Fisheries Management Plan

2009-2013

loch lomond
FISHERIES TRUST

CONTENTS

1 INTRODUCTION AND BACKGROUND

The varied fish assemblages of lochs and rivers within the Lomond catchment area contribute a significant biological and economic resource. Local populations of powan, brook, river, sea lampreys and Atlantic salmon have attracted both national and European conservation priority status with designations implemented to attempt to protect them. However, there are a great many more fish species present within the Lomond catchment and local populations contribute greatly to the biodiversity and general value of the area. Loch Lomond is famed for its sea trout and salmon angling opportunities and in more recent years a growing number of specialist coarse anglers have targeted the large pike and shoals of other coarse fish that abound.

Fisheries management in the Lomond system is delivered by several different organisations. The Loch Lomond Angling Improvement Association owns or leases much of the fishing rights and has managed the fishery for over a century. Other private riparian owners, notably Glen Falloch estate, run and manage their own fishings. The Loch Lomond Fisheries Trust (LLFT) was established in 2001 through a partnership between riparian owners, Loch Lomond Angling Improvement Association (LLAIA) and the Scottish Federation of Coarse Anglers (SFCA). This is a charitable organisation with a remit to undertake research untended to underpin management of the fish and fishery.

Since 2002 the Loch Lomond and Trossachs National Park Authority has been the statutory authority covering most of the catchment. However, there is no organisation with a statutory responsibility for fisheries management as no District Salmon Fisheries Board exists in the area. LLTNPA launched its new Biodiversity Action Plan (NPBAP) in 2009 and the LLFT fisheries management plan is closely aligned with and augments the goals and priorities of the NPBAP as they relate to fish and freshwater habitats.

While not directly involved in fisheries management a number of other statutory bodies have key indirect roles. Scottish Natural Heritage is particularly important in the Lomond catchment as the river Endrick – the principal tributary - has been designated an EU Special Area of Conservation (SAC) for Atlantic Salmon, and river and brook species of lampreys. Scottish Natural Heritage is primarily responsible for safeguarding the SACs but there is an onus on “competent authorities”, to uphold the objectives of the SACs which is to maintain a favourable conservation status of the designated species.

The Scottish Environment Protection Agency (SEPA) will also play an increasing role through implementing the provisions of the EU Water Framework Directive through River Basin Management Plans (RBMP). As well as powers to regulate abstraction, engineering and other activities, this has also placed a requirement on SEPA to monitor fish populations.

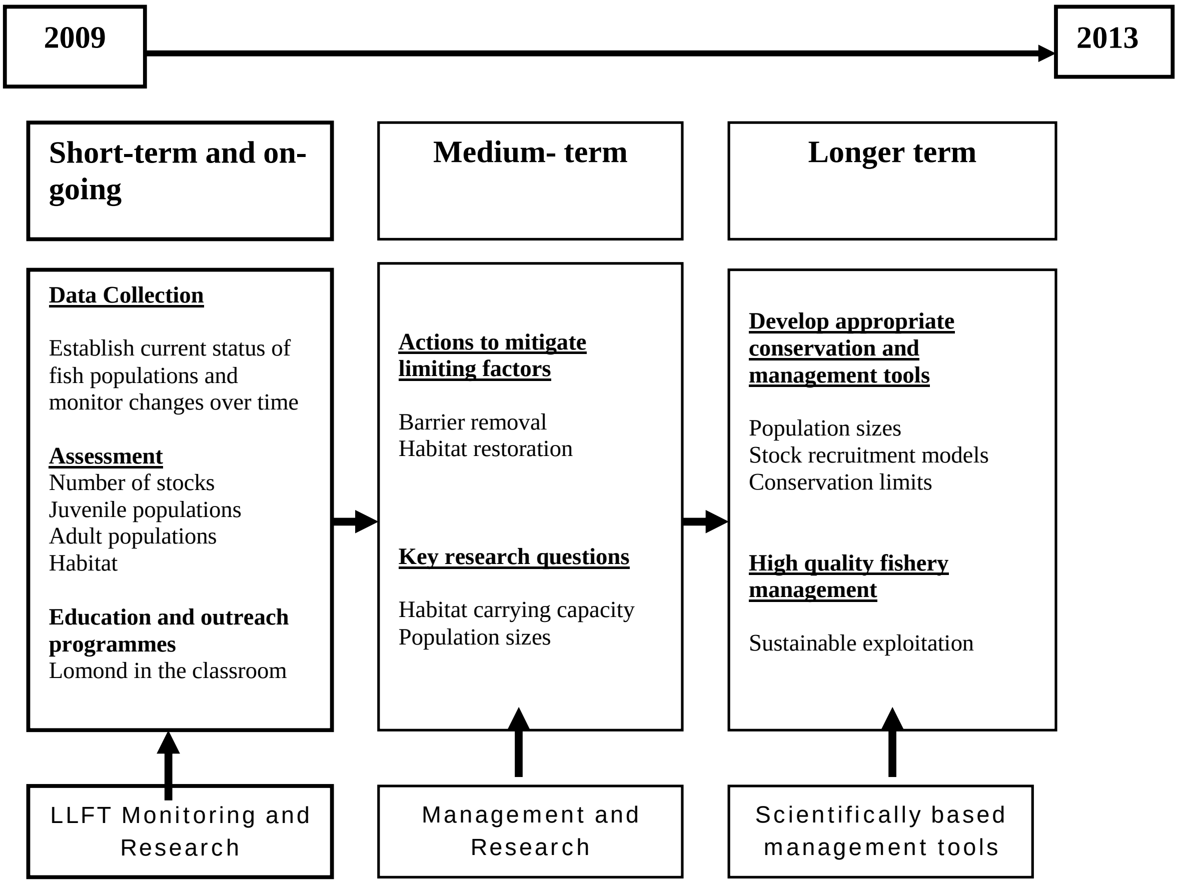
This Fisheries Management Plan sets out a framework for implementation of LLFT’s vision over the next five years 2009-2013 and identifies priorities which seek to find a common purpose between the respective interests and stakeholders to help take freshwater fisheries management forward in the coming years. This plan has been prepared with grant support from Scottish Government as part of a Scotland wide programme of fisheries management planning under the Strategic Fisheries Framework (2007).

The long term vision statement of LLFT is to

Develop understanding and gather the evidence required to conserve and enhance naturally self sustaining populations of native fish and, where these are exploited, to promote the effective management of long term sustainable sport fisheries.

The key aims embedded within the plan are intended to drive conservation and enhancement of the native fish populations of Loch Lomond and the aquatic habitats on which they depend. This will facilitate high quality management of fish species and ensure the long-term sustainability of wild native populations both a conservation asset and as an exploited resource.

Fig. 1.1. Schematic showing the progression of local fisheries management by the Loch Lomond Fisheries Trust



2 THE LOCH LOMOND CATCHMENT

2.1 Introduction

The LLFT management area (Fig 2.1) comprises the watershed defined by all tributaries draining into Loch Lomond, Loch Lomond itself and the river Leven to its confluence with the Clyde estuary at Dumbarton. The principal sub catchment is the river Endrick which is an EU designated Special Area of Conservation (SAC). All other tributaries fall entirely within the Loch Lomond and Trossachs National Park the main sub catchments comprising the rivers Fruin, Luss, Douglas and Inveruglas to the west and the river Falloch to the north.

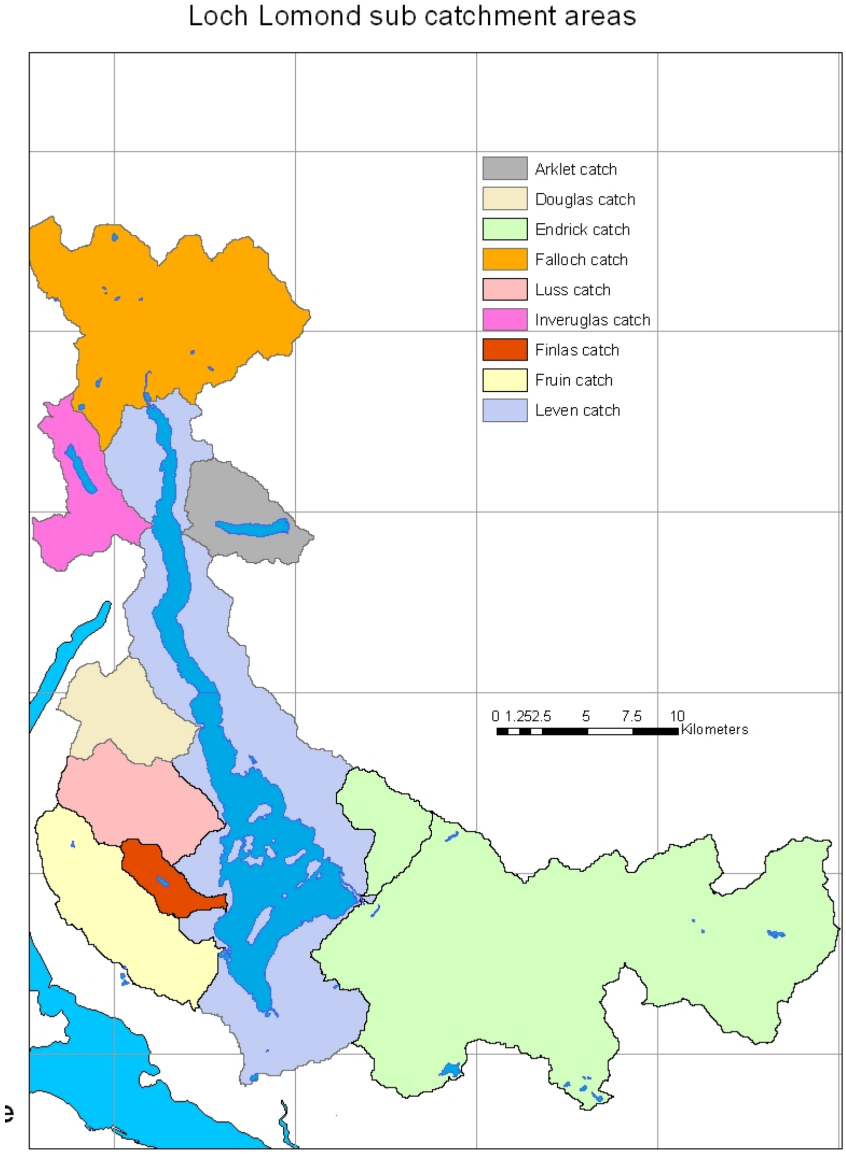


Figure 2.1 The LLFT management area, including sub-catchments.

2.2 Geology

The northern part of the Lomond catchment is of typical "highland "character with high energy streams draining a narrow, steep sided glacial trough which form the main loch. South of the Highland boundary fault this gives way to a topography which is more "lowland" in nature but flanked in the far south-east by the volcanic inliers of the Campsite Fells.

This north – south contrast is clearly demonstrated in a comparison of the three largest sub catchments (Table 1).

Table 1: A comparison of the three largest sub-catchments in the Lomond catchment

	NORTH	SOUTH WEST	SOUTH EAST
	FALLOCH	FRUIN	ENDRICK
Catchment area (km2)	113	161	264
Mean altitude (m)	438	190	171
Mean slope (m/km)	254	178	86
% base rich rock	3	66	
Conductivity	43	75	178

The complex geology of Loch Lomond is defined by the West Highland boundary fault which traverses the Loch, marking the division between the highlands in the north and the lowlands in the south. North of the boundary fault is characterised by metamorphic geology dominated by quartz-mica schist and slates, most of which outcrops at the surface (fig 2.2).

To the south, most of the area is overlain by glacial tills together with some fluvio-glacial sands and gravels and more recent alluvial deposits comprising the Endrick valley floor. Bedrock geology is dominated by old red sandstone, though this outcrops relatively infrequently, and the basalts of the Campsie Fells which flank the Endrick catchment at the southern extreme. There are also some significant areas of blanket peat bog from which the headwaters and some tributaries of the river Endrick originate.

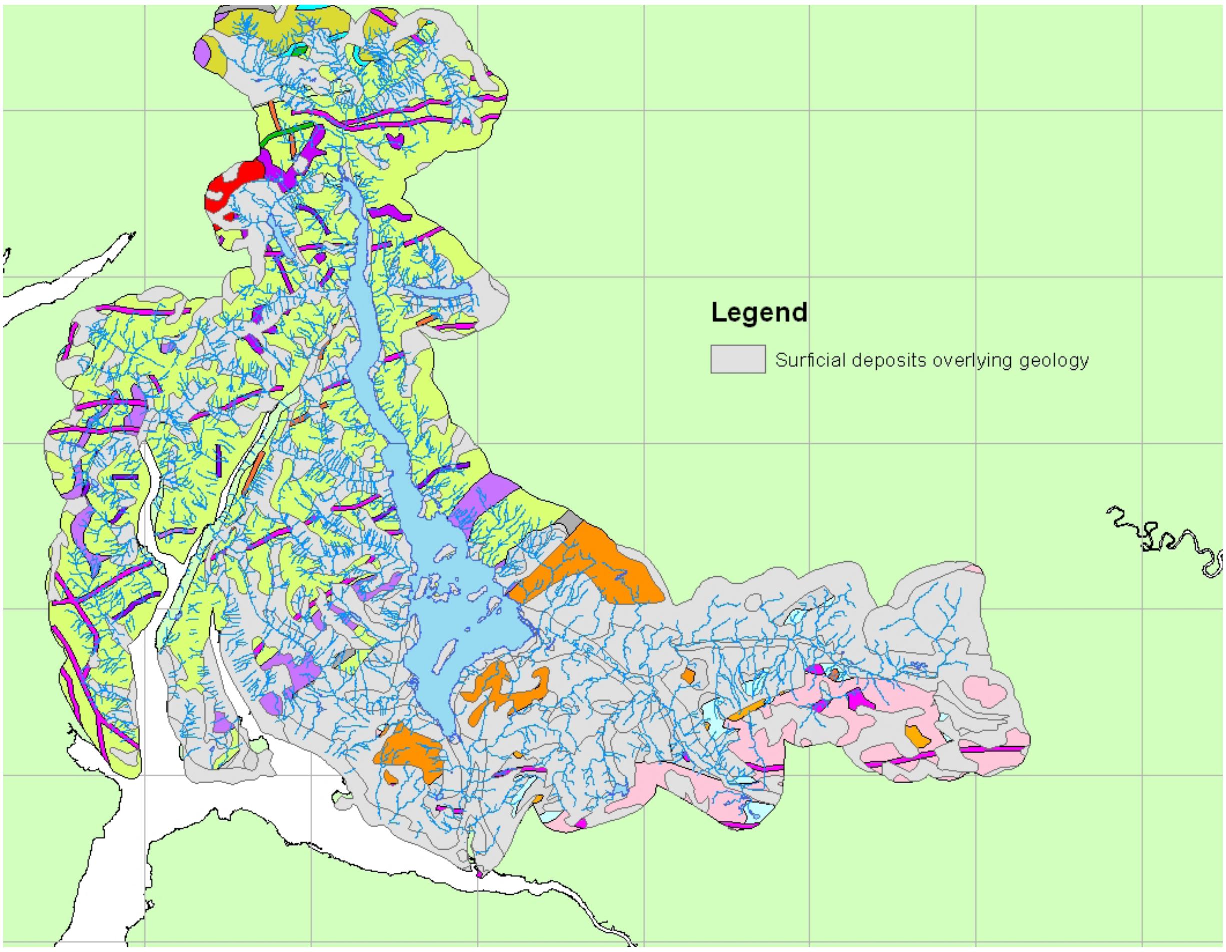


Figure 2.2 Surficial geology in the Lomond catchment.

2.3 Land use

The majority of the catchment is dominated by rough pasture with the more northerly and upland areas characterised by heather moorland together some significant areas of peat bog, particularly towards the south-eastern limits of the Endrick catchment and the Falloch. In the more lowland southern part of the catchment improved grassland is the dominant land use on the lower slopes and floor of the Endrick valley. There are also some significant areas of improved grassland in the south-west especially within Glen Fruin although rough pasture remains the dominant land use in this catchment. The only substantial area of urban development within the Lomond catchment is confined to the extreme south where the river Leven is highly urbanised (Fig 2.3).

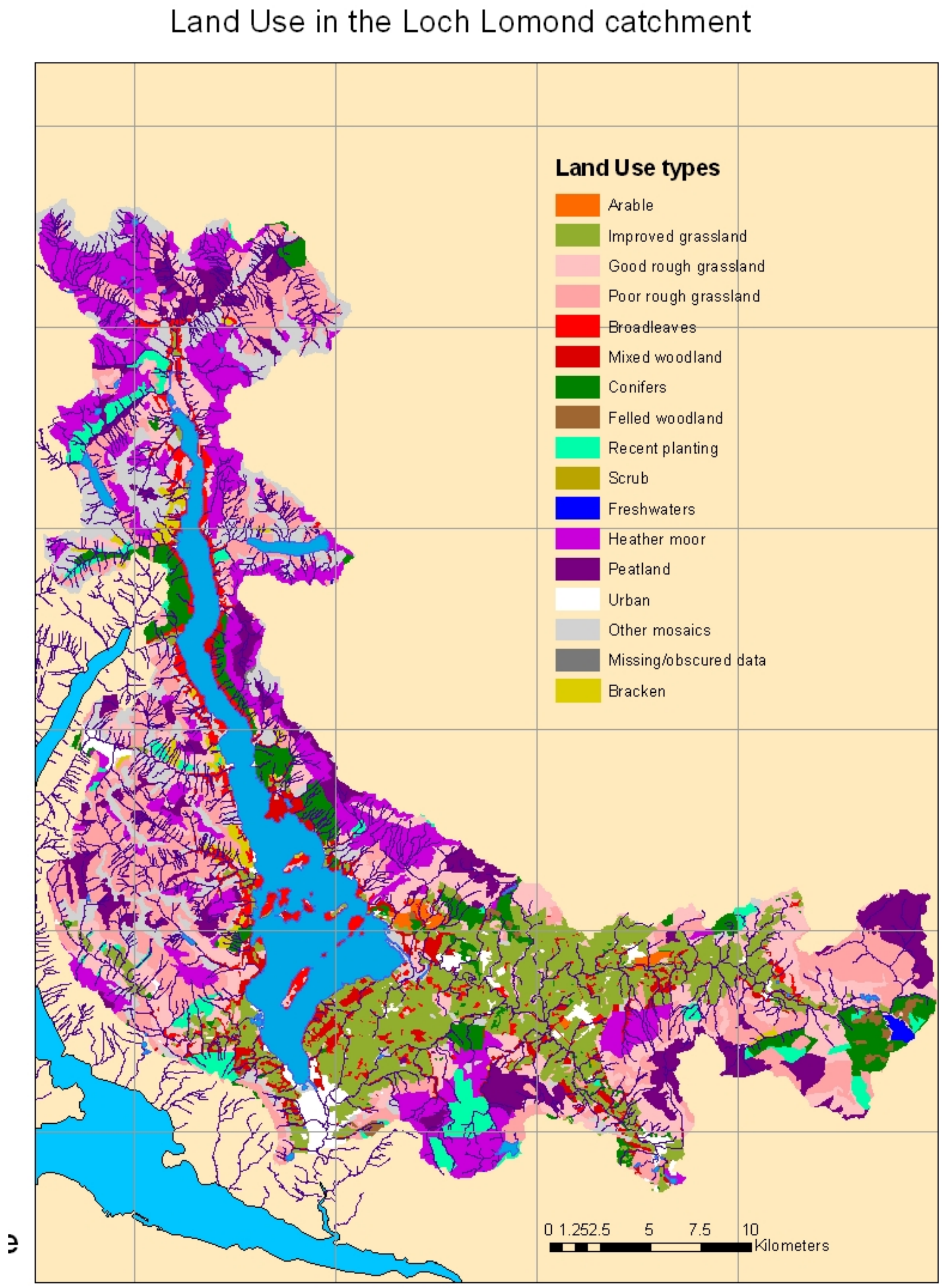


Figure 2.3: Land use in the Lomond catchment

2.4 Climate and hydrology

The Lomond catchment generally experiences mild and wet climatic conditions. Within catchment, mean annual rainfall shows a clear northwest–southeast pattern, with the north and west receiving the majority of precipitation. Thus, rainfall in Glen Falloch is almost twice that experienced in the Endrick catchment (see Table 2).

Table 2: Summary of flow rates and precipitation for four sub-catchments

	LEVEN	ENDRICK	FALLOCH	LUSS
Catchment area (km2)	784.3	219.9	80.3	35.3
Mean flow (cumecs)	43.79	7.3	5.98	2.65
Q95	8.41	0.6	0.253	0.2
Q10	85.86		16.48	6.77
Mean annual rainfall (mm) 1961 - 90	2025	1500	2842	2340

Figure 2.4 illustrates this northwest-southeast pattern using a 10 year dataset from the Met Office Land Surface Stations dataset. Gartocharn (NS 425857) weather station in the southeast of the catchment, records, on average, 55% less rainfall than the Sloy weather station to the northwest (NN 321098) over this 10 year period.

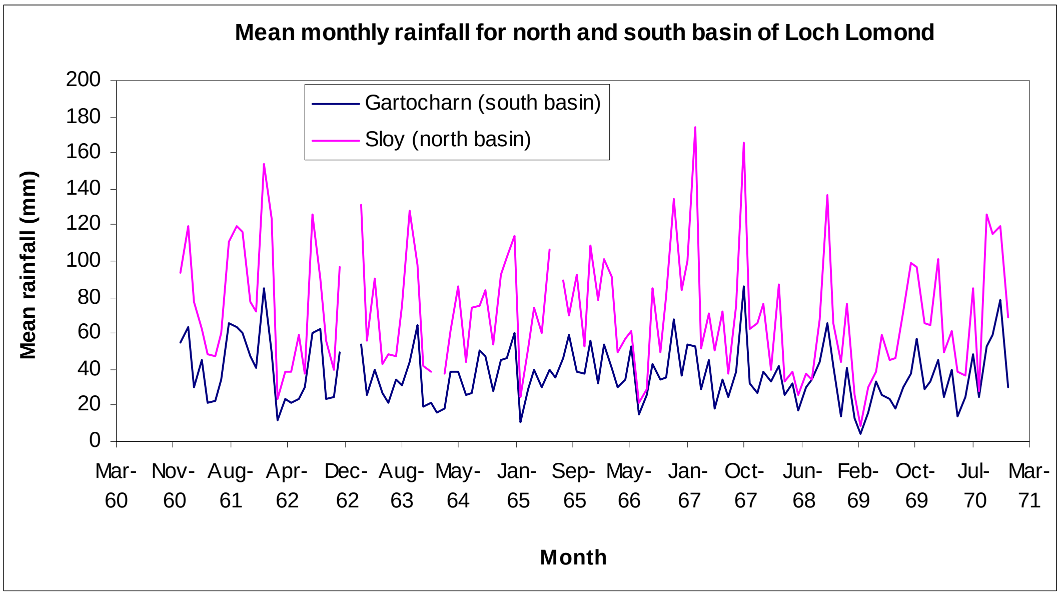


Figure 2.4: Mean monthly rainfall (mm) from 1960 to 1970, for two contrasting sites in the Lomond catchment: Gartocharn weather station (southeast) and Sloy weather station (northwest).

All major tributaries of the system have unregulated regimes which are naturally very responsive, with the exception of the Inveruglas which is heavily modify by the Loch Sloy dam and associated hydro scheme. The outflow from Loch Lomond has been controlled since the construction of the Leven barrage in 1971 since which time the regime of the river Leven has been highly regulated.

3. FISH POPULATIONS OF THE LOMOND SYSTEM

3.1 Atlantic salmon

3.1.1 Distribution

The distribution of salmon throughout the catchment is primarily controlled by locations of impassable obstructions detailed in the map below (Figure 3.1). The main salmon spawning and nursery areas are the Endrick main stem (up to the falls at the Loup of Fintry) and its major tributary the Blane, and the River Fruin. The river Leven and the lower reaches of the Luss also have significant spawning populations (defined as a genetically distinct non-interbreeding group).

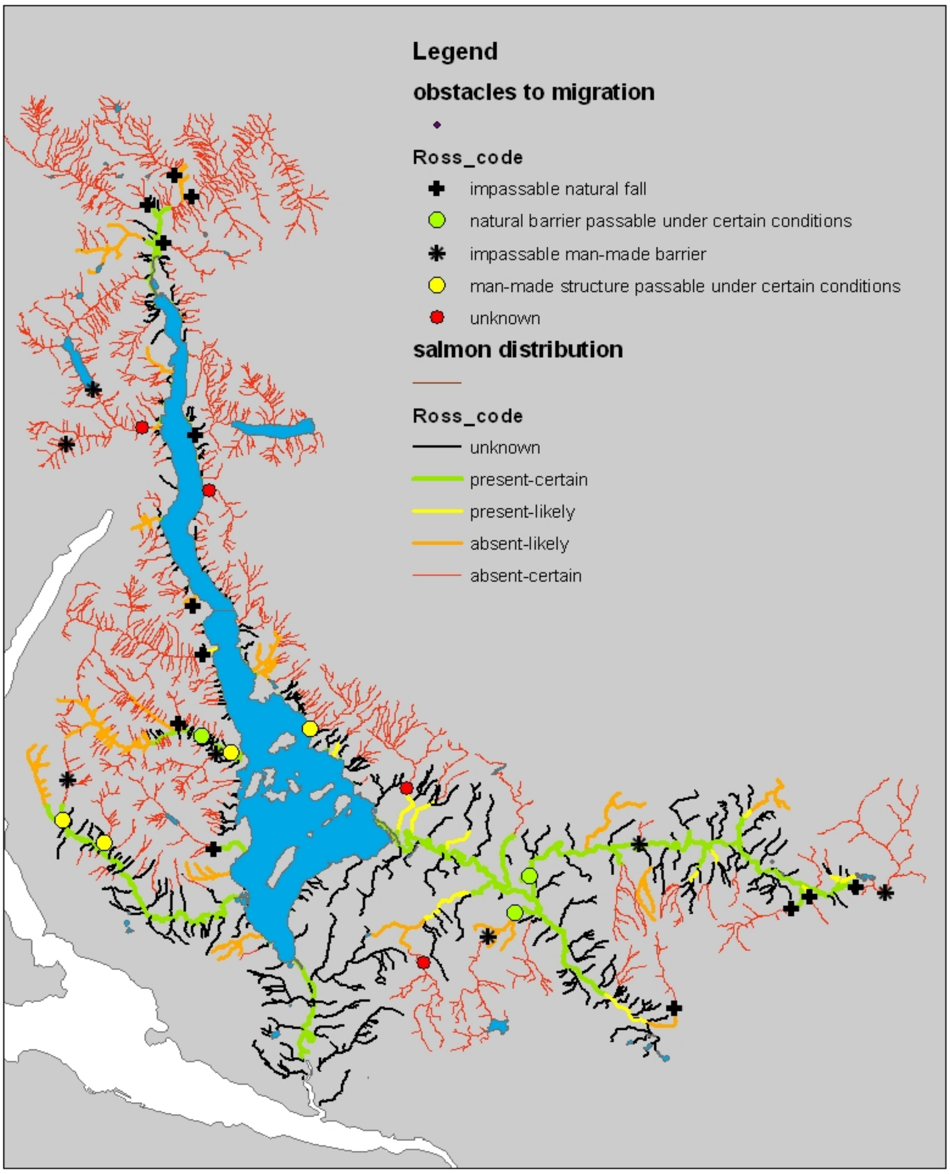


Figure 3.1: Map showing accessible areas for Atlantic salmon and obstacles to migration in the Lomond catchment

Electro-fishing sites surveyed by LLFT (2003-2007) clearly demonstrate the Endrick catchment, Fruin and Leven as the most important salmon producing areas (fig 3.2).

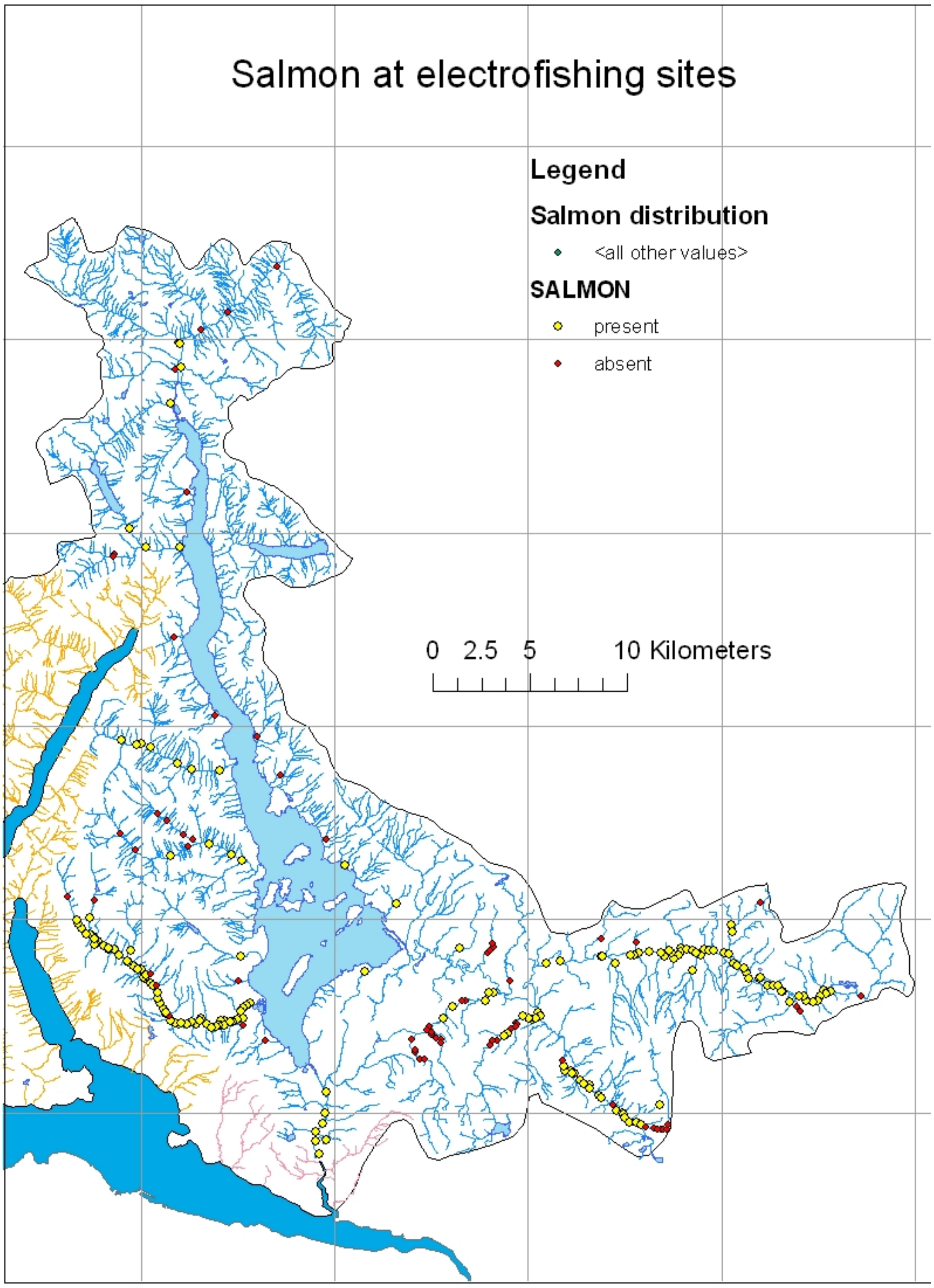


Figure 3.2: Map showing presence/absence of salmon at LLFT electrofishing sites since 2003

In the river Endrick, timed electrofishing surveys for fry (age 0+) indicate that the majority of salmon spawning takes place in the upper Endrick main stem in the areas around Fintry (Figure

3.3). There is a large supply of gravel into this area and river morphology is predominantly characterised by riffles consisting of mobile gravels and more stable cobbles which provide excellent summer nursery habitats for 0+ salmonids. Further downstream in the middle zone there is a marked decline in fry abundance which is probably limited by a relative lack of available spawning habitat due to a deficit of gravel. Parr are proportionately more abundant in this zone due partly to a greater availability of deeper rearing habitats for older fish to grow on.

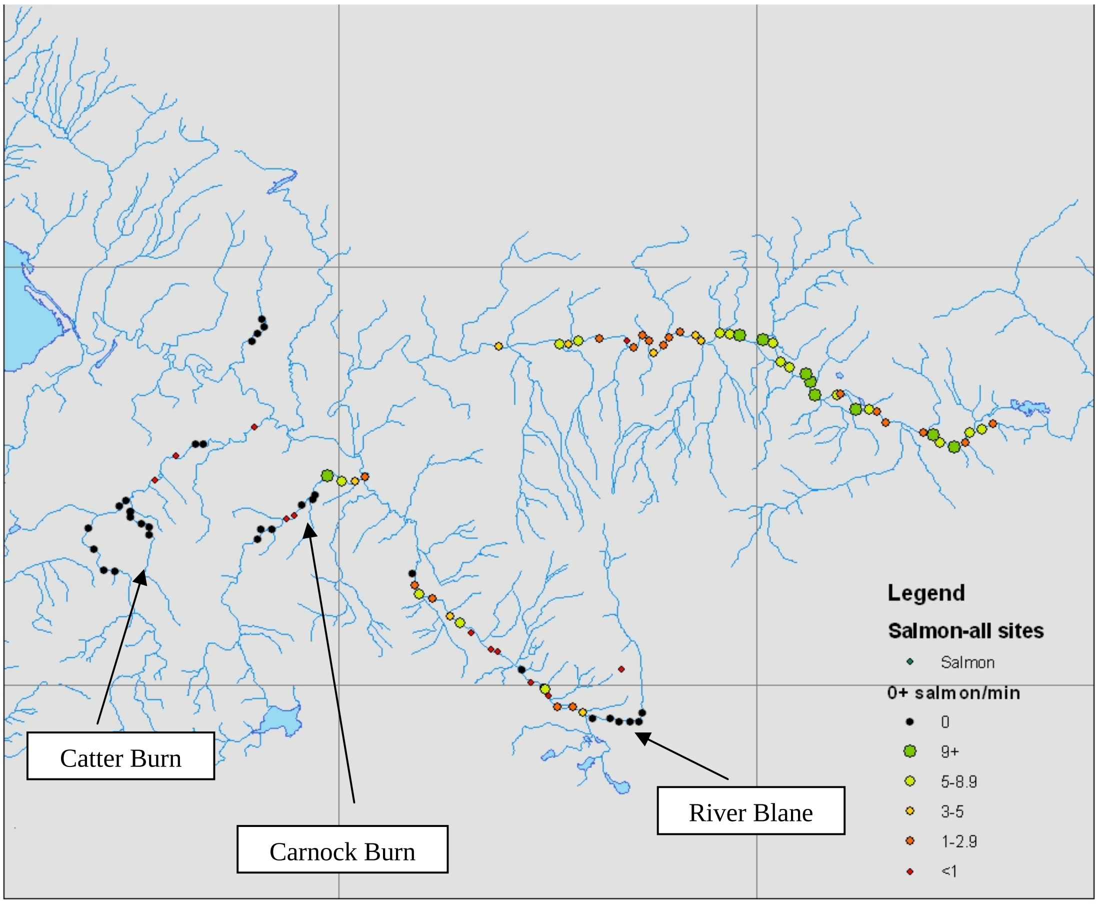


Figure 3.3: Variations in abundance (CPUE) for 0+ salmon in the river Endrick in 2007

A smaller but significant amount of juvenile production takes place in the Blane system where the gradient is sufficient to provide clean spawning gravels. Impassable falls mark the upper limits of salmon distribution in the Endrick, Blane and Carnock but there is no apparent reason for the virtual absence of salmon in the Catter burn which is fully accessible to migratory fish.

The fish community in the main stem of the River Fruin is dominated by salmon virtually up to the upstream limit of migration (Figure 3.4). Catch per unit effort for 0+ fry derived from timed electro-fishing demonstrate marked variations in abundance throughout the mainstem with five clear zones. The lower river is clearly split into 2 contrasting zones; a downstream zone of generally poor abundance and an upper zone of very high abundance. It is unlikely that habitat is sufficiently different between these two zones to account for this and it is possible that this may suggest that water quality may be an issue in the lower Fruin.

The middle river zone has naturally poor fry abundance due to a geology change which results in a high gradient channel of predominantly bedrock/boulder substrate characterised by step –pool sequences affording little gravel accumulation. This is in marked contrast to the upper river which comprises a low gradient alluvial channel of gravel substrates. This is characterised by a downstream zone of very high abundance and an upstream zone of low – moderate salmon abundance with proportionally more trout. However, reasons to account for this difference in productivity between these two upper zones are unclear.

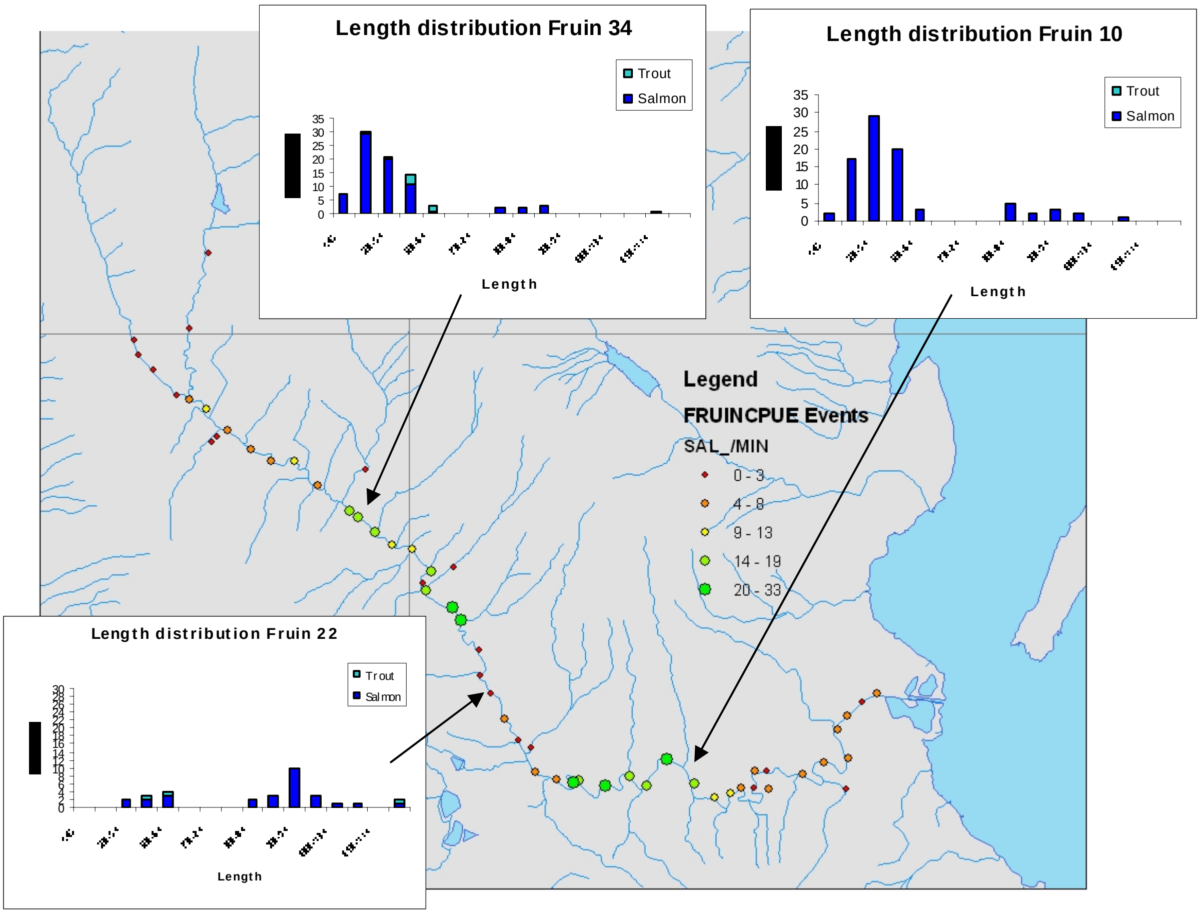


Figure 3.4: Variations in abundance (CPUE) for 0+ salmon in the river Fruin in 2006

3.1.2 Biological Characteristics

Figure 3.5 below shows a typical age structure for the upper Endrick. The site shown is located approximately 400m downstream of the Loup of Fintry and is typical of a high abundance site for 0+ salmon. Modal lengths for 0+ and 1+ year classes are 70mm and 115mm respectively. A 2+ year class comprises fish <130 mm. Density estimates per 100 m^2 for each year class were; 0+, 152; 1+, 28; and >1+, 6.

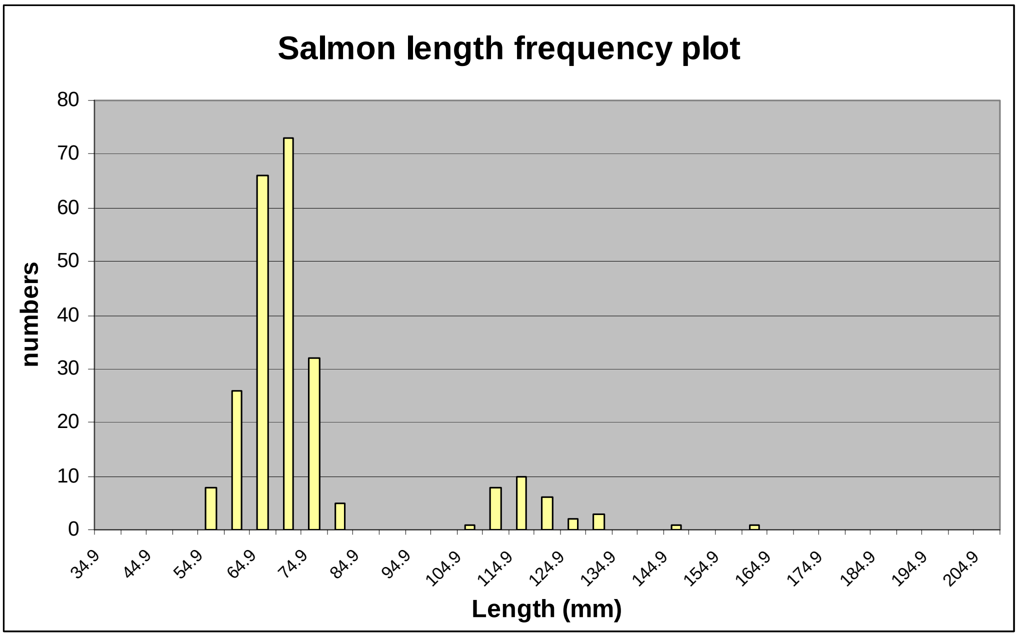


Figure 3.5: Typical age structure for Atlantic salmon in the river Endrick in 2006 showing 3 year classes (upper site near the limit of migration)

The presence of a 2+ year class indicates that some salmon from the upper river are migrating as S3 smolts. Trapping of out-migrating salmon smolts in spring 2008 indicated that a significant proportion of salmon migrate as S3's although the majority remain in freshwater for 2 years before migrating at age 2.

Table 3: Fork length of salmon of different age classes in tributaries of the Endrick in 2004

Site Code	0+ mean±s.d. fork length (mm)	no 0+	1+ mean±s.d. fork length (mm)	no 1+	2+ mean±s.d. fork length (mm)	no 2+
Carnock	67.8±5.4	33	109.0±10.4	3		0
Boquhan		0	95.0	1	123.0±1.4	2
Blane	72.5±4.9	2	113.5±6.8	8		0
Balglass		0	120.1±7.1	8		0
Gonachan	68.0±4.0	18	109.9±6.5	10	132.0	1

The generally lowland character of the river Endrick results in relatively rapid growth rates with age 1+ parr typically around 109 – 120 mm (modal length) see Table 3.

Juvenile salmon appear to grow more slowly in the river Fruin than in the Endrick with modal lengths for 0+ and 1+ typically in the order of 60 and 100mm respectively. There is virtually no indication of any parr older than 1+ suggesting that Fruin salmon typically smolt as S2's. Densities at high production for 0+ salmon range from 127 – 180 per 100 m^2 with moderate sites around 60 per 100 m^2. The length - frequency graph below (Figure 3.6) show a typical population structure for a high density site on the Fruin main stem (ie. 17.6 per 100 m^2).

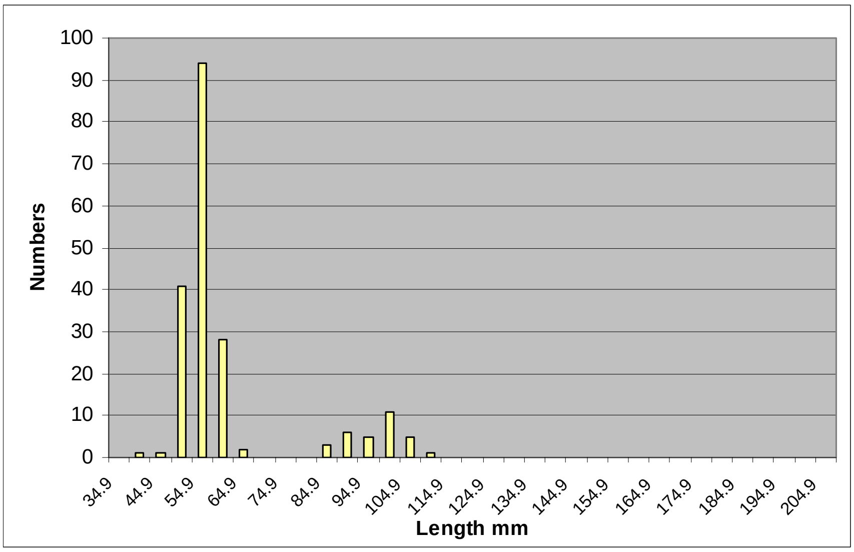


Figure 3.6: Age structure for Atlantic salmon at high density site on the river Fruin 2006.

In contrast, in the northern part of the Lomond catchment where there is limited salmon recruitment in the river Falloch densities (2005 – 07) have ranged from 4 – 19.2 per 100 m^2. First summer growth rates are much slower with 0+ modal lengths in the order of 52 mm by end September. 1+ salmon range from 80 – 115 mm in length (Figure 3.7).

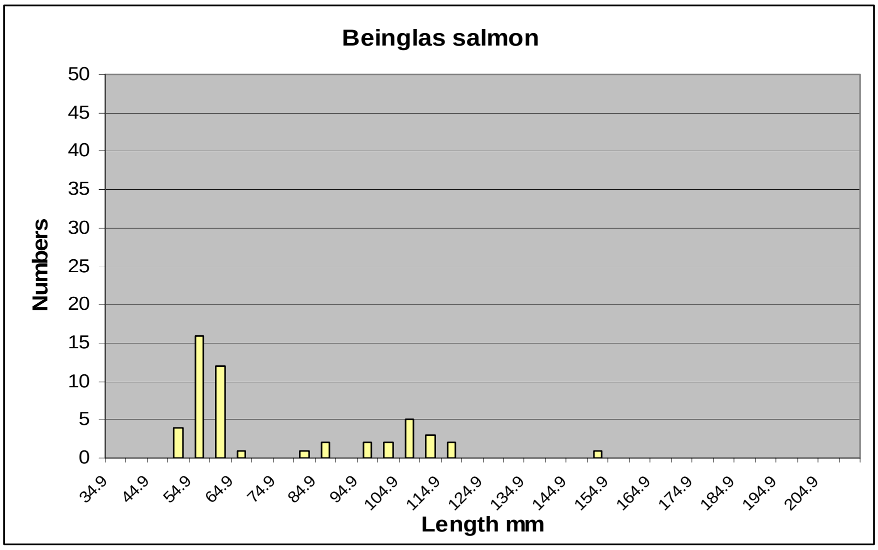


Figure 3.7: Age structure for Atlantic salmon in the Beinglas burn (Falloch tributary), 2005 to 2007.

3.1.3 Genetic structuring of Atlantic salmon populations

The structuring or separation of a stock into distinct breeding populations is a function of strong homing behaviour to natal spawning areas combined with the fact that spawning timings differ and spawning locations are spatially fragmented.

These breeding populations are the fundamental biological units which define the biological characteristics and determine local abundance of a particular river's stock of salmon. For example, it is now understood that genetics strongly influences timings of smolt migrations and of adult spawning returns to freshwater together with resilience to stresses in the natal environment affecting juvenile survival rates and recruitment.

Each salmon has a unique combination of genetic variants by which it and its offspring can be identified which in turn enables breeding populations to be identified as genetically different by virtue of the uniqueness of their individuals. This variation can be sampled by taking a small sample of tissue, e.g. a scale or fin clip and the information used to investigate population structuring in the salmon stock.

A preliminary study in 2006/07 conducted by LLFT in collaboration with FRS demonstrated clear genetic structuring of salmon populations between sub catchments within the Lomond system (fig 3.8). Samples of fish taken from the same river cluster together but show significant genetic differences between rivers. The rivers Fruin, Luss and Leven (lower part of diagram) form distinct groupings separate from each other and also from those of the Endrick (top part of diagram). It is notable to have such a high degree of spatial structuring at such small geographical scales. This indicates that salmon homing to different parts of the system have evolved in separation, partly by the effect of the Loch, such that no significant interbreeding has occurred between them. Results also suggest that within river structuring is highly likely within the river Endrick.

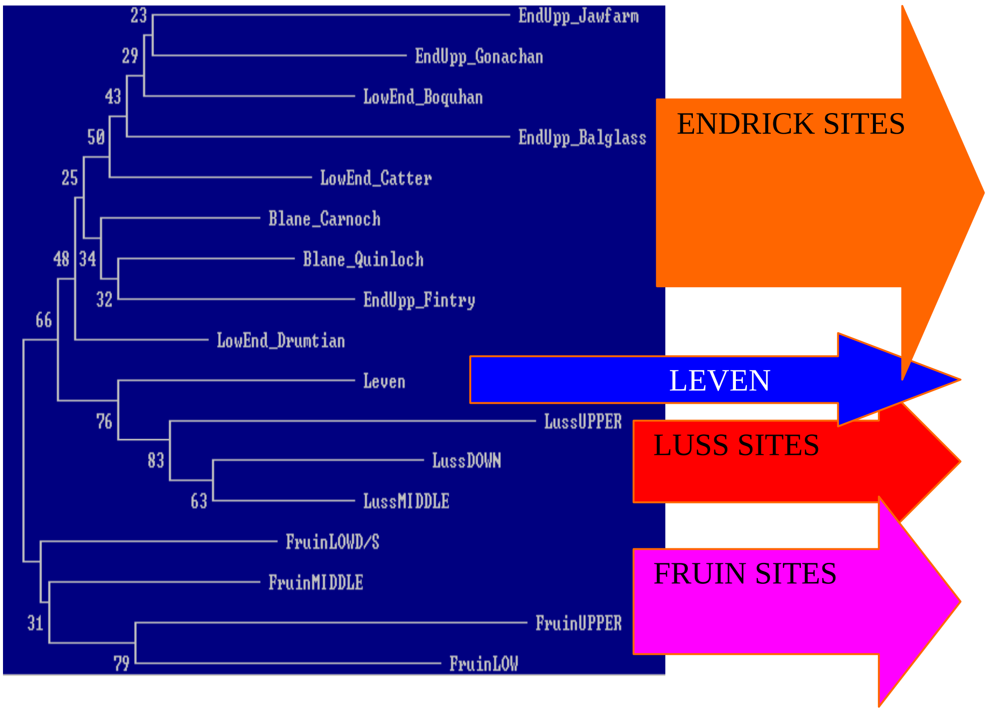


Figure 3.8: Cluster dendrogram showing genetic separation between Atlantic salmon from tissue samples taken from juveniles in different parts of the Lomond catchment in 2005

3.2 Brown (Sea) Trout:

3.2.1 Distribution

Brown trout are distributed throughout the catchment and it is likely that most important sea trout producing areas are within the Endrick catchment but the rivers Luss and Falloch are also significant systems in their own right. Juvenile trout are widespread in the river Fruin, which is not regarded as a major sea trout producing system with the majority of trout production confined to the headwaters. In addition, some small burns which drain directly into the loch can be very productive (e.g. Ardess burn at Rowardennan).

Sea trout production in the Endrick catchment takes place primarily in the tributaries. Timed electrofishing surveys for fry conducted in 2007 demonstrated that the Endrick main stem is only sparsely populated by trout being used principally by salmon. The Blane and its main tributary the Carnock burn is probably the most important sea trout producing area of the catchment. The Catter burn also has a significant population although this has suffered serious decline in the last 20 years due largely to pollution and siltation problems. The lower reaches of many of the feeder burns into the main Endrick are also particularly important nursery areas for trout (notably the Boquhan and Walton burns) (Figure 3.9).

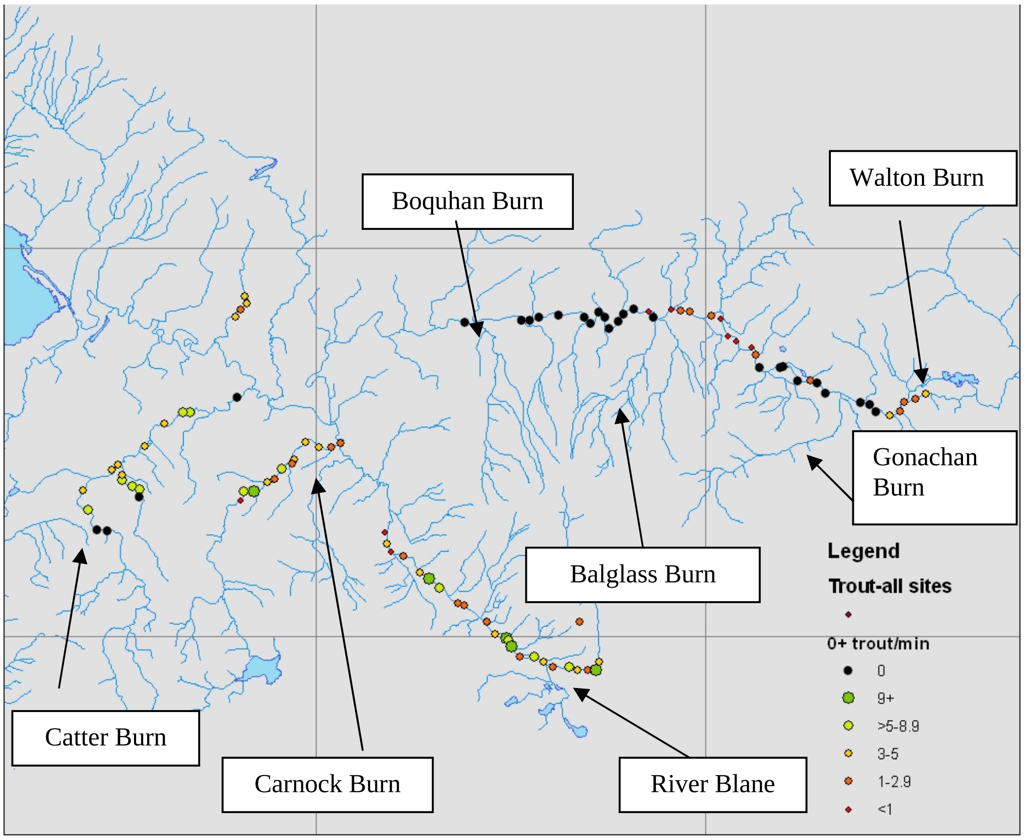


Figure 3.9: Variations in abundance (CPUE) for 0+ trout in the river Endrick in 2007 and locations of quantitative electrofishing sites.

3.2.2 Biological Characteristics

Monitoring sites on the lower reaches of the most productive tributaries show that Boquhan burn has particularly high 0+ densities year on year ranging from 150 – >300 per 100m^2. The Gonachan burn ranges from 88 – 166 per 100m^2 over the same period but with a greater proportion of parr reflecting greater habitat variety at the site (Figure 3.10). This compares with densities at the top of the main river Endrick where trout are present in sympatry with salmon of 31 per 100m^2 for age 0+ and 2.6 per 100m^2 for 1+. This demonstrates the importance of small streams to trout production in the catchment.

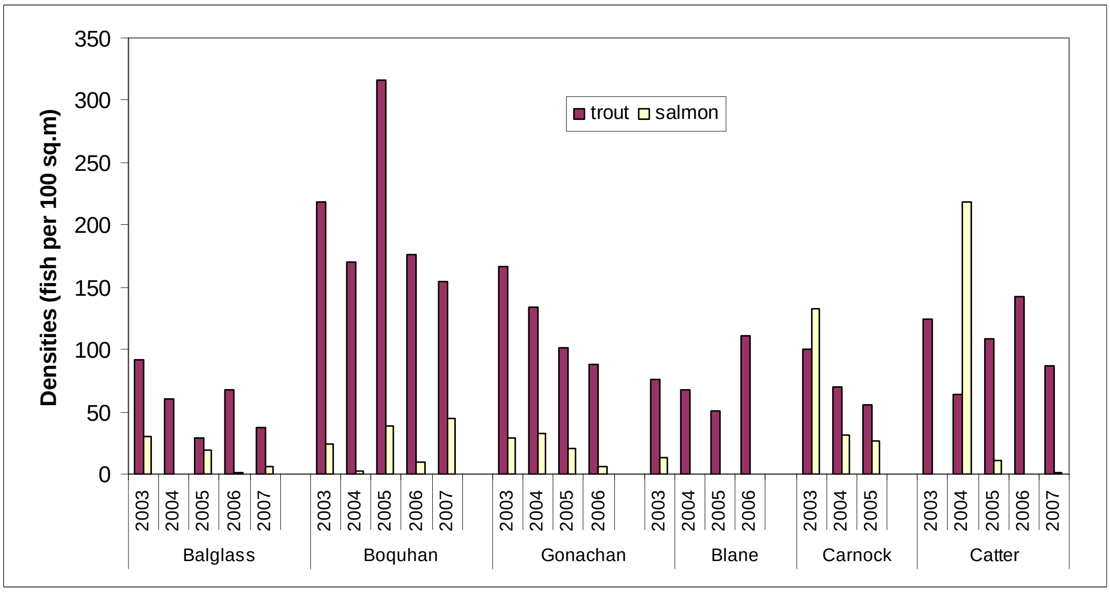


Figure 3.10: Annual variation in juvenile densities at monitoring sites on tributaries of the river Endrick since 2003

Total densities in the upper Blane typically range between 50 - >100 per 100m^2 with a significant proportion of parr (age >0+) in the order of 20 per 100m^2. A comparable annual monitoring site on the Catter burn shows fewer and smaller parr relative to the Blane. Densities per 100m^2 at this site for the last 3 years (2005 – 07) have ranged from 75 – 142 for age 0+ and >12 for parr.

The river Blane is a nutrient rich lowland stream and trout show rapid growth with modal lengths of the 0+ year class approximately 60mm in July and reaching 80mm but the end of the first summer. 1+ fish are typically 105mm in length by the second summer. The population structure derived from quantitative surveys shows four distinct age classes with significant numbers of trout >1+ (Figure 3.11).

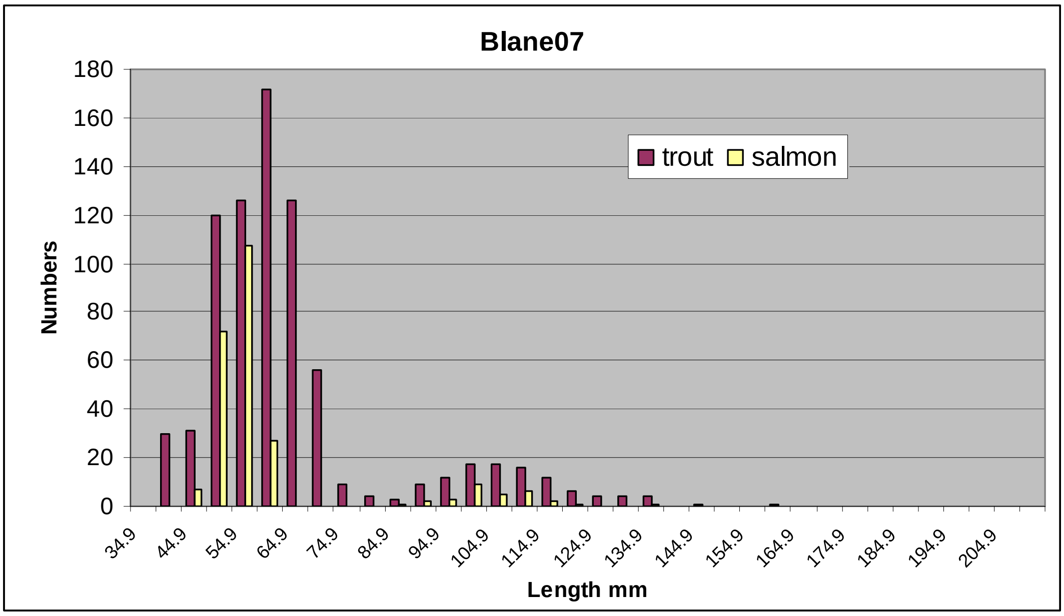


Figure 3.11: Population structure for the river Blane derived from all timed electrofishing sites in 2007.

A number of 3+ age fish (> 130mm) are recorded which probably remain as resident brown trout. However, captures from a smolt trap in the lower Endrick in 2008 indicated that a significant proportion of sea trout migrate as S3 and S4 smolts although the majority appear to be S2's (Figure 3.12).

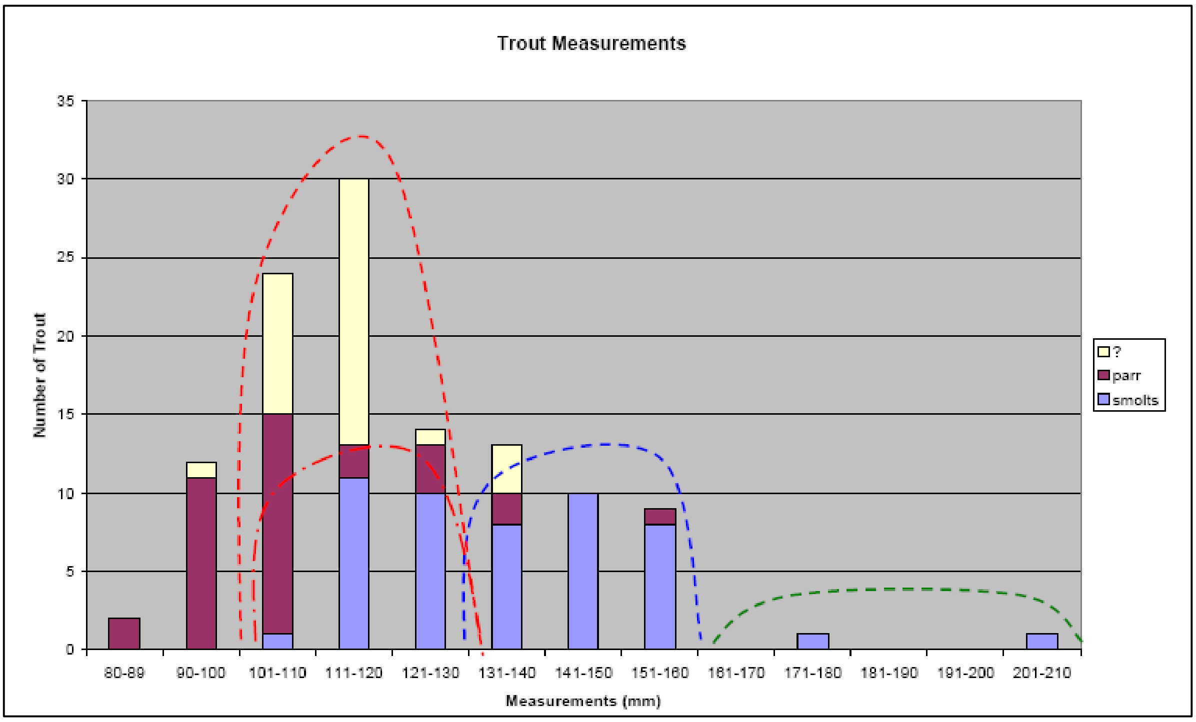


Figure 3.12: Proportion of migrating sea trout smolts captured in the lower Endrick in 2008. Red dashed line S2, blue dashed line S3 and green dashed line S4 smolts.

The upland streams of the Lomond catchment show a marked contrast to the Endrick. Figure 3.13 details the relatively low densities at sites on the Falloch, one on the main river upstream of the Falls of Falloch ranging from 11 – 19 per 100m^2 and the Beinglas burn downstream of the falls and accessible to sea trout with densities in the range of 10 – 46 per 100m^2. The age structure in the upper site is dominated by fish age1+ and older with very few fry and individuals present age > 3+ over 200mm fork length.

The Beinglas shows population structure dominated by 0+ trout which are slow growing, attaining a modal fork length of approximately 52mm at the end of summer. The Ardess burn enters Loch Lomond midway up the east side and is a high gradient stream draining metamorphic rocks typical of many Lomond feeder burns. However, the importance of some of these small streams to trout production is demonstrated by densities comparable to many Endrick burns ranging from 88 – 130 per 100m^2 (Figure 3.14). Growth rates are slow and comparable to those of the Falloch.

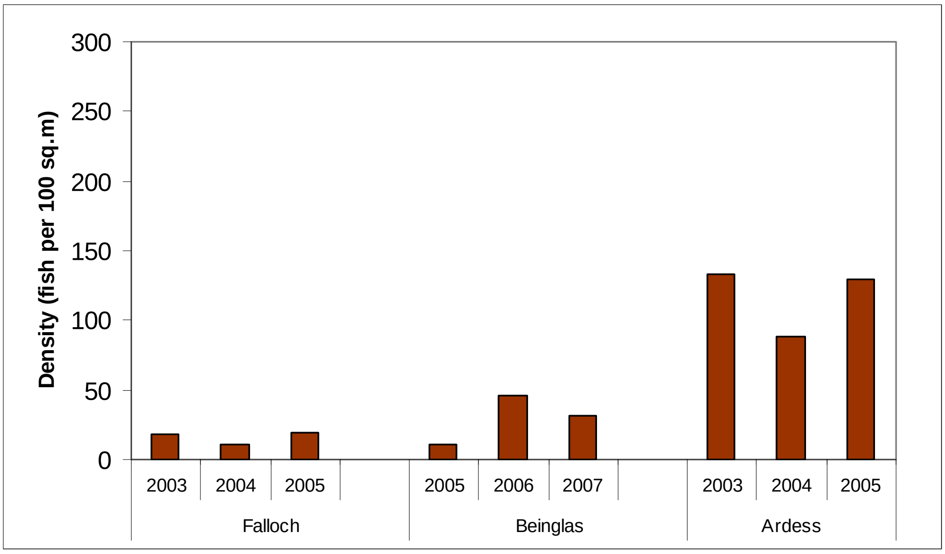
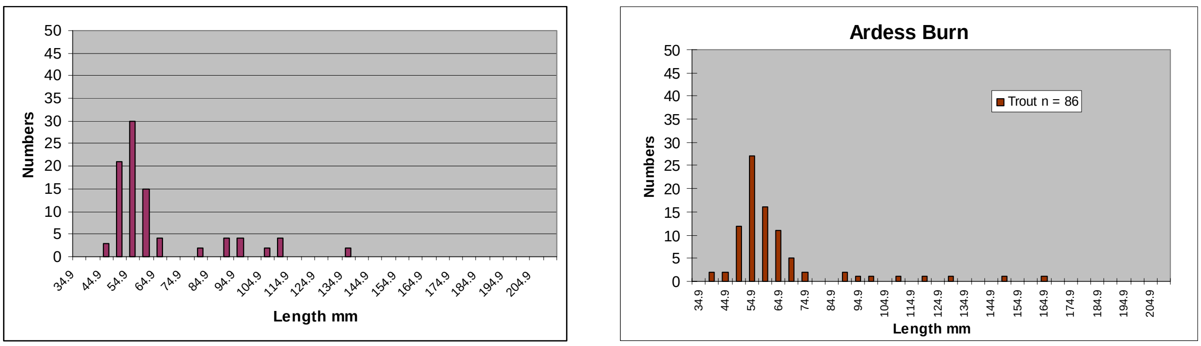


Figure 3.13: Densities of trout at selected upland sites in the north of the catchment



(a) **(b)**

Figure 3.14: Age structures of trout in (a) the Beinglas Burn (River Falloch) and (b) the Ardess Burn (Rowardennan)

3.3 Sea lamprey

3.3.1 Distribution

Present in Loch Lomond, the lower reaches of the River Endrick (Hunter *et al*. 1959;Maitland 1966b), and the Luss Water (Brown 1891). Present in the River Leven during anadromous migration but also known to spawn there. A later study in the mid 1980's failed to encounter sea lamprey in the River Endrick (Maitland *et al*. 1994;Morris and Maitland 1987).

3.3.2 Local biological characteristics

The sea lamprey is native to the catchment but not common. Some sea lampreys, uniquely in mainland Britain, remain in Loch Lomond and feed there on coregonids (Maitland 1980; Maitland *et al*. 1994). Anglers and net fishermen have reported lampreys attached to salmon, sea trout, brown trout and powan in Loch Lomond.. Those on powan are assumed to be river lampreys, but this may not be the case with salmon and sea trout, as a feeding sea lamprey of 200 mm was found on a rod caught salmon. Maitland *et al*. (1994) records several independent accounts of spawning in the upper river Leven, (the only known spawning site in the catchment) and found larval sea lampreys solely in the river Leven.

3.4 River lamprey

3.4.1 Distribution

Present in Loch Lomond , the River Endrick (as far upstream as Potts of Gartness, between October and March) and in the River Blane (as far upstream as Dumgoyach) (Maitland 1966b;Maitland *et al*. 1994).

- *Local biological characteristics*

The presence of two discrete morphs in the sexually mature river lamprey of the Endrick have been reported (Morris 1989; Maitland *et al*. 1994; Adams *et al*. 2008). The small body size morph is atypical for the species and feeds entirely in freshwater Loch Lomond (anadromy is typical for the species) and for a period of only a few months (15-18 months is typical and congruent with the typical form) (Maitland *et al*. 1994). The large body morph ranges in size from 280 to 360mm and the small body morph from 166 to 257mm. Adams *et al*. (2008) found that the large body morph has become more abundant over time. Stable isotope analysis has confirmed the small body morph river lamprey are freshwater feeding, and that the large body morph river lamprey feed in the marine environment

3.5 Brook lamprey

3.5.1 Distribution

Adult brook lampreys are common during winter and spring in the lower parts of virtually all the tributaries feeding the south and middle basins of Loch Lomond as well as the main loch. They have been recorded in the Cailness Burn and Douglas Water (tributaries feeding the northern part of the loch). They are common in the Auchentullich, Milarrochy and Mar Burns. They are also found in the river Leven (from the loch outflow downstream to the tidal limit) and in small streams running into the river, e.g. the Murroch Burn. In the River Endrick they occur from the mouth to the upper Endrick as far as Fintry (Maitland, 1966).

- *Local biological characteristics*
-

Adams *et al*. (2008) showed through stable isotope analysis that brook lamprey feed solely in freshwater revealed it to be feeding at the base of the food chain, consistent with filter feeding as an ammocoete.
Maitland *et al*. (1994) found larvae and metamorphosed (transformed) adults occupying similar riverine habitat and ammocoete larvae, in some numbers, occupying silt beds in Loch Lomond (the latter being collected in grab samples from silted littoral areas in the south basin). Several large larvae without the normal pigmentation were collected (a 'golden' form, not albino). Transformed brook lamprey were common in the tributaries after October. Adult brook lampreys from the River Endrick ranged from 115-170 mm (Maitland, *et.al* 1994), though a later study in 2004/5 found a range of 150-190mm (Bissett et al. 2005). Spawning migration in the Endrick brook lamprey takes place during late September to April. They spawn in April and May when hundreds may congregate on suitable gravel beds. Nest building and spawning in brook lampreys have been observed at many sites in the Lomond catchment. In the lower Endrick below Drymen bridge, spawning was always later than that of river lampreys and at higher temperatures. At the bottom end of the large pools below Drymen bridge, dozens of occupied nests are often seen in April and May (Maitland *et al*. 1994).

Brook and river lamprey of the Endrick catchment

Using data from (Morris and Maitland 1987) as a baseline, (Adams *et al*. 2008) examined changes in the abundance of river lamprey (considering each morphotype separately) and the brook lamprey over a 21 year period. Although lower catches of lamprey (all species combined) were recorded in 2004-5, compared with 1983-4, these differences were not statistically significant (Table 4). However, there is evidence that the larger morph is becoming relatively more abundant. The catch rate of the large body morph river lamprey was statistically higher in 2004-5 than in 1983-4 but catch rates of the small body morph river lamprey were lower in 2004/5 compared to 1983-4 and very close to statistical significance. The catch rate of brook lamprey was lower in 2004-5 than in 1983-4, though not statistically significant.

Table 4: Mean and standard error (SE) catch per unit effort (CPUE) of large body size and small body size river lampreys, and brook lampreys collected from traps in the River Endrick between September and December each year in 1983/4 and in 2004/5 and a test of catch rate differences over time.

	Mean CPUE		ANOVA	P
	1983/84	2004/5		
All lampreys	1.66	0.34	$F_{1,38}$=2.11	0.155
Brook lamprey	1.40	0.30	$F_{1,38}$=1.88	0.178
Small River Lamprey	0.26	0.03	$F_{1,38}$=3.91	0.055
			Mann Whitney	
Large River Lamprey	0	0.01	U=117	0.001

3.5 European eel

- *Distribution*
-

Eels are native to the catchment and are widespread. Figure 3.15 shows eel distribution, as bycatch during electrofishing surveys for juvenile salmonids. Eels are very abundant in the main Loch where there has been a commercial fishery.

- *Local biological characteristics*

Little is known about the current status of this important species in the Lomond catchment but it is possible that they are in decline as elsewhere.

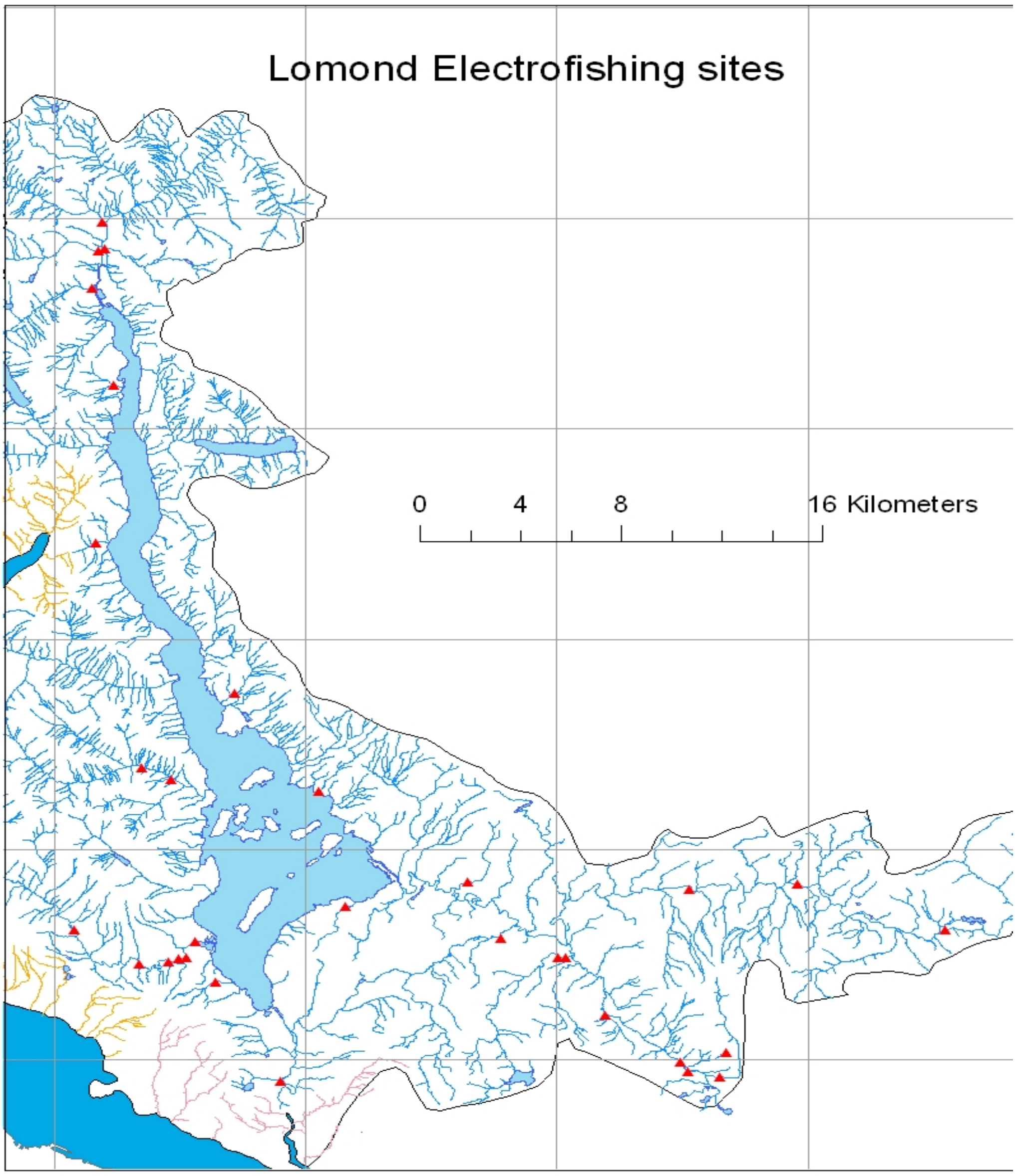


Figure 3.15: Distribution of eels captured during salmonid electrofishing surveys

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3.7 Powan

3.7.1 Distribution

Present in Loch Lomond, first described by Monipenny (1612). Occasional in the very lowest reaches of the River Endrick. Refuge populations were introduced to Lochs Carron and Sloy between 1986 and 1988.

3.7.2 Local biological characteristics

In the first detailed study of powan in Loch Lomond, (Slack et al. 1957), records “powan are abundant in Loch Lomond…..far more so than any other fish.” Adams (1994) confirms this to be the case into the mid-1990’s, with powan being the dominant fish in gill net surveys in 1988-89. Until recently the only documented change in abundance occurred in 1968, when the population suffered massive mortality associated with fungal infection and an epidemic of 'bald spot disease' (Roberts et al., 1970). However, recent net capture and sonar data (Etheridge unpublished, University of Glasgow) points to a rapid decline in the Loch Lomond powan population.

Etheridge (pers. comm., University of Glasgow) reports that gill net catches of powan at the main known spawning sites on Loch Lomond in 2006-07 were around 33% of catches at the same sites in the mid 1980’s. In addition the catch rate of powan in Loch Lomond, in known spawning areas was approximately 50% of Loch Carron and 20% of Loch Sloy (where the spawning sites are not known). These data exclude sampling where no powan were caught and as a result underestimates the differential between sites. Powan eggs are predated upon by adult powan, brown trout, and more latterly by the non-native ruffe (Adams and Tippett 1991;Slack *et al*. 1957) which has been a major contributor to declining powan populations.

3.8 Stoneloach

- *Distribution*
-

(Hunter *et al*. 1959) records stone loach as present in Loch Lomond but limited to the south basin. Electrofishing surveys show stone loach are present in the southern part of the catchment being most widespread and abundant throughout the Endrick catchment (apart from the uppermost and lowermost reaches).

3.8.2 Local biological characteristics

Stone loach are native to the catchment. In a study of the fauna of the River Endrick, (Maitland 1966b) records stone loach showing a preference for habitats with good weed cover, sandy and stony substrates and moderate current. This study also records fry as more abundant in the mainstem Endrick than in tributary streams, ranging in size up to 10.5cm and feeding on various species of larval chironomidae.

3.9 Minnow

- *Distribution*
-

Minnows are widespread in Loch Lomond especially in the southern parts. Electrofishing surveys show that minnows are common in most parts of the Endrick with the exception of the upper reaches which agrees with the findings of Maitland (1966b). Minnows are also abundant in the rivers Fruin and Leven and their distribution appears to be mainly confined to the southern part of the catchment, although one population is recorded in the Wood Burn (on the eastern shore of Loch Lomond).

- *Local biological characteristics*
-

In a study of the fauna of the River Endrick, Maitland (1966b) records 0+ minnows as rare in tributary streams being abundant in large shoals (several thousand individuals) in the mainstem Endrick with adults ranging up to 9 cm in size. Spawning in the Endrick occurs in May, June and July (Scott 1963), the primary adult spawning grounds being tributary streams.

3.10 Three-spined and Nine-spined Stickleback

3.10.1 Distribution

Both three-spined and nine-spined stickleback are present in Loch Lomond and other lochs and ponds throughout the catchment (Hunter *et al*. 1959) but 9-spined sticklebacks have not been recorded in riverine habitats. Three-spined stickleback are quite widely distributed in the upper Endrick and Blane but are rarely found elsewhere in electrofishing surveys for salmonids, although these tend to be negatively biased against habitats likely to hold sticklebacks.

3.10.2 Local biological characteristics

Three-spined sticklebacks spawn in the Endrick in weed beds in still water and fry are abundant in the spawning grounds during the summer months (Maitland 1966b). Habitat preference is for slow-moving water with weed cover and where they are present fish are usually abundant with adult size ranging up to 6.5cm. Three-spined sticklebacks are generally more abundant in the catchment than nine-spined, however, in a very few locations the converse is true (Adams, pers. comm.)

3.11 Perch

3.11.1 Distribution

Widespread throughout Loch Lemon and other lochs in the catchment and the lower reaches of the River Endrick and Falloch.

- *Local biological characteristics*
-

In a study by Adams (1994), perch accounted for 5% of total catch in gill net surveys in Loch Lomond from 1988 to 1990. Perch spawn in April and May, depositing their eggs on weeds in shallow bays and backwaters, three or four individuals being generally engaged in spawning together. Perch spawning in the River Endrick has been recorded below Drymen, in areas of low flow. Perch in the mid-basin of Loch Lomond undertake an annual spawning migration similar to that seen in Lake Windermere (Giles and Tippett 1987). Timing of the migration may be cued by photoperiod with it taking place during mid-summer.

3.12 Roach

3.12.1 Distribution

Present in Loch Lomond, the lower reaches of the River Endrick (Maitland 1966) and the upper reaches of the river Leven (Brown 1891).

3.12.2 Local biological characteristics

Roach are locally abundant throughout Loch Lomond. Adams (1994) records roach as 15% of total catch in gill netting surveys in 1988-1990 but patchy in distribution. More recent surveys (unpublished data, Etheridge pers. comm., University of Glasgow) have shown roach as 19% of the total catch. Roach in Loch Lomond migrate inshore to spawn (Adams *et al*. 1994). In the River Endrick the majority of the population undertakes a spawning migration up to faster-flowing water above Drymen where the eggs are deposited on vegetation and, post-hatching, the fry move downstream from the spawning grounds (Maitland 1966b). Roach have been recorded hybridising with bream (Adams and Maitland 1991).

3.13 Pike

3.13.1 Distribution

Widespread throughout Loch Lomond (Robertson 1888), the Dubh Lochan and the lower reaches of the River Endrick (Maitland 1966b).

3.13.2 Local biological characteristics

Adams (1994) records pike as 3% of total catch in gill netting surveys in 1988-1989 in Loch Lomond. Shafi (1969,1974) and Shafi and Maitland (1971b) reveal stable patterns of growth throughout life cycle of pike in Loch Lomond and the Dubh Lochan, with females consistently growing faster than males. Powan and trout were the primary prey for pike in Loch Lomond. Female pike from Loch Lomond produced an average of 29.36 eggs·kg body weight^{-1}. Adams (1991) revealed changes in pike predation in Loch Lomond due to the increasing presence of ruffe. In the 1950s-60s, the major prey item for pike was powan (57% of prey) and, in 1989-90, ruffe had become the commonest prey item (44%).
Pike in the lowest reaches of the River Endrick typically feed on small roach and are also know to spawn in this area (Maitland 1966b).

3.14 Flounder

3.14.1 Distribution

Present in Loch Lomond, the river Leven and the extreme lower reaches of the River Endrick.

- *Local biological characteristics*
-

The flounder is native to the catchment but accounted for less than 1% of total catch in gill net surveys of Loch Lomond in 1988-89 (Adams,1994). It does not spawn in freshwater and is presumed to migrate to the Clyde estuary to breed.

3.15 Thick-lipped mullet

3.15.1 Distribution

Recorded mainly in the river Leven (Lumsden & Brown 1895; Scott & Brown 1901) but there are unpublished accounts in the early 1970's (by Glasgow University Field Station staff) of unknown mullet species captured in gill nets in Millarochy Bay, Loch Lomond.

3.15.2 Local biological characteristics

No available information.

3.16 Ruffe

3.16.1 Distribution

Found widely throughout Loch Lomond, the lower Endrick and other slow flowing tributaries (Adams 1994). Only excluded from fast-flowing tributaries (Adams and Maitland 1998).

3.16.2 Local biological characteristics

Ruffe were introduced to the Loch Lomond catchment some time before the early 1980's and underwent an exponential population increase between 1982 and 1992 (Adams 1994;Maitland and East 1989). For the remainder of the 1990's the population appeared to stabilise, though at a relatively high level, and gill netting surveys conducted throughout Loch Lomond showed that the high abundance of ruffe recorded were representative of a large population throughout the loch (Adams and Maitland 1998). Ruffe are known to feed preferentially on powan ova (84% of total diet) and compared with native predators (brown trout and adult powan), maintain a higher winter feeding rate (Adams and Tippett 1991).

Unpublished data from trash screens at Ross Priory pumping station (on the south shore of Loch Lomond), for the period 1982 to 2002, has revealed that the population appears to have stabilised around this time (Adams and Maitland 1998). Sample netting in 2006–07 (unpublished data, Etheridge pers. comm., University of Glasgow) suggests that ruffe comprise around 48% of the fish community. This figure is double the recorded figure in gill netting surveys during 1988-89, where ruffe accounted for 24% of total catch (Adams 1994)

3.17 Crucian carp

3.17.1 Distribution

This species is recorded in one site in the lower catchment of the River Endrick.

3.17.2 Local biological characteristics

This species is non-native and was first recorded in 1991 (Adams and Mitchell 1992). There are no data on long term establishment of a population although electrofishing at the site of its first discovery found more than one year class present and this species is capable of spawning at relatively low temperatures (Adams 1994).

3.18 Gudgeon

3.18.1 Distribution

Present in Loch Lomond and the lower Endrick.

3.18.2 Local biological characteristics

A non native species introduced via a small loch in the Endrick valley. Captures in 1981, in the lower reaches of the River Endrick, were indicative of a viable established population (Maitland et al. 1983). Abundant in the River Endrick in 1988-89 (2.3% of total catch), it was evident that the species had moved into Loch Lomond by 1990 (commonly caught in eel traps in the Balmaha area) (Adams 1994;Adams and Tippett 1990).

3.19 Chub

3.19.1 Distribution

Present in the lower Endrick (not further upstream than the Pots of Gartness – an impassable barrier). Despite no obvious impediment to colonisation, there are no recorded captures in Loch Lomond.

3.19.2 Local biological characteristics

This non-native species became established by the mid 1980's (Adams et al. 1990). Chub are considered common by coarse anglers in the River Endrick, however there is some doubt as to the long term viability of this species (non-optimal spawning conditions due to low water temperatures at this latitude) (Adams 1994). Adams (1994) records chub as 2.3% of catch in surveys of the lower river Endrick in 1988-1989.

3.20 Dace

3.20.1 Distribution

Present in Loch Lomond (as far north as Rowardennan), the River Endrick (not above the Pots of Gartness – an impassable barrier) and the river Blane.

3.20.2 Local biological characteristics

The first established population was recorded in the mid 1980's in the lower Endrick by (Adams et al. 1990). Adams (1994) records dace, in gill net surveys of Loch Lomond in 1988-89, as accounting for 3% of the fish community. In surveys of the River Endrick, the same study found dace accounting for 28% of catches.

3.21 Rainbow trout

3.21.1 Distribution

Present in the Lomond catchment (Lamond 1931;Maitland 1966a)

3.21.2 Local biological characteristics

Lamond (1931) records its introduction into several small lochs and reservoirs. Its continuing presence in the catchment is probably mostly maintained by farm escapees.

3.22 Tench

3.22.1 Distribution

There are three records of tench in Loch Lomond towards the end of the 19th century (Lumsden and Brown 1895;Young 1870) and one from the 1990's (Grant *et al*. 1997).

3.22.2 Local biological characteristics

First recorded in 1870, the population survived for only a few years before dying out (Maitland 1972). Recent records are the result of more recent introductions. It is unlikely that this species has established because the temperature required for successful spawning is slightly higher than that achieved in Loch Lomond but the current status of this species is unknown,

3.23 Bream

3.23.1 Distribution

There is one scientific record of bream in Loch Lomond (Etheridge and Adams, 2008)
But many anecdotal records from the lower river Endrick and southern part of the Loch.

3.23.2 Local biological characteristics

This species is non-native to the catchment and its establishment success and status is unknown.

4. FISHERIES AND EXPLOITATION

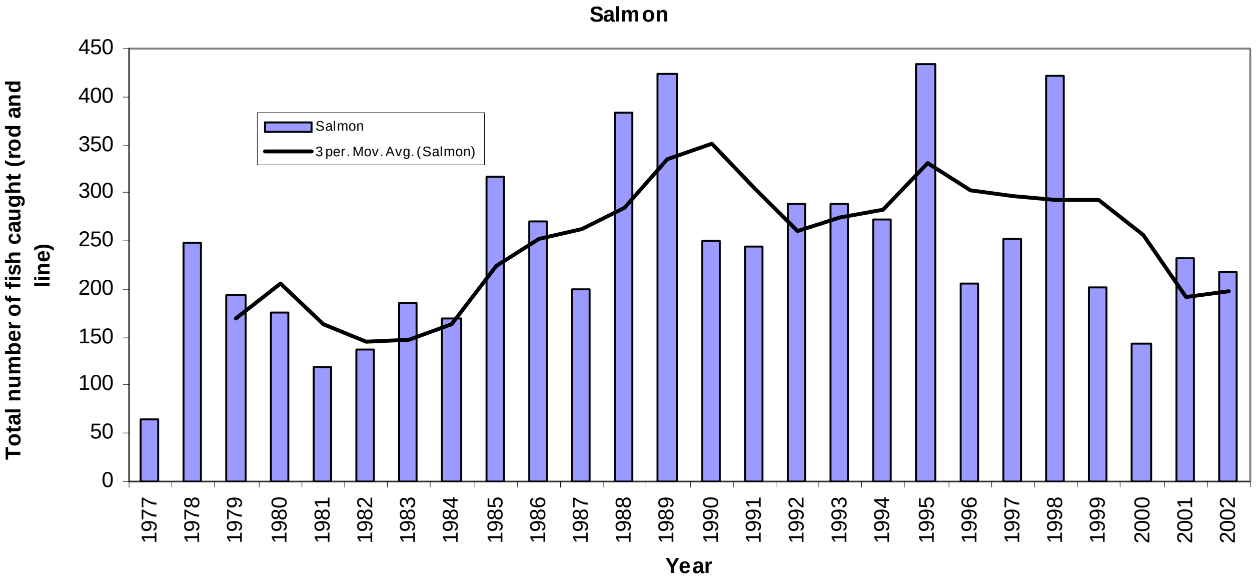
4.1 Salmon and sea trout rod catches

A salmonid sport fishery in the Loch Lomond catchment has been noted as early as 1656 (Frank, 1694) and continues to the present day, representing the most valuable sport fishery, in terms of exploitation, within the catchment. The establishment of the Loch Lomond Angling Improvement Association (LLAIA) in the latter part of the 19th century saw the leasing of angling rights to Loch Lomond, River Leven and many other watercourses within the catchment. Stocking of salmon and sea trout from other parts of Scotland was undertaken in the late 1800's and large numbers were reared in a hatchery at Rossdhu in the following 50 years. Up until the 1970's large numbers of eyed ova were annually stocked into several tributaries, however recent policy favours selective stocking.

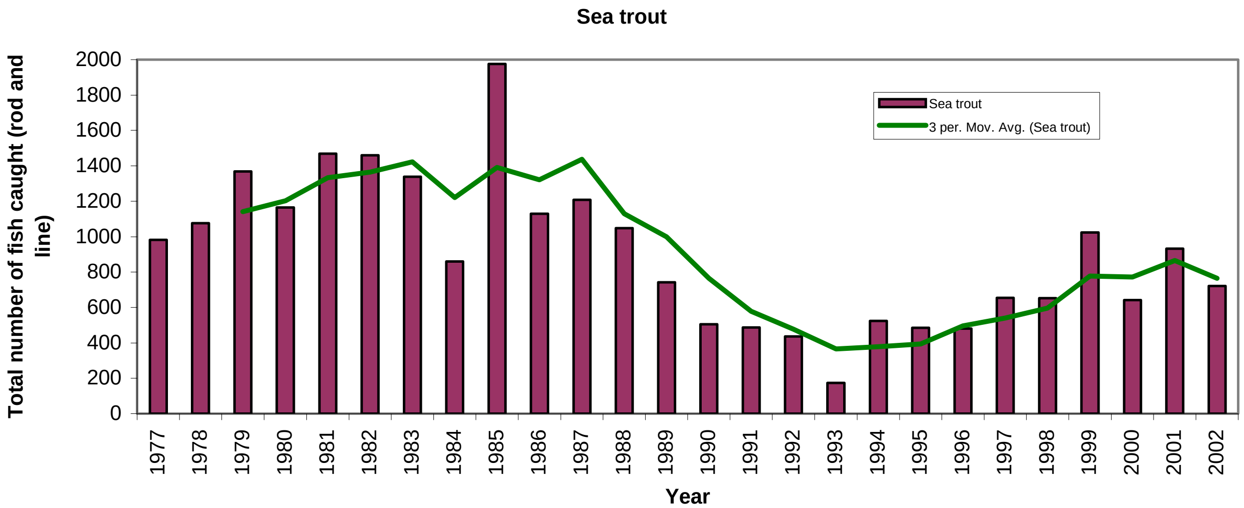
LLAIA catch data for 1977 to 2002 indicates that the salmon fishery produced 150 – 350 to rods (from three year average) annually compared with sea trout catches between 400 – 1500 (Fig 4.1). Mean annual rod catch for salmon for this same period was 244 and 905 for sea trout. These data are not corrected for fishing effort nor do they take into account variability in the rate of data return. However, there has been a statistically significant decline in sea trout numbers over the entire time series ($p= 0.001$, 21df, adj $r^2= 0.328$, $t= -3.636$).

A long term time series for sea trout rod catches in the River Falloch dating from 1934 to 2007 (Figure 4.2) shows a period of expansion from the mid 1950's through to the mid 1980's. The sharp decline following this period climaxes around the mid 1990's with an increasing trend thereafter. This trend is closely correlated with the pattern of sea trout catches for west coast of Scotland as a whole.

Table 5 and Figure 4.3 show data on mean salmon and sea trout rod catches for the period 1981 to 2002. The pattern of exploitation from 1981 to 2002 shows that ca.75% of all salmon are taken in Loch Lomond and the River Endrick in approx equal proportion suggesting it is likely that the Endrick population is the most heavily exploited by anglers. Sea trout are mainly taken from Loch Lomond and the River Leven which together comprise 75% of all catches, with most of the remainder taken from the Endrick. The Leven continues to produce most sea trout but since the declines to the early 1990s numbers taken from the Loch and the Endrick have reduce to similar levels to that of salmon.



a)



b)

Figure 4.1: Total rod catch of salmon (a) and sea trout (b) for Endrick, Fruin, Leven and Lomond catchments. Based on angler data returned to the LLAIA. (Source: LLAIA).

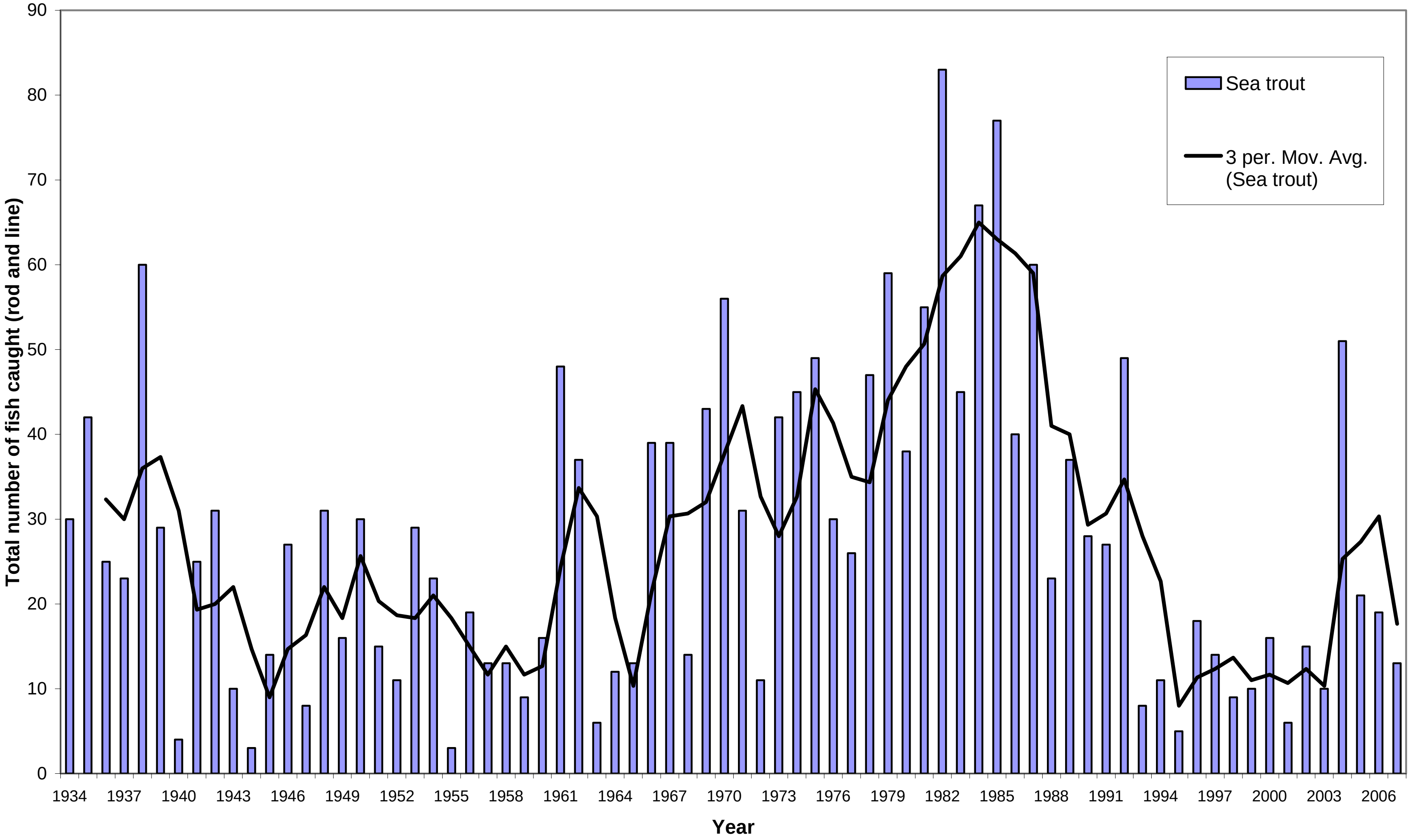


Figure 4.2: Total rod catch of sea trout in the River Falloch from 1934 to 2007. (Source: Glen Falloch Estate)

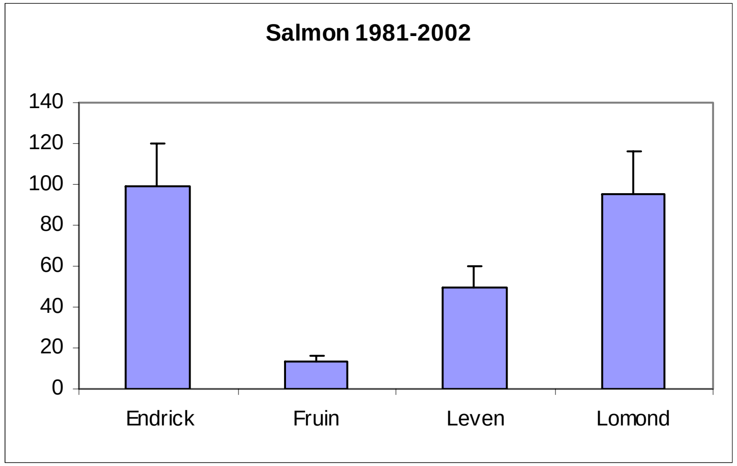
Table 5: Summary of data for salmon and sea trout throughout the catchment from 1981-2002. (Source LLAIA)

Salmon 1981-2002

	Total	Mean	N	SE	% of total
Endrick	2169	98.59091	22	21.01965	38.40%
Fruin	296	13.45455	22	2.868519	5.24%
Leven	1083	49.22727	22	10.49529	19.17%
Lomond	2100	95.45455	22	20.35098	37.18%
	5648				

Sea trout 1981-2002

	Total	Mean	N	SE	% of total
Endrick	4095	186.1364	22	39.68441	21.62%
Fruin	636	28.90909	22	6.163439	3.36%
Leven	7597	345.3182	22	73.62208	40.11%
Lomond	6612	300.5455	22	64.07651	34.91%
	18940				



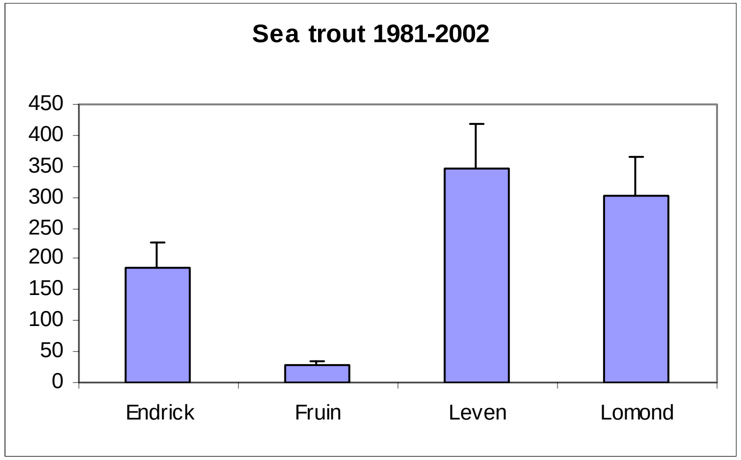


Figure 4.3: Mean rod catch (salmon and sea trout) for four sub-catchments for the period 1981-2002.

5. FACTORS AFFECTING FISH POPULATIONS

5.1 Marine Mortality

There has been a progressive decrease in the survival of salmon in the sea and an associated decline in growth rates and condition since the peak in the 1960s and 70s. This has affected all of the British Isles and has been most marked since 1990. Large scale hydrobiological changes in the north Atlantic, are now generally thought to be responsible for declines in food availability for post smolts at sea. It is now becoming clear that warmer sea surface temperatures driven by climate change are an important mechanism in this process. Changes in marine mortality appear to have had a differential effect on different sub-populations of salmon. Spring salmon, in particular large multi sea winter fish, appear to have been most severely affected.

These problems are being exacerbated by aquaculture and studies in Wester Ross, Lochaber and elsewhere have shown high correlation between salmon farming practices and sea lice levels on the Scottish west coast. Sea lice loadings are a major cause of mortality especially to post smolts of salmon and sea trout as well as increasing the susceptibility of adults to secondary infection. It is thought that sea lice infestation has been a primary cause of the crash in west coast sea trout population since the 1980's.

5.2 Predation

5.2.1 Seals

The Scottish grey seal population is increasing annually. Although research has shown that most seals travel widely to feed on white fish at sea, it is likely that there can be significant predation pressure on adult salmonids at certain times of the year in bottleneck areas such as estuaries especially from rogue seals which occasional enter Loch Lomond.

5.2.2 Piscivorous birds

Increasing bird predation in specific parts of the catchment may be an issue locally, for example herons and breeding goosanders now appear to be more numerous in salmonid nursery areas (e.g. upper Endrick) than in the past and may be having an impact on fry populations in these areas.

However, the extent to which avian predation makes a significant impact on salmonid populations overall is not well established. Data from the most recent Loch Lomond bird count surveys suggest numbers of cormorants are remaining largely static. Studies in the past on diets of both cormorants on the Loch and herons on the Endrick indicated that salmonids constituted a relatively small proportion of the diet of both bird species. It is probable that seals and piscivorous predators such as pike have a greater impact but no data are available.

5.2.3 Pike

Pike predation on migrating salmon smolts and brown trout populations is likely to be significant particularly in areas such as the Lower Endrick and Endrick bank. However, pike are indigenous to the Lomond system and have always been highly regarded by anglers who appreciate pike as a sport fish in their own right.

5.3 Exploitation:

Currently, fishery regulations such as catch and release, slot limits and other measures are inadequate to safeguard salmon and sea trout stocks from over exploitation and it is fair to assume that spring salmon in particular are currently subject to unsustainable pressure. However, at present we have little knowledge of what represents sustainable or unsustainable exploitation from the salmon and sea trout fishery within the catchment and it is essential for this knowledge gap to be addressed.

5.4 Factors acting in freshwater that are limiting Juvenile Salmonid Production

5.4.1 Water Quality:

Water chemistry is a major control on the production of juvenile salmonids especially in upland areas. Even where physical habitats are good, salmonid production tends to be lowest where chemical fertility is poor.

Much of the variation in stream fertility will be related to geology, but anthropogenic effects are also important. A readily measured surrogate for ionic concentration in river water is electrical conductivity. There is a marked north – south gradation in conductivity in the Lomond catchment from very low in the north (~ 15 *us*) where waters run off base poor granitic rocks to highest in the south east (> 250 *us*).

Much of the southern basin of the Lomond catchment suffers from diffuse pollution from agriculture. The Endrick catchment has the highest conductivities which are partly the result of nutrient enrichment from arable land. However, the highest standing stocks of juvenile salmonids are found in the Endrick and other lowland streams draining the more fertile southern parts of the basin.

The Endrick/Blane in particular is affected by significant point source discharges from domestic waste treatment works notably at Fintry, Balfron, Drymen and Blanefield. This contributes significantly to eutrophication resulting in changes to invertebrate fauna, effecting food sources for fish , and increasing fine sediment loadings which and can impact on the quality of spawning habitats due to silting up of gravel substrates.

5.4.2 Water Abstraction

Water abstraction is a significant issue in the Lomond catchment. Some extreme examples exist of near total abstraction of some significant rivers (eg Inveruglas). The EU Water Framework Directive has recently given SEPA the power to require retrospective improvements so it is therefore a particularly relevant time to consider abstraction. The main sources of abstraction are identified below.

5.4.2.1 Agricultural irrigation

Agricultural irrigation is a significant issue during dry summers in the southern part of the catchment particularly the Endrick which has the most arable land. This can reduce flows in the summer months resulting in habitat reduction for juvenile salmonids.

5.4.2.2 Public water supplies

The entire Lomond catchment has been a regulated system for domestic water supply since the construction of the Leven barrage in 1971. The barrage operated by Scottish Water maintains loch levels higher in summer than would be the case naturally. The primary impact of this has been on the hydrological regime of the out flowing river Leven. This has been heavily modified such that the natural cycle of seasonal flows has been replaced resulting in the removal of moderate size flushing flows and lower summer flows augmented by regular small pulse releases. It is known that this has an affect on the nature and timing of adult fish running the Leven and may contribute at certain times of the year to fish becoming “bottlenecked” and vulnerable to increased predation and exploitation. It is also likely that this artificial flow regime may be having adverse effects on juvenile recruitment dynamics in the Leven.

Abstraction for domestic supply also takes place in the Endrick and a significant portion of the upper catchment is impounded by Carron Valley reservoir dam resulting in increased low flows in summer. This is regulated by a compensation release but the ecological suitability of this is not known and has never been adequately assessed.

The upper Fruin catchment is an important salmon spawning area. The lower reaches of many of the tributaries in upper catchment are affected by severe dewatering from abstractions both for agriculture and domestic supply. A number of significant streams become completely dry in summer resulting in considerable loss of habitat for juvenile salmon. In particular, the Auchengaich burn is badly affected by a small water supply reservoir and complete abstraction occurs except when very high flows result in spillage at the weir. There is no compensation flow is in operation on this stream.

5.4.2.3 Hydro-power

Hydro power is becoming increasingly important as part of the national drive towards renewable energy. Loch Lomond has a number of new schemes either confirmed or at the planning stage. Most significant are the run of the river schemes in Glen Falloch and also the river Douglas which is currently under construction. The Douglas is inaccessible to migratory salmonids and the Falloch schemes for the most part return water to the lower river such that it is only resident brown trout that are potentially affected. LLFT has been closely involved with these schemes to ensure that impacts on fish populations are kept to a minimum.

The largest hydro scheme operating since the 1950s on Loch Lomond is the Loch Sloy pumping station owned by SSE. This has severely impacted the Inveruglas water resulting in almost complete abstraction of much of this watercourse in summer. The Inveruglas is accessible to migratory salmonids and is known to have once held a natural population of salmon which is now doubtful. The capacity of the pumping station is due to be increased and so this is an appropriate time for SEPA to consider setting an appropriate compensation flow in order for this watercourse to meet its ecological objectives under the Water Framework Directive.

5.4.3 Man-made obstructions:

Dams, weirs, road culverts and other constructions partially or fully obstruct the passage of migratory fish from some parts of their natural range in the Lomond catchment. However, the extent of this problem is much less significant than on some other rivers which have a greater industrial history or a greater level of natural fish access.

Nevertheless, culverts and impoundments are present on some tributaries of the Endrick Water such as the Carnock burn resulting in the loss of significant nursery areas for migratory fish species. The Loch Sloy dam and other impoundments and diversions associated with the hydro scheme act as significant barriers to migration on the Inveruglas Water. In the upper catchment of the Fruin Water a sub surface oil pipeline crosses the lower reaches of a number of tributaries and at low flows acts as a barrier to migration resulting in loss of connectivity with main river. Impoundments at the army base in the headwaters set the upstream limit to migration.

5.4.4 Habitat

5.4.4.1 River Morphology and the physical structure of salmonid habitat

The riverine environment is conditioned by river channel morphology which is a product of the relationships between discharge, gradient and sediment supply. These, in turn are governed by macro-scale variables such as climate and geology

The morphology of lowland alluvial channels provides a greater diversity of habitat features for salmonids than steep, upland streams. In low gradient rivers such as the Endrick depositional processes tend to dominate and the distribution of local bed scour and aggradation associated with converging and diverging flows produces characteristic morphological features of pools, riffles and meanders The form of pool and riffle sequences are also influenced by sediment supply as coarse, angular gravels will lock together creating “armour” against bed erosion to form stable riffle bars.
These features provide the physical structure of habitat and low gradient streams tend to be correlated with higher mean standing stocks because they produce a greater diversity of habitat features than upland rivers

5.4.4.2 Habitat diversity as a population limiting factor

Habitat diversity is of fundamental importance because availability of suitable habitats determines the numbers of fish that a stream can support. This is known as the carrying capacity. Different life stages of salmon and trout require specific habitat conditions such that amounts and types of different microhabitats can act to limit abundance. Thus, absence of a critical habitat type for a particular life stage will act as a population limiting factor creating a “habitat bottleneck” at that stage of the life cycle.

Natural habitat diversity will also determine the relative juxtaposition of spawning and rearing habitats for salmon and trout and there is usually a surfeit of one or the other. In much of the upper Endrick and Fruin there is a surfeit of shallow spawning habitats, often exacerbated by grazing induced erosion. However, many of the upland tributaries such as the Falloch are dominated by bouldery habitat which is good nursery habitat for parr but poor for spawning.

5.4.4.3 Habitat degradation

Human impacts have significantly affected riverine habitats both through riparian land uses and direct channel alterations. Some important issues include:

Channel realignment and dredging

In low gradient agricultural areas the great majority of streams have been subjected to historical “channelization” – i.e. natural meandering channels have been straightened for land drainage purposes. Channelization results in a loss of natural physical variation and restoration of channel sinuosity is now widely promoted in the UK and is often considered to be one of the key goals of the Water Framework Directive.

Many streams in agricultural areas have been dredged to improve land drainage. Such works can be very damaging. Spawning gravel is removed and fish cover is reduced by the removal of larger stones, weed and encroaching vegetation.

While there was little or no control over such activities in the past, new work is nowregulated by SEPA’s Controlled Activities Regulations. However, there is a considerable legacy from the past. The river Leven was regularly dredged in the past and has had significant channel re-alignment associated with urban development of the floodplain. Both dredging and re-alignment for land drainage remain significant issues in the upper Fruin and river Blane. Removal of gravel from the middle reaches of the Endrick main stem has resulted in the reduction of salmonid spawning areas.

Riparian grazing

Riverine fish habitats can be impaired by overgrazing of the riparian zone. Grazing can remove the cover provided by marginal vegetation, accelerate bank erosion leading to wider, shallower and slower channels and increase sediment loads. Grazing does most damage in relatively low gradient streams which have easily erodible banks, gravel or sand beds and subject to high cattle or sheep densities. Much of the Endrick catchment is severely affected by this issue and significant areas of the Fruin especially in the upper catchment.

While there are significant amounts of riparian grazing in the upland areas of the northern Lomond catchment the coarser bed and bank materials provide a much greater resilience to grazing. Indeed in some stony tributaries some grazing induced erosion may have the beneficial effect of providing gravel input to the stream.

5.4.5 Climate change and hydrology:

The expected continued rise in global temperatures will become a major challenge for freshwater fisheries. Impacts at sea will have a major bearing on migratory fish populations in ways which may be very difficult to predict.

Within freshwater there is evidence of increasingly extreme weather events, whether flash floods or droughts, which may prove even more damaging. Changing weather patterns in the last 20 years have resulted in a 20% increase in rainfall in Loch Lomond resulting in increased frequency of flood events and flashiness of river regimes. It is likely that this trend could impact on the recruitment dynamics of salmonids in tributaries with floods increasing redd damage and even washout of juvenile fish and invertebrates.

Another concern is the likelihood of prolonged low flows in summer which reduces availability of juvenile habitat and can act as a bottleneck to parr survival where densities are high. Fry are often largely restricted to very shallow marginal riffle and the abundance of such habitat is likely to vary under different flows which may mean that fry survival is likely to be affected by summer flows. A trend towards increasing severity of summer spates may result in high fry mortality.

In addition, changes in the temperature of the Loch have been highlighted by work currently being undertaken at the University of Glasgow. Recent findings have shown that the temperature has risen by 1.8^{o}C in the last twenty years. This has potentially major implications for the entire aquatic ecosystem and could affect fish diets, growth rates, spawning times and migrations seasons to mention only a few.

Modifications to land use also impact on hydrology. Land especially in the Fruin and Endrick catchments has increased drainage densities resulting in 'flashy' flow regimes (i.e. during high rainfall events river levels increase more quickly) leading to redd wash out and increased fry mortality. It also has geomorphological implications exacerbating bank erosion and associated habitat loss.

5.4.6 Diffuse agricultural pollution

Diffuse pollution from agriculture has been identified by SEPA as one of the most significant environmental impacts affecting the ecological status of some waterbodies in the Lomond catchment. The river Endrick has the main problems of run-off of excess nutrients and other agrichemicals from land, run-off from farm yards and steadings and run-off of sediments from bare fields. Sediment release caused by poaching of the ground by livestock is also a major local issue.

Diffuse pollution is not only generated in fields adjacent to major fish holding watercourses but from any part of the drainage system, including the smallest ditches and temporary rills which may form in fields following heavy rain. Potential solutions include improved nutrient budgeting, installation of permanently vegetated buffer strips and other silt trapping features along critical pollutant pathways and changes to agricultural practices.

5.4.7 Sheep dip

The introduction of synthetic pyrethroid sheep dips in the 1990s created a serious pollution threat. These dips are extremely toxic to freshwater invertebrates and very small discharges can devastate invertebrate communities for kilometres. Serious incidents in the recent past have affected parts of the River Endrick, the Luss Water and the Douglas Water and populations are depressed in these areas as a result. Fortunately, SP dips have been withdrawn from sale since 2005 and SEPA have prioritised monitoring in the most vulnerable areas.

5.5 Alien species

5.5.1 Introductions of non-native fish

Loch Lomond has had various introductions of non-native species and to date there are nine introduced fish species currently in the catchment. Interactions between native and alien species can result in wholesale changes to aquatic ecosystems. Recent work at the University of Glasgow has shown that ruffe introduced since in 1982 has been a major cause in the decline of powan populations in Loch Lomond as they predate on powan eggs. Other studies have shown that dietary shift has occurred in pike towards ruffe as the dominant prey item.

5.5.2 American signal crayfish

American signal crayfish have been found at a number of sites within the Clyde catchment although they are not yet in Lomond. Signal crayfish are a highly aggressive invasive species which can form very densepopulations and can fundamentally affect the ecology of stillwaters and rivers. They are omnivorous and will eat fish, invertebrates, waterweed and detritus. Once established they are extremely difficult to control or eradicate. Arrivals of such alien species threaten to destroy natural ecosystem function with a consequent loss of native biodiversity.

5.5.3 Disease and parasites:

A major concern at present is the threat posed to salmon from the parasite *Gyrodactylus salaris* which has spread from the Baltic area to many parts of Europe. While Baltic strains are naturally immune other stocks are susceptible to extremely high mortalities. At present the UK is *Gs* free but its arrival in Scotland would decimate any population into which it became introduced. Prevention of the introduction of this parasite is a national and local priority.

5.5.4 Alien plant species

Several invasive plant species are becoming increasingly common in the Lomond catchment. These include a number of invasive aquatic species which are out competing native flora in places and riparian species such as Japanese knotweed which is an extremely pernicious plant, which can completely dominate riverbanks.

5.6 Fish farm escapes

Inter-breeding between farmed and wild salmon has been shown to reduce the genetic fitness of a population if it occurs consistently over a number of years especially where the wild population is fragile. Loch Lomond is fortunate that no pelagic fish farms are present in the Clyde estuary but escapes from cages in Loch Fyne, Loch Striven and elsewhere have impacted the Lomond system. A series of escapes in 2006 resulted in large numbers of farmed fish being caught in the River Leven and there were records of these fish entering the River Falloch and the Ross Burn demonstrating their ability to penetrate the catchment and interact with wild fish. Engagement with aquaculture interests through the TWG is necessary to ensure work is on going to minimize escapes.

6 MANAGEMENT ACTIONS REQUIRED TO PROTECT AND IMPROVE FISH POPULATIONS

A programme of priority actions for management has been produced for the Lomond catchment in order to address some of the pressures identified in section 5. The fundamental goal of sustainable fisheries management is the accurate diagnosis of population-limiting factors and identification of bottlenecks to salmonid production and as such the primary focus of actions is to address pressures acting to limit juvenile populations in freshwater.

6.1 WATER QUALITY AND CHEMISTRY

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.1.1	Temperature data should continuously be monitored in all sub catchments and some natural controls.	LLFT	
6.1.2	Simple water chemistry indices (e.g. conductivity) should be continuously monitored in regulated and unregulated tributaries.	LLFT	
6.1.3	Conduct base-line surveys of macro-invertebrates across whole catchment to identify sites where water quality maybe limiting fish production.	LLFT, SEPA	
6.1.4	A research project will examine the effects of STW on local fish and invertebrate populations in the river Blane	LLFT, GU, SEPA	

6.2 WATER ABSTRACTION

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.2.1	Continue to provide advice and make representations on planning and CAR applications regarding new hydro schemes and other forms of abstraction.	LLFT	
6.2.2	A research project should be initiated to establish potential effects of abstraction by new run-of-river hydro schemes in steep upland areas on juvenile salmon and trout populations	LLFT, LLTNP, SEPA, GU	
6.2.3	Work to restore sufficient flows to tributaries in the upper the River Fruin to mitigate juvenile habitat loss in summer	LLFT, LLTNP, SEPA,	
6.2.4	Support provision of a suitable compensation flow to the Inveruglas to restore a self-sustaining salmon population which fully utilizes the available channel up to the Loch Sloy intake.	LLFT, SEPA, SSE	
6.2.5	Undertake research to model potential juvenile habitat gains in nursery streams affected by abstractions and associated dewatering.	LLFT, LLTNP, GU	

6.3 HABITAT

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.3.1	**Habitat inventories -** catchment wide habitat walk – over surveys of all tributaries should be conducted to provide an inventory of availability and quality of nursery habitats throughout the system.	LLFT	

6.3.2	Seek funding to undertake an aerial photo-survey of the entire Lomond catchment to provide a digital inventory of instream habitat, riparian land use and areas/sources of habitat degradation.	LLTNP, LLFT, GU	
6.3.3	Define upstream limits to migration and quantify total useable habitat area accessible to migratory salmonids.	LLFT	
6.3.4	**Habitat enhancements -** Where livestock overgrazing is resulting in severe bank erosion and channel over widening riparian buffer zone enhancements including bank protection, fencing and planting should be carried out (eg. upper Fruin and Endrick). This should focus on important nursery areas. Where landowners are in agreement and there is clear benefit in doing so, fences should be erected to exclude livestock from watercourses. Where traditional fencing is inappropriate consideration should be given to electric-fencing or other means	LLFT, LLTNP, LLAIA, SNH, SEPA, FCS, SRDP	
6.3.5	Establish a research project to investigate existing differences in juvenile populations between grazed and un-grazed river reaches and different riparian land uses.	LLFT, LLTNP, SNH, GU	
6.3.6	Collaborate with SNH, LLTNPA, SEPA and support initiatives to reduce diffuse pollution and sediment inputs through establishment of riparian buffer zones.	ALL	
6.3.7	Historical in stream habitat works which are inappropriate and malfunctioning (such as croys and rock weirs) should be removed where they are exacerbating bank erosion.	LLFT, SEPA, LLAIA	

6.4 RIVER MORPHOLOGY AND CONNECTIVITY

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.4.1	Identify all barriers (artificial/natural) to migration	LLFT	
6.4.2	Instigate a programme of easement of artificial obstructions to restore connectivity and increase availability of nursery habitat	LLFT, SEPA	
6.4.3	Identify areas where large scale hydro-geomorphic instability is exacerbating habitat loss due to bank erosion and channel over-widening (eg. Endrick/Fruin) and seek joined up multi-agency approaches to restoration	ALL	
6.4.4	Identify areas from which gravel removal has resulted in a deficiency in salmon and trout spawning habitat and consider ways of increasing spawning gravel abundance in naturally stable streams where this limits fish production.	LLFT, SEPA	
6.4.5	Engage with landowners, SEPA and others to seek to restore spawning gravel in areas where this is required and ensure that unconsented gravel extraction and inappropriate river modifications are prevented.	LLFT, SEPA	

6.5 HYDROLOGY AND FLOW REGIMES

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.5.1	Encourage land management practices which reduce the speed of run-off – e.g. blocking of upland drainage where this is now unnecessary, increasing floodplain storage, changes in land use.	SEPA, SNH, LLTNP	
6.5.2	Research should be conducted into the effects of major flow variations, especially extended summer low flows, on habitat availability and juvenile recruitment in nursery areas	LLFT, GU, SEPA	

6.6 AGRICULTURAL POLLUTION

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.6.1	Cooperate with SEPA or any other initiatives to reduce diffuse pollution from agriculture	ALL	
6.6.2	Support initiatives to maintain the ban on sale of synthetic pyrethroid sheep dips and conduct regular monitoring of fish populations in areas vulnerable to sheep-dipping.	LLFT, SEPA	
6.6.3	Initiate a research project to investigate effects of nutrient status / diffuse pollution on invertebrates and fish diets in the river Endrick	LLFT, SNH, GU	
6.6.4	Identify sites which should form the basis of bi-annual invertebrate monitoring to supplement the current sampling undertaken by the SEPA.	LLFT, SEPA	

6.7 PREDATION

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.7.1	Regular coordinated counts of piscivorous birds should be made on the Loch and its major tributaries	LLFT, LLTNP, RSPB	
6.7.2	A research project should be conducted into the diet of goosanders and herons around the Endrick bank and lower Endrick in winter. If salmonids are a significant part of the diet a further research project should be conducted into the use of the lower Endrick by pre-smolting salmon in winter.	LLFT, RSPB, LLTNP	
6.7.3	A study into the distribution and diet of pike should be conducted in and around the lower reaches of major tributaries	LLFT	

6.8 NON NATIVE FISH SPECIES

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.8.1	Collaborate with LLTNPA as appropriate with invasive species management programme under NPBAP: ISP4 invasive fish monitoring	LLFT, LLTNP	
6.8.2	Conduct baseline netting surveys of Loch Lomond and lower reaches of the rivers Endrick and Falloch to assess presence, distribution and relative abundance of non-native fish.	LLFT	

6.8.3	Work with LLTNP and others to seek opportunities to establish a fixed fish trap in the lower Endrick as part of the invasive fish survey programme within the NPBAP	LLFT, LLTNP, SNH	
6.8.4	Where possible resource a series of stand alone research projects to explore local interactions and potential adverse effects of non-native species on the ecology and biology of indigenous fish species	LLFT, GU	

6.9 ALIEN SPECIES

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.9.1	Collaborate with LLTNPA as appropriate with invasive species management programme under NPBAP: as below	LLFT, LLTNP	
6.9.2	NPBAP: ISP 2 invasive aquatic and riparian plants in Endrick catchment	LLFT, LLTNP	
6.9.3	NPBAP: ISP 6 surveys for Japanese knotweed	LLFT, LLTNP	
6.9.4	NPBAP: ISP 10 contribute to and promote aware of G salaries through signage and other measures	LLFT, LLTNP, LLAIA	

6.10 DISEASES AND PARASITES

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
6.10.1	Continually promote awareness of the threat posed by *Gyrodactylus salaris* (GS) amongst the angling community and other river users.	LLFT, LLAIA	

7 RESEARCH AND MONITORING PRIORITIES

In order to promote healthy populations of fish that are naturally self sustaining, key research priorities have been identified. These will address fundamental knowledge gaps about the health of fish populations in the Lomond system and be used to develop scientifically based tools that will enable better informed management to be undertaken in the future.

7.1 SALMON AND (SEA) TROUT POPULATIONS

7.1.1 Status of adult populations

It is not possible to achieve long term sustainable management of salmon and brown (sea) trout populations without first understanding the size, character and distribution of these populations. Estimating population size and monitoring change over time is essential in order to identify management needs

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.1.1a	Conduct annual redd counts in important spawning areas of major tributaries to estimate abundance and variation in adult spawning stocks	LLFT	
7.1.1.b	Establish a series of fish counters across the catchment to monitor adult population sizes in the rivers Endrick, Luss and Leven. This will provide information on changes in population size over time and run timings etc allowing required spawning escapement to be estimated.	LLFT, LLTNP, LLAIA, SNH	
7.1.1.c	Collaborate with other agencies to secure additional funding for installation of automated Vaki fish counter in the river Endrick	LLFT	
7.1.1.d	Liaise with SEPA and others to acquire funding to install resistivity type “logie” fish counter on the newly upgraded weir on the river Luss.	LLFT	
7.1.1.e	Examine feasibility of sourcing collaborative funding to install a purpose built resistivity type “logie” fish counter on the river Leven.	LLFT	
7.1.1.f	Establish a suite of fish traps in small burns important for sea trout production to assess spawning population sizes	LLFT, LLTNP, LLAIA,	

7.1.1.g	Seek opportunities to establish a fixed adult trap for salmon in the lower Endrick or river Leven.	LLFT, LLTNP, LLAIA, SNH	

7.1.2 Status of juvenile populations

Monitoring of stocks is an important element in fisheries management to obtain information on the status of fish populations and to identify problems.

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.1.2.a	Long term monitoring of smolt outputs using rotary screw traps in the rivers Leven and Endrick. This will enable annual estimates of smolt production for the whole the system which will allow total adult spawning stock size to be estimated.	LLFT	
7.1.2.b	Conduct a research project to assess the effectiveness of Rotary Screw Traps for estimating smolt production using a mark and recapture experiment. This will establish a robust method of calibration relating actual fish captures in the traps to total migration.	LLFT, LLTNP, GU	
7.1.2.c	Continue routine monitoring of juvenile abundance using electro fishing surveys throughout all running waters accessible to migratory salmonids	LLFT	
7.1.2d	Continue to develop calibrations for semi-quantitative fry surveys in different habitat types to enable them to be used to estimate population sizes	LLFT	
7.1.2e	Source a research project to quantify numbers of semi-quantitative fry index sites needed to provide statistically robust measures of change in population size over time	LLFT, GU	

7.1.3 Genetic structuring and biological characteristics of populations

It is now well established by studies using modern DNA based techniques that salmon in different river systems belong to different breeding populations. Breeding populations can be defined as 'groups of individuals, within which mating is more of less random, but among which interbreeding is more of less absent'. This structuring or separation of a stock into distinct breeding populations is a function of strong homing behaviour to natal spawning areas combined with the fact that spawning timings differ and spawning locations are spatially fragmented. To properly manage salmonid populations it is necessary to understand the nature of this population structuring within the Lomond area and determine both the number of sub populations present and the extent of separation.

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.1.3.a	Continue catchment wide genetic sampling programme for salmon (fig 7.1) as part of Scotland wide RAFTS initiative to identify spatial structuring of genetically discrete stock components in support of SALSEA project	LLFT, RAFTS, FRS	
7.1.3.b	Estimate the 'effective' number of breeders in each sub population of salmon to allow required spawning escapement targets to be defined.	LLFT, FRS	
7.1.3.c	Identify locations of nursery areas for different sub populations especially in respect to identifying areas important for recruitment of "spring" salmon.	LLFT, FRS	
7.1.3.d	Research programme to identify strength of the spring run component of the salmon stock by assigning adult fish captured in the rod fishery to their population of origin	LLFT, FRS, GU	
7.1.3.e	Commence catchment wide genetic sampling programme for sea trout to identify spatial structuring of genetically discrete stock components. Link to Celtic Sea Trout Project	LLFT	
7.1.3.f	Continue and expand scale collection programme for juveniles and smolts to include adults caught by rods. Use to investigate population age-structures, growth rates and life-history strategies.	LLFT, LLAIA, VOLDAC	

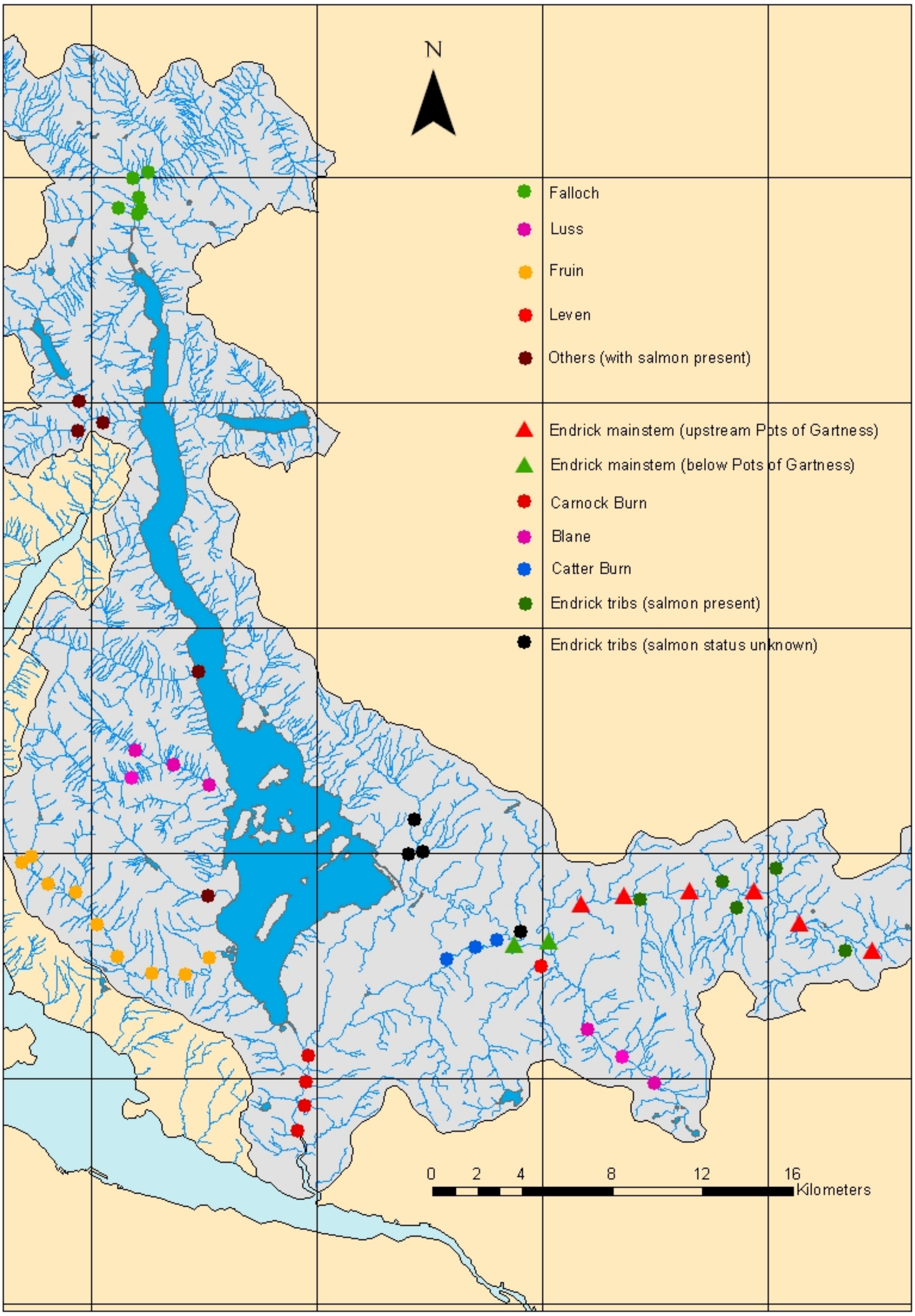


Fig. 7.1. Spatial distribution of genetic sampling sites in the Lomond catchment

7.1.4 Habitat carrying capacity

Availability of nursery habitats areas need to quantified at a whole catchment scale in order to identify the potential capacity for juvenile production of different sub catchments within the Lomond system.

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.1.4.a	Use GIS to map distributions and total areas of different habitat types (spawning/nursery/adult holding). Use habitat areas to develop a simple measure of habitat carrying capacities in the major tributaries	LLFT	
7.1.4.b	Identify and map the most/least productive spawning and nursery areas using electro-fishing data on juvenile abundance and relating these to habitat areas (above).	LLFT	
7.1.4.c	Establish estimates of total juvenile production for both salmon and trout (from 7.1.4.a/b above) and relate to habitat carrying capacity. Identify areas where habitat is under-utilised and use this information to identify factors limiting juvenile production and where there is potential for production to be increased.	LLFT	
7.1.4.d	Undertake a research project to assess statistically the most important habitat factors determining juvenile salmon and trout abundance using habitat measurements from electrofishing survey sites across the catchment.	LLFT, GU	

7.1.5 Stock – recruitment relationships

Understanding the relationships between the adult population size and the amount of juvenile production is fundamental in order to develop management tools that can be used to ensure enough spawning adults of each population return to fully stock the available habitat for the next generation

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.1.5.a	Estimate adult escapement – ie the numbers of spawning adults required from each sub-population to maintain population sizes	LLFT	
7.1.5.b	Develop estimates of egg deposition required to fully stock the available juvenile habitat for the next generation	LLFT	
7.1.5.c	Work towards development of stock – recruitment curves to establish the numbers of spawning adults necessary to maximize juvenile production and smolt output from the principal tributaries. These models are vital management tools and a necessary precursor to setting sustainable conservation limits.	LLFT, GU	
7.1.5.d	Source a research project to investigate stock-recruitment for sea trout in a sub catchment where adult population size can be established by trapping	LLFT, GU, LLAIA	

7.1.6 Conservation Limits

Conservation limits are used to define the levels of natural spawning and recruitment necessary to maintain healthy, self sustaining wild populations. These are essential to enable appropriate fishery management objectives to be set.

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.1.6.a	Define conservation limits for salmon and sea trout populations. These are the levels below which adult spawning stocks must not be allowed to drop in order to maintain natural recruitment at healthy levels. For salmon these limits must be based on the sizes of genetically discrete sub populations.	LLFT, GU	

7.1.6.b	Instigate a programme to collect better information from anglers on the numbers of returning adults caught and removed from the rod fishery. This information is essential in order to define sustainable conservation limits	LLFT, LLAIA, VOLDAC	
7.1.6.c	Promote the ethos of catch and release (especially for hen fish and larger fish) and campaign for a no-kill policy to be applied to all "spring" salmon caught before 1st June	LLFT, LLAIA, VOLDAC, LLTNP	
7.1.6.d	Consideration should be given to a study by tagging (or some other means) to establish exploitation rates of salmon running the River Leven at different times of the year.	LLFT, LLAIA, VOLDAC,	

7.2 FRESHWATER (RESIDENT) BROWN TROUT

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.2.1	Survey status of brown trout populations above impassable falls (eg upper Endrick, Carnock burn, Douglas, Falloch)	LLFT	
7.2.2	Conduct a research project to examine the population dynamics of brown trout in the Upper river Falloch	LLFT	
7.2.3	Source a research programme to examine life history strategies of trout. This will focus on spring migrations of trout parr from the river Endrick screw trap and seek to investigate their use of the loch as rearing habitat.	LLFT, GU	
7.2.4	Conduct a systematic programme of rod and line surveys to assess status of ferox trout populations in Loch Lomond	LLFT, FRS	

7.3 EUROPEAN EEL

More information is needed to assess the status of eel which is known to be in decline throughout its native range. The geography of the Loch Lomond catchment makes it potentially an ideal site for assessing the status of eel populations on the west coast of Scotland in general.

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.3.1	Set up an eel trapping programme at various locations throughout the catchment to assess current status of eel populations in Lomond	LLFT, GU	
7.3.2	Record distribution and abundance of eels caught as part of routine monitoring surveys for juvenile salmonids.	LLFT	
7.3.3	Seek opportunities to establish a fixed eel trap in the lower Endrick	LLFT	

7.4 PIKE

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.4.1	Assess current status of pike populations in the loch and lower rivers Endrick and Falloch using a combination of netting surveys to determine distribution and abundance	LLFT	
7.4.2	Organise a series of angler event days in conjunction with PAAS to collect data on pike abundance and distribution	LLFT, PAAS	
7.4.3	Instigate a tagging programme for adult pike to examine movements, growth rates and survival	LLFT, PAAS, GU	
7.4.4	Commence a dietary analysis from captured pike to examine seasonal shifts in feeding behaviour and in particular extent of predation on smolts in vicinity of Endrick bank and lower Falloch	LLFT, PAAS, GU	

7.5 LAMPREY AND POWAN

These species are of the highest conservation value and as such are identified in the NPBAP as key species requiring further fundamental research

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.5.1	Where appropriate work with LLTNPA and other agencies in assessing status of river lamprey populations in the Endrick SAC and powan in Loch Lomond	LLFT, LLTNP, SNH, SCENE	

7.6 FRESHWATER PEARL MUSSELS

SNH have identified the Fruin as a key site for re-introduction of this once native species.

ACTION	DESCRIPTION	KEY ORGANISATIONS	TIMESCALE
7.6.1	Work with SNH and others to support and assist re-introduction of freshwater pearl mussels to the river Fruin.	LLFT, LLTNP, SNH	

8 EDUCATION

8.1 Lomond in the classroom

Provision of outreach education within the Loch Lomond catchment is an important part of the constitution of the Loch Lomond Fisheries Trust. In order to meet its educational remit LLFT is running an innovative project with local schools engaging young people with their local environment and ecology of Loch Lomond and its fish populations.

Eggs from locally sourced powan and brown trout are incubated and hatched in the classroom in specially adapted aquaria. LLFT provides an outreach programme of teacher support during this period prior to the fish being released into the environment.

This project is unique because powan are one of the rarest freshwater fish in the UK and in Scotland are native only to Loch Lomond and Loch Eck. As such they are listed in schedule 5 of the Wildlife and Countryside Act and research at SCENE has shown the Lomond population is under serious threat. Consequently, powan eggs are very difficult to acquire but are available to LLFT as part of a captive rearing programme being undertaken at SCENE.

A schools based initiative using powan has a unique local dimension and has already proved to be an exciting first in Scotland. A parallel programme using locally sourced sea trout eggs supplied by LLAIA is running simultaneously. It is planned to expand these projects into more local schools in the future and expected this will generate high profile interest in addition to offering local children the opportunity to gain a genuine insight into "very local" ecology literally outside their classroom door.

8.2 Adult education

LLFT staff will also work with LLTNP in support of the outdoor education programme. This will include running workshops and field training for the local angling community, conservation and interest groups and the general public.

9 IMPLEMENTATION AND DELIVERING IMPROVEMENTS

9.1 Funding and delivery

This document outlines a large number of tasks and projects which are required to be delivered if the fish and fisheries of the Loch Lomond system are to realise their full potential. Much of this work will, by its nature, need to be undertaken over a number of years to enable acquisition of robust long term data on the status of fish population and changes over time. In addition, practical measures such as habitat improvements will require regular post work monitoring to determine their effectiveness and inform future management.

Resourcing this ambitious programme will be a challenge and for many of these projects to be delivered there will be a need for LLFT to secure significant additional income streams and ultimately to recruit additional personnel with biological training. At present much of this work is conducted with volunteer staff and graduate students engaged on field related projects. These will continue to remain an important and necessary component for delivery of key aspects of this plan.

Some important funding streams have already been established, for example Scottish Government funding in conjunction with RAFTS. This supports vital voluntary contributions from riparian owners and Glasgow University which continues to support the Trust through its links with SCENE where LLFT has a base. However, sourcing funding to carry out specific projects will become increasingly dependent on schemes such as the SEPA restoration fund and the LLTNP Natural Heritage Grant Scheme and further funding streams will need to be identified in order to take forward much of the work.

Thus, the first stage in implementation of this Fisheries Management Plan is to prioritise improvement projects and research actions on the basis of cost-benefit, achievability and opportunity. Priority project proposals can then be worked up, costed and delivered. Sourcing funding through collaborative working with a wide range of partner organisations will be the key to delivery of many of the elements within the plan. Some of the legislative frameworks through which LLFT will work closely with statutory organisations are detailed below.

9.2 Scottish Environmental Protection Agency (SEPA)

The Water Framework Directive provides the overarching legislative framework for protection of the aquatic environment. SEPA is the statutory authority charged with implementing WFD objectives by direct regulation of controlled activities (polluting discharges, abstractions, impoundments and engineering activities) which put the water environment at risk of not achieving good status or which have a significant adverse impact upon “the interests of other users of the water environment”.

Over the past three years SEPA has progressively improved its assessment of the impacts of controlled activities using environmental data and the new WFD standards. This has generated a revised list of water bodies which are definitely at risk of not achieving good status (these are known as 1a water bodies) which has been presented in the Significant Water Management Issues report published in 2007. Much of the southern part of the Loch Lomond catchment has been classified as" at risk" water body. WFD legislation provides opportunity for LLFT to engage in this process through interaction with SEPA in two main ways;-

- *River Basin Planning Advisory Groups:*

To support river basin planning across Scotland SEPA has formed a National Advisory Group and a comprehensive network of Area Advisory Groups working more locally. Fisheries interests are represented in all of these groups by individual DSFB or Trusts as Area Advisory Group members and the Association of Salmon Fishery Board / RAFTS as National Advisory Group members. The Clyde Area Advisory Group covers the area of the Loch Lomond Fisheries Trust.

LLFT is a member of this AAG and is working with members to help support the preparation and implementation of the River Basin Management Plan for the River Basin District and the Area Management Plan for the advisory group area. Further information on the river basin planning process is available from SEPA's website. (http://www.sepa.org.uk/wfd/rbmp/index.htm).

- *Controlled Activity Regulations:*

The Controlled Activity Regulations (CAR) provide SEPA with the opportunity to regulate a range of activities which can relate to fishery management issues. In addition to existing controls on point source pollution (which are revised as part of these regulations) SEPA now regulates activities including:

- Water abstractions
- Water impoundments and
- River engineering works

Diffuse source pollution will also be controlled via General Binding Rules. Further information on these regulatory regimes is available from SEPA's website.(http://www.sepa.org.uk/wfd/regimes/index.htm)

The implementation of these regimes by SEPA provides opportunities to better protect the water environment to the benefit of fish and fisheries. A formal regulatory process allows third party representations to be made at certain times such that SEPA must advertise all licences where it considers that "good ecological status" objectives will not be achieved through the licence conditions. This allows any interested parties to make representations to SEPA to inform its regulatory decision and LLFT uses these opportunities to respond to relevant consultations in order to achieve better environmental outcomes for the aquatic resources of the Loch Lomond catchment.

The National and Area Advisory groups themselves cannot make or be involved in regulatory decision making but their members are clearly well informed to respond to relevant licence advertisements where this is required. As a member of the Clyde Area Advisory Group, LLFT is well placed to inform licence determinations in this way.

9.3 Scottish Natural Heritage (SNH)

SNH are the statutory organisation responsible for monitoring condition of SAC rivers. Consequently, the work of LLFT on the river Endrick is recognised by SNH as a significant input to monitoring of salmon populations and is locally very supportive of the Trust and to implementation of the objectives of the fisheries management plan on the river Endrick.

9.4 Loch Lomond and Trossachs National Park Authority (LLTNPA)

The Lomond catchment lies within the National Park. LLFT liaises closely with the park ecologist and others and is recognised as a key partner organization in the delivery of key objectives under the “lochs, rivers and ponds” component of the National Park Biodiversity Action Plan 2009.