A5.1 Ecology

A5.1.1 Introduction

A5.1.1.1 This Technical Appendix presents the following information in support of Chapter 5 Ecology & Nature Conservation of the Environmental Statement (ES):

- Ecology Team: overview of ecology team.
- Baseline Survey Methods: the methodology employed by Caledonian Conservation Ltd in order to provide baseline information on the habitat and protected species interests at the development site and adjacent land. All deviations from guidance due to access restrictions are discussed and justified.
- Baseline Survey Results: the results of surveys carried out by Caledonian Conservation Ltd from September 2012 to August 2013.
- References.

A5.1.2 Ecology Team

A5.1.2.1 Caledonian Conservation Ltd was commissioned to carry out baseline field surveys and an assessment of the potential effects of the proposed development on ecological receptors at the Proposed Development. Ecology field surveys were completed by Chris Cathrine (Director), Eamonn Flood (Ecologist), Cameron MacIver (Associate Ecologist), Stuart Spray (Associate Ecologist), Frazer MacFarlane (Associate Ecologist), Louise Huby (Associate Ecologist), Sean Reed (Associate Ecologist) and Glen Norris (Assistant Ecologist). The ecological assessment was undertaken by Chris Cathrine, Eamonn Flood and Frazer MacFarlane. Fisheries surveys and baseline fish population assessment were completed by Chris Conroy (River Naver Fisheries), Chris Cathrine and Eamonn Flood.

A5.1.3 Baseline Ecology Surveys

A5.1.3.1 A full suite of ecology surveys were used to gain an informed Ecological Impact Assessment including:

- Phase 1 Habitat Survey and Protected Mammal Survey;
- National Vegetation Classification; and
- Freshwater Pearl Mussel Survey.

A5.1.3.2 Further details of the proposed surveys are provided in the following sections.

Extended Phase 1 Survey

A5.1.3.3 An Extended Phase 1 Habitat Survey was conducted within the Proposed Development site on 1st – 4th March, 30th July and 6th – 7th August 2013. This survey records signs of protected species (particularly mammals) and map the habitats in this area to a Phase 1 level.

Phase 1 Habitat Survey

A5.1.3.4 Standard Phase 1 Habitat Mapping methodology was used to identify habitat areas of ecological importance, as outlined in the Handbook for Phase 1 Habitat Survey published by the Joint Nature Conservancy Council (2010).

A5.1.3.5 Once this survey detected habitats that may be associated with those listed on Annex I of the Habitats Directive or Ground Water Dependent Terrestrial Ecosystems (GWDTEs) these were then

subjected to National Vegetation Classification (NVC) level surveys as appropriate (Scottish Environmental Protection Agency [SEPA] 2012; UK Technical Advisory Group on the Water Framework Directive [UKTAG] 2003; UKTAG 2009).

Protected Mammal Survey

A5.1.3.6 A protected mammal survey was undertaken within the Proposed Development site. This survey targeted otter (*Lutra lutra*), water vole (*Arvicola amphibius*), red squirrel (*Sciurus vulgaris*), badger (*Meles meles*), wildcat (*Felis silvestris*) and pine marten (*Martes martes*).

A5.1.3.7 All signs and sightings were recorded on large scale maps, and locations marked using hand held GPS devices.

Otter

A5.1.3.8 A full otter survey was conducted following standard methodology and using an appropriate field guide (Bang and Dahlstrøm 2006; Chanin 2003). Field signs included:

- Holts – below ground resting places;
- Couches – above ground resting places;
- Prints; and
- Spraints – faeces used as territorial markers, with a characteristic sweet odour.

Pine Marten

A5.1.3.9 Suitable habitat was searched for pine marten scats (droppings), for possible dens such as cavities in rocks, cliff or scree, root plates, tree cavity, piles of timber, buildings and open den in ground level vegetation and for live pine martins (O'Mahony *et al.*, 2005).

A5.1.3.10 Any scats found were collected and sent for DNA analysis.

Badger

A5.1.3.11 All ground within the core survey area was searched for field signs of badger, following standard methodology and using appropriate field reference guides and SNH guidance (Bang and Dahlstrøm 2006; SNH 2001). Badger field signs include:

- Setts – burrows indicating badger setts (level of activity and other signs may allow determination of sett type, *i.e.* main sett, annexe sett, subsidiary sett or outlying sett);
- Prints;
- Latrines (and dung pits used as territorial markers);
- Hairs – highly distinctive, and often become snagged on fences;
- Feeding signs – snuffle holes (small scrapes where badgers have searched for earthworms, insects or tubers); and
- Paths.

Wildcat

A5.1.3.12 Suitable habitat within 200m of the proposed wind farm were searched for potential wildcat dens such as hollow trees, rock crevices, rabbit burrows, disused badger setts, under fallen debris, old fox earths, rock cairns, large piles of logs and hollows under trees roots with a view to installing a remote

camera trap outside the potential den to confirm if the it was being used by wildcat (Kilshaw 2011; Kilshaw and Macdonald 2011; Davis and Gray 2010).

Water Vole

A5.1.3.13 Areas of potentially suitable habitat were surveyed following standard methodology and using an appropriate field guide (Bang and Dahlstrøm 2006). This involved recording the following field signs:

- Faeces – recognisable by their size, shape, and content, and also distinguishable from rat droppings by their smell, if not desiccated;
- Latrines – faeces are often deposited at discrete locations known as latrines;
- Feeding stations – food items are often brought to feeding stations along pathways and haul out platforms, indicated by neat piles of chewed vegetation up to 10cm long;
- Burrows – appear as a series of holes along the water's edge distinguishable from rat burrows by size and position;
- Lawns – may appear as grazed areas around burrows;
- Nests – where the water table is high, above ground woven nests may be found;
- Footprints – tracks may occur at the water's edge leading into vegetation cover, and may be distinguishable from rat footprints by size; and
- Runways – low tunnels pushed through vegetation near the water's edge, which are less obvious than rat runs.

Red Squirrel

A5.1.3.14 All blocks of woodland and conifer plantation within the survey area were surveyed for evidence of red squirrel following Forestry Commission guidance (Gurnell *et al.*, 2009). Red squirrel field signs included:

- Live squirrels;
- Dreys; and
- Feeding remains.

A5.1.3.15 Surveys involved walking random transects in the conifer plantation within the survey area, stopping approximately every 50m to look for field signs.

National Vegetation Classification (NVC)

A5.1.3.16 An NVC survey was considered necessary due to the large areas of modified bog reported in the phase 1 survey. A full NVC survey was completed in the core survey area (Figures 5.7 and 5.8) in order to identify any areas of good quality peatland habitats which may be included under Annex I of the Habitats Directive which may also be associated with the adjacent Caithness & Sutherland Peatlands Special Area of Conservation (SAC) and Cnoc an Alaskie Site of Special Scientifc Interest (SSSI). This survey also ensured that any potential Groundwater Dependent Terrestrial Ecosystems (GWDTEs) were identified in accordance with guidance (SEPA 2012). The NVC survey was completed under suitable weather following the methods described in Rodwell (2006). Communities were compared with the published descriptions given in Rodwell (1991 et seq) and in Averis *et al.* (2004).

A5.1.3.17 Aerial photos were reviewed to give an overview of the site and to identify broad distributions of vegetation types and a generalised site walkover was undertaken, noting the main NVC communities present.

A5.1.3.18 The NVC communities identified were then mapped resulting in the community accounts, following the categories listed in Rodwell (1991 et seq), with particular reference to communities of conservation concern.

A5.1.3.19 Results from the NVC survey were then used for identifying GWDTEs using the relevant guidance SEPA (2010), with the process of identifying wetlands also being informed by the methodology published in 'SNIFFER (2009) WFD95 – A Functional Wetland Typology for Scotland".

Freshwater Pearl Mussel Survey

A5.1.3.20 Freshwater pearl mussels were surveyed for in May 2013 avoiding high discharge of watercourses usually associated with winter. A presence/absence search was completed for the River Vagastie and habitat suitability surveys were undertaken for the Vagastie and three burns (Allt na h-Aire, Allt Bealach an Fhuarain and Allt a' Chraisg) within the standard 600m sensitivity buffer. In addition to the sections of the watercourses that intersect the buffer, 0.1km upstream and 0.5km downstream, which may be indirectly affected, were also surveyed. To search for mussels a bathyscope (a clear-bottomed bucket) was used to view the river bed.

A5.1.3.21 A habitat suitability survey of the river and its substrate was undertaken by walking alongside the watercourse. As areas of habitat suitable to mussels were found, the river was entered and intensively surveyed using a bathyscope in suitable conditions, as specified in Freshwater Pearl Mussel Survey Protocol for use in site specific projects produced by SNH, including;

- Bright light, clear water, low flow regime;
- In water sufficiently shallow for safe wading;
- In an upstream direction, checking favourable sites; and
- Making sure no disturbance of the river bed occurs.

A5.1.3.22 If alive mussels or dead shells were found a transect 50m x 1m would have been searched. If there were less than 250 mussels found then each one would be measured. If there were more than 250 mussels in the transect then 1m x 1m quadrats would be laid at 10, 20, 30, 40 and 50 metre intervals. The counts of these quadrats would then extrapolated to provide an estimate for the 50m transect. The measurements would be used to create a size/age profile, important in proving the presence of juveniles and ultimately indicating active recruitment at the location. A mussel equal to or less than 65mm in length is considered to be juvenile whilst those equal to or less than 30mm are considered to be under five years old and therefore indicators of recent recruitment.

A5.1.3.23 Site details of each 50m transect are recorded on a standard recording form. Factors recording include;

- An eight figure grid reference;
- Average width and depth;
- Substrate composition;
- Adjacent land-use;
- Bankside vegetation;
- Evidence of impacts; and
- Details of any discussions with local people concerning the river.

A5.1.4 Results

Phase 1 Habitat Survey

A1.3.2 Mixed Plantation Woodland

A5.1.4.1 Blocks of mixed plantation were present on the eastern perimeter of the Proposed Development. Although the trees had been planted some 17 years ago, due to the deep peat and extreme weather conditions experienced for the majority of the year, the trees were stunted and sparsely spaced (Phase 1 TN4, see Photo A5.1.5).

A4.2 Recently felled coniferous plantation

A5.1.4.2 Recently felled plantation was present at TN13. The area appeared to have been felled during the past one or two years.

B1.2 Semi-improved acid grassland

A5.1.4.3 Small patch of semi-improved acid grassland was present at TN10. This habitat was enclosed with a dry stone wall and was likely to be used, historically, as a holding pen for livestock.

C1.1 Continuous bracken

A5.1.4.4 Small patches of continuous bracken (*Pteridium aquilinum*) were present along the banks of the Allt na h-Aire water course, along the road side and in the mixed plantation.

D2 Wet dwarf shrub heath

A5.1.4.5 Wet heath was present along the roadside where the peat was less than 0.5m deep. It should be noted that the boundary of the habitat as shown on the Phase 1 habitat map (see Figure 5.5 and 5.6) was based on educated guess work. Core samples recording the depth of the peat would allow more accurate mapping (Peat mapping has subsequently been carried out by Mouchel see Volume 2 Chapter 9 Other Issues: Soil and Water, TA 9.1 of the ES).

D6 Wet heath/acid grassland mosaic

A5.1.4.6 Wet heath/acid grassland mosaic was present along the banks of the Allt na h-Aire water course where the depth of peat was less than 0.5m (see Photos A5.1.1).

E1.7 Wet modified bog

A5.1.4.7 Wet modified bog was the most abundant habitat in the survey area and was the result of extensive ditches being cut in to the original blanket bog habitat which slowly lowered the water table over time. The best examples of where the wet modified bog habitat most closely resembles the original blanket bog habitat were around the peat pools such as at TN9. The species present in the wet modified bog were similar to those expected in wet heath habitat. However, where the peat was exposed it was clear that it was over 0.5m deep. Species present included blaeberry (*Vaccinium myrtillus*), cross-leaved heath (*Erica tetralix*), common cotton grass (*Eriophorum angustifolium*), sedges (*Carex sp.*), and sphagnum mosses.

G1 Standing water

A5.1.4.8 Peat pools were present throughout the wet modified bog habitat. The pools were relatively small often measuring just 4 or 5m by 10 or 15m. The pools were also shallow measuring from just 10 or 20cm deep to 1m deep in places (see Photos A5.1.10, A5.1.11 and A5.1.12).

G2 Water course

A5.1.4.9 Allt na h-Aire water course in the north of the survey area approximately 1m to 3m wide and just a few centimetres deep at the time of the survey with a rocky bed and no shade provided by scrub or trees (see Photos A5.1.1). The Allt Bealach an Fhuarain (see photo A5.1.2) water course which ran along the south western edge of the survey area was also 1m to 3m wide and just a few centimetres deep at the time of the survey with a rocky bed and no shade provided by scrub or trees. A number of smaller water courses were also present in the survey area.

J2.3.5 Wall

A5.1.4.10 The only wall present with in the survey area was a dry stone wall enclosing a small area of semi-improved acid grassland at TN10.

J2.3.6 Dry Ditch

A5.1.4.11 An extensive system of manmade ditches were recorded throughout the wet modified bog habitat. The ditches were approximately 30cm wide and between 60cm and 1m deep depending on the level of erosion. TN3 three was an example of a typical ditch. Photos A5.1.3 and A5.1.4 show examples of the ditches recorded during the survey. Although many were dry in places at the time of the survey, the ditches were clearly still operational.

J5 Other Habitat

A5.1.4.12 Other habitat included the tarmacadam single track road running along the south eastern border of the survey area

A5.1 Table Phase 1 habitat survey summary.

Phase 1 code	Description	EC Habitats Directive	UKBAP	LBAP
A1.3.2	Mixed plantation woodland			Y
A4.2	Recently felled coniferous plantation			
B1.2	Semi-improved acid grassland			
C1.1	Continuous bracken			
D2	Wet dwarf shrub heath - Acid		Y	Y
D6	Wet heath/ acid grassland mosaic.		Y	Y
E1.7	Wet modified bog		Y	Y
G1	Standing water		Y	Y
G2	Water course			Y
J2.3.5	Wall			
J2.3.6	Dry ditch			
J5	Other habitat			

A5.2 Table Phase 1 habitat survey Target Notes.

TN	Details	Grid Reference
1	Allt na h-Aire water course in the north of the survey area approximately 1m to 3m wide and just a few centimetres deep at the time of the survey with a rocky bed and no shade provided by scrub or trees (See Photo A5.1.1)	NC5443932647
2	Allt Bealach an Fhuarain water course which ran along the south western edge of the survey area was also 1m to 3m wide and just a few centimetres deep at the time of the survey with a rocky bed and no shade provided by scrub or trees (see Photo A5.1.2)	NC5184227983
3	An extensive system of manmade ditches were recorded throughout the survey area. The ditches were approximately 30cm wide and between 60cm and 1m deep depending on the level of erosion. TN3 three was an example of a typical ditch. Photos A5.1.3 and A5.1.4 show examples of the ditches recorded during the survey.	NC5285629518
4	Blocks of mixed plantation were present on the eastern perimeter of the proposed development. Although the trees had been planted some 30 years ago, due to the deep peat and extreme weather conditions experienced for the majority of the year, the trees were stunted and sparsely spaced. The open canopy allowed patches of heather (*Calluna vulgaris*) to flourish. Large patches of bracken (*Pteridium aquilinum*) was also present (See Photo A5.1.5).	NC5443231043
5	The open canopy in the mixed plantation allowed patches of heather (*Calluna vulgaris*) to flourish (see Photo A5.1.5).	NC5478431383
6	The ground flora under the open canopy mixed plantation was a mosaic of acid grassland, patches of bracken (*Pteridium aquilinum*) and patches of heather (see Photo A5.1.6)	NC5387029430
7	Wet modified bog was the dominant habitat within the survey area with sphagnum mosses *Sphagnum spp*, heather (*Calluna vulgaris*), cross-leaved heath (*Erica Tetralix*) and common cotton grass (*Eriophorum angustifolium*) (see Photo A5.1.7, A5.1.8, A5.1.9)	NC5249829464
8	The species present in the wet modified bog were similar to those expected in we heath habitat. However, where the peat was exposed it was clear that it was over 0.5m deep.	NC5231927539
9	The best examples of where the wet modified bog habitat closely resembles blanket bog were around the peat pools such as at TN9. Species present included blaeberry (*Vaccinium myrtillus*), cross-leaved heath (*Erica tetralix*), common cotton grass (*Eriophorum angustifolium*), sedges (*Carex sp.*) and sphagnum mosses (see Photos A5.1.10, A5.1.11 and A5.1.12)	NC5273432082
10	Semi improved acid grassland was present in a small area of enclosed pasture at TN10.	NC5374729120

11	Wet heath was present along the roadside where the peat was less than 0.5m deep.	NC5435529854
12	The habitat on the banks of the Allt na h-Aire water course comprises wet heath/acid grassland mosaic (see Photos A5.1.1).	NC5345231772
13	Recently felled conifer plantation	NC5426930579

Protected Mammals Results

Otter

A5.1.4.13 Although otter is common and widespread in the wider area, no otter holts or evidence of otter were recorded within 200m of the footprint of the core survey area. However, otter spraints and footprints were found in the wider area, with the nearest signs being located 300m from the proposed borrowpit and 400m from the nearest turbine location (see Figue 5.8).

A5.1.4.14 Habitat along Allt na h-Aire, in the north of the survey area, and Allt Bealach an Fhuarain, which ran along the south western edge of the survey area, were assessed as being suitable for foraging but was sub-optimal for establishing a holts.

A5.1.4.15 The River Vagastie located on the other side of the A836 single track road was more suitable for otter holts with many overhanging trees. However, estate staff reported that otter was rarely seen on this stretch of water. Little of this watercourse is within 200m of the proposed development footprint, although signs of otters were found beyond this buffer (see Figure 5.11).

A5.1.4.16 Estate staff reported the otter were regularly seen on the River Mudale some 2.5km north of the Proposed Development.

A5.1.4.17 A single otter record was provided within 500m of the Proposed Development site by the Highland Biological Recording Group (HBRG), however this was only accurate to 1km.

A5.1.4.18 It is possible that otters may use water courses in the wider area, and may also forage or commute over the Proposed Development site.

Pine Marten

A5.1.4.19 Estate staff reported that pine marten were regularly recorded nearby, however, no pine marten scats or potential pine martin dens were recorded within the footprint of the Proposed Development.

A5.1.4.20 Due to the lack of suitable habitat within the core survey area a camera trap was placed in the nearest suitable habitat, in coniferous woodland near Altnaharra (See Figure 5.1). No pine martens were detected.

A5.1.4.21 The stunted mixed plantation located on the south eastern boundary of the Proposed Development was considered to represent good potential foraging habitat for pine marten. However, the majority of the core survey area (and application site boundary) does not offer suitable pine marten habitat. Furthermore, it is estimated that between 86ha and 166ha of woodland is required to support an individual pine marten while a minimum of 250ha of woodland is required to support a pair (Balharry *et al.*, 1996). Studies have also shown that male pine marten territories in fragmented upland coniferous woodland can be very large (23.63km^2), and even female territories can be large in this environment (8.83km^2) (Caryl 2008).

A5.1.4.22 The core survey area does not offer a significant extent of woodland, and so it is considered highly unlikely that pine martens would be present within the application site boundary, or that this habitat is important to any peripheral territories.

Badger

A5.1.4.23 Although badgers are common and widespread in the wider area, no badger setts or evidence of badgers were recorded within 200m of the footprint of the core survey area. Furthermore, the habitat throughout much of the site does not offer 'diggable' substrates for the establishment of setts, which is essential for badgers (Roper 2010).

A5.1.4.24 Estate staff reported that there were no badger setts within the survey area.

A5.1.4.25 No evidence of badger was recorded during the survey.

Wildcat

A5.1.4.26 No wildcat dens or signs were found within the core survey area. Furthermore, wildcats prefer good cover for hunting and shelter, which is not offered by the degraded bog habitat within the application boundary (Davis and Gray 2010). Therefore, habitat is sub-optimal for wildcat.

A5.1.4.27 Due to the lack of suitable habitat within the core survey area a camera trap was placed in the nearest suitable habitat, in coniferous woodland near Altnaharra (See Figure 5.1). No wildcats were detected.

A5.1.4.28 Estate staff reported that no wildcat had been seen in the vicinity of the Proposed Development in recent years.

A5.1.4.29 The stunted mixed plantation located on the south eastern boundary and the lower slopes within the perimeter of the Proposed Development were considered to represent good potential foraging habitat for wildcat.

Water vole

A5.1.4.30 No evidence of water voles was found within the core survey area and no records were provided relevant to the proposed development site, although they are known from the wider area (based on HBRG data).

A5.1.4.31 However, a water vole colony was found at Loch Ben Harrald, over 3.3km from the Proposed Development (see Figure 5.11).

A5.1.4.32 The water courses within the core survey area were considered unsuitable for water vole due to the gradient and/or the rocky substrate. Most of the water courses also appeared too shallow to support water voles. Some of the peat pools, however, represented good habitat for water voles.

Red squirrel

A5.1.4.33 Although red squirrel are known to be present nearby, no evidence of red squirrel was recorded during the course of the survey.

A5.1.4.34 The stunted mixed plantation located on the south eastern boundary of the Proposed Development was considered to be suboptimal for red squirrel.

A5.1.4.35 There is no suitable habitat for red squirrels within the core survey area. The small area of stunted woodland within the application site boundary is unsuitable for this species as trees are short and sparsely scattered with a fully open canopy (SNH 1997).

National Vegetation Classification

Site Description

Open Ground

A5.1.4.36 A walkover survey showed the vast majority of the site consisting of a large scale mosaic of two plant communities, M17b *Trichophorum germanicum - Eriophorum vaginatum* bog typical of the North West Highlands and M15 *Trichophorum germanicum - Erica tetralix* wet heath (Figures 5.7 and 5.8). M17 bog occupies most of the poorly drained, gently sloping moorland tops (Photo A5.1.15) and M15 wet heath the slightly drier, steeper slopes (Photo A5.1.16). Dotted around the bog communities are pools of M2 and M3 bog vegetation and open water (Photo A5.1.15). Probably due to heavy grazing, areas of *Molina caerulea* dominated bog occur across the site which has been labelled M17mol as this community does not adequately fit any of the typical M17 sub communities. Alongside many of the burns draining the site M25 *Molinia caerulea - Potentilla erecta* mire is found along with occasional areas of U4 acid grassland, mainly along the burns Allt a' Chraisg and Allt Bealach an Fhuarain. M6 sedge mires occur alongside some of the shallow burns draining the site and to a small extent in wetter hollows on some lower slopes. Some of the steeper slopes on the moorland to the north of Creag Riabhach contain the damp heaths H21 *Calluna vulgaris - Vaccinium myrtillus - Sphagnum capillifolium* and H22 *Vaccinium myrtillus - Rubus chamaemorus*.

A5.1.4.37 The steeper, rockier and more morphologically complex ground around Creag Riabhach, Meall an Fhuarain and the high ground between them contains a more varied mosaic of communities (Photo A5.1.17). As well as the above mentioned bog and heath communities the higher rockier areas with thin soils have the prostrate montane heaths - H17 *Calluna vulgaris - Arctostaphylos alpina*, H14 *Calluna vulgaris - Racometrium lanuginosum* and H13 *Calluna vulgaris - Cladonia arbuscula*. H10 *Calluna vulgaris - Erica cinerea* heath occurs occasionally on small areas of well drained slope with a sunny aspect. Where some minerals have been washed into flushes a few, tiny areas of base rich M10 *Carex dioica - Pinguicula vulgaris* mire occur.

A5.1.4.38 Small areas of U20 *Pteridium aquilinum - Galium saxatile* are found along the roadside and the lower reaches of burns and a patch W23 *Ulex europaeus - Rubus fruticosus* habitat occurs close to Vagastie Bridge and the roadside also contains a small area of wet, neutral MG10 *Holcus lanatus - Juncus effusus* pasture south of the bridge.

Plantation

A5.1.4.39 The forestry plantation marked on OS maps (c. NC532850) to the south of the site is generally an assemblage of M25 *Molinia* grassland, M15 wet heath (Photo A5.1.14) with stands of wet acid woodland dominated by *Betula* and *Salix* species with a species poor understory of *Molinea caerulea* with a scattering of other grasses (Photo A5.1.13) . Such species poor habitats have no NVC type (Averis et al 2004), the *Betula* and *Salix* species also form scattered scrub throughout the lower slopes of the exclosure. Burns drain the plantation eastwards with H10 dry heath along the well-drained banks mixed with *Molinia caerulea* and other grasses (M25b). Small knolls on the lower slopes have communities of H12 heath (Figure 5.8).

A5.1.4.40 The wetter basin opposite the track leaving Vagastie (c. NC539287) has a mosaic of M17b bog and M15a wet heath with some evidence of flushing.

Community Descriptions

A5.1.4.41 The core survey area at Creag Riabhach was found to contain 21 separate plant communities (with their sub communities). These will be categorised here according to their conservation interest with regard to the Habitats Directive and also with regard to their SEPA designation for groundwater dependency.

Annex I 7110 Active Raised Bogs

- M2 Sphagnum cuspidatum/Sphagnum fallax bog pool; and

- M3 Eriophorum angustifolium bog pool.

A5.1.4.42 M2 *Sphagnum cuspidatum/fallax* bog pool and M3 *Eriophorum angustifolium* bog pool. Although no raised bog exists on the site or indeed the area bog pool communities occurring in blanket bog are of considerable ecological value. The site contains bog pools with a mixture of M2 and M3 communities and open water. M2 communities can be important habitats for insects and thus feeding grounds for upland birds such as Golden Plover *Pluvialis apricaria*, Greenshank *Tringa nebularia* and Dunlin *Calidris alpina*. Bog pools can also be a valuable breeding ground for frogs, upland populations of which are becoming increasingly rare. Furthermore such pools can contain rare bryophytes and vascular plants. M3 is of less conservation interest than other bog pools (Averis *et al*., 2004). The large areas of bog on Creag Riabhach are dotted with pools of both M2 and M3, in particular around and to the south of Beinn na Glas Choille and the ridgeline running from Ben Harrald to Creagan an Diridh. Pools are also located in hollows around the summit of Creag Riabhach. Small pools, dried out at the time of the survey, are found occasionally throughout the bog and wet heath

Annex I 7130 Blanket Bogs

- M17 *Trichophorum cespitosum - Eriphorum vaginatum* blanket mire; and
- M25 *Molinia caerulea - Potentilla erecta* mire.

A5.1.4.43 M17 *Trichophorum cespitosum - Eriphorum vaginatum* blanket mire. This mire, with M15 wet heath, constitutes most of the site, indeed apart from the rockier summits around Creag Riabhach, some of the steeper ground and parts of the forestry exclosure the site can be considered a large scale mosaic of M17 and M15 mire. Two sub communities of M17 which are described in the literature occur at Creag Riabhach and for the purposes of the survey another, *Molinia caerulea* dominated sub community, is added - M17mol. All sub communities form a mosaic with each other and other, mostly M15, NVC communities. The community as a whole occurs on deep, waterlogged peat, characterised by the presence of *Eriophorum vaginatum* with *Sphagnum papillosum*, other vascular plants are common such as *Eriophorum angustifolia*, *Trichophorum germanicum, Calluna vulgaris, Narthecium ossifragum* and *Potentilla erecta* as well as other sphagnum species such as *S. capillifolium*. At Creag Riabhach as elsewhere the bog is dotted with bog pools.

A5.1.4.44 M17a. This occurs in the most consistently wet conditions and is mostly found at the north end of the core survey area, mostly in a mosaic with the more abundant M17b.

A5.1.4.45 M17b. This is a drier sub community with more *Racometrium lanuginosum*, it covers a larger area of the site probably through modification of the site through drainage, grazing and possible past burning. Large areas of the site show the distinct knobbed appearance of the *Racometrium lanuginosum* hummocks associated with M17b.

A5.1.4.46 M17mol. Differentiated from similar *Molinia caerulea* dominated communities by the presence of *Eriophorum vaginatum* and probably formed through the degrading of bog through drying and grazing, this sub community occurs in small areas by the burns draining the area and also on the slopes above Vagastie bridge.

A5.1.4.47 Due to its global rarity, along with other blanket bog communities, M17 is considered to be of great ecological importance and conservation importance (Averis *et al*., 2004) and the UK has a special responsibility for its protection. It can be an important habitat for invertebrates as well as nesting waders such as Dunlin *Calidris alpina* and Greenshank *Tringa nebularia* (Averis *et al*., 2004).

A5.1.4.48 M25 *Molinia caerulea - Potentilla erecta* mire. Like the *Molinia* dominated M17mol, this community is found along the burns draining the site, above Vagastie bridge and also in the forestry exclosure, M25 is typically found alongside water courses with aerated, acid soils (Averis *et al.*, 2004). Most of the M25 at Creag Riabhach consists of little else but *Molinia caerulea* and is labelled simply as M25. A little of the grassier M25b occurs in the forestry exclosure.

Annex I 4010 North Atlantic wet heaths

- M15 Trichophorum germanicum - *Erica tetralix* wet heath

A5.1.4.49 M15 *Trichophorum germanicum - Erica tetralix* wet heath. This is a very variable community covering vast areas of the North West Highlands (Averis *et al.*, 2004). Two sub communities of this type are found on the site;

A5.1.4.50 M15b. Much of the site consists of M15b Along with bog communities it makes up most of the open land, with M15 occupying the slightly better drained slopes particularly on the southern end of the site (around Beinn na Glas Choille). This is the most common sub community of this type consisting of patches of *Calluna vulgaris, Trichophorum germanicum, Erica tetralix*, *Molinia caerulea, Merica gale*, and at Creag Riabhach a good deal of *Eriophorum angustifolia* overlying a discontinuous carpet of *Sphagnum capillifolium*, some other grasses and herbs are present such as *Festuca* species, *Deschampsia flexuosa, Narthesium ossifragum* and *Juncus squarrosus*. Other bryophytes are present such as *Pleurozia purpurea* and *Cladonia* lichen species *Cladonia arbuscula, C. ciliate, C. uncialis ssp biuncalis*. Some flushing is apparent in lower slopes with *Carex panacea* and *Carex echinata* present although not enough for it to be considered sub community M15a.

A5.1.4.51 M15c. This is a drier sub community with bryophytes common, particularly *Racometrium lanuginosum* as well as Cladonia species (Averis *et al.*, 2004).

Annex I 4030 European Dry heath

- H9 *Calluna vulgaris - Deschampsia flexuosa* Heath;
- H10 *Calluna vulgaris - Erica cinerea* heath;
- H12 *Calluna vulgaris - vaccinium myrtillus* heath; and
- H21 *Calluna vulgaris - Vaccinium myrtillus - Sphagnum capillifolium* heath.

A5.1.4.52 Both H9 and H12 communities occupy tiny areas in the forestry exclosure, adjacent to the road south east of the site and cannot be considered to be of any significance. These are recorded for completeness only.

A5.1.4.53 H10 *Calluna vulgaris - Erica cinerea* heath. This vegetation type is found on the well drained banks of burns draining the south eastern slopes within the forestry exclosure and the slopes above the walled enclosure at c. NC538291 as well as in a tiny pocket, due north of the mast on pt 421. It consists of the H10c sub community, mostly *Calluna vulgaris* and *Erica cinerea* with no special distinguishing species (Averis *et al.*, 2004).

A5.1.4.54 H21 *Calluna vulgaris - Vaccinium myrtillus - Sphagnum capillifolium* heath. North of Creag Riabhach on steep north and north east facing slopes are banks of H21. The cool humid slopes allow *Sphagnum capillifolium* to carpet the ground beneath a dense, shaggy layer of *Calluna vulgaris* (Averis *et al.*, 2004). This is considered to be of high conservation value as part of the suite of upland heaths far more widespread in Britain than elsewhere in Europe and a potential habitat for rare, oceanic bryophytes (Averis *et al.*, 2004).

Annex I 4060 Alpine and Boreal Heath

- H13 *Calluna vulgaris - Cladonia arbuscula* heath
- H14 *Calluna vulgaris - Racometrium lanuginosum* heath
- H17 *Calluna vulgaris - Arctostaphylos alpinus* heath
- H22 *Vaccinium myrtillus - Rubus chamaemorus* heath

A5.1.4.55 H13 *Calluna vulgaris - Cladonia arbuscula* and H14 *Calluna vulgaris - Racometrium lanuginosum* heaths occur in mosaics on the more exposed, rockier locations around the summits of Creag Riabhach and surrounding prominences. Other communities occur on the prominences around pt. 330 (c. NC537313) and a little further north (c.538316). The thin, prostrate mats of vegetation can withstand the cold winds and frosts of these exposed locations with any snow lie being blown clear by strong winds. (Averis *et al.*, 2004). It is more montane community than the other dry heaths on site (H10/H12). This vegetation type was often found to be heavily eroded by large herbivores.

A5.1.4.56 H17b *Calluna vulgaris - Arctostaphylos alpinus* heath. Occupying similar ground and in close proximity to the other prostrate heaths (H13/14) occurs this vegetation type, namely on two small prominences around Creag Riabhach, on two knolls at the southern end of the site (at NC5223227981 and NC5237928063) and at pt. 330(c. NC537313) (Figure 5.8 NVC Target Notes 6 and 7). This is another prostrate heath although the less montane sub species H17b. It too as a low mat of *Calluna vulgaris* with other ericoids *Arctostaphylos alpinus, Empetrum nigrum ssp nigrum, Erica cinerea* and *Vaccinium myrtillus*. It has a diversity of lichens including the *Cladonia* species *C. arbuscula, C. ciliate,* and *C. uncialis ssp biuncalis* This community would normally be found above 500m but at the high latitude this can be as low as 200m (Averis *et al.*, 2004). It is another important lichen rich montane habitat (Averis *et al.*, 2004).

A5.1.4.57 H22 *Vaccinium myrtillus - Rubus chamaemorus* heath. Two small areas of this vegetation type occur on the North western slopes of Creag Riabhach. This is a damp heath with an abundance of bryophytes associated with late lying snow, it is an important habitat for the *uncommon Rubus chamemorus* and good potential habitat for rare Atlantic liverworts (Averis *et al.*, 2004).

Annex I 7230 Alkaline fens

- M10 *Carex dioica - Pinguicula vulgaris* mire.

A5.1.4.58 M10 *Carex dioica - Pinguicula vulgaris* mire. This, more basic flush community, occurs very locally in small flushes on the North side of Creag Riabhach. It consists of small sedges such as *Carex viridula ssp viridula* along with *Pinguicula vulgaris* and a covering of brown mosses such as *Scorpidium scorpioides* and other moss species, growing on the slightly enriched soils around the flushes are the more calcicolous plants such as *Thalictrum alpinum* and *Selaginella selaginoides*.

Ground Water Dependent Terrestrial Ecosystems (GWDTEs)

A5.1.4.59 Of the 62 vegetation communities identified by SEPA as being potentially groundwater dependent wetlands, eight have been recorded in the core survey area:

Highly Groundwater-Dependent Wetlands

A5.1.4.60 Two vegetation communities considered to be highly groundwater-dependent were found at Creag Riabhach;

- M6 *Carex echinata - Sphagnum fallax* mire; and
- M10 *Carex dioica - Pinguicula vulgaris* mire.

A5.1.4.61 M6 *Carex echinata - Sphagnum fallax* mire. These are fairly species poor mires mostly of the sub community M6b with plentiful sedges, mostly *Carex nigra* as well as *Carex panacea* rising above a carpet of *Sphagnum denticulatum* and *Sphagnum fallax*. These sub communities occur in small flushes and depressions above the Allt Bealach an Fhuarain and as well as along the side of burns draining East from the site. As small pasture of M6c/d sub community dominated by *Juncus effusus* and *Juncus acutiflorus* occurs by the small dam (marked waterfall on the OS map) with a more species rich sward.

A5.1.4.62 M10 *Carex dioica - Pinguicula vulgaris* mire. This community is described above

Moderately Groundwater-Dependent Wetlands

A5.1.4.63 Two vegetation communities have been recorded that are considered to be moderately groundwater-dependent;

- M15 *Trichophorum germanicum - Erica tetralix* wet heath.
- MG10 *Holcus lanatus - Juncus effusus* rush-pasture.

A5.1.4.64 M15 *Trichophorum germanicum - Erica tetralix* wet heath. This community is described above.

A5.1.4.65 MG10 *Holcus lanatus - Juncus effusus* rush-pasture. This mire community is of little conservation interest (Averis *et al.*, 2004) and occurs in one small area along the roadside south of Vagastie bridge.

Wetlands of low Ground Water Dependency

- M2 *Sphagnum cuspidatum/Sphagnum fallax* bog pool;
- M3 *Eriophorum angustifolium* bog pool;
- M17 *Trichophorum cespitosum - Eriphorum vaginatum* blanket mire; and
- M25 *Molinia caerulea - Potentilla erecta* mire.

A5.1.4.66 All of these communities are described above as they coincide with Annex I habitats

Other Communities found around Creag Riabhach.

A5.1.4.67 Other plant communities were recorded which also do not qualify as Annex I habitats and are found at the edge of the site in the case of the woodland communities or alongside the main road, mostly outlying the site

- W4mol - *Betula pubescens - Molinia caerulea* woodland.

A5.1.4.68 The lower slopes of the forestry exclosure have small stands of wet acid woodland, mainly *Betula pubescens* and Salix caprea with occasional *Salix auricea*, *Pinus sylvestris, Alnus glutinosa* and Corylus *avellana*. The understory of these small stands is species poor mix of mainly *Molinea caerulea* with some *Festuca* and *Agrostis* species and small herbs. There is no NVC type for such species poor, planted stands which have been labelled W4mol as they most closely resemble W4 woodland habitat.

- U4 *Festuca ovina - Agrostis capillaris - Galium saxatile* grassland.

A5.1.4.69 U4 acid grassland and its sub community U4b occur, respectively, in a tiny pocket north of Creag Riabhach and in another small area close to the small dam (marked waterfall on the OS map).

- U20 *Pteridium aquilinium - Galium saxatile* community
- W23 *Ulex europaeus - Rubus fruticosus* community
- MG10 *Holcus lanatus - Juncus effusus* rush pasture.

A5.1.4.70 Small areas of *Pteridium aquilinium* (U20) and *Ulex europaeus* (W23) lie alongside the road to the east of the site, tiny area of MG10 *Holcus lanatus - Juncus effusus* rush pasture.

A5.3 National Vegetation Classification Target Notes.

TN	Grid reference	Notes
1	NC5529932714	*Molinia caerulea* area, light in colour in otherwise M17 area.
2	NC5527832726	Sink hole with *M. caerulea*.
3	NC5521732709	Another sink hole with M25 and *Empetrum nigrum, Carex nigra* and *Pedicularis vulgaris*.
4	NC5433131816	*Molinia* rich M17, slightly flushed.
5	NC5433131816	*Racomitrium lanuginosum* hummocks with dry M2 bog pools (Photo A5.1.18)
6	NC5223227981	H17 Knoll with strange hole filled with bedding
7	NC5237928063	H17 Knoll
8	NC5209128473	M6b, *Carex nigra* around periphery, core area of flush consists of bare peat-6, *Ericphorum angustifolia* -6, *Sphagnum cuspidata* (blackened) -6 *Drosera rotundifolia* -3, *Narthesium ossifragum* -3, *Trichophorum germanicum*-2, *Menica gale* -1, *Carex rostrata* -1
9	NC5320029463	M6b Flush, grassy component from M. caerulea
10	NC5327530252	Species poor H14. Notable species-*Cetraria islandica*, wind clipped *Calluna vulgaris, Racomitrium lanuginosum* and some *Nardus stricta*
11	NC5343430596	Rock outcrop with *Arctostaphylos alpinus* amongst fragments of H14/H13
12	NC5336530524	Area with shallow pools mostly bare peat/open water or M3. M17b on lower slopes. Species poor H14 on drier slopes above

Species list

Alchemilla alpina
Achillea millefolium
Achillea ptarmica
Agrostis capillaris
Agrostis sp
Anthoxanthum odoratum
Antennaria dioica
Anthriscus sylvestris
Arctostaphylos alpinus uva ursa
Atrocomium palustre
Bellis perennis
Betula nana
Betula pubescens
Blechnum spicant
Blinaia acuta
Calluna vulgaris
Campanula rotundifolia
Campylopus atrovirens
Carex bigelowei
Carex binervis
Carex dioica
Carex echinata
Carex viridula
Carex nigra
Carex panacea
Carex pulicharis
Carex pulifera
Carex rostrata
Carex viridula ssp lepidocarpa
Carex viridula ssp oedocarpa
Cerastium fontanum
Cetraria islandica

Claacnia ciliata
Claacnia rangiferina
Claacnia uncialis
Claacnia sp.
Cyncsurus cristatus
Dactylcrhiza maculata
Descnampsia flexuosa
Digitalis purpurea
Diphasium alpinum
Drosera intermedia
Drosera rotundifolia
Empetrum nigrum ssp hermaphroditum
Empetrum nigrum ssp nigrum
Eriaymicn. nor.-scriptus
Equisetum arvense
Erica cinerea
Erica tetralix
Eriophorum Angustifolium
Eriophorum vaginatum
Euphrasia agg
Festuca ovina
Festuca rubra
Festuca vivipara
Fissana verna
Galium saxatile
Heracium agg
Holcus lanatus
Hylocomium splendens
Hyperzia selago
Hypochaeris radicata
Hypnum jutlandicum
Ilex aquilifolium
Juncus articulatus
Juncus bufonis
Juncus effusus
Juncus squarrosus
Juniperus communis
Lathyrus linifolius
Listera ovata
Lotus corniculatus
Luzula campestris
Luzula multiflora
Luzula sylvatica
Lycopodium alpinum
Lycopodium clavatum
Lysimachia nummularia
Melampyrum pratense
Menyanthes trifoliata
Molinia caerulea
Myrica gale
Narous stricta
Narthesium ossifragum
Orecpteris limbosperma
Oxalis acetosella
Pedicularis palustre
Pedicularis sylvatica
Peltigera canina agg
Pinguicula vulgaris
Pinus sylvestris
Plantago lanceolata
Pleurozium purpurea
Pleurozium schreberi
Poa annua
Poa pratensis
Poa trivialis
Polygala serpyllifolia
Polypodium vulgare
Polytrichum commune
Populus tremula
Potentilla erecta
Primula vulgaris
Pteridium aquilinum
Quercus
Ranunculus acris
Ranunculus repens
Racomitrium lanuginosum
Rhytidiadelphus loreus
Rhytidiadelphus Squarrosus
Rhytidiadelphus triquetus
Rubus chamaemorus
Rumex acetosella
Salix arbuscula
Salix aurita
Salix caprea
Salix cinerea agg
Scorpidium revolvens
Scorpidium scorpioides
Selaginella selaginoides
Sorbus aucuparia
Sphagnum capillifolium
Sphagnum compactum
Sphagnum cuspidatum
Sphagnum denticulatum
Sphagnum fallax
Sphagnum magellanicum
Sphagnum palustre
Sphagnum papillosum
Sphagnum tenellum
Succisa pratensis
Taraxicum officinale
Thalictrum alpinum
Thymus polytrichus
Trichophorum germanicum
Trifolium repens
Ulex europea
Vaccinium myrtillus
Vaccinium ursa
Vaccinium vitis-idaea
Valeriana officinalis
Vicia palustre
Vicia riviniana
Vicia tricolor

Freshwater Pearl Mussel Survey

A5.1.4.71 Optimal freshwater pearl mussel habitat was found to be confined to a small area of the River Vagastie, over 600m from the borrow pit and over 5km from the nearest turbine location (Target Notes 1, 2 and 3 in Table A5.4 and Figure 5.9). River Vagastie habitat was found to be sub-optimal upstream and nearer to the site – features included large series of bedrock substrates, outcrops and gorges together with slow moving flows, meandering channels & silty sediments (Target notes 4-14 in Table A5.4 Figure 5.9). Habitat on the Allt na h-Aire, Allt Bealach an Fhuarain and Allt a' Chraisg was found to be sub-optimal – features included bedrock, boulders, unstable banks and a lack of gravels.

A5.1.4.72 No freshwater pearl mussels were found during detailed surveys of the limited suitable habitat on the River Vagastie.

A5.4 River Vagastie Habitat Suitability Survey Target Notes.

Target Note	Grid Reference	Substrate (%)	Bankside Habitat	Watercourse Characteristics	Other notes
1	NC5672133595	Cobble 90% / Gravel 10%	Lined by semi natural alder	High water quality, good speed and flow, 8m wide	Start Point
2	NC5665633512	Cobble 90% / Gravel 10%	Lined by semi natural alder. Deciduous plantation (10yo) and mown field either side.	High water quality, good speed and flow, 8m wide	Stonefly, Caddisfly and mayfly larvae present
3	NC5658133463	N/A			Sheep gate
4	NC5637733159	Bedrock 90% / Cobbles 10 %	Steep banks of heather, blaeberry and alder. Open moorland beyond	Fast white water, cascade, flumes, shutes, pools and riffles.	Deep gorge, 10m width
5	NC5630532980	Bedrock 90% / Cobbles 10 %	Lined by semi natural alder / Open Moorland	Steep waterfall	
6	NC5566732409	Bedrock 90% / Cobbles 10 %	Lined by semi natural alder / Open Moorland	End of bedrock section	
7	NC5566732409	Boulders 55% / Cobbles 20 % / Stones 20 % / Gravels 5 %	Lined by semi natural alder / Open Moorland	Heterogenous substrate	
8	NC5560732361	Bedrock 65% / Cobbles 25 % / Stones 10 %	Lined by semi natural alder / Open Moorland	Deep pool, turbulent	Gorged Ravine
9	NC5551432228	N/A	Lined by semi natural alder / Open Moorland		End of gorge Bedrock Section

Target Note	Grid Reference	Substrate (%)	Bankside Habitat	Watercourse Characteristics	Other notes
10	NC5546732150	Cobble 90% / Boulders 10 %	Lined by semi natural alder / Open Moorland	High water quality, good speed and flow, 6-7m wide	
11	NC5529131882	Bedrock 60% / Boulders 40 %	Lined by semi natural alder / Open Moorland		Suboptimal Habitat
12	NC5458530633	Silt 100%	Open moorland	Slow, meandering	Unstable banks
13	NC5388928970	Bedrock 40% / Boulders 20 % / Cobbles 40 %	Open moorland	River substrate alternates between stretches of bedrock and large cobbles	
14	NC5325427208	Boulders 40% / Cobbles 30 % / Pebbles 20 % / Gravels 10 %	Open moorland	6m width, 10cm depth, shallow, low flow	By Vagastie Road Bridge

A5.5 Allt na h-Aire Burn Habitat Suitability Survey Target Notes

Target Note	Grid Reference	Substrate %	Bankside Habitat	Watercourse Characteristics	Other notes
15	NC5490433034	Bedrock 30 % / Pebbles 35% / Gravels 35%	Bankside erosion / Headwater on Open Moorland	Low flow / Fast Flowing / Unpolluted	
16	NC5408632394	Boulders 90% / Cobbles 10%	Bankside erosion / Headwater on Open Moorland	Low flow / Narrow Channel / Unstable Substrate	Fast flowing /Poor salmon spawning potential
17	NC5335831730	Bedrock 40 % / Boulder 30 % / Pebbles 30 %	Bankside erosion / Headwater on Open Moorland	Very narrow, at most 2m	

A5.6 Allt a' Chraisg and Allt Bealach an Fhuarain Habitat Suitability Survey Target Notes.

Target Note	Grid Ref	Description	Bankside Habitat	Watercourse Characteristics	Other notes
18	NC5273726887	Cobble 30%, very coarse and coarse gravel 70%		Water Depth 5cm	Allt a' Chraisg Watercourse

Target Note	Grid Ref	Description	Bankside Habitat	Watercourse Characteristics	Other notes
19	NC5262526870	Boulder 30%, cobble 60%, very coarse and coarse gravel 10%		10cm	Allt a' Chraisg Watercourse
20	NC5252126850	Outcrop - then continuing as above			Allt a' Chraisg Watercourse
21	NC5244126305	Bedrock 70%; boulder 10%; cobble 20%			Allt a' Chraisg Watercourse
22	NC5233426337	Deeper pools		1m	Allt Bealach an Fhuarain Watercourse
23	NC5203126790	Boulder/cobble pile - very dynamic			Allt Bealach an Fhuarain Watercourse
24	NC5201226842	Rocky bed, channel a trickle - Headwaters		5cm	Allt Bealach an Fhuarain Watercourse
25	NC5187827019	Boulder 40%; Cobble 60%. 100m down from weir		10cm	Allt Bealach an Fhuarain Watercourse
26	NC5184427107	Weir - 1.5m high. No water coming over - Headwaters			Allt Bealach an Fhuarain Watercourse
27	NC5180427177	100m up from weir. Boulder 40%; cobble 50%; v coarse gravel 10%		20cm	Allt Bealach an Fhuarain Watercourse
28	NC5183627386	Outcrop			Allt Bealach an Fhuarain Watercourse
29	NC5177627711	Boulder 50%; cobble 40%; v coarse gravel 10%		20cm	Allt Bealach an Fhuarain Watercourse

Target Note	Grid Ref	Description	Bankside Habitat	Watercourse Characteristics	Other notes
30	NC5188927900	Outcrop			Allt Bealach an Fhuarain Watercourse - No Photo
31	NC5189628121	Boulder 30%, cobble 40%, v coarse gravel 30%		10cm	Allt Bealach an Fhuarain Watercourse - No Photo
32	NC5188028434	Outcrop & series of small waterfalls for 500m - Headwaters			Allt Bealach an Fhuarain Watercourse
33	NC5193628802	Mainly bedrock. A covering of algae - Headwaters		15cm	Allt Bealach an Fhuarain Watercourse
34	NC5189829085	Peaty substrate with gravel and sand - Headwaters		30cm	Allt Bealach an Fhuarain Watercourse
35	NC5193829343	Channel narrows - Headwaters		3cm	Allt Bealach an Fhuarain Watercourse
36	NC5202029409	Falls, bedrock -Headwaters			Allt Bealach an Fhuarain Watercourse
37	NC5207829540	Bedrock. End of survey		20cm	Allt Bealach an Fhuarain Watercourse

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A5.1.5.28 UKTAG. 2009. *Guidance on the identification of groundwater dependent terrestrial ecosystems: Annex 1 – NVC plant communities and dependency on groundwater.* UKTAG.

A5.1.6 Photos

A5.1.1 Allt na h-Aire (Phase 1 TN1). © Stuart Spray

A5.1.2 Allt Bealach an Fhuarain (Phase 1 TN2). © Stuart Spray

A5.1.3 Ditch at Phase 1 TN3. © Stuart Spray

A5.1.4 Example of man-made ditches. © Stuart Spray

A5.1.5 Mixed plantation at Phase 1 TN4. © Stuart Spray

A5.1.6 Image of mixed plantation taken from single track road. © Stuart Spray

A5.1.7 Wet modified bog habitat. © Stuart Spray

A5.1.8 Wet modified bog habitat. © Stuart Spray

A5.1.9 Wet modified bog habitat. © Stuart Spray

A5.1.10 Peat pools. © Stuart Spray

A5.1.11 Peat pools. © Stuart Spray

A5.1.12 Peat pools. © Stuart Spray

A5.1.13 Forestry exclosure from the road. © Eamonn Flood

A5.1.14 Upper slopes of the forestry plantation showing mosaic of Molinia grassland and heath. © Eamonn Flood

A5.1.15 M17 bog with M2/M3 bog pools. © Eamonn Flood

A5.1.16 M15 wet heath. © Eamonn Flood

A5.1.17 Montane heath on upper slopes of Creag Riabhach. © Eamonn Flood

A5.1.18 NVC TN 5, Racometrium hummocks and dried M2 bog pools.

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TECHNICAL APPENDIX 5.2

Creag Riabhach Wind Farm – Baseline Fish Population Assessment

Creag Riabhach Wind Farm – Baseline Fish Population Assessment

DOCUMENT CONTROL

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Author - Chris Conroy BSc (Hons) MSc MIFM

SUMMARY OF JUVENILE SALMON SURVEY RESULTS AT SITES WITHIN THE PROPOSED CREAG RIABHACH WIND FARM STUDY AREA*

Area Delineated Multi-Run Depletion Site					Minimum Density (Fish per 100m^2) During Recorded During Last Survey at Site				
					Atlantic Salmon (*Salmon salar*)		Brown Trout (*Salmo trutta*)		Eel (*Anguilla anguilla*)
Sub Catchment	Year of Survey	Site Name	Site Code	Grid Ref.	Fry (0+ Year Class)	Parr (1++ Year Class)	Fry (0+ Year Class)	Parr (1++ Year Class)	All Year classes
Altnaharra	2012	Altnaharra Burn (above falls)	ALT01	NC 5639 3473	44.7 - 'Excellent' ↔	9.9 - 'Good' ↑	6.2 - 'Good' ↑	0.0 - 'Absent' ↓	2.5 - ↑
Burn	2012	Altnaharra Burn (below falls)	ALT02 (SCM)	NC 5680 3507	15.6 - 'Moderate' ↓	46.9 - 'Excellent' ↔	3.3 - 'Poor' ↑	2.5 - 'Moderate' ↑	4.1 - ↓
Vagastie	2012	Vagastie (football field)	VAG01 (SCM)	NC 5683 3357	61.2 - 'Excellent' ↔	50.7 - 'Excellent' ↔	5.7 - 'Moderate' ↑	0.0 - 'Absent' ↔	1.0 - ↑
	2012	Vagastie (middle)	VAG02 (SCM)	NC 5456 3070	5.4 - 'Poor' ↔	20.6 - 'Excellent' ↑	1.1 - 'Very poor' ↑	2.2 - 'Poor' ↓	2.2 - ↑
	2012	Vagastie (upper)	VAG03	NC 5324 2717	0.0 - 'Absent' ↓	11.0 - 'Good' ↑	0.0 - 'Absent' ↔	7.3 - 'Excellent' ↑	1.2 - ↑
	2012	Vagastie (above catchwater)	VAG04	NC 5180 2715	0.0 - 'Absent' ↔	0.0 - 'Absent' ↔	1.4 - 'Very Poor' ↓	5.7 - 'Good' ↑	0.0 - 'Absent' ↔
Tirry	2007	Below Vagastie tranfer	ST05	NC 5738 1339	8.0 - 'Poor' ↓	2.0 - 'Very Poor' ↔	10.0 - Excellent' ↑	0.0 - 'Absent' ↔	0.0 - 'Absent' ↔
	2012	Above Vagastie transfer	ST06	NC 5231 2450	12.3 - 'Moderate' ↑	1.9 - 'Very Poor' ↓	13.3 - 'Excellent ↑	4.7 - 'Good' ↓	0.0 - 'Absent' ↔

↑ Increase in classification of site since last survey
↔ No change in classification of site since last survey
↓ Decrease in classification of site since last survey

Altnaharra Burn in table = Allt na h-Aire Burn in text.

EXECUTIVE SUMMARY

DESIGNATED SITES

- The River Naver and its tributaries are designated as an SAC due to their importance for Atlantic salmon and freshwater pearl mussels.

ALLT NA H-AIRE BURN

- A natural obstruction to the passage of migratory salmonids is located on the Allt na h-Aire burn approximately 750 metres above its confluence with the River Mudale.
- In 2012 the area below the falls supported 'moderate' densities of salmon fry and 'excellent' densities of salmon parr. The site above the falls is artificially supported by the introduction of hatchery bred salmon.
- Spawning success and fry survival below the falls is thought to be heavily influenced by river level and subsequent accessibility for adult salmon; however it is clear that it provides an important spawning and nursery area. The presence of 2+ year old parr suggests that the burn may be important for recruitment of Multi Sea Winter (MSW) salmon and in particular the vulnerable 'spring' component.
- Trout were naturally distributed both above and below falls on the Allt na h-Aire Burn. Those present above the falls are likely to form part of a glacial relic population. Those below the falls are likely to be from both migratory and non-migratory trout origin.
- 'Good' densities of trout fry were recorded above the falls in 2012, with trout parr being 'absent'. 'Poor' densities of trout fry and 'moderate' densities of trout parr were recorded below the falls. Overall, densities of juvenile trout were found to be highly variable from year to year.
- The eel was distributed above and below the falls on the Allt na h-Aire Burn. The majority were juvenile (elvers) present in relatively low densities.

RIVER VAGASTIE

- A 'catchwater' structure across the upper Vagastie diverts water into the neighbouring Shin catchment as part of the Loch Shin Hydropower Scheme. This presents a physical barrier to the upstream and downstream migration of salmon and eels, reduces downstream flows and changes flood flow characteristics.
- The lower reaches of the River Vagastie provide an important spawning and nursery

area for both juvenile salmon and trout. However, spawning is limited in the mid to upper reaches; this is believed to be as a result of abstraction and morphological pressures relating to the catchwater.

- The lowest site on the Vagastie catchment was found to support 'excellent' densities of both salmon fry and parr. Parr densities in the middle reaches were also classed as 'excellent'; however fry densities fell to a 'poor' classification indicating low spawning success.

- Salmon parr densities in the upper reaches of the Vagastie below the catchwater fell to a 'good' classification with fry found to be 'absent'. An absence of entire year classes of fish over successive years suggests that this area is particularly sensitive to changes in environmental conditions. This is thought to be due to the effects of low flows resulting from the catchwater.

- There has been an overall trend for increasing salmon and trout parr densities at sites on the Vagastie in recent years. The presence of 2+ year old parr suggests that the River Vagastie may be important for the recruitment of MSW salmon and in particular the vulnerable 'spring' component.

- The lower reaches of the Vagastie were found to support 'moderate' densities of trout fry. This decreased to 'very poor' densities in the middle reaches, with fry being 'absent' directly below the catchwater. Fry densities increased once again above the catchwater, although only achieving a 'very poor' classification.

- Trout parr were found to be absent at the lowest site on the Vagastie, with 'poor' densities in the middle reaches and 'excellent' densities directly below the catchwater. Densities fell slightly above the catchwater, although still achieving a 'good' classification.

- Eels were found to be present at all sites below the catchwater but absent above it. This suggests that the structure creates a barrier to the upstream passage of eels.

RIVER TIRRY

- Water transferred from the Vagastie contributes a significant proportion of the flow in the main River Tirry. The Tirry's migratory salmonid populations have significantly reduced since the construction of the Lairg Dam, which presents a barrier to the upstream migration of salmon and downstream migration of smolts. The catchment is currently supported by the introduction of hatchery bred salmon fry.

- The nearest site below the Vagastie transfer was found to support 'poor' densities of salmon fry and 'very poor' densities of parr. This section of the River Tirry has not been subject to stocking since at least 2005 and as such these densities are likely to be indicative of natural recruitment.

- Minimum salmon fry densities at the site directly above the confluence were found to support 'moderate' populations of salmon fry and 'very poor' populations of salmon parr. The fry densities at this site are likely to be artificially supported by the introduction of hatchery bred fry upstream of the site

- 'Excellent' densities of trout fry were present at the site below the confluence in 2007, however they were found to be 'absent' in all previous years. Trout parr were only noted as being present in 2005 when 'very poor' densities were recorded. Both trout fry and parr were consistently present above the confluence. Overall trout densities were found to be highly variable from year to year.

- No eels have been recorded at the sites on the Tirry to date. This suggests that they are either present in naturally low numbers, or unable to negotiate structures downstream from the site such as the Lairg Dam.

LAMPREY SPECIES

- Existing information on the distribution and abundance of lamprey ammocoetes within the study area is limited. However, the presence of juvenile *Lampetra* spp in the lower reaches of the River Vagastie has been confirmed, with a number of these positively identified as brook lamprey. The same is true for the River Mudale in close proximity to the mouth of the Allt na h-Aire Burn.

- The falls on the Allt na h-Aire Burn, the catchwater on the River Vagastie and the Lairg Dam on the Tirry are likely to act as barriers to the distribution of lamprey. In addition to this, the presence and/or abundance of lamprey species is likely to decrease with distance travelled upstream on the Vagastie.

- A detailed lamprey monitoring programme would be required to establish the baseline distribution and abundance of lamprey species within the study area.

ARCTIC CHARR

- There is currently no evidence to suggest that Arctic charr frequent or spawn in the Vagastie, Allt na h-Aire Burn, or any other rivers with the Naver of Tirry catchment. However, given its status as a UKBAP Priority Species, the presence of Arctic charr in

Loch Naver is noted.

RECOMMENDATIONS

- It is important that best practice is followed and that all appropriate measures are taken to mitigate potential impacts on water quality and quantity resulting from the development.

- In addition to this a robust monitoring plan should be developed to monitor any residual effects that may or may not remain after mitigation.

Contents

ACRONYMS AND ABBREVIATIONS

BACI	Before and After Control Impact
DOC	Dissolved Organic Carbon
ERA	Ecological Research Asssociates
HMWB	Heavily Modified Water Body
IUCN	International Union for Conservation of Nature
KSFT	Kyle of Sutherland Fisheries Trust
MSW	Multi-Sea-Winter (salmon)
RNF	River Naver Fisheries
SAC	Special Area of Conservation
SCM	Site Condition Monitoring
SEPA	Scottish Environment Protection Agency
SFCC	Scottish Fisheries Coordination Centre
SNH	Scottish Natural Heritage
SSE	Scottish and Southern Energy
SSSI	Site of Special Scientific Interest
UKBAP	United Kingdom Biodiversity Action Plan
WFD	Water Framework Directive

1 INTRODUCTION

The Baseline Fish Population Assessment (BFPA) has been produced by Chris Conroy BSc (Hons) MSc MIFM, the superintendent and biologist at River Naver Fisheries (RNF) as part of the Environmental Statement for the proposed Creag Riabhach Wind Farm development. The BFPA has been produced by Chris Conroy as he has the best experience, expertise and knowledge to professionally undertake the work.

This report provides a baseline fish population assessment for the proposed Creag Riahbach Wind Farm development, on land forming part of the Altnaharra Estate. The assessment is largely based on the results of electric fishing surveys carried out by RNF in 2012 on those watercourses that flow through or are directly adjacent to the proposed development area. Data was also kindly provided for the River Tirry catchment by the neighbouring Kyle of Sutherland Fisheries Trust (KSFT).

The RNF carry out regular juvenile salmonid surveys at sites across the River Naver catchment as part of a rolling fisheries monitoring programme. The results are primarily used to provide a measure of the extent to which spawning and nursery habitats are being utilised by Atlantic salmon (*Salmo salar*) and brown trout/sea trout (*Salmo trutta*). This provides an assessment of the demographic structure of the populations, identify adverse environmental impacts and highlight recruitment failures and to assess the success of restocking programmes.

The results of the juvenile salmon surveys also provide information on the presence and abundance of other species including the European eel (*Anguilla anguilla*). Alternative sources of information are used to assess the presence of Arctic charr (*Salvelinus alpinus*) and lamprey species within the study area.

2 KEY SPECIES OF INTEREST

This section of the report identifies the key species of interest as outlined in the Creag Riabhach Wind Farm Scoping Opinion (The Scottish Government, 2013) and the protection afforded to each within conservation legislation. The information provided for each species is based on that found on the Scottish Natural Heritage (SNH) website[1].

2.1 ATLANTIC SALMON (*Salmo salar*)

Atlantic salmon are listed on Appendix III of the Bern Convention and Annex II and V of the EC Habitats & Species Directive. The multi-sea-winter component of the Atlantic salmon population is included in the UK Biodiversity Action Plan (UKBAP) Priority Species List.

The River Naver is designated as a Special Area of Conservation (SAC) due to its importance for Atlantic salmon and Freshwater pearl mussels (*Margaritifera margaritifera*). The river and its tributaries support a high-quality Atlantic salmon population that is representative of the most northerly part of the species' range in the UK.

2.2 BROWN/SEA TROUT (*Salmo trutta*)

Although brown trout are not a qualifying species for the Naver SAC, they are a UKBAP Species and therefore deemed to be of national importance. As such they deserve consideration and so are included in this assessment.

Sea trout are the sea-running form of the brown trout. Scottish rivers were colonised by sea trout at the end of the last Ice Age, and their descendents form the populations of brown trout and sea trout we know today (both *Salmo trutta*). Of particular conservation value are the original colonisers, i.e. those fish which occupied isolated loch and streams immediately after the retreat of the ice c.10,000 years ago, the descendents of which can still be identified today.

Neither forms of trout, freshwater resident or sea trout, receive extensive protection within conservation legislation. Some protection in terms of exploitation controls exist within fisheries legislation and sea trout are further protected within fisheries acts relating to the protection of 'salmon'[2]. In 2007, however, both ancestral brown trout forms and sea trout were added to the UK Biodiversity Action Plan Priority Species List.

[1] http://www.snh.gov.uk/about-scotlands-nature/species/fish/freshwater-fish/
[2] Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003

2.3 EUROPEAN EEL (*Anguilla anguilla*)

The European eel is listed as 'critically endangered' on the International Union for Conservation of Nature (IUCN) Red List. A widespread decline has led the European Commission to develop an Eel Recovery Plan (Council Regulation No 1100/2007). This aims to return European eel stocks to sustainable levels. Each Member State is required to establish national Eel Management Plans, with an Eel Management Plan for Scotland developed by Marine Scotland Science in 2008. The European eel was also added to the UKBAP Priority Species List in 2007.

2.4 LAMPREY SPECIES

There are three lamprey species present in UK; brook lamprey (*Lampetra planeri*), river lamprey (*Lampretra fluviatilis)* and sea lamprey (*Petromyzon marinus*). All three species are afforded protection within conservation legislation:

- Brook Lamprey Annex II of the EU Habitats Directive Appendix III of the Bern Convention.
- River Lamprey Annexes II and V of the EU Habitats Directive Appendix III of the Bern Convention and are on the UKBAP Priority List.
- Sea Lamprey Annex II of the EU Habitats Directive Appendix III of the Bern Convention and are on the UKBAP Priority List.

2.5 ARCTIC CHARR (*Salvelinus alpinus*)

The Arctic charr is closely related to the Atlantic salmon and the brown trout. The majority of Arctic charr populations in Scotland occupy still waters and are not found to occupy rivers. Currently, Arctic charr are a conservation feature in five Sites of Special Scientific Interest (SSSI) and are present in a number of water bodies protected for other purposes, either under the Natura 2000 network or the National Nature Reserve series. The conservation value of Arctic charr within the UK has been further recognised by their addition to the UKBAP Priority Species List in 2007.

3 METHODOLOGY

This section of the report details the method used by the RNF to survey watercourses that flow through or are directly adjacent to the proposed development area. The primary aim of these surveys was to monitor juvenile salmonids (salmon and trout) populations, however the presence and abundance of other species was also noted.

3.1 INTRODUCTION

Electric fishing is considered to be the best and most cost-effective sampling method for monitoring juvenile salmonid populations from a catchment-wide perspective (Cowx & Fraser, 2003). It provides accurate and precise spatial and temporal information which can be used to inform management decisions.

The RNF is a member of the Scottish Fisheries Coordination Centre (SFCC). The SFCC provides protocols relating to data collection and recording of information. It has developed a database for entering and storing data in an agreed format. Since 2007 the River Naver Fisheries have carried out all of its surveys to the standards required by the SFCC and data are recorded using the agreed format.

3.2 AREA DELINEATED MULTI-RUN DEPLETION (QUANTITATIVE SURVEYS)

This method attempts to quantify the density of fish within a unit area of the riverbed. As a quantitative method this allows comparisons between sites of different sizes and characteristics (SFCC, 2007).

Stop nets are positioned at the top and bottom of the survey reach, isolating an area of approximately 100m^2 and preventing fish from moving into or out of the site. The reach is then electric fished a minimum of three times. The fish are removed after each successive run allowing the number of fish present within the survey reach to be determined (fish per 100m^2).

Capture net choice depends upon the flow type, habitat and target fish, but remains the same for sites that are to be compared. Banner nets are preferred when shallow riffles are surveyed (see **Figure 3-1** below), but where the habitat types are more variable dip nets are more useful.

As it is usually impossible to catch all fish present at a site, irrespective of the number of times a site is surveyed, the basic number of fish captured during the survey is referred to as a minimum population estimate. An estimate of the total population can be made from the

number of fish caught in a sample. This is based on the rate at which the catches on successive electric fishing runs drop off and the total number of fish caught. For the estimation to be valid, the removal method must significantly reduce the population size with each successive sampling run. The estimate is made using the SFCC Database which analyses depletion catches with a weighted maximum likelihood estimator described by Carle and Strub (1978).

Figure 3-1 Delineated multi-run depletion method showing banner net

The results of surveys are classified using a simplified version of the SFCC Scottish national classification scheme (Godfrey, 2005) (see **Table 1** below). This was based on data obtained from 1,600 sites across Scotland. It involves assigning the densities of salmon and trout fry and parr at each site a classification ranging from A (Excellent) to F (Absent).

Table 1 River Naver Salmon and Trout Density Classification scheme

Salmon Fry (no. per 100m^2)	Classification	Salmon Parr (no. per 100m^2)
0	**F – Absent**	0
<4.7	**E – Very Poor**	<2.6
4.7 to <10.3	**D – Poor**	2.6 to <5.1
10.3 to <20.3	**C – Moderate**	5.1 to <9.1
20.3 to <42.1	**B – Good**	9.1 to <15.8
>42.1	**A – Excellent**	>15.8

Trout Fry (no. per 100m^2)	Classification	Trout Parr (no. per 100m^2)
0	**F – Absent**	0
<3.1	**E – Very Poor**	<1.3
3.1 to <4.5	**D – Poor**	1.3 to <2.3
4.5 to <6.0	**C – Moderate**	2.3 to <4.0
6.0 to <9.3	**B – Good**	4.0 to <6.1
>9.3	**A - Excellent**	>6.1

3.3 DATA COLLECTION

At all sites the number of salmon and trout and their fork lengths (to the nearest millimetre) are recorded (see **Figure 3-2** below). The numbers of individuals from other species are also recorded. Scale samples are taken from a representative batch of fish in order to determine their ages and therefore, the size of fish in each different year class. This allows the densities of fry (fish less than one year old i.e. 0+) and parr (fish more than one year old >1+) to be determined individually. The fish are allowed to recover fully from the effects of handling before being returned to the river.

Figure 3-2 Counting and recording the fork length of salmon parr captured during a survey

A detailed habitat survey is performed for each electric fishing site, with information on flow characteristics, depths, substrate type and quality, in-stream, bank and canopy cover and site dimensions. In addition, photographs and water temperature measurements are taken.

4 STUDY AREA

This section of the report defines the study area for the Creag Riabhach Wind Farm Proposal baseline fish population assessment. This is based on the identification of those watercourses that originate from, flow through or are directly adjacent to the proposed development area as presented in **Figure 4-1a and 4-1b** below. The confluence of such waters with Loch Naver was taken to be the limit of the assessment.

4.1 ALL NA H-AIRE BURN

The Allt na h-Aire Burn originates at the north end of the proposed development site and flows north east before joining the lower reaches of the River Mudale. Two long-term RNF electric fishing survey sites exist on the Allt na h-Aire Burn (see **Table 2** below), both of which were last sampled on the 8th August 2012.

Table 2 Details of electric fishing survey sites on the Allt na h-Aire Burn

Site Code	Date Last Surveyed	NGR	Location
ALT01	02/08/12	NC 5639 3473	Allt na h-Aire Burn (above falls)
ALT02 (SCM)	02/08/12	NC 5680 3507	Allt na h-Aire Burn (below falls)

4.2 RIVER VAGASITE

The River Vagastie originates from the south west of the proposed development site before flowing north along the east edge of the site and draining into Loch Naver. A number of its tributaries drain the proposed development area. Four long-term RNF electric fishing survey sites exist on the River Vagastie (see **Table 3** below), all of which were sampled between the 15th and the 30th August 2012.

Table 3 Details of electric fishing survey sites on the River Vagastie

Site Code	Date Last Surveyed	NGR	Location
VAG01 (SCM)	15/08/12	NC 5683 3357	River Vagastie (lower by football field)
VAG02 (SCM)	30/08/12	NC 5456 3070	River Vagastie (middle)
VAG03	30/08/12	NC 5324 2717	River Vagastie (upper by Vagastie Bridge)
VAG04	30/08/12	NC 5180 2715	River Vagastie (above catchwater)

4.3 RIVER TIRRY

The River Tirry arises 10km south of Altnaharra and travels approximately 20km south before flowing into Loch Shin. Although it does not naturally form part of the Naver Catchment, the Tirry receives water from the River Vagastie as part of a water transfer scheme. During the 1950's a structure was built across the upper Vagastie catchment to divert water into the neighbouring Shin catchment as part of the Loch Shin hydropower scheme. Two of the KSFT long-term River Tirry electric fishing survey sites were considered in this assessment (see **Table 4** below).

Table 4 Details of electric fishing survey sites on the River Tirry

Site Code	Date Last Surveyed	NGR	Location
ST05	13/09/07	NC 5738 1339	Downstream of confluence with Allt an Locha Ghaineamhaich (Vagastie tranfer)
ST06	27/08/12	NC 5231 2450	Upstream of confluence with Allt an Locha Ghaineamhaich (Vagastie tranfer)

Figure 4-1a Location of RNF Electric Fishing Survey Sites with the Study Area

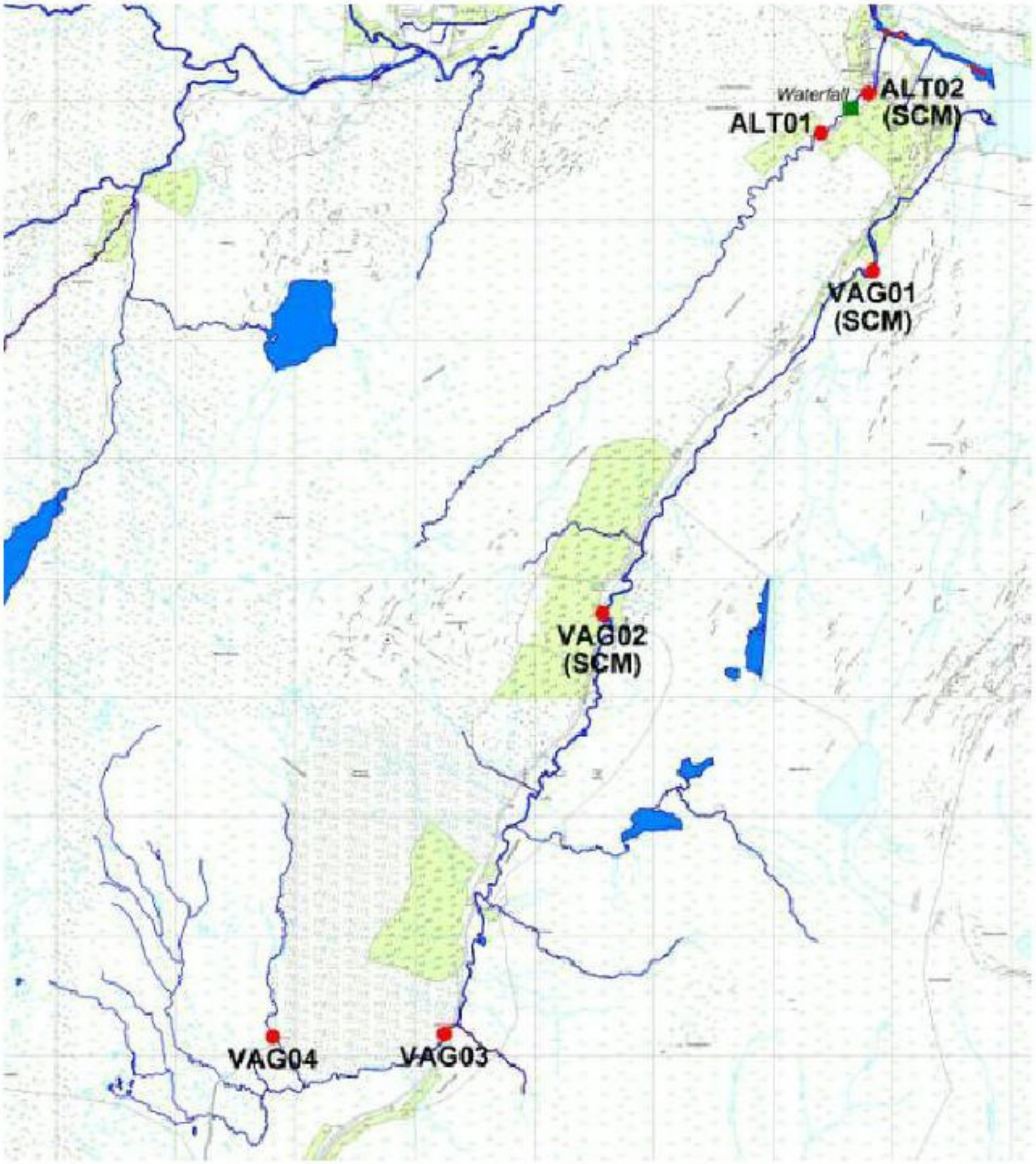
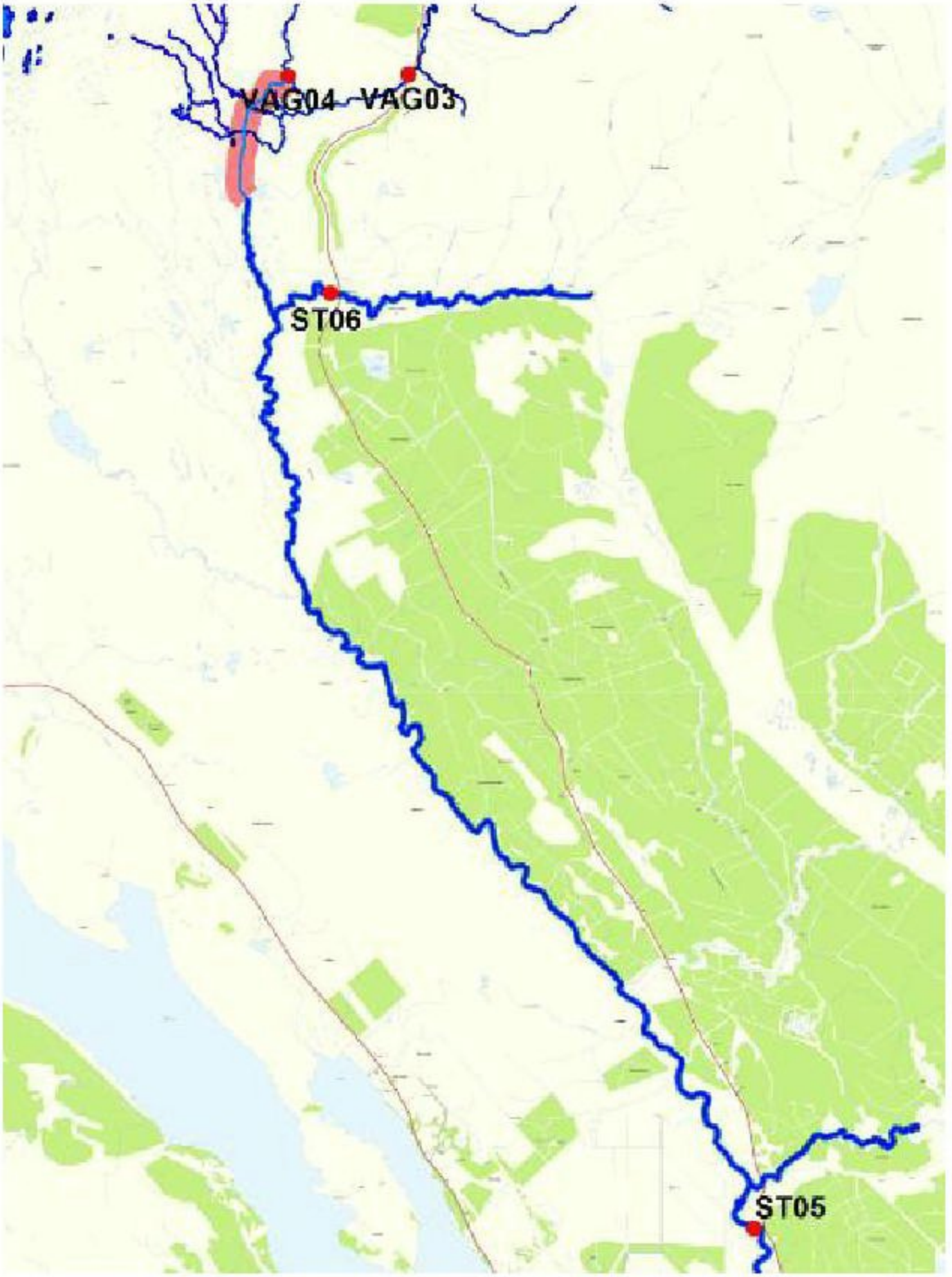


Figure 4-1b Location of KSFT Electric Fishing Survey Sites with the Study Area



5 ALLT NA H-AIRE BURN

5.1 INTRODUCTION

The Allt na h-Aire a Burn joins the right bank of the River Mudale approximately 150m below the main A836 road bridge (NC 569 356). It is the lowest tributary on the Mudale catchment and has a total length of approximately 8km. Riparian land use throughout its length is dominated by moorland heath. A number of coniferous forestry blocks in its lower reaches have recently been clear felled and replanted with native tree species.

An impassable falls exists approximately 750m upstream from the Allt na h-Aire a Burn's confluence with the Mudale and just 200m upstream from the A836 road bridge at the Altnaharra Hotel (see **Figure 5-1**). As a result of this only 9% of the catchment is naturally accessible to salmon.

Figure 5-1 Impassable falls on the Allt na h-Aire Burn (downstream view)

The area above the impassable falls on the Allt na h-Aire Burn was stocked with hatchery bred salmon for the eleven year period between 1994 and 2004. Stocking was then suspended following concerns over the source of brood stock and potential genetic implications.

A revised 'Stocking Strategy' was approved by Marine Scotland and Scottish Natural Heritage and implemented in April 2011 when approximately 22,184 'unfed' salmon fry of local provenance (within 10km of the receptor site) were introduced above the impassable falls. A further 22,986 hatchery bred salmon (c.5,500 'eyed ova' and c.17,486 'unfed' fry) were introduced between January and March 2012 (see **Figure 5-2** below).

Figure 5-2 RNF staff introducing salmon 'eyed ova' into an artificial 'redd' above the impassable falls on the Allt na h-Aire Burn

Subject to the relevant permissions being granted, stocking above the falls will continue until 2014 with up to 25,000 hatchery bred salmon introduced per annum. A detailed assessment of the impacts of a full four years stocking will then be undertaken, after which an informed decision will be made with regards to future stocking operations.

5.2 SITE ALT01 – ALLT NA H-AIRE BURN (ABOVE IMPASSABLE FALLS) (02/08/12)

5.2.1 Site Description

This long-term monitoring site is located approximately 250m above the impassable falls on the Allt na h-Aire Burn (NC 5639 3473). It was originally chosen to monitor the success of the 1994 to 2004 stocking programme. A photograph of the survey site (downstream view) is presented in **Figure 5-3** below.

Figure 5-3 Photograph of electric fishing site ALT01 taken in 2012 (downstream view)

Clear felling of coniferous forestry adjacent to the site was completed in 2010 and subsequent replanting with native species was carried out in 2011. The newly planted saplings were introduced into 'mounds' and extend to within approximately 30 metres of the river bank. Deer have been excluded from the area, resulting in significant re-growth of riparian vegetation.

The bank face and bank top vegetation on both banks were described as 'simple', i.e. predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc).

Prior to commencement of the survey the site was described as having 'excellent' in-stream cover with the water level being 'low' and 'clear'. The key in-stream physical habitat characteristics recorded at the site are summarised in **Table 5** below and compared to the requirements of both salmon fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 5 Summary of the key in-stream physical habitat characteristics recorded at ALT01 compared to the requirements of salmon fry and parr (Hendry & Cragg-Hine, 1997).

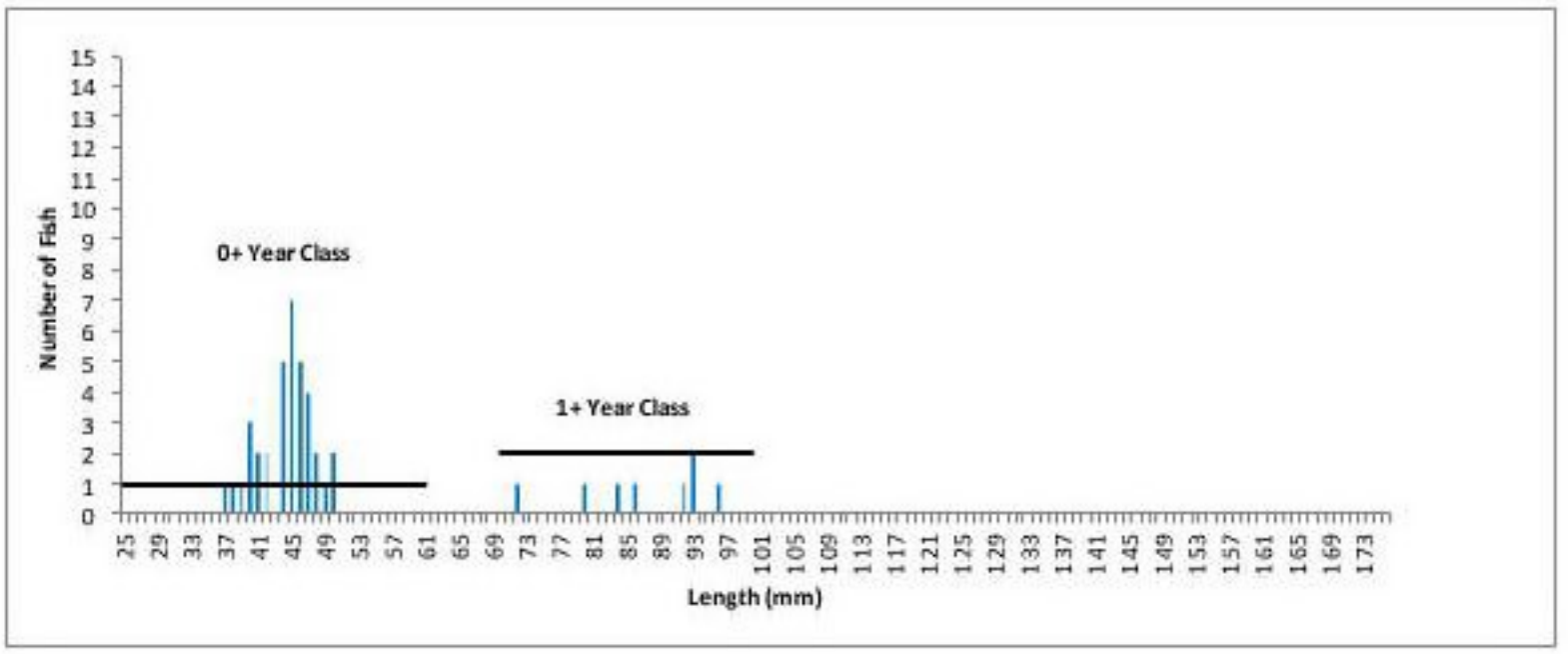
Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	5 to 20 cm (average 10.4 cm)
Velocity	50 to 65 cm/s	60 to 75 cm/s	30 to 50 cm/s (average 40 cm/s)
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	15% gravel, 15% Pebble, 55% cobble and 15% boulder

River levels on the day of the survey were recorded as being 'low', with the average water depth (10.4 cm) and velocity (40 cm/s) being more suited to salmon fry than parr. However, levels on the Allt na h-Aire Burn are known to vary considerably and as such the depth and velocities at the site under medium or 'normal' conditions are likely to be more suited to both fry and parr. The substrate at the site was found to be dominated by cobbles between 64 and 256 mm in size, meeting the requirements of both fry and parr.

5.2.2 Atlantic Salmon

The length frequency histogram for ALT01 (see **Figure 5-4** below) indicates the presence of two year classes of juvenile salmon in 2012.

Figure 5-4 Length frequency histogram for juvenile salmon captured during the 2012 survey at ALT01



As the falls below the site are impassable to adult salmon we can confidently conclude that any juveniles present are the result of hatchery introductions. The strong 1+ year class of fish indicates high survival of the eyed ova and unfed fry introduced in spring 2012. The 1+ year class represents those fish introduced as unfed fry in spring 2011 and also indicates good survival rates.

The minimum salmon fry density recorded at ALT01 in 2012 was 44.7 per 100m^2 ('excellent' classification), with a parr density of 9.9 per 100m^2 also being recorded ('good' classification) (see **Table 6** below).

Table 6 Observed 2012 salmon densities at site above the impassable falls on the Allt na h-Aire Burn (ALT01)

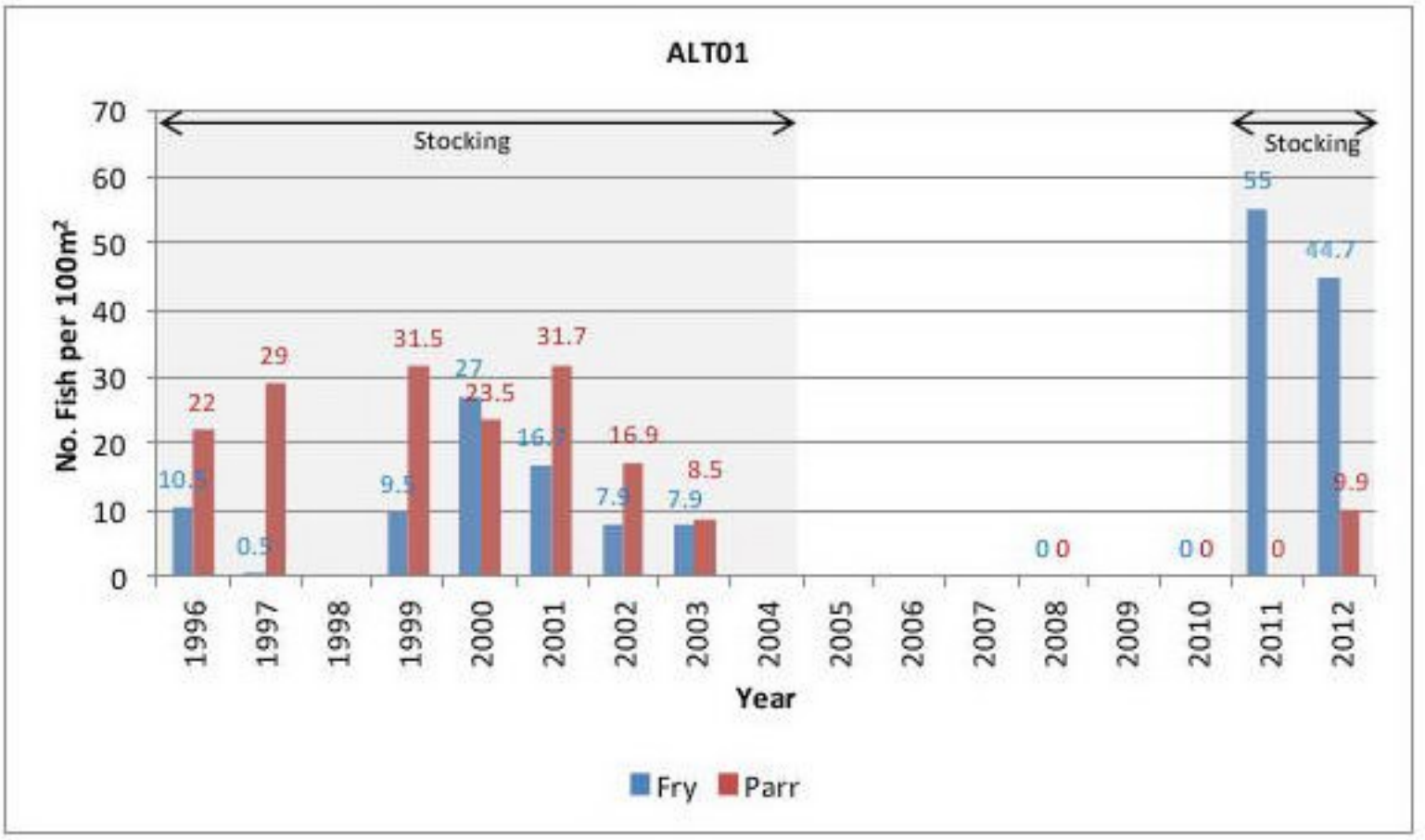
Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	21	10	5	-	**36**	**48.4**	**44.7**	**A - 'Excellent'**
1+ (parr)	7	1	0	-	**8**	**9.9**	**9.9**	**B - 'Good'**
Total	**28**	**11**	**5**	**-**	**44**	**58.3**	**54.6**	
Number Salmon Missed					**17 (61)**			

As this site is located above impassable falls, any salmon present are known to have originated from hatchery introductions. This is clear when we consider the densities of fry and parr recorded at the site since 1996 compared to that during the key stocking periods (see **Figure 5-5** below).

The results of surveys completed during the original stocking period (1994 to 2004) indicate that juvenile salmon were consistently present, albeit at varying densities. Stocking ceased in 2004 with the next surveys being completed in 2008 and 2010, when both fry and parr were found to be absent.

The revised stocking strategy was implemented in spring 2011, with a survey completed later that summer. Salmon fry were recorded as being present once again for the first time since 2003, although salmon parr remained absent. This is a clear indication that all juvenile salmon present at the site originated from the stocking earlier that year.

Figure 5-5 Minimum densities of salmon fry and parr recorded at site ALT01 above the impassable falls on the Allt na h-Aire a Burn (1996 to 2012)



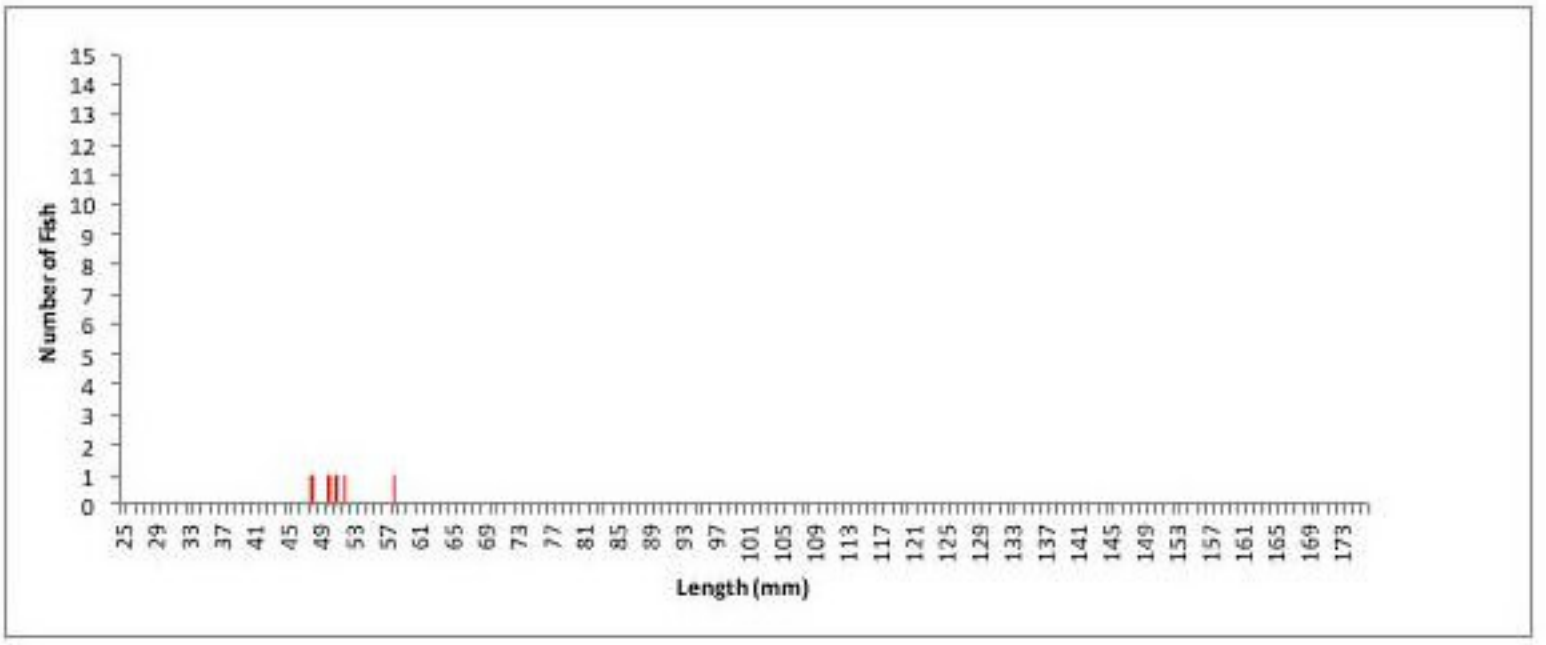
Stocking continued in 2012 and salmon fry were once again recorded as being present at the site. In addition to this, salmon parr were also found to be present for the first time since 2003. These fish were clearly the survivors of the 2011 introduction and indicate good survival of the hatchery bred fish to at least the 1+ year class.

The success of the revised stocking strategy is due in part to careful site selection and determination of optimum stocking densities. It is believed that the care taken to ensure that eggs and fry were only stocked into areas meeting their key habitat requirements has resulted in the particularly high survival rates.

5.2.3 Brown/Sea Trout

Trout recorded at site ALT01 in 2012 ranged between 48mm and 50mm in length and fell within the 0+ year class fish (see **Figure 5-6** below). This is a clear indication of successful wild trout spawning above the falls on the Allt na h-Aire Burn.

Figure 5-6 Length frequency histogram for brown trout captured during the 2012 survey at ALT01



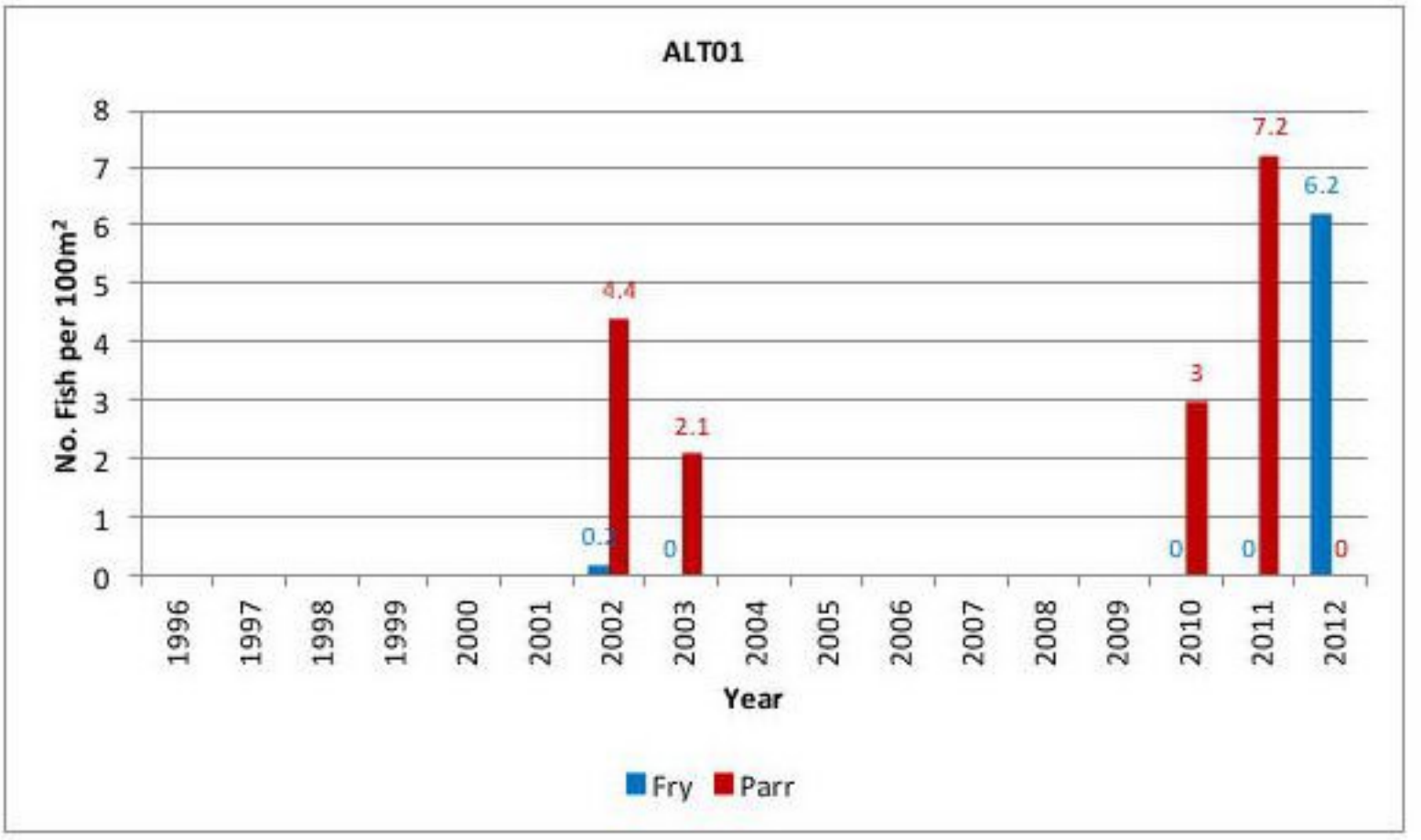
The minimum trout fry density recorded at ALT01 in 2012 was 6.2 per 100m^2 ('good' classification), with parr being 'absent' from the site (see **Table 7** below).

Table 7 Observed 2012 trout densities at site above the impassable falls on the Allt na h-Aire Burn (ALT01)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	4	1	0	-	5	6.203	6.203	B - 'Good'
1+ (parr)	0	0	0	-	0	0	0	F – 'Absent'
Total	4	1	0	-	5	6.203	6.203	
Number Salmon Missed					2 (7)			

A comparison of the total densities of trout recorded at site ALT01 from 2002 to 2003 and 2010 to 2012 are presented in **Figure 5-7** below. These are the only years that the densities of trout captured at ALT01 were recorded.

Figure 5-7 **Minimum densities of trout fry and parr recorded at site ALT01 above the impassable falls on the Allt na h-Aire Burn (2002 to 2012)**



The densities of trout fry recorded at site ALT01 in 2012 (6.2 fish per 100m^2) were the highest on record, indicating particularly high fry survival. Trout parr were found to be absent from the site for the first time this year.

No data exists for the period between 2004 and 2009 following cessation of the original stocking programme. It is therefore not possible to determine whether trout densities improved during this period or to establish a good baseline condition for trout (i.e. the situation prior to stocking).

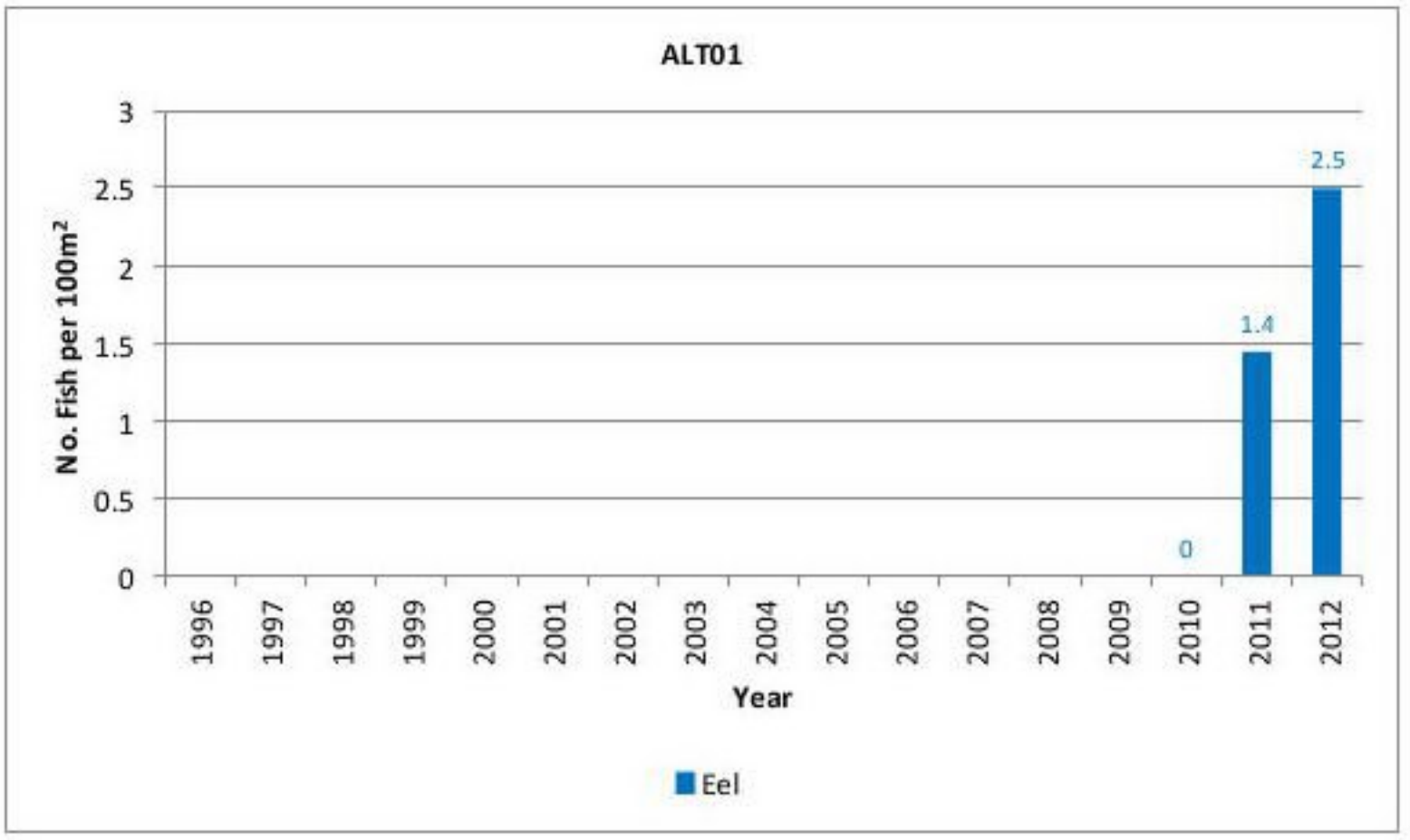
Youngson (2007) suggests that stocking fish from hatcheries into streams above obstructions that are impassable to spawners places native populations of non-migrant salmonids such as brown trout at risk. He describes that most obstructed streams support native populations of non-migrant trout. Many of these enclosed populations of trout have evolved separately for 10,000 – 12,000 years since they became isolated in the aftermath of the last glaciations. Youngson suggests that the resulting diversity is of great intrinsic interest and should not be inadvertently disrupted by passing reared salmonids above impassable falls.

5.2.4 European Eel

Eels were found to be present at site ALT01, indicating that they are able to negotiate the falls on the Allt na h-Aire Burn. All of those recorded were <15cm indicating that they were juveniles (referred to as elvers). Minimum densities of eels recorded at the site between

2010 and 2012 are presented in **Figure 5-8** below.

Figure 5-8 Minimum densities of eels recorded during juvenile salmon surveys at site ALT01 (2010 – 2012)



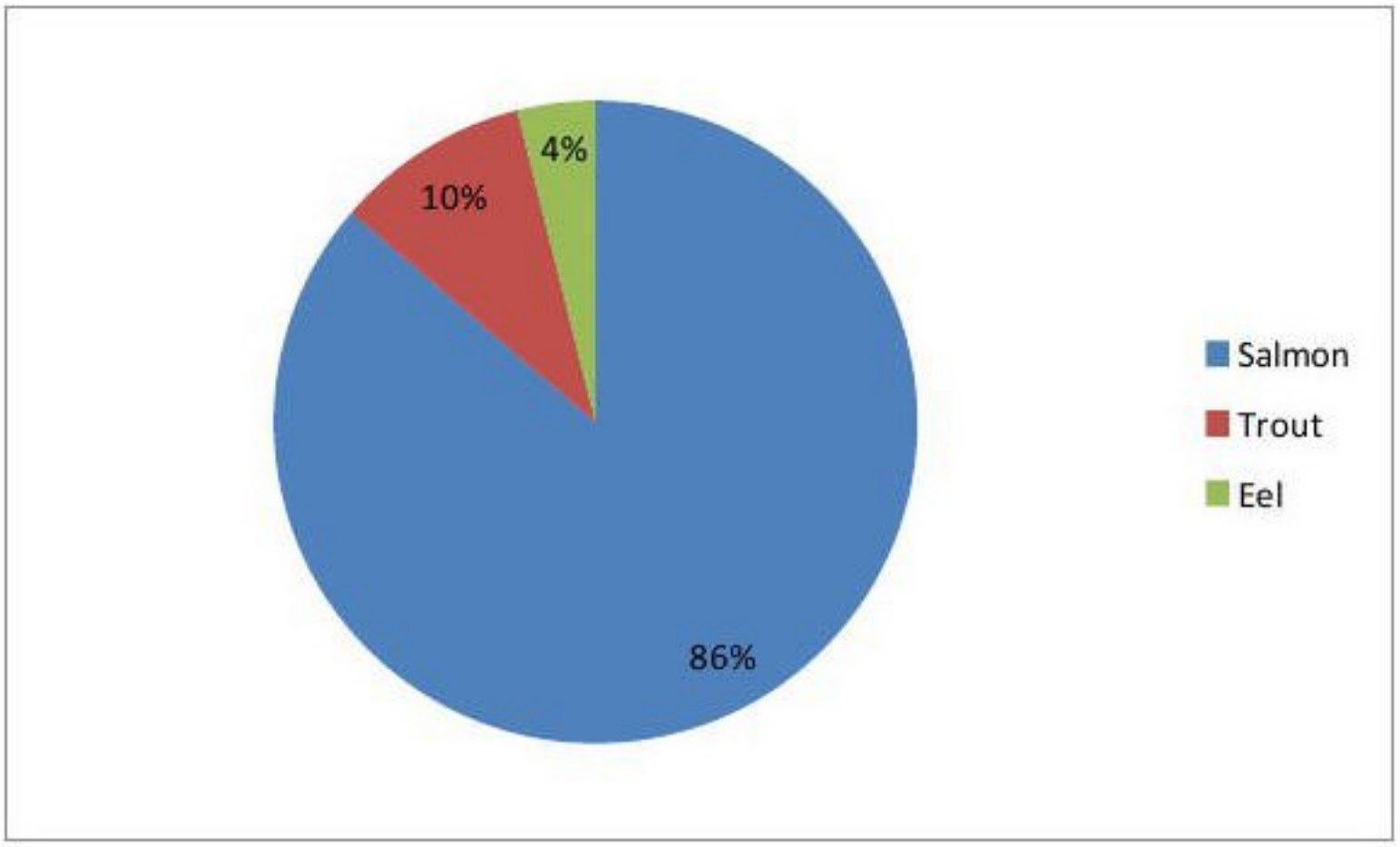
The densities of eels recorded in 2012 (2.5 per 100m^2) were the highest since 2010 (when eels were found to be absent). This suggests that there may have been a slight improvement in the numbers of elvers accessing this site over the study period.

5.2.5 Species Composition

Five trout and a two eel were recorded at the site, together with forty four juvenile salmon (see **Figure 5-9** below). This means that salmon were the dominant species with 86% of the total (compared to 86% in 2011), followed by trout with 10% of the total (compared to 11% in 2011) and eels with 4% of the total (compared to 2% in 2011).

The presence of eels at the site indicates that they are able to negotiate the falls on the Allt na h-Aire Burn. Given the nature of the falls it is most likely that the trout are part of a native population of non-migrant trout.

Figure 5-9 Proportion of each fish species (percentage) present at site ALT01 in 2012



5.3 SITE ALT02 (SCM) – ALLT NA H-AIRE BURN (BELOW IMPASSABLE FALLS) (02/08/12)

5.3.1 Site Description

This survey site is located directly below the impassable falls on the Allt na h-Aire Burn (NC 5680 3507) and approximately 50 metres upstream of the A836 road bridge next to the Altnaharra Hotel. The site provides baseline information on the importance of the lower reaches of the Allt na h-Aire Burn as a spawning and nursery area for salmon. It has been chosen as one of the Naver SAC Site Condition Monitoring (SCM) locations. A photograph of the survey site (downstream facing view) is presented in **Figure 5-10** below.

Figure 5-10 Photograph of electric fishing site ALT02 (SCM) in 2012 (downstream view)

Recent clear felling forestry works were noted upstream from the site as described in **Section 5.2** of this document. A wide buffer strip of moorland heath and an access track exist between the river and forestry blocks on the right bank. The land on the left bank was dominated by moorland heath, recently 'mounded' and planted with native tree species.

The site falls within an area fenced in 2011 to exclude deer and prevent damage to the newly planted tree saplings. This has resulted in significant natural regeneration of riparian vegetation. A 'water gate' was also installed on the fence line where it crosses the burn just

above the road bridge and downstream of the survey site.

The bank face and bank top vegetation on both banks were described as 'simple', i.e. predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc).

Prior to commencement of the survey the site was described as having 'excellent' in-stream cover with the water level being 'low' in height and 'clear' in colour. The key in-stream physical habitat characteristics recorded at the site are summarised in **Table 8** below and compared to the requirements of both fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 8 Summary of the key in-stream physical habitat characteristics recorded at ALT02 (SCM) compared to the requirements of fry and parr (Hendry & Cragg-Hine, 1997).

Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	5 to 50 cm (average 15 cm)
Velocity	50 to 65 cm/s	60 to 75 cm/s	29 to 50 cm/s (average 37 cm/s)
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	25% gravel, 25% pebble, 25% cobble and 15% boulder, 10% Bedrock

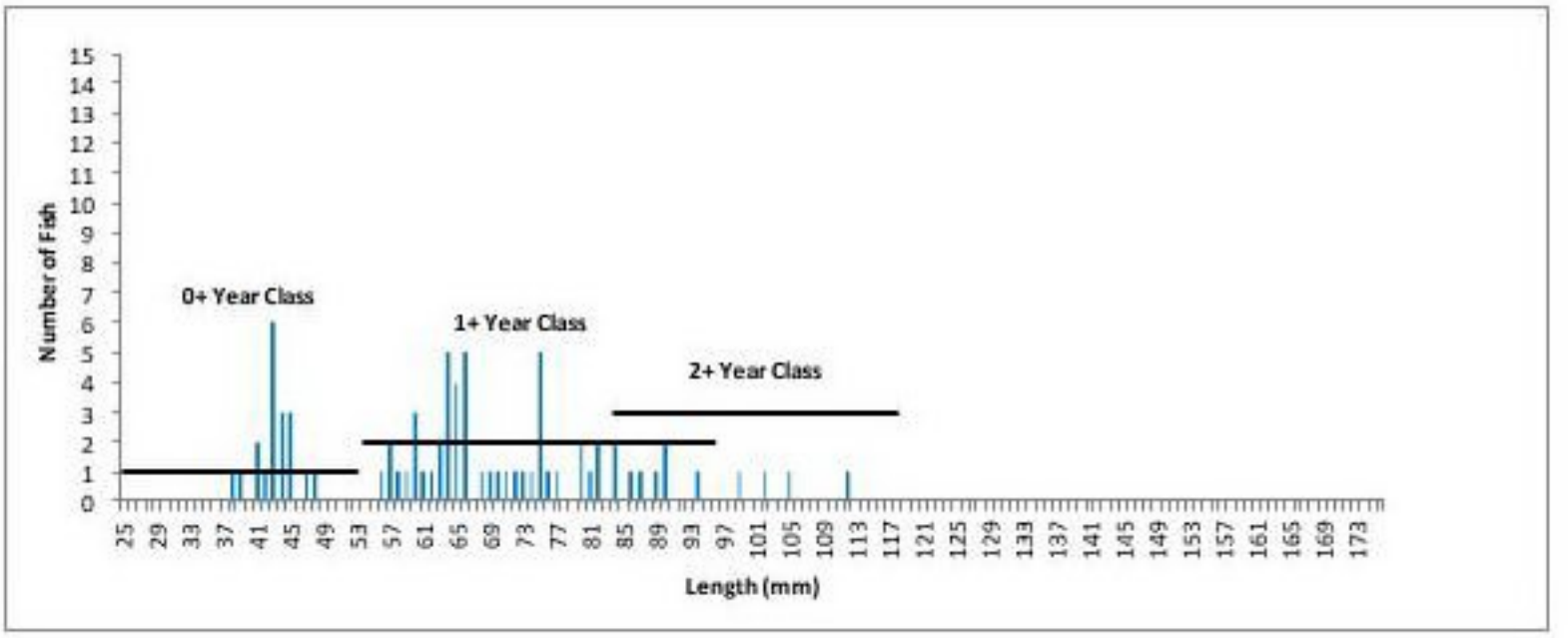
The average water depth at the site on the day of the survey (15cm) was most suited to salmon fry. However, the depths varied considerably throughout the site from shallow riffles (5cm in depth) suited to fry to a particularly deep pool at the upper end (50cm in depth) more suited to parr.

River level and resulting velocities (average 37 cm/s) were higher than when last surveyed in 2011 (average 23 cm/s) and lower than the optimum requirements of either fry or parr. A good range of substrate types offered ideal habitat for a range of life stages of the salmon including spawning, fry and parr.

5.3.2 Atlantic Salmon

The length frequency histogram for ALT02 (SCM) (see **Figure 5-11** below) indicates that three year classes of fish were present at the site in 2012. A strong 1+ year class in relation to the 0+ year class suggests that either fry survival in 2012 was low, fry survival in 2011 was high, or that parr have migrated into the site from other areas.

Figure 5-11 Length frequency histogram for juvenile salmon captured during the 2012 survey at ALT02 (SCM)



In 2012 the 0+ year old fish ranged between 38mm and 48mm in length. The largest fish from which scale samples were taken was a 112mm parr aged at 2+ years old. This fish is likely to smolt at 3 years old. This is a particularly important point given that 3 year old salmon parr often go on to become 'spring fish' when returning as adults. The 'spring' fish are those that enter the river before May. The 'spring' component of the Naver salmon population is known to be in decline and particularly vulnerable.

Minimum salmon fry densities at ALT02 (SCM) were found to be 15.6 per $100m^2$ indicating that it supports 'moderate' populations of salmon fry (see **Table 9** below). This suggests that in 2011 adult salmon were able to access this area to spawning, although only with low success. Parr densities were found to be 46.9 per $100m^2$ indicating that it supported 'excellent' populations of salmon parr.

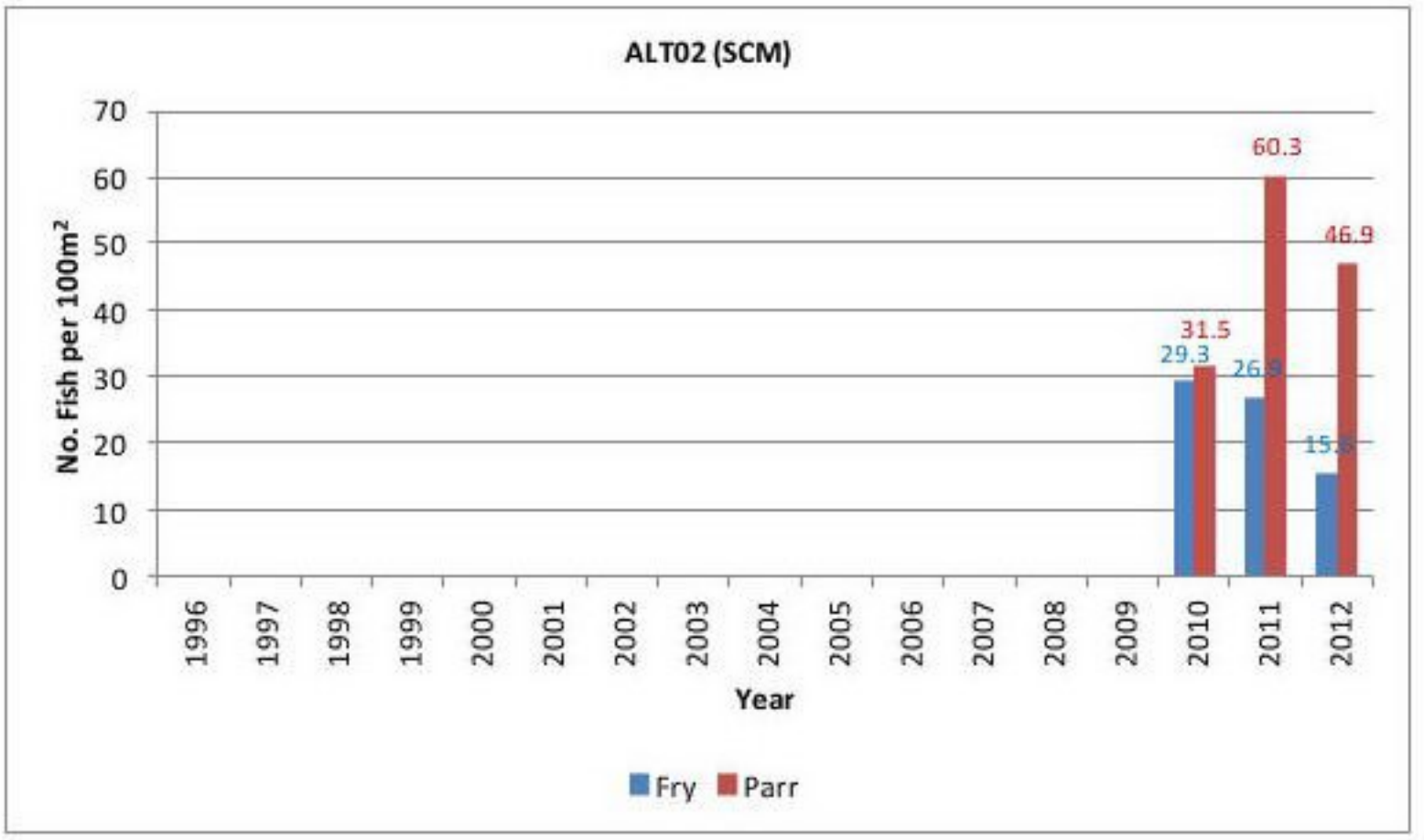
Table 9 Observed 2012 salmon densities at site below the impassable falls on the Allt nah-Aire Burn - ALT02 (SCM)

Age	Fish Count					Density Estimate (fish per $100m^2$)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+	7	4	8	-	19	-	15.625	C - 'Moderate'
1+	35	15	7	-	57	50.164	46.875	A – 'Excellent'
Total	42	19	15	-	76	-	62.500	
Number Salmon Missed					22 (98)			

When compared to the results of previous surveys (see **Figure 5-12** below), the densities of fry recorded in 2012 (15.6 fry per $100m^2$) were significantly less than in 2011 (26.9 fry per

100m^2), resulting in a decrease in classification from 'good' to 'moderate'. This decrease is thought to be due to the extremely low river levels recorded during the spawning season in 2011 and subsequent restricted access for adult salmon.

Figure 5-12 Minimum densities of juvenile salmon fry and parr recorded at site ALT02 (SCM) below the impassable falls on the Allt na h-Aire burn (2010 to 2012)



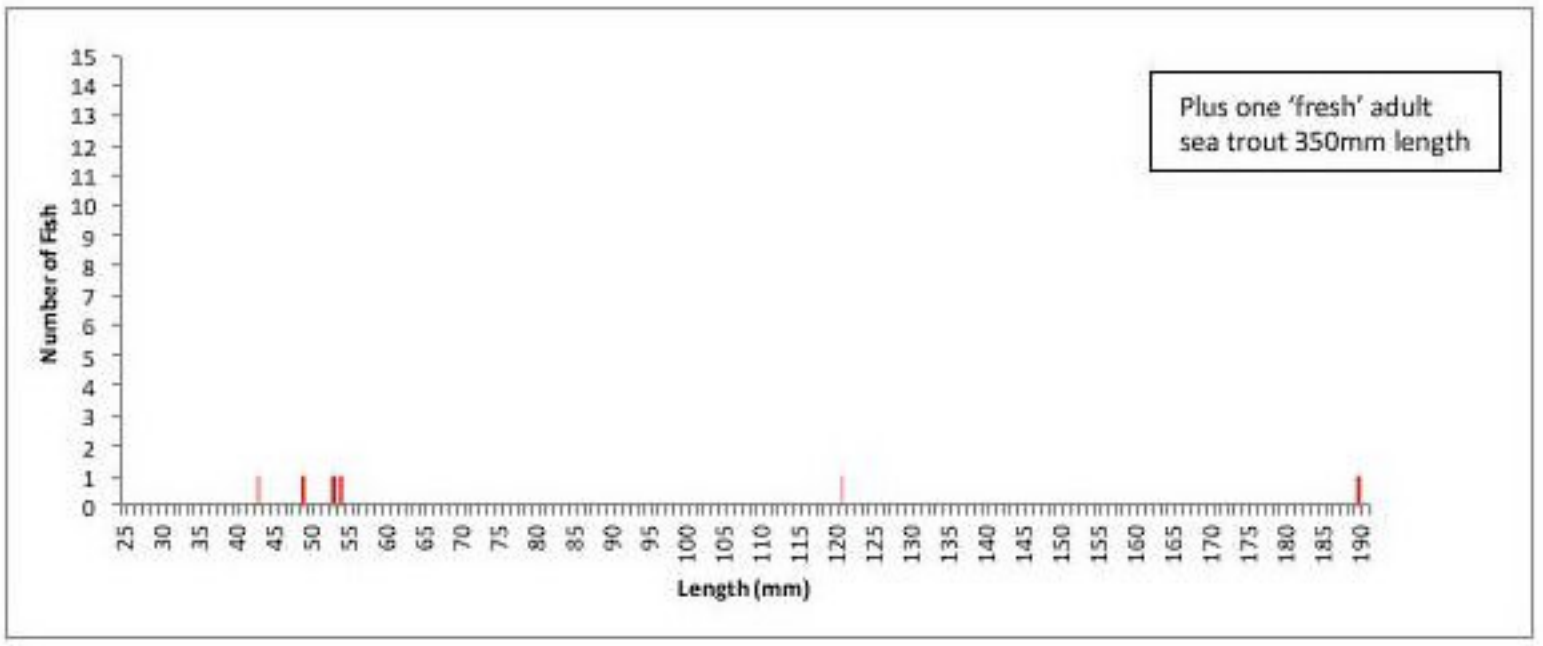
The density of parr recorded at the site in 2012 (46.9 fry per 100m^2) was lower than that recorded in 2011 (60.3 fry per 100m^2), but higher than that in 2010 (31.5 fry per 100m^2). Despite this variation the site has retained an 'excellent' parr classification.

5.3.3 Brown/Sea Trout

The majority of trout recorded at the site in 2012 ranged between 43mm and 54mm and represented the 0+ year class (see **Figure 5-13** below). This indicates that trout spawn below the falls on the Allt na h-Aire Burn.

Three further year classes of trout were also found to be present, with largest fish being a 350mm 'fresh' run sea trout with an age of 2.1+ as determined by scale reading. This fish spent two years in the river before dropping downstream and spending a further year at sea. It then returned to fresh water and rapidly made its way to the Allt na h-Aire Burn where we believe that it is likely to spawn. This is the first confirmed report of an adult sea trout in the Allt na h-Aire Burn.

Figure 5-13 Length frequency histogram for brown trout/sea trout captured during the 2012 survey at ALT02 (SCM)



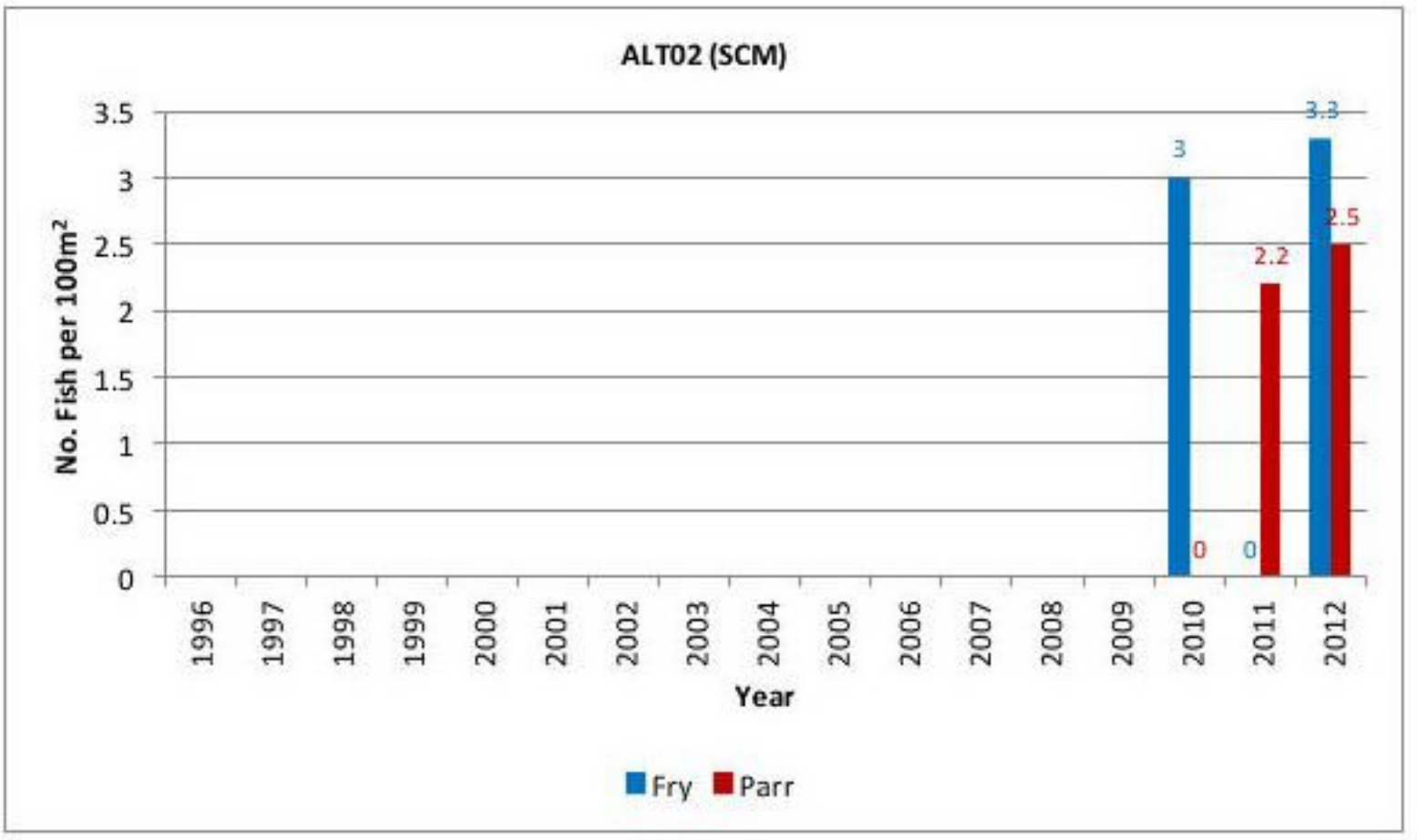
The minimum trout fry density recorded at ALT02 (SCM) in 2012 was 3.3 per 100m^2 ('poor' classification), with parr densities being recorded at 2.5 per 100m^2 ('moderate' classification) (see **Table 10** below).

Table 10 Observed 2012 trout densities at site below the impassable falls on the Allt na h-Aire Burn - ALT02 (SCM)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	4	0	0	-	4	-	3.289	D - 'Poor'
1+ (parr)	1	2	0	-	3	2.467	2.467	C – 'Moderate'
Total	5	2	0	-	7	-	5.756	
Number Salmon Missed					1 (8)			

A comparison of the densities of trout fry and parr recorded at site ALT02 (SCM) between 2010 and 2012 is presented in **Figure 5-14** below.

Figure 5-14 Minimum densities of trout fry and parr recorded at site ALT02 (SCM) below the impassable falls on the Allt na h-Aire Burn (2010 to 2012)

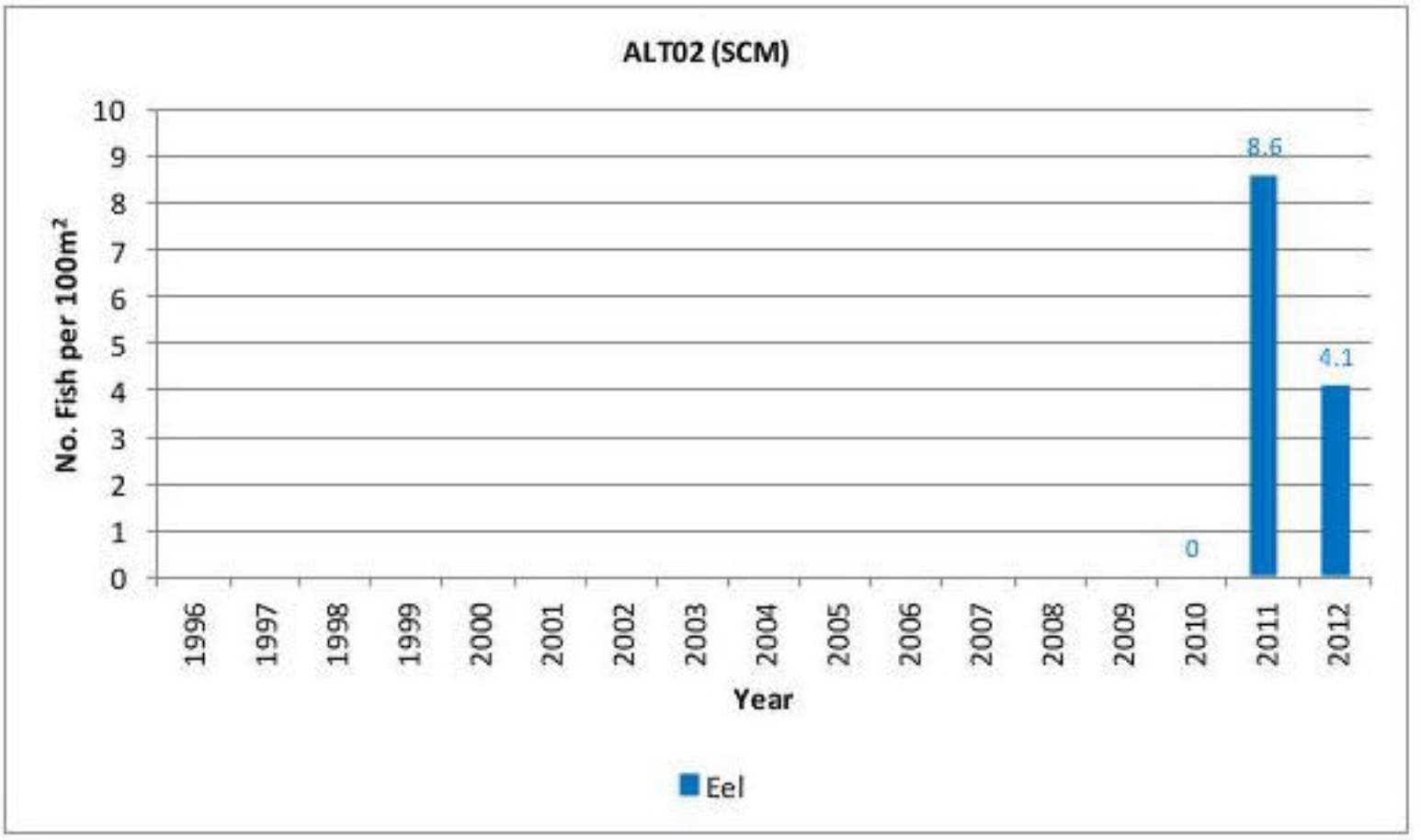


The densities of both trout fry (3.3 fish per 100m^2) and parr (2.5 fish per 100m^2) recorded at site ALT02 (SCM) in 2012 were the highest since it was first surveyed in 2010. It is however clear that the densities of juvenile trout at this site are highly variable.

5.3.4 European Eel

Eels were found to be present at site ALT02 (SCM) in 2012. All of those recorded were <15cm indicating that they were juveniles (referred to as elvers). Minimum densities of eels recorded at the site between 2010 and 2012 are presented in **Figure 5-15** below.

Figure 5-15 Minimum densities of eels recorded during juvenile salmon surveys at site ALT02 (SCM) (2010 – 2012)



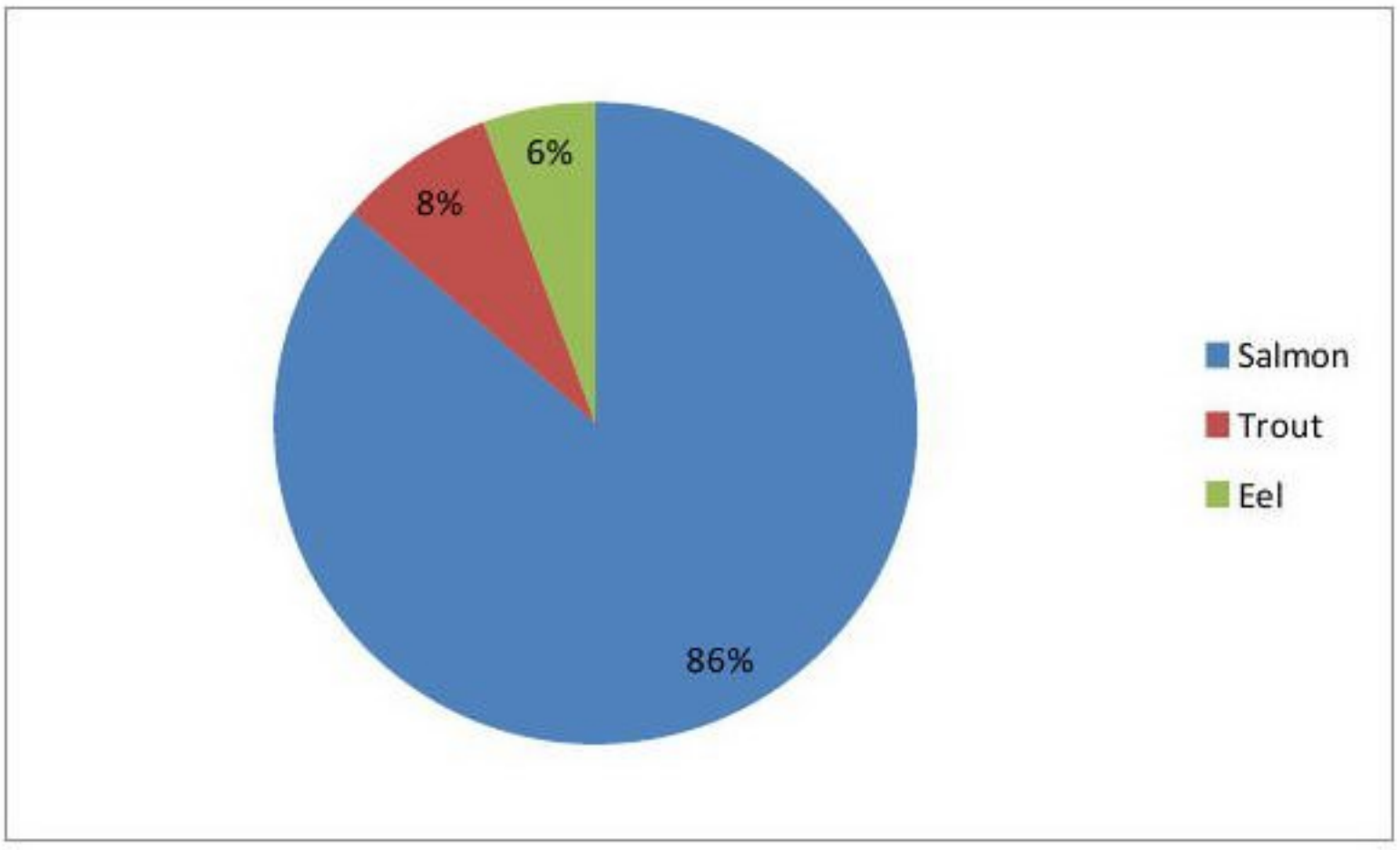
The densities of eels recorded in 2012 (4.1 per 100m^2) was less than that in 2011 (4.1 per 100m^2), but greater than 2010 when they were found to be absent. Eel densities recorded below the falls were higher than those above the falls.

5.3.5 Species Composition

Seven trout and a five eels were recorded at the site, together with seventy six juvenile salmon (see **Figure 5-16** below). This means that salmon were the dominant species with 86% of the total (compared to 86% in 2011), followed by trout with 8% of the total (compared to 2% in 2011) and eels with 6% of the total (compared to 9% in 2011).

Minnow (*Phoxinus phoxinus*) were also present at the site in 2011 but not recorded in 2012. The minnow is an invasive non-native species (native to England and Wales but not Scotland) that competes with salmonids for food and space and feeds on salmonid eggs and fry. Overall, the species composition above and below the falls in 2012 was found to be very similar.

Figure 5-16 Proportion of each fish species (percentage) present at site ALT02 (SCM) in 2012



5.4 SUMMARY

- A natural obstruction to the passage of migratory salmonids is located on the Allt na h-Aire Burn approximately 750 metres above its confluence with the River Mudale.

- In 2012 the reach below the falls was found to support minimum densities of 15.6 fry per 100m^2 ('moderate' classification) and 46.9 parr per 100m^2 ('excellent' classification). Spawning success and fry survival below the falls is thought to be heavily influenced by river level and subsequent accessibility for adult salmon; however it is clear that it provides an important spawning and nursery area.

- Salmon populations in the reach above the falls are artificially supported by the introduction of hatchery bred 'eyed ova' and 'unfed fry', with minimum densities of 44.7 fry per 100m^2 ('excellent' classification) and 9.9 parr per 100m^2 ('good' classification) being achieved. Should hatchery operations cease then salmon would soon become absent from the area above the falls.

- The average density of salmon fry recorded across all sites on the Allt na h-Aire Burn in 2012 was 30.15 per 100m^2 ('good' classification) with the average density of parr being 28.4 per 100m^2 ('excellent' classification). The presence of 2+ year old parr indicates that the burn is likely to be a spawning and nursery area for vulnerable 'spring' salmon.

- The 2012 survey results indicate that trout are distributed throughout the Allt na h-Aire Burn. Those present above the falls are likely to form part of a glacially relic population of particular conservation value. Those below the falls are likely to be from both sea and brown trout origin.

- Minimum trout densities of 6.2 fry per 100m^2 ('good' classification) were recorded above the falls in 2012 with trout parr being absent. The densities of fry below the falls were significantly lower (3.3 per 100m^2 'poor' classification) with parr densities of 2.5 per 100m^2 ('moderate' classification). Densities of juvenile trout are highly variable from year to year.

- The average density of trout fry recorded across all sites on the Allt na h-Aire Burn in 2012 was 4.8 per 100m^2 ('moderate' classification) with the average density of parr being 1.2 per 100m^2 ('very poor' classification).

- Eels were distributed throughout the Allt na h-Aire Burn, with densities below the falls (4.1 per 100m^2) higher than those above (2.5 per 100m^2). The majority of eels recorded in 2012 were juvenile (elvers) and present in relatively low densities. The average density of eels recorded across all sites on the Allt na h-Aire Burn in 2012 was 3.3 per

$100m^2$.

6 RIVER VAGASTIE

6.1 INTRODUCTION

The River Vagastie arises from the slopes of Meall an Fhuarain to the north and Cnoc an Alaskie to the east. Three major tributaries (Allt Bealach an Fhuarain, Allt Meadhonach and Allt a' Chuil) meet to form the Allt a' Chraisg (NC 520 267). This in turn flows under the A836 (Lairg road) becoming the River Vagastie at the croft at Vagastie (NC 535 282). A photograph of the river (downstream view) is presented in **Figure 6-1** below.

Figure 6-1 The Allt a' Chraisg upstream of the A836 (downstream view)

The Vagastie flows approximately 13km from the start of Allt a' Chraisg to its confluence with Loch Naver at Altnaharra (NC 578 348). It is joined by two major tributaries: Feith Bad an Loch (NC 538 289) approximately 9 km from the loch; and Allt Loch na Glas-choille (NC 567 335) approximately 2 km from the loch.

The banks of the upper catchment are dominated by moorland heath. Mature alders begin to appear in low numbers along the banks of the middle reaches, with commercial coniferous forestry blocks and more recently planted native blocks dominating the hills of

the left bank (see **Figure 6-2**). Mature native alders become more abundant on the banks of the lower reaches of the river. The wider environment in this area has been enhanced through the clearance of coniferous forestry blocks and replanting with native species. Areas have also been fenced to allow natural regeneration through the exclusion of deer.

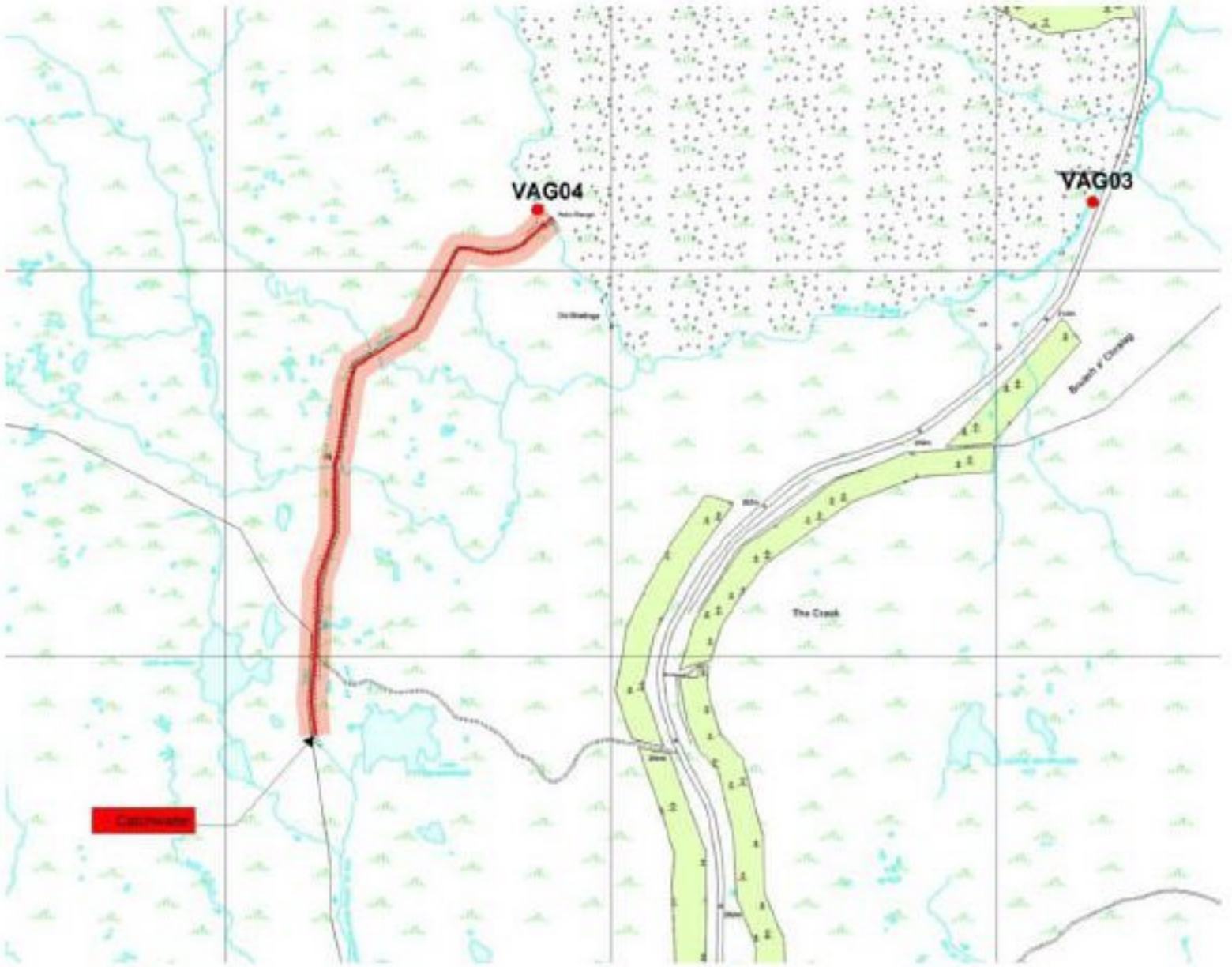
Figure 6-2 Mature alders in low numbers along the middle reach of the river with commercial forestry block in the background

6.2 SCOTTISH AND SOUTHERN ENERGY CATCHWATER

The first Water Framework Directive (WFD) River Basin Management Plan (RBMP) identified the River Vagastie as a designated Heavily Modified Water body (HMWB). This is as a result of abstraction and morphological pressures resulting from the production of renewable electricity.

During the 1950's a structure was built across the upper Vagastie catchment to divert water into the neighbouring Shin catchment as part of the Loch Shin hydro-power scheme. This consists of a concrete dam and canal system or 'catchwater' impounding the Allt Bealach, Allt Meadhonach and Allt a' Chuil (see **Figure 6-3**) and exporting flow to the River Tirry (which in turn flows into Loch Shin).

Figure 6-3 Path of concrete dam and canal system or 'catchwater' impounding the Allt Bealach, Allt Meadhonach and Allt a' Chuil



Through this designation the Scottish Environmental Protection Agency (SEPA) as the competent authority, recognise that the SSE catchwater impacts on the River Vagastie such as to deviate the river hydro-morphology from that of the natural system. Potential impacts of the Vagastie transfer on fish populations are as follows:

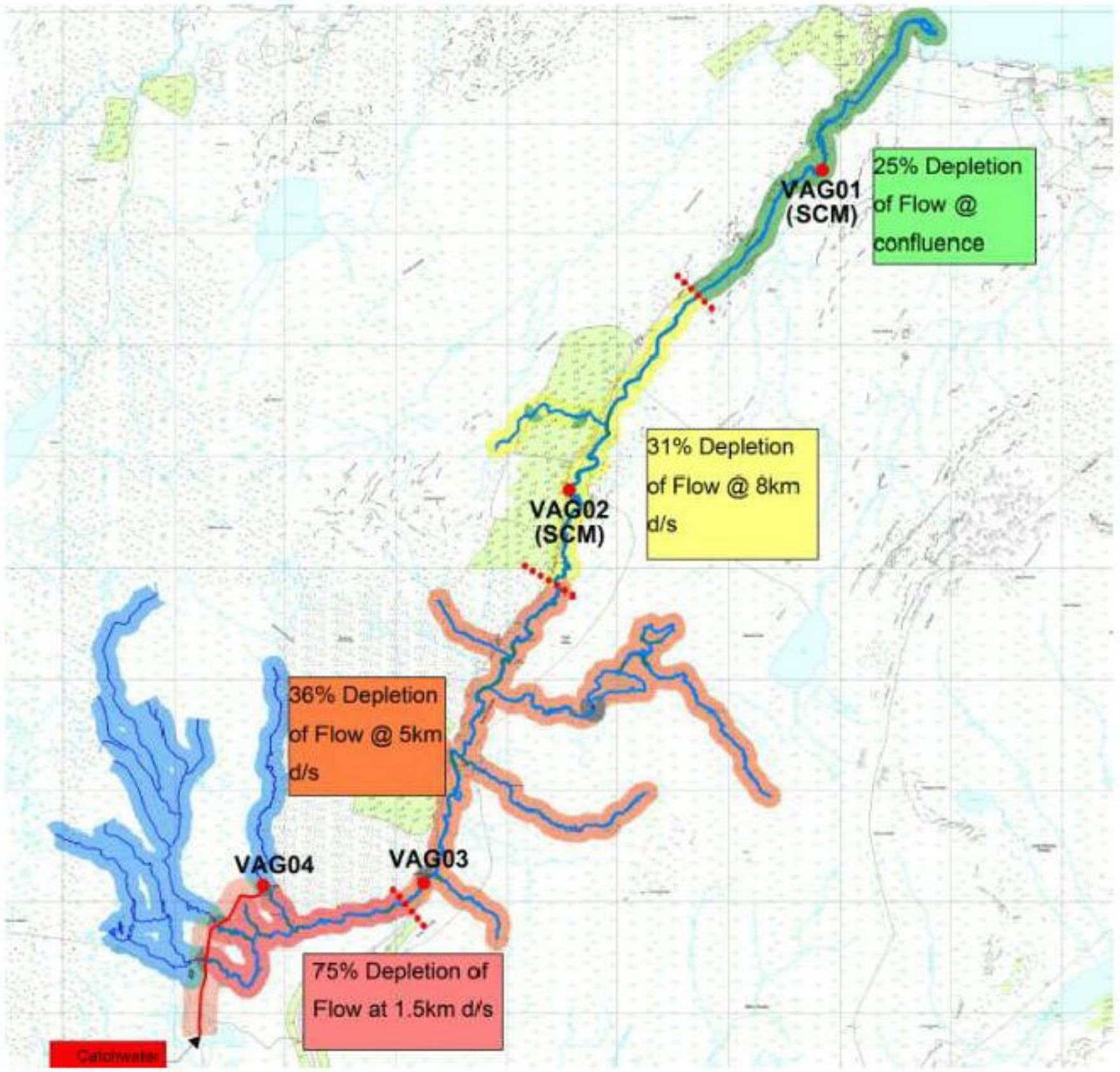
- Presenting a physical barrier preventing the upstream and downstream migration.
- Reducing downstream flows (particularly low and moderate flows) and degrading the wetted habitat usable to fish (in terms of the length and area of the river which is covered in water to a minimum depth). Along the river this is reflected as:
    - An ephemeral stream (acting like a headwater) in the reach immediately downstream of the catchwater;
    - The flow characteristics of the upper river in the middle reaches of the river; and
    - The flow characteristics of the middle reaches of the river in the lower river.
- Changing high flow (flood flow) characteristics in the river, with:

- Potential impact on fish migration trigger flows;
- Overall reduction in the energy of flood flows, reducing the "work" of the river in moving, sorting and turning over the bed material (with substrate from the headwaters trapped behind the catchwater), degrading the physical habitat; and
- Increase in risk of scour flows – under high rainfall conditions the impoundment is understood to overtop and the ephemeral reach immediately downstream of the impoundment transform from zero flow to very high flow.

A recent SEPA hydrological assessment has shown that the combined catchment area above the impoundments is 8km^2 (SEPA, 2008). As the total catchment of the River Vagastie is 37km^2 this means that the impoundments are diverting 22% of the total catchment area.

SEPA concluded that the diversion of water from the headwaters of the Vagastie depletes flows by a proportion of approximately 75% 1.5km downstream of the impoundments, decreasing to approximately 36% 5km downstream of the impoundments, 31% 8km downstream of the impoundments and 25% at its confluence with Loch Naver. **Figure 6-4** below shows the positions of each survey site in relation to the impoundment and zones of depleted flows.

Figure 6-4 Position of each survey site on the River Vagastie in relation to the impoundment and zones of depleted flows.



6.3 SITE VAG01 (SCM) – RIVER VAGASTIE AT ALTNAHARRA FOOTBALL PITCH (15/08/12)

6.3.1 Site Description

This site is located on the River Vagastie approximately 2km upstream from its confluence with Loch Naver (NC 5683 3357) and alongside the old Altnaharra football pitch. It is the lowest site on the Vagastie catchment situated approximately 50m below the Allt Loch na Glas-choille (an important tributary in terms of flow input). A photograph of the survey site (upstream view) is presented in **Figure 6-5** below.

Figure 6-5 Photograph of electric fishing site VAG01 (SCM) taken in 2012 (upstream view)

The riparian land on the left bank consists of a mixture of old growth broad leaf trees close to the river and a mixture of recently planted broad leafs and natural regeneration up to approximately 40m from the river. The right bank of the river is fringed by old growth broad leaf trees running into moorland heath grazed by sheep and red deer.

The bank face vegetation on both banks was described as being 'simple', i.e. predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc). The bank top vegetation on both banks was described as being

'complex', i.e. four or more vegetation types including scrub or trees.

Prior to commencement of the survey the site was described as having 'excellent' in-stream cover and the water level was recorded as being 'low' in height and 'clear' in colour. Both upstream and downstream stop nets were used, together with hand nets due to the low river levels.

The key in-stream physical habitat characteristics recorded at the site are summarised in **Table 11** below and compared to the requirements of both fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 11 Summary of the key in-stream physical habitat characteristics recorded at VAG01 (SCM) compared to the requirements of fry and parr (Hendry & Cragg-Hine, 1997).

Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	5 to 15 cm (average 10.6 cm)
Velocity	50 to 65 cm/s	60 to 75 cm/s	30 to 50 cm/s (average 40 cm/s)
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	25% gravel, 25% pebbles, 25% cobbles, 25% Boulder.

The range of depths recorded at the site were between 5cm and 15cm, closely matching the requirements of salmon fry. Depths were not ideal for salmon parr. Velocities on the day of the survey varied between 30 cm/s and 50 cm/s (with an average of 40 cm/s), falling well short of the ideal requirements of both fry and parr.

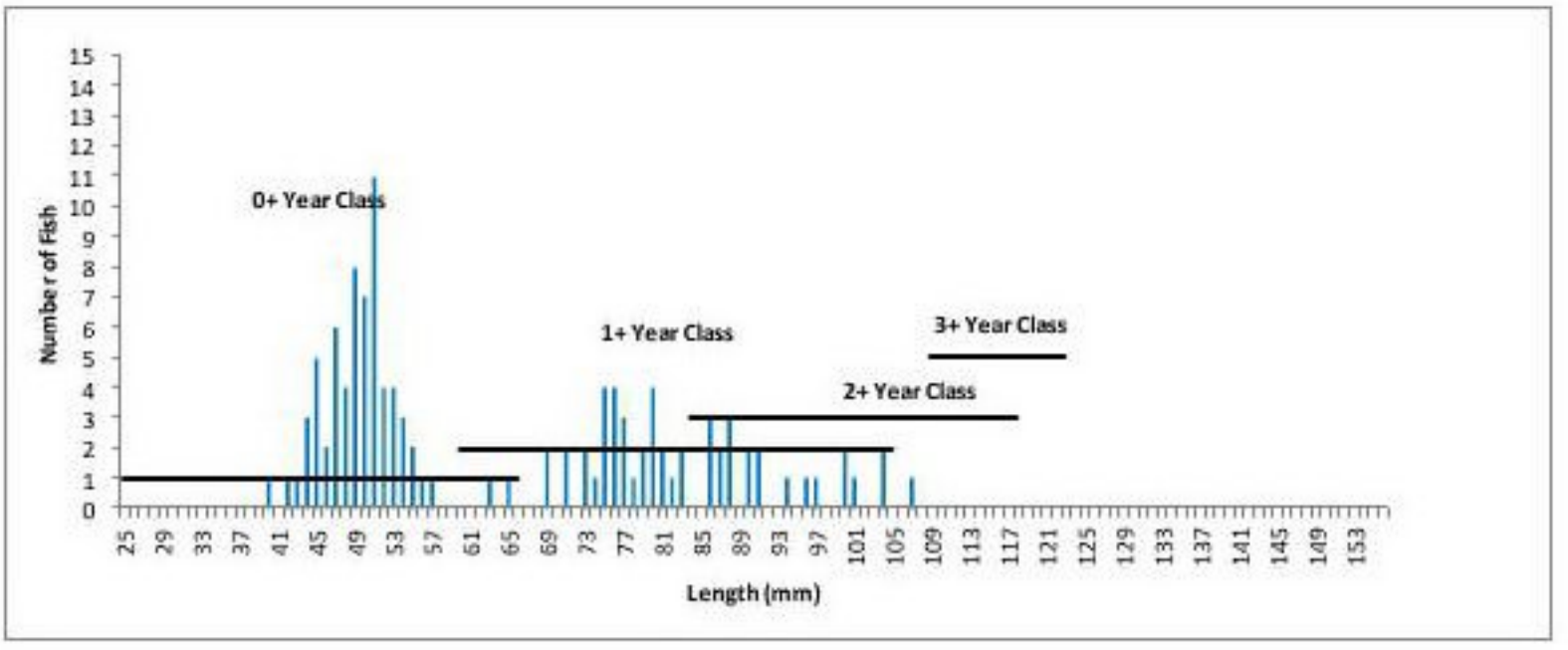
A good range of evenly distributed substrate types offered ideal habitat for a range of life stages of the salmon including spawning, fry and parr. This is a significant change from 2010 when the bed substrate was recorded as being dominated by pebbles (25%) and cobbles (65%), with gravel and boulders also present in smaller quantities. This together with further observations suggest that there has been a change in the bed of the river, possibly associated with the heavy flooding recorded in December 2010 and subsequent bed movement.

In summary, the physical habitat characteristics at the site seem to be more suited to the requirements of salmon fry than parr. It would therefore be expected that the site should support at least good densities of fry but also support at least moderate populations of parr.

6.3.2 Atlantic Salmon

The length frequency histogram and scale reading results for VAG01 (SCM) indicate the presence of three year classes of fish, including 0+ year old fry, 1+ year old parr and 2+ year old parr (see **Figure 6-6** below). In 2012 the 0+ year old fish ranged between 40mm and 57mm in length. The largest fish from which scale samples were taken was a 107mm parr aged at 2+ years old.

Figure 6-6 Length frequency histogram for juvenile salmon captured during the 2012 survey at VAG01 (SCM)



Minimum salmon fry densities at VAG01 (SCM) were found to be 61.2 per 100m^2 indicating that it supports 'excellent' densities (see **Table 12** below). Parr densities at the site were found to be 50.7 per 100m^2 indicating that it also supports 'excellent' populations of salmon parr.

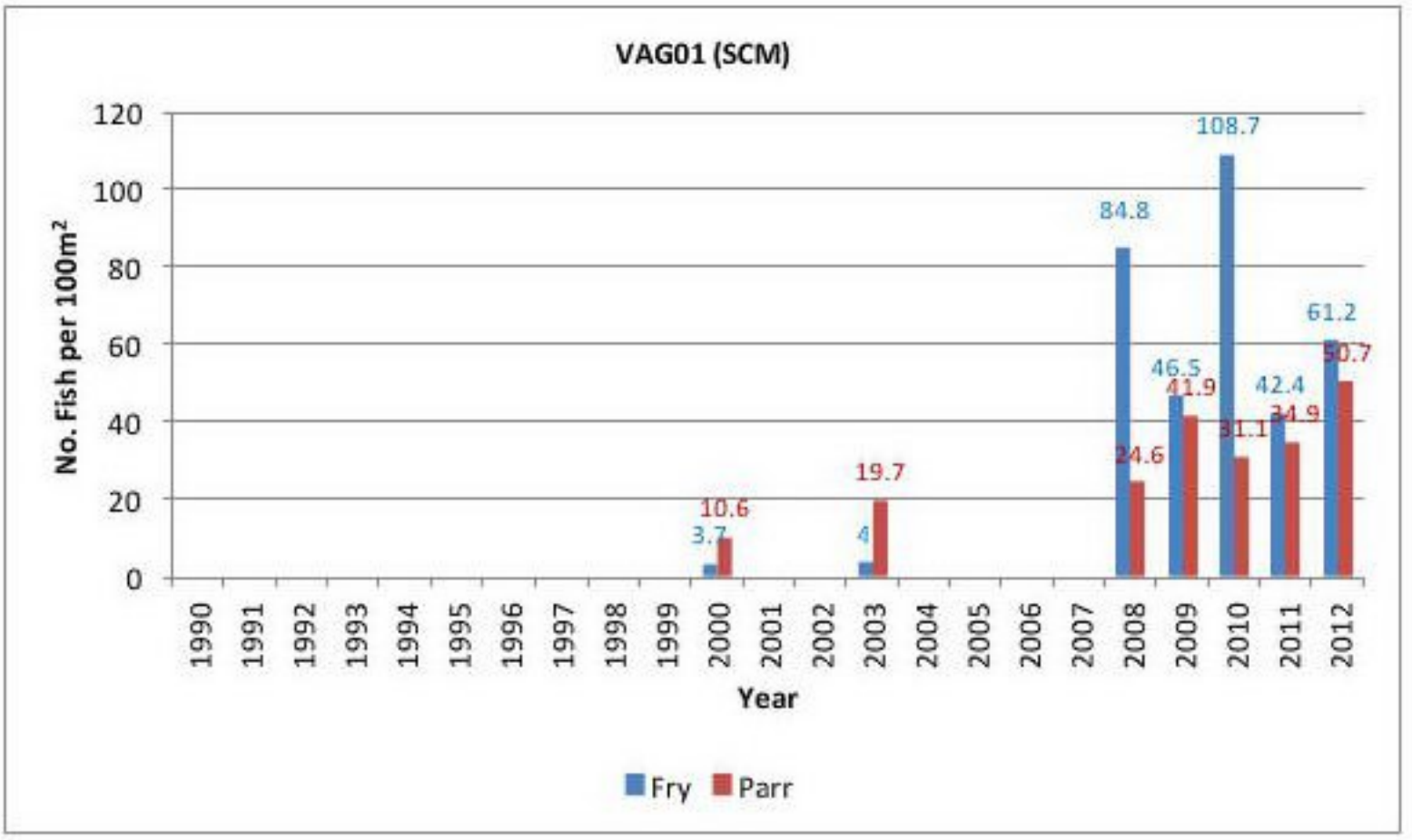
Table 12 Observed 2012 salmon densities at site on the River Vagastie at Altnaharra football pitch VAG01 (SCM)

Age	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+	32	21	11	-	64	73.586	61.162	A- 'Excellent'
1+	32	15	6	-	53	54.472	50.650	A- 'Excellent'
Total	64	36	17	-	117	128.058	111.812	
Number Salmon Missed					22(139)			

The densities of fry recorded in 2012 (61.2 per 100m^2) were greater than those in 2011 (42.4 per 100m^2) but significantly less than the peak densities recorded in 2008 (84.8 per 100m^2)

and 2010 (108.7 per 100m^2). Despite this the site has maintained an 'excellent' fry classification since 2008, with an overall trend for increasing densities (see **Figure 6-7** below).

Figure 6-7 Densities of juvenile salmon fry and parr recorded at the site on the River Vagastie at Altnaharra football pitch VAG01 (SCM)



Fry densities are known to vary considerably from year to year, e.g. if a redd is located within a survey reach the densities of fry will be much higher than if the red was located just downstream of the site. They are therefore best used as a measure of the distribution of spawning rather than for studying general long-term trends in juvenile salmon populations.

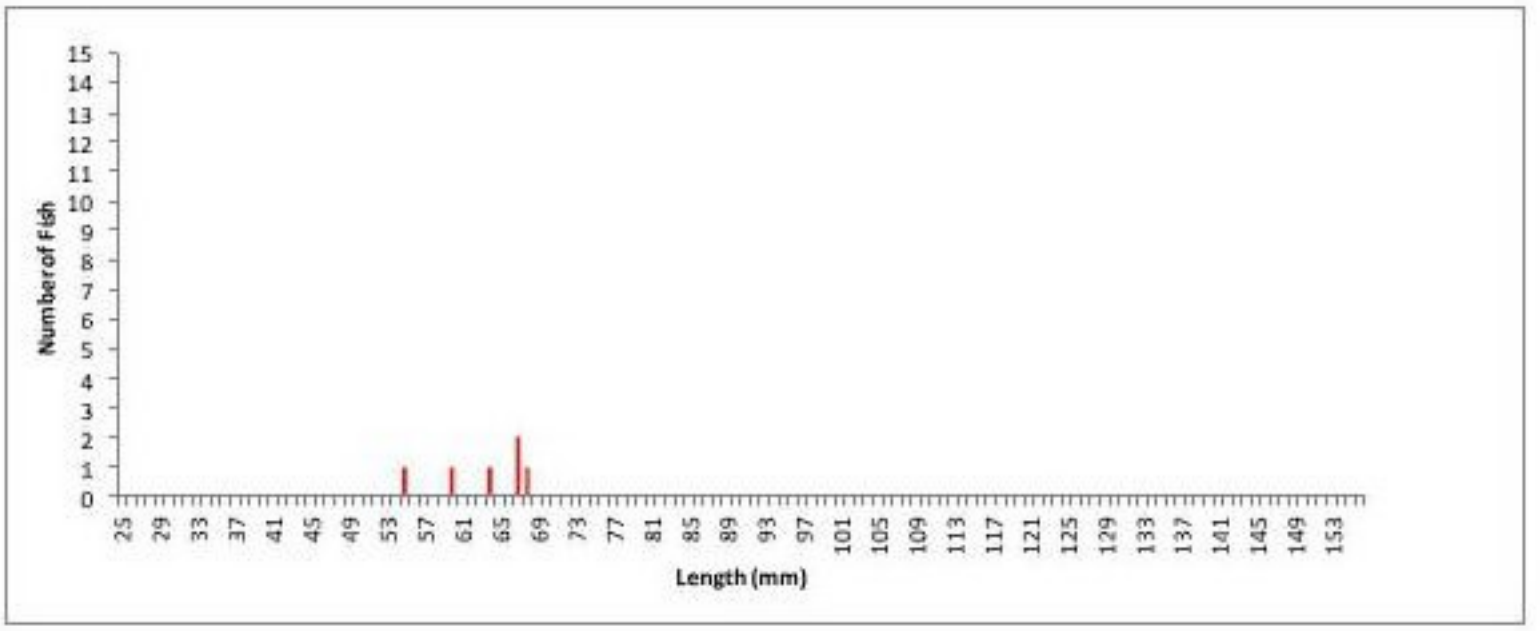
The parr densities recorded at the site have consistently achieved 'excellent' classification since 2003. There has also been a clear trend for improving densities since 2000 when 10.6 parr per 100m^2 were recorded. The survey in 2012 produced the highest densities of parr (50.7 per 100m^2) recorded to date at site ALT01 (SCM).

Parr densities give a much better indication of the general 'health' of juvenile salmon populations than fry. The habitat characteristics of the site present a limiting factor to the densities of parr that it can support (known as the 'carrying capacity'). Because the site does not meet all the habitat requirements of salmon parr it will only be able to support a limited density, i.e. once all the available habitat is taken up there will be no more room for additional parr.

6.3.3 Brown/Sea Trout

The majority of trout recorded at the site in 2012 ranged between 55mm and 68mm and are thought to represent the 0+ year class (see **Figure 6-8** below). This indicates that trout successfully spawned at the site in 2011. No further year classes of trout were recorded.

Figure 6-8 Length frequency histogram for brown trout/sea trout captured during the 2012 survey at VAG01 (SCM)



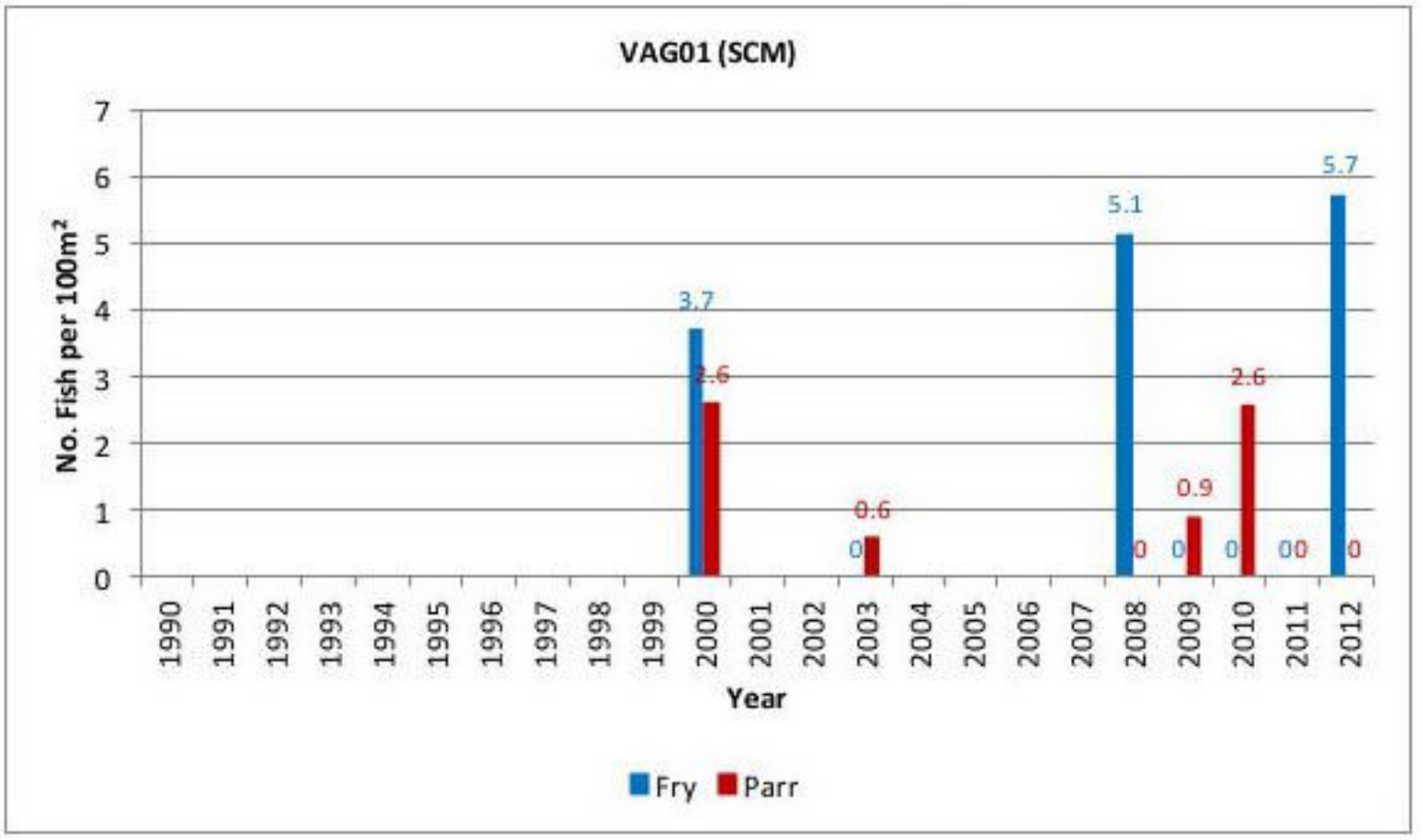
The minimum trout fry density recorded at VAG01 (SCM) in 2012 was 5.7 per 100m^2 ('moderate' classification), with parr being absent from the site (see **Table 13** below).

Table 4 Observed 2012 trout densities at site on the River Vagastie at Altnaharra football pitch VAG01 (SCM)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	4	1	1	-	6	5.734	5.734	C – 'Moderate'
1+ (parr)	0	0	0	-	0	0.000	0.000	F – 'Absent'
Total	4	1	1	-	6	5.734	5.734	
Number Salmon Missed					1 (7)			

A comparison of the total densities of trout recorded at site VAG01 (SCM) between 2000 and 2012 are presented in **Figure 6-9** below.

Figure 6-9 Minimum densities of trout fry and parr recorded at site VAG01 (SCM) at Altnaharra Football Pitch (2000 to 2012)



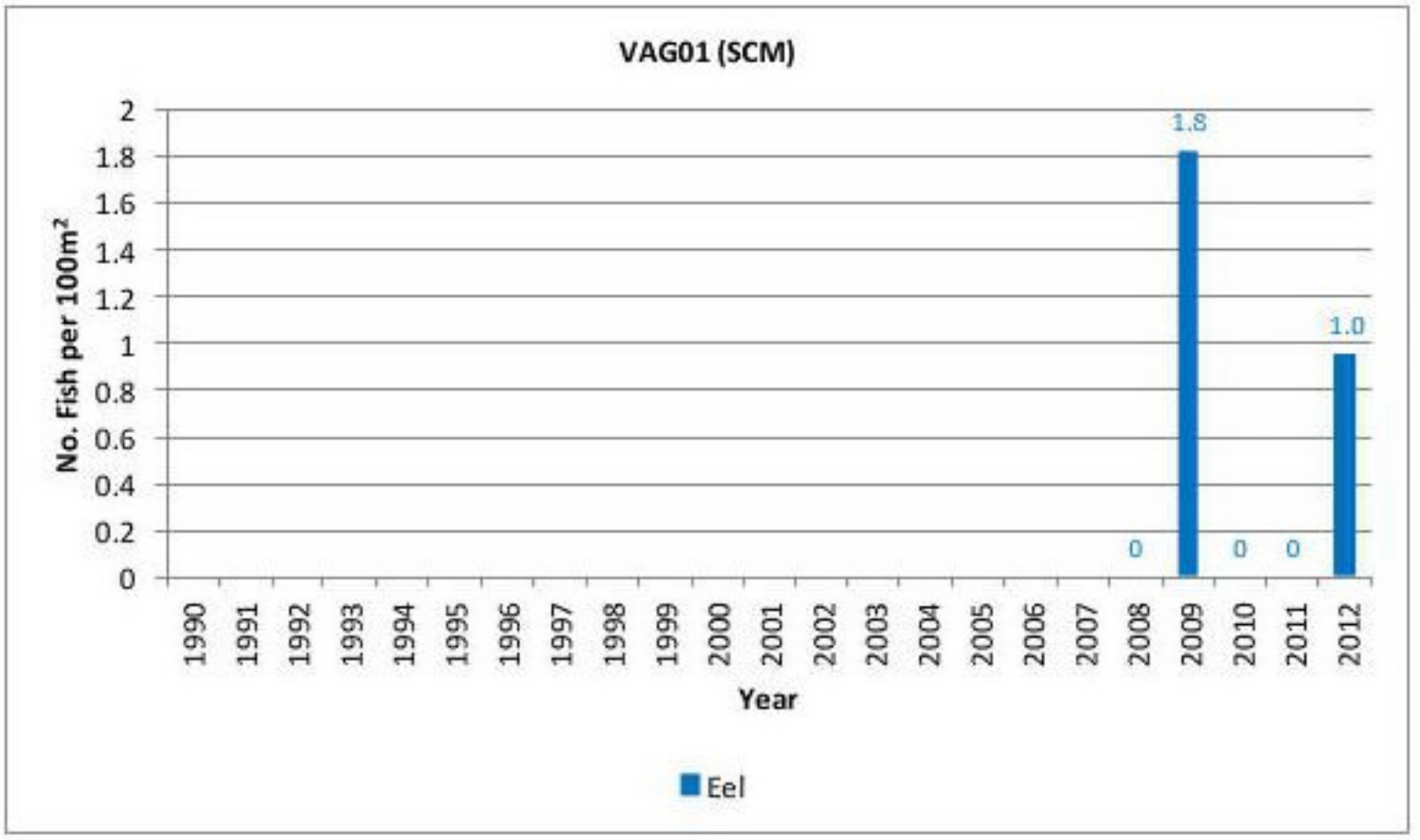
The density of trout fry recorded in 2012 (5.7 fish per 100m^2) was the highest on record. However, trout parr were found to be absent. Overall, the trout densities at the site have varied considerably from year to year, with trout found to be completely absent during the 2011 survey.

6.3.4 European Eel

Eels were found to be present at site VAG01 (SCM) in 2012. All of those recorded were <15cm indicating that they were juveniles (referred to as elvers). Minimum densities of eels recorded at the site between 2010 and 2012 are presented in **Figure 6-10** below.

The densities of eels recorded in 2012 (1.0 per 100m^2) were greater than in 2010 and 2011 when eels were found to be absent. However, eels were recorded at slightly higher densities in 2009 (1.8 per 100m^2). Overall it seems that eel densities at this site are highly variable.

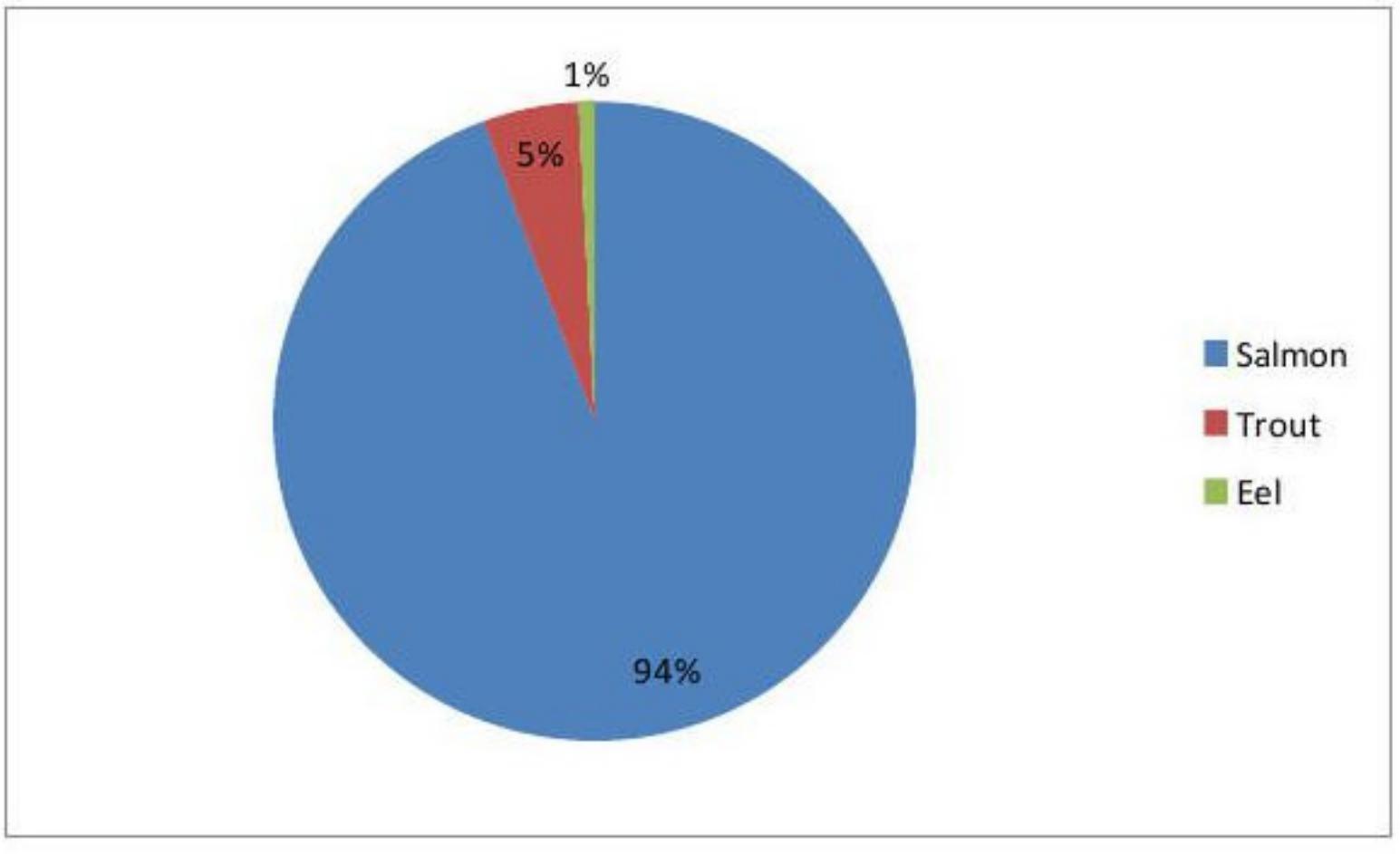
Figure 6-10 Minimum densities of eels recorded during juvenile salmon surveys at site VAG01 (SCM) (2008 – 2012)



6.3.5 Species Composition

Six trout and a one eel were recorded at the site, together with one hundred and seventeen juvenile salmon (see **Figure 6-11** below).

Figure 6-11 Proportion of each fish species (percentage) present at site VAG01 (SCM) in 2012



This means that salmon were the dominant species with 94% of the total (compared to 100% in 2011), followed by trout with 5% of the total (compared to 0% in 2011) and eels with 1% of the total (compared to 0% in 2011).

6.4 SITE VAG02 (SCM) – MIDDLE REACHES OF THE RIVER VAGASTIE (30/08/12)

6.4.1 Site Description

This site is located in the middle reaches of the River Vagastie (NC 5456 3070) approximately 6.5km upstream from its confluence with Loch Naver. It is situated adjacent to a recently felled coniferous forestry block and just downstream from a small set of 'passable' falls. A photograph of the survey site (downstream view) is presented in **Figure 6-12** below.

Figure 6-12 Photograph of electric fishing site VAG02 (SCM) taken in 2012 (downstream view)

The riparian land on both banks consists of moorland heath grazed by sheep and red deer. Mature old growth alders also fringe the river on the right bank, although in very low densities. On the opposite site of the road (on the left bank) is the site of a coniferous forestry block which was cleared in 2011.

The bank face and bank top vegetation on both banks was described as being 'complex', i.e. four or more vegetation types including scrub or trees. Prior to commencement of the survey the site was described as having 'excellent' in-stream cover and the water level was recorded as being 'medium' height and 'clear' in colour. Both upstream and downstream

stop nets were used, together with a combination of banner and hand nets.

The key in-stream physical habitat characteristics recorded at the site are summarised in **Table 14** below and compared to the requirements of both fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 14 Summary of the key in-stream physical habitat characteristics recorded at VAG02 compared to the requirements of fry and parr (Hendry & Cragg-Hine, 1997).

Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	10 to 45 cm (average 24.8 cm)
Velocity	50 to 65 cm/s	60 to 75 cm/s	30 to 100cm/s (average 67 cm/s)
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	5% gravel, 5% pebbles, 15% cobbles, 35% boulder, 40% bed rock.

The depths recorded at the site ranged between 10cm and 40cm matching the requirements of both salmon fry and parr. This was also true for the velocities on the day of the survey (30 to 100cm/s), with the average velocity (67 cm/s) being more suited to parr.

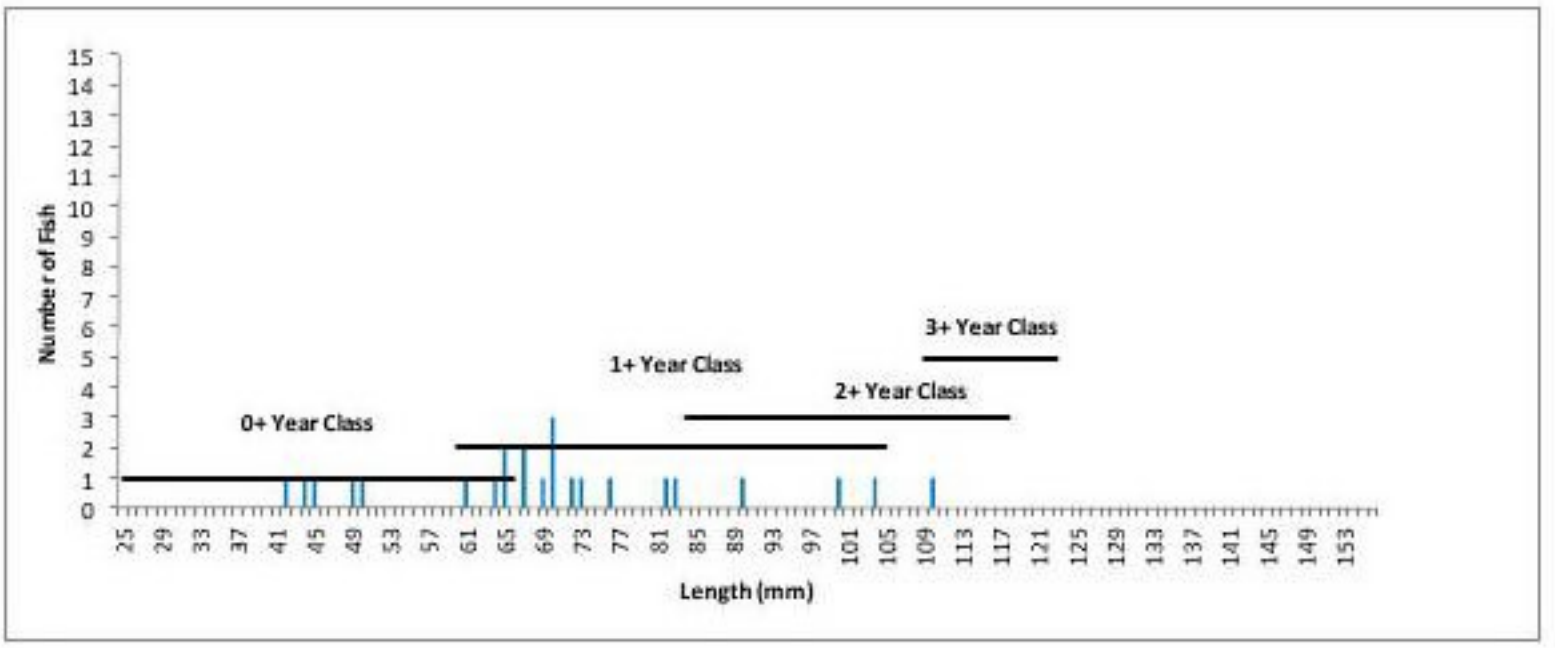
The bed substrate was dominated by cobbles (15%) boulders (35%) and bedrock (40%), however gravel and pebbles were recorded in much lower proportions. This indicates that the substrate was more suitable for parr, with fry habitat being limited.

In summary, the physical habitat characteristics at the site seem to be more suited to the requirements of salmon parr than fry. We would therefore expect that the site should support at least good densities of parr but no more than moderate populations of fry.

6.4.2 Atlantic Salmon

The length frequency histogram and scale reading results for VAG02 (SCM) indicate the presence of three clear year classes of fish including 0+ year old fry, 1+ year old parr and 2+ year old parr (see **Figure 6-13** below).

Figure 6-13 Length frequency histogram for juvenile salmon captured during the 2012 survey at VAG02 (SCM)



The 0+ year class was poorly represented with just five individual fish ranging between 42 and 50mm in length. The low numbers indicate a low spawning success at this site in the winter of 2011/2012. This may be due to a lack of suitable fry habitat, with the numbers of 0+ fish captured at this site being significantly less that at VAG01 (SCM) lower in the catchment.

The number of individuals recorded in the 1+ year classes were higher than in the 0+ year class. This is unusual as one would expect a decrease in numbers year to year due to natural mortality. This suggests that at least some of the fish in the 1+ year classes have migrated into this site from other areas in the river (either upstream or downstream).

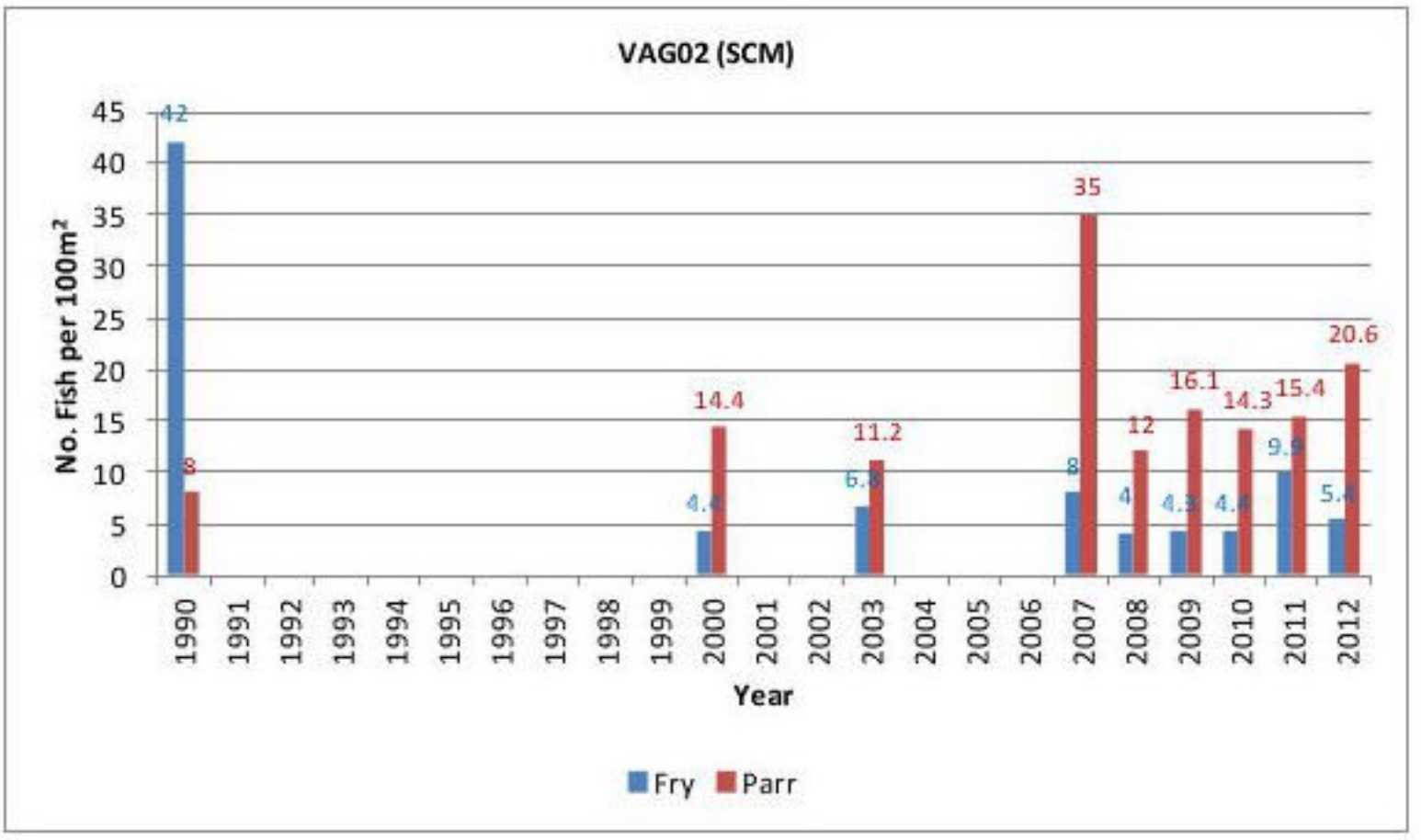
Salmon fry densities at VAG02 (SCM) were found to 5.4 per $100m^2$, indicating that it supports 'very poor' densities of fry (see **Table 15** below). This is lower than the 'moderate' densities predicted from the habitat assessment. Parr densities at the site were found to be 20.6 per $100m^2$ indicating that it supports 'excellent' populations of salmon parr as predicted from the habitat characteristics recorded at the site.

Table 15 Observed 2012 salmon densities at site in the middle reaches of the River Vagastie VAG02 (SCM)

Age	Fish Count					Density Estimate (fish per $100m^2$)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+	2	2	1	0	5	5.411	5.411	D - Poor
1+	5	5	5	4	19	30.303	20.563	A - Excellent
Total	7	7	6	4	24	35.714	25.974	
Number Salmon Missed					7 (31)			

A comparison with the results of surveys in previous years (see **Figure 6-14** below) indicates that a 'poor' fry classification at this site is not unusual. This may be due to the limited availability of fry habitat at the site, the effects of low flows resulting from the catchwater, or a combination of both.

Figure 6-14 Densities of juvenile salmon fry and parr recorded at the site in the middle reaches of the River Vagastie VAG02 (SCM)



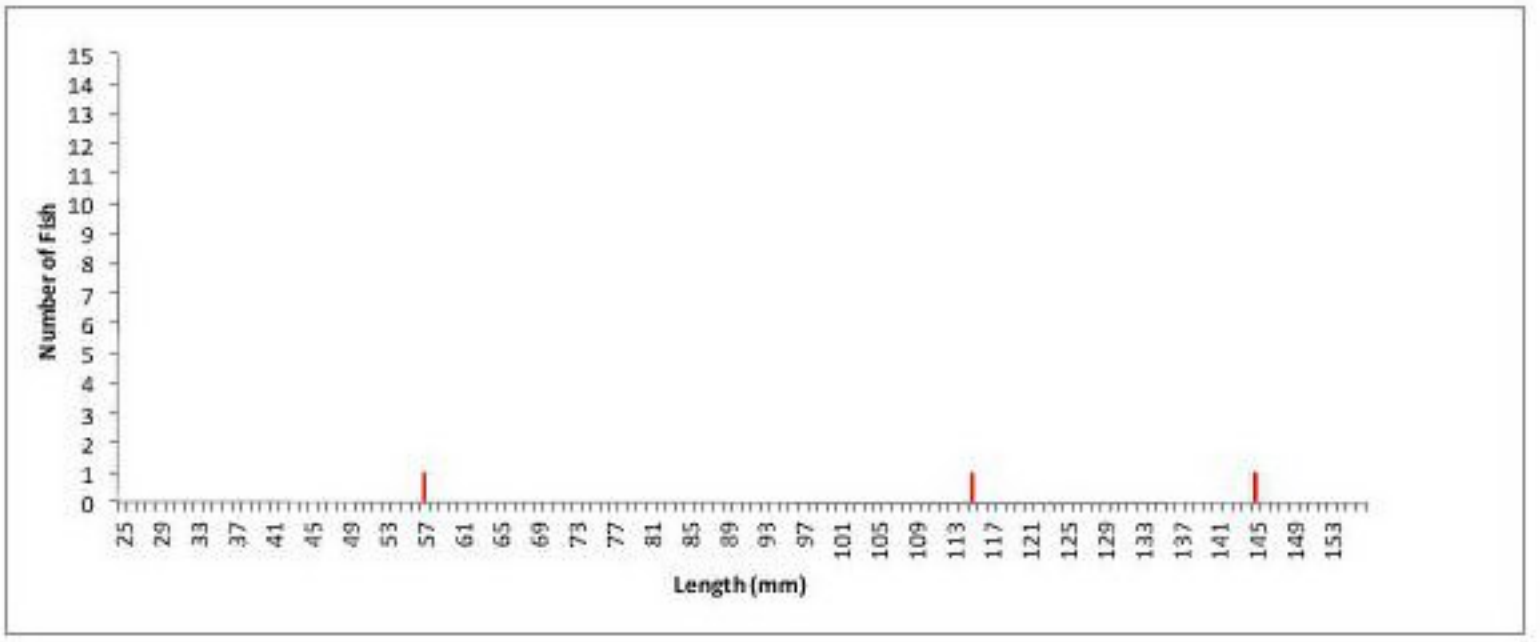
It should be noted that densities of 42 fry per 100m^2 ('excellent') were recorded during a survey at this site in 1990. This suggests a significant change in the status of salmon stocks in the Vagastie sometime between 1990 and 2000. The exact reason is not known, but it may well be due to a change in water management at the catchwater.

There has been an overall trend for increasing salmon parr densities at VAG02 (SCM) since the site was first investigated in 1990 (8 per 100m^2 'moderate' classification). Densities peaked at 35 per 100m^2 ('excellent') in 2007, before dropping back down to 'good' (12 per 100m^2) in 2008. The densities of parr recorded in 2012 (20.6 per 100m^2) were the second highest on record for this site

6.4.3 Brown/Sea Trout

The trout recorded at the site in 2012 ranged between 57mm and 145mm and are thought to represent three year classes of fish (see **Figure 6-15** below). The 57mm fish was the only representative of the 0+ year class, indicating that trout spawning was limited at this site.

Figure 6-15 Length frequency histogram for brown trout/sea trout captured during the 2012 survey at VAG02 (SCM)



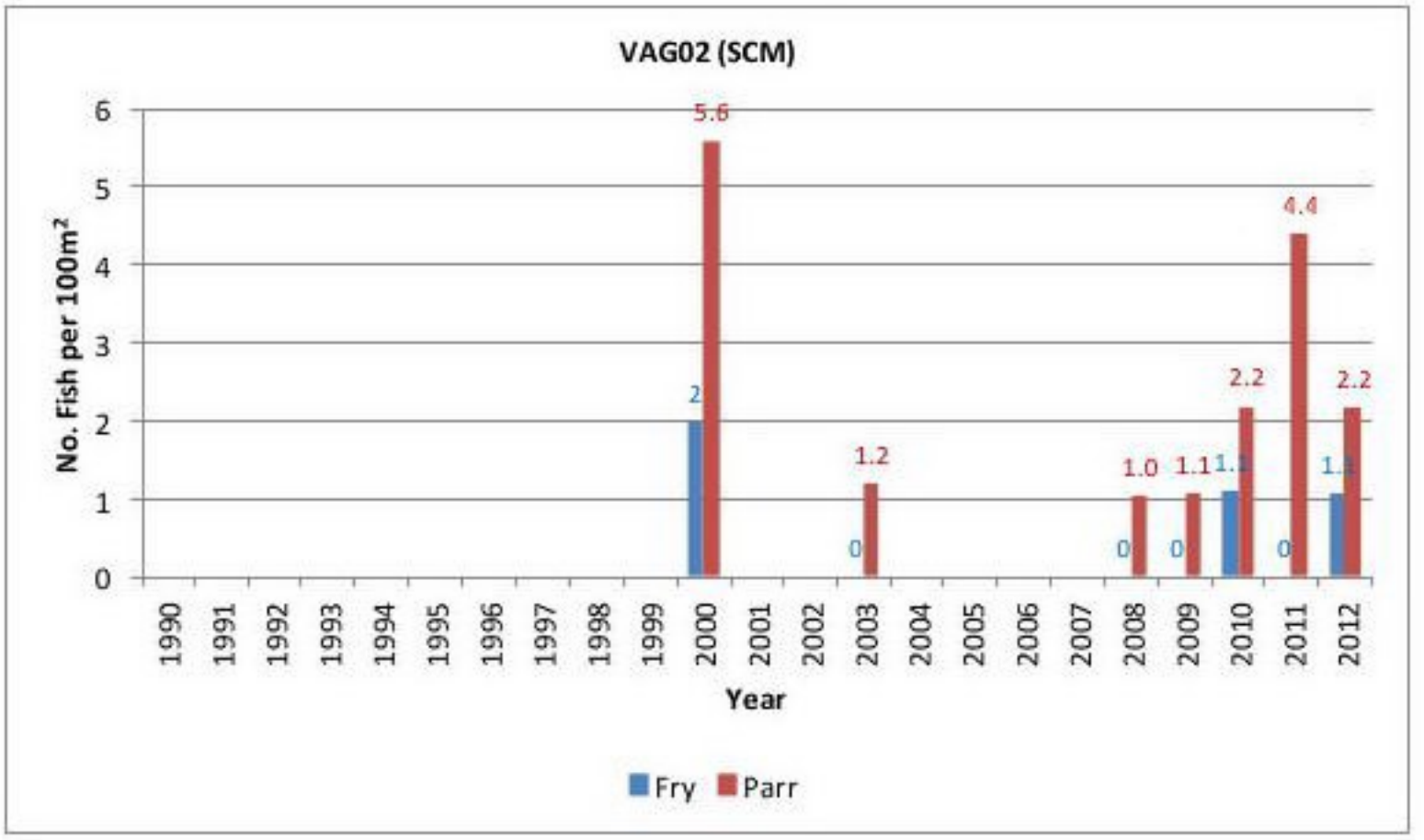
The minimum trout fry density recorded at VAG02 (SCM) in 2012 was 1.1 per 100m^2 ('very poor' classification), with parr densities being recorded at 2.2 per 100m^2 ('poor' classification) (see **Table 16** below).

Table 16 Observed 2012 trout densities at the site in the middle reaches of the River Vagastie VAG02 (SCM)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	1	0	0	-	1	-	1.082	C – 'Very Poor'
1+ (parr)	2	0	0	-	2	-	2.165	F – 'Poor'
Total	3	0	0	-	3	-	3.247	
Number Salmon Missed					0 (3)			

A comparison of the total densities of trout recorded at site VAG02 (SCM) between 2000 and 2012 are presented in **Figure 6-16** below.

Figure 6-16 Densities of brown trout/sea trout recorded at site VAG02 (SCM) in the middle reach of the Vagastie (2000 to 2012)



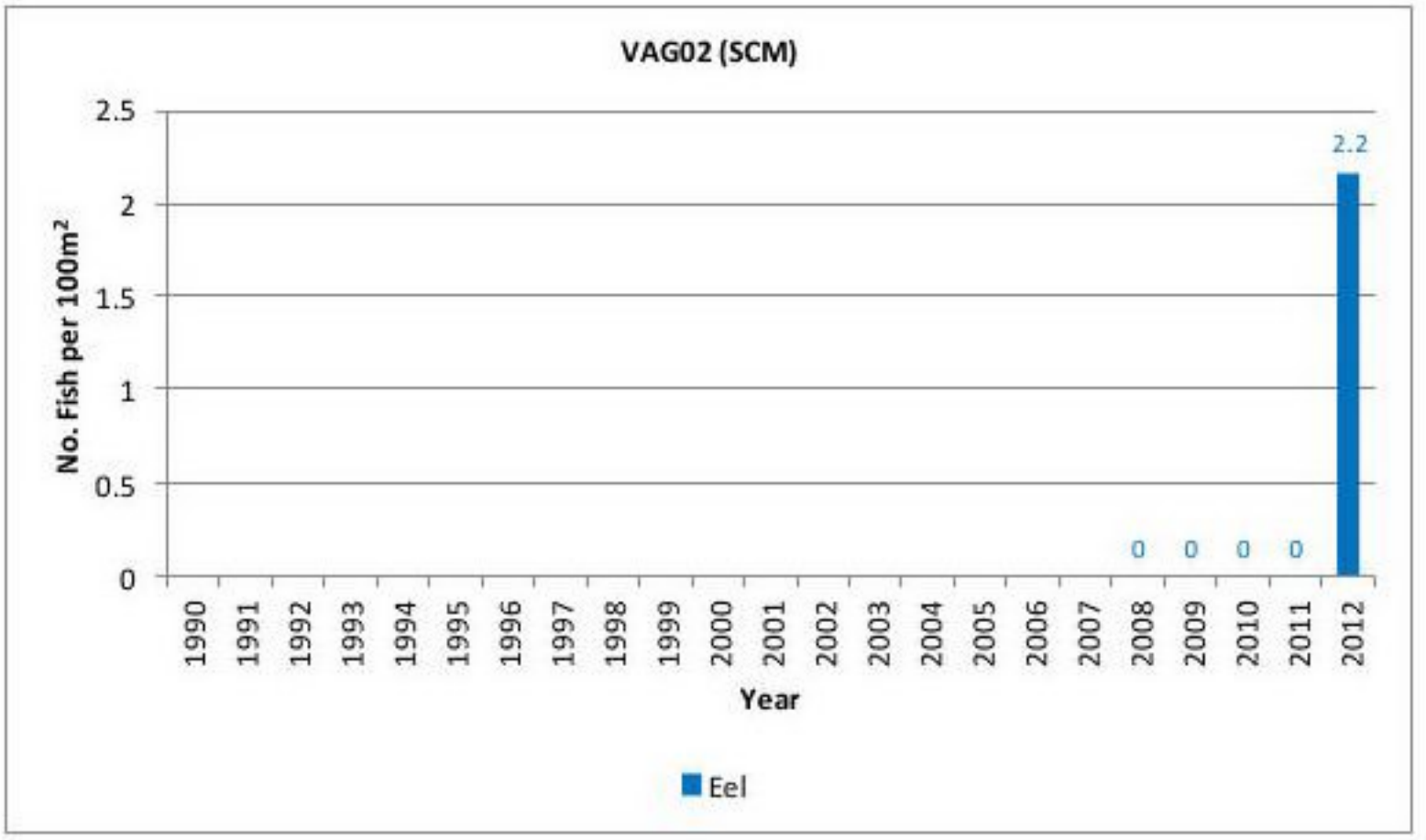
The densities of fry trout recorded in 2012 (1.1 fish per 100m^2) were greater than in 2011 (0.0 fish per 100m^2) and the joint second highest since 2000 (2 fish per 100m^2). Densities of trout parr in 2012 (2.2 fish per 100m^2) were less than in 2011 (4.4 fish per 100m^2) but still relatively high (in comparison to previous years). Overall, fry densities have been consistently poor, with a trend for improving parr densities.

6.4.4 European Eel

Eels were found to be present at site VAG02 (SCM) in 2012. All of those recorded were <15cm indicating that they were juveniles (referred to as elvers). Minimum densities of eels recorded at the site between 2010 and 2012 are presented in **Figure 6-17** below.

The densities of eels recorded in 2012 (2.2 per 100m^2) were greater than between 2008 and 2011 when eels were found to be absent. Overall it seems that eel densities at this site are generally low or absent.

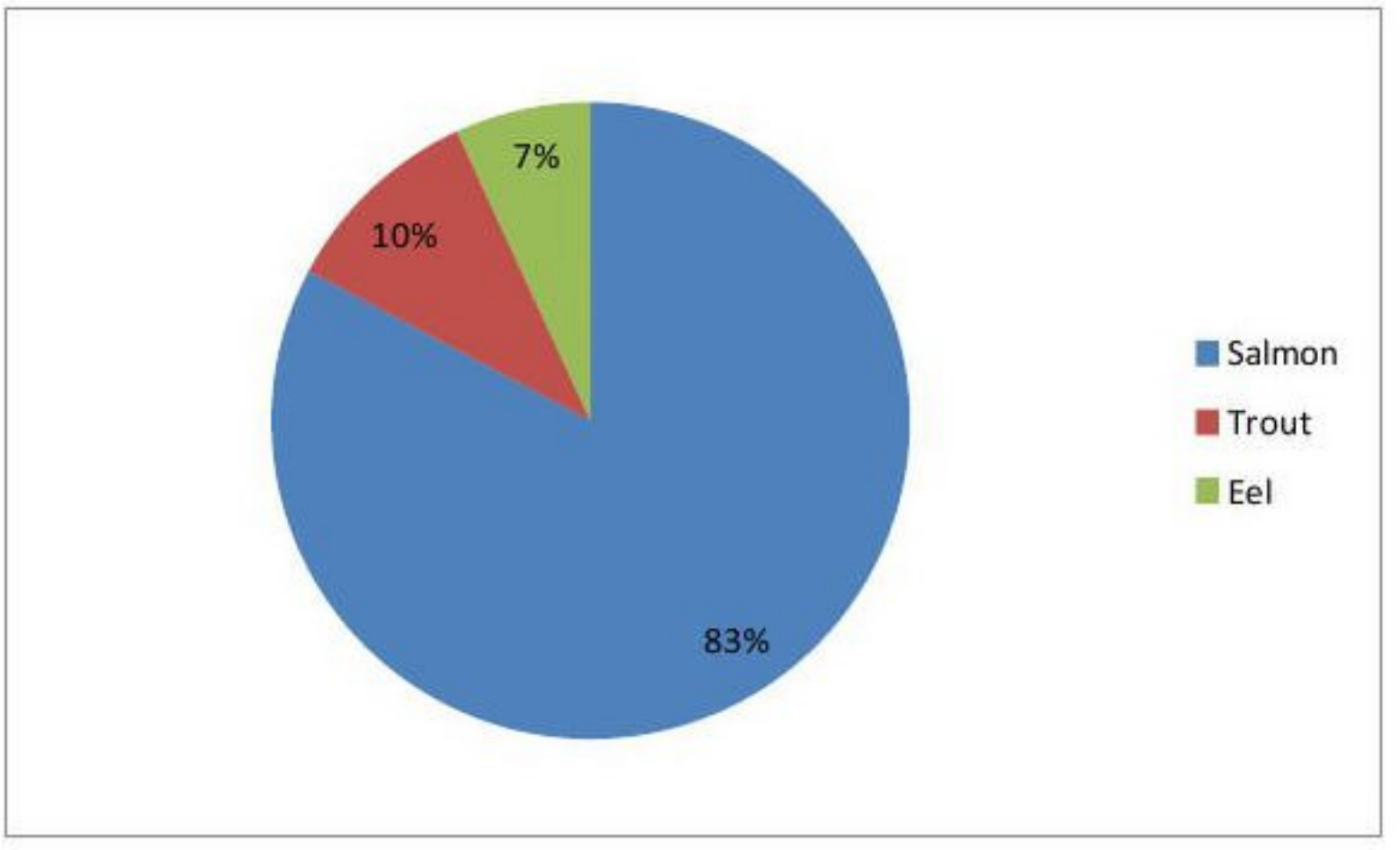
Figure 6-17 Minimum densities of eels recorded during juvenile salmon surveys at site VAG02 (SCM) (2010 – 2012)



6.4.5 Species Composition

Three trout and two eels were recorded at the site, together with twenty four juvenile salmon (see **Figure 6-18** below).

Figure 6-18 Proportion of each fish species (percentage) present at site VAG02 (SCM)



This means that salmon were the dominant species with 83% of the total (compared to 85% in 2011), followed by trout with 10% of the total (compared to 15% in 2011) and eels with 7% of the total (compared to 0% in 2011).

6.5 SITE VAG03 – UPPER REACHES OF THE RIVER VAGASTIE (30/08/12)

6.5.1 Site Description

This site is located on the Allt a' Chraisg approximately 135m above the A836 (Lairg road) (NC 5324 2717). Flows at the site are known to be significantly depleted by the catchwater which is situated approximately 2km upstream of its location. A photograph of the survey site is presented in **Figure 6-19** below.

Figure 6-19 Photograph of electric fishing site VAG03 taken in 2012 (upstream view)

The riparian land on both banks is dominated by moorland heath grazed by red deer. In contrast to the lower reaches of the river, mature old growth alders are absent.

Areas of the river bed were covered with orange coloured sediment. This is typical in areas producing iron-bearing ground water, where the iron is oxidized to ferric hydroxide upon encountering the toxic environment of the surface. This is not unusual for the Naver catchment, but the sediment would usually be washed away during high flows. This together with the fact that large amounts of algae were also present is indicative of low flows at the site.

The bank face and bank top vegetation on both banks was described as being 'simple', i.e.

predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc).

Prior to commencement of the survey the site was described as having 'moderate' in-stream cover and the water level was recorded as being 'medium' in height and 'coloured'. Both upstream and downstream stop nets were used together with hand nets.

A summary of the key in-stream physical habitat characteristics recorded are summarised in **Table 17** below and compared to the requirements of both fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 17 Summary of the key in-stream physical habitat characteristics recorded at VAG03 compared to the requirements of fry and parr (Hendry & Cragg-Hine, 1997).

Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	5 to 30 cm (average 17 cm)
Velocity	50 to 65 cm/s	60 to 75 cm/s	20 to 30 cm/s (average 27 cm/s)
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	2% fine organic matter, 2% sand, 5% gravel, 5% pebbles, 25% cobbles, 51% boulder, and 10% bed rock.

The depths recorded at the site ranged between 5cm and 30cm, meeting the requirements of both salmon fry and parr. Velocities on the day of the survey were higher than in previous years due to the 'medium' water levels and varied between 20 cm/s and 30 cm/s (with an average of 27 cm/s). Despite this they still fell well below the ideal requirements of both fry and parr.

The bed substrate was dominated by cobbles (25%) and boulders (51%) providing excellent habitat for parr. Gravel and pebbles were also present providing fry habitat, although in much lower proportions (5% each). There were relatively high proportions of inorganic matter and sand covering the bed substrate, most likely associated with low flows. This could act to 'smother' gravels and limit the survival of fry. This coupled with high summer water temperatures resulting from low flows is likely to significantly reduce the survival of both fry and parr at the site.

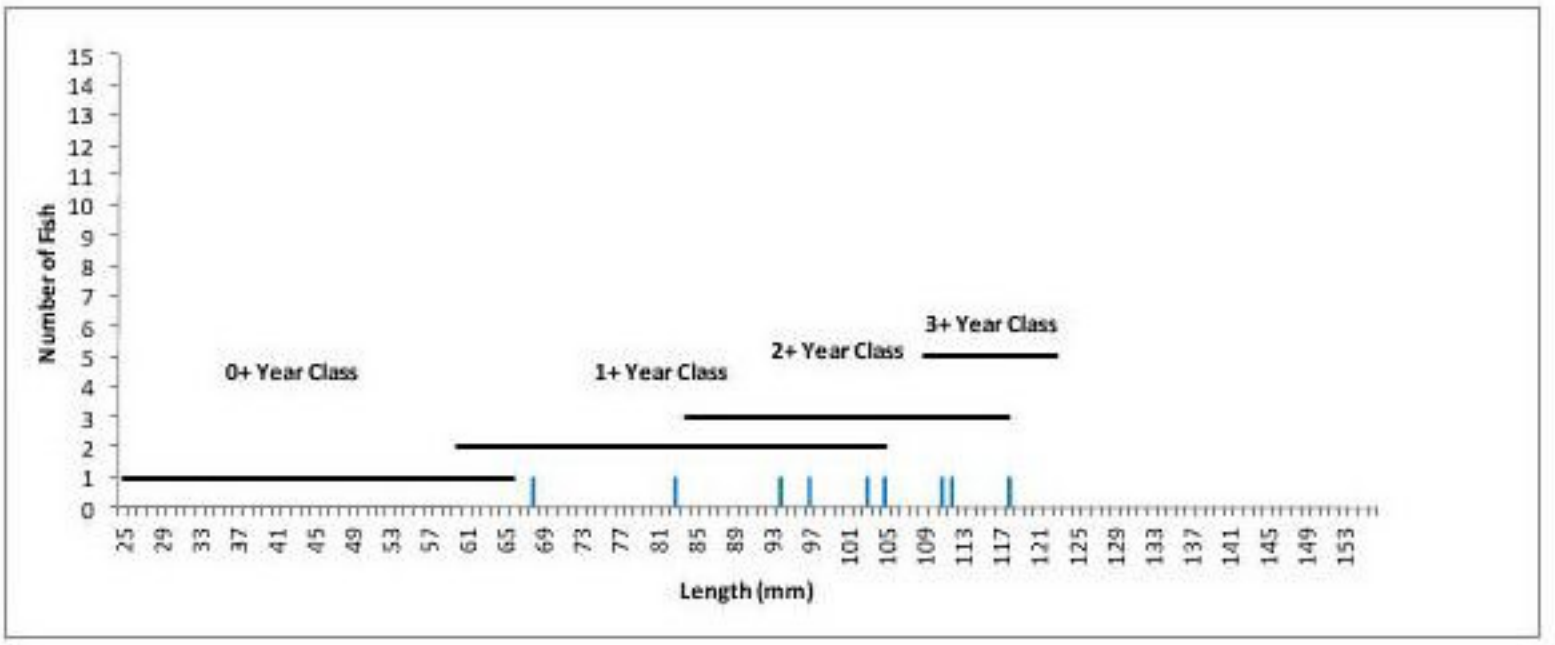
Although the basic bed substrate at the site provides habitat for salmon fry and parr, the effects of low flows (in particular high water temperatures and sedimentation) are likely to limit the survival of fry in particular.

6.5.2 Atlantic Salmon

The length frequency histogram and scale reading results for VAG03 indicate an absence of

0+ year old fish (see **Figure 6-20** below) in 2012. Both 1+ and 2+ year classes were confirmed as being present.

Figure 6-20 Length frequency histogram for juvenile salmon captured during the 2012 survey at VAG03



When the site was surveyed in 2010, a 0+ year class of fish was found to be present, however the 1+ year class was absent. The absence of year classes of fish at this site over successive years supports the theory that spawning success and fry survival varies from year to year depending on environmental conditions.

It is possible that low flows on the River Vagastie in the winter of 2011 obstructed adult salmon from reaching their spawning grounds in the upper reaches. Alternatively, adverse environmental conditions during the incubation of eggs and alevins (such as a combination of low flows and extreme cold or a high water event 'washing' out the eggs) may have reduced their survival rates.

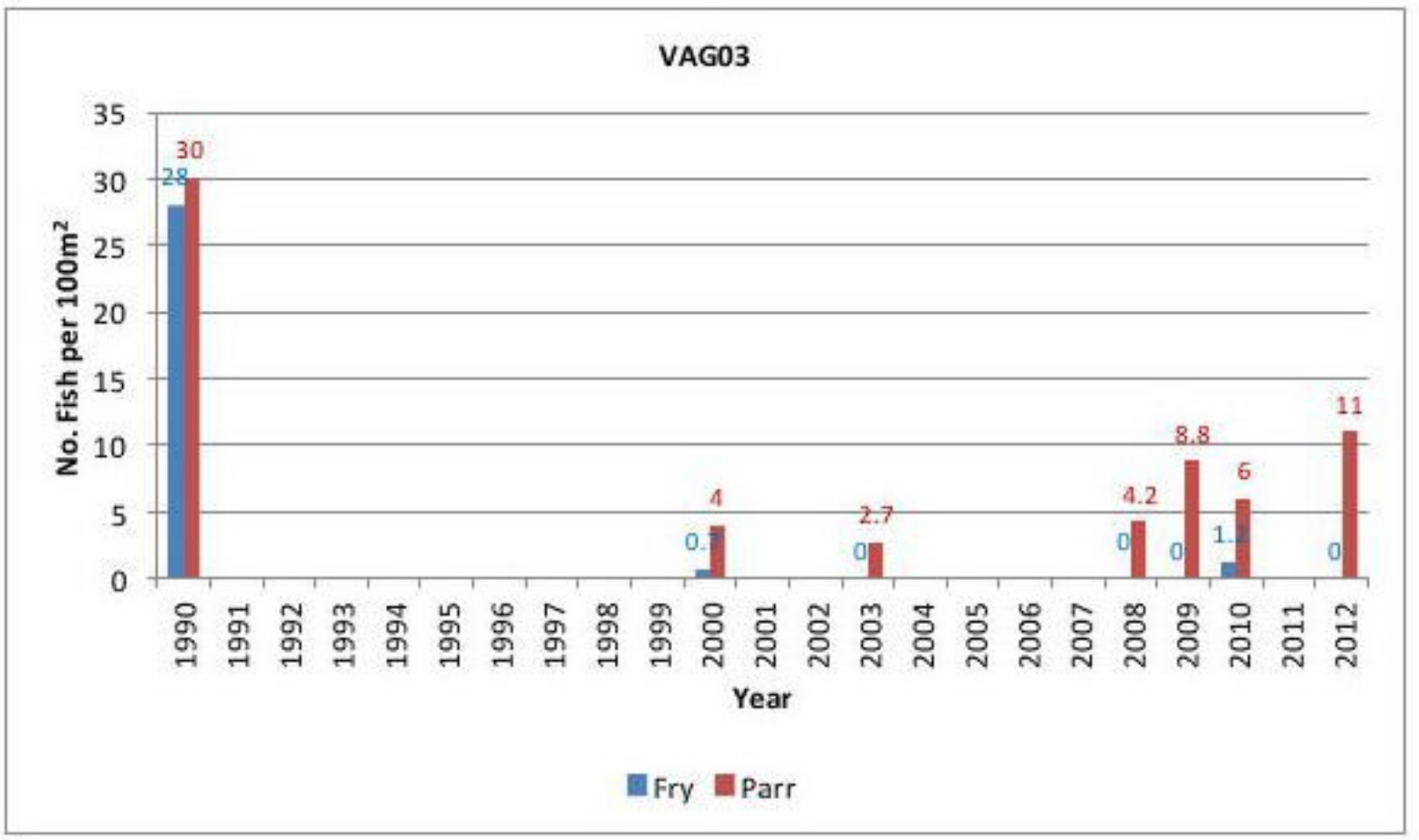
Parr densities were found to be 11 per 100m^2, indicating that it supports 'good' populations of salmon parr (see **Table 18** below). This is higher than expected given the habitat characteristics at the site and the poor densities of fry. This suggests that salmon do spawn relatively successfully somewhere in the proximity of this site, with parr migrating into this area to utilise the available habitat (whether it be from upstream or downstream locations).

Table 18 Observed 2012 salmon densities at site in the upper reaches of the River Vagastie VAG03

Age	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+	0	0	0	-	0	0.000	0.000	F – 'Absent'
1+	6	1	2	-	9	10.989	10.989	B – 'Good'
Total	6	1	2	-	9	10.989	10.989	
Number Salmon Missed					0 (9)			

A comparison with the results of surveys in previous years (see **Figure 6-21** below) indicates that a 'very poor' or 'absent' fry classification at this site is not unusual. This may be due to the poor spawning or fry habitat availability, the effects of low flows resulting from the catchwater, or a combination of both.

Figure 6-21 Densities of juvenile salmon fry and parr recorded at the site in the upper reaches of the River Vagastie VAG03



Shearer (1991) recorded salmon fry densities of 28 per 100m^2 ('good') and parr densities of 30 per 100m^2 ('excellent') in 1990. Since this first survey at the site, densities have decreased significantly. This is possibly due to a change in the catchwater management regime as discussed previously.

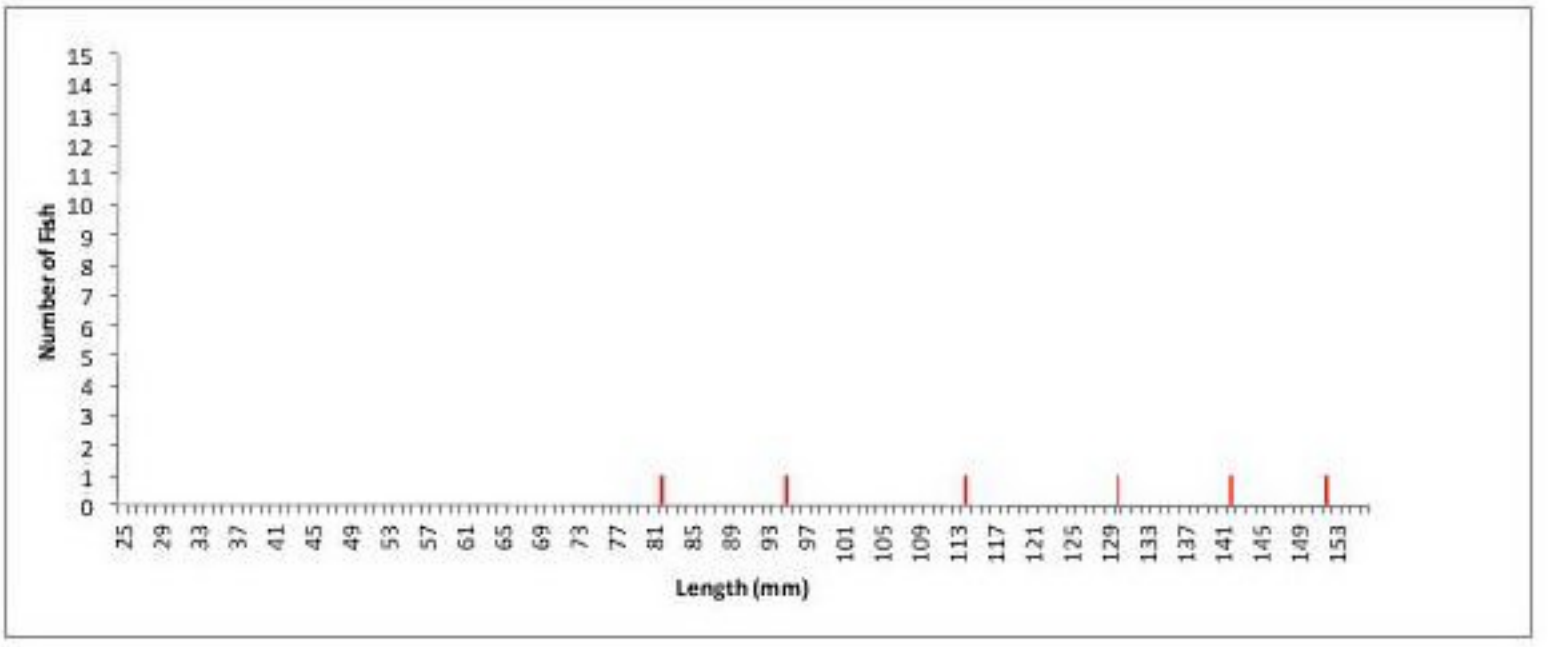
Densities of parr have remained relatively low since 2000 (in comparison to other sites in the catchment), however there has been an improvement in recent years. Densities of parr increased from 2.7 per 100m^2 ('poor') in 2003, to 8.8 per 100m^2 ('moderate') in 2009 and a

high of 11 per 100m^2 ('good') in 2012.

6.5.3 Brown/Sea Trout

Trout recorded at the site in 2012 were found to range between 82mm and 152mm in length (see **Figure 6-22** below). This indicates an absence of 0+ year old trout (fry), as was found to be the case for salmon.

Figure 6-22 Length frequency histogram for brown trout/sea trout captured during the 2012 survey at VAG03



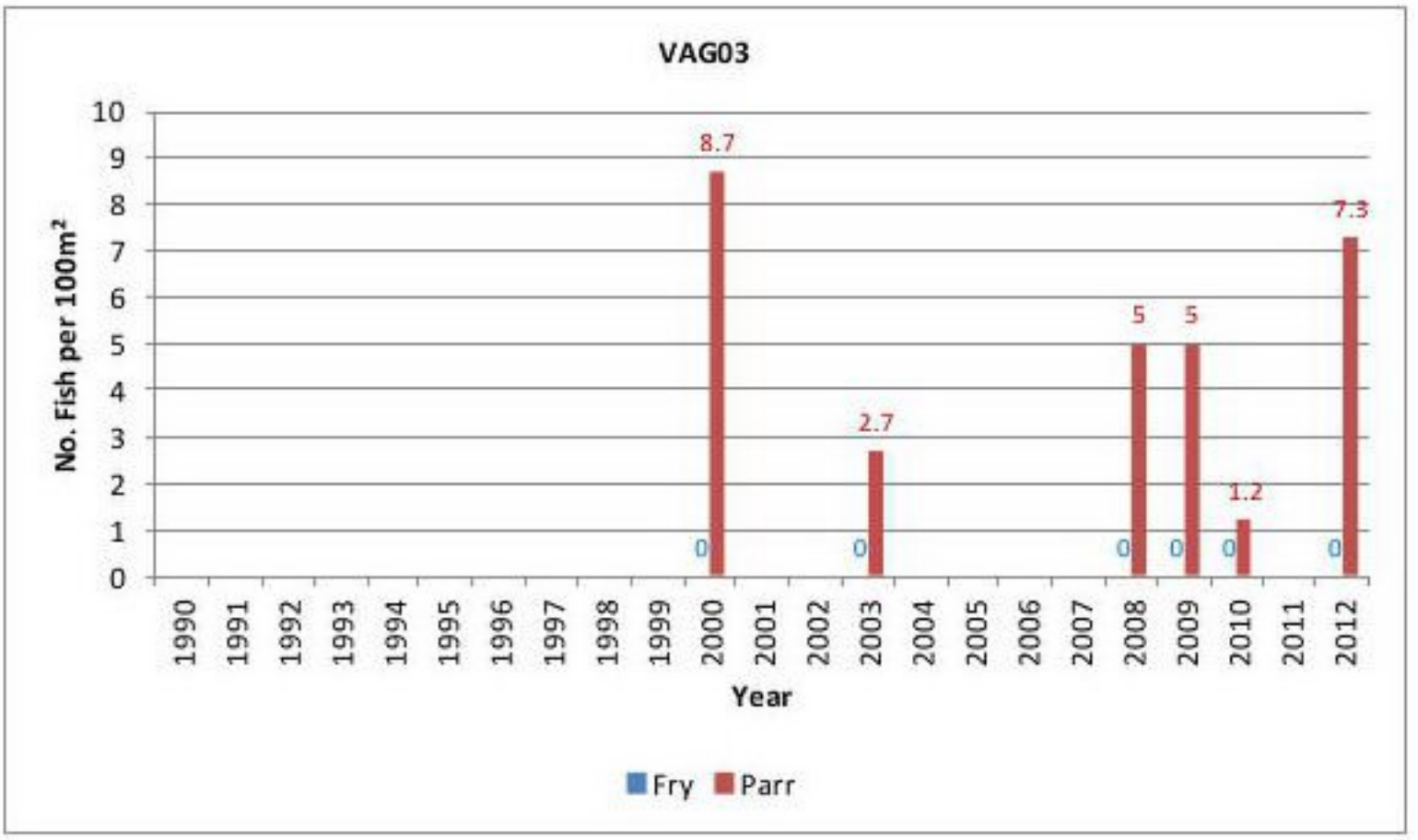
Despite the absence of fry, the minimum parr density recorded at VAG03 was 7.3 per 100m^2 ('excellent' classification) (see **Table 19** below).

Table 19 Observed 2012 trout densities at the site in the upper reaches of the River Vagastie VAG03

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	0	0	0	-	**0**	**0.000**	**0.000**	**F – 'Absent'**
1+ (parr)	5	1	0	-	**6**	**7.326**	**7.326**	**A – 'Excellent'**
Total	**5**	**1**	**0**	**-**	**6**	**7.326**	**7.326**	
Number Salmon Missed					**0 (6)**			

A comparison of the total densities of trout recorded at site VAG03 between 2000 and 2012 are presented in **Figure 6-23** below.

Figure 6-23 Densities of brown trout/sea trout recorded at site VAG03 in the upper reaches of the River Vagastie VAG03



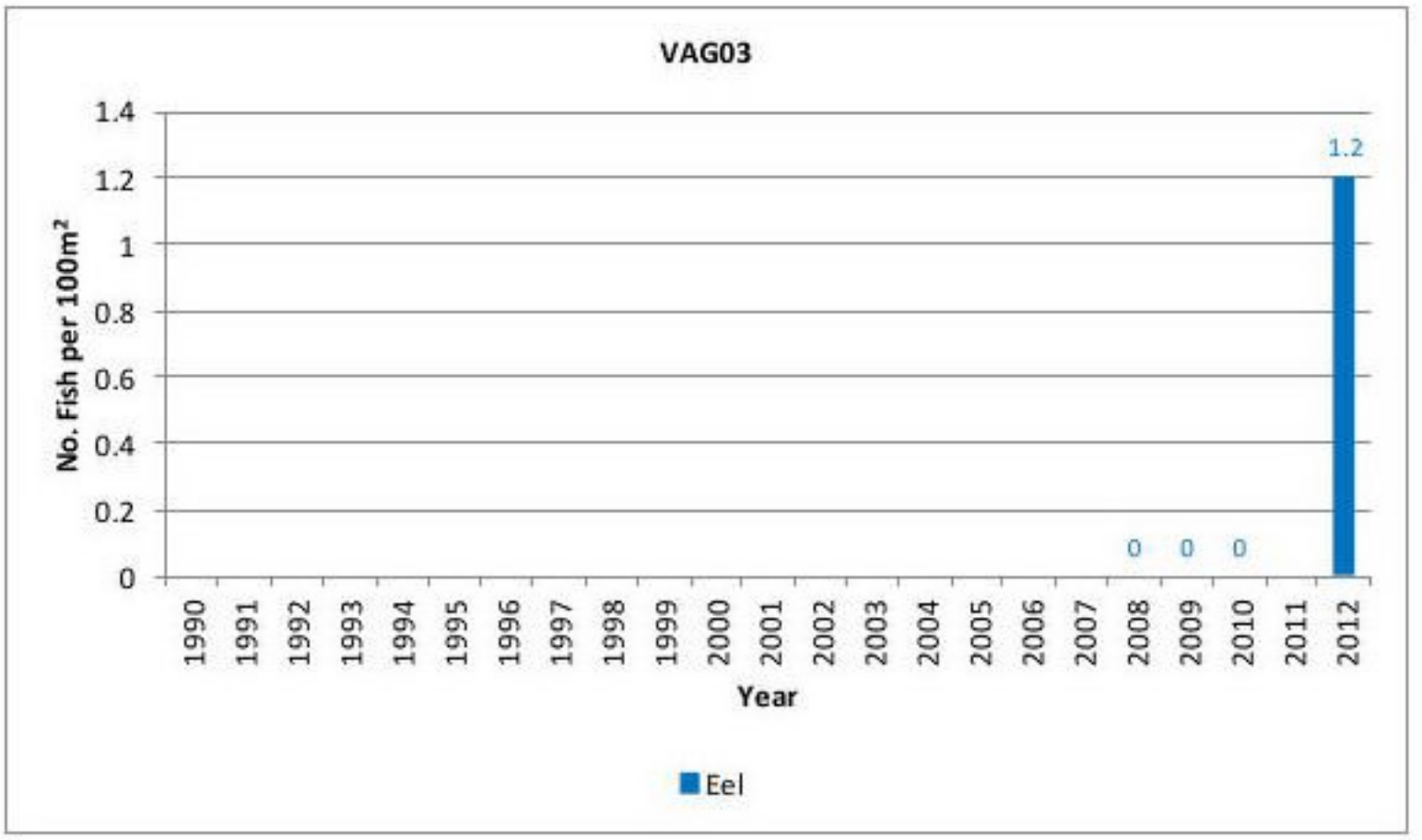
Trout fry have been consistently absent from the site since 2000. The densities of trout parr recorded in 2012 (7.3 fish per 100m^2) were the second highest since the site was first surveyed in 2000 (8.7 fish per 100m^2). Overall, the trout densities at the site have varied considerably from year to year.

6.5.4 European Eel

Eels were found to be present at site VAG03 in 2012. All of those recorded were <15cm indicating that they were juveniles (referred to as elvers). Minimum densities of eels recorded at the site between 2010 and 2012 are presented in **Figure 6-24** below.

The densities of eels recorded in 2012 (1.2 per 100m^2) were greater than in 2010 and 2011 when eels were found to be absent. Overall it seems that eel densities at this site are generally low or absent.

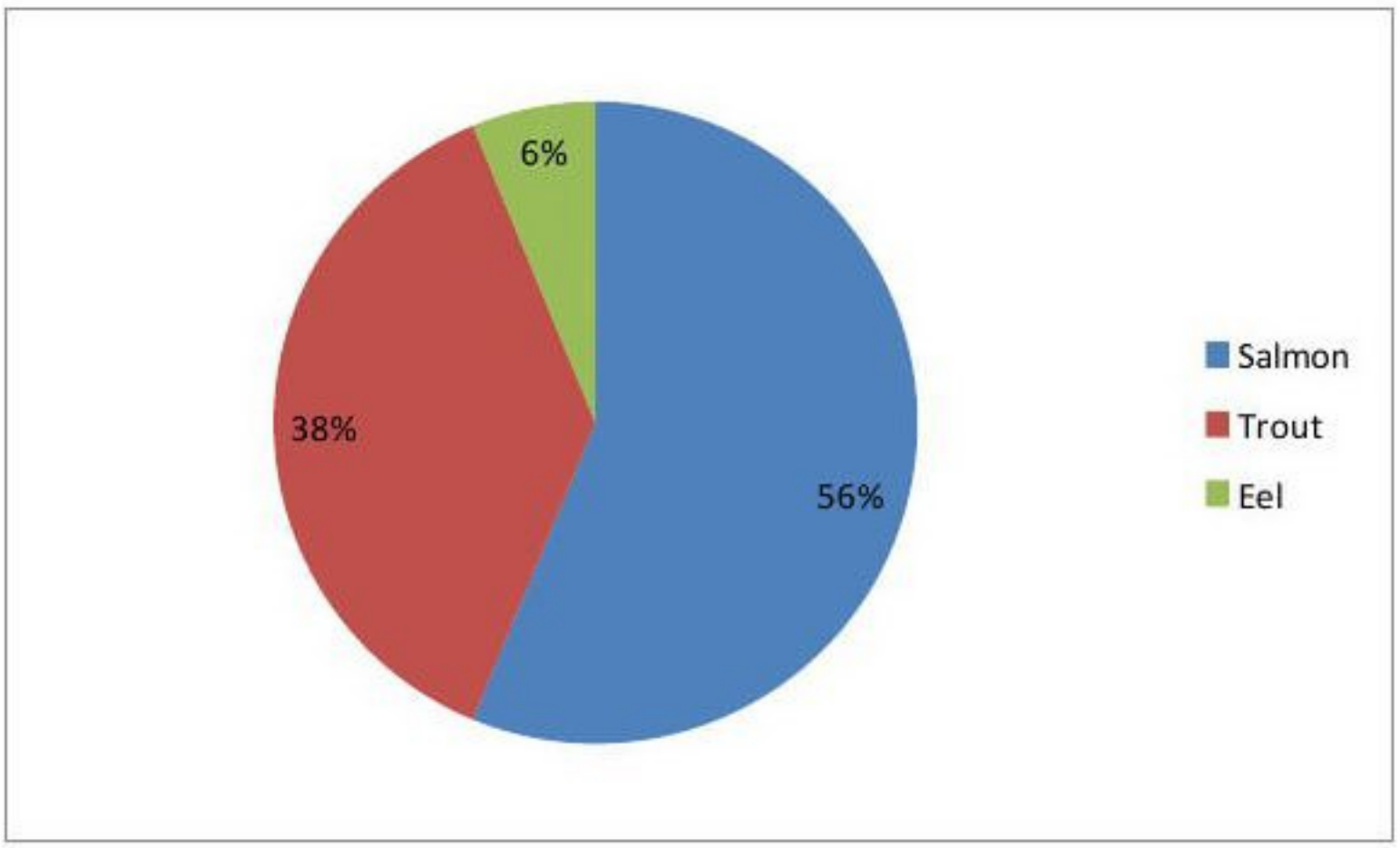
Figure 6-24 Minimum densities of eels recorded during juvenile salmon surveys at site VAG03 (2008 – 2012)



6.5.5 Species Composition

Six trout and one eels were recorded at the site, together with nine juvenile salmon (see **Figure 6-25** below).

Figure 6-25 Proportion of each fish species (percentage) present at site VAG03



This means that salmon were the dominant species at the site with 56% of the total (compared to 86% in 2010), followed by trout with 38% of the total (compared to 14% in

2011) and eels with 7% of the total (compared to 0% in 2011).

6.6 SITE VAG04 – RIVER VAGASTIE ABOVE CATCHWATER (30/08/12)

6.6.1 Site Description

This site is located approximately 40 metres above the catchwater on the Allt Bealach an Fhuarain (NC 5180 2715). Under normal flow conditions 100% of the water from this burn is directed into the catchwater canal, after which it flows into the River Shin catchment, via the River Tirry. This site was added to the existing Vagastie sites to help assess the impacts of the catchwater on the passage of adult salmon. A photograph of the survey site (upstream view) is presented in **Figure 6-26** below.

Figure 6-26 Photograph of electric fishing site VAG04 taken in 2012 (upstream view)

The riparian land on both banks consists of moorland heath grazed by wild red deer. In contrast to the lower reaches of the river, mature old growth alders are absent.

The bank face and bank top vegetation on both banks were described as being 'simple', i.e. predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc).

Prior to commencement of the survey the site was described as having 'excellent' in-stream cover and the water level was recorded as being 'medium' height and 'clear'. Both upstream

and downstream stop nets were used together with a combination of banner and hand nets.

A summary of the key in-stream physical habitat characteristics recorded are summarised in **Table 20** below and compared to the requirements of both fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 20 Summary of the key in-stream physical habitat characteristics recorded at VAG04 compared to the requirements of fry and parr (Hendry & Cragg-Hine, 1997).

Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	5 to 20 cm (average 12.8 cm)
Velocity	50 to 65 cm/s	60 to 75 cm/s	50 to 70 cm/s (average 60 cm/s)
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	5% gravel, 20% pebbles, 50% cobbles, 25% boulder

The range of depths recorded at the site were between 5cm and 20cm (average 12.8cm), closely matching the requirements of salmon fry. Velocities on the day of the survey varied between 50cm/s and 70cm/s (with an average of 60cm/s). This range met the requirements of both fry and parr and was significantly higher than those recorded at VAG03 just 2km below the catchwater.

The bed substrate was dominated by pebbles (20%), cobbles (50%) boulders (25%) although gravel (5%) was present in much lower proportions. This indicates that the substrate was suitable for both fry and parr.

The physical habitat characteristics at the site indicate that it is suited to the requirements of both salmon fry and parr. As such, at least 'good' densities of each would be expected in this reach of the burn if free passage for adult salmon was available.

6.6.2 Atlantic Salmon

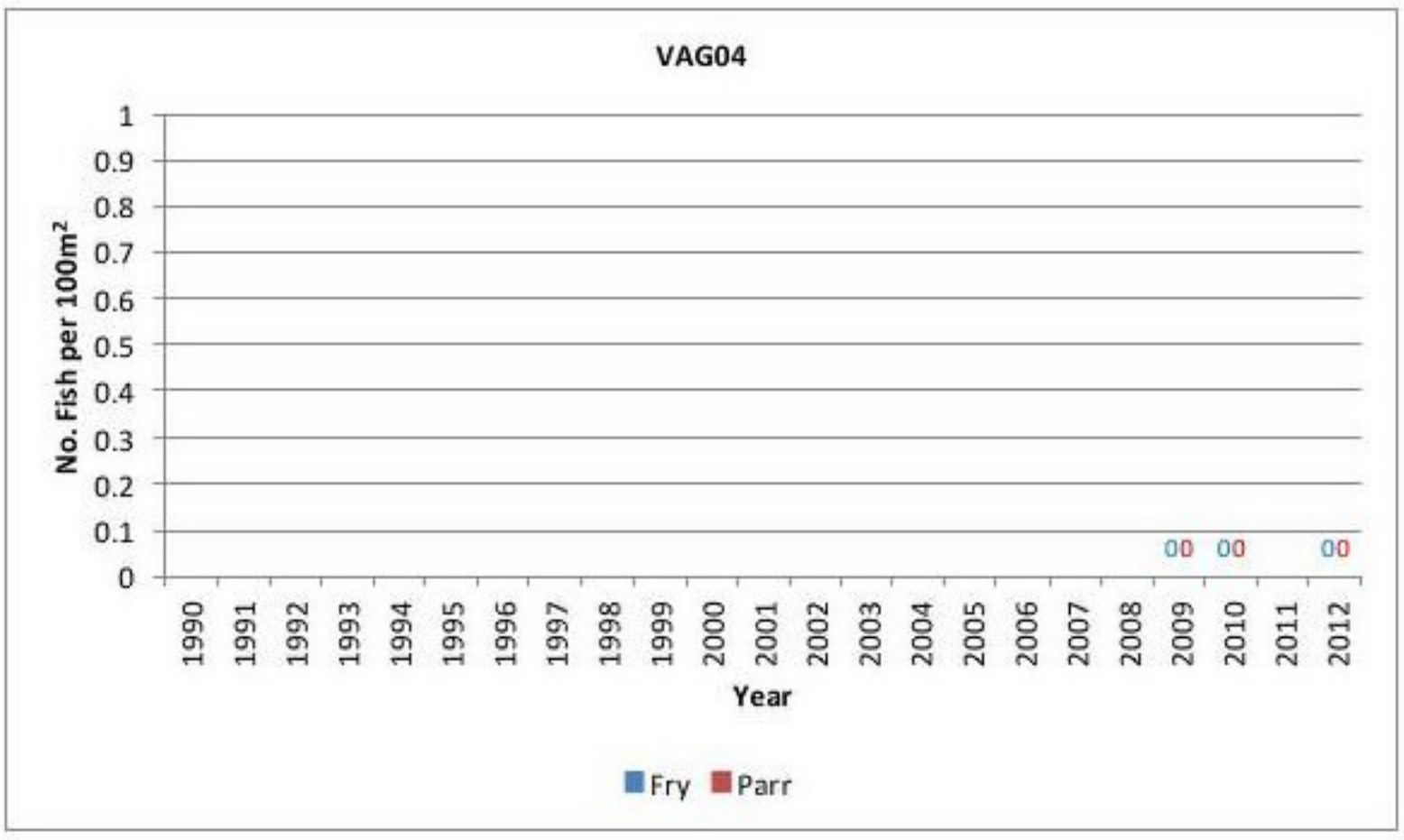
Both salmon fry and parr were found to be absent at site VAG04 in 2012 (see **Table 21** below). This was expected given the fact that the site is located above an impassable barrier to salmon.

Table 21 Observed 2012 salmon densities at site VAG04 above the catchwater on the River Vagastie

Age	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+	0	0	-	-	0	0.000	0.000	F – Absent
1+	0	0	-	-	0	0.000	0.000	F – Absent
Total	0	0	-	-	0	0.000	0.000	
Number Salmon Missed					0 (0)			

A comparison with the results of surveys in previous years (see **Figure 6-27** below) indicates 'absent' fry and parr classifications at this site are normal. Even if low numbers of adult salmon were able to negotiate the catchwater under certain water conditions, any resulting smolts would migrate downstream into the Shin catchment rather than the Naver catchment.

Figure 6-27 Densities of salmon fry and parr recorded at the site above the catchwater on the River Vagastie VAG04

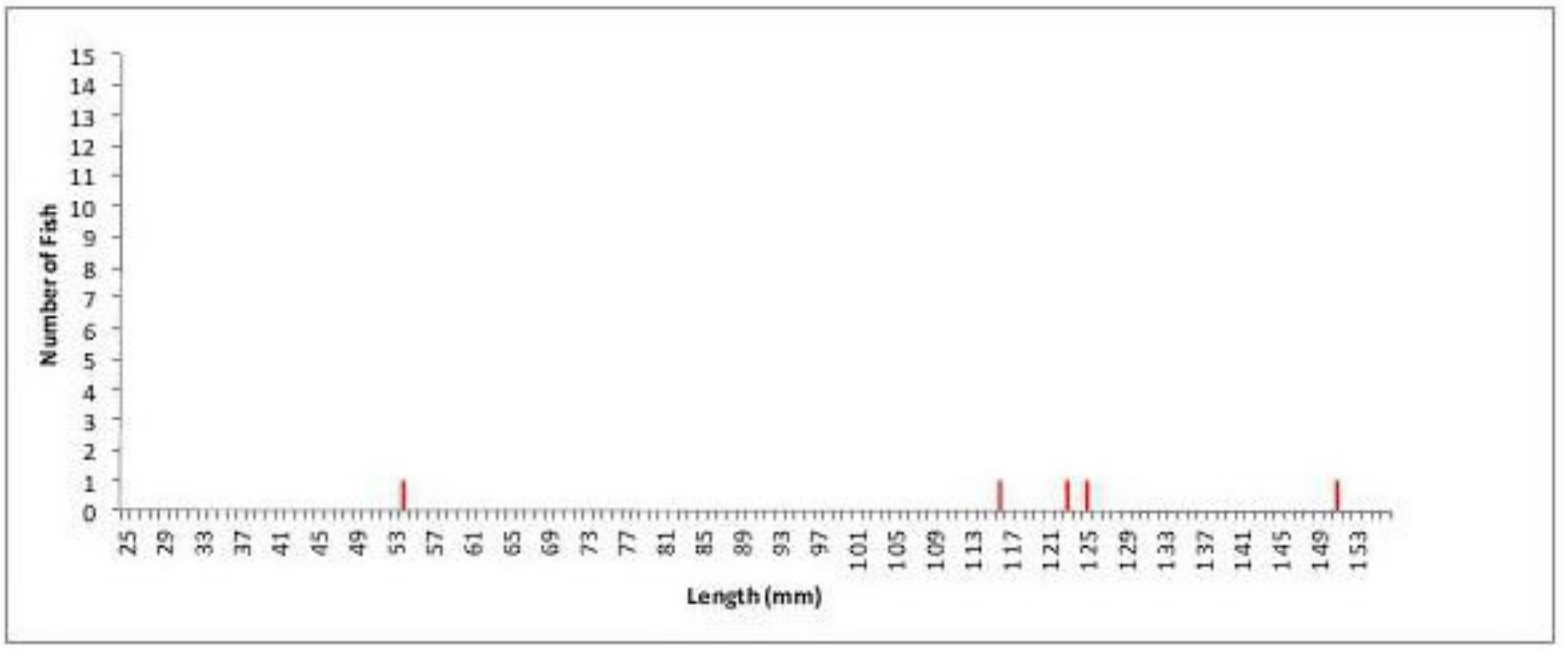


6.6.3 Brown/Sea Trout

Trout recorded at the site in 2012 were found to range between 54mm to 151mm in length and are thought to represent three year classes of fish (see **Figure 6-28** below). The 54mm fish was the only representative of the 0+ year class, indicating that trout spawning was

limited at the site in 2011.

Figure 6-28 Length frequency histogram for brown trout/sea trout captured during the 2012 survey at VAG04



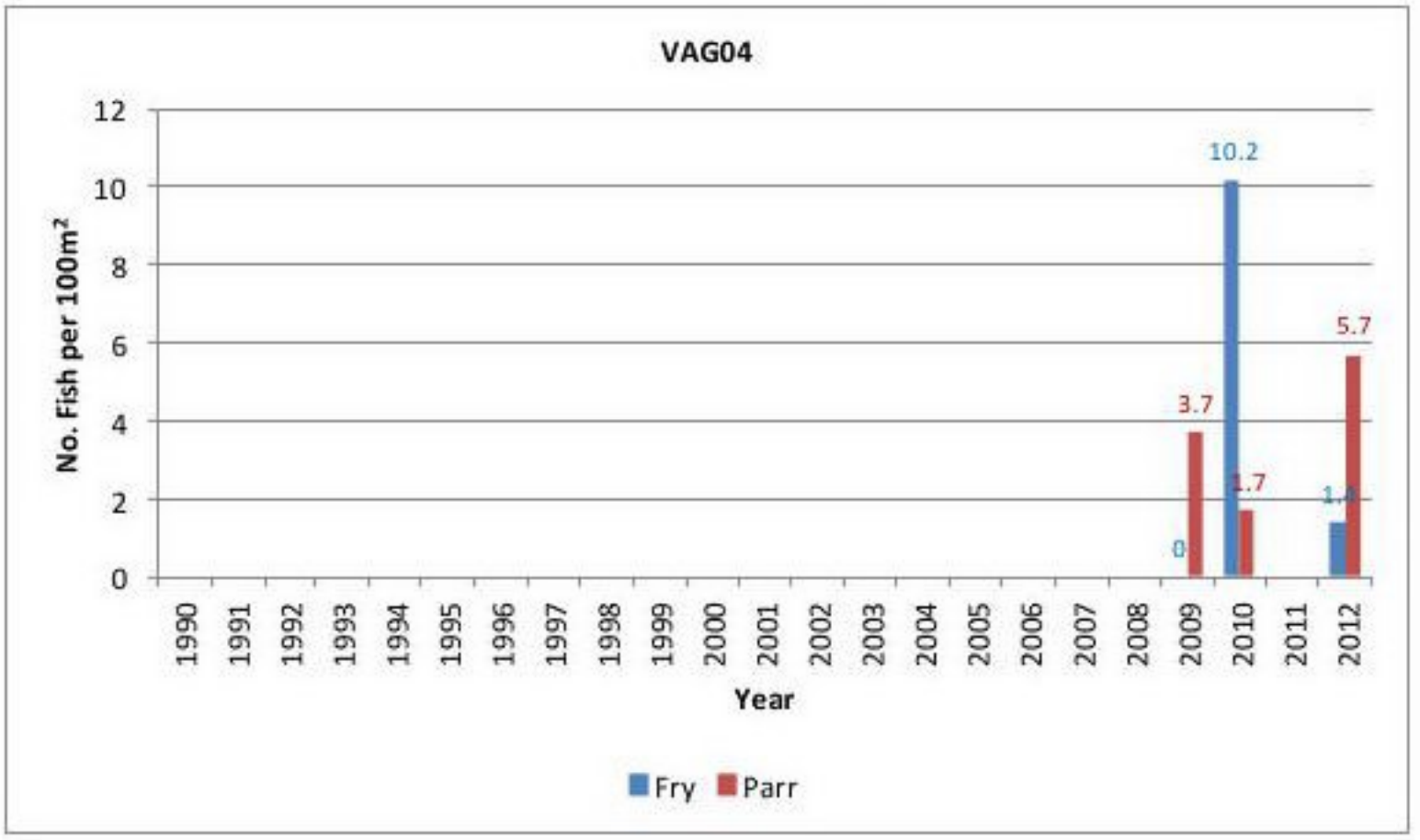
The minimum trout fry density recorded at VAG04 in 2012 was 1.4 per 100m^2 ('very poor' classification), with parr densities being recorded at 5.7 per 100m^2 ('good' classification) (see **Table 22** below).

Table 22 Observed 2012 trout densities at site VAG04 above the catchwater on the River Vagastie

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	1	0	-	-	1	-	1.412	E – 'Very Low'
1+ (parr)	4	0	-	-	4	-	5.650	A – 'Good'
Total	5	0	-	-	5	-	7.062	
Number Salmon Missed					2 (7)			

A comparison of the total densities of trout recorded at site VAG04 between 2009 and 2012 are presented in **Figure 6-29** below.

Figure 6-29 Densities of brown trout/sea trout recorded at site VAG04 above the catchwater on the Vagastie (2009 to 2012)

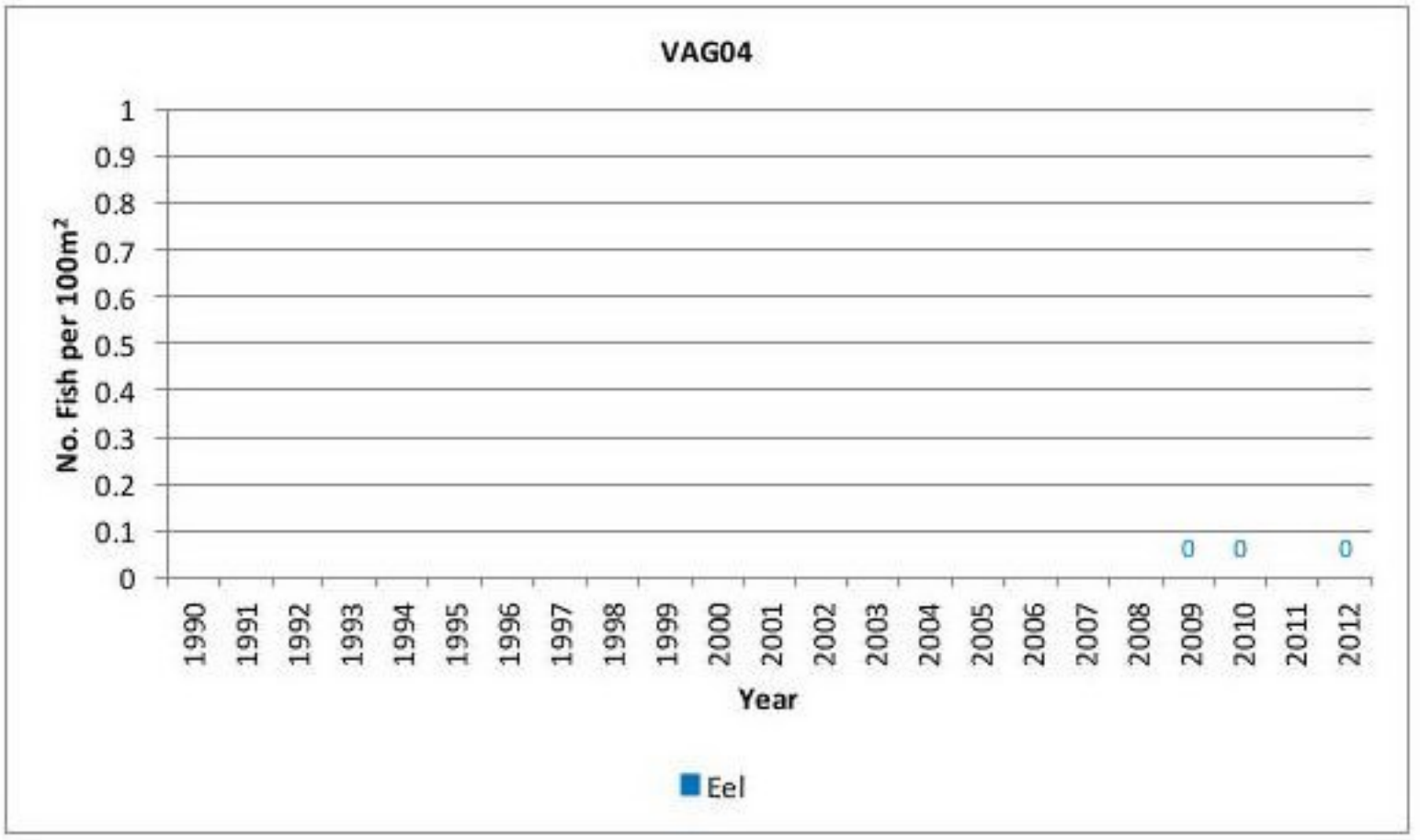


The densities of trout fry recorded in 2012 (1.4 fish per 100m^2) were significantly lower than in 2010 (10.2 fish per 100m^2) but higher than in 2009 (0 fish per 100m^2). Trout parr densities recorded at the site in 2012 (5.7 fish per 100m^2) were the highest since the site was first surveyed in 2009. Overall, the trout densities at the site have varied considerably from year to year.

6.6.4 European Eel

Eels were found to be absent from site VAG04 in 2012, as has been the case each time a survey was completed (see **Figure 6-30** below). This suggests that the area above the catchwater is inaccessible to eels.

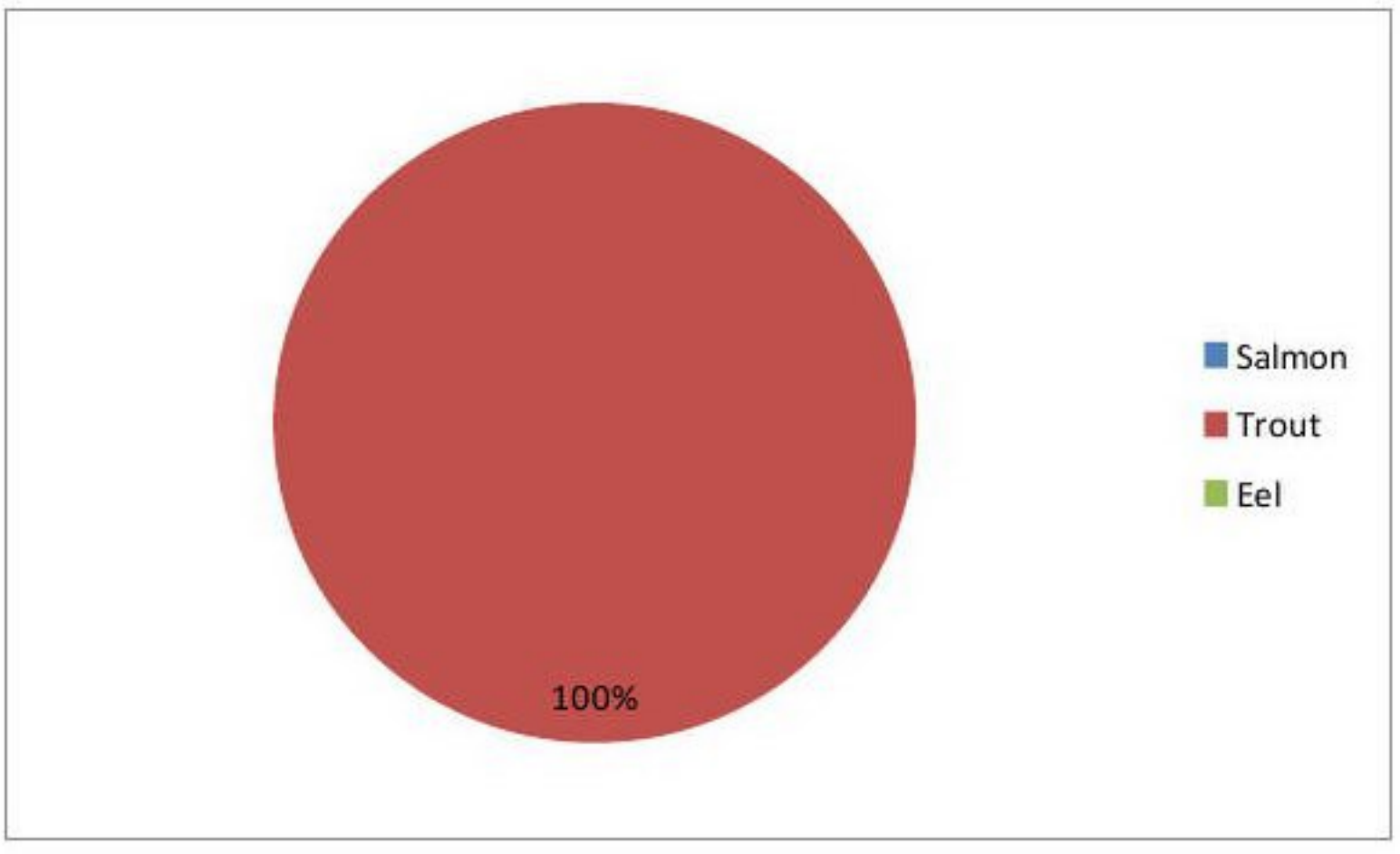
Figure 6-30 Minimum densities of eels recorded during juvenile salmon surveys at site VAG04 (2009 – 2012)



6.6.5 Species Composition

Although juvenile salmon were found to be absent at the site, five trout were found to be present, making up 100% of the total species composition (see **Figure 6-31** below).

Figure 6-31 Proportion of each fish species (percentage) present at site VAG04



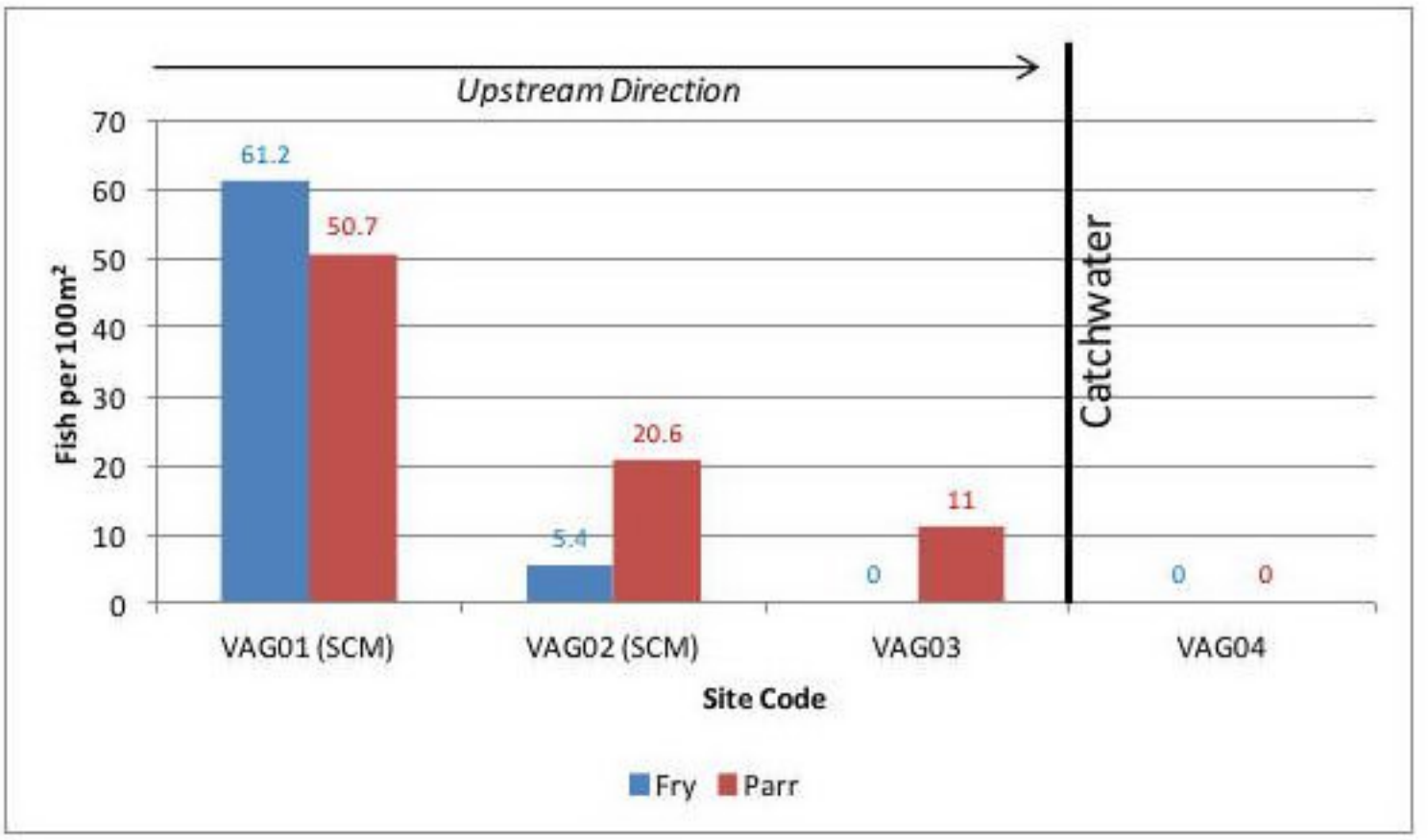
These trout are unlikely to have evolved as part of a glacial relic population because access to this section of burn would have been unobstructed until the 1950's when the catchwater was built. Nonetheless, they could now be described as being an enclosed population.

6.7 SUMMARY

- A man made 'catchwater' structure across the upper Vagastie diverts water into the neighbouring Shin catchment (via the River Tirry) as part of the Loch Shin Hydropower Scheme. This presents a physical barrier to the upstream and downstream migration of fish in the Vagastie, reduces downstream flows and changes flood flow characteristics.

- The results of the 2012 electric fishing surveys on the Vagastie catchment indicate that the densities of both salmon fry and parr decrease with distance travelled upstream towards the catchwater (see **Figure 6-32** below).

Figure 6-32 Densities of salmon fry and parr recorded at sites along the Vagastie



- The lowest site on the Vagastie catchment (VAG01 SCM) was found to support 'excellent' densities of both salmon fry (61.2 per 100m^2) and parr (5.7 per 100m^2). Parr densities at the site in the middle reaches (VAG02 SCM) were also classed as 'excellent' (20.6 per 100m^2); however fry densities fell to a 'poor' classification (5.4 per 100m^2) indicating low spawning success.

- Salmon parr densities at the site in the upper reaches of the Vagastie below the catchwater (VAG03) fell to a 'good' classification (11.0 per 100m^2); however fry were found to be 'absent'. An absence of entire year classes of fish at this site over successive years suggests that it is particularly sensitive to changes in environmental conditions, most likely due to the effects of low flows resulting from the catchwater.

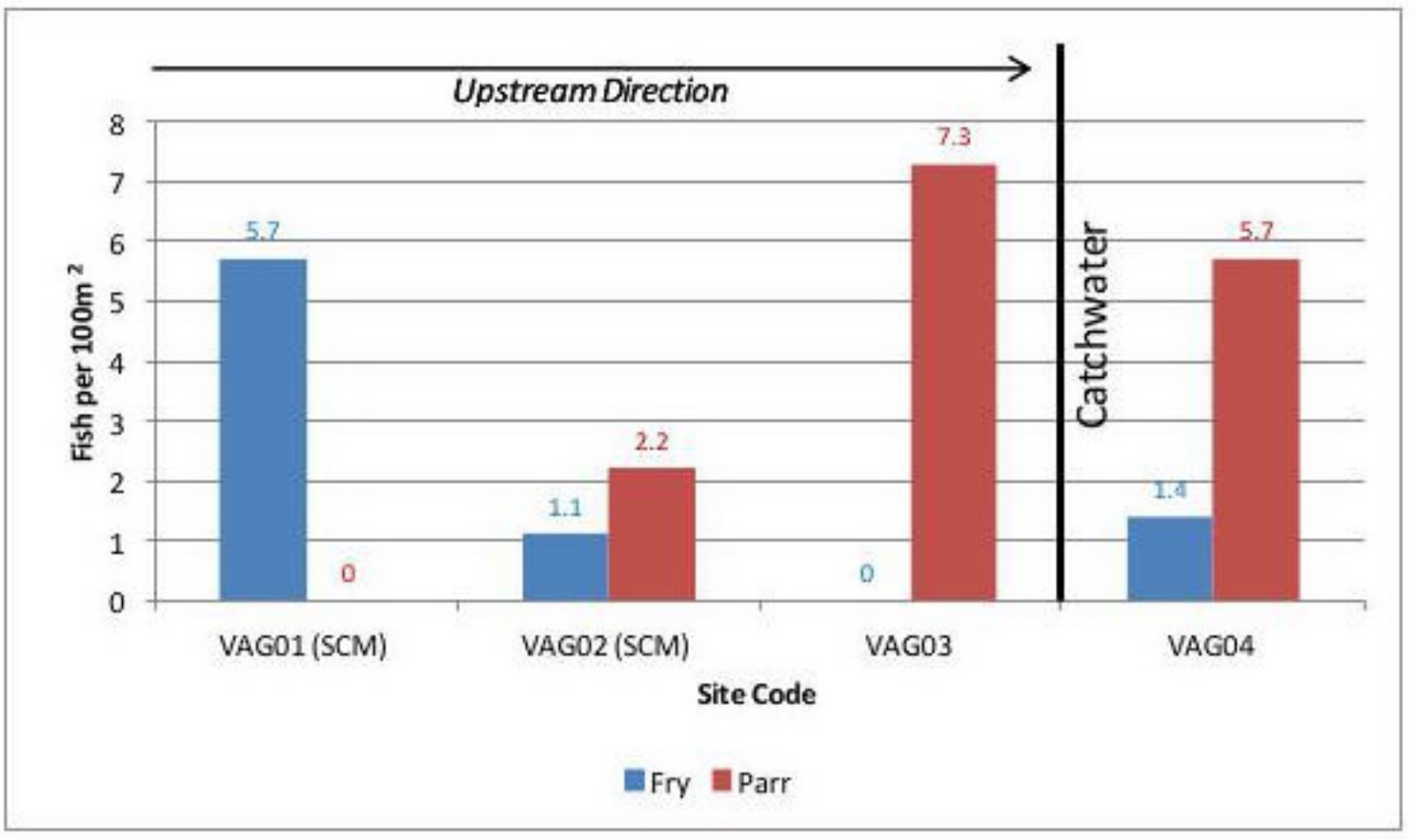
- Both salmon fry and parr were found to be absent from the site above the catchwater (VAG04). A comparison with the results of surveys in previous years indicates that this is normal and that the structure is impassable to salmon.

- Despite the effects of the catchwater, there has been an overall trend for increasing salmon parr densities at sites on the Vagastie in recent years. The average densities of salmon fry recorded across all sites on the River Vagastie in 2012 was 16.7 per $100m^2$ ('moderate' classification) with the average density of parr being 20.6 per $100m^2$ ('excellent' classification).

- The average density of salmon fry recorded across all sites on the Vagastie in 2012 was 16.7 per $100m^2$ ('moderate' classification), with the average density of parr being 20.6 per 100^2 ('excellent' classification).

- The results of the 2012 electric fishing surveys on the Vagastie catchment indicate that the densities of trout fry decrease with distance travelled upstream towards the catchwater, with the opposite true for trout parr which increase towards the catchwater (see **Figure 6-33** below).

Figure 6-33 Densities of trout fry and parr recorded at sites along the Vagastie



- The lowest site on the Vagastie catchment (VAG01 SCM) was found to support 'moderate' densities of trout fry (5.7 per $100m^2$). This decreased to 'very poor' densities in the middle reaches at VAG02 SCM (1.1 per $100m^2$), with fry being 'absent' at VAG03 directly below the catchwater. Fry densities increased once again above the catchwater,

although only achieving a 'very poor' classification (1.4 per 100m^2).

- Trout parr were found to be absent at the lowest site on the Vagastie (VAG01 SCM), rising to 'poor' densities in the middle reaches at VAG02 SCM (2.2 per 100m^2) and 'excellent' densities at VAG03 directly below the catchwater (7.3 per 100m^2). Densities fell slightly above the catchwater (5.7 per 100m^2), although still achieving a 'good' classification.

- Despite the effects of the catchwater, there has been an overall trend for increasing salmon parr densities at sites VAG02 (SCM), VAG03 and VAG04 on the Vagastie in recent years. Parr densities at site VAG01 (SCM) have varied considerably from year to year although remaining relatively low.

- The average densities of trout fry recorded across all sites on the River Vagastie in 2012 was 2.1 per 100m^2 ('very poor' classification), with the average density of parr being 3.8 per 100m^2 ('moderate' classification).

- Eels were found to be present at all sites below the catchwater but absent above it, suggesting that the structure creates a barrier to the upstream passage of eels. Densities varied from a high of 2.2 per 100m^2 at site VAG02 (SCM) to a low of 1.0 per 100m^2 at site VAG01 (SCM). The average density of eels recorded across all sites on the River Vagastie in 2012 was 1.1 per 100m^2.

7 RIVER TIRRY

7.1 INTRODUCTION

The River Tirry arises 10km south of Altnaharra and travels approximately 20km south before flowing into Loch Shin. Although it does not naturally form part of the Naver Catchment, the Tirry receives water from the River Vagastie as part of a water transfer scheme.

In the 1950s, the level of Loch Shin was raised by over 10 metres by the construction of Lairg Dam as part of a hydro-electric scheme. As part of this scheme a structure was built across the upper Vagastie catchment to divert water into the Shin catchment via the Allt an Locha Ghaineamhaich (see **Figure 7-1** below).

Figure 7-1 Confluence of Allt an Locha Ghaineamhaich (left) carrying water from the Vagastie into the River Tirry (right) (upstream view)

Water transferred from the Vagastie contributes a significant proportion of the flow in the Allt an Locha Ghaineamhaich (see **Figure 7-2** below) and to the main River Tirry directly downstream of its confluence with the Tirry.

Figure 7-2 Allt an Locha Ghaineamhaich (in foreground) at the point that it joins the flow from the Vagastie (larger water body in background) (downstream view)

Migratory salmonid populations on the Tirry have been significantly reduced since the construction of the Lairg Dam. Returns of adult salmon over the structure are estimated at 100 to 150 fish per year (Richard Sankey (KSFB), *per comms*) and problems with smolt escapement have been identified. As a result the catchment is subject to stocking and smolt relocation programmes. Other significant pressures in the Tirry catchment include those associated with the presence of coniferous forestry blocks and their clearance.

A number of long-term Kyle of Sutherland Fisheries Trust (KSFT) electric fishing survey sites exist on the River Tirry. This baseline assessment considers the nearest existing sites above and below the influence of the River Vagastie.

7.2 SITE ST05 – RIVER TIRRY (DOWNSTREAM OF VAGASTIE INPUT) (13/09/07)

7.2.1 Site Description

This long-term monitoring site is located approximately 16km below the confluence of the Allt an Locha Ghaineamhaich (carrying water from the Vagastie) with the River Tirry (NC 5738 1339). A photograph of the survey site (downstream view) is presented in **Figure 7-3** below.

Figure 7-3 Photograph of electric fishing ST05 taken in 2013 (downstream view)

The bank face and bank top vegetation on both banks were described as 'simple', i.e. predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc).

Prior to commencement of the survey the site was described as having 'good' in-stream cover, with the water level being 'low' and 'clear'. The key in-stream physical habitat characteristics recorded at the site are summarised in **Table 23** below and compared to the requirements of both salmon fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 23 Summary of the key in-stream physical habitat characteristics recorded at ALT01 compared to the requirements of salmon fry and parr (Hendry & Cragg-Hine, 1997).

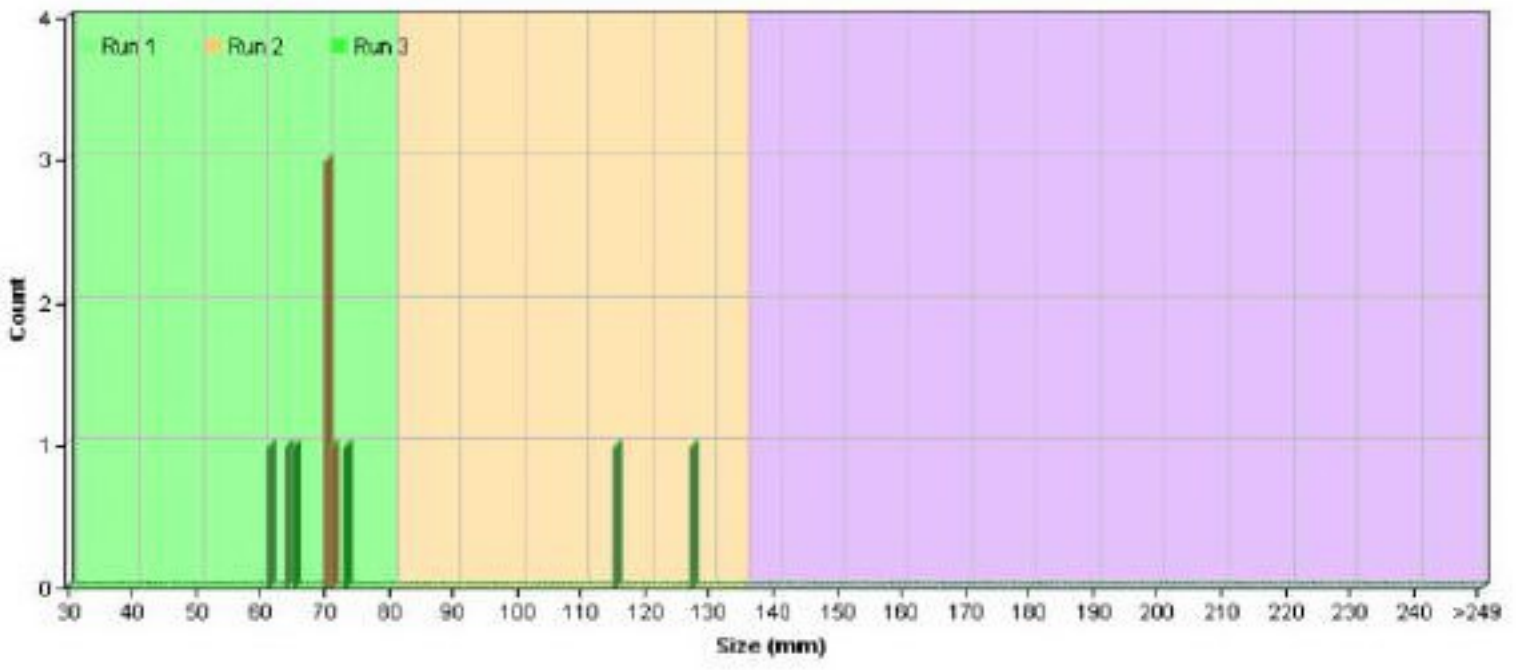
Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	-
Velocity	50 to 65 cm/s	60 to 75 cm/s	-
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	40% silt, 20% gravel, 40% Pebble

Neither the water depth nor velocity was recorded on the day of the survey. The substrate at the site was found to consist of relatively high proportions of gravel (20%) and pebble (40%), indicating that it had the potential to provide good spawning and fry habitat, with parr habitat limited. Silt was also recorded in high proportions (40%) which may act to limit spawning success.

7.2.2 Atlantic Salmon

The length frequency histogram for ST05 (see **Figure 7-4** below) indicates the presence of two year classes of juvenile salmon in 2007.

Figure 7-4 Length frequency histogram for juvenile salmon captured during the 2007 survey at ST05



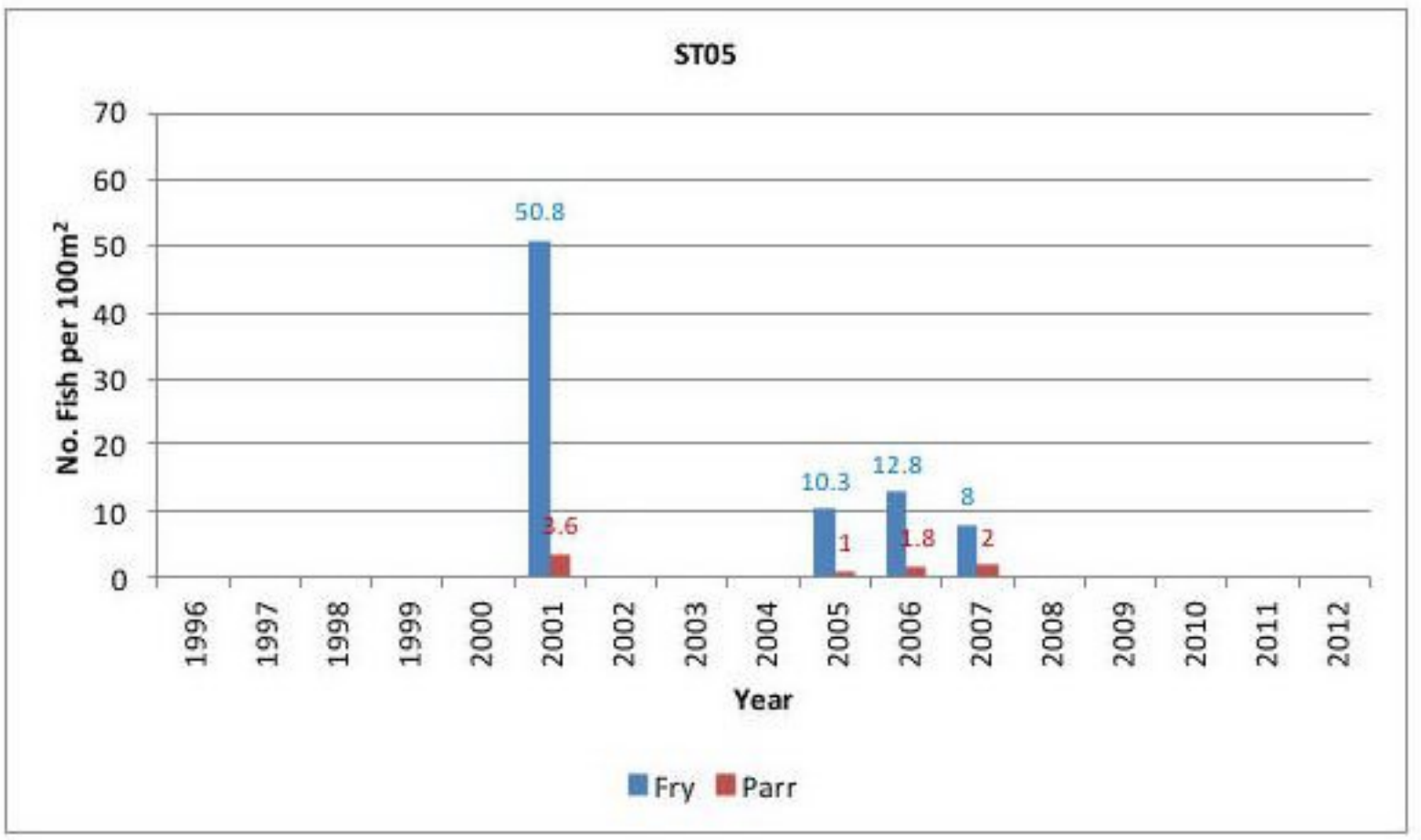
The minimum salmon fry density recorded at ST05 in 2007 was 8 per 100m^2 ('poor' classification), with a parr density of 2 per 100m^2 also being recorded ('very poor' classification) (see **Table 24** below).

Table 24 Observed 2007 salmon densities in the River Tirry at site below the confluence of the Allt an Locha Ghaineamhaich (ST05)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	2	4	2	-	8	-	8.003	A - 'Poor'
1+ (parr)	2	0	0	-	2	-	2.001	B - 'Very Poor'
Total	4	4	2	-	10	-	10.004	
Number Salmon Missed					-			

The results of surveys completed between 2001 and 2007 indicated that both salmon fry and parr were consistently present at the site (see **Figure 7-5** below). The highest fry densities were recorded in 2001 (50.8 per 100m^2 'excellent' classification). Since then fry densities have only achieved 'moderate' to 'poor' classification. Salmon parr densities have been consistently low, ranging from 3.6 per 100m^2 ('poor' classification) in 2001 to 1.0 per 100m^2 ('very poor' classification) in 2006.

Figure 7-5 Minimum densities of salmon fry and parr recorded at site ST05 below the confluence of the Allt an Locha Ghaineamhaich (2001 to 2007)

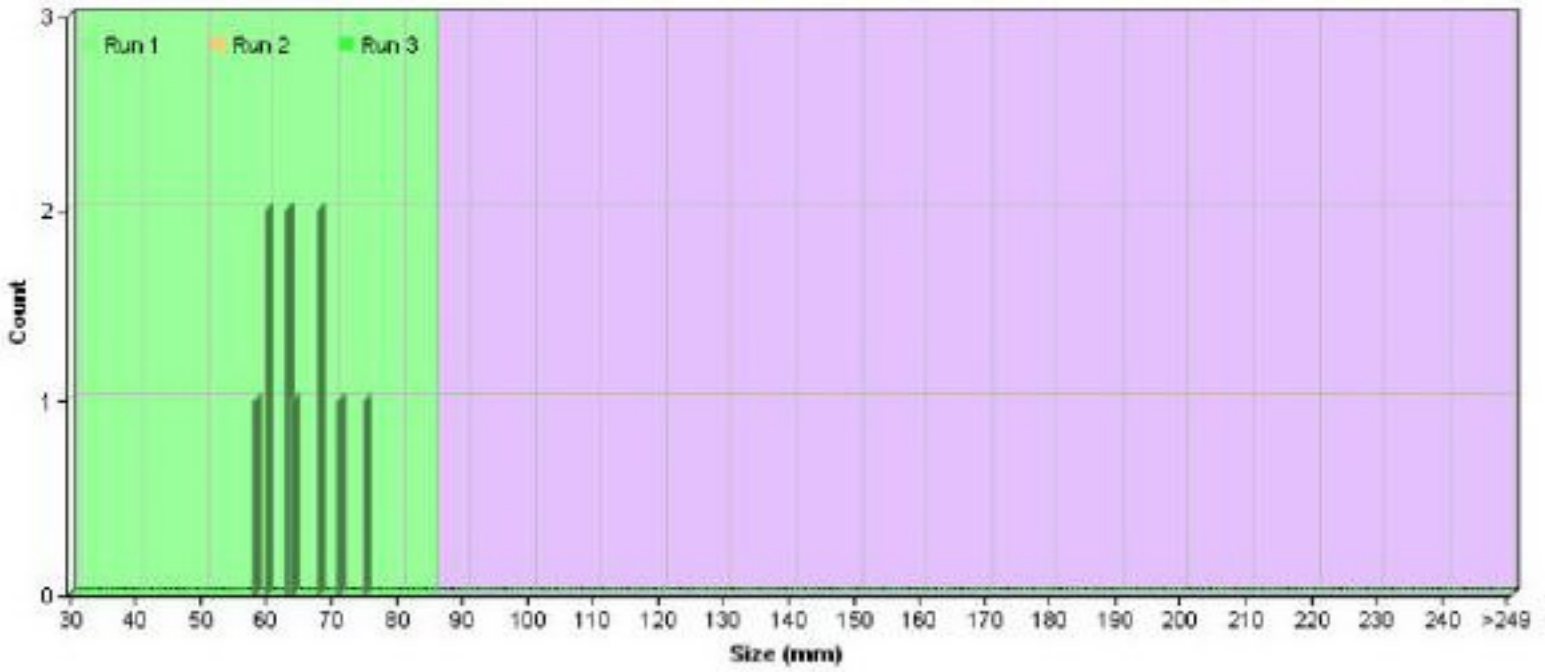


This section of the River Tirry has not been subject to stocking since at least 2005 and so the densities of fry and parr recorded since then are likely to be indicative of natural recruitment. It is possible that the site was stocked prior to 2001 (accounting for the higher than average fry densities); however the stocking records for this period were not available.

7.2.3 Brown/Sea Trout

Trout recorded at site ST05 in 2007 ranged between 58mm and 75mm in length and fell within the 0+ year class fish (see **Figure 7-6** below). This is an indication that wild trout spawn in this reach of the river, with the resulting fry having a relatively high growth rate.

Figure 7-6 Length frequency histogram for juvenile trout captured during the 2007 survey at ST05



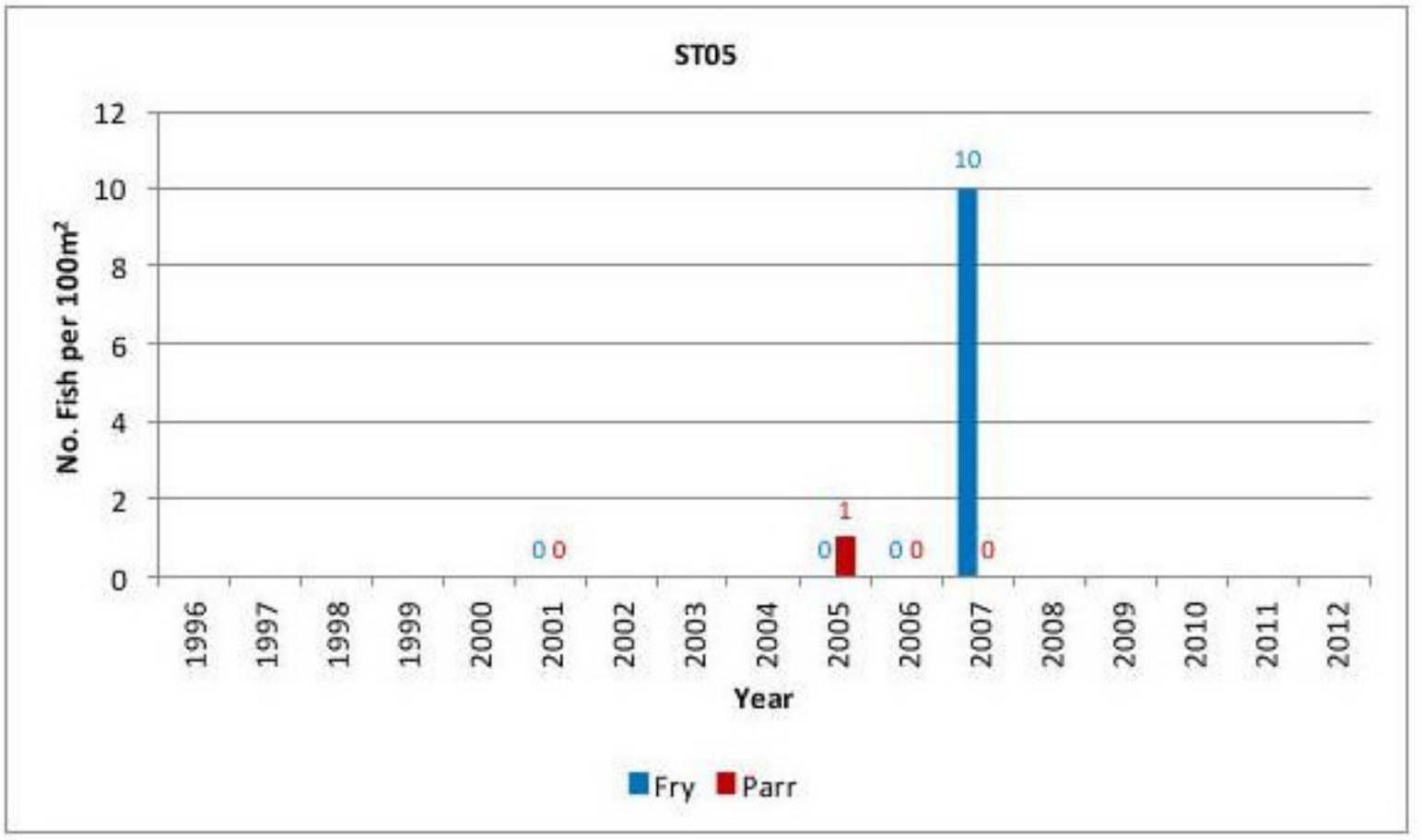
The minimum trout fry density recorded at ST05 in 2012 was 10 per 100m^2 ('excellent' classification), with parr being 'absent' from the site (see **Table 24** below). The lack of 1+ year old fish at the site may be due to the close proximity of the site to Loch Shin, into which they are likely to migrate.

Table 24 Observed 2007 salmon densities in the River Tirry at site below the confluence of the Allt an Locha Ghaineamhaich (ST05)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	10	0	0	-	**10**	-	**10.004**	**B - 'Excellent'**
1+ (parr)	0	0	0	-	**0**	-	**0**	**F – 'Absent'**
Total	**10**	**0**	**0**	-	**10**	-	**10.004**	
Number Salmon Missed					-			

A comparison of the total densities of trout recorded at site ST05 from 2001 to 2007 is presented in **Figure 7-7** below.

Figure 7-7 Minimum densities of trout fry and parr recorded at site ST05 below the confluence of the Allt an Locha Ghaineamhaich (2001 to 2007)

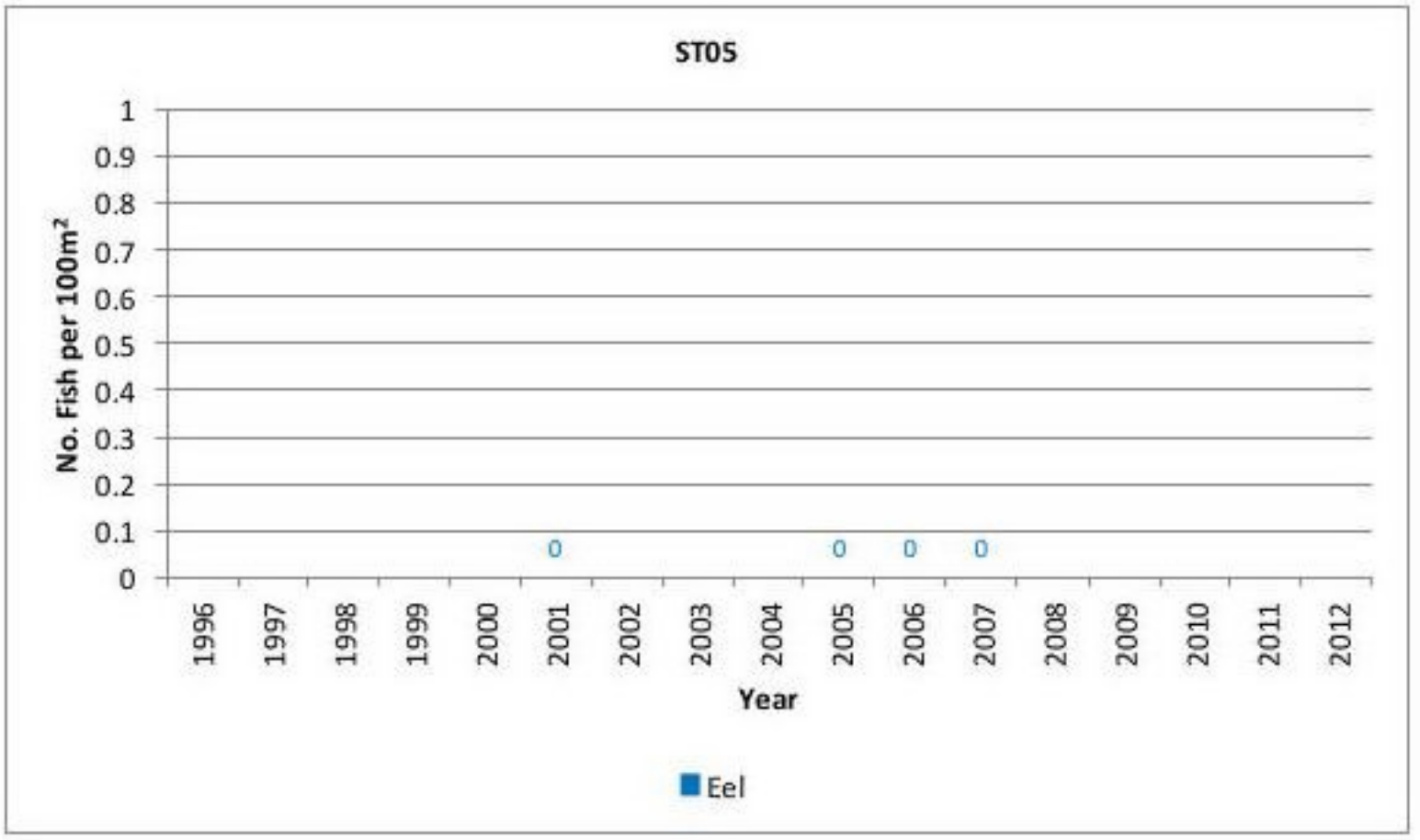


Trout fry were found to be 'absent' from the site each year other than 2007. The reason for the sudden improvement in 2007 is unknown and may be a 'one-off'. Trout parr were recorded at the site in 'very poor' densities during the survey in 2005, but were found to be 'absent' in the other years that it was surveyed. This suggests that trout densities at the site are naturally low.

7.2.4 European Eel

No eels were recorded at site ST05 between 2001 and 2007. This suggests that they are either present in naturally low numbers or unable to negotiate structures downstream from the site such as the Lairg Dam (see **Figure 7-8** below).

Figure 7-8 Minimum densities of eels recorded during juvenile salmon surveys at site ST05 (2001 – 2007)



7.2.5 Species Composition

Ten salmon and ten trout were recorded at the site, together with between 11 and 100 minnows. This means that minnows were the dominant species with salmon and trout recorded in equal numbers.

7.3 SITE ST06 - RIVER TIRRY (UPSTREAM OF VAGASTIE INPUT) (27/08/012)

7.3.1 Site Description

This survey site is located approximately 1km above the confluence of the Allt an Locha Ghaineamhaich (carrying water from the Vagastie) with the River Tirry (NC 5231 2450). The reach directly above this site is supported by the introduction of hatchery bred salmon fry. A photograph of the survey site (upstream view) is presented in **Figure 7-9** below.

Figure 7-9 Photograph of electric fishing site ST06 in 2013 (upstream view)

The bank face and bank top vegetation on both banks were described as 'simple', i.e. predominantly 2-3 vegetation types, with or without scrub or trees, but including tall or short herbs (e.g. grass and nettles etc).

Prior to commencement of the survey, the site was described as having 'good' in-stream cover with the water level being 'medium' in height and 'clear' in colour. The key in-stream physical habitat characteristics recorded at the site are summarised in **Table 25** below and compared to the requirements of both fry and parr as determined by Hendry & Cragg-Hine (1997).

Table 25 Summary of the key in-stream physical habitat characteristics recorded at ST06 compared to the requirements of fry and parr (Hendry & Cragg-Hine, 1997).

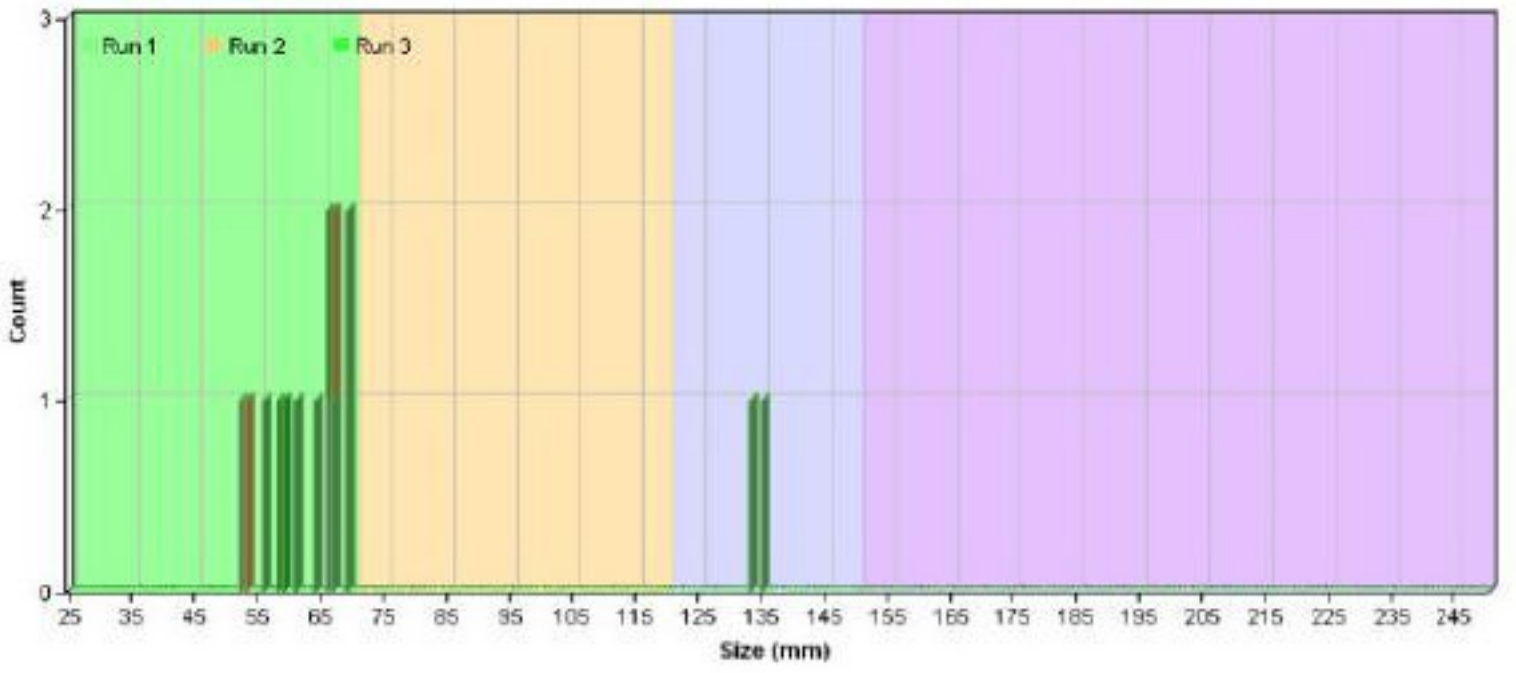
Habitat Characteristic	Fry Requirements	Parr Requirements	Site Conditions
Water Depth	≤20 cm	20 to 40 cm	-
Velocity	50 to 65 cm/s	60 to 75 cm/s	-
Substrate	Gravels and cobbles (16 to 256 mm)	Cobble up to Boulder (64 to 256 mm)	10% gravel, 20% pebble, 30% cobble and 40% boulder

Neither the water depth nor velocity was recorded on the day of the survey. The substrate was found to be dominated by cobbles (30%) and boulders (40%), providing excellent salmon parr habitat. Fry habitat was also present in the form gravel (10%) and pebble (20%).

7.3.2 Atlantic Salmon

The length frequency histogram for ST06 (see **Figure 7-10** below) indicates that two year classes of fish were present at the site in 2012. The strongest was the 0+ year class, with the 1+ year class absent and low numbers present in the 2+ year class.

Figure 7-10 Length frequency histogram for juvenile salmon captured during the 2012 survey at ST06



The 0+ year old fish ranged between 52mm and 70mm in length. This is an indication that salmon fry in this reach of the river have relatively high growth rates. The 1+ year class of fish were found to be absent, with very low numbers of 2+ fish present at the site. This suggests that juvenile survival at this site is low.

Minimum salmon fry densities at ST06 were found to be 12.3 per 100m^2 indicating that it supports 'moderate' populations of salmon fry (see **Table 26** below). Parr densities were found to be 1.9 per 100m^2 indicating that it supported 'very poor' populations of salmon parr.

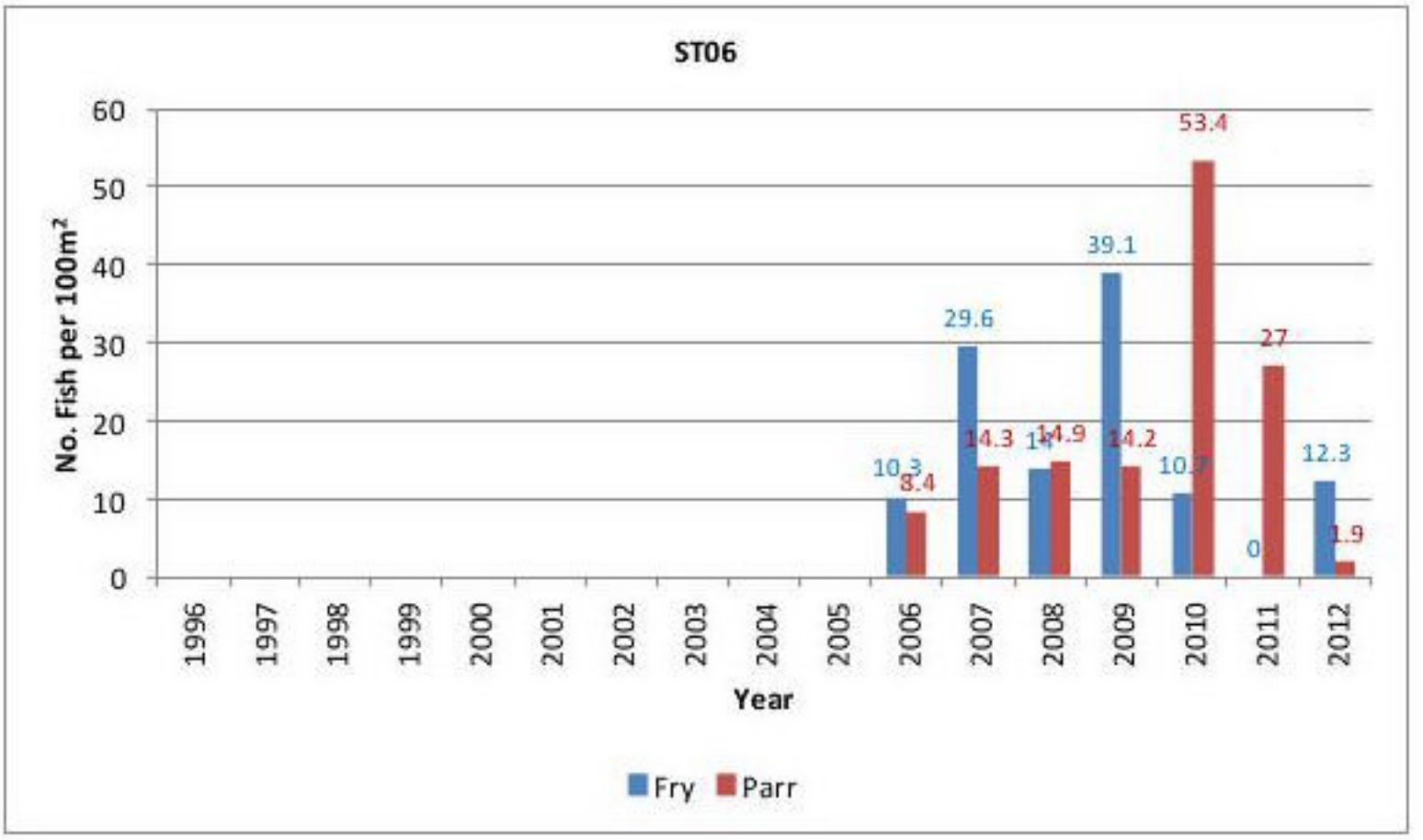
Table 26 Observed 2012 salmon densities in the River Tirry at site above the confluence of the Allt an Locha Ghaineamhaich (ST06)

Age	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+	8	2	3	-	13	13.258	12.311	C – ' Moderate'
1+	2	0	0	-	2	-	1.894	E – 'Very Poor'
Total	10	2	3	-	15	13.258	14.205	
Number Salmon Missed					-			

The results of previous surveys at the site (see **Figure 7-11** below) indicate that the densities of fry recorded have varied considerably, from 39.1 per 100m^2 ('good' classification) in 2009 to being completely absent in 2011. A similar pattern is seen in the salmon parr densities which ranged from a high of 53.4 per 100m^2 ('excellent' classification) in 2010 (following high fry densities in the previous year) to a low of 1.9 per 100m^2 ('very poor' classification) in 2012 (following an absence of fry in 2011).

The variability in densities is most likely to be a result of the introduction of hatchery bred fry upstream of the site. The nearest stocking site is located just upstream of the road bridge approximately 100m upstream of ST06 (Hugh Mackenzie KSDSFB, *per comms*). If this is the case then it is likely that natural densities of juvenile salmon at this site would be significantly lower.

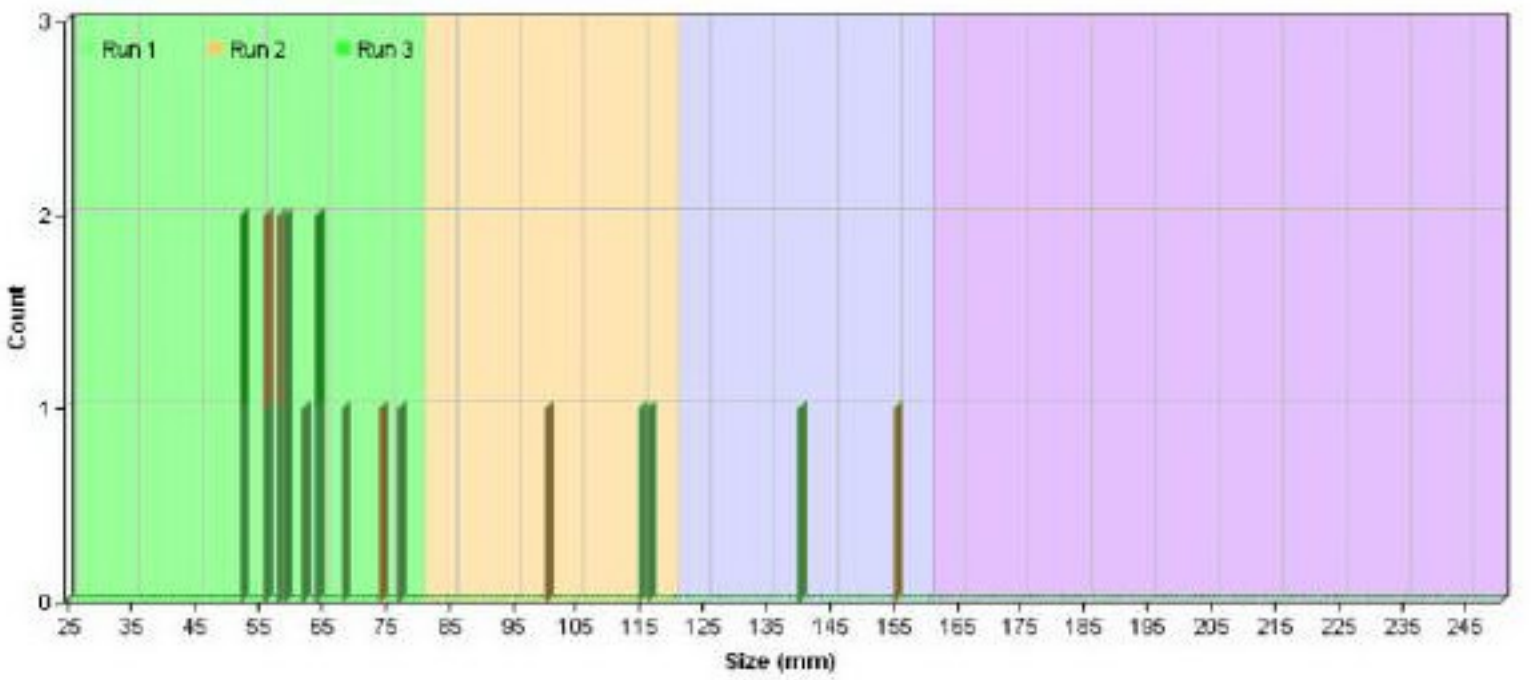
Figure 7-11 Minimum densities of salmon fry and parr recorded at site ST06 above the confluence of the Allt an Locha Ghaineamhaich (2006 to 2012)



7.3.3 Brown/Sea Trout

The majority of trout recorded at the site in 2012 ranged between 53mm and 77mm and represented the 0+ year class (see **Figure 7-12** below). This indicates that wild trout spawn in or near to the survey site and that their fry have good growth rates. Another two year classes of trout were also found to be present (1+ and 2+ years old) in lower numbers. The largest fish was a 155mm trout aged at 2+ years old.

Figure 7-12 Length frequency histogram for juvenile trout captured during the 2007 survey at ST06



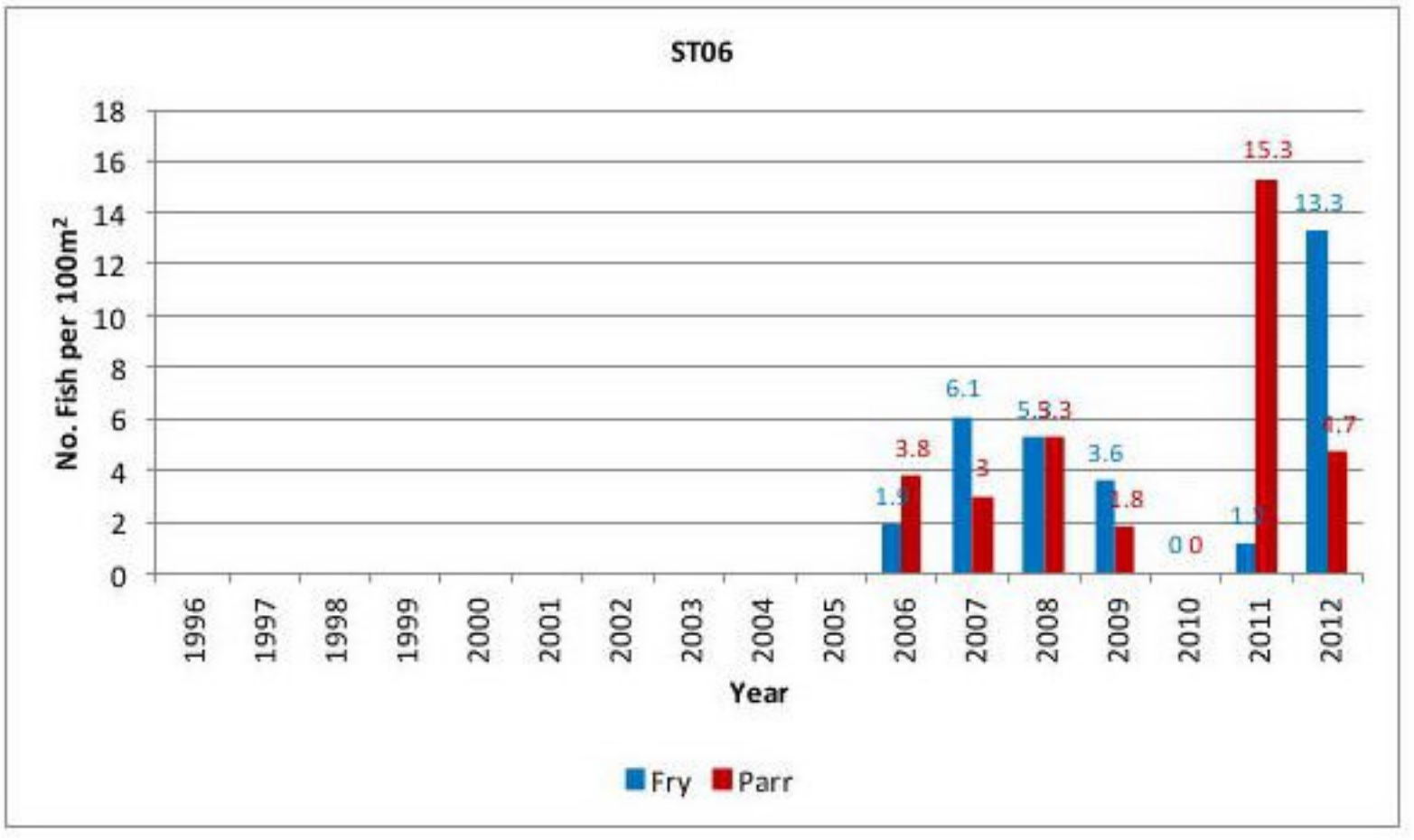
The minimum trout fry density recorded at ST06 in 2012 was 13.3 per 100m^2 ('excellent' classification), with parr densities being recorded at 4.7 per 100m^2 ('good' classification) (see **Table 27** below).

Table 27 Observed 2012 trout densities in the River Tirry at site above the confluence of the Allt an Locha Ghaineamhaich (ST06)

Age (years)	Fish Count					Density Estimate (fish per 100m^2)		Classification (based on Min. Estimate)
	Run 1	Run 2	Run 3	Run 4	Total	Carle & Strub	Minimum	
0+ (fry)	9	3	2	-	14	13.258	13.258	A - 'Excellent'
1+ (parr)	3	2	0	-	5	4.735	4.735	B – 'Good'
Total	12	5	2	-	19	17.993	17.993	
Number Salmon Missed					-			

A comparison of the densities of trout fry and parr recorded at site ST06 between 2006 and 2012 is presented in **Figure 7-13** below.

Figure 7-13 Minimum densities of trout fry and parr recorded at site ST06 above the confluence of the Allt an Locha Ghaineamhaich (2006 to 2012)



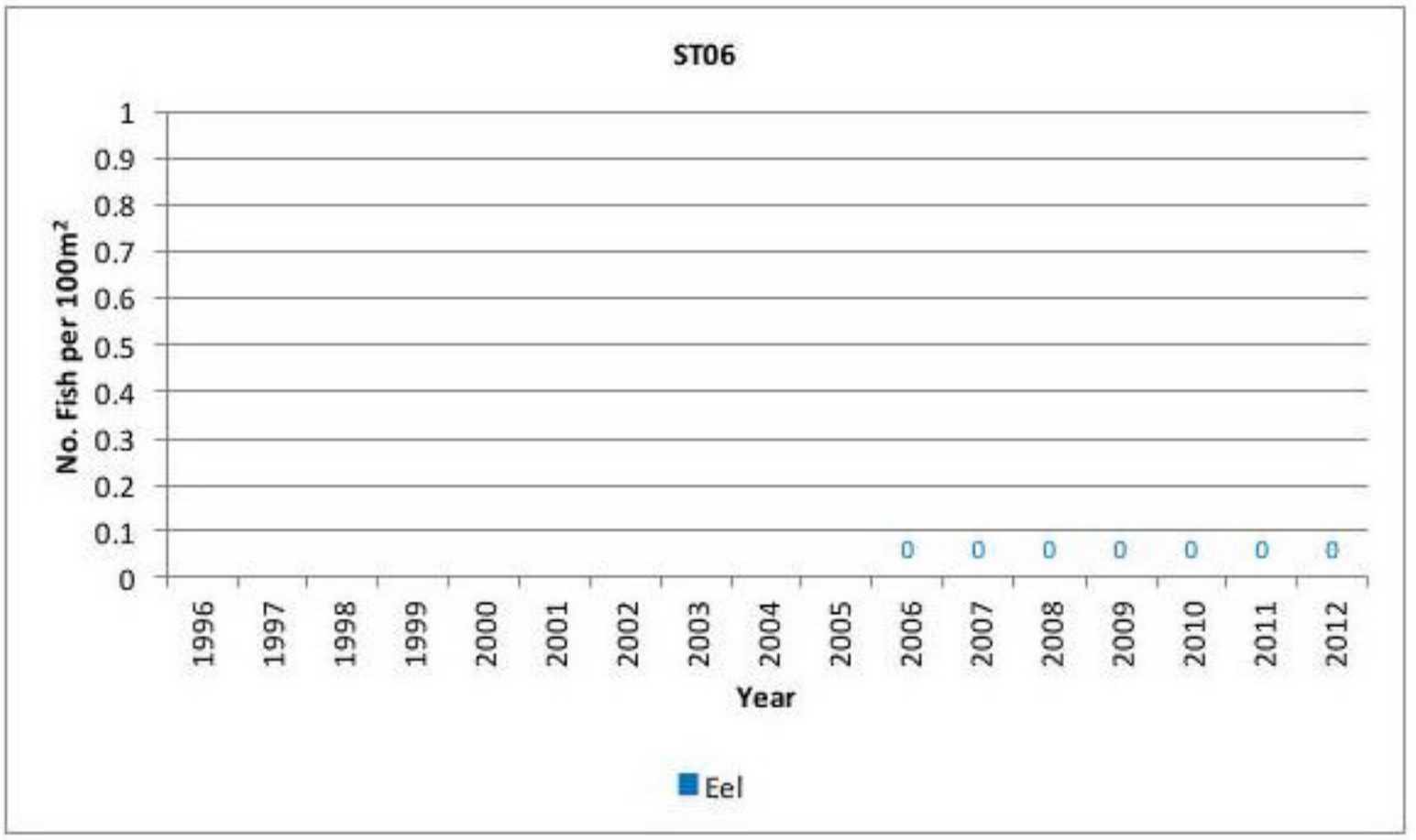
The densities of trout fry in 2012 (13.3 fish per 100m^2) were the highest recorded at the site since it was first investigated in 2006. They were also significantly higher than in 2011 when 1.2 fish per 100m^2 ('very poor' classification) were recorded and in 2010 when trout fry were found to be 'absent'. Trout parr densities in 2012 (4.7 fish per 100m^2) were above average

for the study period, but significantly lower than the 15.3 fish per 100m^2 ('excellent' classification) recorded in 2011. Trout parr were found to be 'absent' from the site in 2010. Overall, trout spawning success and survival at the site seems to be variable. This is most likely due to environmental factors such as river level or water quality.

7.3.4 European Eel

No eels were recorded at site ST05 between 2006 and 2012. This suggests that they are either present in naturally low numbers or unable to negotiate structures downstream from the site such as the Lairg Dam (see **Figure 7-14** below).

Figure 7-14 Minimum densities of eels recorded during juvenile salmon surveys at site ST06 (2006 to 2012)



7.3.5 Species Composition

Fifteen salmon and nineteen trout were recorded at the site, with no other species recorded as being present. This means that trout were the dominant species at the site.

7.4 SUMMARY

- The level of Loch Shin was raised by the construction of Lairg Dam. As part of this scheme a structure was built across the upper Vagastie catchment to divert water into the Shin catchment via the Allt an Locha Ghaineamhaich. Water transferred from the Vagastie contributes a significant proportion of the flow in the main River Tirry directly downstream of its confluence with the Tirry.

- Migratory salmonid populations on the Tirry have significantly reduced since the construction of the Lairg Dam. It presents a barrier to the upstream migration of salmon. Problems with smolt escapement have also been identified. As a result the catchment is subject to large scale stocking and smolt relocation programmes. Other significant pressures in the Tirry catchment include those associated with the presence of coniferous forestry blocks and their clearance.

- The nearest site below the confluence of Allt an Locha Ghaineamhaich with the Tirry (ST06) was last surveyed in 2007. The minimum salmon fry density recorded was 8 per $100m^2$ ('poor' classification), with a parr density of 2 per $100m^2$ ('very poor' classification). This section of the River Tirry has not been subject to stocking since at least 2005. As such the densities of fry and parr recorded since then are likely to be indicative of natural recruitment.

- Minimum salmon fry densities at the site directly above the confluence of Allt an Locha Ghaineamhaich with the Tirry (ST06) were found to be 12.3 per $100m^2$, indicating that it supports 'moderate' populations of salmon fry. Parr densities were found to be 1.9 per $100m^2$ indicating that it supported 'very poor' populations of salmon parr. The fry densities at this site are likely to be artificially increased through the introduction of hatchery bred fry approximately 100 metres upstream of the site, with natural densities being significantly lower.

- 'Excellent' densities of trout fry (10 per $100m^2$) were present at the site below the confluence (ST05) in 2007. They were found to be 'absent' in all previous years. Trout parr were only noted as being present in 2005 when 'very poor' densities were recorded (1 per $100m^2$). Both trout fry and parr were consistently present above the confluence (ST06), reaching densities of 13.3 and 4.7 per $100m^2$ respectively. Overall trout densities were found to be highly variable.

- No eels have been recorded to date at ST05 or ST06. This suggests that they are either present in naturally low numbers or unable to negotiate structures such as the Lairg Dam downstream from the site.

8 LAMPREY SPECIES

This section of the report presents a review of the available data regarding the presence and abundance of lamprey species in those watercourses that flow through, or are directly adjacent to the proposed development area.

8.1.1 Introduction

All three species of lamprey spawn in fresh waters, with the juveniles of all three species, being found within the same catchments, using similar microhabitats, but with varying geographical distribution (Harvey & Cowx, 2003). Sea lampreys are typically found in the lower reaches of rivers, while river and brook lamprey are more closely associated with the middle and upper catchment, where their ranges often overlap (Harvey & Cowx, 2003).

After hatching, the young elongate larvae, known as ammocoetes, swim or are washed downstream by the current to areas of sandy silt in still water where they burrow and spend the next few years in tunnels (Maitland, 2003). The standard methodology for sampling lamprey species involves assessment of populations of these ammocoetes.

8.1.2 Sampling Methodology

The assessment of ammocoete populations requires a different electric fishing survey technique to that used for juvenile salmonids. Following identification of a suitable survey area (optimal or sub-optimal habitat) a rigid quadrate framework with a base area of $1m^2$ is used delimit the sampling area (Harvey & Cowx, 2003).

A single electric fishing anode is used to energise the substrate area within the rigid quadrat framework, with the ammocoetes 'drawn out' their burrows by cycling the electric fishing equipment on and off for a fixed length of time (2 minutes) (Harvey & Cowx, 2003). The immobilised ammocoetes are removed using a fine-mesh hand net before being transferred to a suitable water-filled container (Harvey & Cowx, 2003).

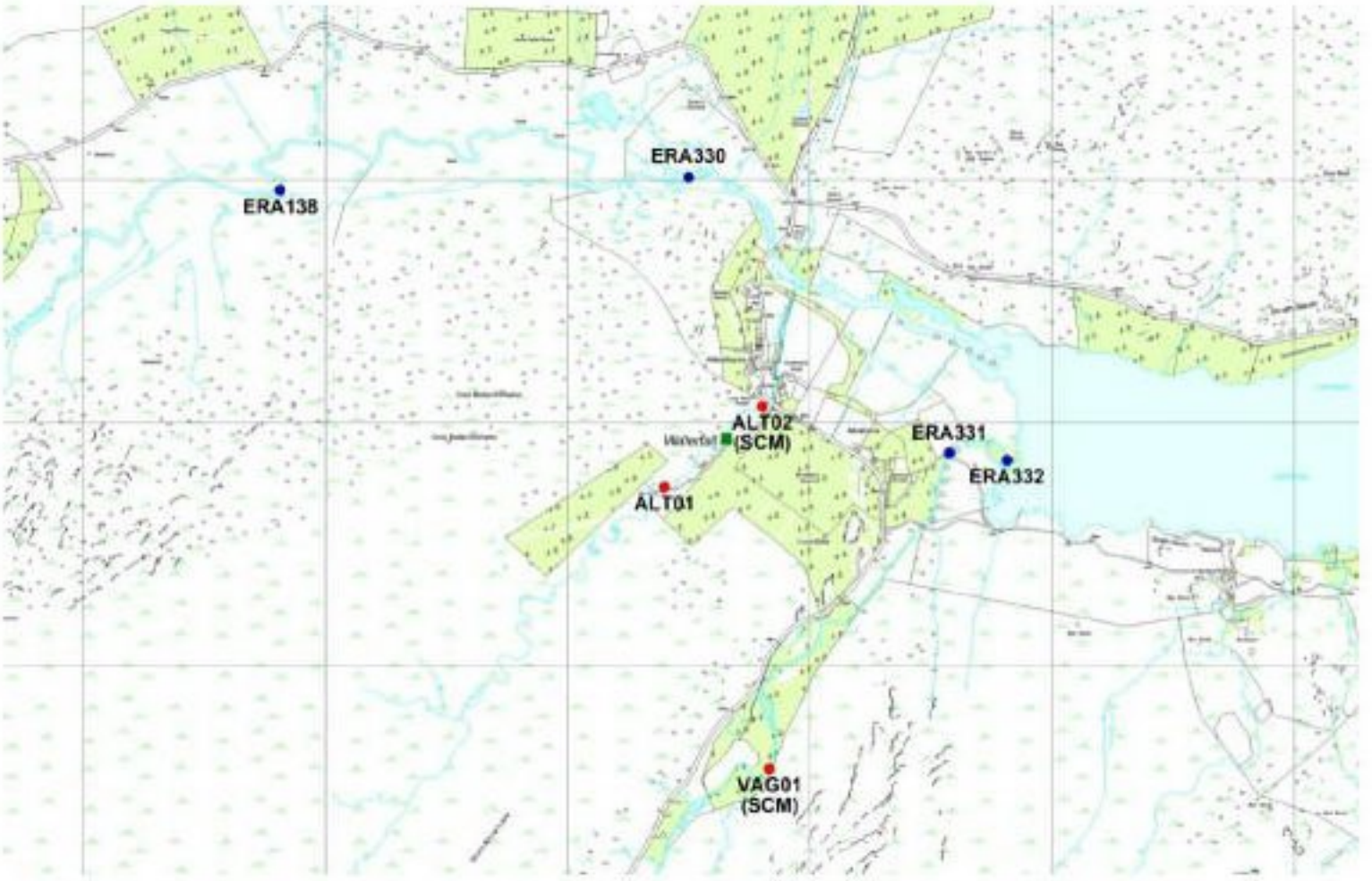
Given the fact that migratory salmonids and lamprey ammocoetes have different habitat preferences, it is unlikely that the presence of lamprey ammocoetes will be detected during juvenile salmonid surveys. Ammocoete surveys need to be undertaken in addition to other fisheries surveys. To date the RNF have not undertaken any such surveys and so data on ammocoete populations is limited to the results of a survey completed by Scottish Natural Heritage in 2004, and other anecdotal reports from across the catchment, details of which are provided in the following sections.

8.1.3 Scottish Natural Heritage (SNH) Lamprey Survey 2004

Ecological Research Associates (ERA) completed a number of Ammocoete surveys across the Naver catchment on behalf of SNH in October 2004. This is the optimum time for surveys as it ensures the capture of a range of size-classes that includes both young ammocoetes and transformers (juveniles transforming in adult larvae).

Of most relevance to this assessment are the two surveys completed in the lower reaches of the Vagastie (ERA331 and ERA332), together with a further two on the lower reaches of the River Mudale just upstream of the Allt na h-Aire Burn (ERA138 and ERA330). The location of these sites in relation to the study area and River Naver Fisheries sites are presented in **Figure 8-1** below.

Figure 8-1 Location of those Ecological Research Associates (ERA) 2004 Ammocoete survey sites (shown in blue) falling within of adjacent to the study area



Ammocoetes were found to be present at all four sites (see **Table 23** below). These were either identified as *Lampetra* spp (i.e. river or brook lamprey) or brook lamprey. The identification of ammocoetes to river or brook lamprey before transformation is not possible in the field using external characteristics (Harvey & Cowx, 2003).

The habitat at these sites is ideal for ammocoetes, with extensive areas of sandy silt in slow moving water located in close proximity to gravel areas in flowing water for adult spawning. This was more so in the Mudale than the Vagastie, as reflected by the relative densities.

Figure 23 Results of SNH lamprey surveys carried out on the River Naver catchment in October 2004 (Recorded by Ecological Research Associates)

Ref no.	Date	NGR	Watercourse	Location	Species	Life stage	Number	Density	Comments
Era138	22/ 10/ 2004	NC 5481 3596	Mudale	Apex of "hairpin" bend (left hand bend).	b	t	1	0.17	Sites are fine sand - little silt. Ammocoetes present to at least 1m depth. Whole river bed is sandy so habitat could be very extensive.
Era330	22/ 10/ 2004	NC 5658 3608	Mudale	Confluence ~300m upstream from bridge at the end of the hotel beat.	l	l	13	3.25	River has sandy banks. Site is 100% sand, little silt. River is slow - lots of silt.
Era27	20/ 10/ 2004	NC 7126 5851	Naver	Behind croy, in line with the car park on the road.	b	t	2	0.40	Site is behind downstream croy. Probably isolated from the main channel at lower flows, but always wetted. Leaf and twig debris present. Mainly coarse sand and twig - no silt.
Era30	20/ 10/ 2004	NC 7240 4929	Naver	Left channel of island upstream of the bridge on the right bank.	b	t	7	0.88	Site was 5 areas of sediment and debris along the right bank on side channel under alders. Lots of well established leaf and twig.
Era136	20/ 10/ 2004	NC 7135 5868	Naver	Large eddy/ pool at cofluence with ditch.	b	t	3	0.25	Note: site very different to first due to high water and dense vegetation - density data not reliable. Site seemed (to deep to see) to have this skin of silt and peat over harder material. Dense mass of vegetation may also have provided matrix within the lampreys lived.
Era137	20/ 10/ 2004	NC 7249 4947	Naver	75m downstream from Rhifail Bridge in join with ditch.	b	t	1	0.67	Most of the river is cobbly and fast with some areas of coarse sand.This site is fine sand with a little silt. Plenty twig and leaf debris.
Era379	20/ 10/ 2004	NC 7126 5851	Naver	Behind croy, in line with the car park on the road.	s	l	3	0.60	Site is behind downstream croy. Probably isolated from the main channel at lower flows, but always wetted. Leaf and twig debris present. Mainly coarse sand and twig - no silt.
Era385	20/ 10/ 2004	NC 7240 4929	Naver	Left channel of island upstream of the bridge on the right bank.	s	l	2	0.25	Site was 5 areas of sediment and debris along the right bank on side channel under alders. Lots of well established leaf and twig.
Era331	22/ 10/ 2004	NC 5757 3487	Vagaslie	20m downstream from bottom end of wood.	l	l	3	1.50	Sites are tiny scalloped edges where a little fine sand and twig debris have gathered. Very shallow and possibly exposed at low water.
Era332	22/ 10/ 2004	NC 5781 3484	Vagaslie	Small inlets on lower snd of braided area ~75m upstream from loch.	l	l	8	1.78	Sites (3) were small islets full of leaves. Sediment shallow. The river is fast and strong, with a gorge at the road. Only habitat present below bridge is in the lower braided area just above the loch.

Species: 'b' – brook lamprey, 'l' – *Lampetra* (brook or river), 's' – sea lamprey

Life Stage: 't' – transformer, 'l' - larvae

8.1.4 Anecdotal Reports of Lamprey Activity

During the week of the 11th to 16th June 2012 RNF staff received reports of sea lamprey spawning in the River Naver. Anglers witnessed a pair of lamprey creating a nest at the neck of Lonnie's Pool (NC 674 383). Other pairs of sea lamprey were subsequently seen by Anglers in the river at Lower Craggie (NC 690 430) and Upper Ma Naire (NC 723 535). All of these sites are located below Loch Naver.

This was followed by a report of large numbers of smaller lamprey witnesses on the lower River Vagastie below Altnaharra Lodge (NC 577 349 in close proximity to sites ERA331 and ERA332). During a visit to the site during the week 18th to 23rd June 2012 a single dead individual was found and positively identified as an adult brook lamprey (see **Figure 8-2** below).

Figure 8-2 Dead brook lamprey (8cm in length) found in the lower reaches of the River Vagastie (June 2012)

The reason for this sudden spate of sightings is likely to be due to the fact that the lamprey spawning coincided with a period of particularly low river levels. This made the lampreys more visible than they might usually have been.

8.1.5 Summary

- Information regarding the distribution and abundance of lamprey ammocoetes within the study area is limited. However, the presence of juvenile *Lampetra* spp in the lower reaches of the River Vagastie has been confirmed, with a number of these positively identified as brook lamprey. The same is true for the River Mudale in close proximity to the mouth of the Allt na h-Aire Burn.

- There must be no significant obstacles in the migratory route of brook lamprey (together with the other species) if they are to successfully travel upstream from their nursery beds to their spawning grounds (Maitland, 2003). The falls on the Allt na h-Aire Burn and the catchwater on the River Vagastie are therefore likely to act as barriers to the distribution of lamprey.

- Both water abstraction and land drainage have negative effects on lamprey populations (Maitland, 2003). They often lead to unstable habitats with variable water levels, which flood and disturb spawning gravels and nursery silts at some times but leave them high and dry at others (Maitland, 2003). It is therefore highly likely that the presence and/or abundance of lamprey species decreases with distance travelled upstream on the Vagastie.

- A more detailed lamprey monitoring programme would be required to establish the baseline distribution and abundance of lamprey species within the study area.

9 ARCTIC CHARR

This section of the report presents a review of available data regarding the presence and abundance of Arctic charr in those watercourses that flow through, or are directly adjacent to the proposed development area.

9.1.1 Introduction

The Arctic charr is a salmonid species (related to the salmon and trout) that is largely distributed within the northern upland areas of the British Isles. Scotland is a stronghold for Arctic charr within the British Isles and 258 Scottish lochs are known to contain this species[3]. They spawn in autumn or in late winter and early spring, usually in the aerated gravel areas along the shore of lochs. While they also occasionally spawn in streams flowing into lochs, emerging fry migrate downstream and generally do not form stream populations[4].

9.1.2 RNF Juvenile Salmonid Surveys

There are no records of Arctic charr having been captured during electric fishing surveys on the River Vagastie, Allt na h-Aire Burn or any other sites across the Naver catchment. Similarly, there are no reports of Arctic charr spawning activity in the rivers flowing into or out of the major lochs. Arctic charr have been seen spawning within Loch Choire on the River Mallart catchment (Lord Joicey, *per comms*).

9.1.3 WFD Survey of Loch Naver (SEPA, 2010)

A Water Framework Directive (WFD) fish population survey was carried out on Loch Naver by the Scottish Environment Protection Agency (SEPA) in July 2010. They are required to monitor fish populations in lochs as part of the classification of Scotland's water environment.

The results of this survey are yet to be published, however Arctic charr were recorded as being present in the Loch (Alistair Duguid SEPA, *per comms*). An example of an Arctic charr captured during a survey of Loch Meadie (in the upper reaches of the Mudale catchment) is presented in **Figure 9-1** below.

[3] http://www.snh.gov.uk/about-scotlands-nature/species/fish/freshwater-fish/charr/
[4] http://www.scotland.gov.uk/Topics/marine/marine-environment/species/fish/freshwater/charr

Figure 9-1 Arctic charr captured during a Marine Scotland survey of Loch Meadie in August 2010

9.1.4 Summary

There is currently no evidence to suggest that Arctic charr frequent or spawn in the Vagastie, Allt na h-Aire Burn, or any other rivers with the Naver catchment. However, given its status as a UKBAP Priority Species, the presence of Arctic charr in Loch Naver is noted.

10 RECOMMENDATIONS

Wind farm developments have the potential to impact on hydrology, hydrochemistry and sediment transport by altering the water run-off processes. As described in this report, a number of watercourses originate from, flow through or are directly adjacent to the proposed Creag Riabhach Wind Farm development area, namely:

- The Allt na h-Aire Burn;
- The River Vagastie; and
- The River Tirry.

The Naver Catchment is designated as an SAC and as such is afforded the highest level of environmental protection available under European legislation. It is possible that the proposed development could have an impact on water quality or quantity. It is therefore important that best practice is followed and that all appropriate measures are taken to mitigate such effects and protect the watercourse and the designated SAC species within it.

In addition to this and to monitor any residual effects which may remain after mitigation; a robust monitoring plan should be developed. This should commence at least three years prior to construction to allow the baseline condition to be established and to account for intra-site and intra-annual variation. A Before and After Control Impact (BACI) design will allow a robust assessment of effects. The monitoring programme should be based on the following four key components:

- **Water Quality** – Composite samplers should be positioned at sites both within the study area and control sites. This will collect water samples over a set period prior to, through and after the construction period. Samples should then be analysed for a range of parameter including turbidity, acid neutralising capability (alkalinity), pH, nutrients, dissolved organic carbon (DOC) and a range of other major ions.

- **Aquatic Macro-invertebrates Assemblages** – Invertebrate samples should be taken from each site (corresponding to the fish survey sites) using standard techniques such as three minute kick samples and Hess samplers. The samples should be indentified to at least species level and measures of abundance and diversity made.

- **Fish Populations** – Each site should be electric fished following SFCC protocol to establish the presence, abundance and age structure of salmon, trout and eels. In addition to this, specific lamprey surveys should be completed in areas of suitable

habitat at each site. This will provide a more detailed picture of the species, distribution and abundance of lamprey within the study area. It should be noted that the optimum period for carrying out surveys for salmon, trout and eels is July –August, where as lamprey surveys should be completed in October (as discussed earlier in this report.

- **Habitat Surveys** – A pre-construction walkover habitat survey of the Allt na h-Aire Burn, River Vagasite and Tirry should be completed following SFCC protocol. This will identify key habitat features. This should be followed by a post construction survey to allow any changes resulting from the proposal to be identified.

It is recommended that a number of new survey sites be established to increase the sensitivity of the monitoring programme. This should include a new site in the upper reaches of the Allt na h-Aire Burn (ALT03), a site within Allt an Locha Ghaineamhaich on the Tirry catchment directly below Vagastie catchwater (ALG01) and a site directly below the confluence of Allt an Locha Ghaineamhaich with the River Tirry (ST05a).

In addition to this, it is recommended that two 'control' sites are established on a watercourse out with the development. These would preferably include sites MEAD02 (SCM) and MEAD03 on the Meadie Burn to the north of the proposed development. These are existing long-term monitoring sites for which a significant data set exists. The locations of all of these proposed sites are presented in **Figure 10-1a and 10-1b** below.

Figure 10-1a Proposed locations of new Naver monitoring sites (orange) in compared to those of the existing sites (red)

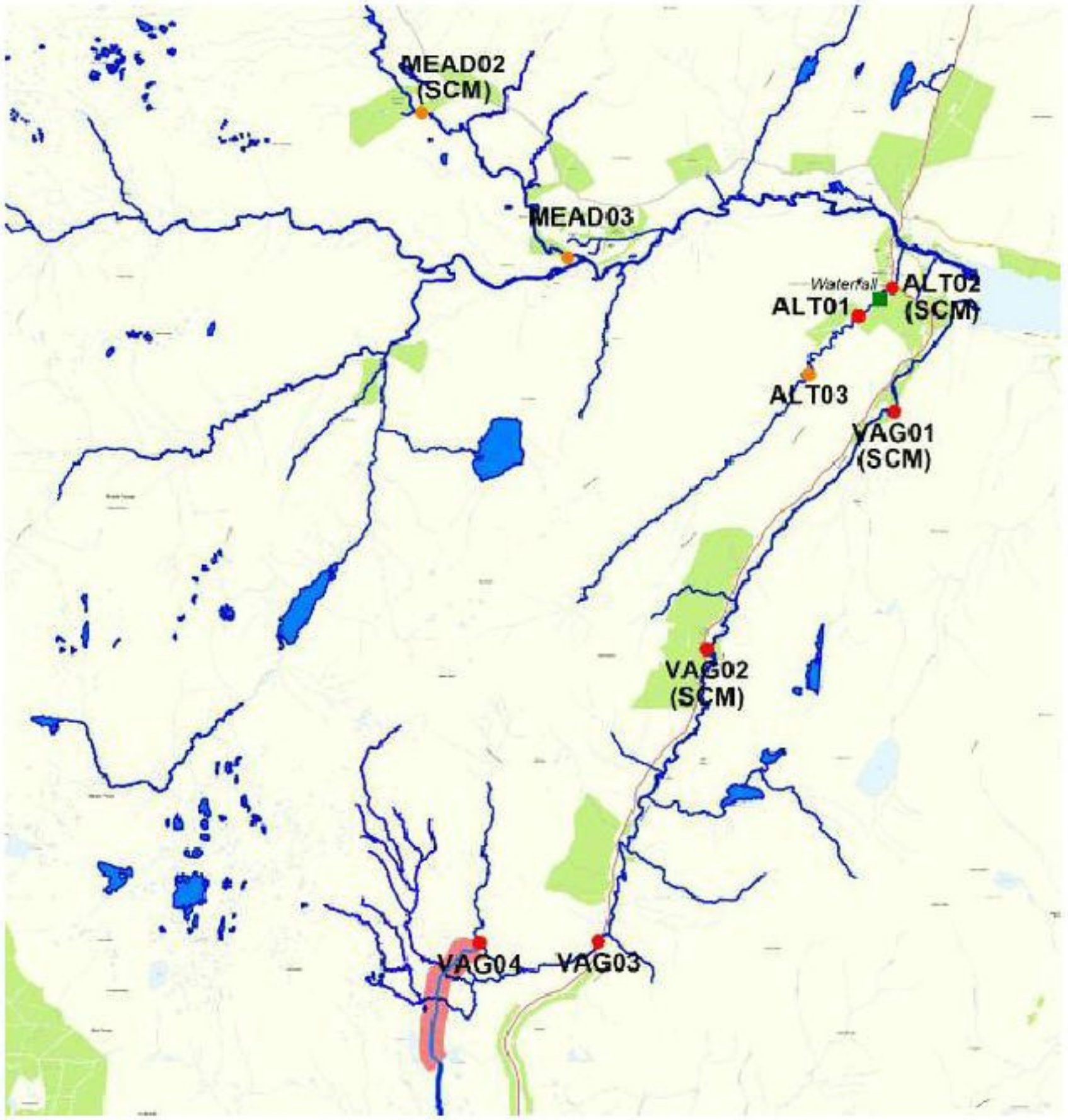
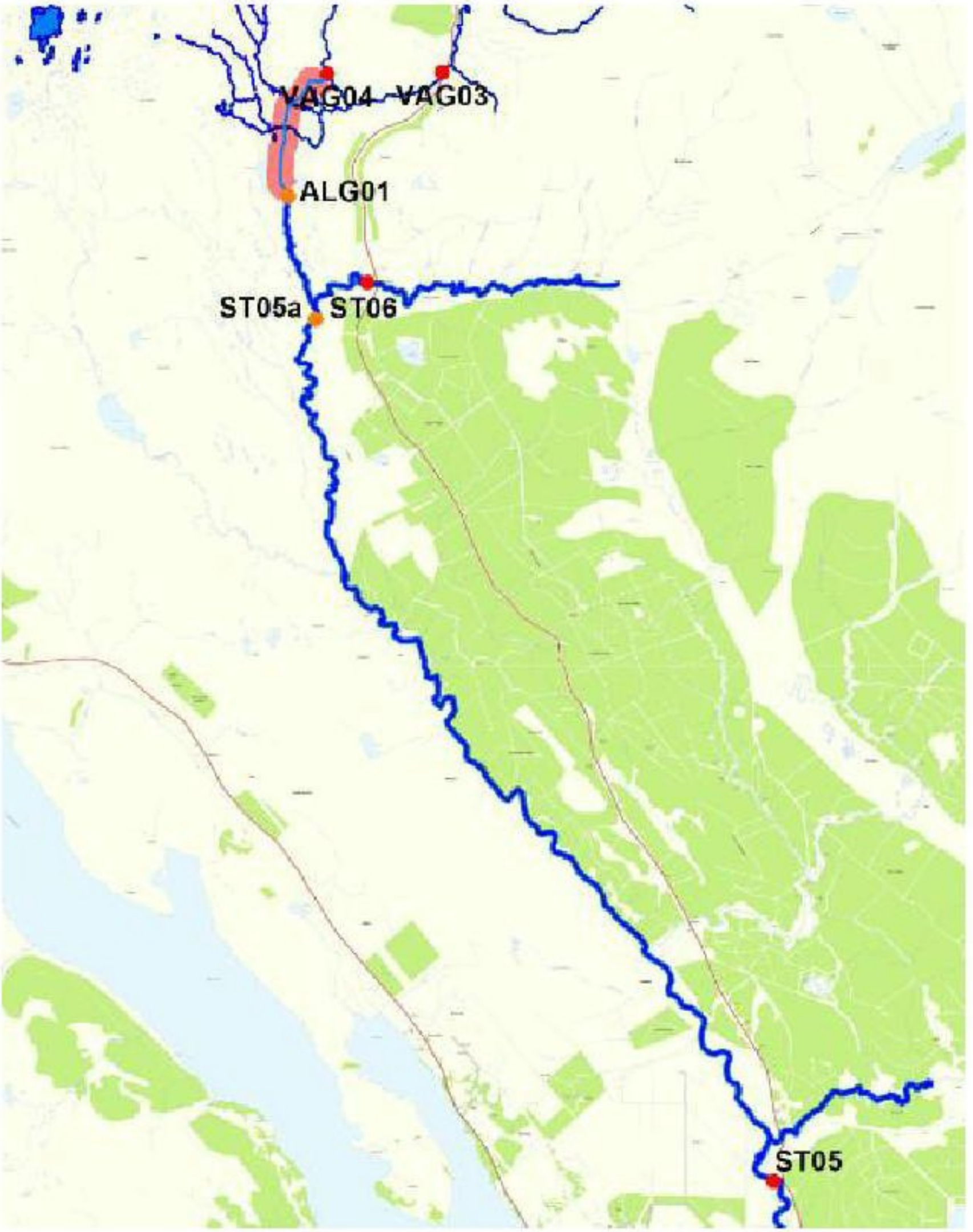


Figure 10-1b Proposed locations of new Tirry monitoring sites (orange) in compared to those of the existing sites (red)



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