optimal to sub-optimal. One additional site was surveyed using the quantitative quadrat technique.

In general sampling was targeted at optimal habitat areas to maximise the chance of capturing sea lamprey ammocoetes (Table 6). However, some sub-optimal habitat areas were examined to determine if these are utilised by any species of lamprey.

Table 6 Summary of habitat type where semi-quantitative electro-fishing was conducted

Habitat Type	Number electro-fished
Optimal	23
Sub-Optimal	5

3.3.1 Sea lamprey ammocoetes

The results from the semi-quantitative electro-fishing survey for sea lamprey (*P. marinus*) are shown in Table 7 and Table 8. Results were disappointing for sea lamprey with only seven sea lamprey ammocoetes captured at six locations (21%). Distribution of sea lamprey ammocoetes ranged from a backwater on the Essil Pool near the mouth of the Spey upstream to Knockando (Table 7). All the sea lamprey ammocoetes were captured in areas of optimal habitat. No clear pattern of distribution can be determined. No *Petromyzon* transformers were captured.

Results in Table 8 indicate that the catch per unit effort (CPUE) (fish.min^{-1}) for *Petromyzon* ammocoetes ranged from 0.1–0.2 fish.min^{-1} and similarly the estimated densities of sea lampreys were low, ranging from 0.1–0.3m^{-2}. *Petromyzon* ammocoetes ranged from 55–105mm in length.

Table 7 Capture locations for *P. marinus* ammocoetes, in the Lower River Spey 2002

Site Code	Easting Northing	Location	Site Quality
L005L1	334370 862998	Essil Pool, Lower Spey	Optimal
L022L1	333221 855722	Lord March Pool, Brae Beat	Optimal
L064L1	326850 843600	Fishing Hut, Lower Wester Elchies	Optimal
L064L2	327300 843700	Opposite Sewage Works, Lower Wester Elchies	Optimal
L077L1	320090 841069	Downstream from Carron Bridge, Carron	Optimal
L084L1	320090 841069	Upstream from Island Roary, Knockando	Optimal

Table 8 CPUE, estimated density (m^{-2}) and length (mm) for survey sites containing *P. marinus* ammocoetes, River Spey 2002

EF Site Code	Area Fished (m^2)	*Petromyzon* ammocoetes			
		Number	CPUE ($fish.min^{-1}$)	Density (m^{-2})	Length (mm)
L005L1	5	1	0.1	0.2	93
L022L1	10	1	0.1	0.1	105
L064L1	5	1	0.1	0.2	55
L064L2	4	1	0.1	0.3	80
L077L1	4	1	0.1	0.3	62
L084L1	8	2	0.2	0.3	60
					73

3.3.2 River and brook lampreys (*Lampetra*)

In contrast to the poor numbers of *P. marinus* ammocoetes captured, *Lampetra* ammocoetes were widely distributed and generally present in good numbers. Both immature juveniles and transformers were captured.

Lampetra were absent from only five (18%) of the survey sites: L12R1, Backwater 300m downstream from Fochabers Bridge; L40L1, Backwater at Island of Dundurcus, Delfur; L43L1, Backwater near 50m upstream from Crofts Farm Burn Rothes/Aikenway; L58L1, Backwater at Craigellachie Bridge; and L58L2, Backwater at Craigellachie Bridge.

Table 9 provides details of the site locations from Spey Bay upstream to Grantown. Table 10 provides details of the numbers of *Lampetra* caught at each site, the CPUE ($fish.min^{-1}$) and an estimated density (m^{-2}). Figure 1 illustrates the CPUE for *Lampetra* ammocoetes and transformers. Where *Lampetra* non-transformers were present CPUE varied from 0.67–12.67 $fish.min^{-1}$ (at L97L1 and L22L1 respectively). Estimated densities of *Lampetra* ammocoetes ranged from 1.9–38m^{-2}.

Figure 2 illustrates the length distribution for all the *Lampetra* captured during the survey. It is difficult to discern any age class patterns from Figure 2 however it is likely that 0+ larvae may range from 19–42mm. No other age cohorts are readily discernable.

Transforming *Lampetra* species were recorded at eight locations (Table 9). In general catches were limited to between one and four transformers although site L22L1 produced 12. *Lampetra* transformer densities ranged from 0.1–0.8m^{-2}. Figure 2 indicates that transformer length ranged from 97–145mm.

Table 9 Locations of lamprey electro-fishing sites in the Lower River Spey 2002

EF Site Code	Date Electro-fished	Easting	Northing	Location	Habitat Quality
L005L1	19/09/2002	334370	862998	Large backwater beside Essil Pool	Optimal
L011L1	19/09/2002	334532	860468	200m downstream from path from ghillies hut, Gordon Castle Water	Sub-optimal
L012R1	28/10/2002	334150	859680	100m downstream from Fochabers Roadbridge	Sub-optimal
L022L1	10/10/2002	333221	855722	Backwater beside Lord March Pool Brae beat 3	Optimal
L035L1	08/10/2002	331450	851600	Mouth of Collie Burn, Delfur	Sub-optimal
L040L1	08/10/2002	329600	850250	Backwater in old channel behind Island of Dundurcus, Delfur	Optimal
L042L1	08/10/2002	329029	850851	Large backwater at upper end of Sourden pool, Delfur	Optimal
L043L1	28/10/2002	328650	850650	Backwater 50m upstream from small burn flowing in at Crofts Farm, Rothes	Optimal
L044L1	29/09/2002	328500	849950	Backwater 50m downstream from Rothes sewage works	Optimal
L044L2	29/09/2002	328570	850088	100m downstream from Rothes Burn confluence, top end of Junction Pool	Sub-optimal
L054L1	18/09/2002	329326	846652	Directly below croy on left bank at Ladies Haugh	Optimal
L056R1	17/09/2002	329361	845626	200m downstream from mouth of Fiddich	Sub-optimal
L058L1	17/10/2002	328759	845314	Backwater downstream from Craigellachie roadbridge, beside farm track	Optimal
L058L2	17/10/2002	328697	845265	Directly beneath Craigellachie roadbridge	Optimal
L063R1	18/09/2002	327600	843788	Backwater 200m upstream from hut at Green bank, Craigellachie	Optimal
L064L1	30/10/2002	326850	843600	Outside fishing hut, Lower Wester Elchies	Optimal
L064L2	30/10/2002	327300	843700	Opposite sewage works, Lower Wester Elchies	Optimal
L070L1	30/10/2002	324800	842900	The Pike Hole, 100m downstream from Lower Wester Elchies hut	Optimal
L073R1	17/10/2002	323822	841734	Backwater directly downstream from Green Burn mouth, Delagyle	Optimal
L077L1	30/10/2002	322500	841200	Downstream side of Carron Bridge, boat mooring	Optimal
L084L1	09/10/2002	320090	841069	15m upstream from Island Roary, beside boat mooring, Knockando	Optimal
L088L1	09/10/2002	318931	841325	10m upstream from ghillies hut, Phones Beat Knockando	Optimal

Table 9 *(continued)*

EF Site Code	Date Electro-fished	Easting	Northing	Location	Habitat Quality
L094L1	09/10/2002	318552	839610	Approx 600m downstream from Blacksboat Bridge	Optimal
L097L1	01/10/2002	318074	838184	Large backwater, 600m upstream from Blacksboat Bridge	Optimal
L103L1	11/10/2002	316300	836882	At footbridge over backwater 30m upstream from confluence, Ballindalloch	Optimal
L111L1	11/10/2002	313400	835203	120m downstream from large shed (old hatchery), Tulchan	Optimal
L116L1	11/10/2002	311615	834547	Backwater, Tulchan	Optimal
L136R1	04/10/2002	307100	829150	Backwater 200m upstream from Cromdale Burn	Optimal

Table 10 Number, CPUE (fish.min^{-1}), and estimated density (m^{-2}) for *Lampetra*, River Spey 2002

EF Site Code	Area fished (m^2)	*Lampetra* Non-transformers			*Lampetra* Transformers			Total *Lampetra*		
		Number	CPUE (fish.min^{-1})	Density (m^{-2})	Number	CPUE (fish.min^{-1})	Density (m^{-2})	Number	CPUE (fish.min^{-1})	Density (m^{-2})
L005L1	5.0	54	3.6	10.8	1	0.1	0.2	55	3.7	11.0
L011L1	2.0	4	1.3	2.0				4	1.3	2.0
L012R1	8.0	0	0.0	0.0				0	0.0	0.0
L022L1	10.0	129	8.6	12.9	12	0.8	1.2	141	9.4	14.1
L035L1	2.0	76	12.7	38.0	1	0.2	0.5	77	12.8	38.5
L040L1	5.0	0	0.0	0.0				0	0.0	0.0
L042L1	5.0	87	7.3	17.4				87	7.3	17.4
L043L1	8.0	0	0.0	0.0				0	0.0	0.0
L044L1	2.0	41	6.8	20.5	1	0.2	0.5	42	7.0	21.0
L044L2	1.0	18	6.0	18.0				18	6.0	18.0
L054L1	5.0	47	9.4	9.4				47	9.4	9.4
L056R1	4.0	40	5.0	10.0	0	0.0	0.0	40	5.0	10.0
L058L1	3.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
L058L2	2.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
L063R1	3.0	30	10.0	10.0				30	10.0	10.0
L064L1	5.0	18	1.5	3.6				18	1.5	3.6
L064L2	4.0	56	4.7	14.0				56	4.7	14.0
L070L1	5.0	50	3.3	10.0				50	3.3	10.0
L073R1	10.0	19	1.6	1.9	1	0.1	0.1	20	1.7	2.0
L077L1	4.0	21	2.3	5.3				21	2.3	5.3
L084L1	8.0	84	7.0	10.5	4	0.3	0.5	88	7.3	11.0
L088L1	3.0	49	5.4	16.3				49	5.4	16.3
L094L1	3.0	110	12.2	36.7				110	12.2	36.7
L097L1	5.0	10	0.7	2.0				10	0.7	2.0
L103L1	10.0	108	7.2	10.8				108	7.2	10.8
L111L1	4.0	39	3.3	9.8	4	0.3	1.0	43	3.6	10.8
L116L1	4.0	81	6.8	20.3				81	6.8	20.3
L136R1	6.0	53	2.9	8.8	2	0.1	0.3	55	3.1	9.2

Figure 1 CPUE for *Lampetra* ammocoetes and transformers on the mainstem Spey 2002

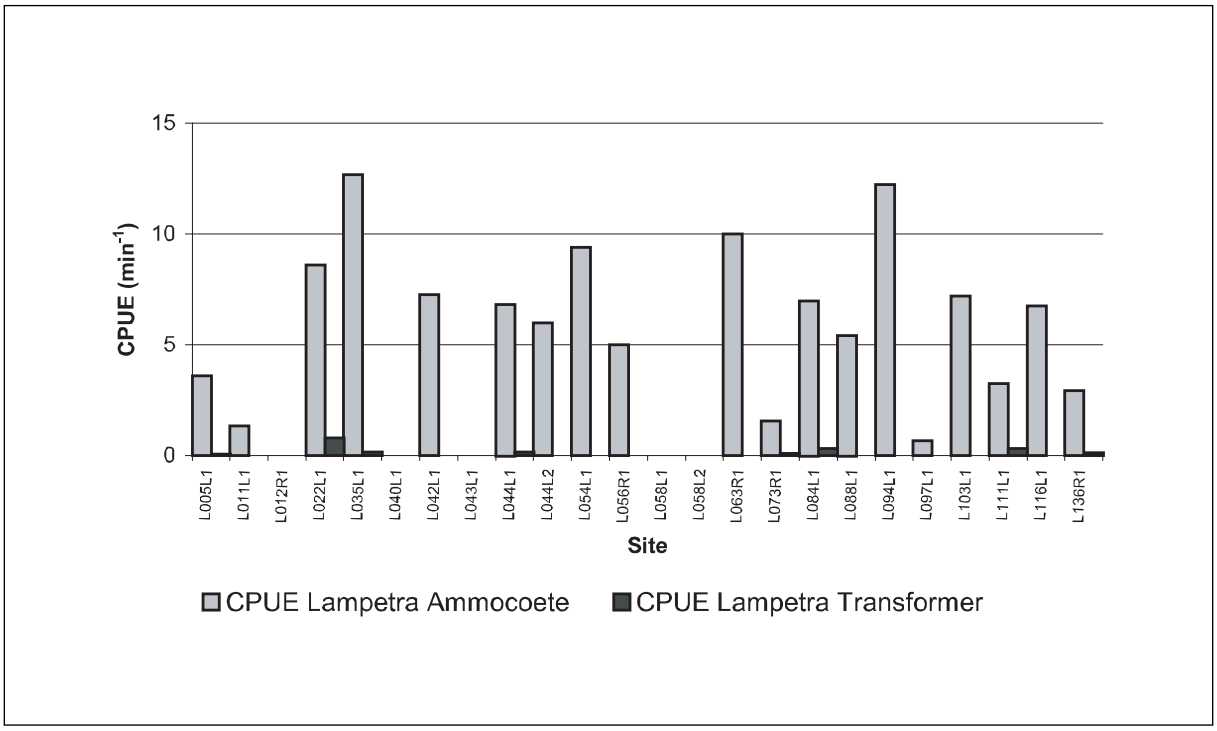
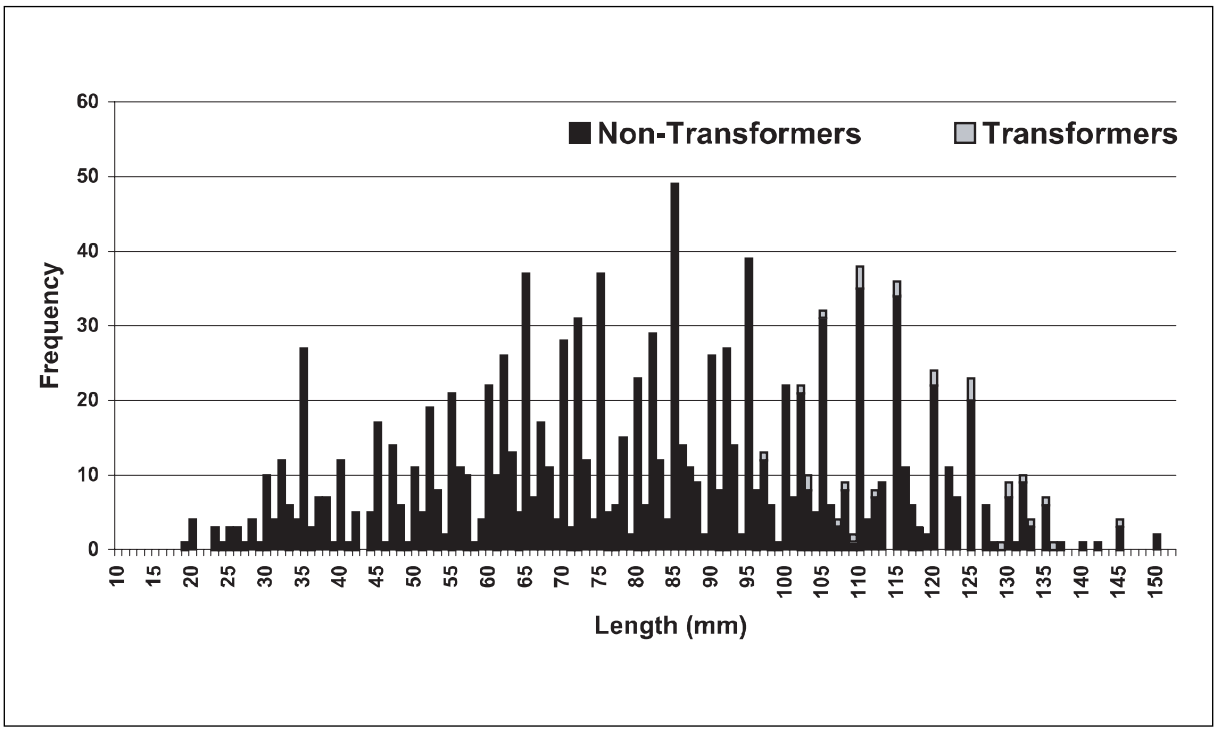


Figure 2 Length-frequency histogram of *Lampetra* captured during River Spey survey 2002



3.4 Quantitative electro-fishing

Initially it was proposed to re-visit areas where sea lamprey ammocoetes were captured and carry out a fully quantitative survey. However, it was clear from the semi-quantitative survey that very few areas contained sea lampreys and therefore more time was devoted to surveying additional areas of suitable habitat. One quantitative estimate was carried out at Lord March, Brae Water (L022L1). Sea lamprey ammocoetes had been captured at this site previously during training with Ross Gardiner (FRS, Freshwater Laboratory) (Table 5) and again during the semi-quantitative survey.

Three 1m^2 quadrats were electro-fished and four 2 minute fishing runs were conducted in each quadrat. To calculate density for the site the catch from each run within each quadrat was combined and the Zippin (1958) depletion model on successive catches was applied. The results are presented in Table 11.

Table 11 Density (m^{-2}) of lamprey ammocoetes estimated at Lord March, Brae Water, (L022L1) on 10th October 2002

Location/Site Code	Easting Northing	Density (m^{-2})			Notes
		Lampetra ammocoetes	*Lampetra* transformers	*Petromyzon marinus* ammocoetes	
Lord March, Brae Water/ L022L1	333221 855722	12	0	0	No *Petromyzon* captured

Results in Table 11 indicate that no sea lamprey ammocoetes or *Lampetra* transformers were captured. The density of *Lampetra* ammocoetes was 12m^{-2}.

3.5 Comparison with earlier Spey survey data

Some comparative data on lamprey larvae in the lower Spey are available from Gardiner *et al.* (1995). In addition some limited data from 1988 are also available from letters and reports submitted to the Spey Fishery Board by Lord Richard Percy who obtained samples for morphological and physiological analysis from the Brae Water area.

Figure 3 Comparison of *Lampetra* densities in 1994 (Gardiner *et al.* 1995) with 2002

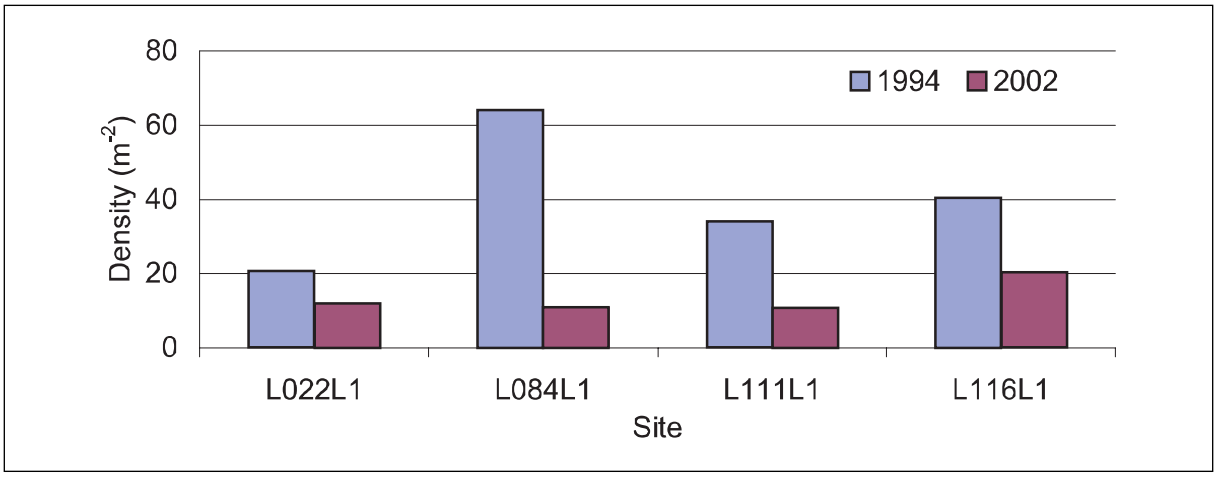


Figure 3 compares *Lampetra* data collected in 2002 with data from 1994, collected by Gardiner *et al.* (1995). The data for sites L022L1 and L084L1 correspond directly with sites S1 and S3 from Gardiner *et al.* (1995) while sites L111L1 and L116L1 are within 1km of sites S4 and S5. The 2002 data presented for L022L1 are from the fully quantitative electro-fishing (Table 9) while the 2002 data presented for the other three sites are calculated using an estimate of area fished during the timed fishing.

The densities of *Lampetra* are lower in all sites during the 2002 survey than in 1994. No data on the area fished by Lord Percy are provided so density comparisons cannot be made.

Table 12 Numbers of Petromyzon ammocoetes recorded at Lord March, Brae Water in 1988, 1994 and 2002

Survey	**No of *Petromyzon* ammocoetes captured at Lord March, Brae Water. (L022L1 or S1)**	**Notes**
Lord Percy 1988	3	No information on fishing time or area was supplied
Gardiner *et al.* 1995	1	One ammocoete was captured during semi-quantitative fishing
Current survey 2002	0–3	Three were captured during identification training day (Table 5)

All three data sets indicate *Petromyzon* ammocoetes are present at the backwater at Lord March. However, numbers are considerably lower than *Lampetra*.

4 DISCUSSION

4.1 *Petromyzon marinus*

Optimal lamprey habitat generally consists of an area of shallow (<50cm) slow flowing water (Malmqvist, 1980) containing several square metres of silt/sand substrate, which also includes organic material/debris (Potter *et al.* 1986). A continuous supply of well-oxygenated water is also important.

The two-point key for characterising lamprey habitat surveys into optimal and sub-optimal habitat (APEM 2002b) proved adequate for identifying prospective habitat for lampreys in the lower Spey. Backwaters or back channel areas adjoining the mainstem were readily identified. In addition, suitable accumulations of silt/sand and organic material deposited (for example behind fishing croys and in slower flowing areas on the inside of river bends) were also recorded.

Almeida and Quintella (2002) indicate that *P. marinus* larvae have differing habitat preferences during their development in the River Mondego, Portugal. Smaller larvae (20–60mm) were commonly found in silty sand substrates while larger larvae (60–140mm) preferred a more heterogeneous substrate of gravel and sand. Larger larvae (>140mm) preferred coarser grained sands and gravel. Similar patterns of distribution may well occur for *Lampetra*. During this survey the four areas where lamprey ammocoetes were absent were composed of very dense substrate, generally closer to 'mud' than riverine deposits of silt and sand. The substrate was also very sticky and earthworms were reported. Each area was under water but water flow through the sites was very slow suggesting that oxygen transfer into the substrate may have been poor.

Key areas of extensive suitable lamprey habitat (>100m^2) were identified (Table 4). Although subsequent electro-fishing surveys produced only a few sea lamprey ammocoetes these areas should be earmarked as important juvenile rearing areas and managed appropriately. They are semi-permanent despite the mobile nature of the lower Spey and may prove a suitable core of areas to begin longer term monitoring.

Previous studies by APEM (2002a), Gardiner *et al.* (1995), and data from Lord Percy submitted to the Spey Fishery Board in 1988 indicate that sea lamprey ammocoete distribution and density are limited in the Spey. The current survey confirms these previous findings. Only six survey sites produced sea lamprey ammocoetes and these were limited to one or two individuals per site. The small numbers that were captured were distributed from the Essil Pool near the mouth of the Spey upstream to Knockando.

Harvey and Cowx (2003) tentatively suggested that an abundance of 0.2m^{-2} *Petromyzon* ammocoetes in optimal habitat indicates favourable condition, and that a density of 0.1m^{-2} would indicate favourable condition from a catchment perspective including areas of suboptimal habitat. The current survey produced an estimated density range of 0.1–0.3m^{-2} which is similar to the above figures. It is important to bear in mind that the density estimates from the lower Spey have been produced using semi-quantitative techniques and are therefore likely to represent a minimum density for each sampling location. However, the limited distribution suggests that there is only a relatively limited population of *P. marinus* juveniles in the river.

It is not clear why so few sea lamprey ammocoetes were captured. All surveyors completed a lamprey identification training day. A guide to identification (Gardiner 2003) and other identification aids such as magnification binoculars and white measuring boards were also used. Thus mis-identification is not considered a problem.

Electro-fishing was carried out during September and October and the latter month was unseasonably mild, providing ideal sampling conditions. Thus, low water temperatures, which can affect electro-fishing success (APEM 2002a), did not prevail. Smaller larvae are also more difficult to catch during electro-fishing (APEM 2002a); however, a good size range of *Lampetra* (20mm upwards) was captured so it is unlikely that smaller *Petromyzon* would have been missed.

The Spey is approaching the northern limit of sea lamprey distribution (Maitland and Campbell, 1992) and reports of adults in the Spey are patchy. A substantial spawning run was observed at Boat o'Brig in July 1989 and dead adults from Craigellachie and Boat o'Garten have also been recorded (R. Laughton *pers. comm.*). Spawning adults were observed as far upstream as Kingussie in July 1985 (Ross Gardiner *pers. comm.*). More recently, in July 2002 five to six lampreys were observed during a freshwater pearl mussel dive survey of the Pollowick Pool, Castle Grant Beat 3, (Peter Cosgrove *pers. comm.*). However, the estimated length of these individuals was approximately 30cm suggesting they were river lampreys rather than sea lampreys. Given these sparse and occasional observations, the return rate and spawning distribution of adults within the Spey is likely to vary considerably.

APEM (2002a) indicated that upstream from Grantown the mainstem is low in gradient and extensive areas of lamprey habitat exist. Although much steeper in gradient and faster flowing, several key areas of suitable lamprey habitat (>100m^2) were identified (Table 4) in the Spey downstream from Grantown. Although subsequent electro-fishing surveys produced only a few sea lamprey ammocoetes, these areas should be earmarked as important juvenile rearing areas and managed appropriately. In general these areas are semi-permanent, despite the mobile nature of the lower Spey, and may proved a suitable core area to begin longer term monitoring.

4.2 *Lampetra*

The current survey indicates that *Lampetra* are widely distributed in the River Spey downstream from Grantown. In general where suitable habitat was found some *Lampetra* would be present. Both ammocoetes and transformers were recorded during the survey. Transforming *Lampetra* can be identified to species in their latter stages of transformation (Gardiner 2003). The current survey was conducted during September and October and was too early to differentiate between the river and brook lampreys.

The current survey concentrated on semi-quantitative electro-fishing in order to cover as many areas as possible and maximise the chance of capturing sea lampreys. The electro-fishing was timed and CPUE determined, along with an estimated density figure. It is clear from these data that *Lampetra* are abundant in many areas. Density estimates were calculated for four sites and compared with Gardiner *et al.* (1995). A decline in the density of *Lampetra* ammocoetes was recorded at each site. Harvey and Cowx (2003) tentatively suggested that in optimal habitat population densities of *Lampetra* ammocoetes greater than 10m^{-2} indicate favourable condition. In the current survey 16 of the survey sites were equal to or exceeded this value, suggesting that the Spey contains a healthy population. However, some care needs to be taken with this approach since the area used to estimate the density was only fished for 2 minutes rather than until the area was completely depleted of lampreys. Therefore, the densities presented in this study should be treated as a minimum density of ammocoetes present at each location. For longer term monitoring a more consistent approach is required.

5 CONCLUSIONS AND RECOMMENDATIONS

Suitable areas of lamprey habitat were identified in the Lower Spey. Many areas are transient and temporary in nature due to the mobile nature of the Spey. However, several key habitat areas, predominantly backwaters, have been identified. Future river management should seek to maintain these areas.

The distribution and density of sea lamprey (*P. marinus*) larvae in the lower Spey is limited. *Lampetra* larvae are more widely distributed and occur in greater numbers. Establishment of a core of sampling sites, particularly at the key habitat areas identified, is recommended to monitor the status of both genera/species and inform future casework.

Semi-quantitative electro-fishing with pulsed DC worked well for the broad-brush approach required in this survey and allows a number of sites to be quickly surveyed. However, for longer term monitoring quantitative electro-fishing to determine density may be more appropriate.

It was evident throughout the survey that many anglers and proprietors knew little of the habitat required and life cycle of the lamprey. Increasing awareness of the lamprey and its requirements is recommended.

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APPENDIX 1 – Location data for potential lamprey habitat from the mouth of the River Spey upstream to Grantown, 2002

Date	Easting	Northing	RCS	Fishing Beat	Location	Bank (Looking down-stream)	Site Quality	Date Electro-fished	EF Site Code
12-Sep-02	334800	864150	S003	Gordon Castle Lower Water	Backwater immediately upstream from Viaduct	Right	Optimal		
12-Sep-02	334370	862998	S005	Gordon Castle Lower Water	Large backwater beside Essil Pool	Left	Optimal	19-Sep-02	L005L1
12-Sep-02	334532	860468	S011	Gordon Castle Upper Water	200m downstream from path from ghillies hut	Left	Sub-optimal	19-Sep-02	L011L1
12-Sep-02	334150	859680	S012	Gordon Castle Water	100m downstream from Fochabers Roadbridge	Right	Sub-optimal	28-Oct-02	L012R1
12-Sep-02	334150	859680	S012	Gordon Castle Water	Backwater 20m in from main channel, approx 300m downstream of Fochabers Roadbridge	Right	Optimal		
12-Sep-02	334050	859650	S013	Gordon Castle Water	5m downstream from Fochabers Roadbridge	Right	Optimal		
12-Sep-02	333980	859400	S013	Brae Water	Backwater 250m upstream from Fochabers bridge 5m in from mainstem	Right	Sub-optimal		
12-Sep-02	333900	858650	S014	Brae Water	Behind croy 250m downstream from ghillies huts	Left	Optimal		
12-Sep-02	333550	858100	S016	Brae Water	Backwater 20m upstream from end of island	Right	Sub-optimal		
12-Sep-02	334600	858400	S016	Brae Water	At mouth of backwater 30m upstream from ghillies hut	Left	Optimal		
12-Sep-02	333950	857400	S017	Brae Water	30m downstream from cliffs at Ordiquish	Left	Sub-optimal		
12-Sep-02	333900	857430	S017	Brae Water	40m downstream from water outlet at end of sandy island	Left	Optimal		
12-Sep-02	333890	857470	S017	Brae Water	At boat mooring near end of fence	Left	Optimal		
12-Sep-02	333275	856843	S020	Brae Water	Large backwater on bend downstream from Aultdearg Pool (Brae Beat 3)	Left	Optimal		
12-Sep-02	333221	855722	S022	Brae Water	Backwater beside Lord March Pool Brae beat 3	Left	Optimal	10-Oct-02	L022L1
12-Sep-02	332700	854350	S027	Brae Water	Top end of Turn Pool (Beat 5) beside boat mooring	Left	Optimal		
12-Sep-02	332700	854400	S027	Brae Water	Turn Pool (Beat 5), Opposite ghillies hut	Left	Sub-optimal		
12-Sep-02	331900	852950	S031	Orton	Backwater directly opposite ghillies upper hut	Right	Optimal		
12-Sep-02	332950	852050	S032	Delfur	Backwater 100m upstream from Delfur Lodge	Right	Sub-optimal		
12-Sep-02	331750	852500	S032	Orton	Backwater at the end of track from Garbitty and beside Jepson-Turner memorial stone	Left	Optimal		
12-Sep-02	331800	851750	S033	Delfur	Under Boat o'Brig road bridge	Left	Sub-optimal		
12-Sep-02	331750	851650	S034	Delfur	200m upstream from Boat o'Brig small backwater at lower end of Collie Pot	Right	Sub-optimal		
12-Sep-02	331450	851600	S035	Delfur	Mouth of Collie Burn	Left	Sub-optimal	08-Oct-02	L035L1
12-Sep-02	331350	851250	S036	Delfur	Otter Pool, beside boat mooring upstream from small green hut	Left	Sub-optimal		
12-Sep-02	329600	850250	S040	Delfur	Backwater in old channel behind Island of Dundurcus	Left	Optimal	08-Oct-02	L040L1

Appendix 1 *(continued)*

Date	Easting	Northing	RCS	Fishing Beat	Location	Bank (Looking down-stream)	Site Quality	Date Electro-fished	EF Site Code
12-Sep-02	329350	850750	S041	Delfur	Thin cover of organic material on cobbles above intake channel at Little Haddie	Left	Sub-optimal		
12-Sep-02	329150	850750	S042	Delfur	Sand deposits on right bank of Sourden Pool (viewed from left bank)	Right	Sub-optimal		
12-Sep-02	328850	850700	S042	Rothes/ Aikenway	Backwater 500m downstream from Lower Aikenway Farm	Right	Sub-optimal		
12-Sep-02	329029	850851	S042	Delfur	Large Backwater at upper end of Sourden Pool	Left	Optimal	08-Oct-02	L042L1
12-Sep-02	328650	850650	S043	Rothes/ Aikenway	Backwater 50m upstream from small burn flowing in at Crofts Farm	Left	Optimal	28-Oct-02	L043L1
12-Sep-02	328650	850700	S043	Rothes/ Aikenway	Small burn flowing from Crofts Farm	Left	Sub-optimal		
12-Sep-02	328570	850088	S044	Rothes/ Aikenway	100m downstream from Rothes Burn confluence, top end of Junction Pool	Left	Sub-optimal	29-Sep-02	L044L2
12-Sep-02	328500	849950	S044	Rothes/ Aikenway	Backwater 50m downstream from Rothes sewage works, connects to mainstem at confluence of Rothes Burn	Left	Optimal	29-Sep-02	L044L1
12-Sep-02	328850	849400	S045	Rothes/ Aikenway	Sandy deposit in front of Lower Rothes hut	Left	Sub-optimal		
12-Sep-02	328750	849650	S045	Rothes/ Aikenway	100m down from Lower Rothes hut	Left	Sub-optimal		
12-Sep-02	328650	849700	S045	Rothes/ Aikenway	100m downstream from pumping station	Left	Sub-optimal		
12-Sep-02	328200	848700	S048	Arndilly	Backwater at Mill Burn	Left	Optimal		
12-Sep-02	328398	847636	S050	Arndilly	500m down from Ghillies House	Left	Optimal		
12-Sep-02	328450	847700	S050	Arndilly	Backwater upstream from Arndilly Home Farm	Right	Sub-optimal		
12-Sep-02	329100	846850	S051	Arndilly	50m upstream from ghillies huts on other bank, 10m upstream from fence on left bank	Left	Sub-optimal		
12-Sep-02	329009	846887	S053	Easter Elchies	20m upstream from hut on right bank at edge of fast water	Left	Sub-optimal		
12-Sep-02	329326	846652	S054	Easter Elchies	Directly below croy on left bank at Ladies Haugh	Left	Optimal	18-Sep-02	L054L1
12-Sep-02	329494	846320	S055	Easter Elchies	Just above main hut at Easter Elchies	Left	Sub-optimal		
12-Sep-02	329458	846401	S055	Easter Elchies	Slack water on bend of Red Craig Pool	Left	Sub-optimal		
12-Sep-02	329361	845626	S056	Upper Arndilly	200m downstream from mouth of Fiddich	Right	Sub-optimal	17-Sep-02	L056R1
12-Sep-02	329137	845382	S057	Easter Elchies	Lower end of backwater, beside old bridge support	Left	Sub-optimal		
12-Sep-02	329185	845426	S057	Easter Elchies	Opposite Fiddich Mouth	Left	Optimal		
12-Sep-02	328759	845314	S058	Easter Elchies	Backwater downstream from Craigellachie road bridge, beside farm track	Left	Optimal	17-Oct-02	L058L1
12-Sep-02	328697	845265	S058	Easter Elchies	Directly beneath Craigellachie road bridge	Left	Optimal	17-Oct-02	L058L2
11-Sep-02	328500	845300	S059	Easter Elchies	Channel on left bank of Heathery Isle	Left	Sub-optimal		
11-Sep-02	328538	845127	S059	Craigellachie	Underneath Telford Bridge	Right	Sub-optimal		
11-Sep-02	328400	844300	S061	Upper Easter Elchies (Macallan)	Small sand deposits on left bank beside Tunnel Pool	Left	Sub-optimal		
11-Sep-02	327600	843788	S063	Craigellachie	Backwater 200m upstream from hut at Green Bank	Right	Optimal	18-Sep-02	L063R1

Appendix 1 *(continued)*

Date	Easting	Northing	RCS	Fishing Beat	Location	Bank (Looking down-stream)	Site Quality	Date Electro-fished	EF Site Code
11-Sep-02	327849	843933	S063	Craigellachie	20-30m upstream from hut, drain outflow	Right	Sub-optimal		
11-Sep-02	326850	843600	S064	Lower Wester Elchies	Outside fishing hut	Left	Optimal	30-Oct-02	L064L1
11-Sep-02	327300	843700	S064	Lower Wester Elchies	Opposite sewage works	Left	Optimal	30-Oct-02	L064L2
11-Sep-02	327350	843700	S064	Lower Wester Elchies	25m downstream from sewage works beside three tree stumps	Left	Sub-optimal		
11-Sep-02	326600	843260	S065	Aberlour Association	80m downstream from Sandy Hole sign, 5m upstream from the drainage burn	Right	Sub-optimal		
11-Sep-02	326500	843250	S066	Aberlour Association	Beside Sandy Hole, downstream from footbridge	Right	Sub-optimal		
11-Sep-02	326400	843150	S066	Wester Elchies	10m upstream from Victoria Footbridge, Aberlour	Left	Sub-optimal		
11-Sep-02	326400	843150	S066	Aberlour Association	200m down from Victoria Footbridge, beside Sandy Hole Pool	Left	Sub-optimal		
11-Sep-02	325950	842750	S067	Wester Elchies	500m upstream from Victoria Footbridge, beside fishing hut	Left	Sub-optimal		
11-Sep-02	326000	842750	S067	Wester Elchies	300m upstream from Victoria Footbridge	Left	Sub-optimal		
11-Sep-02	325600	842400	S068	Wester Elchies	Pool Shuan, close to end of access track across Haugh of Delltoulie	Left	Sub-optimal		
11-Sep-02	324926	842798	S070	Delagyle	200-300m Downstream from Delagyle bothy	Right	Sub-optimal		
11-Sep-02	324800	842900	S070	Wester Elchies	The Pike Hole, 100m downstream from lower Wester Elchies hut	Left	Optimal	30-Oct-02	L070L1
11-Sep-02	324250	842600	S072	Wester Elchies	Mouth and lower part of small burn entering Wester Elchies from Craigneach Woods	Left	Sub-optimal		
11-Sep-02	323822	841734	S073	Delagyle	Backwater directly downstream from Green Burn mouth	Left	Optimal	17-Oct-02	L073R1
11-Sep-02	323950	841950	S073	Wester Elchies	Pool of Brock in front of small fishing hut	Left	Sub-optimal		
11-Sep-02	324050	842100	S073	Wester Elchies	Downstream side of fishing weir, approx 100m upstream from Delagyle hut on right bank	Left	Sub-optimal		
11-Sep-02	323600	841600	S074	Laggan	10m downstream from field in front of Laggan House, 50m upstream from burn mouth	Left	Sub-optimal		
11-Sep-02	323450	841450	S075	Laggan	Left bank of Delchapel Poll, 100m downstream from Carron House	Left	Sub-optimal		
11-Sep-02	322500	841200	S077	Laggan	Downstream side of Carron Bridge, boat mooring	Left	Optimal	30-Oct-02	L077L1
11-Sep-02	322450	841200	S077	Lower Wester Elchies	Backwater, 30m upstream from Carron Bridge	Left	Optimal		
11-Sep-02	320888	841995	S081	Carron	Slack water at edge of Pool Voulin	Right	Optimal		
11-Sep-02	320150	841700	S083	Knockando	100m downstream from Island Roary	Left	Sub-optimal		
11-Sep-02	320182	841969	S083	Carron	Behind croy at Pool Vrenen	Right	Sub-optimal		
11-Sep-02	320090	841069	S084	Knockando	15m upstream from Island Roary, beside boat mooring	Left	Optimal	09-Oct-02	L084L1
11-Sep-02	320100	840940	S085	Knockando	Long Pool, at boat mooring	Left	Sub-optimal		
11-Sep-02	320057	840886	S085	Knockando	On the right bank 150m downstream from ghillies hut on left bank	Right	Sub-optimal		

Appendix 1 *(continued)*

Date	Easting	Northing	RCS	Fishing Beat	Location	Bank (Looking downs-tream)	Site Quality	Date Electro-fished	EF Site Code
11-Sep-02	319627	840889	S086	Knockando	Small stream mouth	Left	Sub-optimal		
11-Sep-02	319094	841582	S087	Phones	Beside fishing hut at upper end of RCS87	Left	Sub-optimal		
11-Sep-02	318931	841325	S088	Phones	10m upstream from ghillies hut	Left	Optimal	09-Oct-02	L088L1
10-Sep-02	318250	840834	S091	Lower Pitchroy	50m downstream from start of RCS91	Right	Sub-optimal		
10-Sep-02	318519	839665	S093	Lower Pitchroy	Small backwater	Left	Sub-optimal		
10-Sep-02	318595	309064	S094	Lower Pitchroy	Backwater behind fallen tree	Right	Sub-optimal		
10-Sep-02	318547	839539	S094	Pitchroy	Beside boat mooring	Left	Sub-optimal		
10-Sep-02	318552	839610	S094	Pitchroy	Approx 600m downstream from Blacksboat Bridge	Left	Optimal	09-Oct-02	L094L1
10-Sep-02	318477	839186	S095	Pitchroy	10m upstream from upper end of Craigroy Island	Left	Optimal		
10-Sep-02	318653	838653	S096	Pitchroy	Backwater, 400m upstream of Blacksboat Bridge, beside Broadwood Pool	Right	Optimal		
10-Sep-02	318441	838686	S096	Pitchroy	Backwater (opposite lorry trailer?)	Right	Sub-optimal		
10-Sep-02	318479	838829	S096	Pitchroy	Backwater	Right	Sub-optimal		
10-Sep-02	318074	838184	S097	Pitchroy	Large backwater, 600m upstream from Blacksboat Bridge	Left	Optimal	01-Oct-02	L097L1
10-Sep-02	318224	838386	S097	Pitchroy	Ditch area beside tree line	Right	Optimal		
10-Sep-02	318225	838375	S097	Pitchroy	Backwater	Right	Sub-optimal		
10-Sep-02	317300	837426	S099	Ballindalloch	Opposite main Ballindalloch fishing hut	Left	Sub-optimal		
02-Sep-02	317354	837435	S100	Ballindalloch	20m upstream of ghillies hut	Left	Sub-optimal		
02-Sep-02	316743	836775	S102	Ballindalloch	100m upstream from Cragganmore Bridge	Right	Optimal		
02-Sep-02	316187	836931	S103	Ballindalloch	Upper end of backwater behind island	Left	Optimal		
02-Sep-02	316300	836882	S103	Ballindalloch	At footbridge over backwater 30m upstream from confluence	Left	Optimal	11-Oct-02	L103L1
02-Sep-02	316004	836848	S104	Ballindalloch	Small inlet downstream from March Pool	Right	Sub-optimal		
02-Sep-02	314731	836416	S107	Tulchan	400m downstream from top of RCS107	Left	Sub-optimal		
02-Sep-02	314469	835639	S108	Tulchan	Drainage ditch opposite ghillies hut Beat D	Left	Sub-optimal		
02-Sep-02	314353	835473	S109	Tulchan	200m upstream from ghillies hut (Beat D) on right bank	Right	Optimal		
02-Sep-02	313694	835209	S110	Tulchan	Backwater towards end of Island	Right	Optimal		
02-Sep-02	313135	835143	S111	Tulchan	Large backwater behind island 350m from top of RCS111	Right	Optimal		
02-Sep-02	313317	835203	S111	Tulchan	Backwater 100m downstream from large shed (old hatchery)	Left	Sub-optimal		
02-Sep-02	313400	835203	S111	Tulchan	120m downstream from large shed (old hatchery)	Left	Optimal	11-Oct-02	L111L1
02-Sep-02	312718	835441	S112	Tulchan	100m downstream from Tulchan Beat C hut	Right	Optimal		
02-Sep-02	312557	835459	S113	Tulchan	Directly opposite Tulchan Beat C hut	Right	Sub-optimal		
28-Aug-02	311817	834852	S115	Tulchan	120m downstream from bench, Speanack Pool	Left	Sub-optimal		
28-Sep-02	311615	834547	S116	Tulchan	Backwater	Left	Optimal	11-Oct-02	L116L1
28-Aug-02	311590	834412	S116	Tulchan	600m upstream from Tulchan Beat D hut	Right	Sub-optimal		
28-Sep-02	311574	833684	S118	Tulchan	Tulchan Beat B	Left	Sub-optimal		

Appendix 1 *(continued)*

Date	Easting	Northing	RCS	Fishing Beat	Location	Bank (Looking down-stream)	Site Quality	Date Electro-fished	EF Site Code
28-Aug-02	311788	833460	S119	Tulchan	20m upstream from footbridge across to island Tulchan Beat B	Left	Optimal		
28-Aug-02	311776	833487	S119	Tulchan	Mouth of backwater opposite new house	Left	Optimal		
28-Aug-02	311800	833014	S119	Tulchan	Backwater at upstream end of large island	Right	Sub-optimal		
28-Aug-02	311721	832858	S120	Tulchan	Opposite Sun House on left bank	Left	Sub-optimal		
28-Aug-02	311559	832339	S121	Tulchan	Under tree 180m from start of RCS 121	Left	Optimal		
28-Oct-02	311641	832371	S121	Tulchan	Sandy deposits under trees	Left	Optimal		
28-Aug-02	311691	832445	S121	Tulchan	350m down from start of RCS121	Left	Sub-optimal		
28-Aug-02	311753	326686	S121	Tulchan	Sandy deposits by boat mooring	Left	Sub-optimal		
28-Aug-02	311153	832248	S122	Tulchan	250m from start of RCS122, Dalvey stream	Left	Optimal		
28-Aug-02	313356	832239	S122	Tulchan	Beside George Pool Tulchan Beat A	Left	Optimal		
28-Aug-02	311202	832186	S122	Tulchan	300m upstream from Dalvey Burn mouth	Right	Sub-optimal		
27-Aug-02	308500	831500	S128	Castle Grant	Upstream side of Dellifure Burn	Left	Optimal		
27-Aug-02	308550	831700	S128	Tulchan	Backwater behind croy 50m downstream from mouth of Dellifure Burn	Left	Sub-optimal		
27-Aug-02	308500	830850	S129	Castle Grant	Slack water downstream from Pollwick Pool	Left	Sub-optimal		
27-Aug-02	308400	830300	S131	Castle Grant	Upper end of Pollwick Pool	Right	Sub-optimal		
27-Aug-02	307650	830250	S133	Castle Grant	Eroded bank mid-way down Polchraine Pool	Right	Sub-optimal		
27-Aug-02	307650	830300	S133	Castle Grant	Eroded area of bank towards lower end of Polchraine Pool	Right	Sub-optimal		
27-Aug-02	307600	830100	S133	Castle Grant	Backwater created by croy at lower end of island above Polchraine Pool	Left	Sub-optimal		
27-Aug-02	307800	829300	S134	Castle Grant	Mouth of Dalchapple Burn	Right	Sub-optimal		
27-Aug-02	307850	829500	S134	Castle Grant	Small backwater 100m downstream from Dalchapple Burn	Right	Sub-optimal		
27-Aug-02	307850	829650	S134	Castle Grant	100m upstream from tip of island on CG Beat 2	Right	Optimal		
27-Aug-02	307450	829000	S135	Castle Grant	100m downstream from mouth of Cromdale Burn	Right	Sub-optimal		
27-Aug-02	307600	829100	S135	Castle Grant	200m downstream from mouth of Cromdale Burn	Right	Sub-optimal		
27-Aug-02	307450	829150	S135	Castle Grant	Backwater beside island downstream from fishing hut on CG Beat 2	Left	Sub-optimal		
27-Aug-02	307100	829150	S136	Castle Grant	Backwater 200m upstream from Cromdale Burn	Right	Optimal	04-Oct-02	L136R1
27-Aug-02	307250	829050	S136	Castle Grant	Small drainage ditch 100m upstream from Cromdale Burn	Right	Sub-optimal		
27-Aug-02	307700	829100	S137	Castle Grant	200m upstream from Cromdale Bridge, beside fence and stile	Right	Sub-optimal		
27-Aug-02	306640	828129	S140	Castle Grant	Large area of sand downstream from boat mooring CG Beat 1	Left	Sub-optimal		
27-Aug-02	306207	827013	S142	Castle Grant	Mouth of Congash Burn (Allt Coire Odhair) area	Right	Optimal		
27-Aug-02	305610	827144	S143	Castle Grant	CG Beat 1, start of RCS143	Left	Sub-optimal		
27-Aug-02	303610	827144	S143	Castle Grant	CG Beat 1, 2m downstream from fence line	Right	Sub-optimal		

Appendix 1 *(continued)*

Date	Easting	Northing	RCS	Fishing Beat	Location	Bank (Looking down-stream)	Site Quality	Date Electro-fished	EF Site Code
27-Aug-02	305190	826982	S144	Castle Grant	Opposite house on left bank	Right	Optimal		
27-Aug-02	304468	826452	S146	Upper Castle Grant	Small inlet 5m downstream from old hut	Right	Sub-optimal		
27-Aug-02	304700	826650	S146	Upper Castle Grant	100m downstream from old hut	Right	Optimal		
27-Aug-02	303995	826340	S147	Upper Castle Grant	Backwater, 25m down from Old Spey Bridge	Left	Sub-optimal		
26-Aug-02	303819	826386	S147	Upper Castle Grant	100m upstream from Old Spey Bridge	Right	Sub-optimal		