WESTER ROSS FISHERIES TRUST

RIVER CARRON FISHERIES MANAGEMENT PLAN 2004–2008

The Highland Council
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SCOTTISH NATURAL HERITAGE

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Corrie Mhor SALMON

WESTER ROSS FISHERIES TRUST

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RIVER CARRON FISHERY MANAGEMENT PLAN 2004–2008

by
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with Bob Kindness and Gordon Macpherson

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Summary

- **Introduction:** The River Carron Fishery Management Plan 2003–2008 presents work carried out by WRFT in 1992–2002 to assess salmon and sea trout stocks and identify factors limiting their abundance, and suggests actions to restore and develop the natural potential of the river system for wild fishes. Recommendations are aimed primarily at maximising the freshwater production of juvenile trout and salmon, since this is largely within the control of riparian owners.

- **Carron catchment:** The River Carron drains mountainous terrain, with peaks of up to 1053m (Sgurr a'Chaorachain) and rises and falls fairly rapidly according to rainfall. The main river flows for 23km from source before entering Loch Carron, a fiordic sea loch with shellfish fisheries, a salmon farm and rich marine biodiversity. There are two lochs within the main valley, Loch Sgamhain (area 59ha, 20km from the tidal limit, with salmon-rearing cages) and Loch Dughaill (area 107ha, 8km from the tidal limit). The catchment has an area 137.8km^2. The rocks underlying the catchment comprise Lewisian gneiss, Torridonian sandstone, Cambrian sediments (mainly quartzites) and an assortment of granulites, schists and gneisses east of the Moine thrust zone. Heather moor is the dominant vegetation, with mosaics of upland grasslands, meadows and bare rock above about 500m. There are several ancient woodland fragments of Scots pine or deciduous trees. The largest wooded area, Achnashellach Forest, is owned by the Forestry Commission and was developed as a commercial forest in the mid-20th century. There are currently exciting plans to restore a large part of this forest to native woodland.

- **Important species and habitats:** Atlantic salmon (*Salmo salar*), Brown trout (*Salmo trutta*), and European eel (*Anguilla anguilla*) were identified within the catchment area during surveys. Arctic charr (*Salvelinus alpinus*) occur in all the main lochs and Lamprey sp. (*Lampetra ?planeri*) have recently been found in Loch Dughaill. Some14 habitats and species that are listed by the EU Habitats and Species directive as 'threatened' are recorded within the Carron catchment, including the Freshwater pearl mussel, Atlantic salmon, and Lamprey. These and other species will benefit directly from actions to conserve and restore freshwater habitats.

- **Salmon and sea trout status:** Catches of salmon and sea trout appear to have fluctuated through the 20th century, rising to their highest levels between1960 and 1990 according to the records of two estates. These records also show that until the 1960s sea trout tended to be dominant. Thereafter, relative numbers of salmon were higher until the 1990s. From the mid-1990s, total catches of both species for the system fell from more than 100 salmon and up to 100 sea trout per year to their lowest levels. This decline tallies with that of other rivers in Wester Ross and appears to be related to the development of the salmon-farming industry within the area. Sea trout may have been particularly vulnerable to sea lice infection and wild salmon to genetic introgression as a result of hybridisation with escaped farm fish. However, during the period 2001–2003 catches of sea trout and salmon rose remarkably. This followed improvements in sea lice management on nearby salmon farms and a stock restoration programme developed by Seafield College, local fish farms and river proprietors.

- **Sea trout and salmon life history:** The report by Nall and Macfarlane (1938)* provides detailed information about respective stocks of the Carron following netting surveys in 1936 and 1937. Most Carron salmon went to sea after two years in freshwater and returned to spawn after two winters at sea. Most sea trout went to sea initially after 3 or 4 years in freshwater. Further scale reading is required to confirm the current situation. In more recent years, most salmon and sea trout were caught from June to September (inclusive). Although fish have been taken in April and May in the past 20 years, there is insufficient information to be able to say whether or not the Carron still supports a discrete population of early running fish.

- **Freshwater habitat:** In addition to Loch Sgamhain and Loch Dughaill, the area accessible to salmon and sea trout comprises 37.3ha of riverine habitat, of which 76% is within the mainstem River Carron. Although suitable spawning habitat is located throughout the accessible area, it is of variable quality: silted or weeded-over in some areas, unstable and vulnerable to 'redd washout' in others. Water quality remains generally 'good'. However, total phosphorus levels (measured by SEPA) have increased within the river over the past 20 years. Grazing by sheep and or deer restricts growth of riparian vegetation along the river banks. Problems

associated with bank erosion and channel instability (lack of fish cover, low invertebrate production) are most severe near Achnashellach and Blackwood. Although not yet a major problem for fisheries, the spread of *Rhododendron ponticum* between Glen Carron Lodge and Loch Dughaill has the potential to further limit the natural productivity of the river by restricting growth of native plants.

- **Production of juvenile salmon and trout:** Recorded densities of juvenile salmon were higher in 1986 than in any year subsequently. Densities of juvenile trout were higher in 1998, 2000 and 2002 than in earlier years. Combined densities of both juvenile trout and juvenile salmon were lower in 1995 and 1996 than in any year since. From electro-fishing surveys, it has not been possible to assess the extent to which fish stocked by Seafield College contributed to a wider distribution and higher densities of juvenile salmon and trout. The maximum salmon smolt output is estimated to be 16,507 (excluding an unknown number from lochs) based on a target egg deposition of 970,585 eggs. This translates to a Minimum Biologically Acceptable Spawning Limit spawning target of 259 adult salmon, and a Management Level of 300. Catch records suggest that salmon spawning targets were exceeded each year until 1994. However, from 1995–2002 numbers of returning salmon appear to have been very low, with a high proportion of farm salmon. It is therefore possible that there has been genetic introgression of the native salmon population with loss of whole life cycle fitness.

- **Fisheries 'Action' Plan:** To conserve and restore stocks of salmon, sea trout and other native fish species and their habitats, and to develop fisheries to their full potential, 13 recommendations are proposed. These are outlined in the table opposite.

References

*Nall, G. Herbert & Macfarlane, P.R.C. (1938) *Sea Trout of the River Carron and Loch Doule (Dhughall), Western Ross-Shire, with an Appendix on Salmon from the Same River.* Fishery Board for Scotland, Salmon Fisheries Report No. IV. HMSO, Edinburgh.

Summary of recommendations forming the River Carron Fishery Management Plan, 2004–2008

	Recommendation	Priority	Action	Costs/Grants
1	Reduce rates of sediment discharge into river and tributaries	high	Forestry Commission, estates.	£50–100,000 (fencing, revetment) Estates, SWG, SNH
2	Eradicate *Rhododendron ponticum* from catchment area.	high	Forestry Commission, estates, SNH, contractors	£1–300,000 to clear 20–50 ha. Forestry Commission, Estates, SWG, SNH, HLF
3	Restore riparian vegetation and flood plain habitat, esp. within Achnashellach forest.	high	Forestry Commission, estates, SNH, Trees for Life	Forestry Commission, Estates, HLF, SNH, volunteers
4	Review salmon and trout stocking programmes.	high	Seafield College, WRFT	UHI, WRFT
5	Monitor use of spawning areas by adult fish	medium	Seafield College, WRFT, estates, local anglers	UHI, WRFT
6	Recondition spawning gravels periodically where required	medium	Seafield College, estates, WRFT	Estates, UHI
7	Investigate impacts of fish farming in Loch Sgamhain and downstream areas	medium	Seafield College, WRFT, Landcatch	UHI, HIE (via AMG)
8	Investigate use of lochs by juvenile salmon and trout	medium	Seafield College, WRFT	UHI
9	Maintain catch and release policy for wild fish	high	Anglers	(none)
10	Maintain netting closures in Loch Carron	high	Estates	(none)
11	Maintain and develop AMA	high	AMG	HIE
12	Investigate lamprey population	medium	Seafield Centre, WRFT, SNH	SNH
13	Investigate minnow distribution and take action to control minnows where possible.	medium	WRFT, estates, Landcatch, Seafield Centre	UHI, SNH

Abbreviations:
WRF Wester Ross Fisheries Trust
UHI University of Highlands and Islands
HIE Highlands and Islands Enterprise (via NW Region AMA programme)
SNH Scottish Natural Heritage
SWG Scottish Woodland Grant scheme

Part 1
Introduction

1.1 Preface

The wild fisheries of Wester Ross and surrounding seas are an invaluable renewable resource. At a time of global climatic change, when the future composition of sea fisheries remains uncertain, healthy populations of wild salmon, trout and charr can provide some assurance that there can always be prolific fisheries. 'Salmonids' are amongst the most successful opportunists: able to colonise, recolonise and to proliferate as the environment changes. Rod fisheries can represent an important source of tourism revenue for the local economy, while both salmon and trout are often 'keystone' species in the ecology of freshwater habitats. In addition, the Atlantic salmon is listed in Annex II of the European Union Habitats and Species Directive, and has therefore been identified as a threatened species requiring conservation action. Faced with an array of pressures from human activities that impact upon aquatic environments, the potential economic and ecological value of wild salmon and trout populations can probably be reached and sustained only through well-informed fisheries management.

After 1985, in common with many West Coast rivers, there was a sharp decline – initially in sea trout and later in salmon catches. By 1995 the Carron was facing extinction. In that year the Seafield Centre, part of Inverness College, initiated a new programme for restocking the Carron. This required the creation of a captive broodstock of both salmon and sea trout, from which eggs, fry, parr and smolts could be produced for release into the river in sufficient numbers to secure a reasonable chance of success when natural spawning by wild stock had been so greatly reduced.

There is already some evidence that the Seafield programme has been a major contributor to the sharp increase in the number of migratory trout caught in the river during the last three years. Some of the recommendations of this report are intended to help guide that programme and to assess its contribution to the restoration of wild fisheries.

1.2 History and Current Restoration Programme

Since 1983 a key element in the development of the River Carron has been the value contributed by salmon farming to the local economy: aquaculture still accounts directly for about 20% of local employment. Throughout there has been a high level of co-operation between farmed and wild fish interests, and the fish-farming industry has supported and assisted restoration of wild fish in the river.

The River Carron was once famous for its sea trout fishing. In 1938, The Fisheries Board for Scotland published a report by Herbert Nall that compared Carron sea trout with those of the Laxford, Ewe and Ailort systems. Nall's study provides invaluable background information, and some indication of the remarkable potential productivity of the Carron fisheries. From about 1950 there was a change in the balance of catches as sea trout declined and salmon improved (see Part 3).

Progeny of sea trout of Carron and Coulin (River Ewe system) origin have been grown on as a captive broodstock in ponds at Glenmore *(Seafield College)*

1.3 Aims of the Fishery Management Plan

The Wester Ross Fisheries Trust (WRFT) is a charity formed in 1996 by river owners, angling clubs and salmon farmers. Its aim is to 'conserve, restore and develop sustainable salmon, sea trout and brown trout fisheries in Wester Ross'. This was to be achieved with a fisheries research programme, the objectives of which are to:

- **Conduct exploratory work to establish baseline information on the status and potential of stocks in the WRFT area.**
- **Monitor and identify trends in stocks and possible factors affecting them.**
- **Produce a Fisheries Management Plan for each river system in the WRFT area aimed at achieving the fishery's potential.**

This report presents the conclusions of the WRFT's work on the River Carron 1997–2002. This work has included juvenile surveys, habitat surveys, studies of acidification and redd washout, and an adult stock assessment. The estimated costs of this work are shown in Table 1.1.

Table 1.1 Estimated costs of producing the River Carron Fishery Management Plan

Juvenile surveys, 1997–2002	£2,500
Habitat survey, 1998, 2003	£2,000
Redd washout project, 2000–2001	£400
Catch records analysis	£1,000
Plan preparation and production	£4,000*
Total	*£9,900*

*(includes in-kind contributions)

Based on these findings a Fishery Management Plan has been developed, with a proposed time scale of five years. The actions suggested are aimed at attaining the natural production of juvenile salmon and trout from the freshwater habitat, and if successful other species listed by the Habitats and Species Directive will also benefit. Since the freshwater environment is largely controlled by the land owners concerned, the plan is designed primarily for them. If required, the WRFT can assist with the implementation of the Plan and review its progress in 2007, when new targets and recommendations can be put forward.

To obtain the best quality of information, much of the work contained in the Plan has been carried out with the guidance of the Scottish Executive agencies, including the Fisheries Research Services (FRS), Scottish Natural Heritage (SNH), and the Scottish Environment Protection Agency (SEPA). The WRFT acknowledges financial assistance provided by and the Highland Council's Landfill Tax Credit Scheme for the production of this Plan.

1.4 The Scottish Fisheries Coordination Centre

The WRFT is one of 15 similar fisheries research and management organisations established throughout Scotland. To ensure that highest quality of fisheries data collected, and the comparability of that data, a Scottish Fisheries Coordination Centre (SFCC) was set up in 1997. The SFCC has developed standard procedures for the surveying of juvenile salmon and trout and their freshwater habitat, and is developing a computer-based Geographic Information System (GIS) to map this and other fisheries information. Habitat surveys and electro-fishing surveys for this plan were carried out according to SFCC's standardised protocols, and detailed field survey records are kept on file in the WRFT office. ❑

Part 2
Salmon and Trout Ecology

by James Butler

2.1 Introduction

Fisheries are usually based on catches of adult salmon and trout. However, adult fish represent only one stage of each species' life cycle. The effective management of fisheries requires an understanding of the entire life cycle of the fish concerned. This section summarises the ecology of west coast salmon and trout, and the factors affecting their abundance.

2.2 Atlantic salmon ecology

2.2.1 Life cycle

The life cycle of the Atlantic salmon is now well understood, and is summarised in Figure 2.1. The key stages are as follows:

- **Redd and eggs**: A 6lb hen salmon will lay approximately 4,800 eggs in several nests or 'redds', usually in November. Salmon spawn in runs and glides with a gravel or cobble bed. Up to 95% of eggs can hatch successfully.

- **Alevins:** Surviving eggs hatch into alevins in early spring, and they remain in the redd until their yolk sacks have been absorbed.

- **Fry:** Once the surviving alevins have begun feeding they are known as fry. These fish disperse from the spawning area and set up feeding territories. Salmon fry favour shallow, faster flowing areas of the river, and competition for space in a well-stocked river will be fierce, resulting in high mortality during their first summer.

- **Parr**: Once the fry have grown for a year they are known as parr. Being larger in size they require more cover to hide from predators than fry, and consequently parr favour faster flowing areas with boulders, cobbles and bankside cover. They feed on insects drifting on the current. Much of this food may fall into the water from bankside vegetation. Salmon parr will also inhabit lochs.

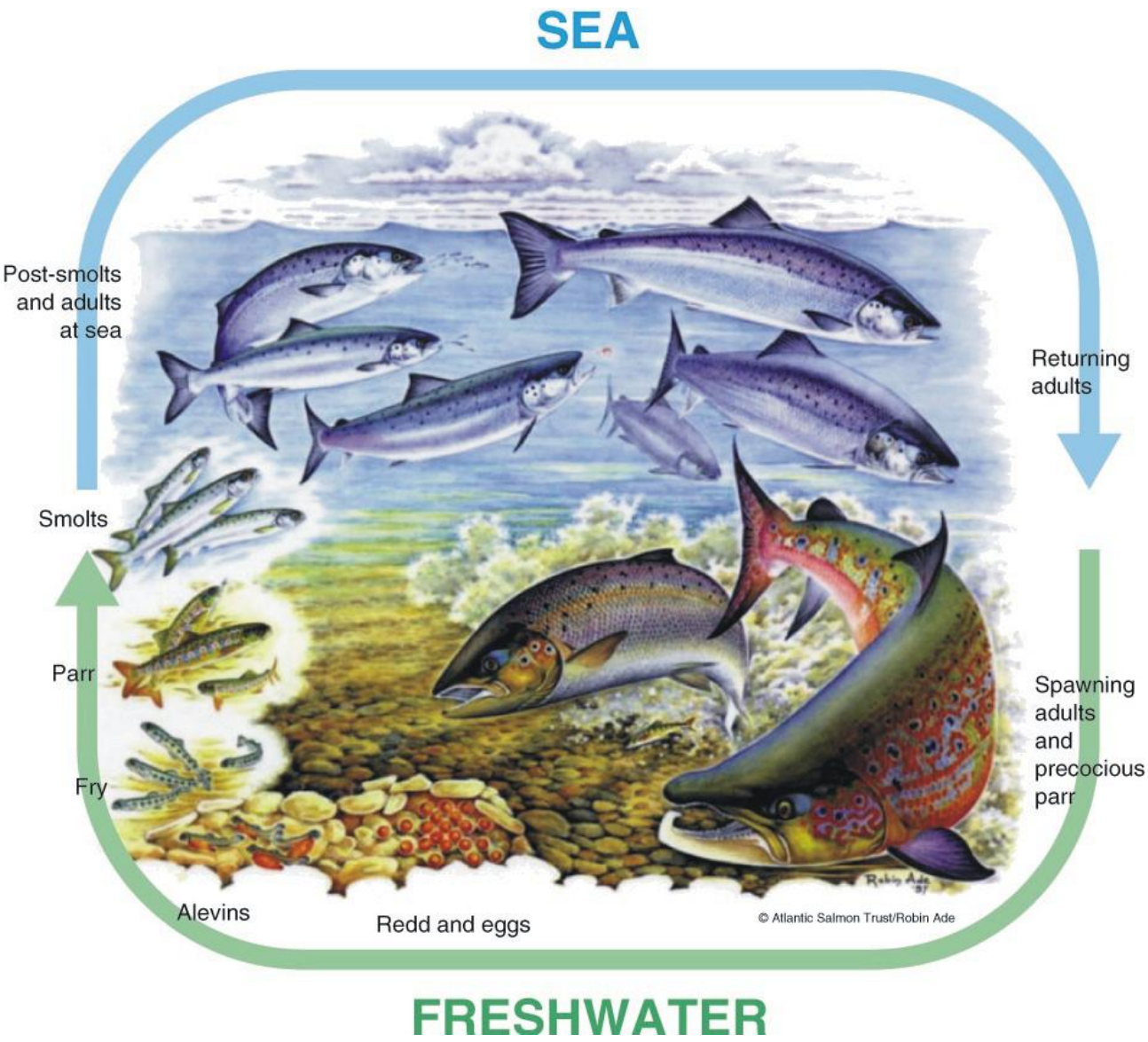
- **Smolts:** Having reached approximately 12cm in length the parr will begin to smolt, turning silver and migrating downstream to the sea during April and May. The further north the river, the shorter the growing season, and therefore the longer parr take to reach smolt size. In Wester Ross most juvenile salmon require three years to smolt, with a minority smolting after two or four years. Salmon smolts leave their estuaries quickly, with most heading into the open sea within two or three days.

- **Post-smolts and adults at sea:** Smolts migrate northwards feeding near the surface on crustaceans and juvenile sandeels, capelin and herring. During this stage they are known as post-smolts. Little is known of the specific feeding grounds of west coast salmon, but most British salmon feed off the Faroe Islands. Salmon that mature in their first year at sea are known as grilse, and these probably migrate no further before turning back to the Scottish coast. Fish that mature in their second or third year (Multi Sea Winter salmon) migrate further north to feed off Greenland and in the Norwegian Sea.

- **Returning adults:** As salmon mature they return southwards towards the Scottish coast, using the Earth's electromagnetic field to navigate. On reaching the coast they locate their natal rivers by smell, and will usually run into the river during high flows after rain. Once in the river the fish darken and take shelter in deep pools or lochs. They stop feeding and rely on their fat reserves for survival and further sexual development.

- **Spawning adults and precocious parr:** As autumn approaches the adult salmon home in on the area or tributary of the river where they were born. The hen selects a suitable place for spawning and digs a series of redds, in which she lays her eggs. These are simultaneously fertilised by the cock salmon, and often mature 'precocious' parr as well. The hen then covers the eggs with a mound of gravel. Having spawned, salmon are known as 'kelts', and these gradually turn silver and drop back into the sea over the winter. A few survive to return and spawn a year later.

Figure 2.1 The life cycle of the Atlantic salmon



2.2.2 Freshwater problems

Factors limiting the abundance of salmon in the freshwater phase of their life cycle are:

- **Redd washout:** During severe winter spates in which the river bed moves, redds can be washed away. Newly-hatched alevins are most vulnerable.
- **Acidification:** Acidification caused by atmospheric pollution can kill salmon eggs and alevins, and if particularly severe will also kill fry. Parr are more resistant to acid events. Coniferous forestry can exacerbate acidity.
- **Pollution:** Contamination of rivers by industrial and agricultural waste (e.g. sheep dip) can kill fish of all sizes.
- **Siltation:** The accumulation of silt in a stream can choke gravel beds, reducing the flow of oxygen to eggs and killing them. Siltation usually stems from run-off during the harvesting of forestry, or severe erosion of agricultural land.
- **Disease and parasites:** Although wild salmon carry many diseases their symptoms are not usually seen until the fish are stressed, for example by high water temperatures. Infectious Salmon Anaemia has become a recent problem in salmon farms, but it probably does not affect wild fish, although they can carry the virus. Of greater concern is the parasite *Gyrodactylus salaris*, which has spread to many parts of Europe from Sweden. Although Swedish salmon are adapted to survive the parasite, foreign salmon stocks are not, resulting in very high mortalities of fry and parr. So far *Gyrodactylus* has not reached the UK.

- **Predation:** Fry, parr and smolts are eaten by a wide range of piscivorous birds in freshwater. The most prevalent predators are mergansers, goosanders and cormorants. Feral mink can also be serious predators of juvenile salmon, but only rarely occur in Wester Ross. Humans and otters are the main predators of adult salmon in freshwater.

2.2.3 Marine problems

- **Feeding:** Fish traps run by the WRFT at Tournaig (Loch Ewe), and the FRS Shieldaig Sea Trout Project (Loch Torridon) indicate that as few as 3% of west coast salmon smolts survive to return to their natal rivers. In the 1960s and 1970s marine survival was as high as 30%. The main cause of this decline is thought to have been climate change in the North Atlantic, which is restricting the availability of food for post-smolts. As a consequence, more smolts die, and the surviving post-smolts and adults grow to smaller sizes than in the past. Furthermore, because Multi Sea Winter salmon remain longer in the sea, they are even less likely to survive and have become more scarce than grilse.

- **Commercial netting:** High seas netting has been vastly reduced in recent years owing to buy-outs by the North Atlantic Salmon Fund (NASF), and quota management by the North Atlantic Salmon Conservation Organisation (NASCO). Drift nets off the west coast of Ireland and Northumberland are of concern to Scottish east coast rivers, but do not directly affect west coast salmon. The greatest netting threats to Scottish west coast salmon were coastal bag and sweep nets, but with the recent local declines in stocks coastal netting stations have become unviable and none are likely to be operated in 2004.

- **Industrial fisheries:** Recent research has shown that salmon post-smolts feed near mackerel and herring shoals, and are accidentally taken as a by-catch by industrial trawlers. The full extent of this problem is not yet known, but research is underway in the North Atlantic to learn more about this problem.

- **Seal predation:** In the 1990s, the Scottish grey seal population was estimated to be growing by 8% per annum, and there were fears that predation on returning adult salmon may have been increasing. However, the extent of seal predation has never been quantified. St Andrew's University Gatty marine Laboratory are developing seal scaring devises which may be of use in estuarine situations for protecting wild salmon and sea trout.

- **Sea lice infestations:** Sea lice epizootics are believed to be primarily a problem for wild sea trout which tend to remain in coastal areas. However, recent studies of salmon post-smolts in Norway have shown that fish leaving fjords with salmon farms have been infected with lethal levels of sea lice, most likely produced by salmon farms in the area.

The grey seal population is growing at 8% per annum *(Inverness News)*

- **Escaped farm salmon:** This problem may occur in either fresh or saltwater, since juvenile salmon are produced in hatcheries and cages in freshwater, and in cages at sea. Escaped salmon will breed with wild salmon, and if this occurs consistently over a number of years, Canadian and Irish research has shown that the wild stock will suffer a cumulative loss of genetic fitness. The level of genetic dilution will be minimal if the wild population is healthy, but the effect is disastrous if the wild stock is depleted. A hybrid population will be more vulnerable

The WRFT Tournaig trap (top) and FRS Shieldaig Sea Trout Project trap (bottom) *(James Butler)*

to marine mortality and any sudden changes in the freshwater environment, leading to possible extinction. See also Box 4.1.

Scottish Executive rod catch records for the north-west statistical region indicate that since 1952 catches have varied widely between years, but have generally increased gradually. However, in the mid-1990s stocks fell suddenly to record low levels, and this has coincided with the rapid expansion of the salmon farming industry on the west coast. However, it is likely that this regional problem has been caused by the combined effects of many of the factors listed above.

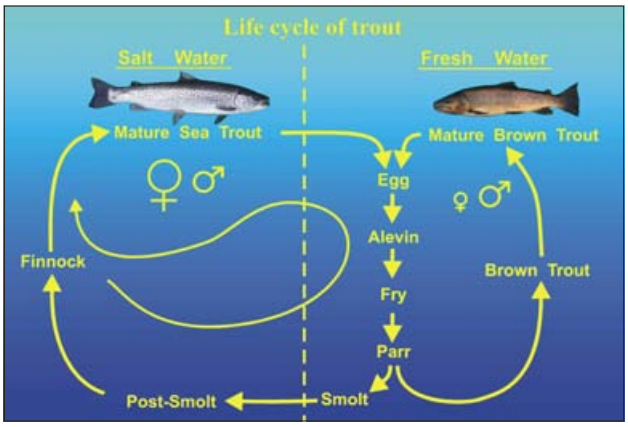


Figure 2.2 The life cycle of Scottish west coast sea trout (*© FRS Freshwater Laboratory)*

2.3 Sea trout and brown trout ecology

2.3.1 Life cycle

The ecology of sea trout and brown trout is less well understood than that of the salmon. The brown trout is very adaptable, and can take many forms. Of principle interest to west coast fisheries is the sea trout, and its relationship with brown trout.

As for salmon, the juvenile stages of the trout's life cycle are confined to freshwater (Figure 2.2). However, there are a few minor differences. First, trout eggs are smaller and their redds are shallower than those of salmon because adult trout are generally smaller than adult salmon. Second, trout begin spawning a few weeks earlier than salmon.

On reaching smolt size young trout can either become sea trout or remain in freshwater as brown trout. In general, most females become sea trout, and most males remain as brown trout (Figure 2.2). Sea trout smolts leave the rivers at the same time as salmon smolts, in April and May. Unlike salmon smolts, however, they remain in the sea lochs for their first summer. At this stage they are termed post-smolts, and by late summer are known as finnock. Some finnock re-enter their river in late summer, although it is not understood why, since the majority are immature. Other finnock remain in the sea lochs for one or two years until they mature and return to their native river to spawn.

Mature sea trout run into their native rivers in the summer and autumn. Female sea trout then pair with male brown trout in October and November and spawn. Sea trout kelts return to the sea, and may run their river annually to spawn up to 12 times, growing to sizes of more than 10lb in weight. As a consequence, most of the trout eggs produced in a healthy sea trout river are laid by larger female sea trout.

Research on brown trout has shown that there may be several races of trout in a river or loch system, of which sea trout may be only one. Other forms of trout include 'slob' trout, which are resident in estuaries and also feed on marine organisms, but do not migrate any further than their natal river mouth. 'Ferox' trout are long-lived brown trout that grow large enough to become successful predators of other fish, and Arctic charr in particular.

2.3.2 Freshwater problems

Many of the problems that affect salmon in freshwater also affect trout. However, there are some minor differences:

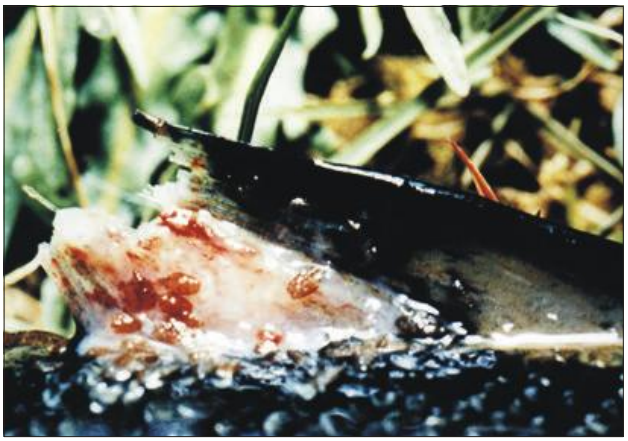
- **Redd washout:** Being smaller fish, trout lay their eggs in shallower redds, and therefore may be more prone to washout.
- **Acidification**: Trout are less sensitive to acidity than salmon.
- **Nutrient enrichment**: Sea trout are thought to have evolved as a result of lack of food, causing females to migrate downstream to the sea, and over time this behaviour has become genetically imprinted. However, if more food becomes available to trout in freshwater, either as a result of a lack of competitors or nutrient enrichment, the fish will lose the physical trigger to migrate to sea. Consequently severe declines in trout numbers may reduce competition for food and encourage sea trout to stay in freshwater as brown trout. To some extent, this may have occurred in Loch Sgamhain. The enriching effect of effluent from freshwater fish cages or agricultural fertiliser can have the same result.

Sea trout (top) may remain in freshwater as brown trout (bottom) if their food supply improves *(James Butler)*

2.3.3 Marine problems

Although sea trout are affected by the same marine problems as salmon, their coastal habits leave them more vulnerable to local influences:

- **Sea lice infestations:** Catch statistics show that sea trout stocks in the north west have been declining slowly since 1952, but the decline accelerated with the rapid growth of the salmon farming industry. It is highly likely that sea lice emanating from salmon farms have been the major cause of the recent collapse, as lethal levels of sea lice have been found on sea trout post-smolts in salmon farming areas, but not in areas without salmon farming. WRFT lice monitoring also shows that in fallow years lice infestations on sea trout fall, and then increase in years when production restarts in the sea loch. However, with use of the new in-feed medicine *SLICE*, on-farm lice management has significantly improved since 2001, and there are signs from some sea lochs of improved health and survival of sea trout in both years of fish farm production cycles.



Sea lice damage to the dorsal fin of a sea trout post-smolt (*S Northcott)*

- **Coastal feeding:** The long-term decline of sea trout prior to salmon farming clearly suggests that another factor has been involved. Although numbers of sea trout were dropping, their average size remained consistent until 1988. One possible explanation for the long-term decline prior to the establishment of salmon farming is the decline in stocks of sea fish. Herring and sprats spawn in west coast sea lochs, and their young form an important component of the sea trout diet. Herring stocks were severely over-fished in the post-war years, and collapsed in the 1970s. The abandonment of the three-mile limit may also have allowed over-fishing of other coastal white fish by industrial vessels, exacerbating the problem.

2.4 Competition between juvenile salmon and trout

Juvenile salmon and trout living in the same rivers tend to live in separate types of habitat, reducing the competition for space. Salmon are better adapted to faster, shallower water, while trout favour deeper, slower-flowing water, and consequently prefer to live in lochs. While salmon favour well-lit areas, trout prefer shade and cover provided by bankside vegetation. However, if the trout's preferred habitat is over-populated they may aggressively colonise the more open areas, out-competing the salmon. In the context of the Carron, this is further considered in Part 4. ❑

Sea trout feed on juvenile sea fish in west coast sea lochs (*James Butler)*

Part 3
The River Carron Catchment

3.1 Location, inshore fisheries, salmon netting and aquaculture

3.1.1 Loch Carron

The River Carron is the main river system entering Loch Carron, a narrow fiordic sea loch of up to 2km wide and approximately 10km long. The loch narrows to only about 500m near Strome, separating the upper loch from the outer loch. The loch has a rich diversity of marine habitats and species, many of which are highlighted in the Wester Ross Local Biodiversity Action Plan.

3.1.2 Inshore fisheries

Loch Carron is a nursery area for sprats, herring, cod, whiting, haddock and saithe. These fish are important prey items for sea trout. However, stocks of these fish have fluctuated around the west of Scotland, in recent years falling to their lowest levels. In summer, mackerel also move into inshore waters to feed on sprats, sandeels and juvenile herring.

Prawns (*Nephrops norvegicus*) are taken both by creel fishermen and by trawlers from inshore waters around Wester Ross. In Loch Carron, suction gear and boats larger than 12m are banned throughout the year, and from 1 October to 31 March there is a ban on all mobile gear. Lobsters have declined within the inner loch over many years. A few lobsters are still taken by creel fishermen further out. Mussels, Horse mussels and winkles are collected by hand at low tide, primarily for local consumption.

- **During the 1970s, trawl surveys were carried out by the Scottish Marine Laboratory (now Fisheries Research Services, FRS) to investigate the local abundance of juvenile herring and sprats. Annual surveys of juvenile fishes are important to establish population trends in coastal areas.**

- **The potential for restoration of productive inshore fish and shellfish fisheries may be considerable. Effective integrated coastal zone management measures (possibly including Marine Conservation Zones) are needed to restore yields of many species within Loch Carron and the surrounding inshore waters. The restoration of healthy coastal fisheries will also ensure an abundance of many of the varied prey items upon which salmon and sea trout feed.**

3.1.3 Neighbouring salmon rivers

In the early 1990s, salmon were recorded in the River Attadale and the Abhainn Bhuachaig. However, no juvenile salmon were found during an electro-fishing survey of the Attadale in 1997. In the Kishorn (16km from the Carron), salmon and stock enhancement programmes are being developed.

- **The genetic variability of wild salmon and trout populations in the west of Scotland is currently being investigated by FRS. These studies aim to identify integral 'populations' and their origins. The occurrence of non-native genes (e.g. from stocked fish or escaped farm salmon) within wild populations may also be recorded.**

3.1.4 Salmon netting around Loch Carron

During the 1970s a net and cobble fishery operated in upper Loch Carron. Catch records have not been seen.

3.1.5 Intensive aquaculture

Ever since the closure of the Oil Rig Construction yard at Kishorn in 1983, the Lochcarron economy has depended heavily on aquaculture and even now it is understood to provide directly for about 20% of local employment. Wild fish management has, therefore, given priority to co-existence and co-operation with farm fish interests, which has been facilitated by all farm facilities on the River Carron being owned by a single company.

Marine

The closest active marine salmon-farming site, operated by Lighthouse of Scotland Ltd, (formerly Highland Fish farmers) is located in Loch Carron approximately 8km from the mouth of the River Carron. Scottish Sea Farms (formerly Hydro Seafoods) have sea cage sites in Loch Kishorn approximately 16km from the mouth of the River Carron, with combined biomass consents totalling over 3000 tonnes.

Freshwater

Lighthouse also operate smolt production cages in Loch Sgamhain. Highland Fish Farmers installed these cages in the early 1980s. Lighthouse also have a hatchery at Tullich (water from Abhainn Bhuachaig). Consented biomasses for the fish farm sites in the area are shown in Table 3.1.

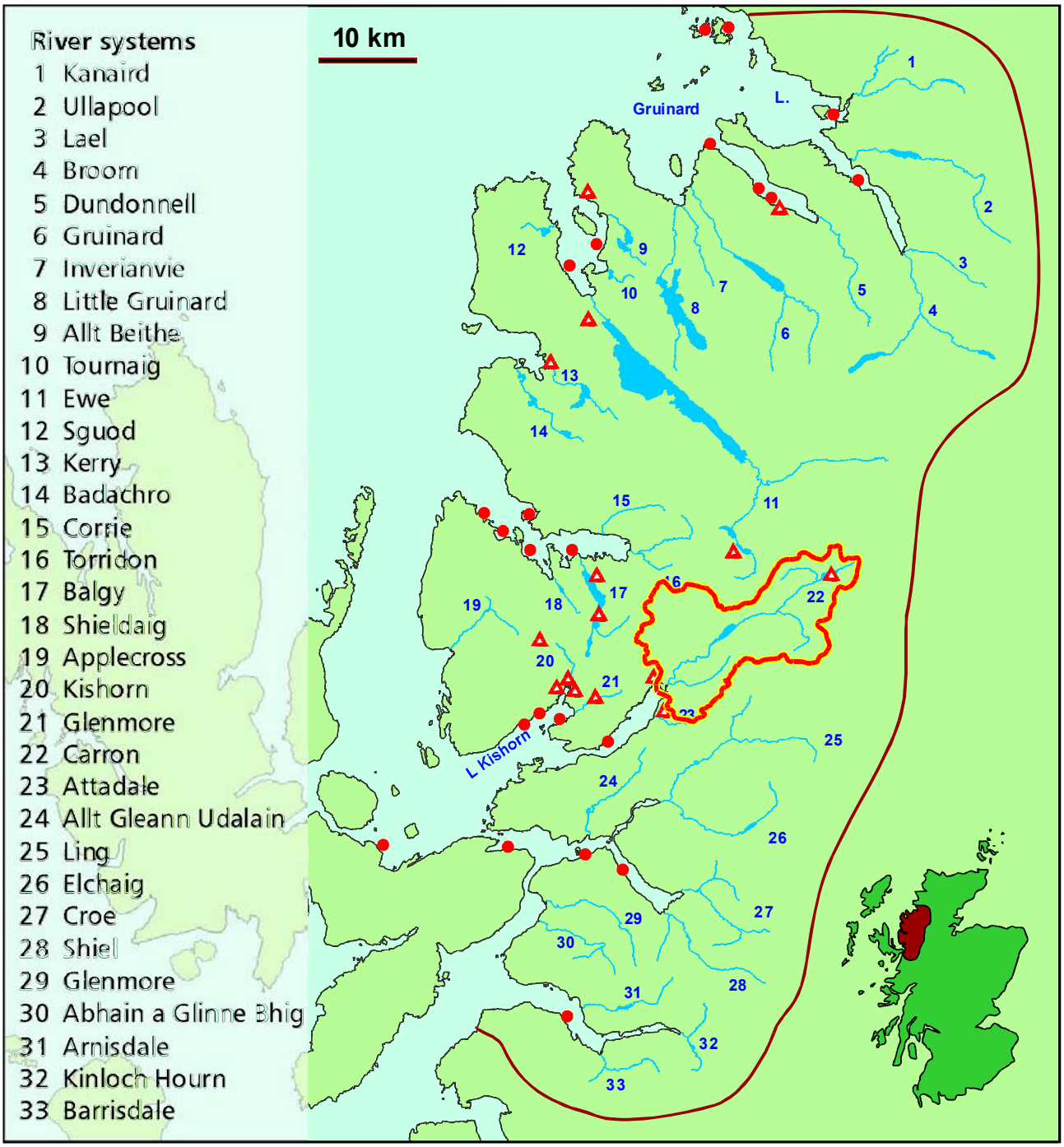


Figure 3.1 The River Carron catchment relative to the WRFT area, and marine (●) and freshwater (△) salmon farm sites, and salmon netting stations (□)

3.1.6 Area Management Agreement

The Tripartite Working Group (TWG) was convened in June 1999 by the Scottish Executive in response to concerns that wild fish stocks were being affected by sea lice associated with cage fish farming. The aims of the TWG are to promote healthy and sustainable wild fisheries and farmed salmon stocks in the west of Scotland. To do this, the TWG fosters local voluntary Area Management Agreements (AMAs) between the salmon-farming companies and wild fisheries interests.

The Loch Carron / Kishorn AMA was signed in April 2001 and gave structure to the informal co-operation that had prevailed for several years previously. The AMA broke new ground in that it included the local freshwater farmed fish interests as well as the marine farms and wild fisheries interests. The signatories were: Highland Fish Farmers (now Lighthouse of Scotland, Ltd), Hydro Seafoods GSP (now Scottish Sea farms), Corrie Mhor Salmon, River Carron Proprietors, River Kishorn Proprietors, Seafield College and WRFT.

Table 3.1 Consented biomasses for fish farms in the Loch Carron / River Carron Area (as of October 2003)

Company	Farm location	Species	Consented biomass
Lighthouse	Loch Sgamhain	salmon	14 tonnes
Lighthouse	Loch Carron, Mid Strome	salmon	1375 tonnes
Scottish Sea Farms	Loch Kishorn, South Shore 1	salmon	1299 tonnes
Scottish Sea Farms	Loch Kishorn, South Shore 2	salmon	1299 tonnes
Scottish Sea Farms	Loch Kishorn, North Shore	salmon	1500 tonnes

The group has since met three times each year and a constructive dialogue has been built up between the partners, with information flowing in both directions. With improved sea lice management in the area and a large-scale stocking programme (see Parts 5 and 6) there are already encouraging signs of recoveries in wild salmon and sea trout populations in the area.

3.1.7 Estuary

The River Carron flows for 2km from the upper tidal limit to its Low Spring Tide point of entry into the sea. At low tide, an intertidal expanse of saltmarsh, sands and mudflats of 4km^2 is exposed. This area supports a large population of worms, bivalves and other invertebrates, and provides rich feeding for many fish and birds.

Fish-eating birds include gulls, divers, Cormorant, Shag, Goosander, Red-breasted Merganser and Heron. Common and Grey seals inhabit inshore waters, and otters live around the coasts and along the rivers.

Although salmon and sea trout can form a significant part of the diet of these animals in local situations, other predators and pests of salmon are also taken (e.g. eels, sea lampreys, pollack). Predation may be a problem when stocks are already severely depleted for other reasons, or where the health of salmon and sea trout smolts is compromised (e.g. because of sea lice infestations).

- **Long-term monitoring of predator occurrence (vs. time) within Loch Carron may help to establish any changes that may impact upon levels of predation of juvenile and adult salmon and trout.**

3.2 Characteristics of the catchment

3.2.1 The Carron catchment

The River Carron has a catchment area of 137.8 km^2 (Figures 3.2 and 3.3). The catchment includes

River Carron estuary comprises a broad expanse of inter-tidal mudflats and saltmarsh *(Peter Cunningham)*

mountainous terrain, with peaks of up to 1053m (Sgurr a' Chaorachain). The main river flows in a southwesterly direction, gathering water from tributaries including the Allt Coire Crubaidh, Allt a' Chonais, River Lair and Fionn Abhainn. There are two main lochs within the main valley: Loch Sgamhain and Loch Dughaill (Figure 3. 2). Loch Sgamhain is between 20 and 30m in maximum depth; Loch Dughaill is between 50 and 60m deep.

3.2.2 Geology

The Carron catchment area is bisected by the Moine thrust zone running northeast–southwest through the hills to the north of the main valley. The mountainous terrain to the north of this line has been glacially carved from Lewisian gneisses, Cambrian quartzites and the more calcareous 'Serpulite Grit and Fucoid Beds'. South of this line, the rocks comprise a complex assortment of hard, generally base-poor metamorphic rocks: predominately granulite, schists and gneisses of the Moine Series. The landscape and 'lochscape' reflect their glacial origin. Within the catchment area are spectacular examples of glacial features including corrie lochs (e.g. Loch Coire lair). Soils are generally nutrient-poor. Peat deposits extend over large parts of the catchment area (especially over ground at 250–550m altitudes).

The fluvio-glacial alluvium of parts of the Strath Carron flood plain provides the only relatively fertile agricultural land within the catchment area.

Movements of large amounts of coarse sediment (boulders, cobbles and pebbles) have occurred in recent years, particularly within Strath Carron. Much sediment has been deposited within the main valley around Lair –Achnashellach, causing the channel to become braided in places. Much of this sediment appears to have originated from burns flowing into the valley through the Achnashellach forest. Gravel extraction works during the past 20 years may have also de-stabilised the streambed.

Below Arineckaig the river has been unstable for many years. The most recent washout, in 1989, greatly altered the river bed, removed 150 metres of 15 metre high bank and deposited silt to fill or affect most pools downstream for several miles. Bank collapse continues, with further erosion and deposition of sediment into the river. Over the past 20 years, there has been a trend towards more intense winter spates owing to the heavier rainfall associated with global climatic change. This all adds up to a more hostile environment for salmon and sea trout recruitment, with a higher risk of destruction of salmon redds and emerging fry associated with excessive stream bed movement (see Part 5).

The Carron estuary enters the sea loch through a series of tidal pools, where returning sea trout and salmon may linger during periods of low water *(Peter Cunningham)*

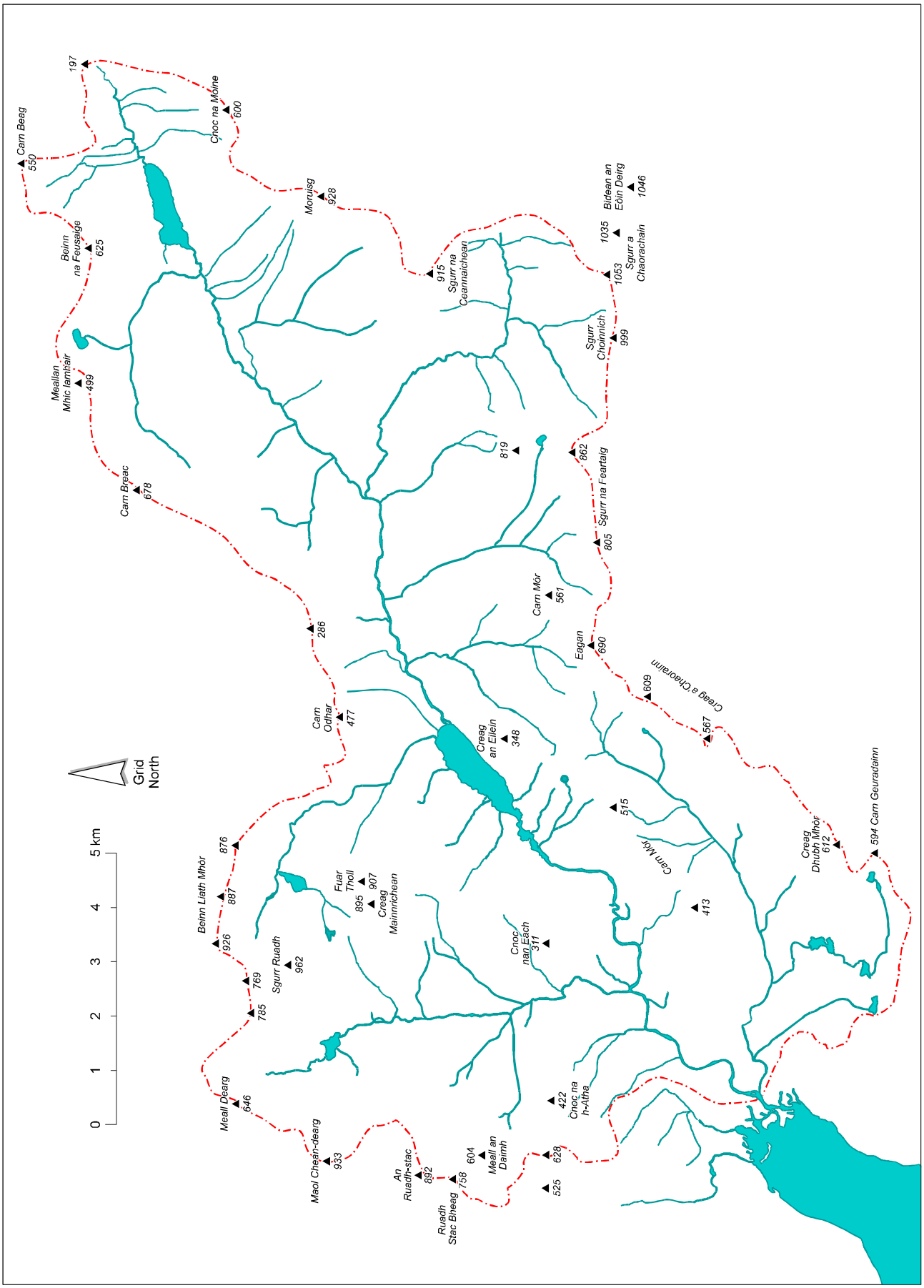


Figure 3.2 The Carron catchment, showing primary watercourses and peaks *(Crown Copyright)*

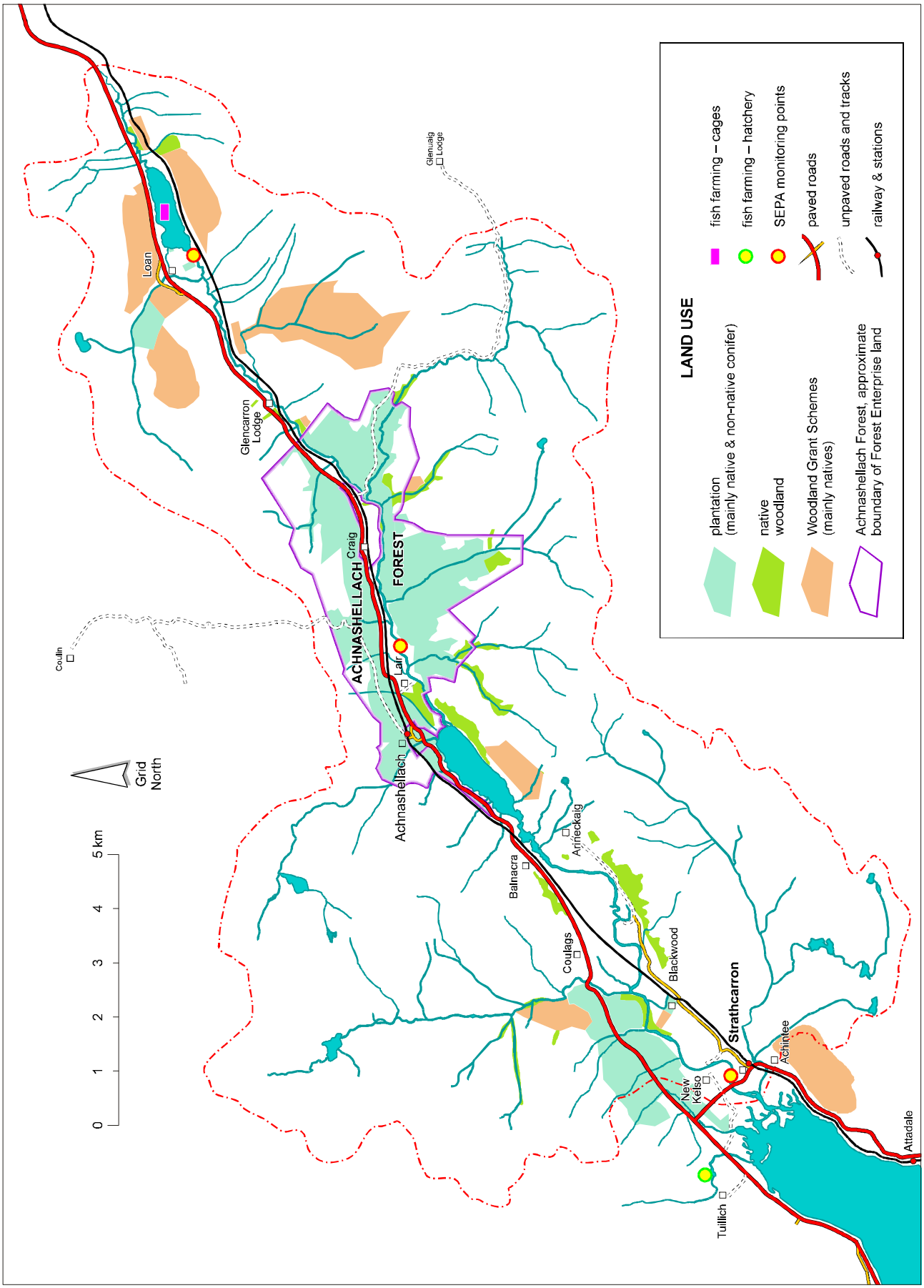


Figure 3.3 Land use in the River Carron catchment including locations of fish farms, SEPA monitoring stations, Forest Enterprise land and Woodland Grant Schemes *(Crown Copyright)*

3.2.3 Climate and rainfall

Wester Ross has a moist maritime climate. Weather patterns are dominated by a westerly, Atlantic air stream. Meteorological records from the National Trust for Scotland's Inverewe Garden at Poolewe show a 20-year average annual maximum temperature of 12.1°C, and average rainfall of 1,734 mm (maximum 2,315 mm; minimum 1,430 mm).

3.2.4 Vegetation

The predominant vegetation type is heather moor (mainly 250–500m altitude), followed by 'other mosaics': mainly of grasses, sedges, mosses and lichens on ground above 500m.

Achnashellach ('field of the willows') Forest is the largest area of commercial forestry within the catchment, and is owned and managed by Forest Enterprise. The forest comprises plantations of exotic conifers on both sides of the main valley. On the south side trees were planted under 'Ancient' stands of mature native Scots pine. At present, commercial production of timber from much of the area is not economically viable, primarily because of the high costs of harvesting. Plans for the future are for the restoration of native woodlands in an area comprising the Carron flood plain from Achnashellach to Craig and the slopes to the south of the main river.

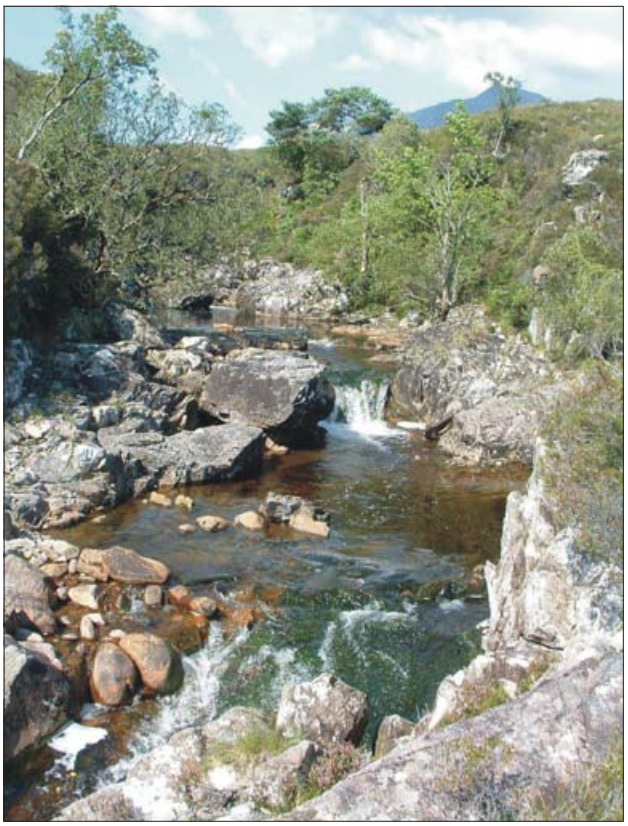
Other areas of conifer plantation within the catchment area are located in the valley of Allt Coire Crubaidh, and in Strathcarron from the banks of the Fionn abhainn to the A960 road north of New Kelso.

There are 'Ancient' native deciduous woodlands on the south side of the valley between Loch Dughaill and Strathcarron. To restore native woodland, several areas have been fenced and planted with native trees under the Woodland Grant Scheme (WGS). Towards the top of the system two blocks were planted from 2001: on the south side of the Allt Coire Crubaidh. A further block was planted above Loch Sgamhain.

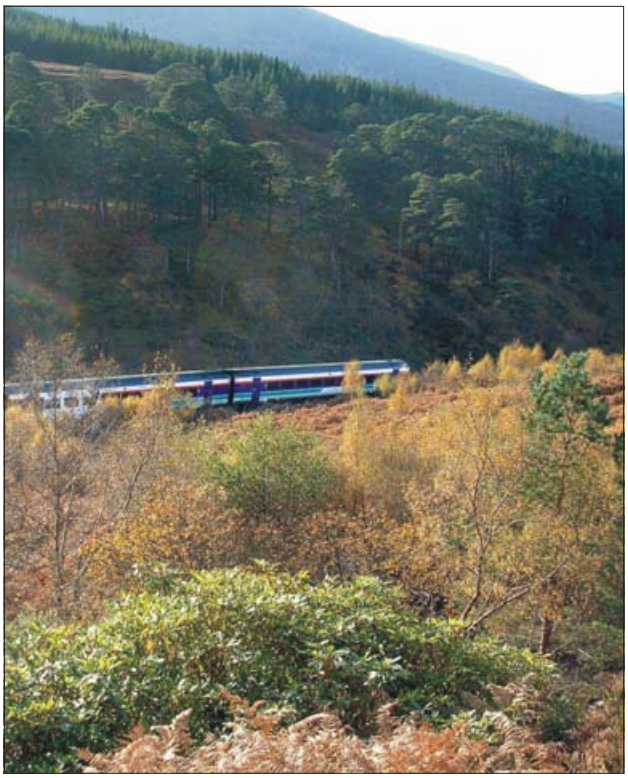
There are also WGS plantings in the valleys of Allt Gharagain (Glencarron), south of Loch Dughaill, and east of the Fionn abhainn near Coulags.

The river embankments and back channels of the River Carron support mature riparian woodlands primarily of alder, Scots pine, birch, willows, oak, ash, rowan, hawthorn and exotic conifers.

Enclosed improved grasslands and arable land are confined to New Kelso farm, a few fields around Lair and to the south of the River Carron between Loch Dughaill and the sea.



Native trees grow along the sides of gorges where sheep and deer are unable to eat them as here along the Fionn abhainn *(Peter Cunningham)*



Vegetation in Glen Carron: top to bottom: exotic conifer plantation (Achnashellech Forest), ancient Caledonian pine woodland; native broadleaves; exotic *R. ponticum* which are spreading along the road, the railway and the river valley *(Peter Cunningham)*

Rhododendron ponticum and other exotic plant species are spreading along the valley between Loch Dughaill and Glencarron lodge (see Part 5).

River shingles near Achnashellach, looking west towards Fuar Tholl (907m). The river is braided and highly unstable in this area *(Peter Cunningham)*

3.2.5 Hydrology

The River Carron is a typical west-coast spate stream that rises and falls rapidly according to rainfall. This is illustrated in Figure 3.4, which shows the discharge of the Carron in 2000, as measured at the SEPA gauging station at New Kelso on the Lower Carron.

Note that summer spates tend to last for 4 or 5 days, with discharge soon returning to levels below 10 m^3/sec (unless rainfall is sustained). Peak flows were recorded between October and March, and lowest flows in the summer. During the late spring - summer period, there were spates in excess of 10 m^3/sec in June, but none in May and August. Although the discharge at which salmon enter the river is unknown, their timing of entry is likely to relate closely to water levels and vary from year to year accordingly.

3.3 Human activities and impacts within the Carron catchment

3.3.1. Human population

Human settlement is largely restricted to the valley of the River Carron. The principle settlements are Glencarron, Craig, Lair, Achnashallach, Balnacra and Coulags linked by the A890 on the north side of the valley, and New Kelso and Strathcarron on the A890. The population increases from in the order of 100 residents during the summer months with tourists passing through or staying within the area.

3.3.2 Land use

The principal land uses are crofting, sheep farming, forestry and wild deer management.

Sporting estates

Deer stalking takes place from August and February inclusive. Red deer are found mainly on the open hill at densities high enough to prevent the regeneration of native trees and various other plant species. In winter, they move to lower ground seeking shelter and food. Above Loch Dughaill Roe deer and Sika deer occur primarily along the riparian corridor and other wooded areas at lower densities.

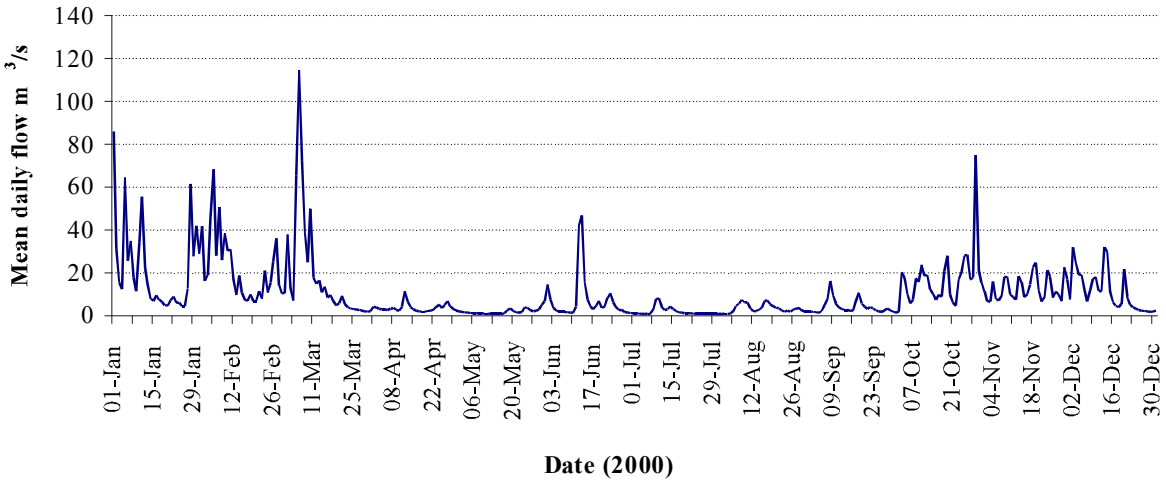


Figure 3.4 Discharge of River Carron at the SEPA gauging station, New Kelso in 2000

Agriculture

The main area of enclosed agricultural land is around the farm at New Kelso. Sheep graze within various parts of the catchment: Loch Sgamhain–Glencarron falls, Arineckaig–Strathcarron and the Fionn Abhainn valley.

Muir-burn

Small areas of heather moor are burnt periodically near Coulags, particularly in early April, with the aim of promoting new growth of vegetation for grazing animals. The long-term impacts of muir-burn upon soil fertility and the biological productivity in the wet west of Scotland are not fully understood. From the fisheries perspective, wind-blow insects from moorland areas can form a substantial part of the diet of trout and juvenile salmon at certain times of year. Insect diversity and abundance relates to soil fertility and vegetation.

Forestry and Woodland Grant Schemes

The largest forest area within the catchment is the Achnashellach Forest, which is owned by Forest Enterprise. This was developed as a commercial forest and planted with exotic conifers primarily during the 1930s and 40s. However, the section to the south of the A890 is no longer commercially viable. Forest Enterprise plan to restore native woodlands in this area. Elsewhere within the catchment, extensive areas of native woodlands are being restored via Woodland Grant Schemes, with the largest areas around Glencarron (see Figure 3.3).

3.3.3 Hydropower

At present there are no active hydropower stations within the catchment area. However, at the time of writing a scoping study is under way for a project at Achnashellach. Initial plans are for a 'run of the river' type scheme, with an intake from the upper River Lair at an altitude of approximately 365m, draining a catchment area of 6.78 km^2, and a pipeline running to a powerhouse, either on the north shore of Loch Dughaill, or discharging into the River Lair by the road bridge.

3.4 Water quality

3.4.1 Freshwater Fish Directive

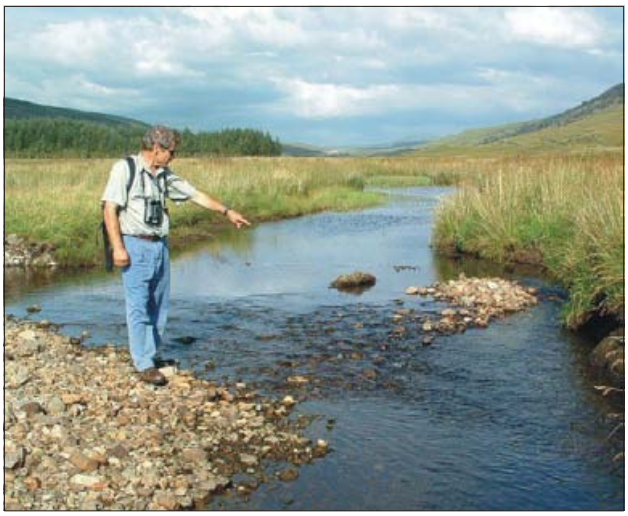
In 1976 the European Economic Community (now the European Union) introduced the Freshwater Fish Directive, which aimed to establish 'quality requirements for waters capable of supporting freshwater fish'. Rivers were divided into salmonid or cyprinid water, and water-quality standards were set for each using certain criteria (e.g. pH, temperature, pollutants). In Scotland, SEPA are responsible for monitoring water quality and for assessing whether rivers are attaining the standards set, and if not, they must identify and rectify the pollution problem. The River Carron was designated as salmonid water under the Directive in 1977.

3.4.2 Scottish River Classification Scheme

In 1996 SEPA established a further water-quality assessment, the Scottish River Classification Scheme. This takes into account invertebrate and water chemistry information to classify rivers from A to D, with rivers graded C and D requiring government action to improve water quality. Most of the River Carron was classified grade A1, indicating no major pollution problems. Below the confluence of the Fionn Abhainn (Coulags burn), the river is classified as A2.

3.4.3 Nutrient status

Water quality is routinely analysed by SEPA from two sampling stations, within the catchment: at the outflow of Loch Sgamhain near the top of the system and at New Kelso about 1km above the high water mark. There has been a gradual increase in the total phosphorus levels recorded in the River Carron from annual means of below 10mg/m^3 to above 12mg/m^3 during the past ten years (Figure 3.5). From the early 1990s this was evident at the Loch Sgamhain site; from 1999 total phosphorus concentrations in excess of 10mg/m^3 have also been regularly recorded in the lower part of the river. Because phosphorus tends to be the nutrient that limits biological production in west-coast rivers and lochs, this may be of some significance to the potential productivity of the river.



Meeting of the waters: confluence of Allt Coire Crubaidh with River Carron below Loch Sgamhain, 11 August 2003. Water from Loch Sgamhain was highly turbid owing to an algal bloom, contrasting with the clearer water from the tributary *(Peter Cunningham)*

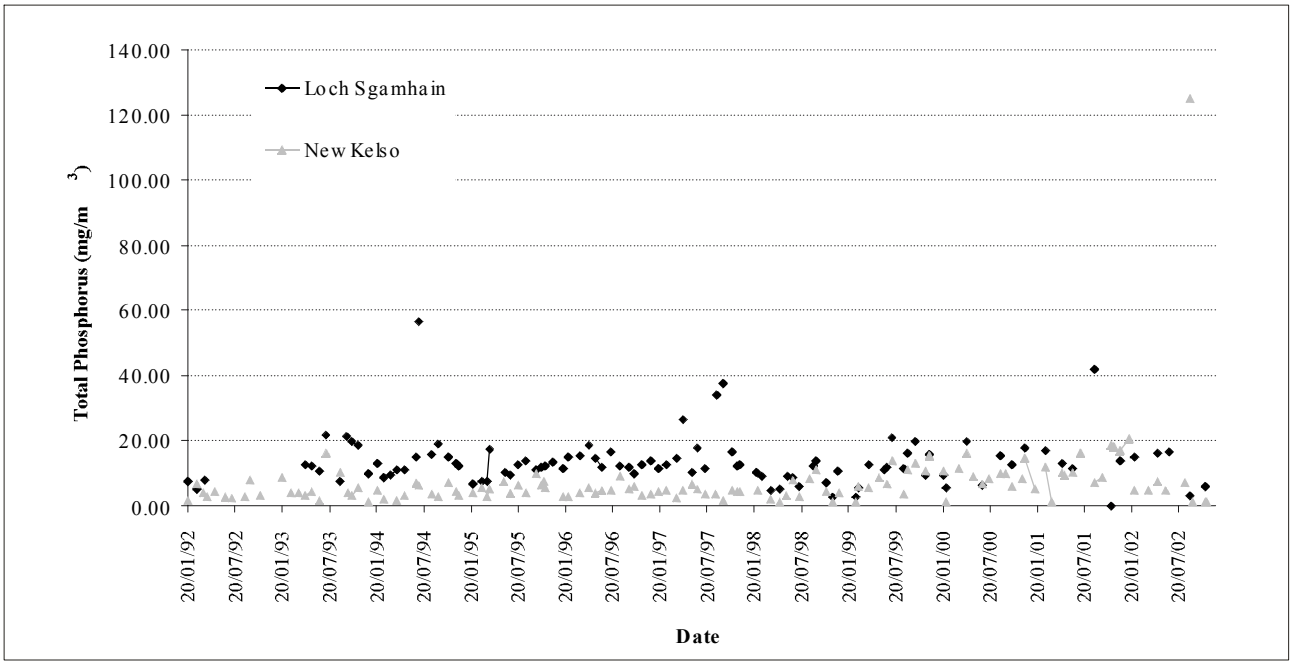


Figure 3.5 Total phosphorus concentrations in the River Carron as measured at the two SEPA monitoring stations, 1992–2002

3.4.4 Water Frameworks Directive

At the time of writing, discussions are ongoing regarding future monitoring under the EU Water Frameworks Directive. After 2005 routine monitoring by the Scottish Environment Protection Agency (SEPA) is likely to include distributions and densities of both aquatic plants and aquatic animals in river systems and coastal waters. The Carron catchment is likely to be included within a 'river basin management area' comprising the northwest of Scotland, extending to 3 nautical miles off shore. Up-to-date information can be found on the SEPA website (www.sepa.org.uk).

3.5 Important species and habitats in the Carron catchment

3.5.1 Habitats Directive species

In 1992 the European Union set out to satisfy the requirements of the Biodiversity Convention signed at the Rio Earth Summit by introducing the Habitats Directive. The primary purpose of the Directive was to establish Special Areas of Conservation (SACs) and Special Protected Areas (SPAs) for rare and endangered habitats or species. SNH are charged with establishing SACs and SPAs in Scotland, but also to promote the sensitive management of all listed species and habitats outside these conservation areas.

At least 14 listed habitats and species occur within the Carron catchment, including the Atlantic salmon (Table 3.2). Five of these, alder woodland, Freshwater pearl mussel, Otters, Red-throated diver and Black-throated diver would benefit directly from action to conserve the catchment's fish stocks and riverine habitats. Conversely, salmon and trout populations will benefit from many of the actions to conserve other listed habitats and species, especially those aimed at maintaining the natural fertility and productivity of the catchment area.

3.5.2 Local Biodiversity Action Plan Species

Local authorities and others are being encouraged to take local action to promote biodiversity, to complement and help deliver national action programmes and projects. At the time of writing, the Wester Ross Local Biodiversity

Table 3.2 Annex I habitats and Annex II species designated by the 1992 EU Habitats and Birds Directive that occur in the River Carron catchment

Annex I	Annex II
• Blanket bogs • Caledonian forest • Alder woodland on flood plain	• Freshwater pearl mussel • Eurasian otter • Lamprey • Atlantic salmon • Red-throated diver • Black-throated diver • Golden eagle • Merlin • Peregrine • Dotterel • Golden plover

Table 3.3 Local Biodiversity Action Plan priority species

Common name	Scientific name	Comment
Spotted flycatcher	*Muscicapa striata*	UK Priority species: riparian woodlands
Water vole	*Arvicola terrestris*	UK Priority species: flood plains
Brown trout	*Salmo trutta*	Local Priority species: lochs and rivers (inc. Sea trout)

Action Plan (WRLBAP) is in preparation, facilitated by the Highland Council. In addition to species listed in Table 3.2, Table 3.3 lists some of the LBAP species of local importance that will benefit from actions to restore freshwater habitats and fisheries. For UK priority species, details can be found on the web at www.ukbap.org.uk.

3.5.3 Fish species

During the course of surveys, the following species were found within the catchment area: Eel, Salmon, Trout, Flounder and Minnow. Arctic charr and Lamprey also occur, and Three-spined sticklebacks are likely to be present.

Brown trout (non-sea going *Salmo trutta*)

In addition to the trout populations in the areas accessible to migratory fish from the sea, many of the rivers and hill lochs have populations of wild brown trout. Over the years, wild trout have been transferred from loch to loch or burn to loch by angling enthusiasts in many parts of Wester Ross. Nevertheless, because of their relative isolation, some lochs still retain distinctive genetic strains of brown trout.

- **The genetic status of wild trout populations within the Carron catchment requires further investigation.**

Arctic charr (*Salvelinus alpinus)*

Scottish populations of land-locked charr originate from sea-going charr populations at the end of the last period of glaciation. Charr are wonderful little fish that can do quite well in aquariums so long as the water temperature is kept fairly cool (below about 15°C). Although WRFT have not surveyed lochs for charr, they are reported to be present in large numbers in both Loch Dughaill and Loch Sgamhain. They also occur in Loch Coire Lair and in some of the lochans on Sgurr na Feartaig to the south of Loch Dughaill (see Sandison, 2001)*.

- **Further investigations are required to determine the distribution of arctic charr within the Carron catchment area and understand charr ecology and the potential to develop charr fisheries, particularly within Loch Sgamhain and Loch Dughaill.**

European eel (*Anguilla anguilla*)

There is growing concern that eel numbers are declining in some parts of their range. In many respects, the life cycle of the eel is the opposite of that of the salmon. Eels spawn in the Sargasso Sea and *enter* freshwater aged 2 years as elvers where they may grow for ten or twenty years before returning to the sea as mature adults. Although eels eat the eggs, fry and parr of trout and salmon, trout and large salmon parr eat small eels.

Ancient Caledonian pine forest in Achnashellach forest near Craig. The skeleton trees are said to have been killed by a fire in the 1970s. Trees for Life has been working in partnership with Forest Enterprise to restore native woodlands in the area *(Peter Cunningham)*

Sand martins nest in the bank here below Loch Sgamhain. Densities of insects including mayflies and other species may be slightly elevated due to nutrient enrichment, providing additional food for birds *(Peter Cunningham, August 2003)*

Elvers ascend rivers in the spring. The electro-fishing surveys suggested that many of them remained within the lower part of the River Carron during their first spring/summer.

- **Further investigations are required to more fully understand the movements and habitat requirements of eels. Ecological inter-relationships between eels and trout, salmon and other species (e.g. predation, competition for food) also require further study.**

Lamprey (*Lampetra* sp.)

Lampreys were recorded in Loch Dughaill in 2003 by Billy Forbes of Seafield College. This is the first recent record of lampreys in Wester Ross. The species identity is still to be confirmed – possibly brook lampreys. [See Appendix VI for update.]

- **Further investigations are required to determine the Lamprey species, and its distribution within the River Carron.**

Minnow, *Phoxinus phoxinus*

Minnows were found during WRFT surveys in burns around Loch Sgamhain and Loch Dughaill, and may have been introduced into the catchment within the last few decades by anglers using live bait. Minnows may compete for habitat and food with juvenile trout. However, they provide a source of food for trout and salmon parr, and Kingfishers.

- **Further research is required to understand relationships between minnows and trout. This will help to determine the long-term value to trout fisheries of minnow control.**

3.5.4 Other species relating to health of fisheries

Otter

Otters are widespread within the catchment, moving between headwater streams and the sea. Otters take both adult and juvenile salmon and trout, and also eels, minnows and sticklebacks. Frogs often represent a large part of their diet, as has been determined from spraint analyses.

Birds

Dippers are resident along the Carron. Common sandpipers, Grey wagtails and Sand martins are summer visitors and breed along the river and lochs; numbers of Snipe and Woodcock increase in the autumn.

These birds feed on invertebrates, and aquatic insects can represent a major part of their diet.

Minnows are particularly abundant in Loch Sgamhain and may be competing with trout. They can be easily caught in traps made from plastic drinks bottles *(Peter Cunningham)*

- **Records of birds such as Dipper and Sand martin within the Carron catchment at different times of year can provide an indication of stream health and aquatic insect abundance.**

Ospreys were reported to have been seen along the Carron valley in recent years. White-tailed eagles are present elsewhere in Wester Ross, with the occasional sighting in the Carron catchment. Both these birds may take trout and sea trout, and the restoration of prolific fish populations will help them to re-establish. Kingfisher populations expand following mild winters. They have recently been recorded along several rivers in Wester Ross.

Aquatic invertebrates

Growth rates and levels of production of juvenile salmon and trout relate to temperature and food availability. Aquatic invertebrates represent the major part of the diet of juvenile salmonids.

Phosphorus enrichment is often associated with negative impacts on the diversity of aquatic invertebrates. However, invertebrate sampling in November 2003 indicated a healthy diversity of mayfly and stonefly species in the upper Carron downstream from the Allt Coire Crubaidh confluence and Loch Sgamhain (M Hammett, *personal communication*).

- **The overall impacts of mild P enrichment on the production of invertebrates including Freshwater pearl mussels and juvenile salmon and trout requires further research.**

- **WRFT has long-term plans to gather and collate data describing the distributions, densities and relative importance of aquatic insects within Wester Ross river catchments. This data may be presented within a second generation of 5-year Fisheries Management Plans for Wester Ross river systems.**

There are a wide variety of natural wetlands and freshwater habitats within the Carron valley. These are likely to support a rich diversity of dragonflies, water beetles and other species. There are a number of opportunities for the restoration of wetland habitats of benefit to both fish and other wildlife, especially in relation to ongoing native woodland restoration within the Achnashellach forest.

References

*Sandison, B. (2001) *Rivers and Lochs of Scotland,* Merlin Unwin Books. ❑

Part 4
Salmon and Sea Trout Fisheries and Stocks

4.1 Introduction

Catch records provide an indication of changes in the abundance of both salmon and sea trout within the River Carron system over the past 50 years. They can also provide valuable information relating to the timing of fish runs into the river and of fish sizes, and provide a basis for adult stock assessments. However, fishing effort and recording varies from estate to estate and year to year. Therefore trends in recorded catches may not have always closely followed those of the fish populations.

Salmon and sea trout are considered together in this section. This is for several reasons:

- The timings of changes in abundance of the two species can be compared.
- Some of the factors relating to changes in abundance may be common for both species.
- Interactions between trout and salmon may influence respective abundance (e.g. competition for spawning habitat, for juvenile habitat and for food).

Catch records were kindly provided by the following estates: Attadale (1889–2002), Glencarron (1922–2002), New Kelso (1972–2002), Achnashellach (1975–2000), and Arineckaig (1983–2002). The Fisheries Board for Scotland report by Nall and Macfarlane (1938) was also examined. Further information was obtained from a report of the records of sea-trout and salmon from the Attadale catch records, comparing the variations over time between the Carron and the Ling from 1889 to 2002.

Gordon Macpherson provides the following comment:

'Alas there is little data from Achnashellach and Loch Dughaill. In the late 50s and 60s this was the most important part of the system in that the Loch represented the biggest and best 'holding pool' and was actively fished by boat. I suspect in a spate river weather conditions and water level greatly influence catches, but these variables have less impact on the loch. Certainly after long periods of low water and no fishing at Attadale, Achnashellach used to be so kind as to offer us a chance on the loch – more productive ... fishing from a boat. Without Achnashellach data any analysis or conclusions could be suspect.'

4.2 Rod catches of salmon

Examining the catch records from all estates from 1983 onwards suggests that the stocks were poorer in the early 1990s than in the 1980s, with a major reduction in numbers occurring from 1995 onwards (Figure 4.1). This pattern reflects the regional trend suggesting that the decline is a reflection of stock abundance and is not due to reduced fishing effort.

As this only gives an indication of the changes in the past 20 years, the Attadale and Glencarron catch records were examined, right back to the first records. It appears from the Attadale records that catches were low and also sporadic in the years before the 1960s, with catches increasing in the 1960s (Figure 4.2). Catches from the 1960s to the 1980s were generally much higher than in previous years although levels fluctuated from year to year, with catches tailing off in the 1990s, as elsewhere in the catchment.

In contrast with the general declines in the early nineties, the Glencarron records show a better catch record in the early 1990s than at any time other than in 1924 (Figure 4.3). The fall in Glencarron catches came at the end of the 1990s.

For both the Glencarron and Attadale records, fishing effort and record keeping may have changed over the years – with increasing effort from the 1960s onwards. Examining both these records shows the importance of the collection of long-term data sets. Without examining historical fishing records, it would be possible to assume

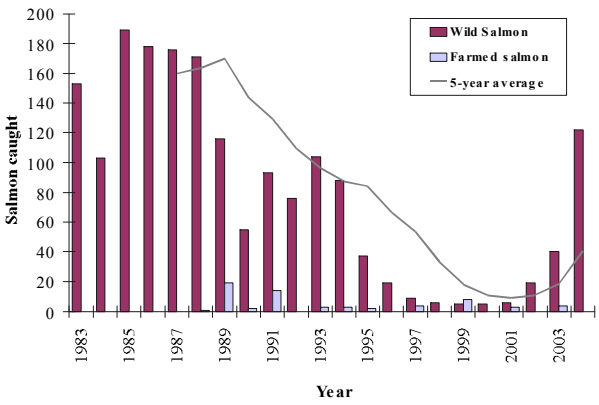


Figure 4.1 Total annual rod catch of adult wild and escaped salmon from the Carron system, 1983–2004

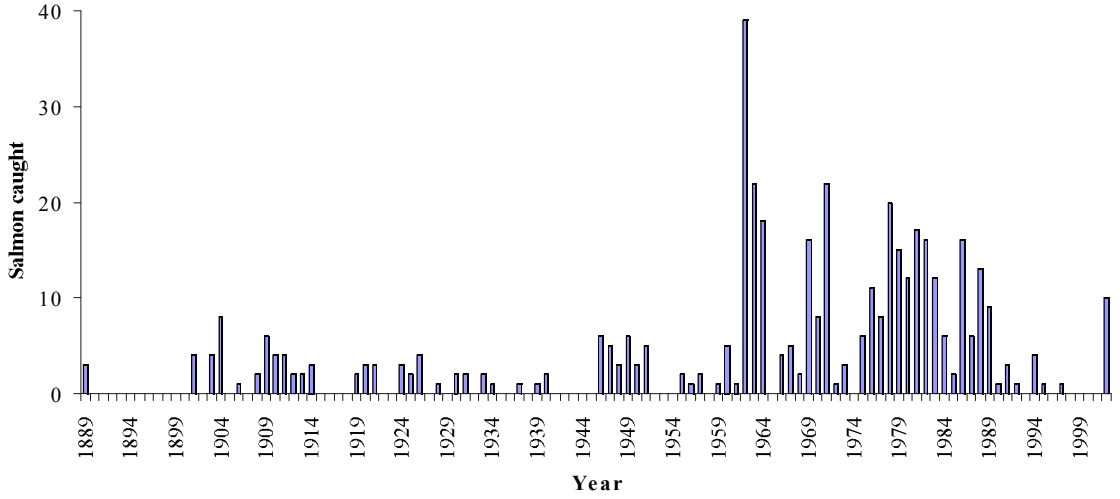


Figure 4.2 Total annual rod catch of adult salmon from the Attadale catch records, 1889–2002

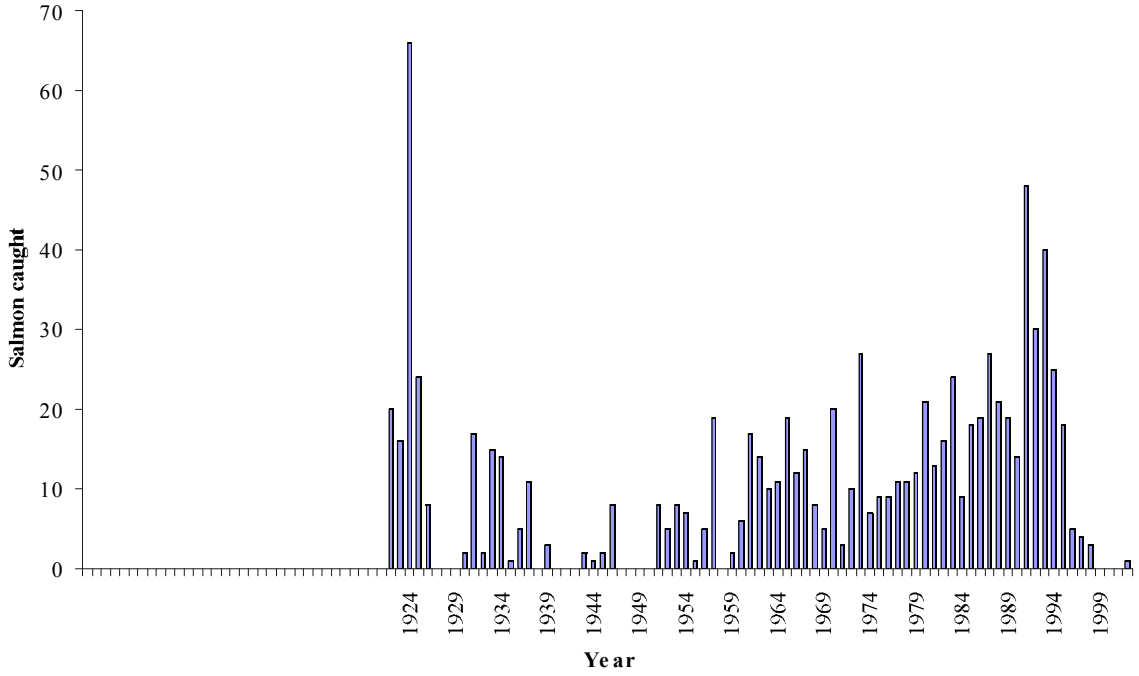


Figure 4.3 Total annual rod catch of adult salmon from the Glencarron catch records, 1922–2002
(Note: no data available for 1999 and 2000)

that the Carron has always had catches as high as those observed from the 1960s onwards. Although this might suggest that intensified fishing pressure has been unsustainable, the old catch records are probably not representative enough to come to these conclusions. It is possible that many more fish were caught in the area in the past and not recorded.

4.3 Escaped farmed salmon

Escapees have been recorded in the catch for 10 of the 14 years since 1988. The first escapees were recorded in 1988 at New Kelso. The New Kelso book also has a note that 30,000 fish were lost from a farm during a storm in January 1989; in this year 14% of the salmon caught by rod were recorded as escapees. In 1999, 8 of the 13 salmon caught (62%) were escapees and as recently as 2001 40% of the catch were still recognised as farm escapees. This may not include the incidence of fish that escaped from the freshwater cages on Loch Sgamhain as fry or parr. Such fish, if they survive at sea, can usually only be recognised by scale reading or profiling of DNA (see Box 4.1).

Over 40% of rod caught salmon in1999 and 2001 were recorded as escaped farmed salmon *(James Butler)*

4.4 Catch and release of salmon

From studies in other river systems, it has been shown that, of the total number of adult salmon that enter a river, the proportion taken by rod and line may vary between 5% and about 50%. Fish that enter the river earlier in the season tend to be more vulnerable than those that enter later in the year. In one study on the Welsh River Dee, rods took 40% of salmon that entered from the sea before the end of May.

Radio-tracking studies have shown that over 50% of rod-caught salmon, if handled correctly following capture and carefully released back into the river, can survive to spawn. 'Catch and release' is recommended by NASCO (North Atlantic Salmon Conservation Organisation). Over the past few years anglers on the Carron have been encouraged to release all salmon, except escaped farm fish, and the proportion of the catch released (or collected for the hatchery, see section 4.10 on Stock enhancement) has increased (Figure 4.4). This policy should be continued until stocks have recovered.

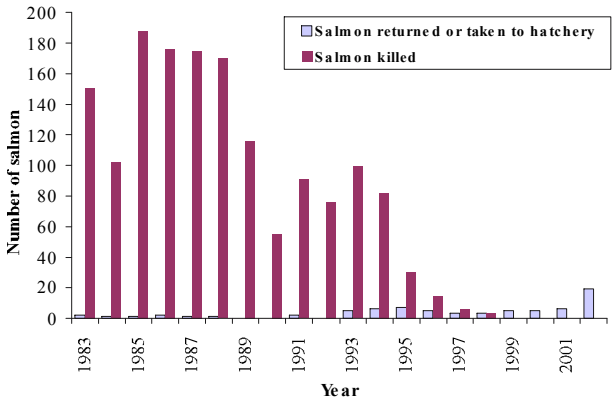


Figure 4.4 Since 1998 all fish captured have been released or kept for the hatchery; many of those 'killed' between 1995 and 1998 were in fact retained for hatchery use

Box 4.1: Escaped farm salmon

Farm salmon are selectively bred to perform well in captivity. Farm salmon have been developed over several generations from a mixture of native salmon from British and Scandinavian rivers or from other origins. Escapes may occur during the freshwater or marine stage of the farm production cycle as a result of accidents or criminal damage. Escaped farm salmon are not always easily recognised, and tend to be under-recorded in rod catches. Scale analysis may be required to confirm a farmed origin of rod-caught fish, especially if the farm salmon escaped as a parr or smolt.

Escaped farm salmon can spawn successfully in the wild. However, studies have shown that the rates of survival to adulthood of the progeny of farm salmon and of native x farm salmon hybrids can be much lower than for native wild fish. Escaped farm salmon that spawn in the wild may compromise the genetic integrity and fitness of native populations, and can reduce the productivity of salmon rivers.

- Whenever possible, anglers should try to differentiate between wild and escaped farm salmon. Guidance leaflets are available from WRFT. Identified farm salmon should not be returned to the water. Any scales that are displaced during capture or handling should be collected (scale packets are available from WRFT biologists); these can help to confirm the status of captured fish.

The 1938 Carron study found that 11% of the salmon caught had spawned once previously, 7% had spawned twice before, and one kelt had just spawned for the fourth time. Of these fish 112 were marked and returned to the water. Four of these were subsequently recaptured as clean fish, one by a coastal net at the River Halladale on the north coast. This suggests that releasing salmon would not only allow them to spawn that season, but may also allow some to return in following years.

4.5 Salmon ages and stock components

Of four samples of salmon scales read by WRFT, one fish went to sea aged 3, another aged 2 and the other two were 1-year-old smolts, presumably escaped farm fish. All fish were taken in 1999. The average weight of salmon caught on both the Glen Carron Estate (Figure 4.5) and the Attadale Estate (Figure 4.6) has decreased since

Numbers of multi-sea winter salmon may have declined disproportionately from the 1970s to the 1990s *(K Starr)*

records first began. Grilse generally weigh up to 8lb, and these records suggest that since the 1970s a higher proportion of the catch record has been of grilse. However, once again these records should be interpreted with caution. It is possible that only the larger salmon were routinely recorded in the earlier years.

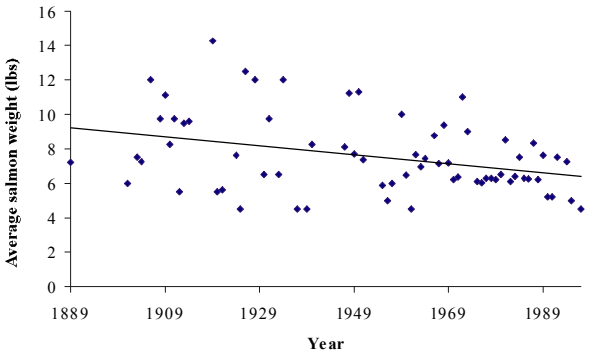


Figure 4.5. The average weights of recorded rod-caught salmon on the Attadale estate has decreased since the early 1990s

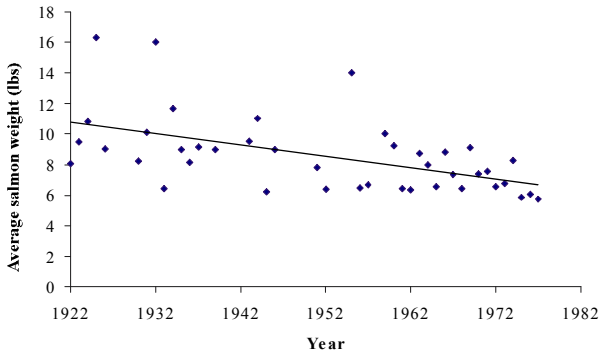


Figure 4.6 The average weights of recorded salmon taken by Glencarron rods declined during the 20th century

4.6 Rod catches of sea trout

Examining the sea trout catch records from all estates from 1983 onwards (Figure 4.7) suggests that the numbers of finnock were declining from the mid-80s onwards until 1999 when only one finnock was caught. In 2000 again only one finnock was caught, but in the past two years the numbers of finnock have increased considerably. In 2003 more than 450 finnock were caught, the highest number recorded during the 20-year period examined. The majority of these fish were taken by Bob Kindness from the lower river. Adult sea trout numbers were low from 1998 until 2000. The numbers of sea trout also increased in 2001, 2002 and 2003, but not to the same degree as the finnock.

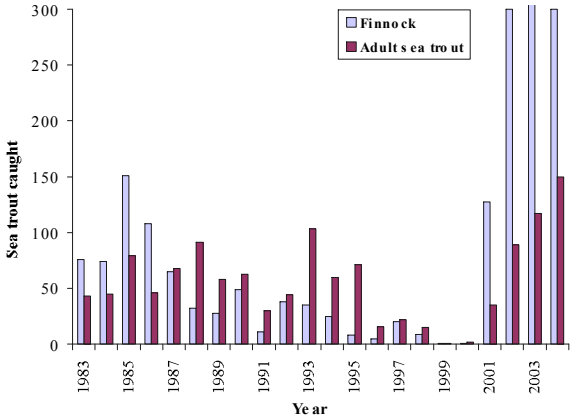
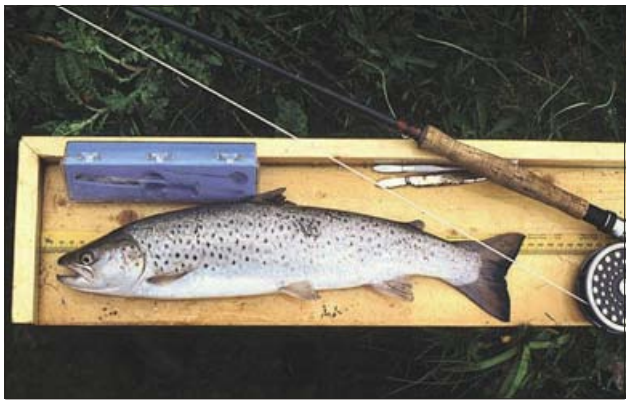


Figure 4.7 Total annual rod catch of adult sea trout and finnock from the Carron system, 1983–2004

As this only gives an indication of the changes in the past 20 years, the Attadale and Glencarron catch records were examined back to the first records (Figures 4.8 and 4.9).

There are a number of periods in the Attadale records when no sea trout were recorded (including during World War 1 and World War 2). However, catches remained fairly consistent until the early 1990s with



Catches of sea trout collapsed during the mid-90s, but then recovered dramatically from 2001, following a restocking programme by Seafield College *(James Butler)*

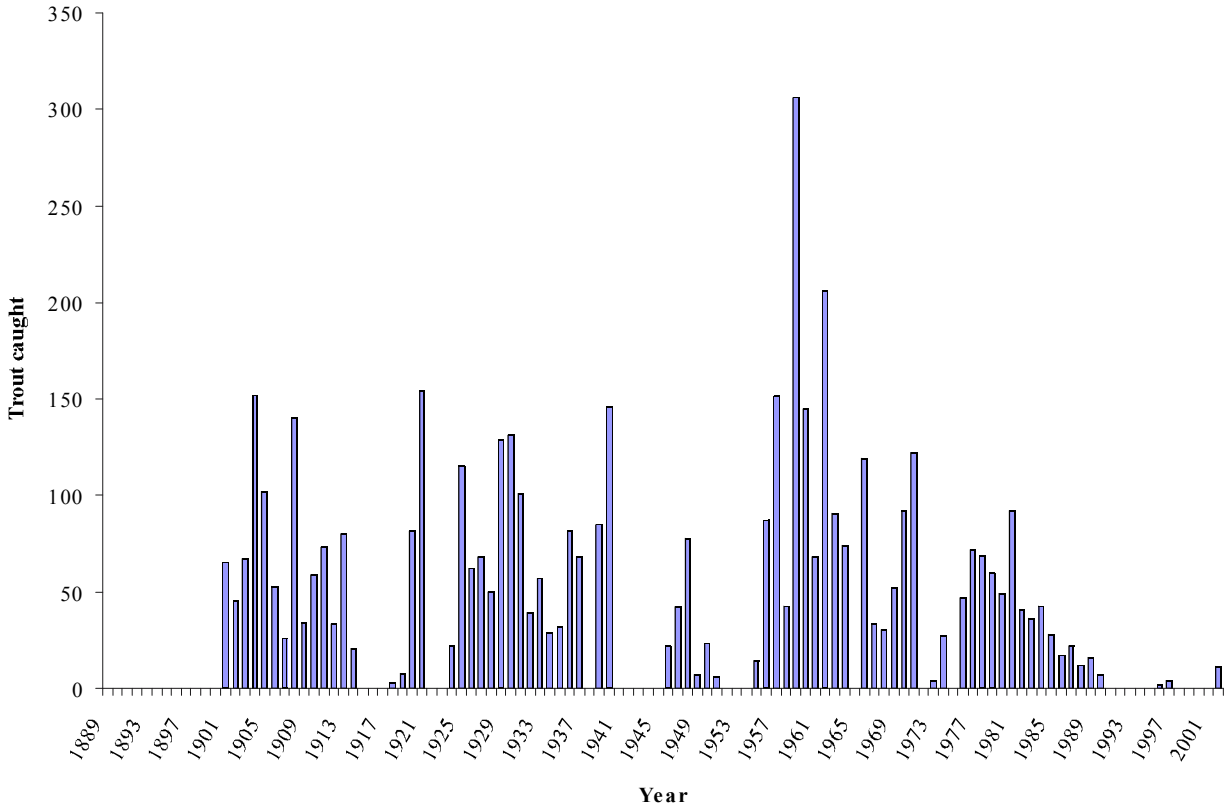


Figure 4.8 Total annual rod catch of sea trout from the Attadale catch records, 1889–2002

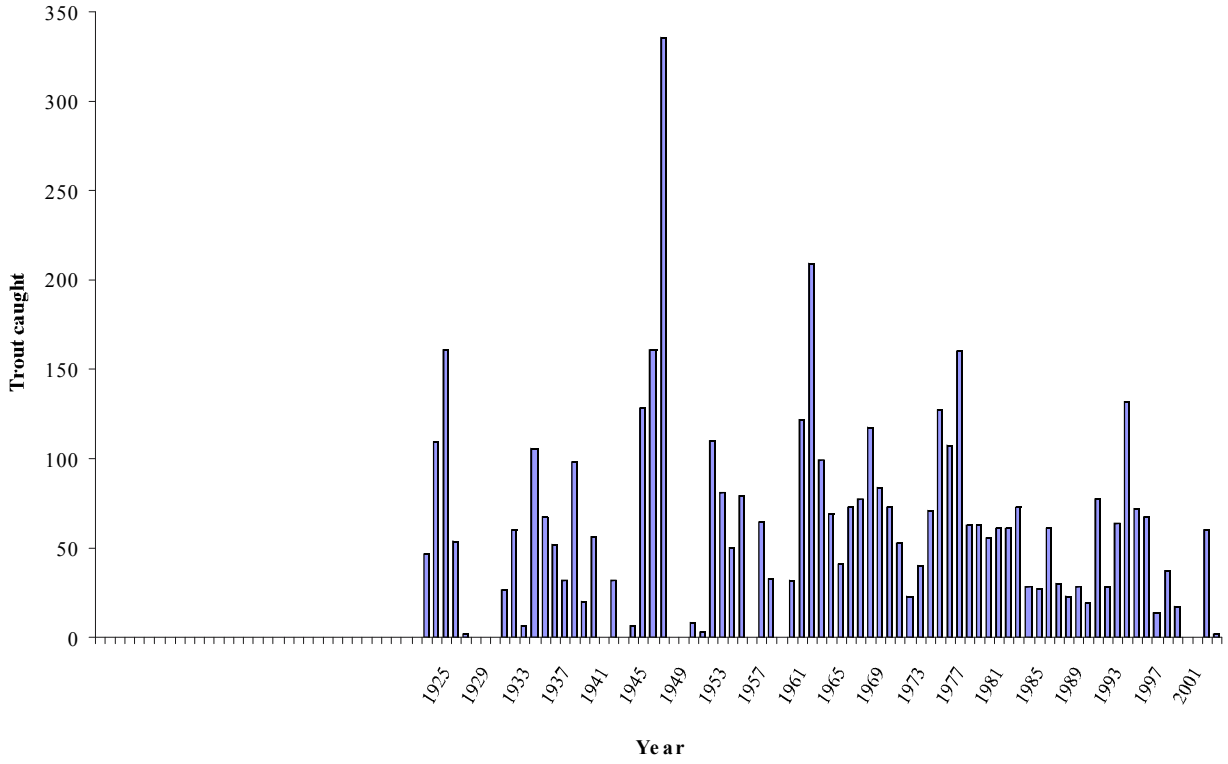


Figure 4.9 Total annual rod catch of sea trout from the Glencarron catch records, 1922–2002
(Note: no data available for 1999 and 2000)

catches fluctuating between 30 and 150 sea trout per year until the early 1990s. The highest recorded catch was of 306 sea trout in 1959. There has never been a period in the past 100 years when recorded catches remained at such a low level as during the 10 years prior to 2002.

In the Glencarron catch records there has been much variation in catch success over the years, with the highest numbers of sea trout in 1946. As for salmon, fishing efforts before the 1960s are thought to have been sporadic, and the years with few fish are more likely to be a consequence of reduced fishing effort rather than low stock levels. Although there is a great deal of variation in these records, it would appear that the numbers of fish caught in the 'good' years has decreased since the 1960s.

Of all the Carron estates, only the Glen Carron Estate continued to record any number of sea trout in catches in the early 1990s. This is rather curious, as one would expect to have records of similar catches lower down the river. One possibility is that some of the Loch Sgamhain fish recorded as 'sea trout' had not in fact been to sea and were actually larger silvery trout, very similar in appearance to sea trout, that had stayed within the loch to feed around the smolt cages. Elsewhere in Scotland, similar trout are taken from time to time from lochs with fish cages.

The return of rod-caught salmon and sea trout, especially females, will hasten recovery of respective populations *(Karen Starr)*

The old fisheries report from 1938 gives some idea of the numbers of sea trout in the system at that time. On three visits to Loch Dughaill between March 1936 and November 1937, Nall netted, marked and released a total of 1001 sea trout and finnock. In November 1937, 1547 sea trout and finnock were netted in two days, and only 5 of these fish bore marks from the previous visits. This suggests that only a small proportion of the overall population had been marked.

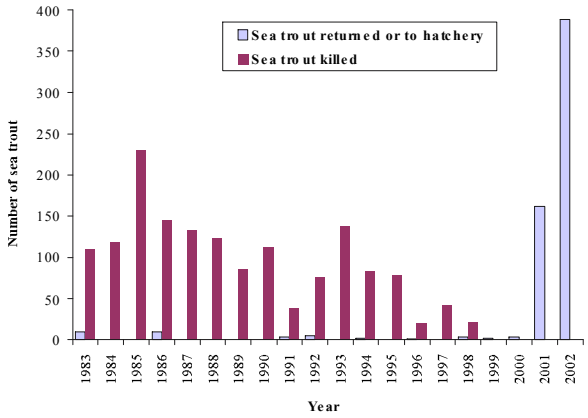


Figure 4.10 In recent years the number of sea trout returned to the river has increased dramatically

4.7 Catch and release of sea trout

Over the past few years the proportion of the trout catch released (or collected for the hatchery, see section 4.10 on Stock enhancement) has increased (Figure 4.10). To restore prolific runs as quickly as possible, this policy should be continued until stocks of adult sea trout have recovered fully.

4.8 Sea trout ages and stock components

Unfortunately the sea trout records from the Attadale Estate were not kept as rigorously as the salmon records and so we can not observe the weights of fish caught. The records from Glencarron show no significant change in average weight of sea trout caught from the 1920s until the 1980s (Figure 4.11).

Of 5 sea trout scale samples read by WRFT, 3 were of fish that first went to sea aged 3 years, and 2 were aged 2 years

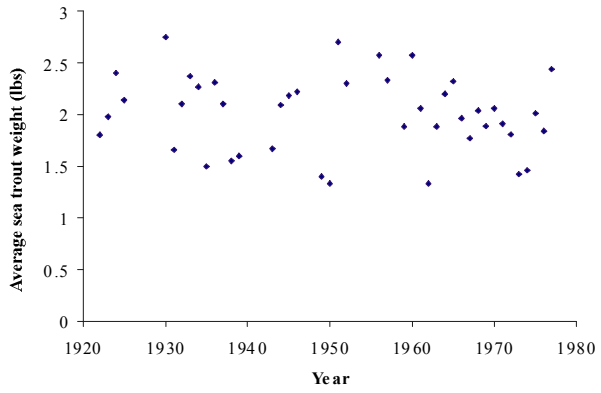


Figure 4.11 No change in the average weight of sea trout has been observed in the Glencarron catch records

at first sea entry. From scale readings, Nall found that in 1937 only 2% of the fish captured had spawned as finnock, the lowest percentage of any Scottish river he had examined. Around 60% first spawned in their second winter, 30% first spawned in their third winter, and a small number did not spawn until their fourth winter after migrating as smolts. Of the fish that had spawning marks on their scales, 73% had previously spawned on more than one occasion. Some had spawned as many as 8 or 9 times, and one was found to have 11 spawning marks. This was the highest number of spawning marks that Nall had ever observed. The proportion of smolts migrating to the sea was as follows: 26% after 2 years in the river, 63% after 3, 10% after 4 and 1% after 5.

4.9 The decline of sea trout and salmon stocks in the Carron

Long-term catch records for both Glencarron and Attadale suggest that during the past 50 years the proportion of sea trout relative to salmon has changed. Sea trout were clearly prolific at the time of Nall's study. Until the 1960s, a higher proportion of the combined catch was of sea trout rather than salmon. However, from the early 1970s, the relative proportion of salmon to sea trout was usually slightly higher.

This may simply relate to changes in record keeping. Sea trout records may be more complete for some periods than for others. However, a similar decline in the numbers of sea trout relative to salmon appears from the 1970s in records of other parts of Wester Ross. Another explanation is that from the 1970s, the Carron salmon population became more successful than the sea trout population.

A 6lb (2.5kg) Carron sea trout is likely to have already spawned 3 or 4 times and be 5–8 years old. In contrast, a 6lb (2.5kg) Carron grilse is likely to be only 3 years old. When fishing pressures at sea increased, the faster-growing fish (salmon) may have been at a relative advantage. Sea trout may have been particularly vulnerable to legal (recorded) and illegal (unrecorded) coastal netting because of their relative longevity and tendency to remain within inshore waters. Peak sea trout catches recorded towards the end of the 1960s prior to the decline in the early 70s may also be an indication of over-exploitation of local sea trout stocks within the area at that time. If so, this may in turn have been partly related to the removal of the 3-mile inshore limit for trawlers.

Ulcerative Dermal Necrosis (UDN) affected many west-coast rivers particularly in the early 1970s. This may also have contributed to a disproportionate reduction in the biomass of spawning sea trout and sea trout egg deposition over subsequent years as fewer sea trout survived to spawn a second or third time. More recently, the contrasting success of sea trout and salmon is likely to relate to further changes within the marine environment. Salmon migrate to distant feeding areas within the open ocean. By remaining within coastal waters, sea trout are more likely to be affected by changes in the abundance of inshore prey species, by inshore predator abundance and, since the mid-1980s, by sea lice epizootics associated with salmon farming. On the other hand, salmon may be more vulnerable to capture as by-catch, for example in the Norwegian Sea mackerel fishery, and to genetic introgression via hybridisation with escaped farm salmon.

Large adult sea trout and salmon have partially-overlapping spawning habitat requirements, and within the Carron their spawning areas may have overlapped. Most of the accessible spawning habitat is within the main river, much of it suitable only for larger fish, normally salmon. When older sea trout were common, trout egg deposition within the main river may have been higher, with many trout eggs being buried relatively deeply by larger female sea trout. The decline in sea trout from the early 1970s would have led to a reduction in trout egg deposition relative to salmon egg deposition. In turn, the reduction in sea trout egg deposition within the main river may have led to increased availability of habitat and food supply for juvenile salmon. To some extent, juvenile salmon and trout compete for territory and for food. Where both species are present, trout tend to be more aggressive and to dominate, especially where the current is slower (juvenile salmon and juvenile trout production are considered in Parts 6 and 7 respectively). It is therefore possible that the production of juvenile salmon subsequently increased as a response to reduced competition from progeny of large sea trout.

Records of observations of spawning salmon and sea trout can provide information from which the spawning areas and spawning requirements (in terms of flow, gravel characteristic, water temperature, etc.) of each species within the system can be determined.

Table 4.1 Numbers of salmon stocked into the River Carron by Seafield Aquaculture Centre, 1999–2001

	2000	2001
Salmon parr/smolts	8,500	12,000
Salmon fry	0	159,570

4.10 Stock enhancement

4.10.1 Salmon

In recent years the Seafield Centre has been stocking the Carron River with fry, parr and eyed eggs taken from wild salmon captured on the Carron River. Scale reading has indicated that two of the original broodstock were probably of farmed origin, leaving the Carron as 1-year-old smolts. However, as these fish had survived at sea and returned to breed when caught they show some degree of adaptation to the river. From 1995 until 2002 approximately 150,000 eyed eggs, 350,000 fry, 14,000 parr and 11,000 smolts have been grown in the Seafield Centre hatcheries and introduced to the river (Table 4.1). The most extensive stocking occurred in 2002 (see Table 4.2 and Appendix 2). In 2002 a release pond was also created on a side burn just above the Cruives Pool. All fish released into the pond were kept within the pool for one week before they were released. These fish were all tagged with a coded wire that is inserted right into the snout to minimise tag loss, and also fin clipped. In the coming years the students at the Seafield Centre will be able to estimate the return success of these stocked fish.

4.10.2 Sea trout stock enhancement

As for salmon, the Seafield Centre at Kishorn has had an extensive stocking programme since 1997 (Table 4.3).

Bob Kindness of Seafield College with a recaptured tagged wild Carron salmon at Attadale *(Seafield College)*

Initially they were unable to obtain Carron sea trout, and the restocking was carried out using a brood stock originally captured from near Coulin in the headwaters of the River Ewe system, an adjacent catchment. The Seafield Centre now has a stock of 3-year-old and 1-year-old sea trout captured from the Carron River. There is a possibility that some of these fish are in fact the returning Coulin offspring, because the river was stocked with Coulin a few years previously. However, even if this is the case, these fish have shown that they are capable of surviving to smolt and return. In February 2003 the first eggs from this new Carron stock crossed with Coulin stock were placed in the river. In future years only the Carron stock will be used for stock enhancement. As for the salmon, the most extensive stocking occurred in 2002,

Table 4.3 Numbers of sea trout stocked into the River Carron by Seafield aquaculture Centre, 1999–2001

	1999	2000	2001
Sea trout parr/smolts	14,000	30,000	15,000
Sea trout parr	77,500		

Table 4.2 Details of salmon stocking in 2002

Date	Type	Number	Release site	Site Code
04/02/02	eggs	30,000	River Taodail	1
05/02/02	eggs	120,000	Burn above Sgamhain, Allt Coire Crubaidh	2,3
11/05/02	smolts	3,000	Release point above Cruives pool	5
18/05/02	smolts	3,000	Release point above Cruives pool	5
10/07/02	fry	40,000	Cruives pool to New Kelso lodge	11
12/07/02	fry	15,000	Railway bridge to release pool	12
07/08/02	fry	25,000	River at Arineckaig	8
09/08/02	fry	18,000	Above and below road bridge	13
12/08/02	fry	14,000	Lower end of Fionn Abhainn, above and below railway bridge	9,10
25/08/02	fry	8,000	East end of Loch Doughaill	6
30/08/02	fry	8,000	West end of Loch Doughaill and Narrows	14
01/09/02	fry	8,000	North shore Loch Doughaill	6

Table 4.4 Details of sea trout stocking in 2002

Date	Type	Number	Release site	Site Code
07/02/02	eggs	50,000	Burns above Cruive Pools	4
08/02/02	eggs	90,000	Golden Valley, Coire a' Bhainidh, Allt a' Chonas	17, 18, 19
26/05/02	smolts	4,000	Release point above Cruives pool	5
07/05/02	fry	75,000	Loch Doughail, River below Fionn Abhain	6,7
14/05/02	fry	20,000	River at Arineckaig	8
09/06/02	fry	10,000	Lower end of Fionn Abhain, river below railway bridge	9,10
10/06/02	fry	3,000	River Taodail	1
20/06/02	fry	15,000	Junction Pool to release Pool	7
09/07/02	fry	11,000	West end of Loch Doughail	6
21/11/02	fry	9,200	Loch Doughail	6
27/11/02	fry	8,800	Loch Doughail	6
10/12/02	fry	2,000	Cruives to Kelso Lodge	11

One that got away: released brown trout of 35cm in the burn above Loch Sgamhain after being taken during an electro-fishing survey. Unfortunately the scale sample contained only replacement scales, and so the fish's age could not be determined *(Peter Cunningham)*

see Table 4.4 and Figure 4.6. Half of the tagged smolts released at the pond on 26/5/02 had been treated with the new in-feed sealice treatment 'Slice'. The return success in coming years will show whether this improves the chance of survival of stocked smolts.

4.11 Conclusions

- **During the period 1900–2002, recorded catches of salmon and sea trout have fluctuated widely. Catches of sea trout were highest during the 1960s, and catches of salmon were at their highest during the 1970s and 80s. During the 1990s, catches of both species fell to their lowest levels for 40 years.**
- **It is likely that majority of Carron salmon go to sea after 2 years in freshwater (S2 smolts) and a minority after 3 or more years, although further scale records are required to confirm this. Rod catches suggest that most Carron salmon return as 'grilse', after spending one winter at sea (1SW salmon), particularly in more recent years.**
- **The decline in sea trout from the late 1960s is most likely to be related to changes in conditions within coastal areas and possibly to a UDN outbreak in the early 1970s recorded elsewhere in Wester Ross. Juvenile salmon may have been able to occupy some of the habitat and to exploit some of the food resources formerly taken by juvenile trout, and this may partly explain the increase in the proportion of salmon relative to sea trout caught during the mid-1970s.**
- **The collapse of both species from the mid-1990s may have a number of causes. Sea lice epizootics emanating from salmon farms may have affected sea trout to a greater extent than salmon. Because of its small size, the salmon population would have been particularly vulnerable to genetic introgression via hybridisation with escaped farm salmon.**
- **From 1997–2002, Seafield College stocked large numbers of trout and salmon eggs and juveniles. By 2003, catches of finnock and sea trout had increased dramatically, exceeding their highest levels on record.**
- **Until it is clear that there are adequate numbers of wild fish spawning throughout the system, the policy of catch and release of salmon and sea trout should be continued wherever possible, especially for salmon. Wild fisheries interests should work together with other stakeholders to ensure favourable conditions for wild fish within coastal areas.** ❑

Part 5
The Freshwater Habitat

5.1 Introduction

The main objective of the Fisheries Management Plan is to maximise the natural output of juvenile salmon and trout from the river. This part of the fishes' life cycle is within the riparian owners' control, whereas marine factors largely are not. This approach is also justified by the fact that the numbers of returning adults will generally depend upon the number of smolts produced by the river system, which in turn is governed by the numbers of juvenile fish that the river can support.

This section assesses the characteristics of the River Carron in terms of current and potential freshwater production. In doing so factors that may limit juvenile production are identified. For salmon and sea trout, the productive capacity of a river system is determined by the area of water accessible to adult fish and by the quality of the habitats therein. Habitats that are good for fish production also tend to support a rich diversity of other wildlife, including aquatic plants, insect larvae (mayflies, stoneflies, caddisflies, dragonflies, water beetles, etc), birds (dipper, sand martin, heron, kingfisher, osprey), and mammals (otter, badger, water vole and other rodents).

5.2 Productive area

A primary aim of the habitat survey in 1998 was to identify the productive freshwater area accessible to salmon, sea trout and brown trout. This involved surveying rivers and tributary burns to assess how far migratory fish would be able to ascend, and the mapping of obstacles such as falls. Electro-fishing for juvenile salmon could sometimes help to establish whether falls were passable or not.

Taking the obstacles into account, the accessible riverine and loch areas were calculated (Table 5.1). These are shown in Figure 5.1. In total the accessible area comprises 1,660,000m² of loch habitat (81.6% of total) and 373,700m² of riverine habitat (18.4%). Loch Dughaill provides 64.5% of the loch habitat. Of the riverine habitat, 76% is within the mainstem River Carron, The most important tributaries in terms of accessible area are the Fionn-abhainn ['Coulags burn'], Allt a' Chonnais and Allt Coire Crubaidh. The River Taodail entering the Carron

Table 5.1 The riverine and loch area (m²) accessible to salmon and sea trout in the Carron catchment

Riverine habitat	**Accessible area (m²)**	**% of riverine**
Main-stem	283,822	76.0
Fionn-abhainn	24,660	6.6
Allt Coire Crubaidh	12,130	3.2
Lair	4,300	1.2
An leth-alt	2,620	0.7
Coire a'Bhainidh	5,300	1.4
Taodail	16,160	4.3
Allt a'Chonais	14,840	4.0
Alltan na Feola	7,630	2.0
Other tributaries	1,840	0.5
Total riverine *(18.4% of total area)*	**373,302**	
Loch habitat	**Accessible area (m²)**	**% of loch**
Loch Sgamhain	590,000	35.5
Loch Dughaill	1,070,000	64.5
Total loch *(81.6% of total area)*	**1,660,000**	
Total area	***2,033,302***	

These falls above Glencarron at NGR 2074 8517 may obstruct fish migration at low flows *(Peter Cunningham)*

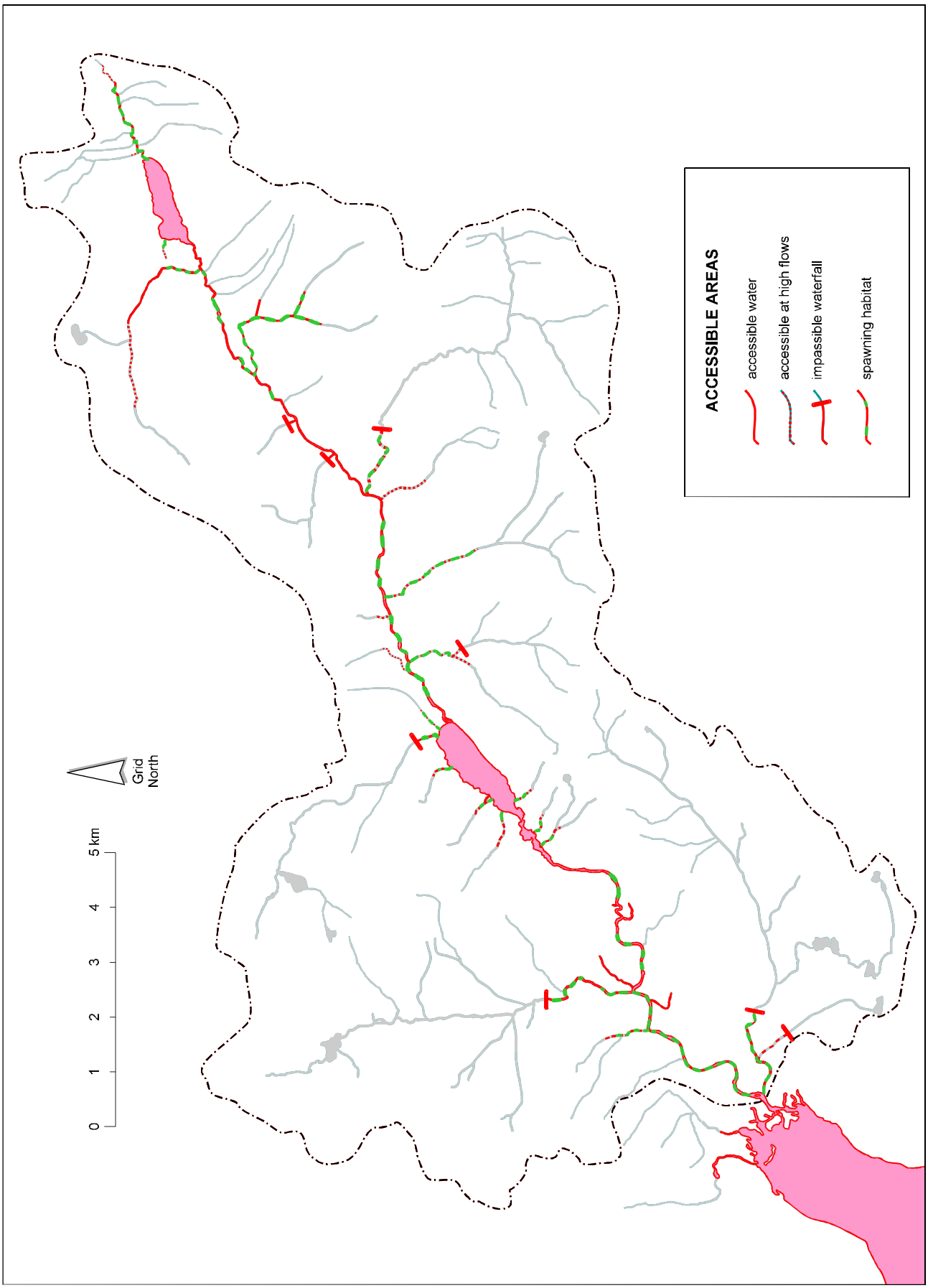


Figure 5.1 Areas accessible to salmon and trout within the River Carron system, also showing locations of principle spawning habitat *(Crown Copyright)*

Table 5.2 Characteristics of the riverine sections of the main-stem River Carron

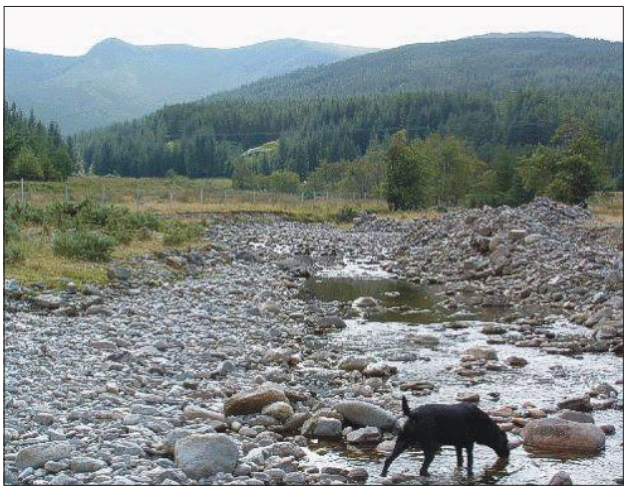
Section	Description and habitat notes
Above Loch Sgamhain	Meandering headwater burn. Some good spawning fords for trout and salmon, some erosion from undercut banks; riparian trees not regenerating.
From Loch Sgamhain to top of gorge section	Low gradient stream with weedy pools. Some very stable but silted spawning fords. Banks heavily grazed – trees unable to regenerate.
Glencarron gorge	Steeper gradient with Glencarron falls at top. *R. ponticum* dominating riparian area near Glencarron lodge.
Allt a' Chaonnais confluence to Loch Dughaill	Decreasing gradient section with sediment deposition and reworking (associated with gravel extraction in past?). Wide flood plain around Achnashellach with back channels, braiding, transverse gravel bars and islands.
Loch Dughaill to sea	Glides and runs. Streambed stable above Aineckaig, thereafter increasingly mobile with bank collapse and erosion. Lack of spawning habitat towards top of section. Thereafter, spawning areas vulnerable to scour associated with erosion and bed-load sediment transportation.

Braided section of River Carron above Loch Dughaill. Wide, shallow channels in this area may impede upstream progress of fish at low flows *(Peter Cunningham)*

Landslip below Arineckaig. Large amounts of glacial deposits have entered the river and been transported downstream to settle out where the gradient is lower (*August 2002, Peter Cunningham)*

Channel mobility relates to rates of sediment deposition. Below Arineckaig is particularly mobile where sediment accumulates *(June 2000, James Butler)*

Erosion in the lower Allt Coire a' Bhainidh in Achnashellach Forest (above). Sediment from bank erosion in the lower part of this stream is being transported into the mainstream River Carron (below) – exacerbating channel instability further downstream *(Peter Cunningham)*



just above the high tide limit is accessible at least as far as the falls approximately 1km above Strathcarron; an additional 58,940m^2 of water may be accessible to salmon and sea trout above these falls.

Access for migratory fish especially above Loch Dughaill is dependent on spate flows. At normal water levels, there is insufficient water depth for salmon (especially adult salmon) to ascend some of the transverse gravel bars in the flood plain around Achnashellach. Rocky sections in the gorge above Craig, including the falls in Glencarron, also obstruct upstream fish passage towards Loch Sgamhain. These obstacles may at one time have influenced salmon stock structuring within the river. Salmon homing towards the upper river may have entered the river earlier in the year than fish from below Loch Dughaill (see Part 4).

The main-stem Carron can be subdivided into five sections (Table 5.2). Sections immediately below lochs are most stable, with little sediment movement, and therefore are potentially more productive in terms of invertebrates and juvenile trout and salmon. Progressively further downstream from lochs are places where large quantities of sediment enter the river (e.g. eroding banks and landslips). Winter spate events may cause excessive scour, washing out salmon and trout eggs and alevins and reducing densities of insect larvae.

5.3 Salmon and trout habitat

5.3.1 Spawning habitat

Suitable spawning areas for trout and salmon are located through most of the river system (Figure 5.1). However, in terms of providing an environment where fish can bury large quantities of eggs easily and where a high proportion of those eggs are likely to survive to hatch, the quality of spawning areas varies. Downstream from areas where there is active erosion (e.g. main river around Achnashellach and nearby tributaries, lower Fionn-abhainn and main river below confluence with it) movement of bed-load sediment in big spates may cause 'redd washout' in some years, restricting fry production in some parts of the river (see section 5.5).

- **To reduce rates of bed-load sediment transportation, efforts to control rates of erosion are required. Primary 'upstream' sources (e.g. eroding corners of tributaries) from which coarse sediment enters the river should be identified, and where possible strategic action taken to stabilise banks. Rates of bank erosion further downstream will subsequently be reduced.**

In contrast, some of the spawning areas in the section of river below Loch Sgamhain appear to have deteriorated because of siltation and extensive weed growth, which

Stable spawning habitat at the outflow of Loch Dughaill *(June 2000, James Butler)*

mean that there is not enough movement of coarser sediments. This may relate to a lack of spawning fish in recent years, or be due to phosphorus enrichment, associated with farm smolt production in Loch Sgamhain, promoting more rapid root growth of water plants. However, it is not yet clear whether juvenile salmon or trout production in this area is limited by inadequate spawning habitat or by other factors. With an apparent abundance of food from nutrient enrichment, production of juvenile fish from this section and downstream sections of the river could even be slightly elevated above normal levels.

- **Further investigations of the impacts (both positive and negative) of farm smolt production in lochs on production of juvenile wild salmon and trout in downstream areas are required.**

Because of the potential importance of Loch Dughaill for production of juvenile sea trout, some of the smaller burns entering the loch may potentially be disproportionately important as spawning and nursery areas for young trout.

- **Efforts should be made to investigate juvenile trout and salmon densities in Loch Dughaill. Annual reconditioning of spawning gravels in the burns around the loch may help to elevate juvenile trout production.**

The habitat surveyor recorded no spawning habitat between Loch Dughaill and Arineckaig. However, anecdotal reports suggest that fish used to spawn in this section. The 'ford' area at the outlet of Loch Dughaill is potentially of importance for both salmon and trout spawning, but is extensively weeded. Fish have been known to spawn on an area of gravel further downstream (G Macpherson, *personal communication*). Some of the gravels may have been stripped away in the section of river below Loch Dughaill during recent spate events, or else weeded over.

- **It may be worth investigating whether spawning areas could be re-established through strategic provision of pebble- or cobble-sized sediments in selected areas.**

Outflow of Loch Dughaill, June 2003. Siltation of spawning gravels and weed growth in this area may have been exacerbated by a lack of spawning activity by salmon or large sea trout in recent years: see also Part 8 *(Peter Cunningham)*

Table 5.3 Distribution of good parr and spawning habitat within the River Carron, from WRFT habitat survey in 1998

Riverine habitat	Accessible area (m^2)	Salmon parr area		Salmon spawning area	
		m^2	% of total parr area	m^2	% of total spawning area
Main-stem	283,822	68,711	64%	931	85%
Fionn-abheinn	24,660	11,012	10%	19	2%
Allt Coire Crubaidh	12,130	5,654	5%	27	2%
Lair	4,300	1,900	2%	10	1%
An leth-alt	2,620	873	1%	9	1%
Coire a'Bhainidh	5,300	2,098	2%	11	1%
Taodail	16,160	6,976	6%	23	2%
Allt a'Chonais	14,840	6,662	6%	13	1%
Alltan na Feola	7,630	3,276	3%	21	2%
Other tributaries	373,302	680	1%	25	2%

5.3.2 Parr habitat

Trout and salmon parr have slightly different habitat preferences. During the spring and summer, parr tend to occupy the faster-flowing sections of the larger rivers or tributaries with cobble or boulder cover. Of the riverine habitat 32.8% was regarded as ideal for salmon parr, with the largest areas above and below Loch Dughaill, in the Allt Coire Crubaidh, and in the Fionn-Abhainn. Trout parr tend to prefer the slower glides, pools in tributary burns, and loch habitat. The two lochs provide potentially the largest areas of 'trout parr' habitat. Weedy pools in the main river below both lochs provide good habitat for trout parr.

For high levels of production, parr of both species require cover and food. Where the streambed has become widened and unstable (such as in the main river around Achnashellach), water depth tends to be relatively shallow and invertebrate densities lower.

Deforestation in Achanshellach forest *(September, 2000, James Butler)*

- **Forest Enterprise's Achnashellach Forest restructuring plan provides an outstanding opportunity for a major flood plain restoration project to develop natural habitat for fishes and other wildlife. See Part 8 for further details.**

5.4 Pollution and acidification

5.4.1 Nutrient levels

There are two SEPA monitoring stations on the River Carron: near the outflow of Loch Sgamhain, at Achnashellach, and at New Kelso. SEPA's classification map of the river system categorises the river above Loch Dughaill as A1 (with no major pollution), and the river at New Kelso as A2. However, in recent years recorded total phosphorus levels at both stations have risen (see Part 3).

During August 2003, a blue green algal bloom in Loch Sgamhain spread downstream into the upper pools of the river. The bloom, investigated by SEPA, was of an *Anabaena* species. SEPA advised the local health authority to put up signs warning the public that the water was toxic and to stay away. Toxic algal blooms tend to be associated with hot sunny weather with either elevated nutrient levels and/or inhibited grazing of phytoplankton by zooplankton. Fish kills may occur if oxygen levels fall, although this is rare. In this instance no dead fish were seen or reported. Algal blooms in Loch Sgamhain were reported before the introduction of cages.

Old sheep fank and dip near Arineckaig *(James Butler)*

Other potential pollution sources within the catchment include sheep dips, discharges from septic tanks or slurry tanks, and run-off from forestry operations (e.g. sediment, nutrients associated with fertilisation). No other recent incidents affecting water quality have been reported to WRFT.

5.4.2 Acidification

In some parts of Scotland – particularly in Galloway – acidification has caused major problems for salmon and trout populations. Rainwater is naturally acidic. Normally the buffering of dissolved organic matter in the water prevents dangerously low pH. But in winter, when the amount of organic matter is lowest, problems may occur. Where rainwater runs off hills of sandstone or granite, pH can fall during winter spates to levels where eggs, alevins and fry may be damaged (below pH 5.5).

As part of an AWCFT (Association of West Coast Fisheries Trusts) collaborative project, five potentially acid-sensitive burns within the Carron catchment were tested in the winter of 1997–1998. Of these, the Fionn Abhainn and the River Lair were found to be acid sensitive. Both these rivers run off a mountainous terrain with peaks of quartzite and gneiss exceeding 900m. However, the Allt Coire-Crubaidh, River Carron above Loch Sgamhain and River Taodail were all found not to be acid-sensitive.

Cages for producing farm salmon smolts in Loch Sgamhain *(Peter Cunningham)*

In November 2003, invertebrate samples were examined from the Allt Coire Crubaidh, the River Carron above Loch Sgamhain, River Carron below the confluence of the Allt Coire Crubaidh and Fionn-Abhainn. Both the relative abundance and the diversity of larval stonefly and mayfly species were highest in the Allt Coire Crubaidh and River Carron above Loch Sgamhain, and lowest in the Fionn-Abhainn.

5.5 Redd washout

One of the possible freshwater problems for Carron salmon and sea trout is the effect of winter spates washing out the gravel redds where salmon and sea trout have laid their eggs. This problem may be becoming more acute because of an increase in the intensity of winter spates in recent years. As part of a study to investigate problems of 'redd washout' in Wester Ross during the winter of 1998–99, a total of 79 artificial redd sites were created in the 18 major river systems in the WRFT area.

Within the River Carron, five artificial redd sites were set up, three in the mainstem river, one in the lower Fionn-Ambainn, and one in the Allt Coire Crubaidh below the A890 road bridge. At the end of November 1998, bone beads of two different sizes, attached to lengths of nylon secured to pegs, were buried at two different depths (15cm and 30cm) within the substrate, to simulate buried ova of salmon and sea trout respectively. By early April, bone beads had been 'washed out' of the gravel at all sites. This study indicated that, compared with sections of some other rivers, such as the Little Gruinard and Kerry, spawning gravels in the Carron were relatively unstable. Salmon and sea trout eggs or alevins would be relatively more vulnerable to redd washout. Further details of the study can be found in Butler (1999) WRFT Annual Review 1998–1999.

Alder trees provide shade and bank stability, Allt Coire a' Bhainidh *(Peter Cunningham)*

5.6 Bank-side vegetation

5.6.1 Native trees and shrubs

Bank-side vegetation has several important functions in the freshwater production of juvenile salmon and trout. Deciduous leaf litter fertilises the stream, providing vital organic input which in turn enhances aquatic insect life, and hence food for young fish. Terrestrial insects falling on to the water from bank-side vegetation also provide an additional food source for fish, particularly during the latter part of the summer. Alders, aspen and some willows are generally regarded as being particularly valuable for riparian areas. Their roots and limbs provide shade and cover for parr, and also reinforce banks, limiting erosion and collapse.

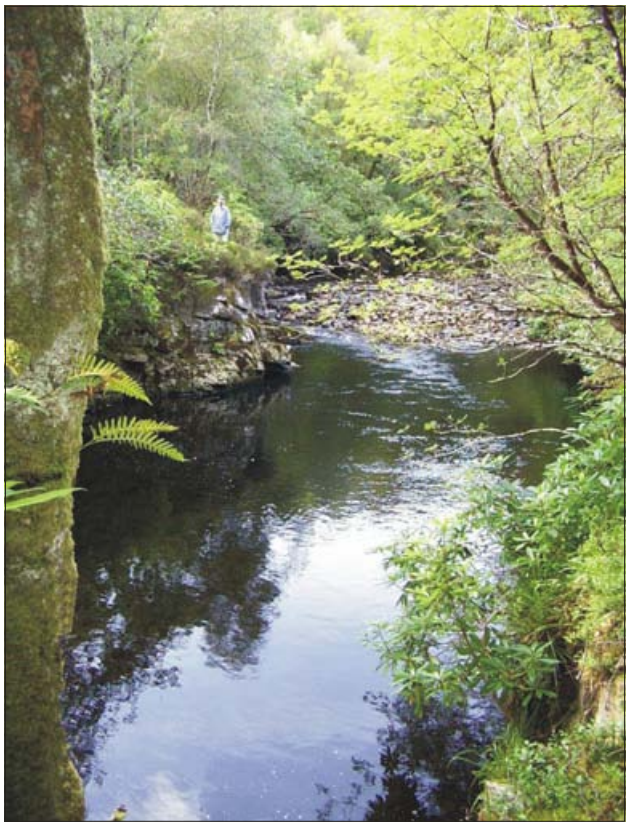
Table 5.4 Accessible parts of Carron system with overhanging trees (1998)

Watercourse	Accessible area (m^2)	Area covered (m^2)	%
Mainstem	283,822	65314.8	27.3
Fionn-abhainn	24,660	1660.5	6.7
Allt Coire Crubaidh	12,130	4993.0	41.2
Lair	4,300	3010	70.0
An leth-alt	2,620	1210.5	46.2
Coire a'Bhainidh	5,300	1810	34.2
Taodail	16,160	2758	17.1
Allt a'Chonais	14,840	4560	30.7
Alltan na Feola	7,630	0	0
Other tributaries	1,840	529.5	65.0
TOTAL	**373,302**	85846.3	26.1

Excessive shading can restrict the growth of aquatic algae and other plants upon which certain important species of aquatic invertebrate feed. Therefore, a mixture of open (especially riffles) and shaded (especially pools) areas is usually considered to provide the best combination of habitats for production of juvenile salmon and trout. Overall, the Carron has a good combination of habitats along both the mainstem and tributary streams. Some of the areas where restoration of riparian bushes could help to stabilise banks, provide rooty pools for fish cover and additional food during summer months are described in Part 8.

5.6.2 Invasive non-native plants

Rhododendron ponticum is spreading in the Carron valley, particularly from around the Achnashellach and Glencarron Lodge areas. They grow along river banks in several places, particularly in the gorge below Glencarron Lodge, and along the north shore of Loch Dughaill. *R. ponticum* can create dense shade and toxins (phenols) from their leaves and roots can accumulate within the soil, preventing growth of other plants for up to 10 years or more following removal of the living plant. Honey produced in areas with high densities of flowering *ponticums* can be toxic. The need to control *R. ponticum* is discussed in Part 8.



Pool in River Carron above gorge, with overhanging *R. ponticum* bush *(August 2002, Peter Cunningham)*

5.7 Predation of juvenile salmon and trout

A river can support only a finite number of fish. Under normal conditions, the growth of juvenile fish exceeds the available food supply and habitat space within the river. Surpluses of fry and parr are produced as weaker individuals are out-competed by faster-growing stronger individuals. Weaker fish are displaced from areas of prime habitat – providing food for predators. Juvenile salmon, trout and eels are a natural part of each other's diet and that of Red-breasted merganser, goosander, cormorant and heron. However, as long as densities of juvenile salmonids are near the carrying capacity of the system, the overall impact of bird predation on smolt production is likely to be minimal.

However, where the carrying capacity of the system has not been reached, predation may be a problem. Studies on the River Dee have indicated that migrating smolts may be particularly vulnerable to predation by mergansers as they head towards the sea. Although it is likely that the smaller, weaker smolts are most vulnerable, the full extent of predation has been difficult to judge.

The RSPB or SEERAD's Fisheries Research Services can advise on protocols for monitoring numbers of fish-eating birds. Licenses to shoot mergansers may be obtained from the Scottish Executive by salmon fisheries boards if there is good reason to believe that a problem exists.

Where there is evidence that predation by seals is a problem, a variation on the employees' firearms license may be obtained to enable seals to be shot in season.

5.8 Conclusions

- **Freshwater habitats within the Carron system have been altered by forestry operations, gravel extraction, grazing pressures and discharges from smolt production cages in Loch Sgamhain. Nevertheless the area accessible to salmon and sea trout, comprising 156,360 m² of riverine habitat, provides good habitat for both trout and juvenile salmon and generally remains in a healthy state.**

- **By area, 64% of the available in-stream habitat for juvenile salmon and 85% of the available salmon spawning habitat is within the mainstem River Carron. Spawning areas in some parts of the River Carron, particularly the river around Achnashellach and the lower river below Arineckaig may be subject to redd-washout during peak flows in late winter with bedload transportation of large quantities of gravel, pebbles and cobbles.**

- **Water quality remains generally good. However, the River Lair and the Fionn-abhainn were both found to be acid-sensitive. Other streams, including the Allt Coire Crubaidh, Taodail and Carron above Loch Sgamhain, were not found to be acid-sensitive. A toxic algal bloom in August 2003 within and below Loch Sgamhain may have been associated with elevated phosphorus levels.**

- **Bank-side habitat is also good, with extensive riparian woodlands of alder and other native trees. The spread of *Rhododendron ponticum* within the catchment may be of concern because of the toxins associated with Rhododendron leaf litter and woody debris.**

- **Numbers of mergansers, goosanders, cormorants and seals should be monitored by river owners (with support from RSPB) if a problem is suspected. Observations of predator damage on rod-caught fish should also be recorded. Water quality remains good. Bankside habitat is also good, with extensive riparian woodlands of alder and other native trees. The spread of Japanese knotweed along river banks should be monitored, but probably does not represent a threat to the productivity of the river (although it is an inconvenience to anglers). The spread of *Rhododendron ponticum* within the catchment may be of greater concern because of the toxins associated with *Rhododendron* leaf litter and woody debris.**

- **Given the present depleted state of salmon and sea trout stocks, numbers of mergansers, cormorants and seals should be monitored by river owners (with support from RSPB) if a problem is suspected. Observations of predator damage on rod-caught fish should also be recorded.** ❑

Part 6:
Freshwater Production of Juvenile Salmon

6.1 Methods

To assess the status of the Carron system's juvenile salmon stock, electro-fishing surveys were carried out in the autumn of 1997, 1998, 2000 and 2002. Two forms of surveying were used: quantitative and semi-quantitative (timed). Quantitative electro-fishing involves closing off a section of juvenile habitat with nets and removing the fish within that section. Once the area of water has been measured, an estimate of the density of fish is made. Semi-quantitative surveys involve timed fishing for a short period of time at a large number of sites. The results give an index of the distribution and abundance of fish over a wider area.

In 1986 the FRS Freshwater Fisheries Laboratory survey established 6 quantitative sites. Three of these sites were re-visited in 1992, and in 1995 and 1996 all 6 were surveyed by the Seafield Centre, Kishorn. These 6 sites and a further quantitative site were used as the basis of WRFT surveys in 1997, 1998, 2000 and 2002. In 2000, 37 semi-quantitative sites were established. In 2002, 5 of these semi-quantitative sites were surveyed, and a further 7 semi-quantitative sites were added.

6.2 Densities of juvenile salmon

The results of the FRS and Seafield surveys in 1986, 1995 and 1996 are shown in comparison with the WRFT results for the same sites in 1997, 1998, 2000 and 2002 (Figure 6.1). Although the levels of fry and parr fluctuate between years, it is clear that the densities of fry and parr after 1995 have never reached the levels observed in 1986. The high level of fry observed in 1998 was partly a consequence of the extremely high number of fry (110 per m^2) caught at the electrofishing site on the Allt Coire Crubaidh only 19 days after 4000 fry were released there by the Seafield Centre. In 2000 no salmon stocking took place; this was also a year of very poor fry numbers. The lack of stocking does not completely explain the low numbers in 2000, as electrofishing sites far away from stocked areas also had reduced fry densities that year. In 2002 the slightly improved numbers of fry recorded may have partly been a consequence of stocking at two electrofishing sites, but two other sites, outwith the stocking areas, had fry densities of up to 28 fry per m^2. Details of stocking in 2002 are given in Section 4.

Parr stocking has been less common than fry stocking, so the parr densities recorded can be used to examine the survival of wild and stocked fry into the following year.

Juvenile salmon from the River Taodail, September 2002. Salmon parr are territorial and their markings are primarily for display to other fish rather than for camouflage *(Peter Cunningham)*

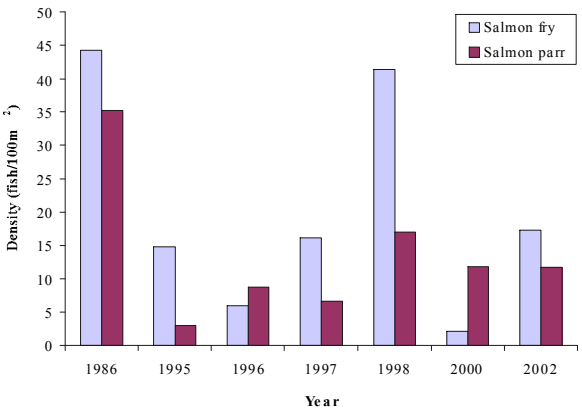


Figure 6.1 Average densities of salmon fry and parr found at 6 quantitative electrofishing sites in 1986, 1995, 1996, 1997, 1998, 2000 and 2002. The WRFT (13 rivers, 1999) average densities of salmon fry and parr were 26 and 10 fish per 100m^2 respectively

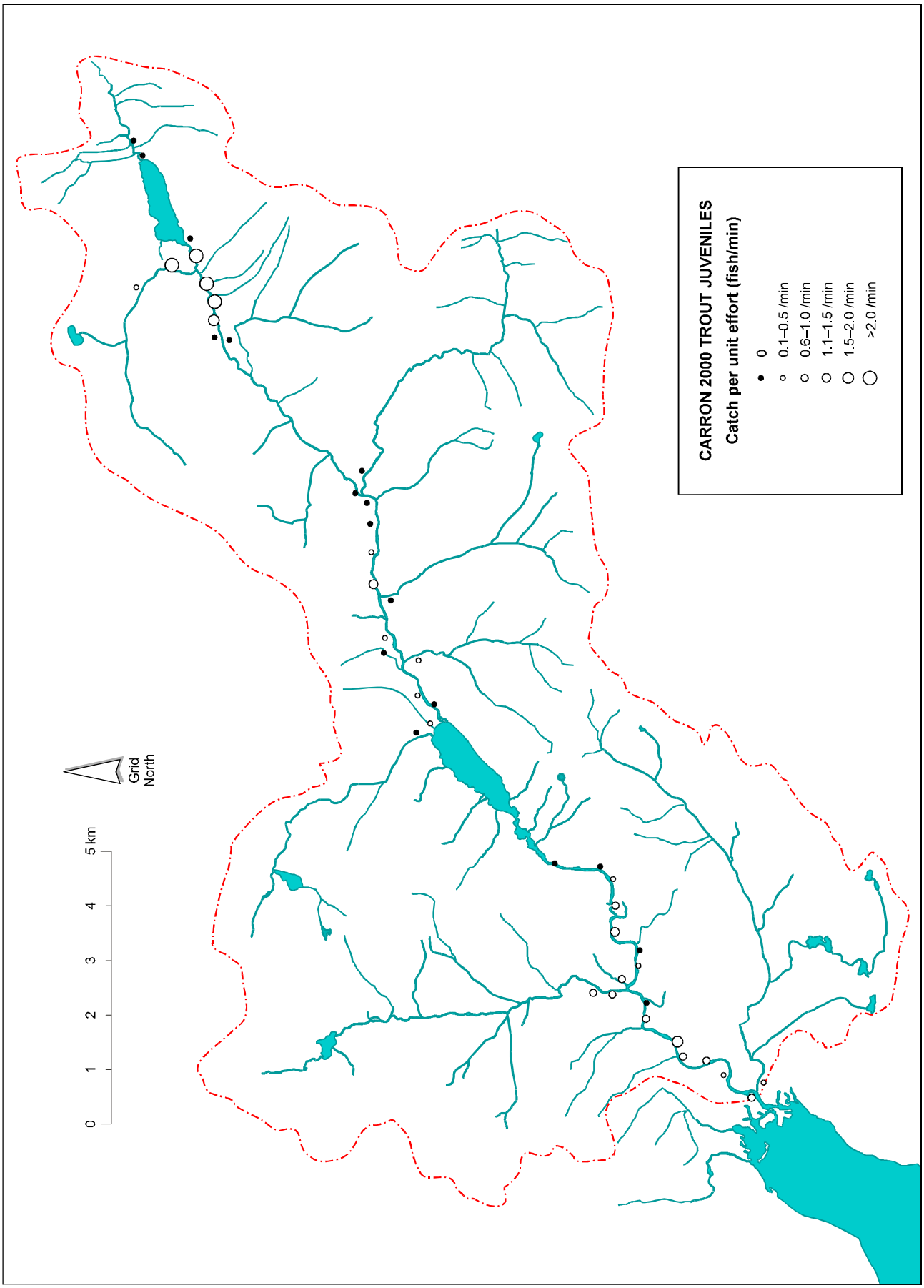


Figure 6.2 Distribution and abundance of salmon fry in the River Carron catchment in 2000, estimated from 44 quantitative and semi-quantitative electro-fishing sites *(Crown Copyright)*

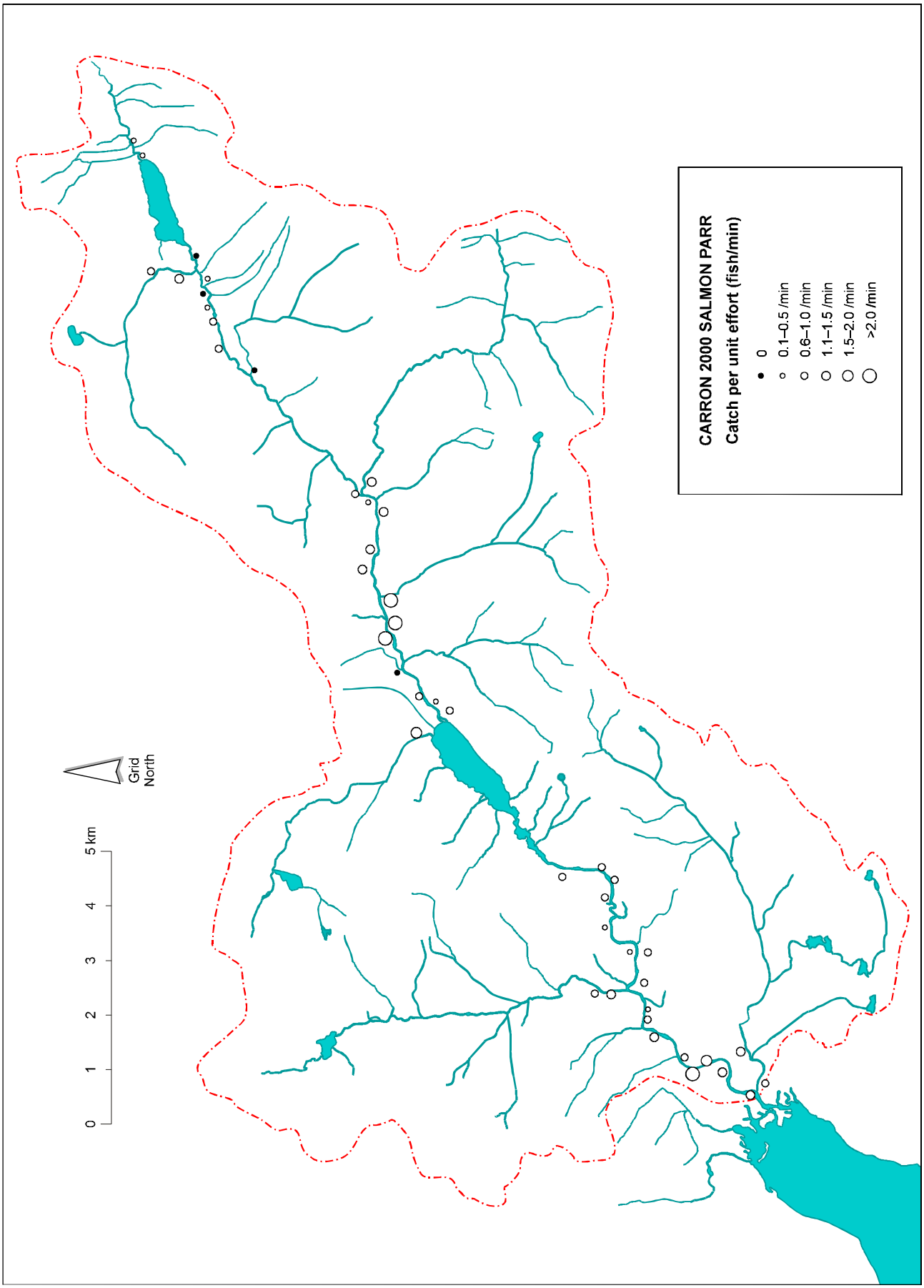


Figure 6.3 Distribution and abundance of salmon parr in the River Carron catchment in 2000 estimated from 44 quantitative and semi-quantitative electro-fishing sites *(Crown Copyright)*

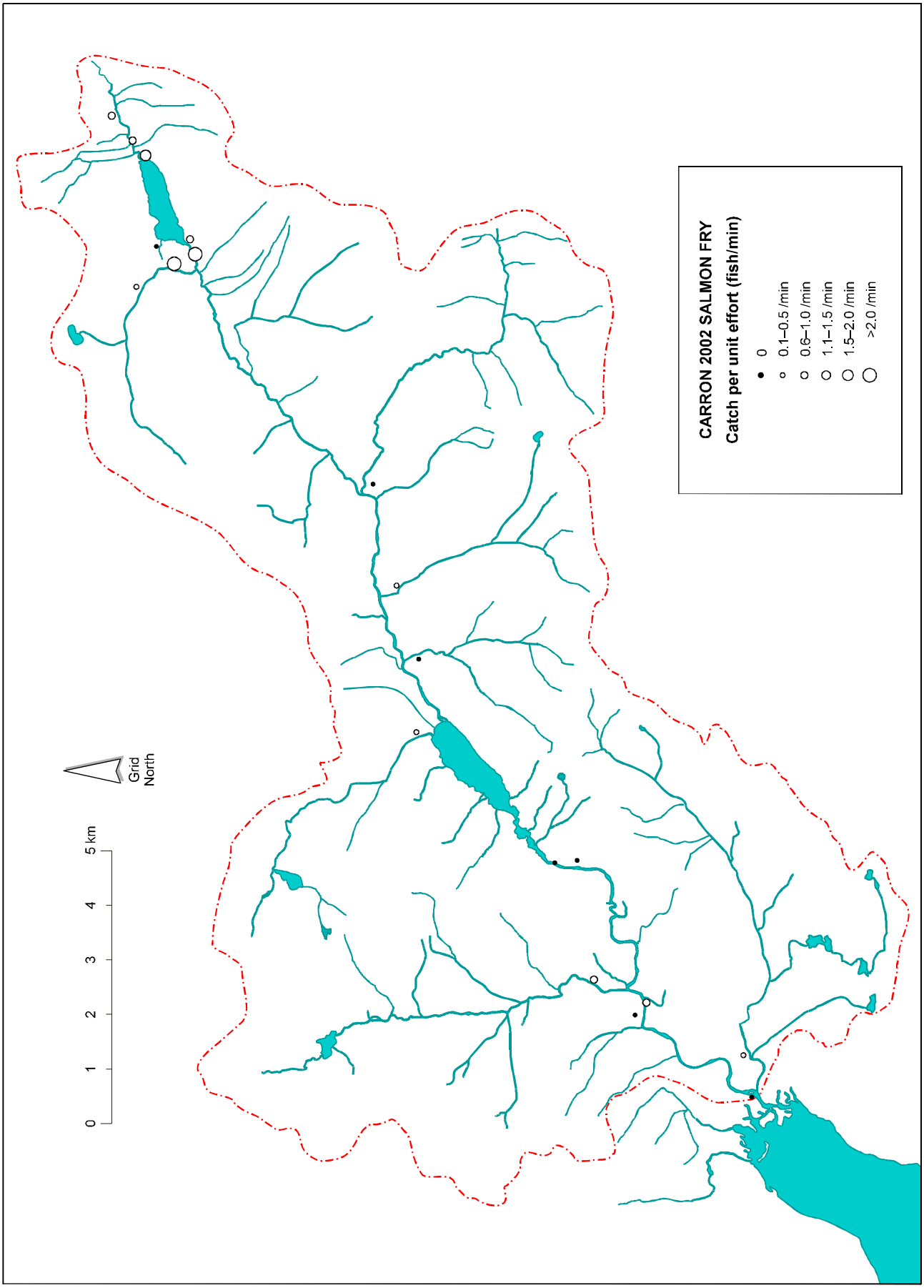


Figure 6.4 Distribution and abundance of salmon fry in the River Carron catchment in 2002, estimated from 19 quantitative and semi-quantitative electro-fishing sites *(Crown Copyright)*

Although the parr densities have not returned to those observed in 1986, it is encouraging to see that they have increased in recent years relative to the densities observed in 1995-97.

6.3 Distribution of juvenile salmon

The timed surveys in 2000 and 2002 gave an indication of juvenile salmon distribution throughout the catchment. As no salmon fry stocking took place in 2000, we can be confident that concentrations of salmon fry can be used to identify areas where successful spawning had occurred the previous year. The distribution was moderate, with 59% of the 44 sites surveyed having fry present (Figure 6.2). The abundance of fry at these sites was poor (only 18% of sites having over 1 fry per minute). The best numbers were found in the Upper Carron and Allt Coire Crubaidh.

However, it has to be remembered that 2000 was a poor year for salmon fry relative to the other years examined by quantitative sampling (Figure 6.1).

In the 2000 survey, salmon parr were found at 40 of the 44 sites surveyed (Figure 6.3). Densities were highest in the section of river near Craig in the Achnashellach Forest. Salmon parr may move both upstream and downstream away from spawning areas.

In 2002, 19 timed sites were used to examine distribution within the catchment. The quantitative surveys showed that fry densities were higher than in 2000. The distribution was slightly improved, with 63% of sites having fry present (Figure 6.4). The abundance of fry remained poor (89% having less than 1 fry per minute). Once again the highest densities were found in sites above the confluence with Allt na Feola.

6.4 Age structure of juvenile salmon

By reading scales taken from juvenile salmon caught during the surveys, it was possible to examine the age structure of the population (Figure 6.5). The age structure suggests that most fish leave the river as smolts after 2 years and some after 3, few 3+ parr were found.

Figure 6.6 shows the length–frequency distribution of juvenile salmon caught during electro-fishing surveys. There has been much variation from year to year in the relative proportions of different sizes of fish. This may relate to the relative strengths of different year classes, but our data is not adequate to determine this further. This figure also includes data for 2002: note the relatively high proportions of smaller fish (0+ fry) recorded during that year, following extensive stocking. This may relate to

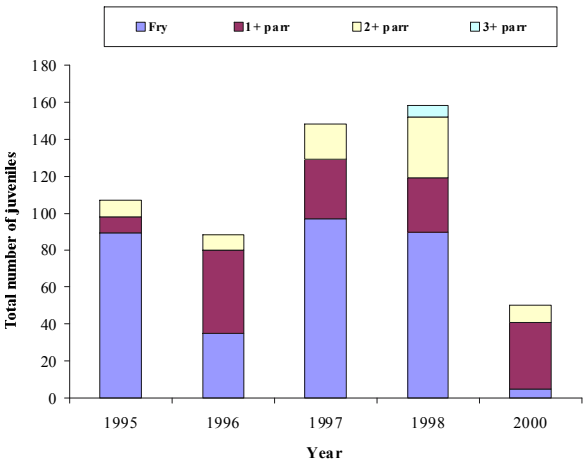


Figure 6.5 Between year comparison of the population structure of juvenile salmon in the Carron system

locally high fry densities at a few sites where the carrying capacity was exceeded and food availability limited growth. Refer to Appendix 1 for further details.

Figure 6.7 shows the overall mean densities of juvenile salmon and trout recorded during electro-fishing surveys in comparison to the numbers of salmon and trout stocked. Although there is no clear relationship between numbers stocked and fish densities, this is partly because the electro-fishing sites established in 1986 are not necessarily in places where the largest numbers of fish have been stocked. Future stocking and electro-fishing surveys should be planned together to enable comparative monitoring of progeny of both wild spawnings and stocked fish.

6.5 Spawning targets for salmon

Long-term research into the Atlantic salmon has led to the development of new management techniques. One such technique is the setting of spawning targets. Every river has a natural carrying capacity for juveniles, based on the accessible area available to spawning adults. By calculating the minimum number of salmon eggs required to saturate the accessible area with parr, and therefore maximise the output of smolts, it is possible to assess from runs of adult fish whether the river is reaching its natural potential. The result of this assessment can then be used to guide fisheries management decisions. Spawning targets are now being recommended by NASCO as a simple method for managing salmon populations on a river-by-river basis, and are currently used in England and Wales, Canada and the USA.

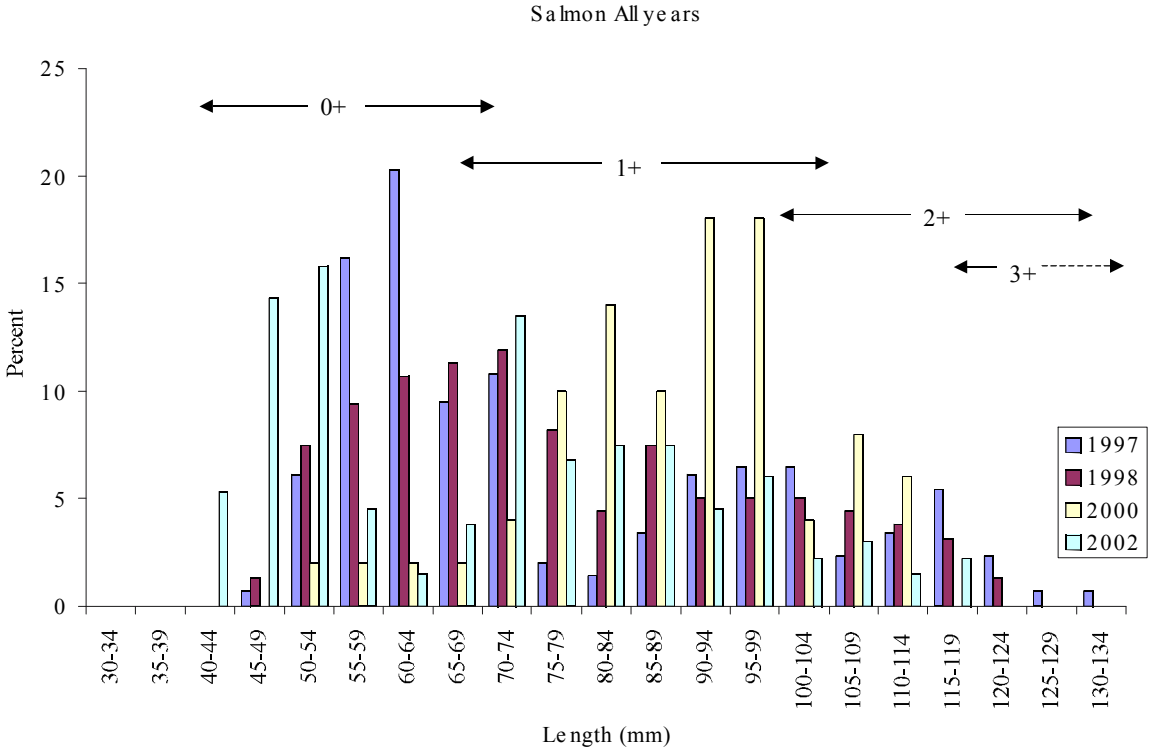


Figure 6.6 The length–frequency distribution of juvenile salmon caught during electro-fishing surveys

The calculation of spawning target begins by estimating the minimum number of eggs (the 'egg target') required to produce the carrying capacity of fry, parr, and smolts in the accessible river habitat (see Appendix 3). For the Carron, at least 970,585 eggs are needed to saturate the accessible riverine area of 373,302 m² (Table 6.1). Using typical egg–smolt mortality rates it can be estimated that, if the egg target has been reached, the riverine habitat should produce a maximum of approximately 16,507 salmon smolts.

Production of salmon smolts from lochs is more difficult to estimate, and varies according to loch fertility and competition/interactions with other fish species, particularly trout. During periods in the past when the sea trout population was strong, the 'niche' available to juvenile salmon would be smaller than during periods with weak runs of sea trout.

- **Further research is required to learn about the production of juvenile salmon and other fish from lochs in Wester Ross.**

The egg target can then be translated into the number of female salmon needed to lay the required quantity of eggs. A female salmon produces approximately 1,250 egg per kg. If the average weight of Carron salmon is 3 kg (6lb 9oz), then one salmon produces approximately 3,750 eggs. Thus, a run of at least 180 hens is required to reach the egg target of 970,585, plus a further 180 males to

Table 6.1 Calculation of the minimum target of salmon eggs required to maximise the smolt output from the accessible area of the Carron catchment

Water body (riverine habitat)	Accessible (m²)	[1]Min egg target	[2]No of salmon	[3]Max smolts
Main-stem	283,822	737,937	197	12,550
Fionn-abhainn	24,660	64,116	17	1,090
Allt Coire Crubaidh	12,130	31,538	8	536
Lair	4,300	11,180	3	190
An leth-alt	2,620	6,812	2	116
Coire a'Bhainidh	5,300	13,780	4	234
Taodail	16,160	42,016	11	715
Allt a'Chonais	14,840	38,584	10	656
Alltan na Feola	7,630	19,838	5	337
Other tributaries	1,840	4,784	5	81
Total	373,302	970,585	259	16,507

Notes:
1 2.6 eggs/m²
2 3750 eggs per spawning pair
3 one smolt per 58.8 eggs

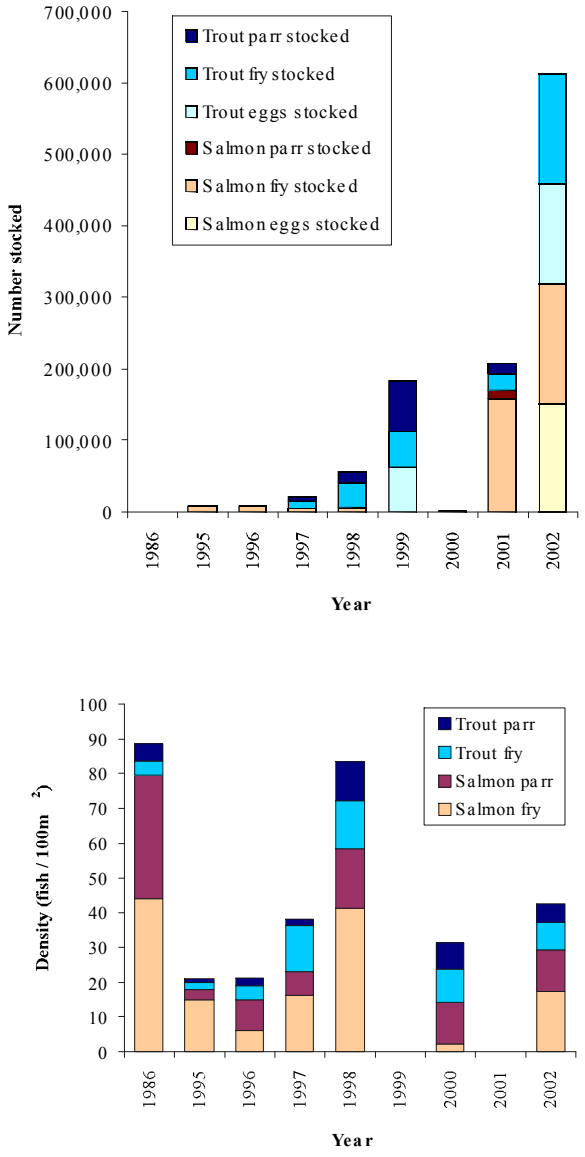


Figure 6.7 Densities of juvenile salmon and trout recorded during electro-fishing surveys (below) in comparison to numbers of fish stocked into the system for corresponding years. Note that there were no surveys in 1999 and 2001

fertilise them, giving a minimum spawning target of approximately 259 salmon.

This minimum level is termed the 'Minimum Biological Acceptable Limit' (MBAL), and is effectively the carrying capacity of the river. To create a safety margin and allow for losses of adults from disease and predation, or loss of eggs due to redd washout, an overestimate is made of the number of adults required (see Appendix 3). This overestimate is the Management Level (ML). The FRS uses a safety margin of 15%, and for the Carron, the ML is therefore 298. Given the possible problems with redd washout in some years, it would be judicious to use this or a higher target instead of the MBAL.

Without a fish counter it is impossible to measure the annual run of salmon into the Carron. However, extensive research on rivers in England and Wales that do have fish counters has shown that on average 15% of salmon are caught on rod and line. The same average figure has been calculated for the River Awe (Argyll) using a counter. Taking this figure, the annual Carron rod catch of wild salmon has been translated into a crude estimate of the total run for each year from 1970 to 2001. After deducting the fish caught and killed, the annual wild escapement (i.e. fish that survived to spawn) can be calculated and compared with the MBAL and ML spawning targets (Figure 6.8).

Rod catches suggest that from 1983–1994 both the spawning targets were attained. However, from 1995–2002 neither spawning target appears to have been exceeded. This interpretation should be treated with caution, especially if fishing effort has varied greatly from year to year.

Given the above precautions, from these analyses the size of the spawning population appears to have collapsed in the mid-1990s. Corresponding production of juvenile fish from natural spawnings in the river is likely to have been limited by a shortage of spawning adults, and perhaps also by redd washout in some sections of the river. The low fry densities in 2000 may be a reflection of this lack of spawning fish; the higher densities in 2002 may be a reflection of recent stocking by Seafield Centre on a large scale.

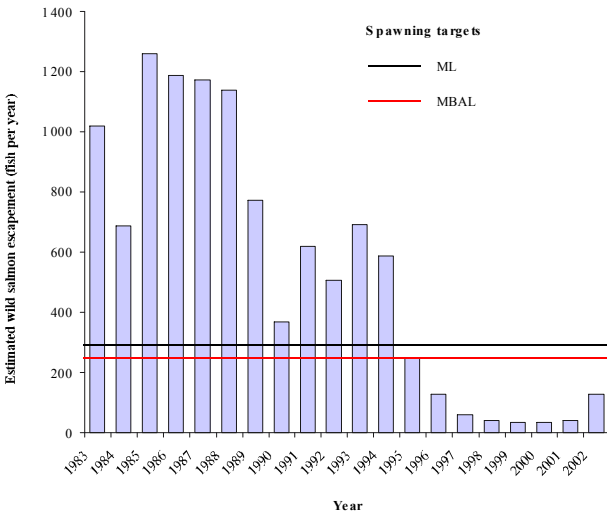


Figure 6.8 Estimated annual runs of Carron wild salmon based on rod catches, 1983–2002, relative to the minimum acceptable biological limit (MBAL) and recommended management level (ML) spawning targets to ensure adequate egg deposition

- **A similar decline has been recorded in fisheries in neighbouring rivers. Although the primary problems for salmon are understood to relate to changes in marine survival, other factors that are common to several watersheds within the area may have also affected production. Washout of eggs, fry and invertebrate larvae (food for fry and parr) from the riverbed may also have increased in recent years (see Part 5). Some of the most productive salmon habitats in Wester Ross are river sections downstream of lochs (e.g. Gruinard, Little Gruinard, Ewe, Kerry) where flows tend to fluctuate less widely and streambeds are more stable.**

However, another possibility is that the native salmon population in the Carron suffered a high degree of genetic introgression during the 1990s, with salmon of farm origin (escapes from Loch Sgamhain cages, or from farms in the sea) outnumbering native fish at spawning times and /or hybridising with native fish. In one study, the progeny of escaped farm salmon were shown to outgrow and potentially to out-compete native wild fish in freshwater. In the same study, whole life cycle survival rates of farm fish were less than 5% of the survival rates for native fish (McGinnity *et al*., 2003)*.

6.6 Conclusions

- **Electro-fishing surveys (1997–2002) indicated that juvenile salmon were distributed throughout the accessible part of the main-stem. The distribution of salmon parr was more even in space (from site to site) and time (from year to year) than that of fry. This may reflect the patchiness of spawning habitat and the vulnerability of salmon redds in some areas to 'redd washout' where eggs and alevins are swept away by large winter spates.**

- **From electro-fishing surveys, it has not been possible to assess the extent to which stocked fish contributed to a wider distribution and higher densities of juvenile salmon. Future electro-fishing surveys should be planned to provide clearer information on both the distribution and densities of progeny from wild spawnings and to be able to monitor the progress of stocked fish and eggs.**

- **The maximum salmon smolt output is estimated to be 16,507 (excluding an unknown number from lochs) based on a target egg deposition of 970,585 eggs. This translates to a Minimum Biologically Acceptable Spawning Limit spawning target of 259 adult salmon, and a Management Level of 300.**

- **Catch records suggest that salmon spawning targets were exceeded each year until 1994. However, from 1995-2002 numbers of returning salmon appear to have been very low, with a high proportion of farm salmon. It is therefore likely that the native salmon population has suffered genetic introgression from escaped farm fish.**

References

*McGinnity, Philip *et al.* (2003) *Fitness Reduction and Potential Extinction of Wild Populations of Atlantic salmon Salmo salar as a Result of Interactions with Escaped Farm Salmon.* Proceedings Royal Society London B. DOI 10.1098/rspb.2003.2520. Available online at http://www.pubs.royalsoc.ac.uk/proc_bio/proc_bio.html ❑

Part 7
Freshwater Production of Juvenile Trout

7.1 Densities of juvenile trout

The electro-fishing surveys carried out in 1997, 1998, 2000 and 2002 (see Part 6) were also used to assess the juvenile trout population. The results of these surveys are shown in comparison with the FRS surveys of 1986, 1992 and Seafield Centre surveys in 1995 and 1996 (Figure 7.1). On average the densities of fry were low until 1997, when they increased markedly. In both 1997 and 1998, this increase can partly be explained by high densities of fry at electro-fishing sites on tributaries less than three months after fry were released by the Seafield Centre. Although the absence of fry restocking coincided with a slight dip in fry numbers at the electro-fishing sites in 2000, the annual average was still high relative to the first three surveys. In 2002 more than 130,000 trout fry were planted out in the Carron system before electro-fishing began, yet this did not appear to influence electro-fishing densities. The fry released into the mainstem may have spread from the release site and therefore caught in lower densities during electro-fishing.

Parr densities increased in 1998 and in recent years have decreased to a level similar to that observed in 1986. Parr have been used less consistently for stocking so the parr densities generally give a good indication of the survival of wild and stocked fry from the previous years.

Caution should be taken when interpreting changes in trout densities. It was not possible to distinguish juvenile sea trout from juvenile resident brown trout and therefore it was not possible to establish whether improved densities were a consequence of improved sea trout spawning, increasing resident trout population or stocking. Furthermore, many of the electro-fishing sites tend to be in relatively shallow habitat with fast-flowing water over pebbles or cobbles where juvenile salmon may be able to out-compete juvenile trout.

7.2 Distribution of juvenile trout

In the 2000 timed survey, trout fry were recorded at 59% of the sites examined (Figure 7.2). Abundance within these sites was low, with only 5% of all sites having over 1 fish per minute. Older trout were found at 54% of the sites examined (Figure 7.3). Fry were better distributed in 2002, being found at 89% of the 19 sites surveyed (Figure 7.4). The densities at these sites were also an improvement on 2000, with 11% of sites having over 1 fish per minute. The relationship between stocking and densities

In many river systems in Wester Ross, sea trout smolts (top) tend to be larger than salmon smolts (bottom), especially where they spend one or more years in a loch environment prior to smolting. The extent to which trout and salmon parr interact within loch environments requires further research *(James Butler)*

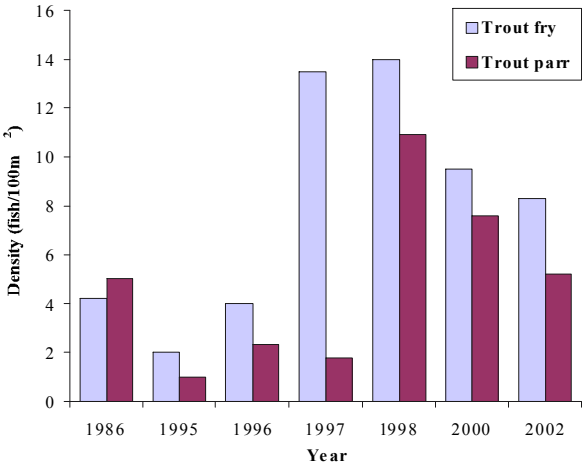


Figure 7.1 Average densities of trout fry and parr found at 6 quantitative electro-fishing sites surveyed in 1986, 1995, 1996, 1997, 1998, and 2000

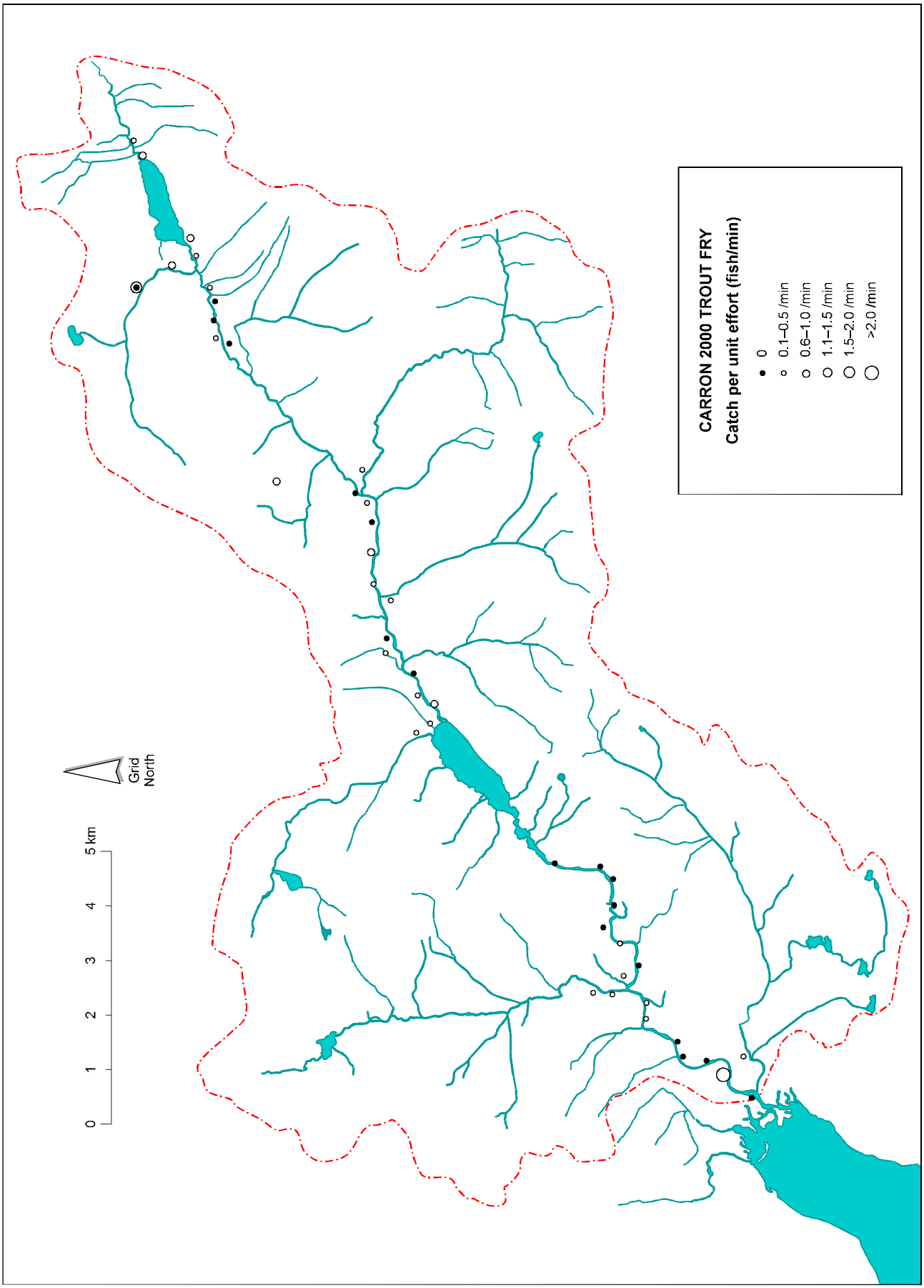


Figure 7.2 Distribution and abundance of trout fry in the River Carron catchment in 2000, estimated from 44 quantitative and semi-quantitative electro-fishing sites *(Crown Copyright)*

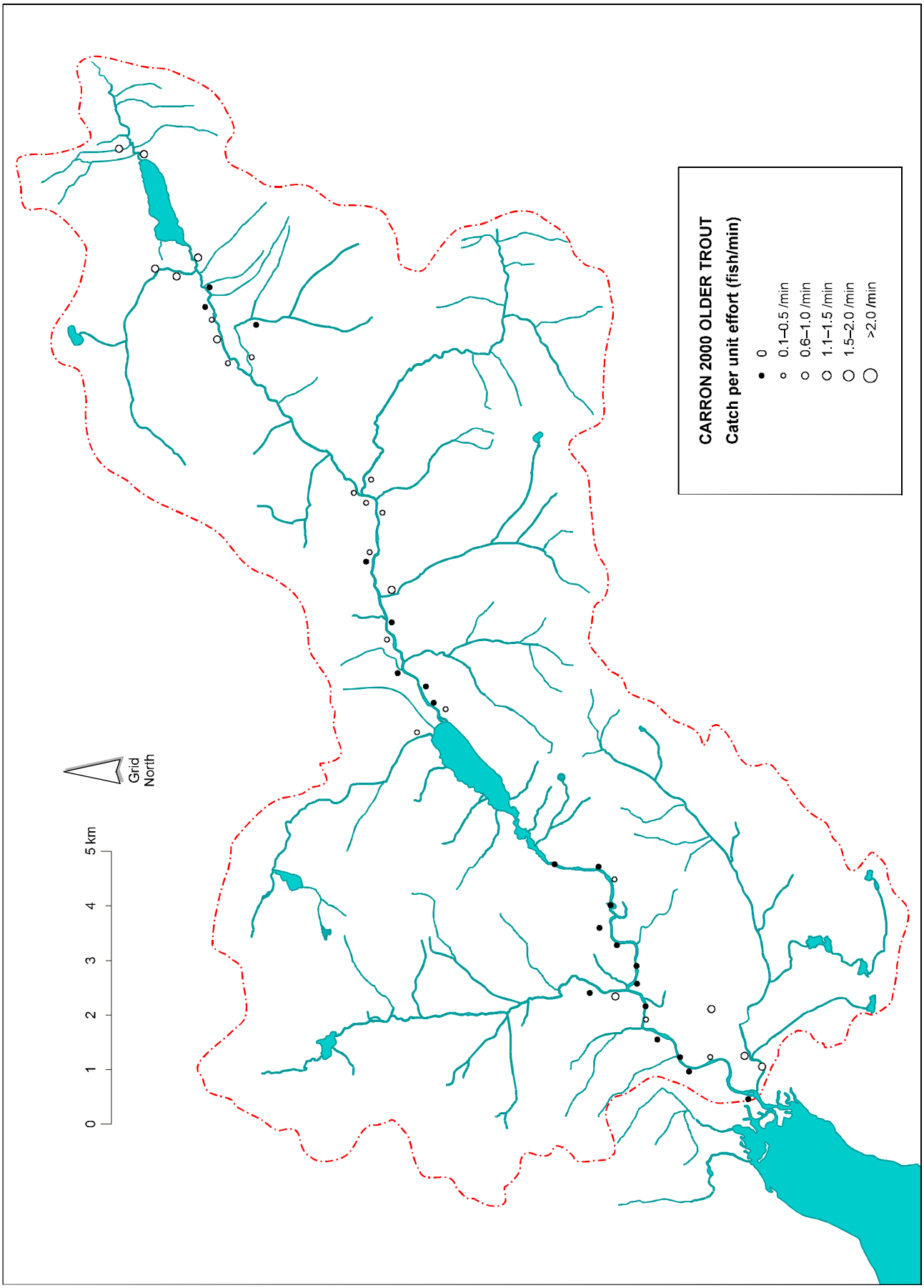


Figure 7.3 Distribution and abundance of trout parr in the River Carron catchment in 2000, estimated from 44 quantitative and semi-quantitative electro-fishing sites *(Crown Copyright)*

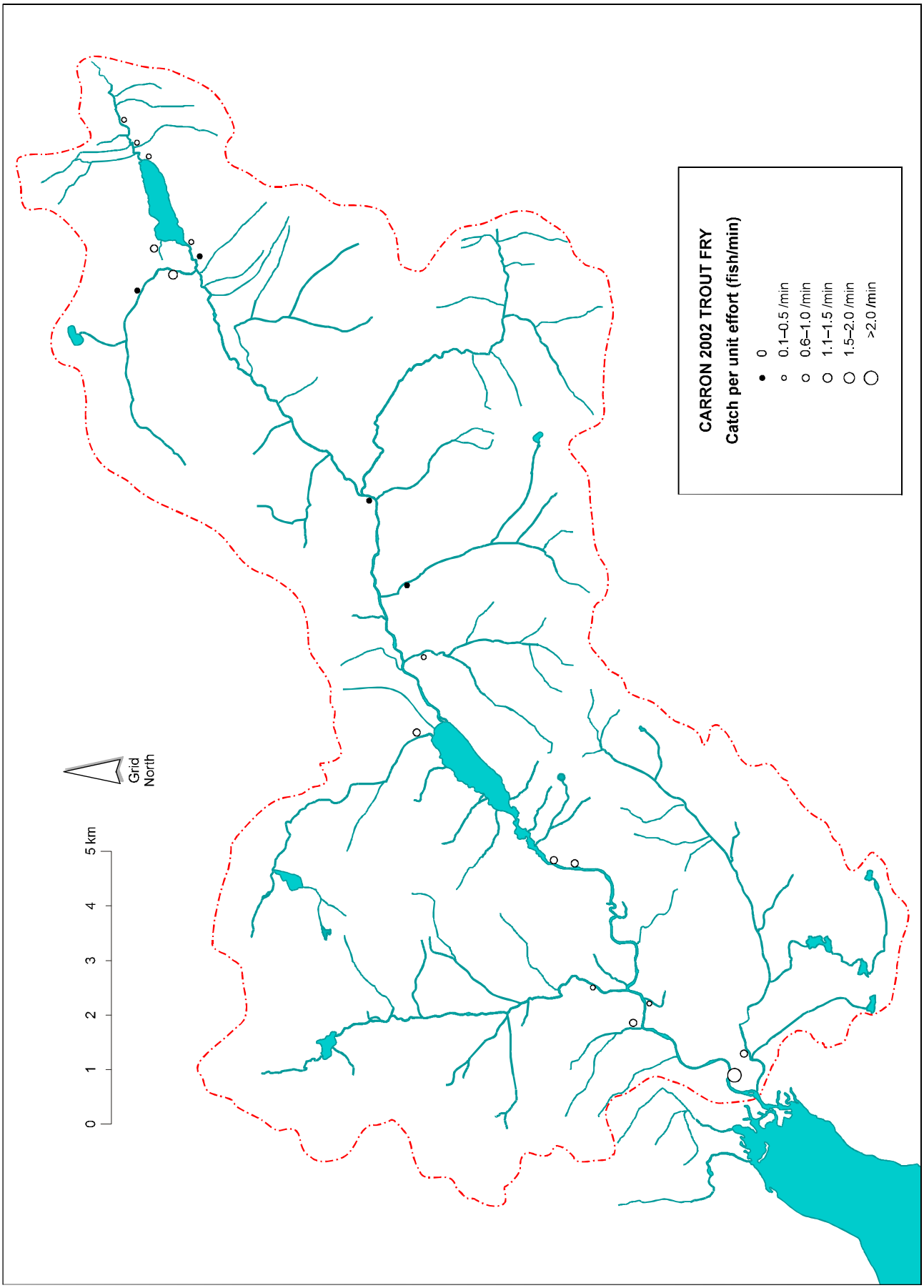


Figure 7.4 Distribution of trout fry in the River Carron catchment in 2002, estimated from 19 quantitative and semi-quantitative electro-fishing sites *(Crown Copyright)*

during electro-fishing is not clear cut, for example the electro-fishing site on the River Taodail was a release site for stocked fry and in 2002 had the highest electro-fishing densities observed. However, the same site also had high densities in 2000 when no fry were released. One main-stem site was in the vicinity of a large release of fry in 2002 yet the density during electro-fishing remained at less than 0.5 per minute. This is likely to be partly related to the type of habitat examined, which may have been better suited to juvenile salmon. Details of trout stocking in 2002 are given in Part 4 and Appendix 2.

7.3 Age structure of juvenile trout

The trout population seems to have been more stable in each year surveyed than the salmon population. The gradation of high fry numbers to low parr numbers with no obvious weak year classes contrasts with the salmon population that had very low fry numbers in 2000.

The age structure suggests that most trout leave the stream habitat after two or three years either to live in the lochs or migrate to the sea as sea trout smolts (Figure 7.5).

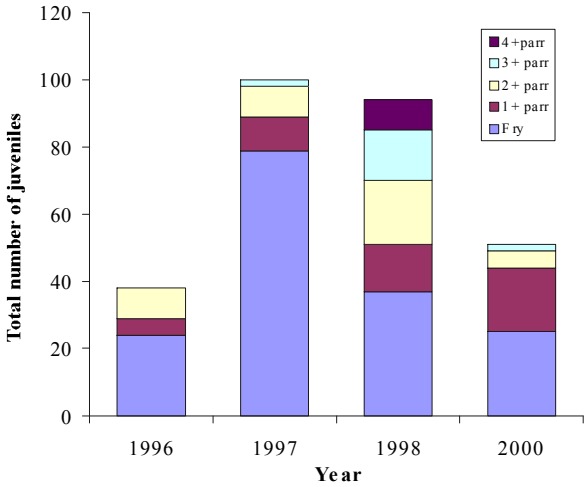
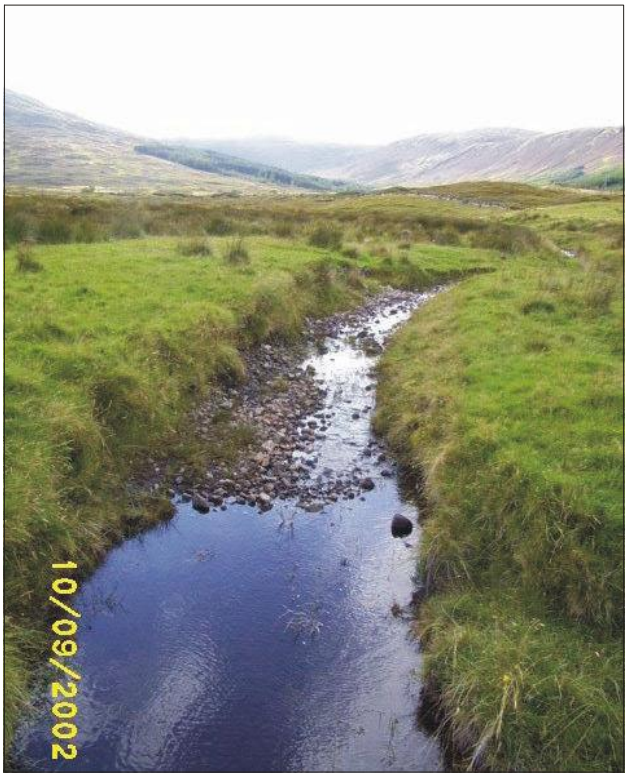


Figure 7.5. Between-year comparison of the population structure of juvenile salmon in the Carron system



Trout fry were outnumbered by minnows in this burn, which flows into Loch Sgamhain *(Peter Cunningham)*

7.4 Competition (and predation) between trout, salmon and minnows

Juvenile trout are known to be more aggressive than juvenile salmon in some situations, and competition between the two can lead to salmon displacement. However, juvenile salmon have larger pectoral fins than juvenile trout and are well adapted to life in faster water (which forms much of the riverine habitat in the Carron), where they may be able to displace juvenile trout.

Unless displaced fish are able to find vacant habitat, they are likely to become progressively weaker. Parr of both species may feed on displaced fry – especially where stocking levels have been high.

Around Loch Sgamhain, densities of minnows were particularly high. Although larger trout eat minnows, trout fry may be out-competed by minnows from some areas.

In 2000 11% of all sites surveyed had no salmon or trout fry present, so competition was not the limiting factor for expansion throughout the catchment at this time. By 2002 all of the 19 sites surveyed had fry present, either one or both species. The 2002 survey showed that, overall, salmon outnumbered trout in the river system. Although there were a small number of larger trout, the majority of the juvenile trout surveyed were between 50 and 80mm, smaller than many of the salmon parr (Figure 7.6). This suggested that salmon parr were not suffering competitive displacement by trout.

Trout stocking should be carried out sensitively to minimise competitive interaction with juvenile salmon, targeting areas where there are the largest areas of vacant 'trout' habitat (smaller streams and ditches adjacent to slower- flowing areas and loch margins).

7.5 Conclusions

- **Densities of trout fry at electro-fishing sites were higher in 1998, 2000 and 2002 than in 1986, 1996 and 1997. Although this appears to be related to the stocking programme by Seafield Centre from 1997 onwards, in 2000 there was no stocking so the occurrence of fry at some sites can only have been a result of natural spawning.**

- **Further work is required to determine levels of juvenile trout production in still water habitats within the River Carron catchment, including Loch Sgamhain, Loch Dughaill and larger pools in the main-stem.**

- **Carrying capacities for juvenile trout and salmon may have been reached or exceeded at some of the stocked electro-fishing sites in some years. To learn more about the benefits and overall consequences of stocking, including interactions between species, closer monitoring is required.** ❑

Part 8
The Fisheries Management Plan, 2004–2008

8.1 Introduction

So far this report has described the Carron catchment and its accessible area, and assessed the stocks of salmon and sea trout and the factors limiting their abundance. The following section puts forward recommendations to rectify those problems that are within the control of the river owners. These are summarised in Table 8.1. Their primary aim is to restore and enhance natural production of juvenile trout and salmon. If successful the measures taken will improve the economic value of the fisheries. They will also contribute towards SNH's obligations to conserve the Atlantic salmon and other species and habitats listed in the EU Habitats and Birds Directive and in the Wester Ross Local Biodiversity Action Plan which occur in the riverine area of the catchment. Together these proposals form the River Carron Fisheries Management Plan, designed to be carried out over the next five years.

The restoration of a prolific fishery in the Carron for sea trout may be somewhat faster than for salmon. This is for two reasons:

- The genetic integrity of Carron trout is likely to have been partly retained within the non-migratory population. The salmon population may have experienced greater loss of fitness as a result of genetic introgression via hybridisation with fish of farm origin. The salmon population (especially early running fish) may therefore take several salmon generations to regain former whole-life-cycle levels of fitness.

- Sea trout feed in inshore waters where local stakeholders have some influence regarding survival and growth (sea lice, food abundance, predation). Salmon migrate to distant sea areas: local stakeholders have less influence over what happens in and en route to and from the Norwegian Sea.

8.2 Summary of preceding action points

Many points and suggestions for further investigations to address fisheries problems have already been highlighted within the context of the foregoing. These are as follows:

2+ year old trout and salmon parr from the Allt a' Chonais, September 2002 The management plan aims to restore and enhance natural production of juvenile salmon and trout *(Peter Cunningham)*

8.2.1 Inshore fisheries, fish farming and wise diplomacy

Salmon and especially sea trout will benefit from good management of inshore waters.

- The potential for restoration of inshore finfish and shellfish fisheries within Loch Carron and surrounding inshore waters may be considerable. Healthy coastal fisheries will ensure an abundance of many of the varied prey items upon which salmon and sea trout feed. More effective integrated management measures may be needed to generate and sustain high yields of many species, including the designation of 'conservation areas' to protect valuable spawning grounds, nursery habitats, and to provide sanctuary for important broodfish.

- The Loch Carron–Kishorn Area Management Agreement (AMA) was established in 2001 and has the overall aim of improving the health of both farmed and wild salmonid stocks, focusing initially on improved control of sea lice (*Lepeophtheirus salmonis*) in fish farms and the elimination of associated problems for wild salmon and sea trout. Continued collaboration between fish farms and wild fisheries interests can benefit wild fisheries in many ways.

- Local stakeholders, especially those who harvest from or discharge into the marine environment, should be given encouragement and support by local authorities to form a partnership or forum within which initiatives to restore or enhance the natural biodiversity and

productivity of inshore waters can be fostered and implemented. This could be achieved through expansion of the Area Management Group to include sea fishers and others.

- Annual monitoring of juvenile sea fishes and important fish and shellfish habitats in coastal areas can help to establish changes from year to year. Some of the most important habitats are highlighted in the forthcoming Wester Ross Local Biodiversity Action Plan. During the

Table 8.1 Summary of recommendations forming the River Carron Fisheries Management Plan, 2003–2007

	Recommendation	Priority	Action	Costs/Grants
1	Reduce rates of sediment discharge into river and tributaries	high	Forestry Commission, estates.	£50,000–100,000 (fencing, revetment) Estates, SWG, SNH
2	Eradicate *Rhododendron ponticum* from catchment area.	high	Forestry Commission, estates, SNH, contractors	£100,000–300,000 to clear 20–50 ha. Forestry Commission, Estates, SWG, SNH, HLF
3	Restore riparian vegetation and flood plain habitat, esp. within Achnashellach forest.	high	Forestry Commission, estates, SNH, Trees for Life	Forestry Commission, Estates, HLF, SNH, volunteers
4	Review salmon and trout stocking programmes.	high	Seafield College, WRFT	UHI, WRFT
5	Monitor use of spawning areas by adult fish	medium	Seafield College, WRFT, estates, local anglers	UHI, WRFT
6	Recondition spawning gravels periodically where required	medium	Seafield College, estates, WRFT	Estates, UHI
7	Investigate impacts of fish farming in Loch Sgamhain and downstream areas	medium	Seafield College, WRFT, Landcatch	UHI, HIE (via AMG)
8	Investigate use of lochs by juvenile salmon and trout	medium	Seafield College, WRFT	UHI
9	Maintain catch and release policy for wild fish	high	Anglers	(none)
10	Maintain netting closures in Loch Carron	high	Estates	(none)
11	Maintain and develop AMA	high	AMG	HIE
12	Investigate lamprey population	medium	Seafield Centre, WRFT, SNH	SNH
13	Investigate minnow distribution and take action to control minnows where possible.	medium	WRFT, estates, Landcatch, Seafield Centre	UHI, SNH

Abbreviations:
WRFT Wester Ross Fisheries Trust
UHI University of Highlands and Islands
HIE Highlands and Islands Enterprise (via NW Region AMA programme)
SNH Scottish Natural Heritage
SWG Scottish Woodland Grant scheme

1970s, trawl surveys were carried out by the Scottish Executive's Marine Laboratory to investigate the local abundance of juvenile herring and sprats. Inshore fishermen, divers, and fish farm workers may also be able to gather useful information.

- To reduce any incentives for illegal fishing, it may be prudent to ensure that local communities are able to share the benefits derived from the restoration of healthy salmonid fisheries. By providing public access via a local angling club, river owners can strengthen local interest and active support for management measures aimed at restoring healthy and productive fisheries.

8.2.2 Fish farming and water quality

Nutrients discharged from cages in Loch Sgamhain may be linked to rising total phosphorus values recorded within the river.

- The availability of the nutrient phosphorus to primary producers (chiefly algae) is likely to limit biological productivity in the Carron. SEPA may be able to investigate why concentrations of Total phosphorus have increased over the past ten years and whether there may be associated impacts (positive or negative) on aquatic biodiversity (e.g. invertebrates such as stonefly and pearl mussel species) and the production of juvenile salmon and trout.

- With changes in the nutrient status of Loch Sgamhain, the nature and ecology of the trout population may have also changed. In other lochs with fish farms (e.g. Loch Damph), large silvery trout described by anglers as 'sea trout' sometimes appear from scale reading to have grown entirely within freshwater. Research is required to assess the extent to which Sgamhain 'sea trout' still migrate to sea!

These stonefly (2 tail filaments) and may fly (3 tails) larvae were found in the Allt Coire Cruibhe in November 2003 *(Peter Cunningham)*

- The outflow of Loch Sgamhain is very weedy, and supports large numbers of minnows. The extent to which minnows and juvenile trout compete for food and habitat could be investigated experimentally. It may be possible to produce larger numbers of trout fry and parr from this area by reducing the minnow population through trapping (see 8.11).

8.2.3 Integrated catchment management

The quality and productivity of the freshwater habitat is affected by management practices 'upstream' within the catchment area.

- To address problems such as those associated with erosion and streambed instability, a systematic land use (vegetation and soil) management study of the Carron catchment area would be of value. The study could aim to contrast the impacts of different land uses (e.g. forestry, sheep pasture, game) and management actions (e.g. timber extraction, muir-burn, stocking densities) upon the overall productivity, economy, biodiversity and capital value of the area. The study could be prepared in collaboration with a university (University of Highlands and Islands?) or land use research institution.

- The study might focus on how to enhance the overall value of natural resources within the area. There may be opportunities for reducing soil and nutrient wastage and for reducing the discharge of coarse sediment (cobbles and boulders) into the Carron and consequent problems for channel management. Issues may include: the impacts of grazing pressures and muir-burn on soil fertility, nutrient leaching and erosion; special native plant communities and associated wildlife (see Part 3); forest harvesting; woodland regeneration; and the spread of undesirable alien plants (see also 8.4)

- With regard to the main-stem River Carron, a primary objective should be to identify the areas of highest erosion and sediment discharge into water courses. Several areas of bank erosion were identified during the habitat survey: please refer to Table 8.2 for some specific action points. This part of the study could form the subject of a postgraduate student thesis, for which financial support may be available.

- An analysis might focus on how pooled investments can most efficiently be targeted for maximum mutual benefit to the river through collaborative action between landowners, their tenants and other people involved with land and biodiversity management within the area, including Forest Enterprise, Lighthouse of Scotland and SNH.

Removal of the tall conifers on the south bank of the river here (near Craig) will allow more sunlight onto the water and stream, enhancing instream bioproduction. Leaf litter from deciduous trees is more palatable and nutritious for instream invertebrates *(Peter Cunningham)*

8.2.5 Assistance from anglers

Information recorded by anglers estate staff and other local people with local knowledge and interest in the river can be of much value in helping interpret changes in the productivity of the fishery and to understand the local behaviour of salmon and trout.

- Whenever possible, anglers should try to differentiate between wild and escaped farm salmon. Guidance leaflets are available from WRFT. Farm salmon should be killed. Until stocks of wild fish have recovered, WRFT recommends that all wild salmon and sea trout should be carefully released, following NASCO guidelines.

- Any fish scales that are displaced during capture or handling should be collected. WRFT can read these and thereby gain information about the growth of the fish in freshwater and in the sea. The identity of escaped farm salmon can also be confirmed by scale reading. Please contact WRFT for scale packets.

- Catches should be carefully recorded. If possible, a WRFT catch effort recording form should be filled in during/following each fishing trip. This information can be used to document changes in the numbers of salmon and sea trout returning to the river and the sizes and condition of returning fish. Please contact WRFT for catch recording forms.

- As stocks recover, public interest in the river is likely to grow. A local angling/field club could be formed, with membership open to local residents, to help to administer and to manage fishing within parts of the system in collaboration with interested local estates. With mutual respect, benefits would accrue both to estates and to the local community.

Table 8.2 Key sections of stream bank where large amounts of sediment are being discharged into the water, identified during the habitat survey in 1998. For most sites, the river is remobilising glacial deposits, including boulder clays and meltwater alluvium. Erosion in areas downstream from these areas tends to be associated with further reworking of these sediments deposited by the river.

Section	Grid reference	Feature	Impact	Suggested action
River Carron above Loch Sgamhain	8532N 2108E	Several eroding sections, often associated with die back of alder trees	Sediment transported down to Loch Sgamhain, causing further scouring en route	See section 8.4
Allt Coire Crubaidh	8522N 2088E	Several sections below road, associated with grazing by sheep	Sediment transported into pools below confluence	See section 8.4
Allt a Chonais	above falls?	Unknown	Sediment deposited in channels of River Carron causing braiding	Unknown
Allt a Coire a' Bhainidh	8489N 2028E (and upstream?	Several erosion areas associated with die back of alders and rapid run off from upstream areas	Sediment deposited in channels of River Carron causing braiding of river channel	Reduction in grazing pressures and restoration of riparian alders
River Carron below Arineckaig	8446N 1967E	Main erosion point with bank collapse, but some sections further upstream	Large input of sediment into river, destabilising river channel all the way to the sea	Requires detailed planning. See section 8.4

Recommendation 1 : Eradicate *Rhododendron ponticum* from the Carron catchment

Rhododendron ponticum (*R. ponticum*) has spread from gardens around Glencarron Lodge and Achnashellach–Lair to cover large areas. In the gorge below Glencarron Lodge, *R. ponticum* forms a thick, dense canopy. *R. ponticum* is seeding across the flood plain in the Achnashellach Forest. It has become well established along the north side of Loch Dughaill.

The removal of *R. ponticum* will have little immediate or obvious direct benefit for wild fisheries. However, if action is not taken, native vegetation along much of the riparian corridor between Loch Sgamhain and Loch Dughaill will be gradually smothered, adversely affecting the biodiversity and the potential to restore and enhance the natural productivity of the river system for fisheries in the long term. As the abundance of native invertebrates declines, the availability of food for juvenile fish will also decline.

Removal of *R. ponticum* can be a sensitive matter, and as yet there are no laws requiring landowners to control it (as there are for ragwort). Note that many other attractive rhododendron species are non-invasive and can be grown in gardens without the same levels of threat to native wildlife and ecology. SNH/SEERAD should give advice and support to gardeners to encourage them to grow alternative species.

- A programme to control and ultimately to eradicate Rhododendron ponticum (but not other Rhododendron species that are not invasive) from the catchment should be developed and implemented as soon as possible. This is probably the most expensive action proposed in the FMP, but is essential if native woodlands, especially those around the Achnashellach area, are to be restored.

- If *R. ponticum* is not eradicated completely, similar action will be required at recurring intervals in the future. At present, the cost of eradication is £3000–5000 or more per hectare, depending on the size and density of bushes, terrain and accessibility (John Parrot, Scottish Native Woods, personal communication).

- As an initial step the distribution and densities of *R. ponticum* within the catchment area should be quantified. SNH may be able to fund a detailed survey of *R. ponticum*, updating records from the survey in 1996.

Recommendation 2: Restore riparian and flood plain habitat

Alder roots help to stabilise riverbanks: reducing rates of erosion, confining river channels and providing additional cover for adult and juvenile fish. Leaf litter from alders, willows and aspen provides an additional source of nutrient for in-stream insect larvae – enhancing food availability and growth rates of young fish

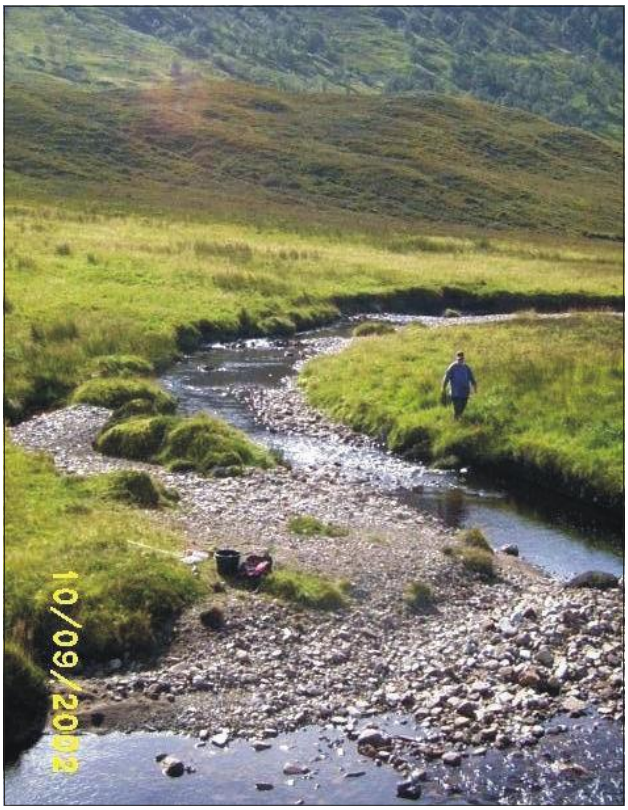
Shade provided by trees can help to moderate water temperatures. However, too much shade may prevent growth of algae and other water plants. Stream sections with groups of bushes providing 'dappled shade' rather than a dense canopy of taller trees tend to support the highest levels of production of young fish.

Along much of the main-stem River Carron and tributary corridors, especially above Loch Dughaill, grazing pressure prevents regeneration of native trees. Restoration of riparian habitats would be particularly beneficial in the following areas (see also Table 8.2 and Figure 8.1):

River Carron above Loch Sgamhain

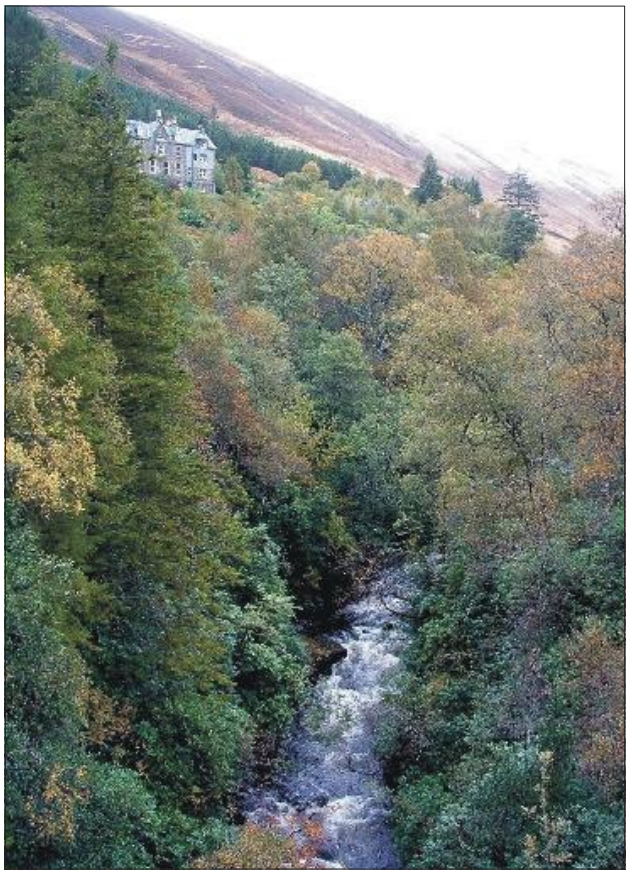
This is the main spawning stream for the loch and is of importance for both sea trout and salmon.

- The restoration of lush riparian vegetation along approximately 1000m of the stream corridor could be achieved by running a fence along the right side of the stream and installing water gates at the top and bottom ends with fences to link with the deer fence around the existing WGS scheme. Estimated cost: £7000–9000. Priority: medium



The Carron above Loch Sgamhain is the principle spawning stream for the loch. The quality of habitat for fish and other wildlife could be improved via restoration of riparian alder scrub *(Peter Cunningham)*

The Allt Coire Crubaidh below the A890. Although this part of the river has extensive areas of gravels suitable for spawning salmon and salmon fry, there is little cover for salmon parr. Smolt production could be increased by allowing restoration of lush riparian vegetation, including alder, willow bushes *(Peter Cunningham)*



Rhododendrons are spreading downstream from the gorge below Glencarron Lodge, restricting production of more useful native plants and animals *(Peter Cunningham)*

Allt Coire Crubaidh

This tributary is likely to have been of particular importance for production of juvenile salmon when early running salmon were a feature of rod catches. The section from the new road down to the confluence with the River Carron is presently heavily grazed, and has become widened in places with shallow pebbly fords. Restoration of alder and willow scrub would help to stabilise the banks, increase food availability, and enhance production of juvenile salmon from this upper section of the river. Further upstream, the gradient is such that bank stability is less of a problem and the primary benefits of riparian woodland restoration would be to increase food availability for juvenile fish. Bushes should be encouraged on the north side of the river here, to maximise the area of sunlit water.

- Prior to fencing, further investigations of fry and parr production are recommended to confirm that smolt production from this area could indeed be enhanced cost-effectively. Enclosing a 1 kilometre stretch within a fence from the confluence upstream would cost approximately £12,000. Priority: medium.

Glencarron

Although the section of river from the confluence of Allt Coire Crubaidh downstream is quite heavily grazed, there are no major erosion points. Weed beds and deep pools provide cover for juvenile and adult fish. No major erosion points were recorded in the lower 2km of the Alltan na Feola.

The river in Achnashellach flood plain above Loch Dughaill is unstable with many braided channels *(Peter Cunningham)*

River Carron between Craig and Lair. A reduction in grazing pressure would allow for growth of alders, willows and other riparian trees, stabilising banks and reducing the discharge of sediment into the river *(Peter Cunningham)*

Allt Coire a' Bhainidh below forestry track, in the Achnashellach forest *(Peter Cunningham)*

- From Glencarron Lodge downstream through the gorge, the management priority is the control and eradication of rhododendrons (see 8.3 above). There are native aspen trees in the gorge that could be used as a source of root cuttings for planting within riparian woodlands elsewhere within the catchment area. Aspen leaves are very palatable and, together with other deciduous leaf litter, can enhance production of aquatic invertebrates.

Achnashellach Forest

This section of river has the potential to be one of the most productive areas for juvenile sea trout and salmon within the Carron system. However, with the development of Achnashellach forest during the mid-20th century, rates of erosion and reworking of sediment may have increased. Sides of the flood plain have been ploughed, fenced and planted with conifers. On the south side of the river, thick gorse and broom scrub dominates.

From Craig downstream the river becomes increasingly braided as it approaches Loch Dughaill. The main sources of coarse sediment (especially cobble and pebble-sized particles) in the recent past appear to have been Allt a' Chonais, Allt Coire a' Bhainidh and perhaps also the Golden Valley burn. Much sediment has been eroded, reworked and deposited within the flood plain, and the river channels are very unstable. For fisheries, the main problems are as follows:

- shallow gravely fords obstruct passage of adult fish except at high water
- there is very little cover for parr, with bare pools and banks
- the river bed is unstable and therefore likely to have lower production of invertebrates and other food for fish
- spawning areas are unstable. Eggs and alevins may be particularly vulnerable to redd washout or exposure to frosts

Achnashellach Native Woodland Restoration Project

At the time of writing, Forest Enterprise has indicated that it no longer regards the forest to the south of the A890 as commercially viable. In the long term, this area could be restored to native woodland. The Forest Enterprise land holding extends across the flood plain, and there is an opportunity for a project to restore and develop native riparian woodlands and to enhance the biodiversity/amenity value of the forest.

Key aims of the project should be as follows:

- Reduction in grazing pressure to allow growth of alders, willows and aspens that can out-shade both gorse and broom. Control of deer grazing requires enclosing the entire area within a deer fence. A major challenge will be to run a deer fence across the flood plain. The main difficulty will be to install a functional water gate across the main river as near Loch Dughaill as possible. One option may be to utilise the supports of the old cable bridge 800 metres above the loch, suspending a new water gate from a restored bridge. The new structure will need to be able to withstand buffeting by large spates laden with large woody debris or else, perhaps more sensibly, be sacrificial and easily reinstated following major spate events. Quite a challenge, but not impossible.

- Over time, the river bed and river channel may stabilise, and fish cover and food abundance will increase. However, to reduce rates of sediment discharge until riparian vegetation has recovered and tree roots have gained sufficient strength to bind lose sediment, revetment may be required in some areas. Once grazing pressures have been reduced sufficiently to allow regrowth of alders, some of the mature alders should be coppiced to let more light on to the water and promote growth of young shoots.

- A network of backwater pools and channels can be restored and enhanced by redirecting water from forestry drains, providing additional 'wet' habitat for invertebrates and other wildlife. Juvenile salmon and trout may move to backwater channels during winter spates.

- A network of footpaths and cycle ways could be developed through the forest to provide access for walkers, anglers and other wildlife & countryside enthusiasts. The footbridge, 800m above Loch Dughaill should be restored.

- Prerequisite to the successful restoration of native woodlands is the eradication of *R. ponticum* from upstream areas (see Recommendation 1).

Loch Dughaill spawning burns

Some of the small burns entering Loch Dughaill are potentially of disproportionate importance for spawning sea trout and fry production. These burns should be inspected annually, vegetation blockages removed and spawning areas reconditioned if required.

Forest Enterprise have ambitious plans to restore native woodland across much of Achnashellach Forest. Success will depend upon whether or not grazing pressures and the spread *of Rhododendron ponticum* can be controlled *(Peter Cunningham)*

The restoration of native woodland within Achnashellach Forest requires a collaborative approach. Benefits of restored natural flood plain habitats will help fisheries and other wildlife and enhance the amenity value of the area for local people and visitors *(Peter Cunningham)*

Achnashellach the 'field of the willows', by the head of Loch Dughaill. Restoration of alder woodland on the flood plain would help a variety of wildlife *(Peter Cunningham)*

Rhododendron and spruce seedlings in the Achnashellach flood plain. These need to be eradicated if native woodlands are to be restored. NGR: 2035E, 8489N *(Peter Cunningham)*

Fionn-abhainn

Top of accessible section (NGR 1954E, 8458N)

The accessible section of the Fionn abhainn has 24,660m of generally good parr habitat, but little good spawning habitat, especially towards the falls (upstream accessible) limit. The aim would be to provide an area for spawning and production of fry to seed downstream areas. The suggestion is to fence off a 400m section of the river from the sheep fank up to the falls and to recondition/maintain areas of suitable substrate for spawning. Only one water gate would be required at the downstream end. Existing trees within this section include, birch, holly, Scots pine, rowan, willows, alder and hawthorn. These trees could provide seed sources. Total cost: £1500: priority medium.

Fionn abhainn below the falls at NGR 1954 8458. The section of river below the gorge here has patches of marginal spawning habitat suitable for salmon. This area could be developed as the main spawning area for the Fionn abhainn by restoring instream and bankside habitat *(Peter Cunningham)*

Lower section (NGR 1955 8448)

The bend here is eroding, and much sediment is being deposited within the river. Sediment has been transported downstream into the main-stem Carron and has continued to scour and destabilise the streambed.

Opposite the old gravel pit, revetment with large boulders has been used successfully to stabilise the foundation of the track: similar revetment and/or live willow stakes could be used to try to reduce the rate of bank erosion here.

Main-stem Carron below Loch Dughaill

Much of the riparian corridor along the Carron below Loch Dughaill is already well wooded. However, bank collapse below Arinackaig has led to the deposition of large amounts of sediment into the river. To stabilise the channel in downstream areas, this section of bank should be stabilised. However, because of the scale of problems here, any remedial action should be carefully planned following further investigations.

Recommendation 3: Monitor the success of salmon and sea trout restocking

The fisheries restoration programme carried out by Seafield College has involved the stocking of both trout and salmon throughout the catchment. The highest numbers of fish were stocked in 2001, 2002 and 2003 (see Part 4). Rod catches of sea trout and salmon increased markedly from 2001–2003, and these increases appear to relate to the stocking programmes. However, it was not always possible to establish from the September 2002 electro-fishing survey where wild fish had spawned in 2001 because some areas had been stocked with eggs or fry earlier in 2002. High densities of fry could have been related either to stocked fish or to spawnings of wild fish.

Bank collapse in the Fionn abhainn at NGR 1956 8447. There are several alternative methods for stabilising erosion scars of this sort *(Peter Cunningham)*

Table 8.3 Suggested stocking programme for River Carron 2004–2006 (see also Figure 8.1)

Section		2004	2005	2006
A	Carron above Loch Sgamhain	stock 50,000+ salmon eggs or fry	no stocking (habitat improvements)	no stocking
B	Loch Sgamhain	stock 100,000+ sea trout fry (reduce minnows)	no stocking (reduce minnow population)	no stocking (control minnows)
C	Carron above Glencarron falls to Loch Sgamhain, including Allt Coire Crubaidh	stock 80,000+ salmon eggs or fry (reduce minnow population)	no stocking (control minnows)	no stocking (control minnows)
D	Alltan na Feola	control – no stocking (habitat improvements)	control – no stocking (habitat improvements)	control – no stocking (nutrient enhancement trial)
E	Carron from Allt a' Chonais to Loch Dughaill, including tributaries in Achnashellach Forest	no stocking (at least until after electro-fishing surveys in July / early August 2004)	stock 100,000+ salmon eggs or fry	no stocking
F	Loch Dughaill and tributaries entering loch	stock 100,000+ sea trout eggs or fry	stock 100,000+ sea trout eggs or fry	no stocking
G	River Carron Loch Dughaill to Fionn-abhainn confluence	stock 100,000+ salmon eggs or fry (refresh spawning gravels & reduce minnow population)	no stocking (refresh spawning gravels & reduce minnow population)	control – no stocking (refresh spawning gravels & reduce minnow population)
H	Fionn-abhainn	no stocking (habitat improvements)	stock 100,000+ salmon eggs or fry (habitat improvements)	no stocking (nutrient enhancement trial)
I	River Carron from Fionn-abhainn confluence to sea	stock 100,000+ salmon eggs or fry	no stocking	no stocking
J	River Taodail	control – stock 50,000 salmon fry above falls	control – stock 12,000 salmon fry above falls	control – stock 24,000 salmon fry above falls

See text for more details, including other suggested action

In 2004 and 2005, it is recommended that some parts of the system remain unstocked (see Table 8.3). This will make it possible to use electro-fishing surveys in 2004 and 2005 to compare fry and parr densities in stocked areas with those in unstocked areas. Leaving some areas unstocked will also ensure that the progeny of any wild fish that have spawned successfully in these areas have the best opportunity to grow without competition from stocked fish. All stocked fish should be progeny of native fish. As early fish generally tend to travel further up river systems, fish stocked towards the upper part of the system should be progeny of earlier river entrants (April–June fish) rather than late entrants (autumn fish).

By 2005, returns of adult salmon from stocked eggs and fry in 2001 and 2002 should be reaching their peak. In 2006 it is proposed that no fry are stocked unless electro-fishing surveys or stock assessments indicate that numbers of wild fish are still inadequate to ensure optimum levels of egg deposition. The results of electro-fishing surveys in 2006 can be used to provide guidance for subsequent stocking from 2007 onwards.

Recommendation 4: Monitor the use of spawning areas by adult fish

Observations of spawning fish and redd counts can provide guidance as to the need for stocking during the following year. Table 8.4 outlines the sections of river that could be prioritised for redd counting.

Sea trout spawning can take place at any time from mid October to the end of December. Salmon tend to start spawning a little later; probably from mid-November until early January. Different spawning areas will be utilised at different water levels. During periods of medium to high flow, fish may run up the smaller burns to spawn (e.g. around Lochs Sgamhain and Dughaill).

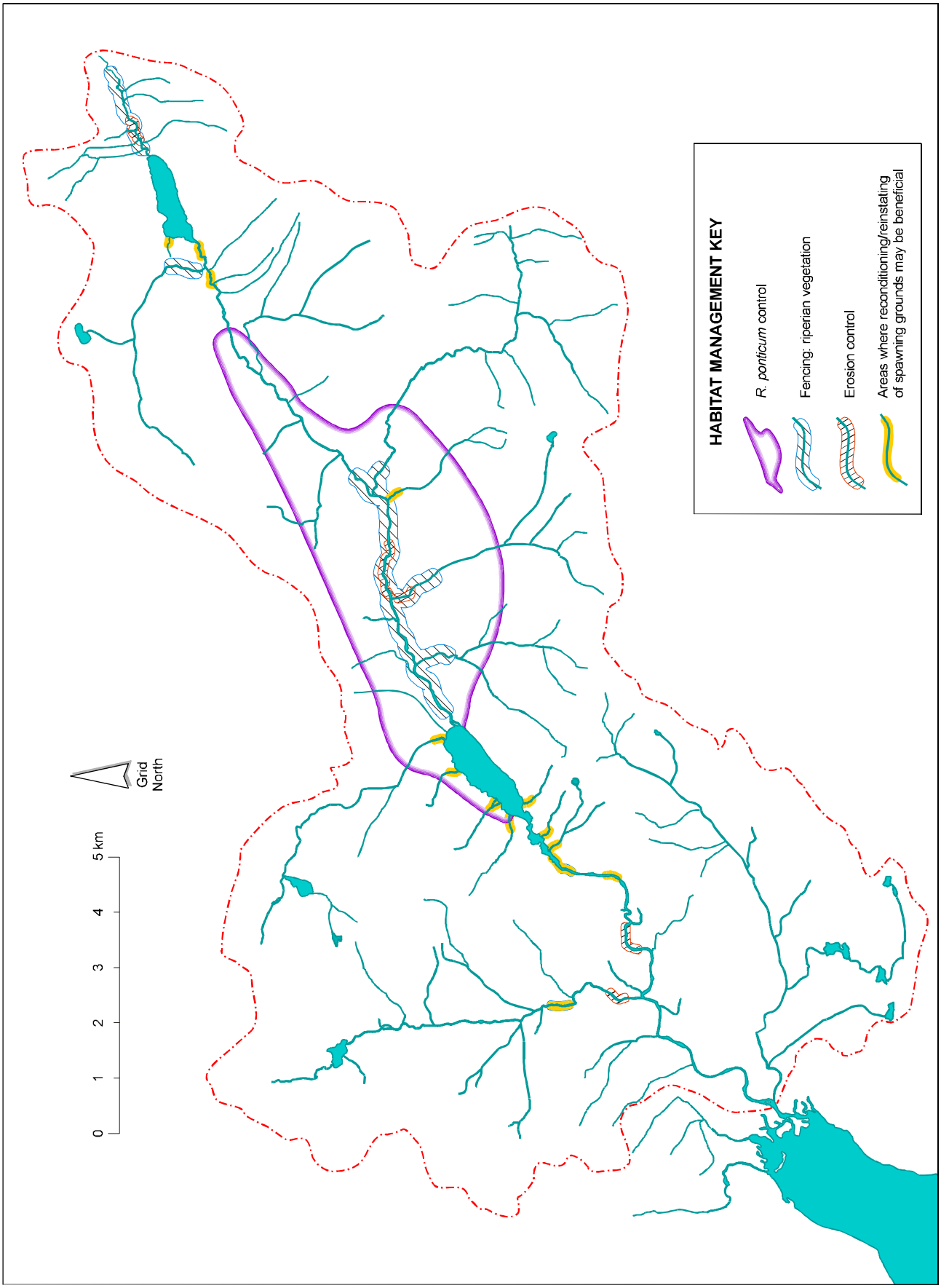


Figure 8.1 Habitat management requirements within the Carron catchment area *(Crown Copyright)*

Spawning activity within the main river, especially below Loch Dughaill, is more likely to occur (and be seen) at lower flows.

Sketch maps should be marked with the location of redds, where possible indicating the times and dates of spawning activity. Please contact the WRFT biologist for recording forms and other information.

Where spawning gravels have become silted up and overgrown by weeds, spawning fish find it more difficult to make redds and to spawn successfully. Studies have shown variation in alevin size and quality according to oxygen levels within redds during incubation.

- Reconditioning/cleaning of spawning gravels in the main-stem Carron below outflows of Loch Sgamhain (around the confluence of Allt Coire Crubaidh) and Loch Dughaill (around stepping stones) in late summer could improve the success of spawning and subsequent fry production. Please contact WRFT biologist for further information.

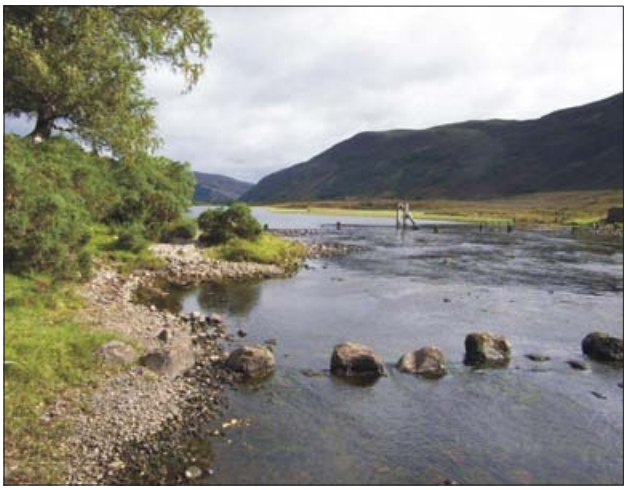
Recommendation 5: Nutrient restoration and enhancement

Across much of Wester Ross, levels of biological production are limited by the availability of phosphorous. In the past during periods when forest cover was greater and ecosystems were more active in terms of nutrient recycling, the amount of nutrients circulating into and out of river systems may have been greater.

The impacts of slight nutrient enhancement on stream biota are still poorly understood. However, an invertebrate sample in November 2003 from the upper River Carron where total phosphorus levels have risen over the past ten years (and following an algal bloom in Loch Sgamhain during the summer of 2003) suggested that the diversity of stonefly species was normal and healthy.

Table 8.4 Suggested areas for monitoring spawning activity of salmon and trout

Section	Times to check	River heights	Comments
Carron above Loch Sgamhain. walk whole accessible length of stream.	mid-October to early December	medium–high	Salmon and trout may run in and out at night, though some are likely to remain in pools by day
Loch Sgamhain spawning burns, especially burns entering NW shore	mid-October to early December	medium–high	Trout may run in and out at night
Allt Coire Crubaidh: the section below road can be checked most easily	mid-October to mid-December	low–medium	Male salmon may linger near newly completed redds
Carron from Allt a' Chonais to Loch Dughaill, including tributaries in Achnashellach Forest	mid-October to mid-December	medium–high	There are several fords / areas where salmon or trout may spawn, but many areas are unstable, and redds may be washed out
Carron from Allt a' Chonais to Loch Dughaill, including tributaries in Achnashellach Forest	mid-October to mid-December)	slow–medium water for main river	Fish may be thinly spread. Spawning in the braided section best located at low water
Loch Dughaill and tributaries entering loch including River Lair	end October to end December	low–medium water; high water for smallest burns	Fish may run in and out of burns at night; male salmon may linger
River Carron Loch Dughaill outflow: stepping stones area downstream	mid-November to January	low–medium water	Do salmon spawn at the outflow from the loch? no fry were encountered in 2000
Fionn-abhainn above road to falls, including tributary entering below sheep fank	end November to end December	medium (high water for tributary)	Do salmon spawn above the sheep fank?
River Carron from Fionn abhainn confluence to sea	November into the New Year	low water	Salmon may spawn in suitable 'fords' all the way down to the tidal reaches



Well-sorted pebble beds by the outflow from Loch Dughaill would normally provide a good spawning habitat. However, siltation and growth of water plants compromise their value for salmon spawning *(Peter Cunningham)*

Within the catchment, the Alltan na Feola, Allt Coire Crubaidh and/or other waters may have also received slightly elevated nutrient discharges following applications of tree fertilisers (especially phosphates) from areas planted during the period 2000–2003 or earlier. Relationships between nutrient levels, invertebrate production and juvenile fish production could be investigated further. Please contact the WRFT biologist for further information.

Recommendation 6: Assess the genetic status of Carron salmon and trout populations and compare with other populations in Wester Ross

It is likely that there has been some degree of genetic introgression of native Carron salmon population via hybridisation with escaped farm salmon. However, the extent and significance of this in terms of the productivity of the fishery is still unknown. In collaboration with Fisheries Research Services (FRS), studies are underway to investigate the genetic variation of wild salmon and trout in the west of Scotland. These studies aim to describe integral fish 'populations' and their origins. The occurrence of non-native genes (i.e. genes derived from stocked or escaped farm salmon) within the wild population may also be recorded.

Recommendation 7: Investigate use of lochs by juvenile trout and salmon

Little is known about the use and distribution of loch environments for production of juvenile trout and salmon. In Newfoundland and the Outer Hebrides, schools of salmon parr have been found in lochs at depths of up to 30m. Methods for investigating lochs include hydro-acoustic surveys and multi-mesh gill net surveys, which have been used elsewhere to learn about the fisheries ecology of lochs with migratory fish populations. With seven fish species (salmon, trout, charr, eel, lamprey species, minnow), Loch Dughaill and Loch Sgamhain are ideally situated for investigations by students from Inverness College.

Recommendation 8: Investigate invertebrate populations

Over the next four years, WRFT aims to monitor the distribution and densities of invertebrate larvae and to learn about the diet of juvenile trout and salmon in Wester Ross rivers. Information will be presented within a second series of Fisheries Management Plans, describing the diversity and abundance of invertebrates in different parts of the catchment area.

Recommendation 9: Investigate lamprey populations

Lampreys were discovered in Loch Dughaill during summer 2003. This is the first known recent record of lampreys within Wester Ross. There has been recent interest in the status of lampreys in UK, and further studies should be undertaken to identify the species and its distribution within the river system.

Recommendation 10: Investigate minnow population, and control if possible

Minnows have recently become established in a number of river systems in Wester Ross, most often probably as unused 'live bait' by anglers. They are now the dominant fish species in parts of the system. There is some evidence that minnows can compete with trout fry for food and habitat. Therefore, if the priority is to produce large numbers of juvenile trout, minnows are not a welcome addition to systems.

Minnows are, however, relatively easily trapped. Traps made out of plastic drinks bottles baited with bread or dog food can be used to catch many hundreds of minnows. It may be possible to control minnow populations in some sections of the system without excessive effort to allow trout fry to grow without competition.

- Trap minnows in spawning burns around Loch Sgamhain and Loch Dughaill, and in out flows of lochs. Investigate whether catches per unit effort decline and whether any difference can be made to minnow population sizes.

- Interactions between minnows and trout of different sizes can be investigated in aquaria: how many minnows salmon and trout parr can eat, what is their preferred prey size, etc.

Kingfishers have recently been recorded in parts of Wester Ross, and minnows are one of their favoured prey species.

- Record kingfisher sightings. ❑

Trees for Life volunteers have been active within Achnashellach Forest over a number of years. Their overall aim is to restore native Caledonian Forest to a large part of the Highlands. This will benefit wildlife and fisheries. Further volunteer work-weeks are planned for 2005 *(Peter Cunningham)*

Appendix I

Electro-fishing results from the River Carron

1 River Carron average fish per 100 metres (according to electro-fishing surveys)

	1986	1995	1996	1997	1998	2000	2002	Average
Salmon fry	44.2	14.8	6.0	16.1	41.4	2.2	17.3	20.3
Salmon parr	35.3	3.0	8.8	6.7	17.0	11.9	11.8	13.5
Trout fry	4.2	2.0	4.0	13.5	14.0	9.5	8.3	7.9
Trout parr	5.0	1.0	2.3	1.8	10.9	7.6	3.5	4.6
Salmon fry stocked	0	8000	9000	5000	6000	0	153000	
Trout fry stocked	0	0	0	10000	35000	0	154000	
Trout parr stocked	0	0	0	7000	15000	0	0	

2 WRFT semi-quantitative (timed) electro-fishing sites and results in 2000

						Fish caught				Catch per unit effort						
						Salmon		Trout		Salmon			Trout			
Date	Code	Location	Grid ref	Time	Cond.	0+	1++	0+	1++	0+	1++	total juv.	0+	1++	total juv.	Notes
02/09/00	CRNT2	Taodail	NG 938419	5	41	0	5	11	4	0.0	1.0	1.0	2.2	0.8	3.0	5 eels
13/09/00	CRN4	Taodail	NG 943421	11.75	42	0	14	3	12	0.0	1.2	1.2	0.3	1.0	1.3	lge stocked m. trout, 3 eels
Taodail sub total				*16.75*		*0*	*19*	*14*	*16*	*0.0*	*1.1*	*1.1*	*0.8*	*1.0*	*1.8*	
02/09/00	CRNT1	Carron	NG 936420	5	46	4	5	0	0	0.8	1.0	1.8	0.0	0.0	0.0	1 eel
02/09/00	CRNT3	Carron	NG 940425	5	46	1	8	0	1	0.2	1.6	1.8	0.0	0.2	0.2	7 eels, 1 flounder
02/09/00	CRNT4	Carron	NG 943427	5	46	3	11	0	0	0.6	2.2	2.8	0.0	0.0	0.0	3 eels
02/09/00	CRNT5	Carron	NG 941433	5	46	5	4	0	0	1.0	0.8	1.8	0.0	0.0	0.0	4 eels
02/09/00	CRNT6	Carron	NG 946435	5	46	8	7	0	0	1.6	1.4	3.0	0.0	0.0	0.0	4 eels
02/09/00	CRNT7	Carron	NG 949441	5	46	4	4	1	1	0.8	0.8	1.6	0.2	0.2	0.4	1 eel
13/09/00	CRN1	Carron	NG 953440	7.5	43	0	2	1	0	0.0	0.3	0.3	0.1	0.0	0.1	1 eel
02/09/00	CRNT8	Carron	NG 955443	5	42	3	3	1	0	0.6	0.6	1.2	0.2	0.0	0.2	3 eels
Carron main stem sub total				*42.5*		*28*	*44*	*3*	*2*	*0.7*	*1.0*	*1.7*	*0.1*	*0.0*	*0.1*	
02/09/00	CRNT9	Fionn Abhainn	NG 955446	5.5	33	4	6	1	4	0.7	1.1	1.8	0.2	0.7	0.9	2 stocked trout
13/09/00	CRN5	Fionn Abhainn	NG 957450	9.25	36	6	8	1	0	0.6	0.9	1.5	0.1	0.0	0.1	4 eels
Fionn Abhainn sub total				*14.75*		*10*	*14*	*2*	*4*	*0.7*	*0.9*	*1.6*	*0.1*	*0.3*	*0.4*	
13/09/00	CRN7	R Lair	NH 002481	5	29	0	9	1	1	0.0	1.8	1.8	0.2	0.2	0.4	6 eels
02/09/00	CRNT10	Carron	NG 959442	5	42	2	5	0	0	0.4	1.0	1.4	0.0	0.0	0.0	6 eels
02/09/00	CRNT11	Carron	NG 964443	5	49	0	1	1	0	0.0	0.2	0.2	0.2	0.0	0.2	
02/09/00	CRNT12	Carron	NG 968446	5	46	6	2	0	0	1.2	0.4	1.6	0.0	0.0	0.0	2 eels
02/09/00	CRNT13	Carron	NG 972446	5	46	3	4	0	0	0.6	0.8	1.4	0.0	0.0	0.0	3 eels
02/09/00	CRNT14	Carron	NG 978448	5	46	0	5	0	0	0.0	1.0	1.0	0.0	0.0	0.0	3 eels
13/09/00	CRNT15	Carron	NG 977454	5	43	2	5	0	1	0.4	1.0	1.4	0.0	0.2	0.2	7 eels
13/09/00	CRNT16	Carron	NG 979458	5	42	0	5	0	0	0.0	1.0	1.0	0.0	0.0	0.0	18 eels
sub total				*35*		*13*	*27*	*1*	*1*	*0.4*	*0.8*	*1.1*	*0.0*	*0.0*	*0.1*	
total main stem to Loch Dughail				*77.5*		*41*	*71*	*4*	*3*	*0.5*	*0.9*	*1.4*	*0.1*	*0.0*	*0.1*	

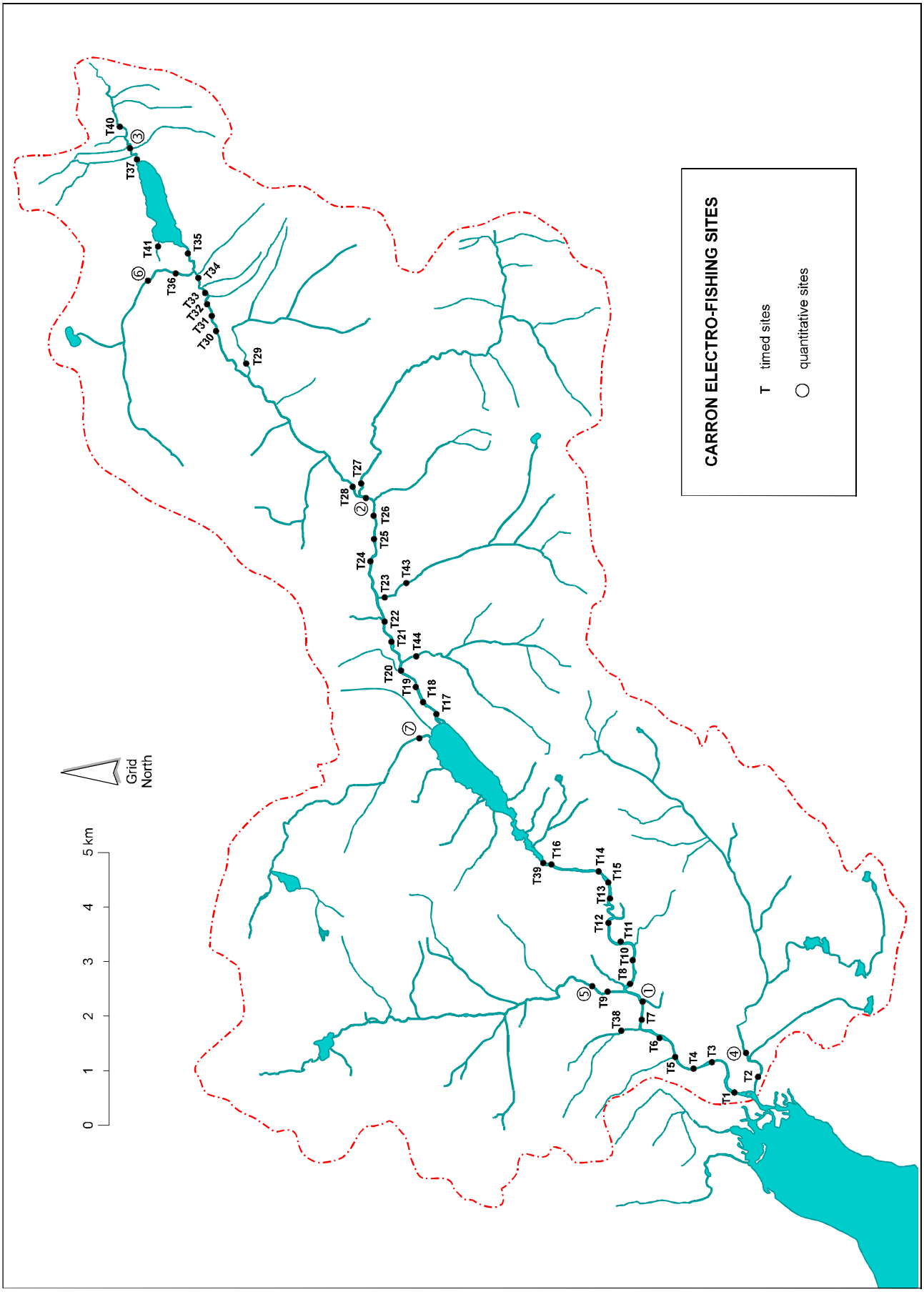
2 WRFT semi-quantitative (timed) electro-fishing sites and results in 2000 *(continued)*

26/09/00	CRNT17	Carron	NH 004477	5	46	1	3	1	1	0.2	0.6	0.8	0.2	0.2	0.4	1 eel
26/09/00	CRNT18	Carron	NH 008480	5	46	0	2	3	0	0.0	0.4	0.4	0.6	0.0	0.6	
26/09/00	CRNT19	Carron	NH 013482	5	46	2	5	1	0	0.4	1.0	1.4	0.2	0.0	0.2	
26/09/00	CRNT 20	Carron	NH 015484	5	46	1	0	0	0	0.2	0.0	0.2	0.0	0.0	0.0	
26/09/00	CRNT21	Carron	NH 020486	5	46	0	14	1	2	0.0	2.8	2.8	0.2	0.4	0.6	1 eel
26/09/00	CRNT22	Carron	NH 026488	5.5	44	3	15	0	0	0.5	2.7	3.3	0.0	0.0	0.0	2 eels
26/09/00	CRNT23	Carron (Coire na Bhainidh)	NH 027487	5	44	0	16	2	4	0.0	3.2	3.2	0.4	0.8	1.2	1 eel
26/09/00	CRNT24	Carron	NH 033490	5	44	6	7	2	0	1.2	1.4	2.6	0.4	0.0	0.4	
26/09/00	CRNT25	Carron	NH 036489	5	44	1	6	3	2	0.2	1.2	1.4	0.6	0.4	1.0	1 eel
26/09/00	CRNT26	Carron	NH 043489	5	44	0	6	0	1	0.0	1.2	1.2	0.0	0.2	0.2	2 eels
27/09/00	CRN2	Carron	NH 046490	11	50	0	2	1	2	0.0	0.2	0.2	0.1	0.2	0.3	2 eels
26/09/00	CRNT27	Carron (allt a chonais)	NH 047492	5	36	0	6	1	2	0.0	1.2	1.2	0.2	0.4	0.6	
26/09/00	CRNT28	Carron	NH 049494	5	44	0	4	0	1	0.0	0.8	0.8	0.0	0.2	0.2	2 eels
27/09/00	CRNT29	Carron (allt na feola)	NH 068513	5	34	0	0	0	2	0.0	0.0	0.0	0.0	0.4	0.4	
27/09/00	CRNT30	Upper Carron	NH 071515	5	50	0	3	1	1	0.0	0.6	0.6	0.2	0.2	0.4	1 eel
27/09/00	CRNT31	Upper Carron	NH 074517	5	49	8	3	0	4	1.6	0.6	2.2	0.0	0.8	0.8	
27/09/00	CRNT32	Upper Carron	NH 079519	5	?	14	1	0	1	2.8	0.2	3.0	0.0	0.2	0.2	
27/09/00	CRNT33	Upper Carron	NH 083520	5.25	49	18	0	1	0	3.4	0.0	3.4	0.2	0.0	0.2	75 minnows
27/09/00	CRNT34	Upper Carron	NH 086522	5	49	30	2	2	0	6.0	0.4	6.4	0.4	0.0	0.4	
27/09/00	CRNT35	Upper Carron	NH 090523	5	49	0	0	4	3	0.0	0.0	0.0	0.8	0.6	1.4	4 minnows
Main stem sub total				*106.75*		*84*	*95*	*23*	*26*	*0.8*	*0.9*	*1.7*	*0.2*	*0.2*	*0.5*	
27/09/00	CRNT36	Allt Coire Crubaidh	NH 087526	5	49	18	6	3	4	3.6	1.2	4.8	0.6	0.8	1.4	
27/09/00	CRN6	Allt Coire Crubaidh	NH 086532	7.2	49	3	5	9	7	0.4	0.7	1.1	1.3	1.0	2.2	
Allt Coire Crubaidh sub total				12.2		21	11	12	11	1.7	0.9	2.6	1.0	0.9	1.9	
27/09/00	CRNT37	Loch Sgamhain burn	NH 107533	5	71	0	2	3	5	0.0	0.4	0.4	0.6	1.0	1.6	30 minnows
29/09/00	CRN3	Loch Sgamhain burn	NH 109534	7.5	71	0	1	3	5	0.0	0.1	0.1	0.4	0.7	1.1	6 minnows
Loch Sgamhain burn sub total				*12.5*		*0*	*3*	*6*	*10*	*0.0*	*0.2*	*0.2*	*0.5*	*0.8*	*1.3*	
Carron Catchment grand total				***245.45***		***156***	***222***	***62***	***71***	***0.6***	***0.9***	***1.5***	***0.3***	***0.3***	***0.5***	

3 WRFT semi-quantitative (timed) electro-fishing sites and results in 2002

						Fish caught				Catch per minute						
						Salmon		Trout		Salmon			Trout			
Date	**Code**	**Location**	**Grid ref**	**Time**	**Cond.**	**0+**	**1++**	**0+**	**1++**	**0+**	**1++**	**total juv.**	**0+**	**1++**	**total juv.**	**Notes**
02/09/02	CRNT2	Taodail	NG 938419	5	41	0	5	11	4	0.0	1.0	1.0	2.2	0.8	3.0	5 eels
09/09/02	CRNT38	Un-named burn u/s of gravel pit - smolt rlease ponds	NG 948442	14.5	39	0	2	9	0	0.0	0.1	0.1	0.6	0.0	0.6	
17/09/02	CRNT	tail of pool d/s of footbridge -stepping stones	NG 978458	10.75	35	0	14	6	0	0.0	1.3	1.3	0.6	0.0	0.6	
17/09/02	CRNT	downstream of footbride-stepping stones	NG 978458	6	36	0	1	6	0	0.0	0.2	0.2	1.0	0.0	1.0	
17/09/02	CRNT	Golden Valley burn - below bridge - water gate	NH 016482	9.75	56	0	3	5	9	0.0	0.3	0.3	0.5	0.9	1.4	
10/09/02	CRNT34	Carron d/s of confluence with Allt Coire Crubaidh	NH 522087	7	49	18	2	0	1	2.6	0.3	2.9	0.0	0.1	0.1	
10/09/02	CRNT36	Allt Coire Crubaidh 100m d/s from steading	NH 087527	6.5	38	17	6	7	0	2.6	0.9	3.5	1.1	0.0	1.1	
10/09/02	CRNT35	Carron - weedy ford at outflow of Loch Sghamhain	NH 090523	6	57	5	1	3	0	0.8	0.2	1.0	0.5	0.0	0.5	17 minnows
10/09/02	CRNT41	un-named burn by steading into loch Sghamhain	NH 092528	5	106	0	0	3	0	0.0	0.0	0.0	0.6	0.0	0.6	>20 minnows
10/09/02	CRNT37	mouth of main burn 20m above Loch Sghamhain	NH 108533	6	40	11	7	1	2	1.8	1.2	3.0	0.2	0.3	0.5	2 minnows, 35cm sea trout?
10/09/02	CRNT40	man burn 500m u/s from Loch Sghamhain	NH 111535	7.5	49	6	4	4	3	0.8	0.5	1.3	0.5	0.4	0.9	
09/09/02	CRN4	Taodail	NG 943421	38	39	17	11	22	7	0.4	0.3	0.7	0.6	0.2	0.8	1 large stocked male trout, 3 eels
19/09/02	CRN1	Carron	NG 953440	11.5	45	10	12	2	0	0.9	1.0	1.9	0.2	0.0	0.2	1 eel
09/09/02	CRN5	Fionn Abhainn	NG 957450	15	26	11	25	3	0	0.7	1.7	2.4	0.2	0.0	0.2	4 eels
09/09/02	CRN7	R Lair	NH 002481	30	21	4	26	17	2	0.1	0.9	1.0	0.6	0.1	0.6	6 eels
17/09/02	CRN2	Carron	NH 046490	22	59	1	20	0	7	0.0	0.9	1.0	0.0	0.3	0.3	2 eels
10/09/02	CRN6	Allt Coire Crubaidh	NH 086532	10	35	3	3	4	0	0.3	0.3	0.6	0.4	0.0	0.4	
10/09/02	CRN3	Loch Sgamhain burn	NH 109534	15	42	15	5	5	6	1.0	0.3	1.3	0.3	0.4	0.7	6 minnows

4 WRFT electro-fishing sites in Carron catchment area *(Crown Copyright)*



Appendix II

Stocking of the River Carron

1 Fish stocked into the River Carron and tributaries by the Seafield Centre (1995–2002)

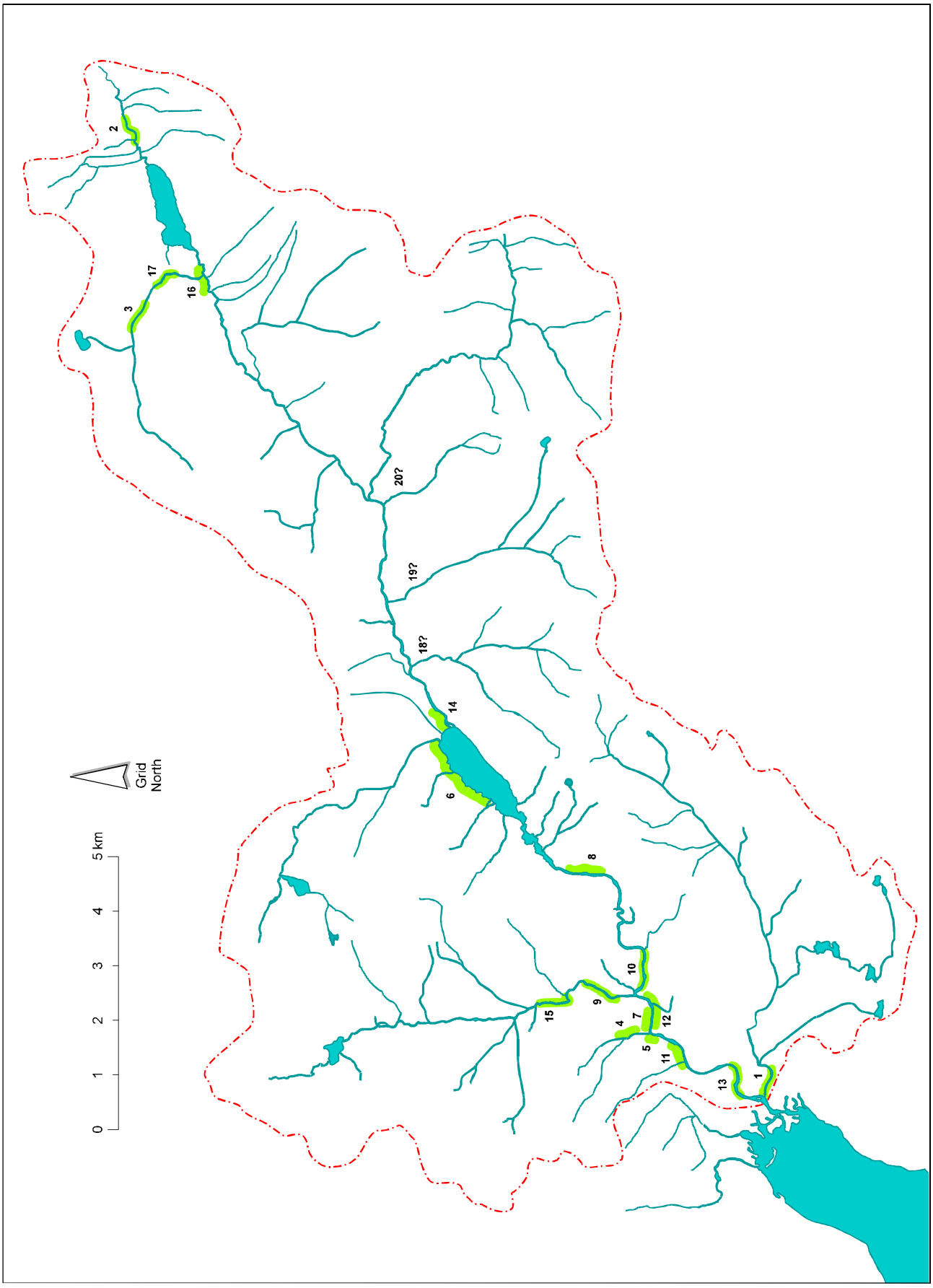
Date	Year	Spe-cies	Type	Qty	Release site	Site Code	Original stock (notes)
07/07/95	1995	s	f	3000	Fionn Abhainn (above falls)	15	
Jun-95	1995	s	f	5000	Allt Coire Crubaidh (above road bridge)	3	
25/06/96	1996	s	f	7000	Allt Coire Crubaidh (below road bridge)	17	
25/06/96	1996	s	f	2000	Main river below Loch Sgamhain	16	
15/06/97	1997	s	f	5000	Fionn Abhainn (below bridge)	9	Wild Carron
19/06/97	1997	st	f	4000	Allt Coire Crubhaidh	3	Coulin/Applecross
19/06/97	1997	st	f	4000	Main river below Loch Skabhain	16	Coulin/Applecross
29/06/97	1997	st	f	2000	Main river at Arineckaig	8	Coulin/Applecross
29/10/97	1997	st	p	4000	Main river at Arineckaig	8	Coulin/Applecross
29/10/97	1997	st	p	3000	Main river below Loch Skabhain	16	Coulin/Applecross
27/06/98	1998	st	f	10000	Fionn Abhainn (above and below bridge)	9	Coulin/Applecross
06/07/98	1998	st	f	10000	From railway bridge to Blackwood	12	Coulin/Applecross
17/07/98	1998	st	f	2000	Glen Carron	12	Coulin/Applecross
17/07/98	1998	st	f	3000	Arineckaig	8	Coulin/Applecross
17/07/98	1998	st	f	10000	Cruives pool and SEPA station	11	Coulin/Applecross
31/08/98	1998	s	f	1000	Allt Coire Crubaidh (above road bridge)	3	Wild Carron
05/09/98	1998	s	f	1000	Fionn Abhain (below bridge)	9	Wild Carron
06/09/98	1998	s	f	4000	Allt Coire Crubaidh (above road bridge)	3	Wild Carron
11/12/98	1998	st	p	10000	Down river from Arineckaig	10	Coulin/Applecross
17/12/98	1998	st	p	5000	Above and below railway bridge	10	Coulin/Applecross
20/04/99	1999	st	f	50000	Glen carron above steading and old road bridge	3	
22/04/99	1999	st	e	63000	River Taodail	1	
06/05/99	1999	st	s	7500	below railway bridge and mouth of Fionn Abhain	12	
20/05/99	1999	st	s	14000	Loch Doughail and lower river	6	
Nov-99	1999	st	p	70000	Loch Doughail	6	
Mar-00	2000	st	s	30000	Loch Doughail	6	(S1 smolts/parr)
Mar-00	2000	st	s	3500	Loch Doughail	6	(S2 smolts/parr)
Mar-00	2000	s	s	5000	Loch Doughail and river at Fionn Abhainn	6,12	(S1 smolts/parr)
Mar-00	2000	s	p	2000			
2001	2001	st	p	15000	Loch Doughail and River Lair	6,	(parr/smolts)
2001	2001	s	p	10000	Loch Doughail Lair and Craig	6	(parr/smolts)
2001	2001	s	p	2000	Carron at Strathcarron	13	(parr/smolts)
2001	2001	s	f	5000	River Lair		
2001	2001	s	f	20000	Carron at Craig		
2001	2001	s	f	10000	Carron below Loch Doughail	8	
2001	2001	s	f	8500	Fionn Abhain (below bridge)	9	
2001	2001	s	f	6500	Carron below road bridge	13	
2001	2001	s	f	30000	Carron at Arineckaig and from Cruives to New Kelso	8,11	
2001	2001	s	f	21000	River Carron from Blackwater downstream	12	
2001	2001	s	f	23000	Fionn Abhain above and below falls	15	
2001	2001	st	f	15000	Loch Doughail islands and narrows below L. Doughail	8	
2001	2001	st	f	8000	Narrows below Loch Doughail	8	

1 Fish stocked into the River Carron and tributaries *(continued)*

Date	Year	Spe-cies	Type	Qty	Release site	Site Code	Original stock (notes)
2001	2001	s	f	10000	Burn above Loch Sgamhain and Allt Coire Crubaidh	2,3	
2001	2001	s	f	2870	Carron at Arineckaig	8	
2001	2001	s	f	10000	Carron at Arineckaig	8	
2001	2001	s	f	7000	Allt Coire Crubaidh	3	
2001	2001	s	f	1200	River above Black pool	10	
2001	2001	s	f	3700	Road bridge Strathcarron	13	
2001	2001	s	f	300	Achintee Burn		
04/02/02	2002	s	e	30000	River Taodail	1	
05/02/02	2002	s	e	120000	Burn above Sgamhain, Allt Coire Crubaidh	2,3	
07/02/02	2002	st	e	50000	Burns above Cruive Pools	4	
08/02/02	2002	st	e	90000	Golden Valley, Coire a' Bhainidh, Allt a' Chonas	18,19,20	
11/05/02	2002	s	s	3000	Release point above Cruives Pool	5	
18/05/02	2002	s	s	3000	Release point above Cruives Pool	5	(S1)
26/05/02	2002	st	s	4000	Release point above Cruives Pool	5	(half Slice-treated)
07/05/02	2002	st	f	75000	Loch Doughail, River below Fionn Abhain	6,7	
14/05/02	2002	st	f	20000	River at Arineckaig	8	
09/06/02	2002	st	f	10000	Lower end of Fionn Abhain, river below railway bridge	9,10	
10/06/02	2002	st	f	3000	River Taodail	1	
20/06/02	2002	st	f	15000	Junction Pool to release Pool	7	
09/07/02	2002	st	f	11000	West end of Loch Doughail	6	
10/07/02	2002	s	f	40000	Cruives pool to Kelso lodge	11	
12/07/02	2002	s	f	15000	Railway bridge to release pool	12	
07/08/02	2002	s	f	25000	River at Arineckaig	8	
09/08/02	2002	s	f	18000	Above and below road bridge	13	
12/08/02	2002	s	f	14000	Lower end of Fionn Abhain, above/below railway br.	9,10	
25/08/02	2002	s	f	8000	East end of Loch Doughail	6	
30/08/02	2002	s	f	8000	West end of Loch Doughail and Narrows	14	
01/09/02	2002	s	f	8000	North shore Loch Doughail	6	
16/09/02	2002	s	f	9600	River below Loch Sgamhain	16	
17/09/02	2002	s	f	4000	River below Loch Doughail	8	
20/09/02	2002	s	f	3400	Fionn Abhain	15	
19/11/02	2002	s	f	5500	Loch Doughail	6	
21/11/02	2002	st	f	9200	Loch Doughail	6	
25/11/02	2002	s	f	6300	Fionn Abhainn	7	
27/11/02	2002	st	f	8800	Loch Doughail	6	
10/12/02	2002	st	f	2000	Cruives to Kelso Lodge	11	
10/12/02	2002	s	f	4000	Cruives to Kelso Lodge	11	

2 Release sites for salmon and sea trout reared by the Seafield Centre, Kishorn, 1995–2002.

See text for more details *(Crown Copyright)*



Appendix III

Readings of salmon scales from the River Carron

2000 (Wild Salmon 2000 from Seafield Centre, most scales taken upon stripping, most scales badly eroded)								
	Date scales taken	**Length (cm)**	**Weight (g)**	**Sex**	**Place stripped**	**Remarks**	**Age**	
DT1a 1st 1/2	21/11/00	71	2763	F	Bob's	Kelt	2.1+	Caught in April summer check in SW phase
DT2a	21/11/00	82	5660	F	Bob's		2.2	springer?
DT2b	21/11/00	85	5920	F	Bob's		2.2	springer? (a very busy scale!)
DT1b 1st 1/2	21/11/00	60	2167	F	Bob's	Larger of Chris's fish	2.1+	
DT1b 2nd 1/2	21/11/00	54	1473	F	Bob's	Chris's smaller fish	2.1+	
DT1a 2nd 1/2	03/12/00	73		F	Bob's		3.2+	2 summer checks in SW phase & erosion
	03/12/00	66		M	Bob's	Check in scales after 2nd FW winter	2.1+	check just before 1st Sea winter

1999								
	Date	**Length (cm)**		**Sex**		**Remarks**	**Age**	
	28/01/99	61		F		kelt, escaped farm smolt	1.1+SM	
	28/01/99	57		F		kelt, summer check in marine phase	2.1+SM	
	28/01/99	59		F		kelt, escaped farm smolt	1.1+SM	
	28/01/99	62		F		kelt	3.1+SM	

Appendix IV

Calculation of wild salmon spawning targets

1 Data used to calculate wild salmon spawning targets

JUVENILE HABITAT	Maximum smolt output	Egg–smolt survival rate	Target egg deposition rate
[1]RIVERINE	0.05/m²	0.017	2.6/m²
[2]LACUSTRINE – Grade 1	20/ha	0.019	1,052/ha (0.105/m²)
[3]LACUSTRINE – Grade 2	7/ha	0.019	368/ha (0.037/m²)

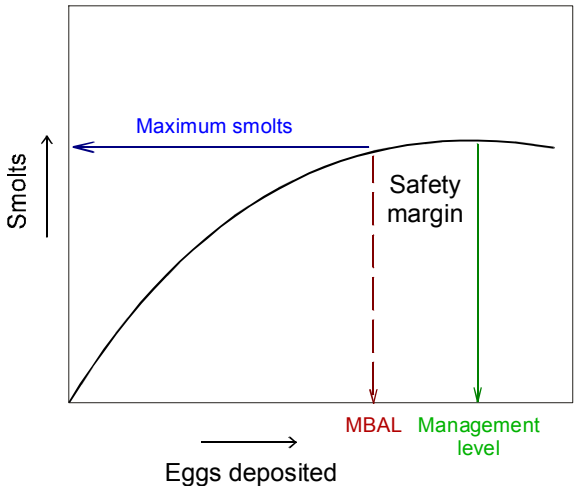
[1] **Riverine habitat** Data are used from the FRS Girnock Burn trap, River Dee. It has been calculated that the riverine area of 58,000 m² above the trap requires a minimum of 150,000 eggs to produce a maximum smolt output of 3,000 fish. This equates to an egg deposition rate of 2.6/m². However, to allow for a 'safety limit' the FRS have increased the target by 15% to 3.0/m².

[2] **Lacustrine habitat – Grade 1** Shallow lochs are more productive than deeper, oligotrophic ones. For the sake of definition, shallow lochs have been termed Grade 1. To estimate the potential smolt output of these lochs, data have been used from the WRFT Tournaig trap. In 1999 the system produced a run of 703 smolts, and scale samples showed that 534 (76%) had grown in Lochs Dalthean and Loch a Chuirn[17]. Both lochans are small, shallow and reedy, and have a total area of 26 ha. This equates to a smolt output of 20/ha, and using the Canadian lacustrine egg-smolt survival rate (see below) of 0.019, an egg deposition target of 1,052/ha was derived. The productivity of lochs for salmon depends on the level of competition from other species. In Tournaig only brown trout and eels are present, and since this is typical of most lochs in the WRFT area, this egg deposition target is probably transferable to other Grade 1 lochs.

[3] **Lacustrine habitat – Grade 2** There are no data available for deeper, unproductive lochs in Scotland. Instead, information for lakes in Newfoundland, Canada, were used, where the average smolt output is 7/ha. It has been calculated for these unproductive lakes that the egg-smolt survival rate is 0.019, yielding an egg deposition target of 368/ha.[3]

2 Biological and management spawning targets

Different forms of spawning target are used within the range of salmon-producing countries. The first is the Minimum Biological Acceptable Limit (MBAL). This egg deposition target is set at the minimum eggs required to produce the maximum number of smolts, and surplus return of adults. However, this target does not allow any contingency for unforeseen disasters (e.g. disease, redd washout, acidification) which might reduce the survival of eggs below that predicted. Consequently some rivers set a management level, that also produces the maximum number of smolts, but aims for a slight overproduction of eggs to compensate for any problems. Management levels also give a degree of security when the data used to calculate spawning targets may be inaccurate. These spawning targets are illustrated in the theoretical stock-recruitment graph opposite.



Appendix V

River Carron restocking programme

Prior to the formation of Wester Ross Fisheries Trust, a programme was initiated to restore salmon and sea trout fisheries in the River Carron. Although outwith the work of the Trust, this programme has generated much interest because catches of both sea trout and salmon have risen. The following has kindly been submitted by Bob Kindness, principal of Seafield College and a WRFT trustee.

A River Re-born? Restoration of the River Carron
by Bob Kindness

Towards the end of the 80s and throughout the 90s, stocks of first sea trout and then salmon collapsed in the majority of West Highland rivers. The River Carron in Wester Ross was no exception, with rod catches dropping to almost nothing by the end of the 90s. In 1999, the recorded catch for the entire river was a paltry 5 salmon, 1 sea trout and 1 finnock. As a fishery, the river was dead.

Reasons for the dramatic decline in returning adults of both salmon and sea trout are much debated. Although individual reasons are often cited, it is much more likely that the decline has been caused by a combination of factors overwhelming the fish. Whilst poor marine survival would appear to underpin the decline, wetter winters and drier summers will also be having an effect on the freshwater phase of the life cycle. Redd wash-out during winter spates and low summer water levels that prevent returning adults from entering rivers will contribute greatly to a lack of juvenile production.

For the Carron, the immediate problem was all too obvious. From electro-fishing surveys, carried out in 1986, 1992 and then through the mid-90s, and from observations of anglers, young stock was disappearing. At the same time, a very simple check on the quality of the habitat available for juveniles indicated that, in general, it was in reasonably good order and certainly not a limiting factor for juvenile production. Indeed the main holding area of the system, Loch Doughail, is likely to have changed very little over the years.

For a migratory stock, poor juvenile production results in a poor smolt run and even fewer returning adults. If a depleted river is to recover within a reasonable time span, it is essential to increase the number of juveniles, irrespective of the reasons for the decline. In most cases this requires re-stocking with appropriate stocks at an appropriate stocking level. This is the approach that has been taken by the Seafield Centre to try to bring the Carron back from the dead.

The majority of stocking programmes rely on catching wild maturing fish as a source of eggs. However, for the Carron, as would be the case with many Highland rivers, it was not possible to catch sufficient wild fish to generate egg numbers that would make stocking worthwhile. To achieve the level of stocking required, it was necessary to establish a captive broodstock for both sea trout and salmon.

Broodstock programme

For sea trout, the first steps were taken in 1994 and for salmon in 1996. Broodstocks were established by retaining a percentage of eggs stripped from wild hens. Fry from these eggs were then reared through to maturity entirely in freshwater. This method was preferred to using wild parr or smolts as a source of broodstock for the following reasons:

- the identity of the original parents is known;
- the number of original parents is known;
- a health check (particularly for IPN, infectious pancreatic necrosis) can be made on the original parents

Broodstocks were established by retaining a percentage of eggs stripped from wild hens *(Seafield Centre)*

before their offspring are used for brood fish. Taking wild fish into a broodstock unit carries the risk of introducing disease since individual fish cannot be tested until they reach maturity;

- Valuable parr or smolts are not removed from the wild
- The husbandry of the fish, particularly feeding, is straightforward since they are in captivity throughout their entire life.

Since the broodstock programme was established, 7 different salmon and 4 sea trout stocks have been established. These are now being held at varying stages of maturity (Table 1).

Crossings are made between year classes to avoid crossing between siblings. The oldest sea trout have now produced eggs in 7 consecutive years, giving a total of around 10,000 eggs per hen to date. The quality of the eggs is still good, and the hens show no signs yet of reaching the end of the road. At one time, such egg production would have been typical of wild West Highland sea trout, since they were a long-lived multi-spawning stock.

Table 1 Seafield Centre captive broodstock 2003

Age (yrs)	Salmon	Sea trout
0+	Carron	
1+	Ling Gruinard	Carron Ba (Mull) Coulin
2+	Dundonnell Gruinard Ling Forsa (Mull)	
3+	Carron Ullapool Dundonnell Forsa	Carron (2)
5+	Applecross (2) Carron (2)	Applecross (4) Coulin (4)
7+	Applecross (4) Carron (4)	Coulin (6)
8+		Applecross (7) Coulin (7)

- The numbers in brackets represent the number of consecutive strippings.
- All the above broodstocks are produced from ova taken from wild fish.
- Since 1998, 8.4 million sea trout eyed ova have been produced.
- Since 2000, 2.3 million salmon eyed ova have been produced.

The sea trout are reared in simple un-lined earth ponds and are hand-fed once per day (*Seafield Centre)*

Facilities for the two broodstocks have been established at two different locations, at Glen Mor, between Lochcarron and Kishorn, for the sea trout, and at Attadale for the salmon. The sea trout are reared in simple un-lined earth ponds and are hand-fed once a day, making routine daily contact with the fish less than 10 minutes. Most of the fish are handled only once per year at stripping time and are generally still in excellent condition, despite their age. The salmon are currently being held in GRP tanks. However, butyl-lined rearing channels for the salmon are under construction to create more natural rearing conditions less likely to cause damage to the fish, which can occur in the tanks. To date more than 10 million eggs have been produced from the broodstocks.

Stocking strategy for the Carron

When the salmon and sea trout stocks in the Carron were in a healthy state, literally millions of eggs would have been deposited annually. Such numbers were necessary to maintain the health and productivity of the system. The current stocking programme for salmon initially used eggs taken from wild fish. The numbers generated were very low and, although contributing something, any additional returning adults would be insignificant in terms of regenerating a viable fishery. However, from 2001 onwards, with eggs from the captive salmon broodstock coming on stream, significantly higher numbers have become available for stocking out. In the case of the sea trout, no stocking was possible until eggs were produced from the captive broodstock, since no wild sea trout could be caught in the Carron. Substantial numbers have now been stocked out, but not from a Carron-based broodstock, which is contrary to some attitudes towards stocking out with non-natives. Although Carron broodstock are now available, the majority of stocked fish to date are from broodstock derived from Coulin (Ewe system) sea trout.

In the light of a major study carried out on the sea trout population in Loch Doughail (the larger of the two lochs in the Carron system) during the 1930s, the choice of sea

Table 2 River Carron stocking record

Year	Salmon)	Sea trout
1995	8,000 fry (WB)	0
1996	9,000 fry (WB)	0
1997	5,000 fry (WB)	17,000 (CB)
1998	6,000 fry (WB)	50,000 (CB)
1999	0	70,000 fry (CB) 21,500 parr/smolts (CB)
2000	8,500 parr/smolts (WB)	30,000 parr/smolts (CB)
2001	159,000 fry (CB) 12,000 parr/smolts (CB)	23,000 fry (CB) 15,000 parr/smolts (CB)
2002	150,000 eyed ova (CB) 175,800 fry (CB) 6,000 smolts from release pond, half Slice treated	140,000 eyed ova (CB) 154,000 fry (CB) 4,000 smolts from release pond, half Slice treated
2003	170,000 eyed ova (CB) 230,800 fry (CB) 3,750 parr (CB) 7,250 smolts (CB), 3,000 of which Slice treated	162,000 eyed ova (CB) 32,000 unfed fry (CB) 253,100 fry (CB) 3,500 parr (CB) 2,000 smolts (CB), half Slice treated

WB = Wild broodstock CB = Captive broodstock

trout stock for the Carron seems highly appropriate. Large numbers of sea trout were netted from the loch and examined before being released. A significant conclusion from the study was that the rivers Laxford, Ewe and Carron, each containing major lochs, each produced 'a similar type of sea trout, which may be called the standard West Coast type'. Therefore, Coulin stock are suitable for the Carron.

Once significant numbers of salmon and sea trout eggs became available from the captive broodstock (Table 2), it was possible to formulate a stocking strategy for the river that would, hopefully, maximise the success from the stocking efforts. Decisions had to be made regarding the numbers to be stocked, the most appropriate locations, and at what stage of the life cycle. The first two decisions were easy to make. Historical information on stock numbers suggested that it would be impossible to over-stock the system given current available resources and, from juvenile stock surveys in recent years, it was known that all parts of the river were well below maximum carrying capacity. A decision on the optimum life cycle stage for stocking out is less easy to make, since many diverse opinions exist. To cover all options, stocking on the Carron used both salmon and sea trout at all stages. The adopted stocking strategy has been to use as much stock as could be produced, stock them into as many parts of the system as possible, including the lochs and use all stages from eyed ova to smolts. In the case of the smolts, these were tagged and released through specially-constructed release ponds (as in Iceland) with half of them being pre-treated with the anti-sea-lice medicine Slice. Some tagged sea trout were recovered in 2003, and it is anticipated that some of the tagged salmon will be caught in 2004.

Catch statistics

Although stock recovery in a river can be demonstrated through juvenile surveys, real recovery has taken place only when the number of returning adults increases. For most rivers, in the absence of traps or counters, rod catches are used to assess the abundance or relative abundance of adult fish. It is generally accepted that rod catches represent between 10% and 20% of the total number of fish entering a river, depending on conditions and fishing effort. For any river this enables meaningful comparisons to be made between years.

For the Carron, good records exist from 1980 onwards for both salmon and sea trout (see Parts 2 and 3) and for the Attadale beat, which takes in the sea pools, they date back to 1901. For the river as a whole, rod catches dropped dramatically through the 1990s to reach their lowest level in 1999. However, following the instigation of the re-stocking programme, the rod catch for both sea trout and salmon has shown a remarkable recovery from 2001 onwards, with catches rising spectacularly year on year. The catches for 2003, a year when good fishing conditions were rare, exceeded all possible expectations. The level of recovery can be put in context by considering the following:

- the combined catch of sea trout and finnock in 2003 of 595 compares with a recorded catch of only 2 in 1999 and 3 in 2000;
- the total of 595 represents a 53% increase on the 2002 catch and 159% increase on the previous highest total since 1980;
- the Attadale 2003 sea trout and finnock catch of 482 is 58% higher than the previous highest total (306 in 1959) since 1901 (Figure5);

- the total catch of 40 salmon in 2003 is 7 times higher than the 5-year average from 1997 to 2001;
- the catch was generated by relatively few anglers (on average no more than one angler per day for the entire river);
- one angler had a season's catch of 16 salmon, 37 sea trout and 366 finnock for the equivalent of 16 full rod days;

three of the riparian owners caught their first salmon for 8 years on their own water.

Conclusions

As a salmon and sea trout fishery in the process of recovery, the Carron has out-performed all other Scottish rivers over the last two years. While stocks, particularly of sea trout, have shown signs of improvement in some other rivers, none has demonstrated such a spectacular turnaround. The obvious question to ask is, what has happened differently in the Carron? The answer would appear to be two-fold:

Firstly, a strong smolt run (especially of sea trout) has been re-established, due largely to the stocking programme. Although very few of the stocked fish were marked in any way for identification, logic dictates that the majority of the smolts are from released stock. From a rod catch of 478 finnock in 2003, simple calculations show that, for the improvement to be due to natural spawning, egg deposition in excess of 2 million from over 3,500 hens would have been necessary in the years 1999 and 2000. During these 2 years, only 3 adult sea trout were recorded in the catch statistics. Clearly, stocking has made the difference.

Secondly, for the increased smolt run to generate such a good return of finnock, the marine environment must have improved, thereby increasing marine survival of post-smolts. This improvement needs to be considered against a background of high salmon farming activity in the area. 2003 was the second year of the cycle for farms in both Lochcarron and Kishorn with a standing biomass in excess of 3,000 tonnes. This appeared to have little or no effect on the wild fish leaving from and returning to the Carron. For a number of years, there has been co-operation between the Carron proprietors and the local salmon farming companies, strengthened more recently by the AMA process. Both companies use Slice to control sea lice, with information on lice numbers being freely available within the AMG. In 2003, early-returning post-smolts were not present at the mouth of the Carron and, in a sample of more than 400 sea trout and finnock, sea lice were either at background levels or absent in all but two fish. Sea lice were not perceived to be an issue for the Carron during the whole of the current farm production cycle.

Lessons to be learned

Salmon and sea trout are very resilient and undoubtedly will recover naturally in depleted rivers if given enough time. However, to get stocks back to a level beyond simply survival and to make a fishery viable may take many years. In the case of the Carron, intervention through stocking has resulted in a recovery to date over a relatively short time. To achieve this, the Carron proprietors have been pro-active both in terms of their approach to the stocks in the river and how the river is used. Having endorsed the work on the stocks, they have realised the importance of fostering community benefit from the river. To this end, the lower two beats on the river have been made available on a day-ticket basis to locals and visitors alike. The benefits of this approach are:

- salmon and sea trout fishing is available in Wester Ross at a very affordable price;
- angling is encouraged to help monitor the success of the restoration programme (all fish caught on the Carron are either released or retained alive for broodstock);
- a wider access to the river is encouraged;
- salmon in the Carron will no longer be regarded as 'just for the laird'.

It is noteworthy that the restoration work on the Carron has been closely parallelled by research conducted through the 1990s on the River Lagan in Belfast. The Lagan lost its salmon stock between 1750 and 1800, but with improved water quality and following a quick and simple assessment of habitat for suitability, a stocking programme began in 1991 using non-native stock from the Bush hatchery. The programme has been very successful, not only in generating good runs of adult salmon (800 in 2000), but also in establishing a naturally spawning stock. A quote from the research paper illustrates the similarities between the programmes for the two rivers:

'The general degree of success encountered in the programme to date indicates the validity of the approach taken toward restoration of the salmon population, i.e. taking a fish-centred approach, using trial stocking to find out how bad (or good) the state of the river was, and building upon success when encountered. Had the initial approach adopted following feasibility study been continued, i.e. to seek funding for a major, fully funded, restoration project based on a "habitat first" basis, it is possible that very little progress would have been made.'

This passage could just as easily have been written for the Carron. The message is clear – be positive, increase the numbers of young stocks, and the benefits will come within a reasonable time scale. I for one am looking forward with eager anticipation to the 2004 angling season on the Carron. ❑

Appendix VI

Lampreys in the River Carron

There are three lamprey species in the UK. Brook lamprey (*Lampetra planeri*) remain in freshwater. River lamprey (*L. fluviatalis*) and Sea lamprey (*Petromyzon marinus*) are anadromous – migrating to sea where they parasitise other fish. After hatching, juvenile lampreys, known as ammocoetes, spend up to 5 years growing in their burrows in silt before developing eyes and teeth and emerging.

In early September 2004, Peter Cunningham and Dr Lorna Brown joined Dr Jon Watt of Ecological Research Associates [ERA] to begin a survey of lampreys within the area as part of a contract for SNH.

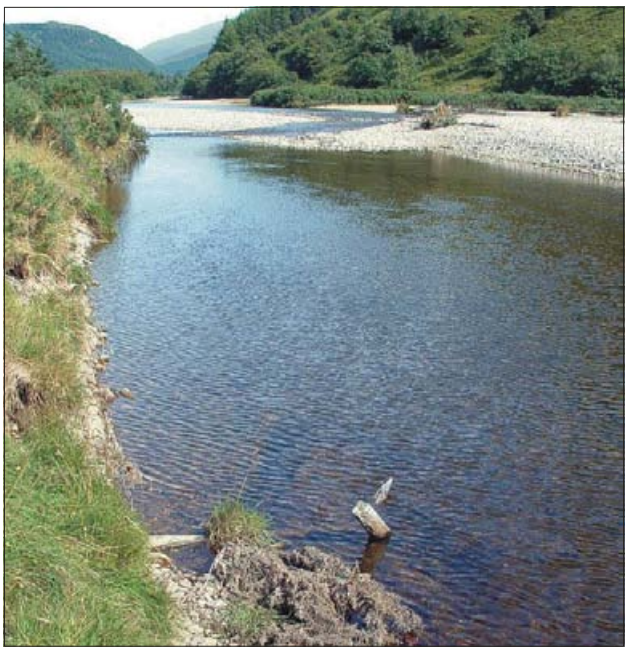
Ammocoetes of both *Lampetra* sp. and *Petromyzon marinus* were found in the River Carron below the bridge at Strathcarron. *Lampetra* sp. were also found above Loch Dughaill, with the highest densities recorded in twigging silt in the mouth of the Achnashellach Burn near Os Lair. No lampreys were found above Glencarron falls.

Ammocoetes (juveniles) of both *Lampetra* sp. (top) and Sea lamprey (bottom) were found in silt under the trees downstream of Strathcarron Bridge

Petromyzon marinus are not know from any other rivers within the area. *Lampetra* have been found in the Croe and Glenmore (Glenelg) rivers, but not further north. So far as is currently known, the River Carron has the highest diversity of native freshwater fish species of any river system within Northwest Scotland.

There is still little information about the distribution of lampreys within the system. Please look out for spawning lampreys, particularly adult sea lampreys, which may be up to 1m long, and make spawning pits in river gravels – most likely between the mouth of the Culag burn and Strathcarron Bridge in May and June. At that time of year, it may be possible to assess the status of the spawning *Petromyzon* population through a snorkel survey.

Brook (or River) Lamprey (gen. *Lampetra*) 'transformers' from the mouth of the 'Achnashellach burn' (below). After spending 4–6 years living in silt, juvenile lampreys transform into adult fish. We would be very interested to hear of any lamprey records for other rivers within the WRFT area.



A few *Lampetra* ammocoetes were found in pockets of silt in the margins of the main stream River Carron here, about 200m upstream from Loch Dughaill. Further surveys are required to determine their distribution within the system

Article and photos by Peter Cunningham

Reference

Sime, Iain (2003) *River Runners – Freshwater pearl mussel, Atlantic salmon and Lampreys*. Scottish Natural Heritage. ❑

Wester Ross has some of the most exciting and prolific wild game fishing in Scotland. Although many of the numerous brown trout lochs can still provide outstanding sport, stocks of salmon and sea trout have declined in many river systems over the past 10–15 years.

Healthy salmon and sea trout populations are not simply of importance to fisheries. These fishes were probably of 'keystone' importance to the development of diverse and productive freshwater ecosystems. The breeding success of birds such as Black-throated diver, Osprey and White-tailed eagle may have been related to the abundance of fish. The distribution of otters and freshwater-pearl mussels may also be partly related to the abundance of trout and salmon.

Wester Ross Fisheries Trust was established in 1996 in response to the need for solutions to fisheries problems and to improve the management of wild fisheries. The Trust employs a full-time biologist and several part-time assistants. This report provides an outline of the following:

- **Catches of salmon and sea trout in the River Carron**
- **Results of juvenile salmon and trout surveys within the catchment**
- **An assessment of the freshwater habitat accessible to salmon and sea trout**
- **Management recommendations and options to restore the natural fisheries productivity of the River Carron system**

Wester Ross Fisheries Trust is a registered charity dedicated to the conservation, restoration and development of healthy and sustainable fisheries in Wester Ross.

New members are always welcome!

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