Little Assynt Lochs Project

Invertebrate Communities of a Gneiss Catchment

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Little Assynt Lochs Project

Report for Culag Community Woodlands Trust

By Caroline Bowes

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Caroline Bowes: email - carolinebowes@live.co.uk

Abstract

The Little Assynt Lochs Project is a study of the aquatic ecosystem on the Little Assynt Estate. Existing ecological records relating to the estate have been sought out. These have been collected in a single spread sheet. A survey of several small lochs in one catchment on the estate has shown that the invertebrate assemblage of the aquatic ecosystem is not abundant, but is reasonably diverse. The members of invertebrate communities identified are mainly acid-tolerant, pollution-sensitive taxa, and as such are consistent with the flora, geology and land-use of the area.

Figure 1: Little Assynt Estate Boundary and Deer Fence. Composite map compiled from Ordnance Survey map and data from SNH (Ordnance Survey of Great Britain)

Estate Boundary

-x-x-x-x Deer Fence

Contents

Introduction

The Little Assynt Lochs Project was a study of aquatic habitats on the Little Assynt Estate. The Little Assynt Estate is owned and managed by the Culag Community Woodland Trust which has provided funding for the project. The remit of the projectwas to gather together and consolidate any accessible information from previous studies, whilst providing fresh information about aquatic ecosystems on Little Assynt from a baseline study of a group of lochs. All this information will be stored in a central data-base. The findings of the project will be used to inform future management of the estate and to support the objectives of the Sutherland Biodiversity Action Plan (2003).

Aims and Objectives

The Project had four objectives, as follows:

1. A desk study to track down and collate existing information.
2. Compilation of a data-base to store existing and future information.
3. A base-line survey of a group of lochs on the estate.
4. Production of a report evaluating the findings from the above.

The aim of the project is to provide an accessible store of information about the aquatic ecosystems on Little Assynt and to provide a base-line from which future monitoring can be carried out.

Background

The Estate consists of around 1200 hectares of dry and wet heath, blanket bog and other communities, overlying the base rock of Lewisian gneiss, which is interspersed with dykes of basic and ultrabasic rock. These dykes take the form of linear ridges and trenches cutting through the landscape. Hollows in the Lewisian gneiss have filled with water, becoming lochs, while depressions in the overlying peat form smaller bog-pools. The resulting landscape is often referred to as "cnoc and lochan". The underlying rock affects the fertility and composition of the soil and the area has a diverse flora. This consists predominantly of communities associated with nutrient poor acid soils, interspersed with areas of vegetation more often associated with mineral-rich soils.

Management

There is little evidence for settlement in the Little Assynt area in prehistoric times. This may be the result of its generally infertile, acid soils or it may be that the evidence for settlement has been obliterated. The area was settled and farmed from medieval times and evidence for that can be seen around the estate in the form of sheilings, occasional ruined buildings and remnants of lazybeds. Land-use changed at the time of the clearances in the early 19th century. From this point onwards the area was used primarily for sheep grazing. Some form of woodland management appears to have been practised on the estate prior to the clearances. Evidence for this lies in trees with the characteristic growth pattern of pollards. (Noble & Bangor-Jones, 2005). The Little Assynt Estate was purchased by the Culag Community Woodland Trust in November 2000 (CCWT). Culag Community Woodland Trust is a charity set up in 1995 to promote and manage local woodlands for the community. Since coming

under the management of the CCWT a large part of the estate has been enclosed within a deer fence. This has resulted in two very different habitats, one in which the natural vegetation is kept cropped by deer and one in which natural regeneration occurs unhindered. The two areas show some marked contrasts. Extensive tree planting has also been carried out using native species and a network of footpaths has been constructed.

Geology

The base rock at Little Assynt is Lewisian gneiss. This is around 3000 million years old, formed by metamorphosis of the parent rock by heat, pressure and folding during a period of tectonic instability in the Precambrian period. Lewisian gneiss is a hard, often acidic rock, providing few nutrients to the overlying soil. The Lewisian gneiss on the Little Assynt Estate is interrupted by dykes composed of comparatively mineral-rich basic and ultrabasic rock. These dykes consist of magmatic material which intruded into fissures in the Lewisian gneiss around 2400 million years ago and are part of the Scourie Dyke Swarm. The rocks of Little Assynt are part of the foreland of the Moine Thrust and have remained geologically inactive since the final mountain building episode of the Proterozoic era of the Precambrian period (around 1700 million years ago) making them some of the world's oldest rocks. The landscape that we see today at Little Assynt is the end result of climatic weathering and glacial action on the mountains raised at that time. The underlying geology impinges directly on the ecology of an area, as the parent rocks are the major source of many of the minerals required to support life. This applies in both terrestrial and aquatic habitats. At Little Assynt the base rock is predominantly acidic, mineral-poor gneiss, interspersed with dykes of mineral-rich basaltic rock (Park, Stewart, & Wright, 2002).

Ecology

Terrestrial

Since the retreat of the last glaciers 11000 years ago a layer of peat has built up on top of the Lewisian gneiss. This varies in thickness and in some places the underlying rock is exposed while in others the peat may be up to a metre deep. The terrestrial vegetation in the area studied consists largely of plants associated with wet dwarf shrub heath (phase one habitat D2) including *Molinea caerulea*, *Erica tetralix*, *Sphagnum spp.* and *Cladonia spp*. This is interspersed with patches of established broad-leaved woodland and associated woodland plants such *as Oxalis acetosella*, *Primula vulgaris* and *Viol ariviniana*. There are also base-rich flushes characterised by *Schoenus nigricans*. On the drier slopes the flora varies with location from acid-loving plants such as *Calluna vulgaris, Gallium saxatile* and *Hypericum pulchrum*, to those such as *Ajuga pyramidalis*, which prefers a base-rich soil. Some of the drier slopes are dominated by stands of bracken (*Pteridium aquilinum*), which grows unhindered here in the absence of grazing and trampling by deer and livestock.

Figure 2: *Primula vulgaris* on the shores of Loch Leitir Easaidh

Mammal records held locally for Little Assynt and contiguous areas include otter, fox, pine marten, field vole, bank vole, water vole, mole, wood mouse and many others. There are also

records for common lizard, slow-worm, adder, palmate newt, common frog and toad and a variety of birds, including reed bunting, lesser redpoll, curlew, common snipe and black throated diver.

Aquatic

The study area comprised six lochs in the the catchment of Loch Leitir Easaidh, ranging in size from small dubh lochans to sizeable water-bodies. The lochs studied are linked by a network of small burns. Some lochs are fed directly by mineral-rich run-off from the dykes, while others are fed largely by flushes and run-off from the surrounding bog. Some loch margins are shaded and sheltered by steep-sided crags and others are exposed. Scattered patches of native woodland, on the shores of Loch Leitir Easaidh, Loch na h-Innse Fraoich and Loch Torr an Lochain, provide partial shade and shelter. The lochs and their connecting burns support a variety of life, including plants, invertebrates, amphibians, fish and birds. Documentation of the aquatic ecosystem of Little Assynt to date has been patchy and sparse. Existing records are held in the archives of a variety of groups and individuals.

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Figure 3: Loch na h-Innse Fraoich looking North West to Quinag

Desk Study

A desk study was carried out by members of CCWT to locate biological records from the Estate and adjacent areas. These records include those held by companies, individuals and bodies involved in biodiversity/conservation monitoring. A preliminary search for data by Eleanor Shields located several small surveys, which were subsequently tracked down by Ian Evans. Some records have come from the National Biodiversity Network (NBN) and records of water beetles and water bugs from the *Atlas of Scottish Water Beetles* (Foster, 2001) and the *Provisional atlas of the British aquatic bugs (Hemiptera, Heteroptera)* (Huxley, 2003) respectively. Data on aquatic molluscs was extracted from Kerney (1999). Many of the data sets lack precise grid references. The data-sets located in the desk survey are summarised below, and the full spread sheet (*Little Assynt bio-records*) is reproduced in appendix 1.

Summary of ecological data relating to Little Assynt

Sources of data stored on Little Assynt bio-records spread sheet	
NBN	The Bat Conservation Trust. Colony Count Survey
NBN	HBRG Vertebrates (not Badger) Dataset
NBN	HBRG Insects Dataset
NBN	BRC. Seed and Leaf Beetle Recording Scheme
NBN	HBRG Badger dataset
NBN	Conchological Society of Great Britain and Ireland
NBN	BRC from Haes, E.C.M. & Harding, P.T. 1997. Atlas of grasshoppers and allied insects in Britain and Ireland. London: HMSO
NBN	BRC Reptile and Amphibian records extracted from the BRC herptiles database.
NBN	BRC Mammal records from Britain from the Atlas of Mammals (1993), with some subsequent records
NBN	Bees, Wasps and Ants Recording Society - Trial Dataset
NBN	BRC Odonata Records for Britain to 1992
NBN	BRC Ground Beetle Recording Scheme
SNH Commissioned Report	Post 1980 records from Atlas of Scottish Water Beetles, Garth Foster (2001). SNH Commissioned Report F00AC337 (Collated by Ian Evans)
SNH Commissioned Report	Pre 1980 records from Atlas of Scottish Water Beetles, Garth Foster (2001). SNH Commissioned Report F00AC337 (Collated by Ian Evans)
Assynt Hydro	Young Associates for Assynt Hydro
Survey	David Pryce (2010). Preliminary report on Malaise Trap results, Loch na h-Innse Fraoich, 2010
Survey	Digger Jackson. Report to RSPB on feeding of black-throated divers
NBN	HBRG Other Invertebrates Dataset
Evans P.A.et al.	*Flora of Assynt* (2002)
NBN	British Lichen Society BLS Mapping Scheme dataset, 1750-2009
NBN	Dr Francis Rose Field Notebook Project
NBN	Bryophyte data for Great Britain from the British Bryological Society held by BRC
NBN	BRC Database for the Atlas of Freshwater Fishes
NBN	Botanical Society of the British Isles Vascular Plants Database
NBN	Scottish Natural Heritage Standing Waters Database
NCC	NCC Scottish Loch Survey 1988

Table 1 Summary of ecological data

Lochs survey

Aquatic invertebrate surveys were carried out at six lochs in the Loch Leitir Easaidh catchment, between June and September 2010. All six lochs lie within the area enclosed by deer fencing and five of them are used for recreational angling. The remaining loch is a small peaty dubh-lochan (number 5 on the map below) with no evidence of a resident fish population. The Lochs studied are shown on the map in Figure 4.

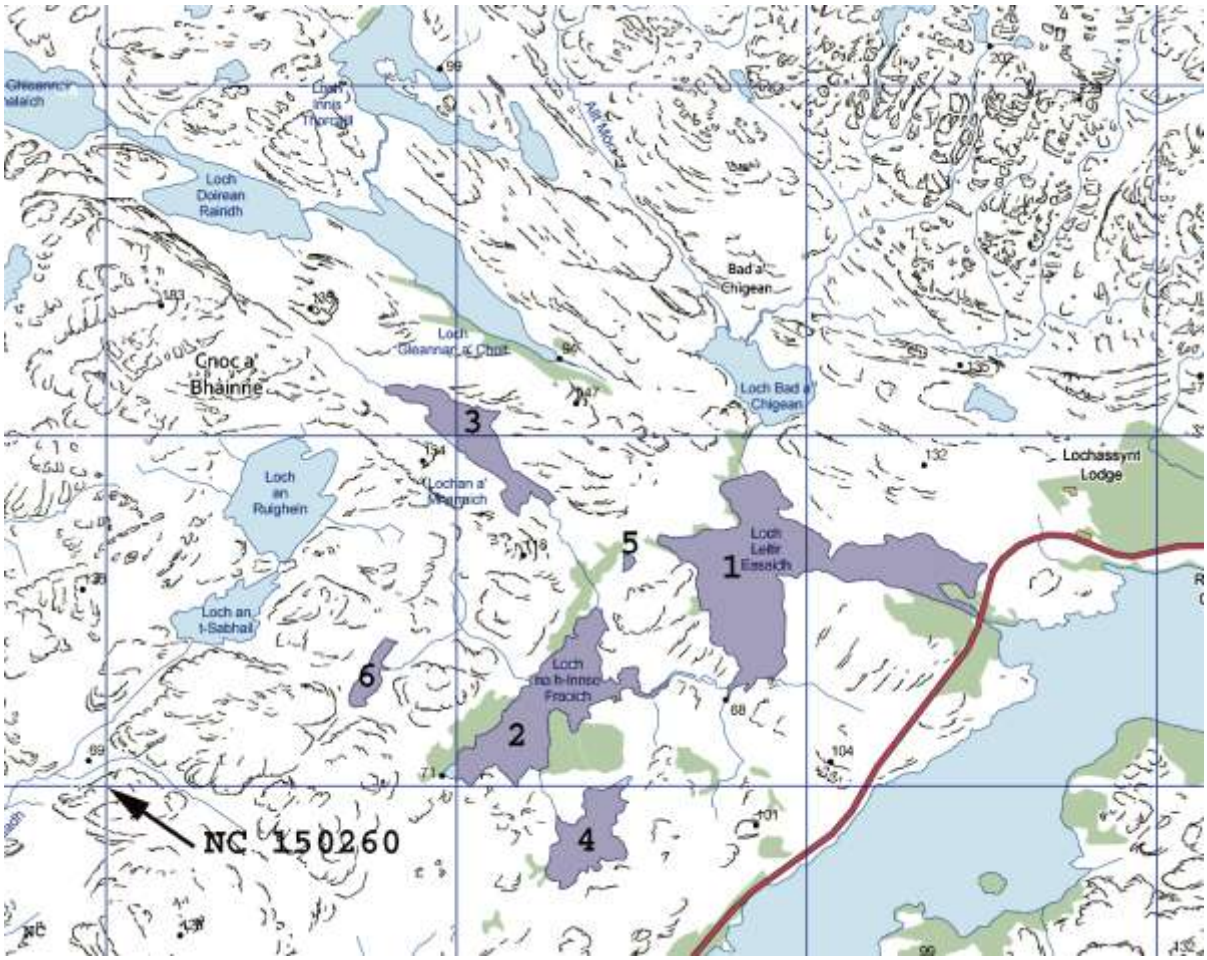


Figure 4: Map showing lochs surveyed (deep blue). (Copyright: Ordnance Survey of Great Britain)

Methods Used

Sampling was carried out using the protocols and equipment described below. All samples were collected between June and September 2010.

Samples were collected using a standard 1mm mesh dip net and by hand searching of stones. The dip net was used for kick sampling or sweeping, depending on the habitat being sampled. Where the substrate consisted of large stones, the stones were lifted and searched for clinging organisms. The procedures used were standardised to ensure that all samples were comparable.

Sample Point Selection

Locations for sampling were chosen to represent the various habitats present in each loch. In lochs with obvious geological features, sampling was carried out at locations both close to and distant from these features. At each sampling point the following parameters were measured prior to sampling, using a Hanna pH/EC/TDS hand held meter (model no. H198129). Note no measurements were taken at sample points 1.1 and 1.2 as the meter was unavailable when these samples were taken.

- pH accuracy ± 0.05
- Temperature accuracy ± 0.5^{o}C
- Conductivity accuracy ± 2%
- Dissolved salts accuracy ± 2%

Sample collection

Dip Net – Kick Sampling: This method was used on substrates of gravel and small stones. The substrate was disturbed with one foot and the sediment kicked towards the dip net which was held in position to catch disturbed material. This was done in 30 second bursts for a total of three minutes at each site, timed with a digital kitchen timer. The contents of the dip net were then tipped into a collecting tray with water from the area being sampled. A quick look through the contents allowed fish and amphibians to be extracted and returned to the water. The rest of the sample was poured into wide mouthed PPE jars preparatory to sorting and fixing the invertebrates.

Figure 5: Kick sampling: Loch Leitir Easaidh

Dip Net – Sweeping: This method was used to sample areas of weed, emergent macrophytes and substrates composed of fine sediment. The net was swept through the vegetation in 15 second sweeps for a total of three minutes at each sampling point. The contents of the net were treated as above.

Hand searching: On stony substrates sixty stones were picked up and examined for clinging organisms. Any invertebrates found were transferred to a universal tube containing 70% IMS or 70% Isopropyl Alcohol.

A mixture of sediment types occurred at many of the sampling sites, in which cases a combination of the above procedures was carried out. In these cases the 3 minute sampling period was divided between the different methods, so that the total sampling time was always equivalent to three minutes.

Sorting, Fixing and Preservation of Samples.

Samples were stored in a fridge pending sorting; most invertebrates can survive in these conditions for one or two days, although there is a risk of carnivores eating some of the rest of the catch. Samples were sorted by placing small amounts of the collected sediment in a petrie dish under a magnifying lamp. Invertebrates were removed with forceps and placed in tubes of 70% alcohol. Preliminary sorting of invertebrates into taxonomic groups was carried out at this stage with separate tubes for each taxonomic group represented in the sample.

Identification

Identification was carried out to species level where possible using Freshwater Biological Association keys and AIDGAP keys. Some specimens have yet to be identified, but it is hoped that the bivalve molluscs can be identified by an expert in that group. All Ephemeroptera, Plecoptera and Trichoptera collected were larvae. In the listings of invertebrates, distinction is made between adult and larval/juvenile forms of Coleoptera and Heteroptera. All Annelida, other than leeches, are Oligochaeta.

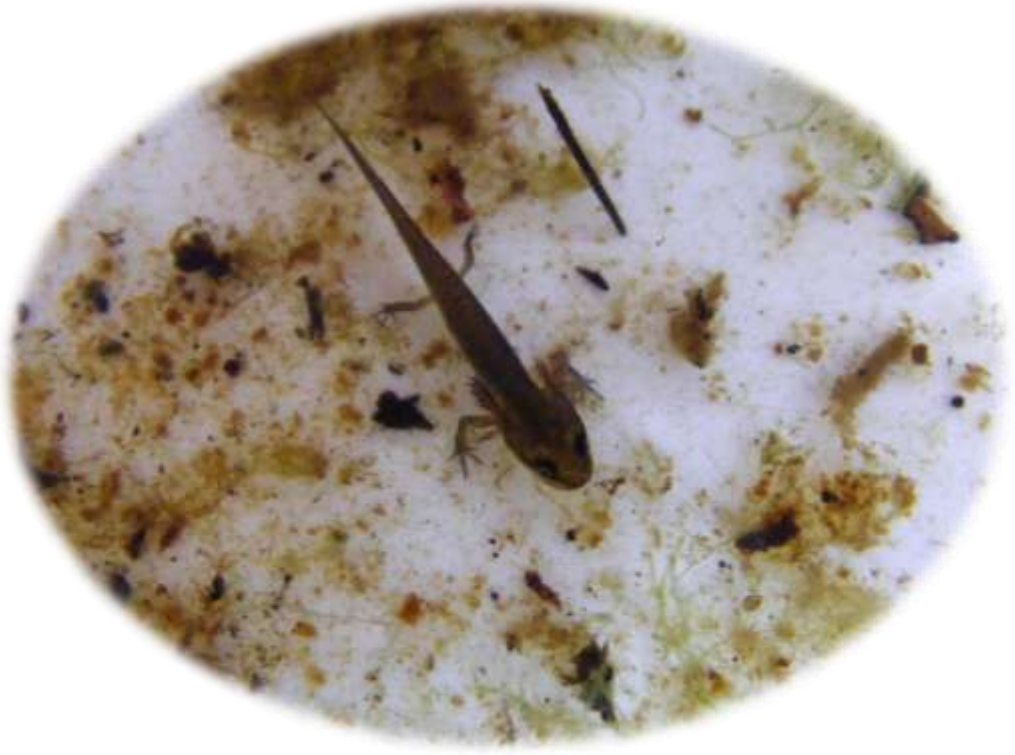


Figure 6: Lissotriton sp.

Results

Six lochs were included in the survey. The locations of these are shown on the map in Figure 4 above. In total 34 samples were taken. The results for each loch are shown below. For purposes of data storage each loch was numbered and sampling points were given codes using the loch number followed by a decimal point and then the sample number. E.g. Loch Leitir Easaidh is loch number 1, the first sample point in Loch Leitir Easaidh is denoted as sample point 1.1. Samples from inflow and outflow burns have a zero before the sample number, for example 1.01 and 1.02 are two inflow burns to Loch Leitir Easaidh.

Sample Site Codes	
Loch and Site Name	**Code**
Loch Leitir Easaidh - Inflow from Loch na h-Innse Fraoich	1.01
Loch Leitir Easaidh inflow 2	1.02
Loch Leitir Easaidh S1	1.1
Loch Leitir Easaidh S2	1.2
Loch Leitir Easaidh S3	1.3
Loch Leitir Easaidh S4	1.4
Loch Leitir Easaidh S5	1.5
Loch Leitir Easaidh S6	1.6
Loch na h-Innse Fraoich inflow 1	2.01
Loch na h-Innse Fraoich inflow 2	2.02
Loch na h Innse Fraoich S1	2.1
Loch na h-Innse Fraoich S2	2.2
Loch na h-Innse Fraoich S3	2.3
Loch na h-Innse Fraoich S4	2.4
Loch na h-Innse Fraoich S5	2.5
Loch na h-Innse Fraoich S6	2.6
Loch na h-Innse Fraoich Canal S1	2.7
Loch na h-Innse Fraoich Canal S2	2.8
Lochan a Mhanaich Outflow SE	3.01
Lochan a' Mhanaich Inflow 2	3.02
Lochan a' Mhanaich Inflow NW	3.03
Lochan a' Mhanaich S1	3.1
Lochan a' Mhanaich S2	3.2
Lochan a' Mhanaich S3	3.3
Loch Torr an Lochain S1	4.1
Loch Torr an Lochain S2	4.2
Loch Torr an Lochain S3	4.3
Loch 5 S1	5.1
Loch 5 S2	5.2
Loch 5 S3	5.3
Loch 6 Outflow	6.01
Loch 6 S1	6.1
Loch 6 S2	6.2
Loch 6 S3	6.3

Loch Leitir Easaidh

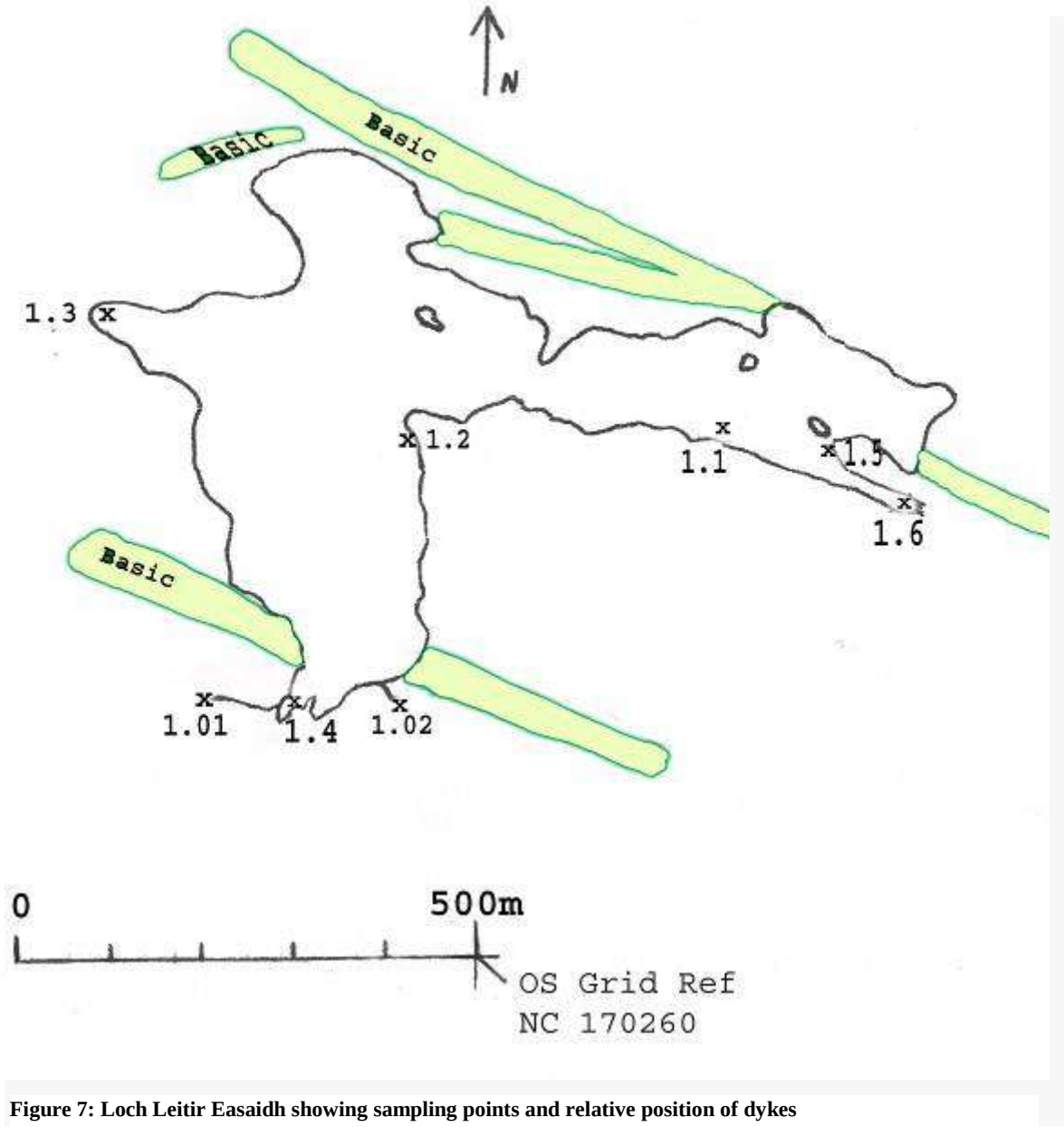


Figure 7: Loch Leitir Easaidh showing sampling points and relative position of dykes

Loch Leitir Easaidh was the biggest loch surveyed with an area of around 17Ha. Its northern and southern edges are bounded by dykes of basic material and its eastern edge abuts an area of faulting. These features give the loch steep sides.

The substrate of the littoral zone of the loch is largely composed of rocks and boulders, sparsely colonised by the flora typical of slightly acidic oligotrophic standing waters. This consists largely of *Lobelia dortmanna*, *Littorella uniflora* and *Ranunculus flammula*. Pockets of fine peaty sediment in the sheltered south-west corner of the loch support vegetation consistent with a more acid regime, including *Utricularia sp.* The sampling stations are described below with tables showing invertebrate communities.

Sample 1.01 (Inflow burn from Loch na h-Innse Fraoich to Loch leitir Easaidh) Sampled on 16th August 2010

Figure 8: ***Cordulegaster boltonii***

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 167262	5.9	17.2	68	34

Sample 1.01 is the small, fast flowing burn which drains from Loch na h-Innse Fraoich into Loch Leitir Easaidh. It emerges from the slow moving canal-like section at the south east corner of Loch na h-Innse Fraoich, from where it has a short run of about 75 metres to the south west corner of Loch Leitir Easaidh. The substrate at the point sampled consisted of boulders, cobbles and gravel, colonised by *Ranunculus flammula.* The dominant bank-side vegetation is *Calluna vulgaris* which overhangs the water, creating deep shade. *Erica tetralix, Myrica gale* and *Molinia caerulea* are also present along with small quantities of *Pteridium aquilinum* and *Betula pubescens*. Other flowering plants noted were tormentil (*Potentilla erecta*) and devil's-bit scabious (*Succisa pratensis*). The pH recorded for the water here was low (5.9) which is in keeping with the invertebrate species recorded.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Bivalvia	?Pisidium sp.	84	1.01
Diptera	Larvae	10	1.01
Ephemeroptera	Serratella ignita	1	1.01
Ephemeroptera	Unidentified	1	1.01
Odonata Anisoptera	Cordulegaster boltonii	15	1.01
Plecoptera	Leuctra fusca	2	1.01
Plecoptera	Leuctra fusca	3	1.01
Plecoptera	Leuctra hippopus/moselyi (immat.)	2	1.01
Trichoptera	Unidentified	8	1.01
Trichoptera (Cased)	Sericostoma personatum	6	1.01
Trichoptera (Caseless)	Hydropsyche siltalai	3	1.01
Trichoptera (Caseless)	Neureclipsis bimaculata	6	1.01
Trichoptera (Caseless)	Polycentropus flavomaculatus	4	1.01
Trichoptera (Caseless)	Polycentropus irroratus	1	1.01

The invertebrate community is dominated by *Cordulegaster boltonii,* for which the habitat described above is typical (Brooks, 2002). The plecoptera species recorded are typical of fast flowing stony burns. The trichoptera species found are all typical of well oxygenated small streams. *Neureclipsis bimaculata* and *Polycentropus flavomaculatus* are particularly associated with lake outlets (Edington & Hildrew, 2005).

Sample 1.02 (Inflow burn 2) sampled on 16th August 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts(ppm)
NC 169262	6.12	14.9	116	58

Sample 1.02 is another burn, this time with a slow to moderate flow. This burn drains across a relatively flat plateau to the east of the main body of Loch Leitir Easaidh. The burn picks up run-off from Torr an Dubh Uidh to the north and Tor ban to the south. The area sampled has a slightly higher pH and noticeably higher concentration of ions than the previous sample.

The substrate here was a mixture of mud and stones. Bankside vegetation is similar to sample 1.01, dominated by overhanging *Calluna vulgaris*, interspersed with *Molinia caerulea* and *Myrica gale*.

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		5	1.02
Coleoptera	Larva	1	1.02
Diptera		3	1.02
Gastropoda		1	1.02
Heteroptera	Gerris lacustris	1	1.02
Odonata Anisoptera	Cordulegaster boltonii	1	1.02
Odonata Zygoptera	Pyrrhosoma nymphula	1	1.02
Trichoptera	Unidentified	1	1.02

Loch Leitir Easaidh

Sample 1.1 Sampled on 3rd June 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 172265	----------Not Recorded----------			

Sample 1.1 was taken from the south shore of Loch Leitir Easaidh, at the foot of Torr an Dubh Uidh. The slope above the sample point is heavily wooded. The dominant vegetation on the steep bank is *Calluna vulgaris*, with some *Myrica gale* and *Molinia caerulea.* Isolated birch, rowan and willow were all present near the water's edge.

Figure 9: Substrate S1.1

The substrate here consists of cobbles, gravel and organic debris. Aquatic plants include *Littorella uniflora* and *Myriophyllum alterniflorum*.

Invertebrates

Taxonomic group	Species	Abundance	location
Diptera		11	1.1
Ephemeroptera	Leptophlebia marginata	11	1.1
Ephemeroptera	Leptophlebia marginata	14	1.1
Ephemeroptera	Leptophlebia vespertina	2	1.1
Ephemeroptera	Paraleptophlebia (tumida?)	1	1.1
Ephemeroptera	Paraleptophlebia sp.	2	1.1
Ephemeroptera	Unidentified	15	1.1
Gastropoda		5	1.1
Odonata Zygoptera	Ischnura elegans	3	1.1
Trichoptera	Unidentified	4	1.1
Trichoptera (Cased)	Limnephilus borealis	1	1.1
Trichoptera (Cased)	Mystacides sp	2	1.1

The invertebrates identified from this site are all inhabitants of oligotrophic standing waters. *Leptophlebia marginata* and *Limnephilus borealis* are both known to tolerate low pH. (The British Species: Ephemeroptera Recording Scheme, 2011) and Wallace, Wallace & Philipson, 2003).

Sample 1.2 Sampled on 3rd June 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 169265	----------	----------	Not Recorded	----------

Sample 1.2 was taken from the east bank of the main body of Loch Leitir Easaidh. Dominant terrestrial vegetation is *Calluna vulgaris* with scattered *Myrica gale* and *Eriophorum vaginatum*.

The substrate here is stony and the water very clear. Aquatic plants were restricted to sparse *Lobelia dortmanna* and *Littorella uniflora*.

Figure 10: Substrate S 1.2 with *Lobelia dortmanna*

Invertebrates

Taxonomic group	Species	Abundance	location
Bivalvia		2	1.2
Coleoptera	Larva	1	1.2
Ephemeroptera	Caenis horaria	1	1.2
Ephemeroptera	Electrogena lateralis	1	1.2
Ephemeroptera	Unidentified	3	1.2
Gastropoda		3	1.2
Odonata Zygoptera	Ischnura elegans	1	1.2
Plecoptera	Diura bicaudata	1	1.2
Trichoptera	Unidentified	3	1.2

The invertebrate assemblage here is again typical of oligotrophic stony lake shores. Within the United Kingdom, *Diura bicaudata* is only found in the North of Scotland.

Sample 1.3 Sampled on 10th June 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 165266	6.65	17.2	67	33

Sample 1.3 was taken at the bottom of a steep wooded slope in a narrow inlet at the north-west corner of the loch. Ground cover on the bank below the trees was predominantly *Myrica gale.* The trees were mostly young birch. The substrate here is sandy and gravelly, with large boulders lining the shore at either side of the apex of the inlet. Aquatic plants were limited to very sparse *Lobelia dortmanna.*

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		9	1.3
Cladocera		1	1.3
Coleoptera	Oulimnius sp.	1	1.3
Copepoda		6	1.3
Diptera		6	1.3
Ephemeroptera	Baetidae sp.	8	1.3
Ephemeroptera	Caenidae sp.	1	1.3
Ephemeroptera	Caenis horaria	2	1.3
Ephemeroptera	Leptophlebia marginata	3	1.3
Ephemeroptera	Leptophlebidae sp.	1	1.3
Gastropoda		1	1.3
Malacostraca	Gammarus sp.	1	1.3
Plecoptera	Leuctra nigra/fusca	2	1.3
Trichoptera	Unidentified	9	1.3

The invertebrate assemblage from sample 1.3 is slightly more varied than that from previous samples and includes one gammarid. The pH here is just within the limits for *Gammarus lacustris* which doesn't occur in waters with pH of less than 6 (Gledhill, Sutcliffe, & Williams, 1993).

Figure 11: Gammarus lacustris

Sample 1.4 Sampled on 16th August 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 167262	5.86	17.8	75	37

Sample 1.4 was taken from the south-west corner of the loch, close to where the burn from Loch na h-Innse Fraoich enters the loch. Vegetation on the bank was a mix of *Calluna vulgaris* and *Myrica gale*. The substrate, composed of fine mud is colonised by a variety of plants including sedges, *Potamogeton sp.* and *Utricularia sp.*

Invertebrates

Taxonomic group	Species	Abundance	location
Copepoda		1	1.4
Diptera		1	1.4
Heteroptera	Gerridae	1	1.4
Odonata Anisoptera	Sympetrum danae	2	1.4
Odonata Zygoptera	Enallagma cyathigerum	1	1.4
Odonata Zygoptera	Ischnura elegans	3	1.4
Trichoptera	Unidentified	1	1.4

Sample 1.5 Sampled on 12th September 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 174265	6.12	12.7	62	35

Sample 1.5 was taken at the west end of the loch, from the wooded area close to the outflow. The water was shallow. The substrate consisted of small stones and gravel and contained leaf litter from the surrounding trees

Invertebrates

Taxonomic group	Species	Abundance	location
Copepoda		1	1.5
Diptera		4	1.5
Ephemeroptera	Caenis horaria	12	1.5
Malacostraca	Gammarus lacustris	1	1.5
Megaloptera	Sialis lutaria	2	1.5
Odonata Anisoptera	Cordulegaster boltonii	4	1.5
Odonata Zygoptera	Enallagma cyathigerum	5	1.5
Plecoptera	Nemoura avicularis	1	1.5
Trichoptera	Unidentified	4	1.5

Sample 1.6 Sampled on 12th September 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 175265	6.00	12.3	60	34

Sample 1.6 was taken from the outflow from Loch Leitir Easaidh, just as it leaves the loch to travel through a conduit under the road. The substrate was stony with patches of gravel and weed.

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		9	1.6
Cladocera		4	1.6
Diptera		3	1.6
Ephemeroptera	Caenis horaria	10	1.6
Ephemeroptera	Leptophlebia vespertina	1	1.6
Ephemeroptera	Paraleptophlebia submarginata	3	1.6
Ephemeroptera	Procleon ?bifidum	1	1.6
Gastropoda		9	1.6
Heteroptera	Gerridae	1	1.6
Plecoptera	Leuctra fusca	2	1.6
Plecoptera	Leuctra hippopus	1	1.6
Plecoptera	Nemoura avicularis	1	1.6
Plecoptera	Unidentified	1	1.6
Trichoptera	Polycentropus sp.	1	1.6
Trichoptera	Unidentified	7	1.6
Trichoptera (Caseless)	Holocentropus dubius	1	1.6
Trichoptera (Caseless)	Neureclipsis bimaculata	2	1.6
Trichoptera (Caseless)	Polycentropus flavomaculatus	3	1.6

Loch na h-Innse Fraoich

Loch na h-Innse Fraoich is another relatively large loch with an area of around 9.5 hectares. Loch na h-Innse Fraoich lies in a basin adjacent to, and south-west of Loch Leitir Easaidh, from which it is separated by a 20m high ridge. A similar ridge runs the length of its north western shore. Loch na h-Innse Fraoich is fed by run-off from these ridges and also by streams issuing from Lochan a' Mhanaich, Loch Torr an Lochain and the small unnamed loch to the west (referred to as loch 6 for the purposes of this survey).

Loch na h-Innse Fraoich has a band of intrusive basic material running from south-west to north-east along its northern edge, and a band of ultra-basic intrusive material running in a similar direction, transecting its southern end.

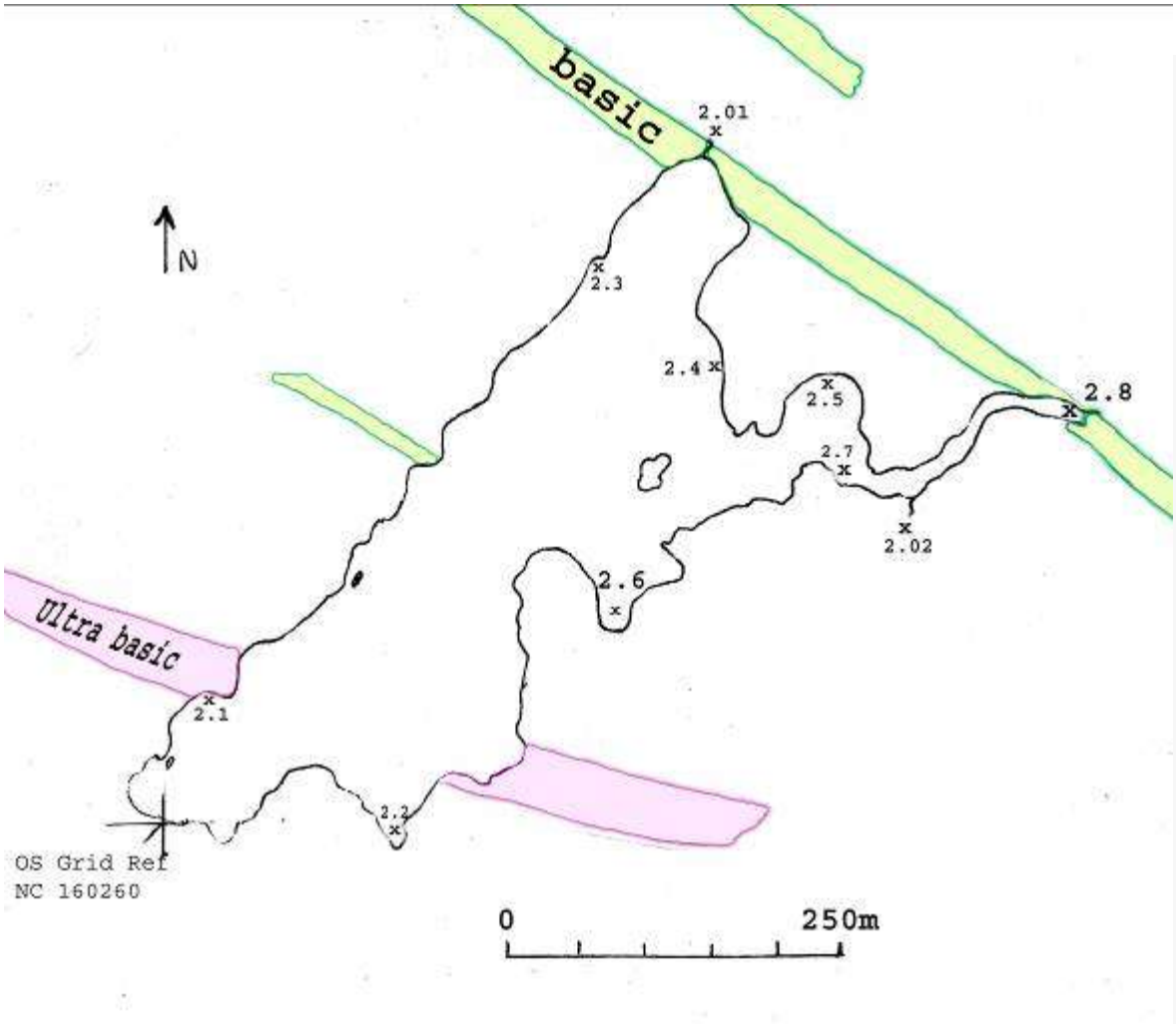


Figure 12: Loch na h-Innse Fraoich - showing sampling points and associated dykes

The littoral zone on the north east side of the loch is generally stony and unproductive with a flora composed of *Lobelia dortmanna, Ranunculus flammula* and *Littorella uniflora*. The south east side of the loch has a similar littoral zone but it is broken up by patches of deep fine mud and a slightly more diverse flora, consisting variously of *Nymphaea alba, Potamogeton sp.* and *Utricularia sp.*

Loch na h-Innse Fraoich

Sample 2.01 (Inflow burn, north east corner) Sampled on 10th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 164265	6.13	16.6	70	34

This small inflow at the east end of Loch na h-Innse Fraoich originates as the outflow from Lochain a' Mhanaich. The substrate consisted of small stones and gravel. The terrestrial vegetation was dominated by over-hanging *Calluna vulgaris* and *Molinia caerulea*.

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		7	2.01
Bivalvia		1	2.01
Coleoptera	Larva	2	2.01
Diptera		1	2.01
Ephemeroptera	Baetidae sp	1	2.01
Plecoptera	Capnia vidua	1	2.01
Plecoptera	Leuctra/Capnia sp	5	2.01
Trichoptera	Unidentified	4	2.01

Sample 2.02 (Inflow burn, south side of 'canal') Sampled on 16th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 166262	5.49	15.1	54	27

This was a small, shallow, slow moving burn with a low pH. It carries run-off from Torr Ban across a boggy area to the west of Loch na h-Innse Fraoich. This area was colonised by *Calluna vulgaris/Myrica gale* and a scattering of *Eriophorum vaginatum*. The sample point was choked with *Sphagnum, Potamogeton* and *Menyanthes trifoliatum*.

Invertebrates

Taxonomic group	Species	Abundance	location
Bivalvia		1	2.02
Diptera		3	2.02
Heteroptera	Gerridae	1	2.02
Odonata Zygoptera	Pyrrhosoma nymphula	2	2.02
Trichoptera	Oxyethira sp	2	2.02

Sample 2.1 Sampled on 6th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 160261	6.07	16.7	71	34

This sample was taken from the wooded area on the north east bank of the loch where a dyke of ultrabasic material appears to run under the loch, emerging just north of sample 2.1. The area was extensively colonised by *Pteridium aquilinum* and well-spaced trees, including birch, rowan and alder. The substrate was a mixture of cobbles and boulders with a *Lobelia dortmanna/Littorella uniflora* community. *Nymphaea alba* was also present.

Invertebrates

Taxonomic group	Species	Abundance	location
Cladocera		3	2.1
Diptera		6	2.1
Ephemeroptera	Caenis horaria	1	2.1
Ephemeroptera	Leptophlebia marginata	1	2.1
Hirudinea	Helobdella stagnalis	1	2.1
Malacostraca	Gammarus sp	1	2.1
Plecoptera	Leuctra inermis	1	2.1
Plecoptera	Nemoura avicularis	7	2.1
Trichoptera (Cased)	Chaetopteryx villosa	1	2.1

Figure 13: Fighting bracken on the approach to Sample site 2.1.

Sample 2.2 Sampled on 6th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 161259	4.96	15.9	56	29

This was a sample from a sheltered corner on the south west bank. A low pH was recorded and the substrate consisted of fine, peaty mud colonised by *Nympahea alba* and sedges. A frog and two palmate newts were recorded here.

Invertebrates

Taxonomic group	Species	Abundance	location
Bivalvia		2	2.2
Coleoptera	Ilybius sp	1	2.2
Diptera		10	2.2
Odonata Anisoptera	Libellula quadrimaculata	6	2.2
Odonata Anisoptera	Sympetrum danae	2	2.2
Odonata Anisoptera	Sympetrum striolatum	1	2.2
Odonata Zygoptera	Ischnura elegans	1	2.2
Odonata Zygoptera	Pyrrhosoma nymphula	4	2.2

Figure 14: Sample Point 2.3

Sample 2.3 Sampled on 10th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 163264	6.2	18.8	73	36

Sample 2.3 was taken from the north end of the north east bank of the loch. The substrate was stony with sparse *Lobelia dortmanna* and a stand of sedge at one side. Bankside vegetation was a mix of *Pteridium aquilinum, Calluna vulgaris, Erica tetralix* and *Molinia caerulea,* with occasional birch and willow.

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		3	2.3
Bivalvia		1	2.3
Cladocera		4	2.3
Copepoda		2	2.3
Diptera		1	2.3
Hirudinea	Helobdella stagnalis	3	2.3
Odonata Zygoptera	Ischnura elegans	1	2.3
Trichoptera (Cased)	Limnephilus sp	1	2.3

Sample 2.4 Sampled on 10th of August 2010.

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved salts (ppm)
NC 164263	6.41	19.6	72	34

This sample was taken on the north east bank of the loch where an area of boggy ground lies between Loch na h-Innse Fraoich and the ridge which forms the eastern bank of Loch Leitir Easaidh. Bankside vegetation consisted of *Calluna vulgaris, Molinia caerulea* and a small quantity of *Myrica gale.* Also present were one birch sapling and one rowan. The substrate here was stony with a sparse flora consisting of *Lobelia dortmanna* and *Ranunculus flammula.*

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		4	2.4
Bivalvia		19	2.4
Cladocera		3	2.4
Ephemeroptera	Ecdyonurus sp.	1	2.4
Gastropoda		1	2.4
Odonata Anisoptera	Cordulegaster boltonii	1	2.4
Odonata Anisoptera	Sympetrum striolatum	1	2.4

Sample 2.5 Sampled on 10th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 165263	5.97	19.8	78	39

Sample 2.5 was taken from a sheltered bay at the start of the canal-like section which precedes the outflow from Loch na h-Innse Fraoich. Bankside vegetation consists largely of *Molinia caerulea* with some *Calluna vulgaris, Erica tetralix* and *Sphagnum spp.* The substrate was composed of mud and organic debris with thick growth of *Potamogeton*, and sedges.

Invertebrates

Taxonomic group	Species	Abundance	location
Cladocera		5	2.5
Diptera		1	2.5
Odonata Zygoptera	Ischnura elegans	2	2.5
Odonata Zygoptera	Pyrrhosoma nymphula	1	2.5

Sample 2.6 Sampled on 16th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 163261	5.82	17.4	70	35

Sample 2.6 was taken from a small bay on the south shore of Loch na h-Innse Fraoich at the edge of a stand of trees. Bankside vegetation included *Calluna vulgaris, Erica tetralix,* and a variety of grasses, mosses and flowering herbs. The substrate was fine mud colonised principally by *Nymphaea alba*.

Invertebrates

Taxonomic group	Species	Abundance	location
Cladocera		1	2.6
Diptera		3	2.6
Odonata Zygoptera	Pyrrhosoma nymphula	3	2.6
Annelida		2	2.7

Sample 2.7 Sampled on 16th of August 2010.

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 165262	6.29	17.4	66	33

This sample was collected from the start of the canal-like section of the outflow from Loch na h-Innse Fraoich, on the opposite side of the water from sample 2.5. The bankside vegetation consisted of *Calluna vulgaris* and *Myrica gale*. The substrate was deep peaty mud with little vegetation.

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		2	2.7
Diptera		1	2.7
Malacostraca	Gammarus lacustris	2	2.7
Odonata Anisoptera	Sympetrum danae	1	2.7
Odonata Anisoptera	Sympetrum striolatum	3	2.7
Odonata Zygoptera	Ischnura elegans	1	2.7
Odonata Zygoptera	Pyrrhosoma nymphula	1	2.7

Sample 2.8 Sampled on 16th of August 2010.

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 167263	6.07	17.0	70	35

This sample was taken from the east end of the canal-like section before it narrows into the outflow burn. At this point it is wide and shallow with a stony substrate, colonised by *Lobelia dortmanna* and *Ranunculus flammula.* *Juncus articulatus* was present at the bank and the terrestrial vegetation, was dominated by *Calluna vulgaris* and *Myrica gale.*

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		9	2.8
Bivalvia		1	2.8
Cladocera		4	2.8
Coleoptera	?Ilybius quadriguttatus	1	2.8
Gastropoda		1	2.8
Odonata Anisoptera	Sympetrum danae	1	2.8
Odonata Zygoptera	Ischnura elegans	1	2.8

Figure 15: Loch na h-Innse Fraoich Looking North West

Lochan a' Mhanaich

Lochan a' Mhanaich lies to the north-west of Loch Leitir Easaidh and Loch na h-innse Fraoich. It is smaller than both of these lochs with an area of about 4 hectares. It is a long narrow loch, orientated northeast - southwest. It lies between two ridges formed by intrusive dykes of basic composition. It is fed by run-off from these ridges and by a burn which enters at the furthest north- west corner. Another smaller burn comes off the northern ridge (Druim Lochan a' Mhanaich), entering the loch about half way along its northern bank. An outflow burn at the southeast tip of the loch runs down to Loch na h-Innse Fraoich. The long northern and southern sides of the loch are steep and covered in *Calluna vulgaris.* The steep sides level out into plateaux at both ends of the loch where grass, and a few flowering herbs, replace some of the heather.

The substrate along both long sides of the loch is composed of large stones with a flora of *Lobelia dortmanna, Littorella uniflora* and *Ranunculus flammula*. Fine mud has accumulated in sheltered pockets at the ends of the loch. A black-throated diver was noted feeding at the north-west end of the loch.

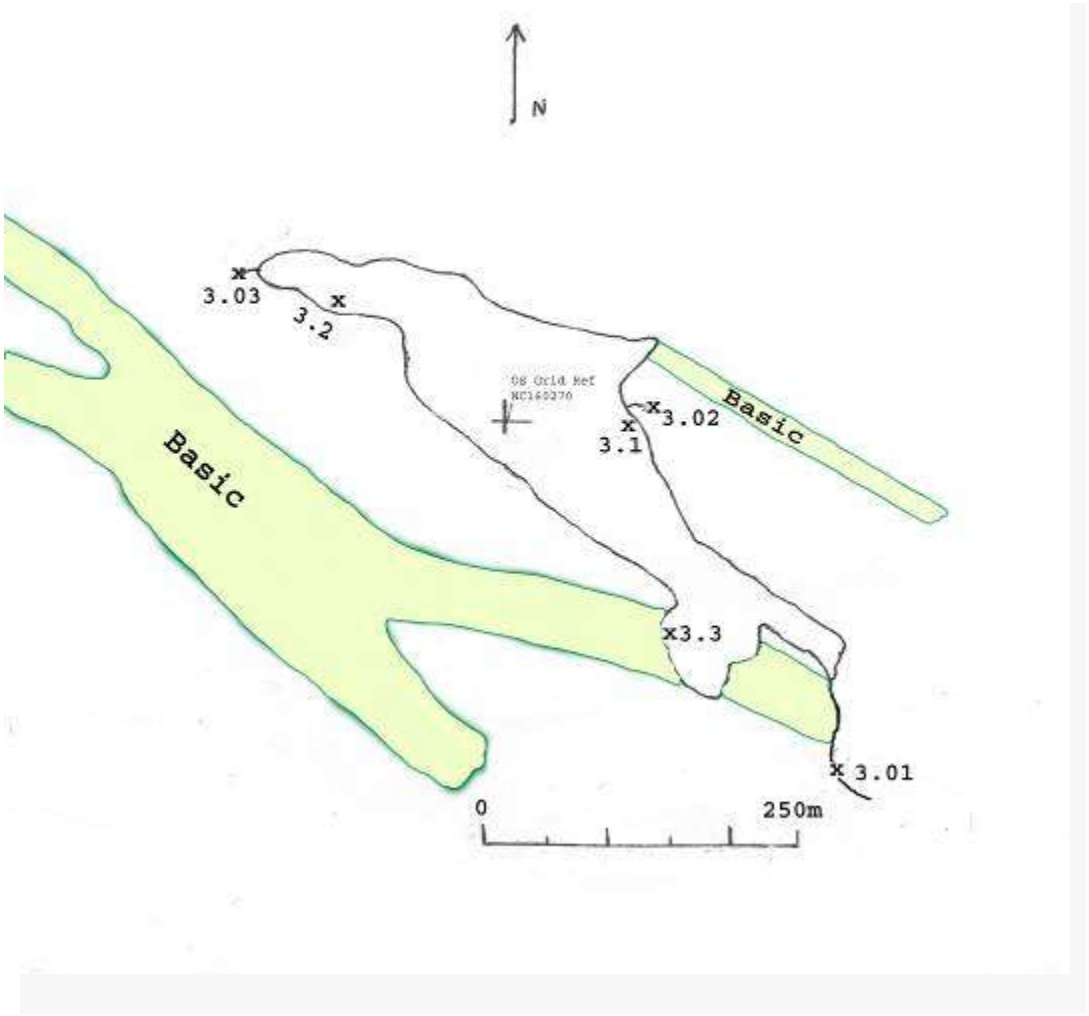


Figure 16: Lochan a; Mhanaich

Lochan a' Mhanaich

Figure 17: Lochain a' Mhanaich

Sample 3.01 (Outflow at south east end) Sampled on 31st July 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 163268	6.56	16.5	65	32

Sample 3.01 is the outflow from Lochan a'Mhanaich. This burn travels across *Calluna*-dominated heath and down a rocky slope to emerge from an area of woodland and bracken at the heathery north west corner of Loch na h-Innes Fraoich. This sampling point was overhung by *Calluna vulgaris*, which along with *Molinia caerulea* constitutes the dominant terrestrial vegetation. The substrate was a mixture of muddy gravel and small stones.

Invertebrates

Taxonomic group	Species	Abundance	location
Annelida		4	3.01
Bivalvia		72	3.01
Cladocera		9	3.01
Coleoptera	Oulimnius sp	5	3.01
Diptera		26	3.01
Gastropoda		48	3.01
Odonata Anisoptera	Cordulegaster boltonii	21	3.01
Odonata Anisoptera	Sympetrum danae	1	3.01
Odonata Zygoptera	Ischnura elegans	1	3.01
Odonata Zygoptera	Pyrrhosoma nymphula	1	3.01
Plecoptera	Leuctra fusca	1	3.01
Plecoptera	Leuctra hippopus/moselyi	6	3.01
Plecoptera	Leuctra inermis/Capnia bifrons	1	3.01
Trichoptera	Unidentified	2	3.01
Trichoptera (Cased)	Sericostoma personatum	1	3.01
Trichoptera (Caseless)	Neureclipsis bimaculata	1	3.01
Trichoptera (Caseless)	Polycentropus flavomaculatus	7	3.01

Sample 3.02 Sampled on 31st July 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 161271	5.88	14.3	44	23

Sample 3.02 was a small weed-choked burn draining from Druim Lochan a' Mhanaich. The substrate was mud and fine gravel, supporting a colony of weed and moss.

Invertebrates

Taxonomic group	Species	Abundance	Location
Plecoptera	Nemoura cambrica	1	3.02
Plecoptera	Nemurella picteti	2	3.02
Trichoptera (Caseless)	Plectronemia conspersa	2	3.02

Sample 3.03 (Inflow, north-west end) Sampled on 31st July 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 158271	5.82	14	43	21

Sample 3.03 was taken from the shallow inflow burn at the northwest end of the loch. The substrate here was composed of gravel and small stones. The bankside vegetation was predominantly C*alluna vulgaris, Erica tetralix* and *Molinia caerulea. Carex rostrata* was present at the edge of the bank.

Invertebrates

Taxonomic group	Species	Abundance	Location
Coleoptera	Unidentified	1	3.03
Diptera		4	3.03
Odonata Anisoptera	Cordulegaster boltonii	5	3.03
Odonata Zygoptera	Pyrrhosoma nymphula	1	3.03
Plecoptera	Leuctra hippopus/moselyi	1	3.03

Sample 3.1 Sampled on 31st July 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 161270	6.35	17.3	66	32

Sample 3.1 was taken from the middle of the north shore, just west of inflow 3.02 at the foot of Druim Lochan a' Mhanaich. The slopes of Druim Lochan a' Mhanaich are covered in *Calluna vulgaris*. The bank of the loch here is half a metre above the water level with

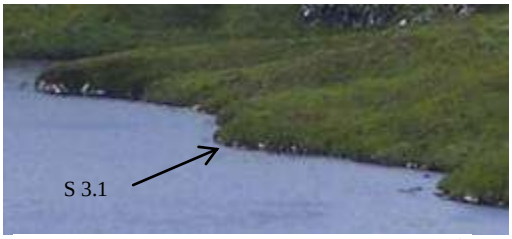


Figure 18: Sample point 3.1 on the north shore of Lochan a' Mhanaich

more or less vertical sides. The substrate consists of boulders and cobbles with a sparse flora of *Lobelia dortmanna* and *Ranunculus flammula.*

Invertebrates

Taxonomic group	Species	Abundance	Location
Cladocera		20	3.1
Ephemeroptera	Heptagenia sulphurea	1	3.1
Ephemeroptera	Heptageniidae	1	3.1
Odonata Zygoptera	Ischnura elegans	3	3.1

Sample 3.2 Sampled on 31st July 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 158271?	6.19	14.5	53	27

Sample 3.2 was another sample from the stony loch-bed. *Lobelia dortmanna* and *Ranunculus flammula* were the only plants present.

Invertebrates

Taxonomic group	Species	Abundance	Location
Bivalvia		11	3.2
Cladocera		3	3.2
Coleoptera	Larva	3	3.2
Diptera		6	3.2
Ephemeroptera	Caenis horaria	1	3.2
Ephemeroptera	Centroptilum luteolum	7	3.2
Ephemeroptera	Ecdyonurus venosus sp	1	3.2
Ephemeroptera	Heptageniidae	1	3.2
Ephemeroptera	Unidentified	3	3.2
Gastropoda		1	3.2
Malacostraca	Gammarus sp.	3	3.2
Odonata Anisoptera	Cordulegaster boltonii	1	3.2
Odonata Anisoptera	Sympetrum danae	1	3.2
Odonata Anisoptera	Sympetrum striolatum	1	3.2
Odonata Zygoptera	Ischnura elegans	1	3.2
Trichoptera (Cased)	Sericostoma personatum	3	3.2

Sample 3.3 Sampled on 31st July 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 161268	6.06	16.3	59	29

This sample was taken from the south east corner of the loch which is markedly different from the rest of the loch. The vegetation on low lying bank consists of *Calluna vulgaris, Myrica gale, Erica tetralix, Eriophorum vaginatum* and sedges. The sample area was in a small pocket of muddy sediment with emergent vegetation and thick growth of *Nymphaea alba* and *Potamogeton sp.*

Invertebrates

Taxonomic group	Species	Abundance	Location
Cladocera		7	3.3
Coleoptera	Gyrinus substriatus	5	3.3
Coleoptera	Hydroporus sp.	1	3.3
Ephemeroptera	Leptophlebia marginata	6	3.3
Gastropoda		2	3.3
Heteroptera	Corixidae juvenile	4	3.3
Heteroptera	Gerris lacustris	1	3.3
Odonata Anisoptera	Aeshna juncea	1	3.3
Odonata Zygoptera	Ischnura elegans	9	3.3
Odonata Zygoptera	Lestes sponsa	2	3.3
Plecoptera	Nemoura cambrica	3	3.3
Plecoptera	Nemoura cinerea	1	3.3

Figure 19: Sample point 3.3

Loch Torr an Lochain

Loch Torr an Lochain is a small loch to the south of Loch na h-Innse Fraoich. It occupies about 3.5 hectares below and to the west of Torr Ban. It has no obvious inflow. The outflow is a small burn draining into Loch na h-Innse Fraoich. The northern corner of loch is at the bottom of a wooded slope. The ground to the east of this is an area of wet heath characterised by *Calluna vulgaris, Molinia caerulea* and *Myrica gale.* The loch has a stony substrate, populated mainly by a *Lobelia dortmanna/Ranunculus flammula* community.

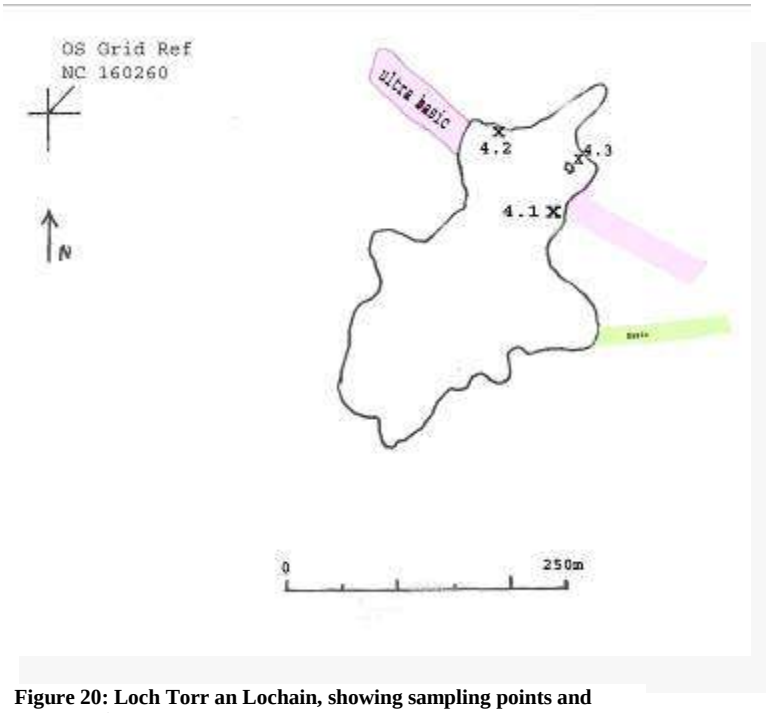


Figure 20: Loch Torr an Lochain, showing sampling points and position of ultrabasic dyke

Figure 21: Loch Torr an Lochain, looking south west

Loch Torr an Lochain

Sample 4.1 Sampled on 13th June 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 164258	7.02	16.7	71	35

This sample was taken from an area of cobbles and boulders which were covered in a slimy coating. The flora consisted of *Lobelia dortmanna* and *Ranunculus flammula.*

Invertebrates

Taxonomic group	Species	Abundance	Location
Annelida		1	4.1
Bivalvia		2	4.1
Ephemeroptera	Caenis horaria	1	4.1
Hirudinea	Glossiphonia complanata	1	4.1
Trichoptera	Chaetopteryx villosa	1	4.1
Trichoptera	Unidentified	1	4.1

Sample 4.2 Sampled on 13th June 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 165259	6.66	16.4	69	34

This sample was taken from a sheltered corner under a steep bank. The substrate was again stony, slimy and sparsely colonised by *Lobelia dortmanna* and *Ranunculus flammula.*

Invertebrates

Taxonomic group	Species	Abundance	Location
Annelida		5	4.2
Cladocera		10	4.2
Coleoptera	Larvae	1	4.2
Diptera		7	4.2
Ephemeroptera	Caenis horaria	9	4.2
Ephemeroptera	Leptophlebia marginata	1	4.2
Hirudinea	Glossiphonia complanata	1	4.2
Odonata Zygoptera	Pyrrhosoma nymphula	1	4.2
Trichoptera (Cased)	Ceraclea senilis	1	4.2
Trichoptera (Cased)	Triaenodes bicolor	1	4.2

Sample 4.3 Sampled on 16th August 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 165260	6.22	17.5	65	32

This sample was taken from around the small island at the north-east end of the loch. The substrate varied from boulders and gravel to fine mud and plant litter. Bankside vegetation consisted of overhanging *Calluna vulgaris* and *Myrica gale*. *Juncus articulatus* was growing at the edge of the loch.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Annelida		6	4.3
Cladocera		20	4.3
Diptera		3	4.3
Ephemeroptera	Ameletus inopinatus	1	4.3
Odonata Anisoptera	Sympetrum danae	1	4.3

Figure 22: Ephemeropteran from Loch Torr an Lochain (Leptophlebia marginata sub imago?)

Loch 5

This was the small unnamed dubh lochan lying on a boggy terrace between Loch Leitir Easaidh and the north east corner of Loch na h-Innse Fraoich. It is about 1000 square metres in area (0.1 hectares) and is deep with a soft peaty substrate and a low pH. The bank is vertical most of the way round with overhanging *Calluna vulgaris.* The exception to this is the northern corner where sphagnum moss slopes gradually into the water. A slow-worm was noted close to this corner, which also produced several palmate newts. The vegetation around the loch was a mixture of *Sphagnum spp., Calluna vulgaris, Myrica gale, Molinia caerulea* and *Eriophorum vaginatum*.

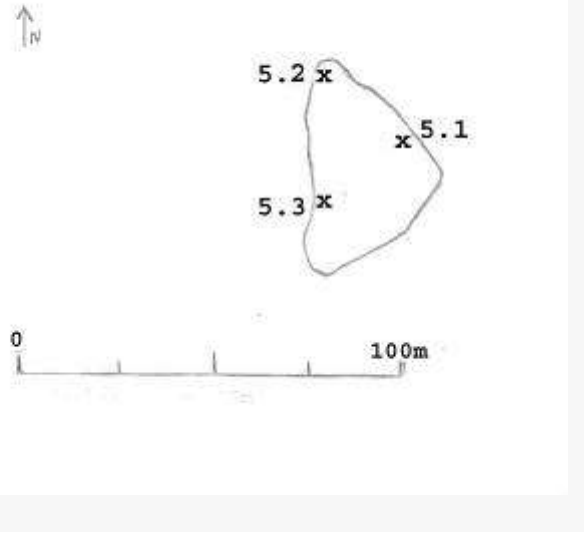


Figure 23: Loch 5

Figure 24: *Nymphaea alba.* North end of Loch 5

.

Loch 5

Sample 5.1 Sampled on 10th June 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 165266	4.35	19.2	51	25

This sample was taken partly by sweeping the open water and partly by dredging the muddy bottom of the loch.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Cladocera		2	5.1
Coleoptera	larva	1	5.1
Heteroptera	Corixidae juvenile	1	5.1
Heteroptera	Notonecta obliqua	2	5.1
Heteroptera	Sigara scotti	2	5.1
Odonata Zygoptera	Ischnura elegans	4	5.1
Trichoptera (Caseless)	Holocentropus dubius	2	5.1

Sample 5.2 Sampled on 10th June 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 164266	4.26	20.4	53	26

This sample was taken from the north corner of loch amongst sphagnum and peaty debris.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Coleoptera	Acilius sulcatus	1	5.2
Coleoptera	Gyrinus substriatus	4	5.2
Heteroptera	Corixidae juvenile	11	5.2
Odonata Zygoptera	Ischnura elegans	4	5.2
Odonata Zygoptera	Lestes sponsa	1	5.2
Odonata Zygoptera	Pyrrhosoma nymphula	1	5.2
Trichoptera (Caseless)	Holocentropus dubius	3	5.2
Trichoptera (Caseless)	Unidentified	3	5.2

Sample 5.3 Sampled on 31st July 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 164267	4.21	15.8	70	27

This sample was taken from the west bank of the loch, by sweeping though the water column, plant stems and peaty substrate. This area was colonised by *Nymphea alba.*

Invertebrates

Taxonomic Group	Species	Abundance	Location
Coleoptera	Larvae	3	5.3
Diptera		12	5.3
Heteroptera	Corixidae juvenile	9	5.3
Heteroptera	Gerridae juvenile	1	5.3
Heteroptera	Notonecta Juvenile	1	5.3
Heteroptera	Sigara scotti	2	5.3
Odonata Anisoptera	Libellula quadrimaculata	2	5.3
Odonata Zygoptera	Ischnura elegans	4	5.3
Odonata Zygoptera	Lestes sponsa	1	5.3
Trichoptera (Caseless)	Holocentropus dubius	1	5.3

Figure 25: Lestes sponsa

Loch 6

Loch 6 is a small un-named loch lying in a dip between the two ridges which separate Loch Leitir Easaidh and Loch na h-Innse Fraoich. The surrounding vegetation is mostly *Calluna vulgaris/Myrica gale/Molinia caerulea,* with scattered *Eriophorum vaginatum* and boggy pools colonised by *Sphagnum* and *Potamogeton*. It is particularly boggy at the south end below the escarpment of Gob Ard. The loch has an area of around 1 hectare. It has no obvious inflow but there are several flushes draining into it. The water has a low pH. A black-throated diver was noted feeding here in early June.

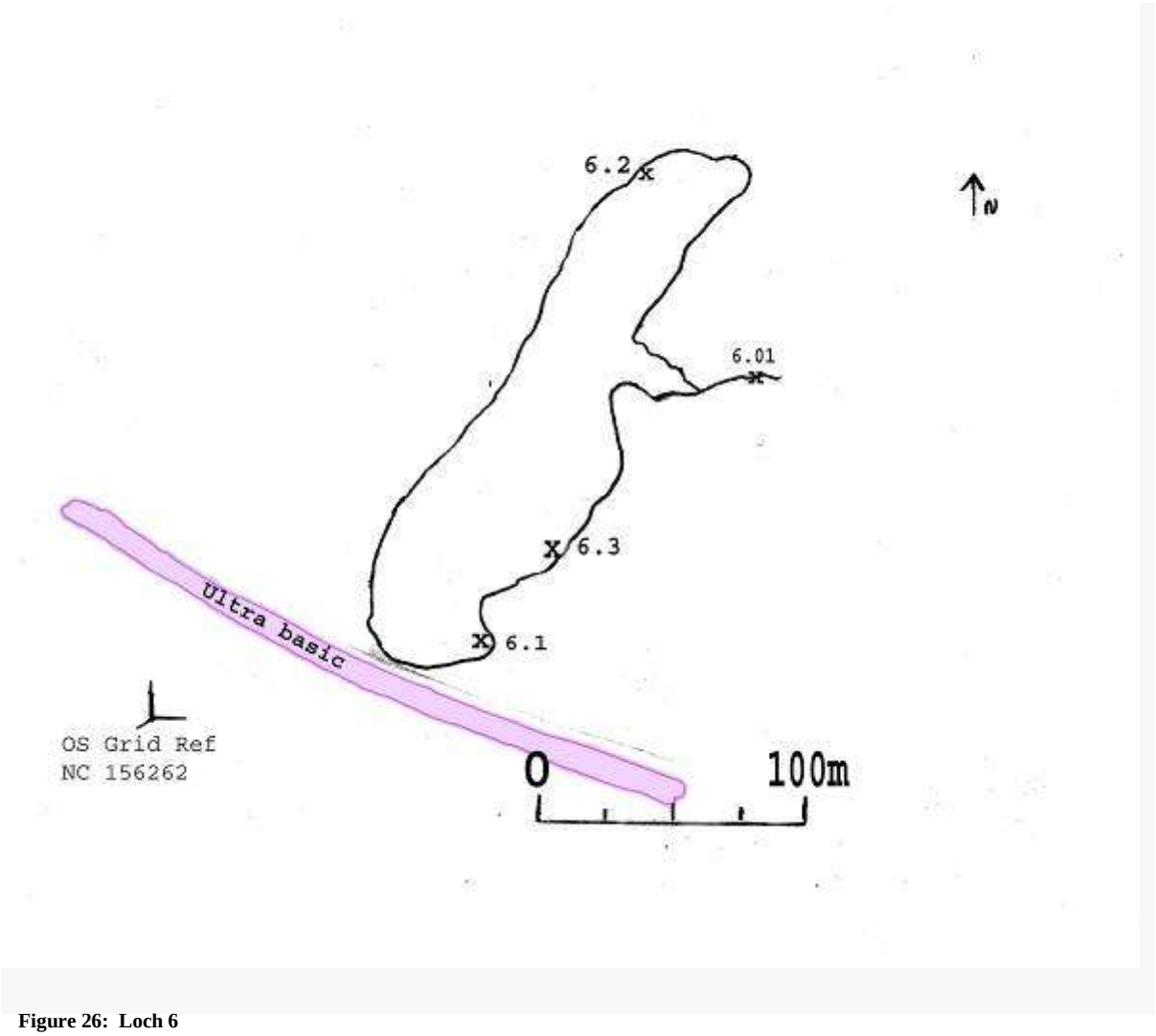


Figure 26: Loch 6

Figure 27: Loch 6 looking north

Sample 6.01 (Outflow) Sampled on 2nd August 2010

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm	Dissolved Salts (ppm)
NC 158263	6.06	16	53	26

This burn crosses the boggy ground beside the loch and flows through a gap in the ridge to the east, and thence down into Loch na h-Innse Fraoich. The substrate at the point sampled is fine gravel.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Diptera		7	6.01
Heteroptera	Gerridae	1	6.01
Heteroptera	Gerridae juvenile	3	6.01
Plecoptera	Leuctra hippopus/moselyi	1	6.01
Trichoptera (Caseless)	Polycentropus irroratus	5	6.01

Sample 6.1 Sampled on 2nd August 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 157262	4.65	15.1	41	21

Sample 6.1 was collected at the south end of the loch, where an area of *Sphagnum*-dominated bog fed by run-off from Gob Ard forms a marshy edge to the loch. In addition to sphagnum this area contains *Potamogeton, Nymphaea alba* and *Eriophorum vaginatum.* This sample had a particularly low pH.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Bivalvia		2	6.1
Cladocera		7	6.1
Diptera		4	6.1
Ephemeroptera	Centroptilum luteolum	1	6.1
Heteroptera	Corixidae juvenile	123	6.1
Heteroptera	Gerridae juvenile	2	6.1
Heteroptera	Hesperocorixa castanea	10	6.1
Heteroptera	Notonecta juvenile	1	6.1
Heteroptera	Sigara scotti	2	6.1
Odonata Anisoptera	Aeshna juncea	13	6.1
Odonata Anisoptera	Sympetrum danae	1	6.1
Odonata Zygoptera	Lestes sponsa	8	6.1

Figure 28: Sample Point 6.1

Sample 6.2 Sampled on 2nd August 2010

Physical parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 158264	5.94	16.4	52	26

Sample 6.2 was collected at the north end of the loch on the east bank. The bank was steep sided and the substrate was muddy and colonised *by Nympahea alba, Potamogeton sp.* and *Utricularia sp.*

Invertebrates

Taxonomic Group	Species	Abundance	Location
Cladocera		16	6.2
Coleoptera	Unidentified	1	6.2
Diptera		4	6.2
Gastropoda		1	6.2
Heteroptera	Corixidae juvenile	1	6.2
Heteroptera	Gerridae juvenile	1	6.2
Odonata Anisoptera	Sympetrum danae	1	6.2
Odonata Zygoptera	Ischnura elegans	30	6.2
Plecoptera	Nemoura cambrica	1	6.2

Sample 6.3

Physical Parameters

Grid Ref.	pH	Temp (O^C)	Conductivity (µs/cm)	Dissolved Salts (ppm)
NC 157262	5.94	16.7	52	26

This sample was collected from a stony area on the west bank of the loch. *Ranunculus flammula* was the only plant present.

Invertebrates

Taxonomic Group	Species	Abundance	Location
Annelida		2	6.3
Cladocera		2	6.3
Diptera		4	6.3
Heteroptera	Corixidae juvenile	3	6.3
Odonata Zygoptera	Ischnura elegans	2	6.3

Summary of Data

Taxa by Frequency of Appearance

Taxonomic Group	Abundance
Annelida	66
Bivalvia	198
Cladocera	121
Coleoptera	33
Copepoda	10
Diptera	141
Ephemeroptera	132
Gastropoda	73
Heteroptera	185
Hirudinea	6
Malacostraca	8
Odonata Anisoptera	87
Odonata Zygoptera	105
Plecoptera	48
Trichoptera	109
Megaloptera	2
Total	**1324**

Figure 29: Acilius sulcatus

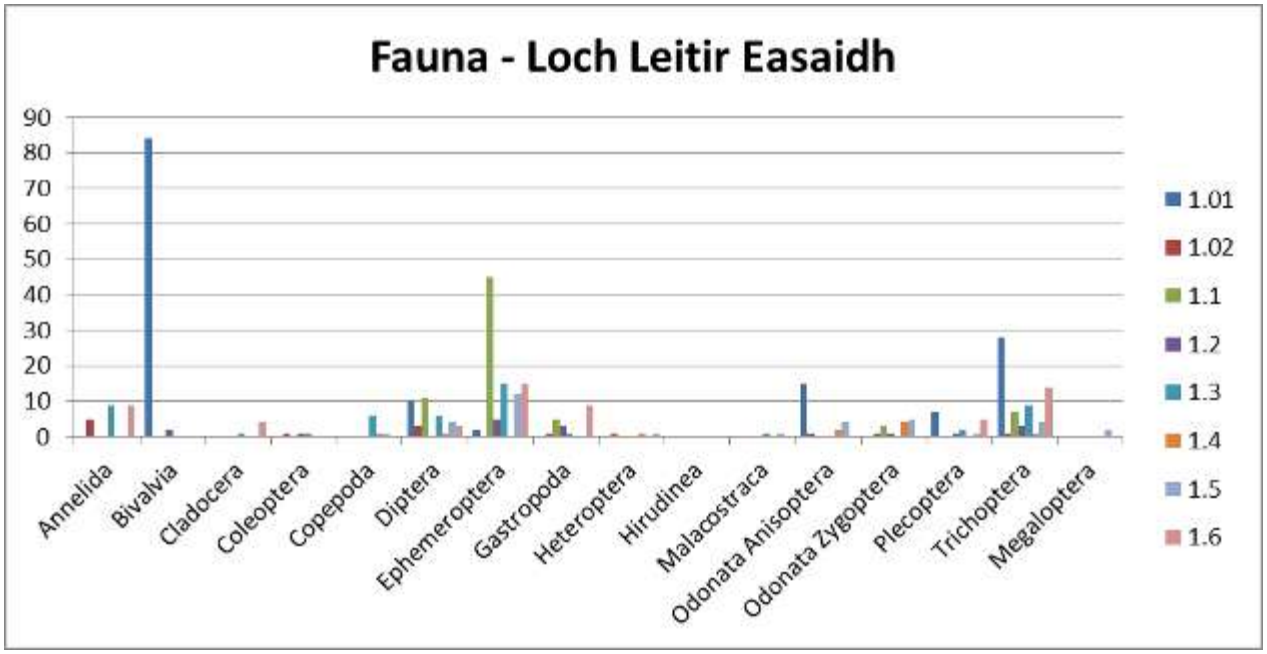
Species List

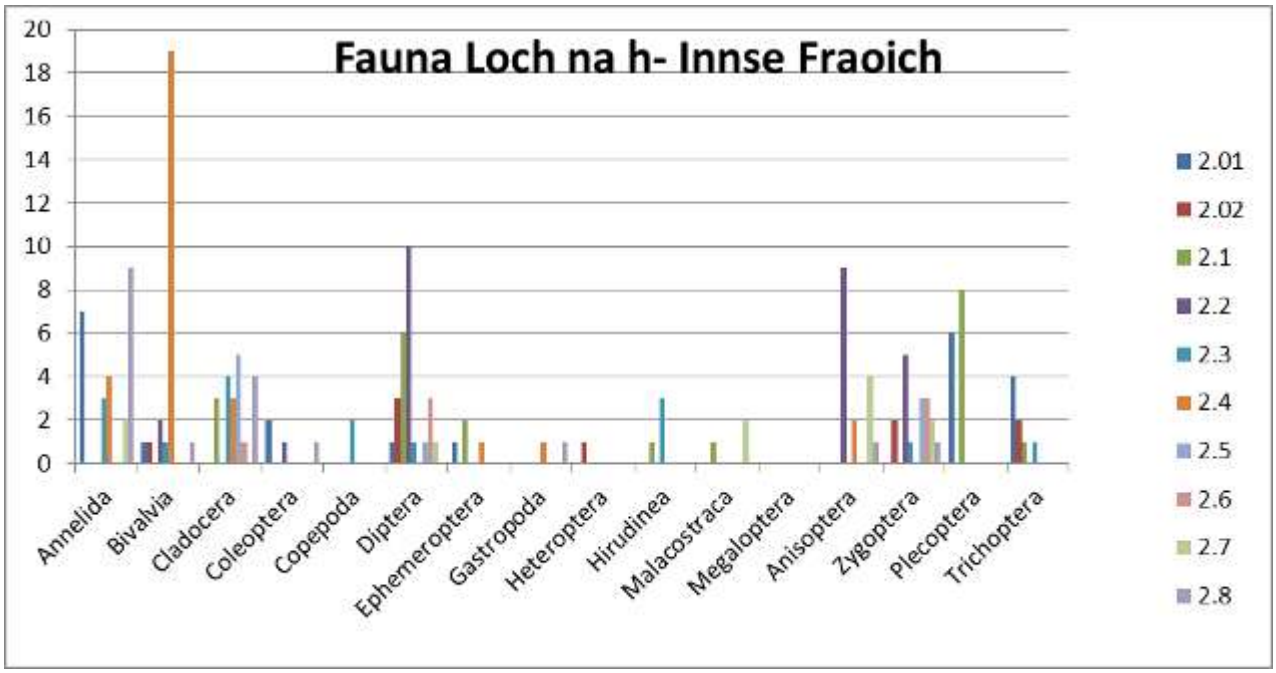
Taxa	Count
Annelida	66
Bivalvia	198
Cladocera	121
Coleoptera	
larva	12
Acilius sulcatus	1
Gyrinus substriatus	9
Hydroporus sp	1
Ilybius quadriguttatus	1
Ilybius sp	1
Oulimnius sp	6
Unidentified	2
Copepoda	10
Diptera	141
Ephemeroptera	
Ameletus inopinatus	1
Baetidae sp	9
Caenidae sp	1
Caenis horaria	37
Centroptilum luteolum	8
Ecdyonurus venosus sp	2
Electrogena lateralis	1
Heptagenia sulphurea	1
Heptageniidae	2
Leptophlebia marginata	36
Leptophlebia vespertina	3
Leptophlebidae sp	1
Paraleptophlebia sp	6
Procleon bifidum?	1
Serratella ignita	1
Unidentified	22
Gastropoda	73
Heteroptera	
Corixidae juvenile	152
Hesperocorixa castanea	10
Sigara scotti	6
Gerridae	4
Gerridae juvenile	7
Gerris lacustris	2
Notonecta Juvenile	2
Notonecta obliqua	2
Hirudinea	
Helobdella stagnalis	4
Glossiphonia complanata	2
Malacostraca	
Gammarus sp	5
Gammarus lacustris	3

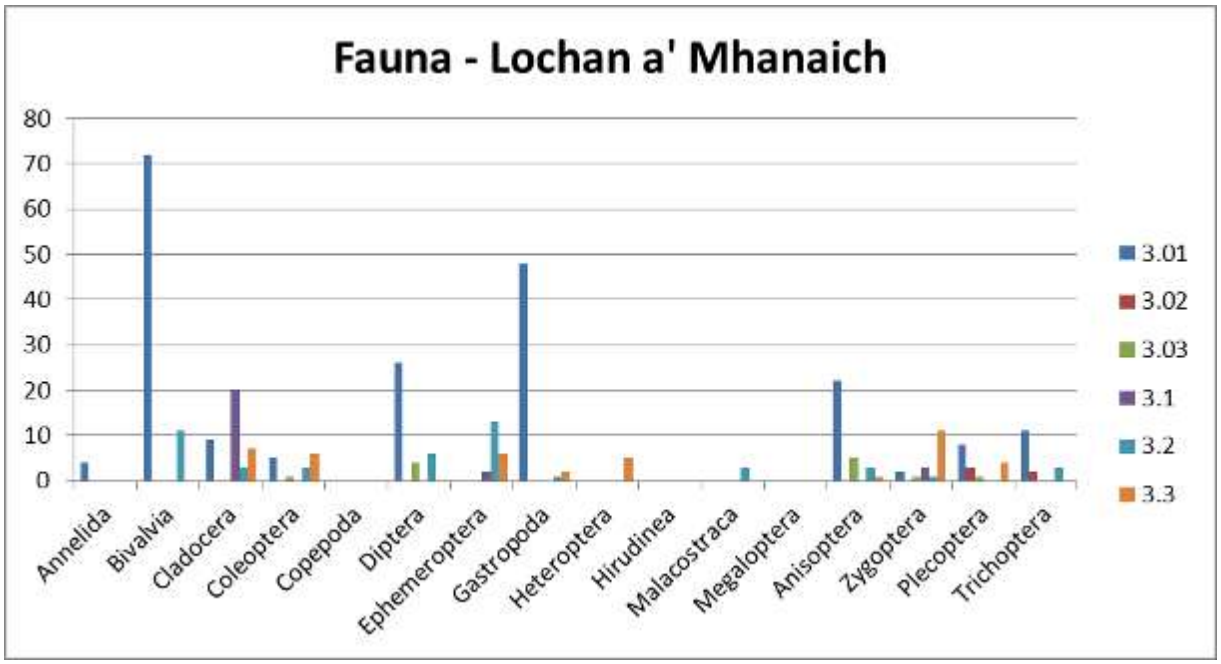
Taxa	Count
Megaloptera	
Sialis lutaria	2
Anisoptera	
Aeshna juncea	14
Cordulegaster boltonii	48
Libellula quadrimaculata	8
Sympetrum danae	11
Sympetrum striolatum	6
Zygoptera	
Enellagma cyathagerum	6
Ischnura elegans	71
Pyrrhosoma nymphula	16
Lestes sponsa	12
Plecoptera	
Capnia vidua	1
Diura bicaudata	1
Leuctra fusca	8
Leuctra hippopus/moselyi	11
Leuctra inermis	1
Leuctra inermis/capnia bifrons	1
Leuctra nigra/fusca	2
Leuctra/Capnia sp	5
Nemoura avicularis	9
Nemoura cambrica	5
Nemoura cinerea	1
Nemurella picteti	2
Unidentified	1
Trichoptera	
Ceraclea senilis	1
Chaetopteryx villosa	2
Holocentropus dubius	7
Hydropsyche siltalai	3
Limnephilus borealis	1
Limnephilus sp	1
Mystacides sp	2
Neureclipsis bimaculata	9
Oxyethira sp	2
Plectronemia conspersa	2
Polycentropus flavomaculatus	14
Polycentropus irroratus	6
Polycentropus sp	1
Sericostoma personatum	10
Triaenodes bicolor	1
Unidentified	47

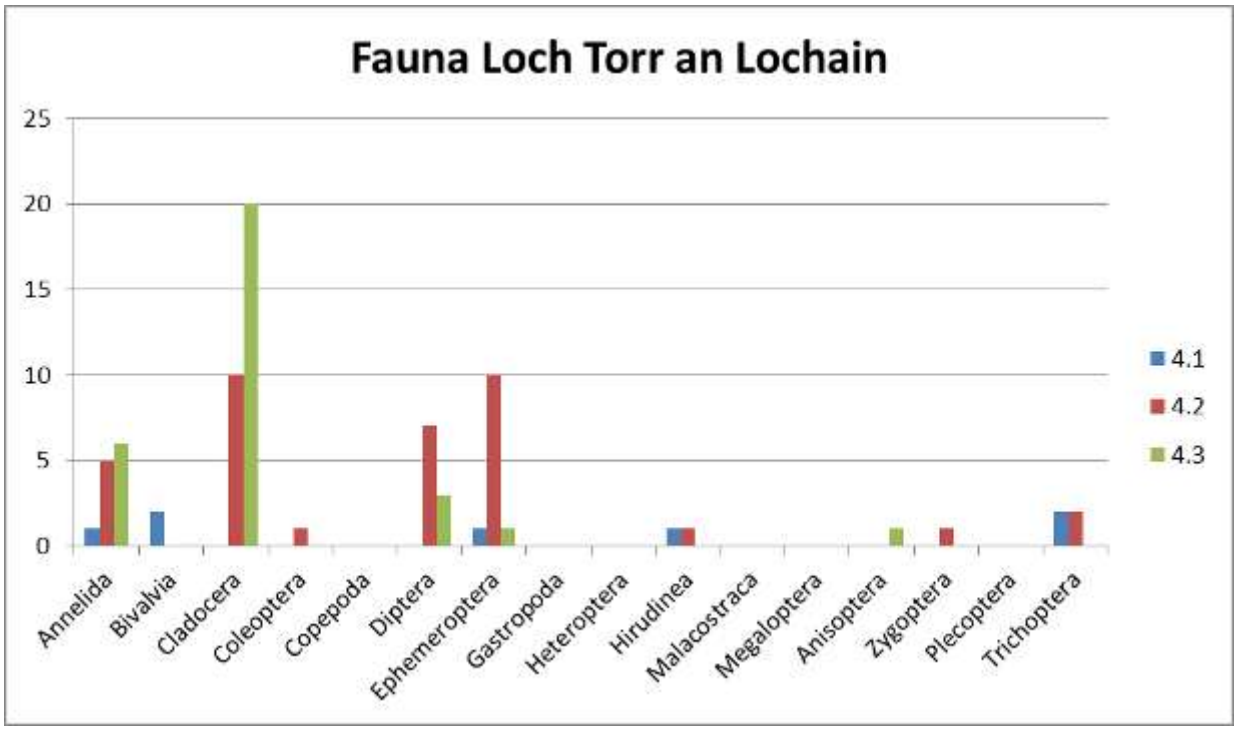
Fauna Distribution Charts

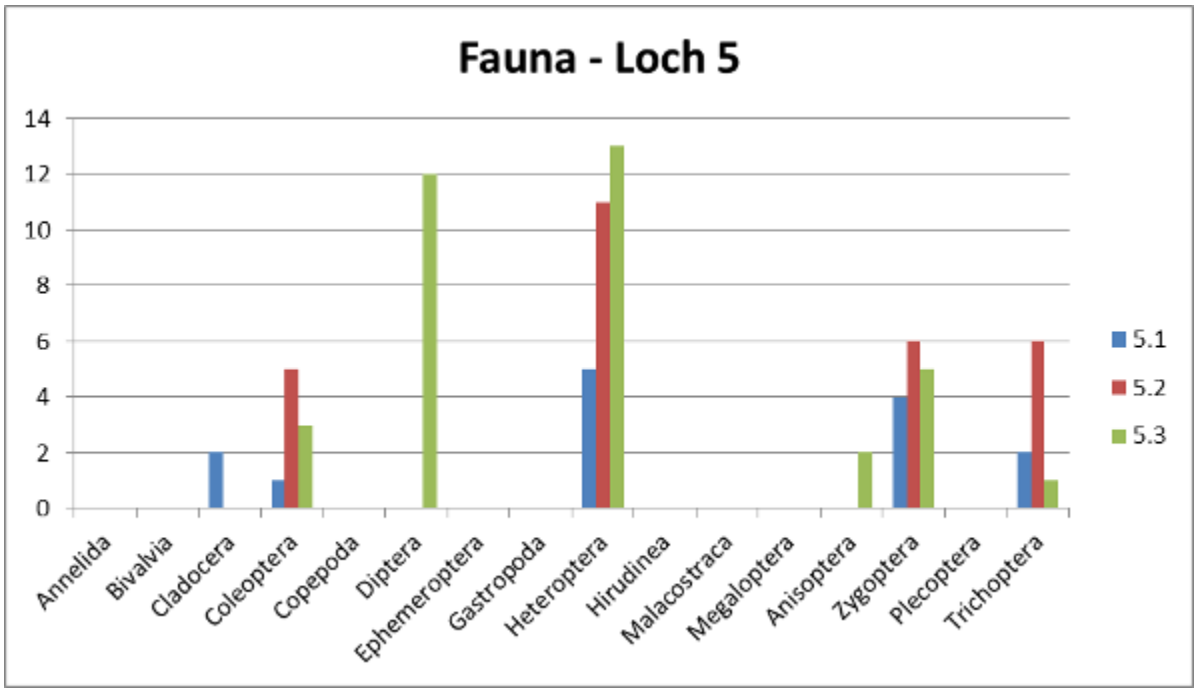
Charts showing the distribution of major taxonomic groups at each loch.

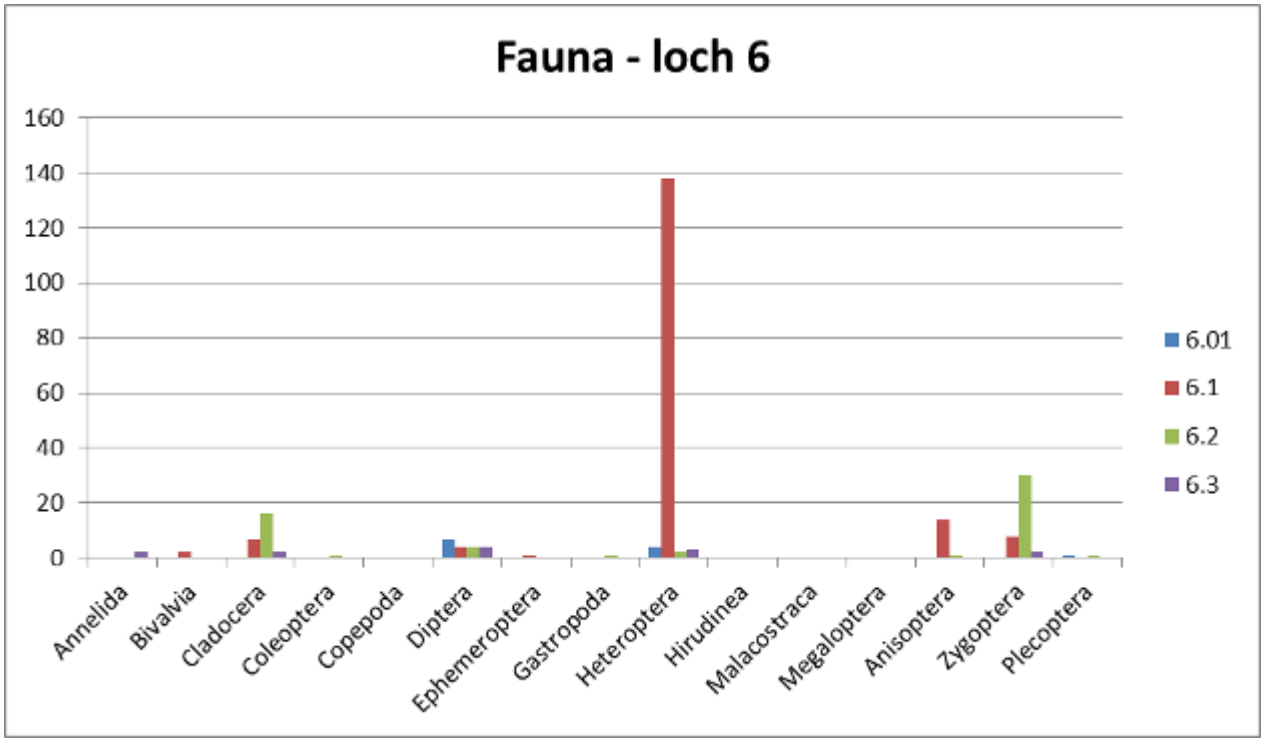





Fauna - Lochan a' Mhanaich
80
70
60
50
40
30
20
10
0
Annelida
Bivalvia
Cladocera
Coleoptera
Copepoda
Diptera
Ephemeroptera
Gastropoda
Heteroptera
Hirudinea
Malacostraca
Megaloptera
Anisoptera
Zygoptera
Plecoptera
Trichoptera
3.01
3.02
3.03
3.1
3.2
3.3


Fauna Loch Torr an Lochain
25
20
15
10
5
0
Annelida
Bivalvia
Cladocera
Coleoptera
Copepoda
Diptera
Ephemeroptera
Gastropoda
Heteroptera
Hirudinea
Malacostraca
Megaloptera
Anisoptera
Zygoptera
Plecoptera
Trichoptera
4.1
4.2
4.3


Fauna - Loch 5
14
12
10
8
6
4
2
0
Annelida
Bivalvia
Cladocera
Coleoptera
Copepoda
Diptera
Ephemeroptera
Gastropoda
Heteroptera
Hirudinea
Malacostraca
Megaloptera
Anisoptera
Zygoptera
Plecoptera
Trichoptera
5.1
5.2
5.3


Fauna - loch 6
160
140
120
100
80
60
40
20
0
Annelida
Bivalvia
Cladocera
Coleoptera
Copepoda
Diptera
Ephemeroptera
Gastropoda
Heteroptera
Hirudinea
Malacostraca
Megaloptera
Anisoptera
Zygoptera
Plecoptera
6.01
6.1
6.2
6.3

Interpretation of the results

The generally mineral-poor status of the parent rock is reflected in the terrestrial vegetation of the area. The vegetation surrounding the lochs is largely *Calluna vulgaris/Myrica gale/Eriophorum*-dominated wet heath with large patches of *Sphagnum* bog and patches of drier heath with a mix of *Calluna vulgaris, Erica tetralix* and *Molinia caerulea*. Interspersed with these are patches of birch woodland and stands of *Pteridium aquilinum.* The wet heath supports a variety of acid-loving plants such as *Narthecium ossifragum, Pedicularis sylvatica, Succisa pratensis,* and *Polygala serpyllifolia.* These, along with species such as *Trichophorum caespitosum*, distinguish their environment as mineral-poor and acidic. The tendency of sphagnum mosses to acidify their surroundings by metabolic activity contributes to the establishment of an environment already made inhospitable by the nutrient poor, acidic parent rock. In contrast to this impoverished environment there also exist pockets of flora which have a higher mineral requirement. These include *Oxalis acetosella* and *Ajuga pyramidalis* on drier ground, and *Menyanthes trifoliatum* and *Schoenus nigricans* in marshy areas.

The nutrient-poor and acidic nature of the land around the lochs is reflected in the quality of the aquatic habitat and the invertebrate communities present therein. The pH in all the lochs studied was below neutral. The pH was particularly low in Loch 5 and unusually variable in loch 6. The mineral content of the water was also very low, as measured by conductivity. There is a restricted flora and fauna which can thrive in these conditions.

The low nutrient status of the lochs is evident from the littoral flora which is consistent with lakes in groups A – C2 of the JNCC Classification of British Lakes (Duigan, Kovach, & Palmer, 2006) These correspond to the EC Habitats Directive **Natural Dystrophic** and **Oligotrophic to Mesotrophic** categories. Flora in the lochs surveyed includes (and is often restricted to) *Lobelia dortmanna, Ranunculus flammula* and *Littorella uniflora.* Also present were *Utricularia sp.* and *Myriophyllum alterniflorum*.

The fauna identified in the course of the survey is in keeping with this assessment of the Little Assynt lochs. Although the abundance of fauna is generally low, there is a relatively high diversity of species over the lochs surveyed. This is generally a sign of a healthy ecosystem.

Many freshwater invertebrates have very specific habitat requirements and those that thrive in clean, well-oxygenated oligotrophic lochs with low levels of dissolved minerals are quite specific to that habitat. Crustaceans and molluscs need sufficient dissolved calcium in the form of $CaCO_3$ to produce a shell or exoskeleton. *Gammarus lacustris*, for example, found at two lochs here, cannot survive at pH of less than 6 and is therefore at the limit of its range here (Gledhill, Sutcliffe, & Williams, 1993). Acid sensitivity is also an issue for many other species including cladocerans, which form an important part of the food web in lochs.

At a glance it appears that the sites with the lowest pH tend to be the ones with muddy/peaty substrates, e.g. Loch 5, Loch 6 and the muddy sites at Loch na h-Innse Fraoich. (See appendix 2 for details of substrates).

Some of the invertebrate species found here are specifically associated with low pH, mineral deficient environments. *Hesperocorixa castanea* and *Sigara scotti were* found at Lochs 5 and 6, which were among the most mineral deficient sites surveyed. Occurrence of these two species has been shown to be associated with low conductivity in meres of the English Midlands (Savage A., 1990). *Nemurella picteti* is an acid-tolerant species, which allows it to thrive in conditions which would be unfavourable to other organisms (Ball, 2009). Certain species of Ephemeroptera, Plecoptera and Trichoptera are used as indicator species for water quality analysis and score highly in the Biological Monitoring Working Party (BMWP) scoring system for aquatic invertebrates. This scoring system grades aquatic invertebrate families according to their sensitivity to pollution. Scores range from 1 – 10. Families scoring 10 are those with highest sensitivity to pollution. The scores for all taxa in a sample are added together to give a total for the sample, known as the BMWP score. The BMWP score is often further refined by expressing it as the average score per taxon (ASPT). This is obtained by dividing the original BMWP score by the number of scoring families present in the sample. Of the species found at Little Assynt, several have a high BMWP score and are therefore indicators of good water quality. These include the Ephemeroptera families *Heptageniidae* (3 found at Lochan a' Mhanaich and Loch na h-Innse Fraoich), and *Leptophlebidae* (found at Loch Leitir Easaidh and Lochan a'Mhanaich). High scoring Plecoptera include the *Leuctridae*, several of which were found at Loch Leitir Easaidh and Lochan a' Mhanaich. The high-scoring Trichoptera, *Sericostomatidae*, were found at Lochan a' Mhanaich and Loch Leitir Easaidh. Leeches (Hirudinea) have a lower BMWP score, indicating tolerance to lower oxygen levels and a mineral or organic enrichment of the water. These were found at the north end of Loch Torr an Lochain which has a relatively high pH. This area appears to have a band of ultrabasic material running under the loch, and the slimy stones noted in this area could be a symptom of mineral enrichment.

In summary it has been demonstrated that the lochs surveyed at Little Assynt are generally acidic, low in dissolved minerals and support a plant and invertebrate community typical of clean well-oxygenated waters. The acidity derives from the acid bedrock and is enhanced by the formation of sphagnum bog on top of this. The presence of bands of mineral-rich rock running through the area have probably injected sufficient mineral deposits into the ecosystem to prevent the pH and concentration of mineral salts from dropping to levels found in the natural dystrophic pools which predominate on the blanket bogs further north. This influx of mineral rich run-off has in places, produced a terrestrial flora more in keeping with a mineral-rich fen. In the case of the lochs, dispersion and dilution of this run-off means that it has only a small, but not insignificant contribution to the overall quality of the environment and the ability of that environment to support a reasonable diversity of invertebrate life.

Conclusion

The Little Assynt Estate supports an interesting mix of habitats. To date there appear to be few invertebrate records relating to the Estate itself, although there are more comprehensive records relating to the wider area encompassing NC12. In general the flora has been more comprehensively recorded than the fauna, (Evans, Evans, & Rothero, 2002), and as yet there appear to be very few invertebrate records for the area as a whole.

The Little Assynt Estate encompasses wide variety of ecosystems, ranging from nutrient-poor acidic bog, to woodland and mineral-enriched fen. Its lochs provide habitat for black-throated divers and are home to a variety of invertebrates which are characteristic of the environmental conditions here.

The erection of the deer fence around part of the estate will allow the terrestrial vegetation to grow unchecked. This may have long term consequences for the aquatic ecosystem in the form of increased water uptake, increased shade and increased deposition of allochthonous material (e.g. leaves, sticks and other mobile products of terrestrial origin) to the water. Over a long period of time changes in the water table and light/shade could result in decreased sphagnum growth, thus leading to altered pH levels in the smaller lochs.

This small survey carried out for the Little Assynt Lochs Project has shown that the invertebrate assemblage in the lochs consists of a variety of species associated with slightly acidic, oligotrophic lochs with low mineral content. It is complemented by the Malaise trapping carried out during 2010 by David Pryce at just one site, on Loch na h-Innse Fraoich.

It would perhaps be interesting to look in greater detail at a few taxa which are known to have very specific habitat requirements, as monitoring of these could provide an early indication of significant habitat changes before they become otherwise apparent. Monitoring of water bugs (Heteroptera) would perhaps be of particular interest, and other groups with particularly sensitive species are the Ephemeroptera, Plecoptera and Trichoptera (which formed a central part of Pryce's survey). Continued monitoring would also contribute to the national records of aquatic invertebrates for this part of Scotland.

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Appendices

Appendix 1- Spread sheets containing ecological data sets relating to NC12

Appendix 2 – Spread sheet containing data from Little Assynt Loch Survey

These appendices are available on the accompanying CD.