Part 4 **Factors limiting fish production in WRFT area**

4.1. Introduction

The productivity of the wild fish populations within the Wester Ross Fisheries Trust area is dependent upon a wide range of inter-related factors. Different fish species or populations are subject to different factors that limit their abundance and growth rates in different areas. Some limiting factors are localised, or cause problems periodically rather than all the time; for example, unstable river habitats, and periods of drought which can limit the production of juvenile salmon. For most fish populations in Wester Ross, levels of production are constrained by the extent and 'quality' (in its broadest sense) of freshwater habitats and the availability of food. For some anadromous (fish which migrate to sea to feed and spawn in freshwater) fishes such as sea trout, salmon, and some lampreys, and for the catadromous (fish which migrate to sea to spawn) European eel, conditions in coastal waters and in the seas beyond limit fish production. Conditions beyond coastal waters are largely outwith the realm of influence of the Wester Ross Fisheries Trust.

Human activities have altered the natural environment over millennia. Wild fish populations have adapted as the pressures upon them have changed. Some fishes are doing rather well: the Eurasian minnow and the Pike have colonised some freshwaters within Wester Ross following introductions; in some waters, domestic effluents or fish farm wastes have created areas of nutrient enrichment, and wild trout, charr, juvenile salmon, eels, and sometimes even flounders, have taken advantage of the elevated abundances of food.

Limiting factors that are judged to be of importance within the Wester Ross Fisheries Trust area are listed in Table 4.1. For some, there is quantitative data to support their inclusion. For others it is not yet possible to provide supporting scientific data; such factors may nevertheless be of importance. Fisheries management is not simply about managing fish populations and the environments in which they live; it is as much about informing those who fish or manage fisheries, surrounding lands and coastal waters of the problems that affect fish populations; of the opportunities for solving them, of the opportunities for raising levels of fish production.

Perhaps the main message that this part of the fisheries management plan tries to communicate is that more often than not, problems for fish populations and fisheries production are multi-factorial. Fisheries management is not usually about addressing just one issue. In order to restore or enhance levels of fish production from lochs and river systems within the WRFT area, many factors need to be considered. Polarised thinking is not the way to address fisheries management issues. That said, sometimes a single issue (e.g. sea lice epizootics for sea trout) has created a 'bottleneck' which has compromised fish health and fisheries productivity to the extent that, until the primary problem has been resolved, other issues are of secondary concern.

The following sections summarise each of the factors considered to affect fish populations and fisheries in Wester Ross.

- **Proposed management actions** for the Wester Ross Fisheries Trust are bulleted at the end of each section; these are outlined in more detail in Part 6 of the plan.

Table 4.1 *Factors limiting fish production and fishery performance in the WRFT area.*

				Affected species				chronic /	local /
Text	Factor	Marine	Freshwater	Salmon	Sea trout	Brown trout	Other spp.	ephisodic	widespread
2.1	**Collapse of coastal fisheries**	yes	no	**major**	**major**	no	no	**chronic**	**widespread**
2.2	**Seal predation**	yes	no	?medium	?medium	no	unknown	ephisodic	local
2.4	**Sea lice infestation**	yes	no	**major**	**primary**	no	no	chronic	local
3.1	**Lack of adult fish (survival)**	yes	yes	**major**	**major**	no	**charr**	chronic	**widespread**
3.2.2	**Inadequate spawning habitat**	no	yes	**major**	medium	**major**	**charr**	chronic	local
3.2.2	**Redd washout**	no	yes	**major**	**major**	minor	**charr**	ephisodic	local
3.2.3	**Lack of cover for juvenile fish**	no	yes	medium	minor	no	no	chronic	local
3.2.3	**Lack of holding pools for larger fish**	no	yes	**major**	minor	medium	no	chronic	local
3.3.2	**Domestic effluent**	no	yes	minor	minor	no	no	ephisodic	local
3.3.2	**Effluent from aquaculture**	yes	yes	minor	minor	**?major +ve**	**charr**	chronic	local
3.3.3	**Lack of instream nutrients and food**	no	yes	**major**	**major**	medium	no	chronic	**widespread**
3.3.4	**Acid flushes**	no	yes	?medium	?medium	?medium	unknown	ephisodic	local
3.3.5	**Degraded riparian soils**	no	yes	medium	medium	medium	no	chronic	**widespread**
3.4.1	**Waterfalls and fish passes**	no	yes	minor	medium	no	no	chronic	local
3.4.2	**Road culverts**	no	yes	minor	medium	minor	minor	chronic	local
3.4.3	**Other man-made obstructions**	no	yes	local	local	local	minor	chronic	local
3.5.1	**Predation by fish**	yes	yes	**?major**	medium	no	unknown	ephisodic	**widespread**
3.5.2	**Fish-eating birds**	yes	yes	medium	medium	minor	no	ephisodic	local
3.5.3	**Otters**	no	yes	medium	minor	minor	minor	ephisodic	local
3.5.4	**Poaching and illegal fishing**	yes	yes	?medium	?medium	medium	no	ephisodic	local
3.5.5	**Overexploitation by anglers**	yes	yes	minor	minor	local	no	ephisodic	local
3.6.1	**Genetic introgression**	no	yes	**major**	medium	medium	no	chronic	?local
3.6.2	**Stocking**	no	yes	medium	medium	medium	no	ephisodic	local
3.6.3	**Escaped farmed fish**	yes	yes	**major**	minor	no	minor	ephisodic	local
3.7	**Non-native & alien species**	no	yes	medium	medium	medium	?possibly	chronic	**widespread**
3.8	**Parasites (excluding sea lice)**	yes	yes	medium	medium	local	minor	ephisodic	local
3.9	**Ecosystem malfunction**	yes	yes	**major**	**major**	medium	unknown	chronic	**widespread**
3.10	**Inadequate knowledge & understanding**	yes	yes	medium	medium	medium	medium	ephisodic	**widespread**
3.10.1	**Inadequate knowledge of loch fishes**	yes	yes	medium	**major**	medium	**charr**	chronic	**widespread**
3.10.2	**Inadequate knowledge of marine ecosystem**	yes	yes	medium	medium	no	eel	chronic	**widespread**
3.11	**Communication & information exchange**	yes	yes	medium	medium	medium	medium	chronic	**widespread**
3.12	**Lack of information / awareness**	yes	yes	medium	medium	**major**	medium	chronic	**widespread**

4.2 Problems within the marine environment

In terms of gaining biomass, salmon and sea trout do most of their growing at sea. There are various problems associated with feeding, predation and over-fishing in the sea beyond inshore waters that are of particular concern to salmon. These are addressed by national and inter-governmental organisations with a broader remit, notably the North Atlantic Salmon Conservation Organisation (www.nasco.int). Closer to home, sea lice remain the primary factor limiting sea trout production. Predation by seals is regarded as a problem in some parts of the WRFT area. However, the impact to fish populations from seals is hard to quantify because of the difficulty in obtaining good scientific information.

4.2.1 Coastal fisheries and their mismanagement

Salmon and sea trout are not the only fish populations to have declined or collapsed in local waters. Catches of whitefish (cod, haddock, flatfish & rays) also collapsed during the 1970s, 1980s and 1990s.

Herring, a major food for sea trout, were over-fished in the 1970s around Scotland. They have since made a partial recovery. In offshore areas, sandeel populations declined in more recent years, with the failure of sea birds (especially terns & auks) to breed successfully in the early 2000s. This has been partly attributed to changes in sea temperatures associated with 'global warming' (see http://www.sahfos.ac.uk).

Wester Ross was formerly a world-class venue for sea angling. The British record rod-caught plaice was taken only four miles from the WRFT office in 'Longa Sound' in 1974. Ullapool hosted the European sea angling championships in the 1970s. Many stocks of white fish (except perhaps pollack) subsequently collapsed in local waters. In 1984, the Inshore Fishing (Scotland) Act removed the three-mile limit that banned the use of mobile gear within three miles of the shore. This opened the inshore fishing grounds to the trawlers. Many local fishermen relate the collapse of inshore fish stocks to the removal of the three-mile limit. Some scallop divers have reported that scallop dredgers have since destroyed inshore reefs, with loss of topography, biota and habitat for numerous aquatic species.

In 2000, the Loch Torridon Creel fishermen were granted provision of an exclusion zone for trawlers. The overall extent to which fish stocks and fish habitats in this area have regenerated is not known. However, there has been little recovery of sea trout numbers entering the FRS Shieldaig trap. In 2007 large shoals of juvenile herring were seen in many sea lochs including Loch Gairloch providing food for sea trout, other fish species and many species of bird.

There is much to do to better understand and manage the inshore marine environment and to protect and rebuild fish stocks and other wildlife therein. Salmon and particularly sea trout populations will benefit from improved management of coastal ecosystems.

- **Proposed action for WRFT:** support collaborative studies which are aimed at providing the information needed to foster good management and protection of the marine environment. Support the formation of the inshore fisheries management group, and representation of someone with a remit to safeguard salmon and sea trout populations within the group of scientists.

4.2.2 Seal predation

Both Common seals and Grey seals occur around Wester Ross. Salmon and sea trout are taken by seals as part of a diet that includes many other kinds of fish and shellfish. Seal numbers increased around Scotland during the 1980s and 1990s. In 1989 there was an estimated 67,000 adult grey seals around the Scottish coastline; by 1998 this had increased dramatically to 110,000 (Sea Mammal Research Unit). More recently the number of Common seals in some parts of Scotland has been in decline (SMRU presentation at Moray Firth Seal Management Meeting, 9 June 2008)

Formerly, salmon netsmen around Wester Ross culled seals in the vicinity of netting stations; the last netting station in Wester Ross ceased to operate early in the 21st century. The netting station in Loch Long (near Dornie) operated for a few weeks in 2007.

The impact of seal predation on Wester Ross sea trout and salmon populations is unknown. Studies elsewhere suggest that salmonid fish normally constitute a minor part of the diet of seals (Middlemas, *et al* 2003). They also show that sometimes an opportunistic seal will move into a river estuary, or even into freshwater, where salmon and sea trout may become a major part of its diet. It is possible that over-wintered finnock and sea trout that enter the sea in late spring, when water temperatures are still cold are particularly vulnerable, especially if their health is compromised by sea lice infection. Local keepers and ghillies often express concern about levels of predation by seals on adult salmon and sea trout that linger in river estuaries awaiting spate flows to enable them to move upstream. In 2005, 8% of salmon taken in the Tournaig trap had damage indicative of seal attacks. Since 2005, the Scottish Executive has granted special permission to estates with fisheries interests to shoot small numbers of rogue Common seals during the close season if it is clear they are targeting wild salmon.

The issue is complex: gadoids, including pollack are also taken by seals. Pollack are also a predator of small sea trout: it is conceivable that in some situations, seal predation has a neutral impact upon sea trout populations.

In 2004 and 2005, WRFT monitored seal numbers at Kyle Rhea in collaboration with St Andrew's University Sea Mammal Research Institute (see Cunningham *et al* 2006). Studies by FRS scientists in Loch Torridon (including sea trout tagging) are providing new data on the significance of seal predation upon wild sea trout. Much more needs to be done to build up an understanding of the predator-prey relationships between seals, pollack and sea trout, and the other fish species that inhabit coastal waters.

- **Proposed action for WRFT:** where seals are considered to be of concern to wild salmon and sea trout fisheries interests, support studies and monitoring projects to clarify seal numbers in local areas to inform management; if necessary support the formation of local seal management groups. Seek advice from Sea Mammal Research Unit (www.smru.st-andrews.ac.uk).

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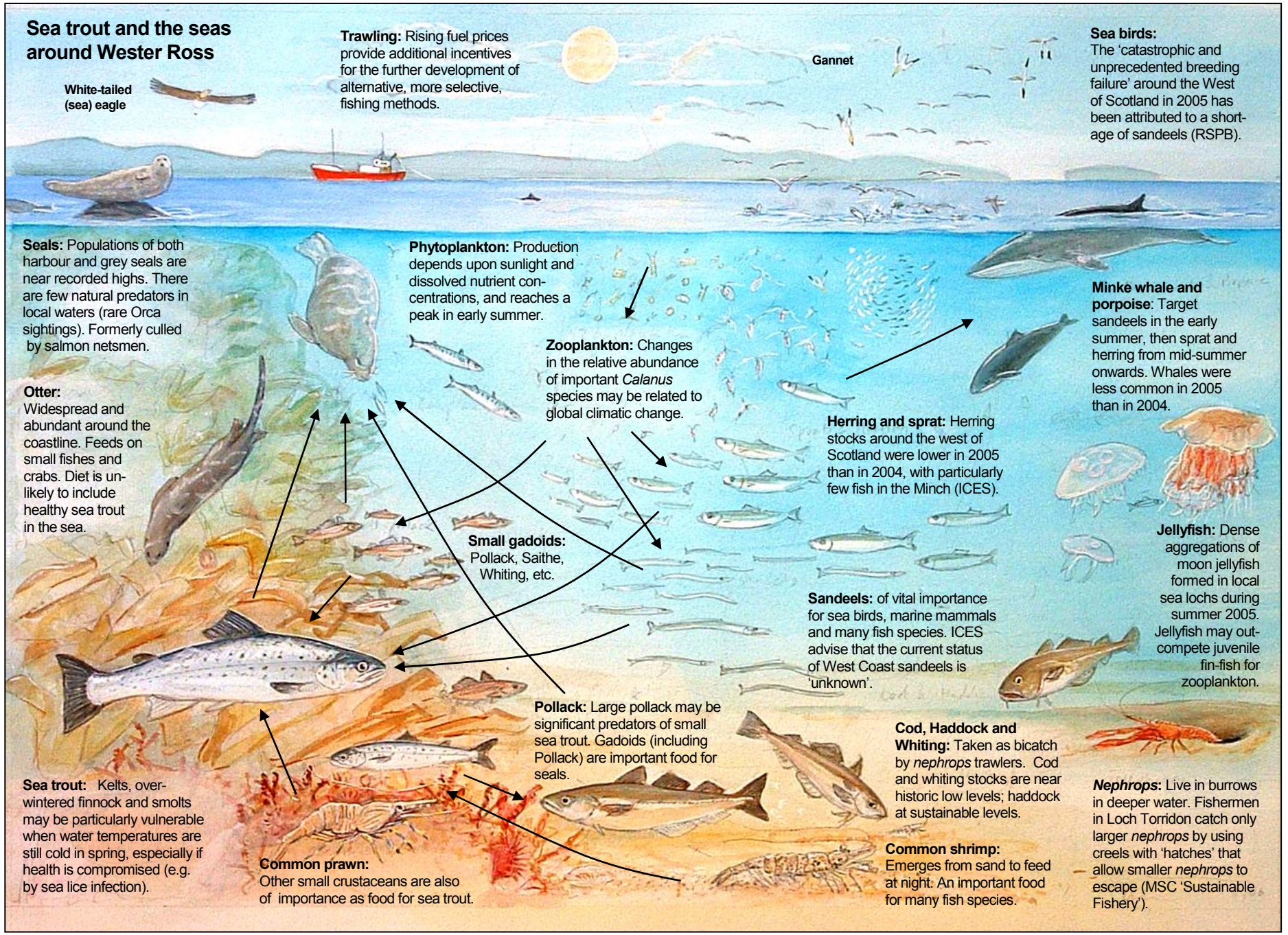
WRFT Fisheries Management Plan 2009+



4.2.3 Salmon farming in WRFT area

Salmon farming began within the WRFT area as a relatively small-scale industry in the early 1980s. Initially, salmon farms appear to have had a minimal impact on stocks of wild fish. At the end of the 1980s stocks of sea trout collapsed and salmon catches declined within many river systems in Wester Ross as they did elsewhere in the west of Scotland, Ireland and Norway where farmed salmon production was increasing. Subsequently, there has been much research to investigate relationships between sea lice levels on wild sea trout and outgoing salmon smolts and the occurrence of sea lice on farmed salmon in nearby farms (see Boxaspin, 2006 for review). The FRS Shieldaig Sea trout Project has investigate problems in Loch Torridon over the past 10 years (find links to Annual Reviews at http://www.frs-scotland.gov.uk/).

By the early 1990s, there were also concerns for the genetic integrity of wild salmon populations. As catches of wild salmon at Red Point Netting station fell in the 1990s to their lowest levels, the proportion of escaped farm salmon in the overall catch increased to over 40% in 1999. Studies by FRS and the Atlantic Salmon Trust demonstrated that female salmon of farmed origin had spawned successfully in several rivers in the area (Webb *et al* 1993).

Please refer to 4.3.6.3 for further discussion of the possible problems associated with escaped farm salmon breeding in the wild.

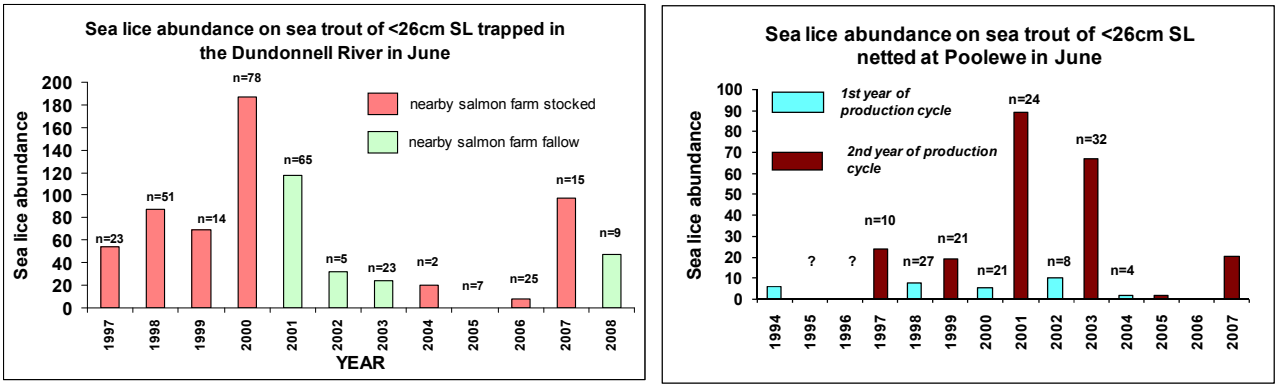
Map & table to insert: Locations of active fish farms around the WRFT area and their biomass consents map (to insert – is data available to public?? Does FRS/TWG have a map which can be used here?)

4.2.4 Sea louse (*Lepeopheirus salmonis*) epizootics

The sea louse, *Lepeophtheirus salmonis* is a natural parasite of salmon and sea trout. The natural host - parasite ecology of sea trout with the sea louse *Lepeopheirus salmonis* is finely balanced. Even prior to the onset of salmon farming, sea trout with 10 or more attached lice were commonly seen around the coasts. However, from the late 1980s much higher levels of lice infestation were found on sea trout, especially closest to fish farming areas. The collapse of sea trout populations and the fisheries they supported, including the Loch Maree sea trout fishery, has been linked to sea lice epizootics. Much has been written about sea lice problems in Wester Ross and related research (see papers / reports by Butler *et al*, Cunningham *et al*, Walker & Butler 2005, Raffell *et al* 2006, 2007 and 2008).

WRFT investigated the sea lice problem from 1996. The Ardessie Sea Lice Study (in collaboration with Ardessie Salmon Ltd.) compared levels of lice on sea trout entering the Dundonnell River with those at the nearby salmon farm (Butler, 2001). Post-smolt sea trout sea lice monitoring was carried out in river estuaries in June from 1997 to 2007. The prevalence and abundance of sea lice on wild sea trout at Poolewe was highest during alternate years, correlating with the 2nd year of the production cycle at nearby farms.

Figure 4.2.1 *The abundance of sea lice on early returned post-smolt sea trout [and other small sea trout] taken in a fyke net set at the mouth of the Dundonnell River (left) and in a gill net set at the mouth of the River Ewe in June.*



Since the year 2000, sea trout carrying high burdens of sea lice (average of more than 30 lice per post-smolt sea trout in a sample of 10 fish) were recorded in the River Ewe at Poolewe in 2001, 2003 and 2007. In 2007, WRFT was initially alerted to a problem by anglers who had taken early returned finnock in mid-May carrying lice burdens of in excess of 100 lice. Scientists employed by FRS made similar observations in Loch Torridon. Heavily infested sea lice were also taken in the Loch Broom area in 2007.

WRFT has no information describing levels of infection by sea lice of wild salmon as they leave local waters. Following a lice epizootic affecting sea trout in Loch Ewe in 2003, it was encouraging that catches of grilse in 2004 in rivers surrounding Loch Ewe were generally good. Because they tend to head straight out to sea, salmon smolts are considered to be less vulnerable to sea lice epizootics than sea trout.

WRFT supports the Area Management Agreement programme. Area Management Groups meet two or three times per year to set management targets to control sea lice on fish farms to levels at which problems for wild sea trout in surrounding waters do not occur. On-farm lice levels are said to have improved significantly since 2000, particularly with use of the in-feed pesticide SLICE (*Emamectin benzoate*). However, due to the very large numbers of salmon held at fish farms, even small numbers of ovigerous lice per fish may lead to production of larvae at levels one or two orders of magnitude greater than from natural sources in the sea loch and surrounding area alone. Weather and sea conditions can

conspire to create problems for wild fish. For example, a dry spring with warm sunny weather can lead to higher levels of infection of sea trout by sea lice.

Unfortunately recent research indicates that SLICE is no longer as effective as it was due to the development of resistance (Lees *et al* 2008). If sea trout populations such as that of Loch Maree and the important fisheries they supported (relative to other local fisheries) are to recover, a solution to recurring sea lice problems which are often contemporaneous with the second year of production cycles at nearby salmon farms, is prerequisite; and of highest priority.

The location of salmon farms relative to tidal currents is of particular importance. If larval lice are swept further out to sea by wind and water currents they may pose less risk to wild fish (at least locally). If lice larvae are swept towards the shore and become concentrated near river mouths, sea trout will be particularly vulnerable. In the Loch Hourn area, there has been some recovery of at least one sea trout fishery located in proximity to a salmon farm.

- **Proposed action for WRFT:** Sea lice remains one of the most important issues for the management of local fisheries resources, specifically sea trout and salmon populations. Sea lice should continue to be monitored on sea trout during periods when sea trout are in the sea. The Trust should continue to actively seek improved on-farm management of sea lice in areas where epizootics have occurred in the past, to ensure that on-farm lice levels are kept below those that cause problems for wild fish. Such levels will vary from loch to loch and farm to farm. Where sea lice epizootics are recurrent, WRFT should continue to seek the relocation of problem salmon farms away from rivers with important sea trout fisheries.

4.3 Freshwater production and associated problems

Freshwater environment

The production of juvenile salmon, trout and other fish species from the rivers and lochs of Wester Ross is limited by a range of factors, some of which affect many rivers; others of which are specific to particular stretches of water. With little agricultural, industrial and domestic effluent entering waters in Wester Ross, there are few pollution problems. 'Space' (the area of suitable habitat available) is not the only factor that limits fish production. Production of fish and other wildlife tends to be limited by the availability of food. In turn, this is determined by the fertility of rivers and the catchment areas from which they drain. Some rivers have always been mobile; perhaps an increasing problem is that of habitat instability. WRFT has previously investigated the 'redd washout' problem; after torrential rain shows in July 2007, floodwaters washed away the railway line by Loch Scamhain and a new channel appeared in part of the upper Rhidorroch River. Eggs, fry, parr and the food they eat (invertebrate larvae) are washed away when the streambed starts to move. This problem can be exacerbated by moor burn, high levels of grazing by livestock and deer, and consequent shallow-rooted vegetation and thin soils.

4.3.1 Lack of spawning adult fish

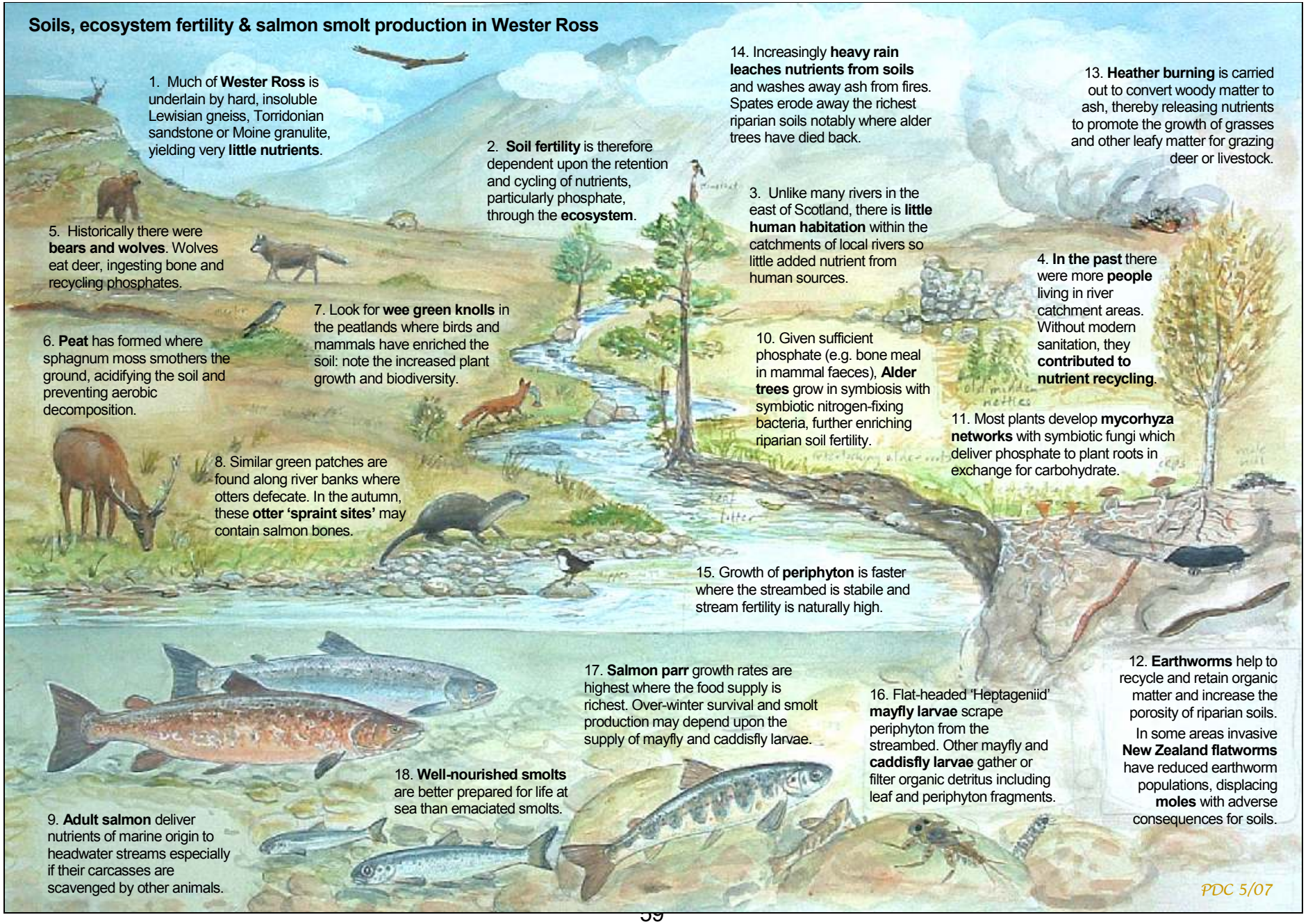
As rates of marine survival of both salmon and sea trout fell in the 1980s and 1990s, fewer adult fish returned to the river systems to spawn. In smaller rivers and headwater tributaries of larger rivers the number of adult fish fell to levels where recruitment of juvenile fish may have been inadequate to maintain populations.

For salmon, juvenile populations were lost from some areas of 'marginal habit', typically in headwater streams furthest from the sea above complex falls or obstacles. During the 1980s or 1990s, juvenile salmon were lost from parts of the upper Kanaird, Lael, upper Gruinard River, upper Bruachaig River (River Ewe system), Balgy headwaters (above Loch an Loin), upper Elchaig, upper Glenmore River and upper Glenbeag River. In addition, populations of juvenile salmon were extirpated from the Tournaig, Sguod and Shieldaig river systems.

More recently, there has been some recolonisation of headwater areas by wild salmon. In 2006 or 2007 juvenile salmon of wild origin were found throughout the accessible parts of the Kanaird and Elchaig by WRFT electro-fishing teams, including areas where they were not recorded in earlier years. Juvenile salmon were also recorded throughout the Tournaig system, and in the Sguod and Cuaig rivers where they had been absent for a year or more. However, salmon of wild origin were still absent from the upper Bruachaig, upper Balgy, upper Glenmore and upper Glenbeag rivers in 2006 / 2007.

For trout populations, it is harder to assess the consequences of a declining number of adult sea trout on the health of a population; because juvenile trout encountered during electro-fishing surveys may be progeny of either sea trout or brown trout that have remained within freshwater.

- **Proposed actions for WRFT:** WRFT electro-fishing teams should continue to monitor salmon populations in marginal areas. Where there is concern that a fish population may be vulnerable, anglers (and fishery managers) should be advised not to fish, or to follow strict 'catch and release' protocol. At the time of writing, stocks of early-running spring and MSW June salmon and sea trout are of particular concern. WRFT should support genetic studies which more clearly define individual populations so that management targets can be developed on a population by population basis. Fishing for eels and char should be discouraged.


Soils, ecosystem fertility & salmon smolt production in Wester Ross
1. Much of **Wester Ross** is underlain by hard, insoluble Lewisian gneiss, Torridonian sandstone or Moine granulite, yielding very **little nutrients**.
2. **Soil fertility** is therefore dependent upon the retention and cycling of nutrients, particularly phosphate, through the **ecosystem**.
3. Unlike many rivers in the east of Scotland, there is **little human habitation** within the catchments of local rivers so little added nutrient from human sources.
4. **In the past** there were more **people** living in river catchment areas. Without modern sanitation, they **contributed to nutrient recycling**.
5. Historically there were **bears and wolves**. Wolves eat deer, ingesting bone and recycling phosphates.
6. **Peat** has formed where sphagnum moss smothers the ground, acidifying the soil and preventing aerobic decomposition.
7. Look for **wee green knolls** in the peatlands where birds and mammals have enriched the soil: note the increased plant growth and biodiversity.
8. Similar green patches are found along river banks where otters defecate. In the autumn, these **otter 'spraint sites'** may contain salmon bones.
9. **Adult salmon** deliver nutrients of marine origin to headwater streams especially if their carcasses are scavenged by other animals.
10. Given sufficient phosphate (e.g. bone meal in mammal faeces), **Alder trees** grow in symbiosis with symbiotic nitrogen-fixing bacteria, further enriching riparian soil fertility.
11. Most plants develop **mycorhyza networks** with symbiotic fungi which deliver phosphate to plant roots in exchange for carbohydrate.
12. **Earthworms** help to recycle and retain organic matter and increase the porosity of riparian soils.
In some areas invasive **New Zealand flatworms** have reduced earthworm populations, displacing **moles** with adverse consequences for soils.
13. **Heather burning** is carried out to convert woody matter to ash, thereby releasing nutrients to promote the growth of grasses and other leafy matter for grazing deer or livestock.
14. Increasingly **heavy rain leaches nutrients from soils** and washes away ash from fires. Spates erode away the richest riparian soils notably where alder trees have died back.
15. Growth of **periphyton** is faster where the streambed is stabile and stream fertility is naturally high.
16. Flat-headed 'Heptageniid' **mayfly larvae** scrape periphyton from the streambed. Other mayfly and **caddisfly larvae** gather or filter organic detritus including leaf and periphyton fragments.
17. **Salmon parr** growth rates are highest where the food supply is richest. Over-winter survival and smolt production may depend upon the supply of mayfly and caddisfly larvae.
18. **Well-nourished smolts** are better prepared for life at sea than emaciated smolts.
PDC 5/07

4.3.2 Physical habitat quality

4.3.2.1 Habitat continuum

There is much variation in riverine habitat quality for juvenile fish. For juvenile salmon, the most productive areas tend to be those where the substrate is stable with plenty of voids in which fish can hide and where water remains clear and flows relatively evenly; with nearby 'spawning' habitat with loose, clean pebble-sized sediment in which adult fish can easily spawn and in which the survival of eggs to hatch is high. Such areas are found in many of the river systems below lochs, where glacial deposits have been winnowed away and gently reworked by water (and spawning fish). The Gruinard River (below Loch na Sealga), Little Gruinard River (below the Fionn Loch) and A' Ghairbhe river (below Loch Clair) are areas of prime juvenile salmon habitat. Densities or CPUE of juvenile salmon in these areas are consistently high relative to other areas of stream habitat in Wester Ross.

At the other end of the in-stream habitat continuum for salmon are riverine areas where there is much movement of sediment, including bed-load sediment transportation and scouring. Such areas, where spawning habitat exists, are vulnerable to redd washout with low rates of survival of eggs. Exceptionally, summer spates may wash out fry and salmon parr, and reduce invertebrate populations. Examples of unstable habitat include the Rhidorroch River (Ullapool River catchment), Strath na Sealga River (above Loch na Sealga), Talladale River (by Loch Maree) and River Carron (above Loch Doughaill).

Much of the variation in habitat stability and the amount of cover is entirely natural, the product of geology, gradient and rainfall. Nevertheless, the rates at which stream banks erode are influenced by catchment management practices. Where riparian vegetation is weakened by heavy grazing pressure and riparian trees are dying back, rates of erosion and sediment input increase, usually to the detriment of fish populations. Past and predicted trends in rainfall intensity are likely to exacerbate the level of habitat instability of some headwater streams.

- **Proposed actions for WRFT:** address habitat issues at the river catchment – ecosystem level where possible. Current proposed activities include a habitat workshop with field excursions to demonstration sites, to show a range of problems and approaches to solving them.

4.3.2.2 Spawning habitat and redd washout

Salmon and Sea trout

The availability, distribution and quality of spawning habitat is a factor which influences the production of both salmon, trout and possibly arctic charr in the rivers and lochs of the WRFT area. There is much natural variation.

Some spawning areas are very stable, with little movement of sediment from year to year other than by spawning fish. Ancestral salmon and / or sea trout spawning redds can be found in parts of the Gruinard River, Little Gruinard River, Bharranch burn (upper Ewe system), and River Kerry in areas where the there are well sorted pebble size sediment.

Some streams have very little good quality spawning habitat. In some system, river gravels are highly mobile (as described above). The problem of redd washout was recognized early on by Dr James Butler. In the winter of 1998-99, the Trust demonstrated via the 'Redd Washout Project' that spawning habitat within many rivers was very unstable. 100% of artificial salmon and sea trout redds were washed out in the Badachro, Applecross, Kishorn, Carron and Attadale Rivers (Butler, 2000). In contrast, less than 30% of artificial salmon redds were 'washed out' in the Little Gruinard, Tournaig, Kerry, Corrie and Shieldaig river systems. Note that subsequent electro-fishing rivers recorded juvenile salmon in these systems; salmon eggs can survive conditions

Formerly spawning areas in streams flowing into Loch Maree were 'reconditioned' each year by ghillies (?under the guidance of Neil Graesser, Buckley, *pers comm.*) to maximize egg deposition and egg burial by sea trout. By removing some of the larger cobble-sized stones on the streambed, areas of smaller pebble sized sediment were exposed for fish to spawn in.

Brown trout

There are over 500 lochs or lochans within the WRFT area. The largest trout are often caught in smaller lochs where there is very limited spawning habitat (or none at all – the fish having been transferred into the loch from a nearby water by a local angler – see WR Wild Trout Project Report 2006). In contrast, other lochs have streams flowing into them with extensive areas of spawning habitat – with high annual recruitment relative to the available food supply. These lochs tend to be populated by large numbers of small trout.

Arctic charr

There are at least two stream spawning arctic charr populations in the WRFT area. Surveys of spawning areas in 2005 and 2006 suggest that recruitment of charr may be restricted by the quality of spawning habitat in these areas.

Since 2000, exceptionally high spate flows, associated with extreme rainfall events may have removed some of the finer sediment (small pebbles and gravel) from marginal spawning habitat from some rivers.

- **Proposed actions for WRFT:** consider projects to restore or enhance natural spawning habitat. At a long-term, catchment scale level, the restoration of thicker soils and vegetation will help to reduce rapid run off particularly following pulses of severe heavy rain (e.g. extreme summer spates). Where long-term supplementary stocking programmes are seen as a way to insure against redd washout, WRFT should seek advice from FRS and provide as much help as possible to ensure that stocked fish do not adversely affect wild populations.

4.3.2.3 Protection and cover for juvenile and adult fish

Salmon fry and parr habitat

Substrate quality is also of importance for juvenile salmon. For juvenile salmon, the best quality habitat is where the streambed is full of fry and parr sized voids, providing lots of cover. The two Gruinard Rivers have much of the finest juvenile salmon habitat within the WRFT area; lochs on respective systems act as sediment traps, and the main rivers below them have extensive areas of run and riffle type habitat over relatively stable, cobble or boulder substrate, with plenty of void space in which juvenile fish can hide.

In 2005, WRFT carried out a detailed quantitative e-fishing survey of the Little Gruinard River SAC as part of a contract from SNH, and recorded some of the highest parr densities of any SAC salmon river in Scotland. It should be noted that the 'parr' recorded at the e-fishing sites were some of the smallest of any river in Scotland!

Stream instability is usually less of a problem for salmon fry and parr than for salmon eggs. However, especially during the autumn and winter months bed-load transportation of sediment (mobilisation of stones on the bed of the stream) at periods of peak flow may wash juvenile fish downstream or kill them.

Following a severe spate on the 13th of September 2006, dead juvenile salmon were observed lying on the banks of the Talladale River near Loch Maree. The entire accessible part of the Talladale River was scoured by bed-load sediment transportation. The road bridge was nearly swept away. The week after the spate, only a few large salmon parr were found in the river nearby (less than 0.2 fish per minute electro-fishing); salmon fry were absent. The Rhidorroch River above Loch Achall is also unstable, a spate during the summer of 2007 led to a major shift in the river channel. The CPUE of both salmon fry and parr at a site near east Rhidorroch was much lower than in 2006.

The Kyle railway line was washed away near Loch Sgamhain between Achnasheen and Achnashellach at about the same time.

Larger fish

Even relatively small rivers, such as the Tournaig system and the River Sguod are capable of supporting a salmon population. For much of the year, especially during summer months, these river are too shallow to allow even a modest sized trout of half a pound (220g) to move between pools. Were it not for the lochs within easy reach of the sea which act as refugia, salmon would be highly vulnerable to predation by otters and unlikely to survive until the spawning season.

A lack of big, deep pools within the headwaters of the Glenmore River and in Abhainn Gleann na Muice and Abhainn Strath na Sealga may be one reason why salmon have been lost from these systems. If pools are too small or shallow, an experienced otter may be able to catch any large fish that it encounters; large numbers of returning fish may be needed to ensure that some survive long enough to spawn.

The addition of cover in the form of large woody debris and tree roots or large boulders in both the streams mentioned above might help to enable salmon to survive periods of low water in the summer.

- **Proposed actions for WRFT:** where a case can be made that holding pools or other habitat has been lost as a direct or indirect result of human activity (e.g. widening of the channel as a result of the loss of riparian trees), site specific projects should be developed to restore or recreate suitable habitat. This point needs further consideration.

4.3.3 Habitat fertility and productivity

4.3.3.1 Nutrient continuum

There is also a continuum in the nutrient status of rivers in Wester Ross. Across much of Wester Ross, biological production is limited by the availability of phosphorus. Rainwater contains little phosphorus; the rocks underlying many of the river catchment areas of Wester Ross rivers yield very little phosphorus. The fertility of the land and waters that flow from the land is therefore largely determined by the ecosystem and by anthropogenic influences.

At one end of the nutrient spectrum are waters which have become over-enriched or eutrophied with nutrients. Elsewhere in Scotland, some rivers have been eutrophied as a result of rain water run-off or leaching from agricultural land where fertilizer has been applied, for example the River Ythan and streams entering Loch Leven. There are no examples of this sort of enrichment in Wester Ross. At the other end of the spectrum are oligotrophic waters, or ultra-oligotrophic waters where phosphorus availability is very low. All headwater streams in Wester Ross are oligotrophic. Waters in virtually all lochs in Wester Ross are oligotrophic with very low productivity. Dissolved nutrient levels are highest in lochs which have salmon smolt production cages.

Habitat fertility is a key factor which determines the productivity of most fish populations in Wester Ross. In November 2007, WRFT held a seminar in Gairloch to consider ecosystem fertility and how changes in biota and land use over the centuries would have affected rates of growth and levels of production of juvenile salmon in Wester Ross streams (see links to presentations on www.wrft.org.uk).

4.3.3.2 Enriched areas – eutrophic waters

(c. SEPA pressure 1: diffuse and source pollution: agriculture, forestry, urban development) and SEPA pressure 2: point source pollution: sewerage, manufacturing, aquaculture, refuse, mining and quarrying)

Domestic effluent

In contrast to other areas of Scotland, discharges of domestic effluent are not major causes of concern in Wester Ross. There have been some localised issues: the Kinlochewe sewage works discharges into the Kinlochewe River. In July 2000, the sewerage tanks at Kinlochewe overflowed into the river; the works were subsequently up-graded. However, fish densities were elevated below a discharge into the Barrisdale River (see Box 4.3.1).

Aquaculture wastes

Dense phytoplankton blooms associated with enrichment were recorded in Loch Tollie in 1999 and 2003, and Loch Sgamhain in 2003. Neither of these lochs are currently active: cages have been removed from Loch Sgamhain (River Carron system). Cages in Loch Tollie (River Ewe system) have been inactive since 2005?.

Loch Damh is the other loch with salmon smolt production in Wester Ross, currently with two farms in operation. The loch is noted for producing large trout and charr, and large salmon smolts have been recorded leaving the system (e.g. Raffell *et al*. 2007)

Salmon smolts have also been produced in Loch Clair and Loch Lundie in former years, and these lochs will have been subject to a degree of enrichment.

Commercial smolt production units are located at the mouth of the River Kerry (Landcatch), with discharge into the sea, at Couldoran (River Kishorn), by the mouth of the Russel burn (Corrie mhor smolts ?discharges into the sea) and formerly at Ardessie (Ardessie salmon). Levels of enrichment and ecological associations have not been investigated by WRFT.

- **Proposed actions for WRFT:** To date, eutrophication has not been a major issue for fish populations or fisheries production in the WRFT area except locally. WRFT survey teams should continue to record the location of nutrient enrichment points, for example septic tank discharges, when undertaking juvenile fish surveys, recording fish densities and sizes above and below.

4.3.3.3 Barren sites - oligotrophic areas

SEPA and other government agencies have yet to formerly recognize that at the other end of the nutrient continuum, there are extensive areas where ecological status and wildlife (including fisheries) productivity has diminished due to cultural oligotrophication. Much of Wester Ross has been heavily grazed by cattle, sheep and deer over hundreds of years. Removal of livestock and deer carcasses from catchment areas represents a net export of nutrients that under more natural ecosystem conditions would have become available to aquatic life.

Formerly there were also more people living in headwater areas, contributing to nutrient recycling in a semi-natural way. In terms of nutrient cycling, people were a part of the ecosystem.

Headwaters of the following rivers appear to have been oligotrophied: Ullapool, Broom, Dundonnell, Gruinard, Little Gruinard (numbers of grouse shot around Fionn Loch as reported in Osgood Mackenzie (1921), were much higher than now), Ewe (e.g. Bruachaig), Torridon, Balgy, Applecross, Ling, Elchaig, Croe, Shiel, Glenmore, Glenbeag, Arnisdale, Barrisdale.

Issues to consider include: deer and livestock grazing; estate management; the need for restoring fertile soils. WRFT held a seminar in November 2007 in Gairloch to address problems associated with ecosystem fertility. Cunningham 2007 provides a summary of presentations and related discussion.

SNH would agree that the approach should be one of restoring ecological processes which regain, retain and redistribute nutrients. SNH would support re-establishment of riparian woodland rather than addition of nutrients directly.

- **Proposed actions for WRFT:** WRFT should seek to restore ecological processes which regain, retain and redistribute nutrients, particularly phosphorus, at the catchment scale. Where this is not possible in the short-term, nutrient restoration trials should be considered. These have been undertaken to raise dissolved phosphorus levels in North America in oligotrophied streams. There is a case for conducting similar trials in Wester Ross (c. Williams, 2007). These could be modeled on the findings of North American trials (e.g. Ward, in Mills (edit) 2003). Support is required from fishery managers and proprietors to initiate a project. Such a project should be carried out in collaboration with SNH and SEPA.

4.3.3.4 Acid flushes

In the winter of 1997 – 1998, the WRFT participated in a collaborative project to monitor acidification on the west coast. Samples from rivers in the WRFT area (then extending as far south as Loch Carron and catchments draining into it) were sent to the FRS Freshwater laboratory for analyses.

Streams which were sensitive to acidification tended to be those where catchment areas had thin soils and vegetation, where water flows directly off the highest mountains. They included the Grudie and Talladale (Loch Maree), Allt Coire Dubh (Torridon), Abhainn Dearg (Balgy), Fionn Abhainn and River Lair (River Carron).

- **Proposed actions for WRFT:** there is little evidence that acidification a major problem in the WRFT area to the extent that fish populations and fisheries production has been adversely affected.

4.3.3.5 Riparian and catchment soils

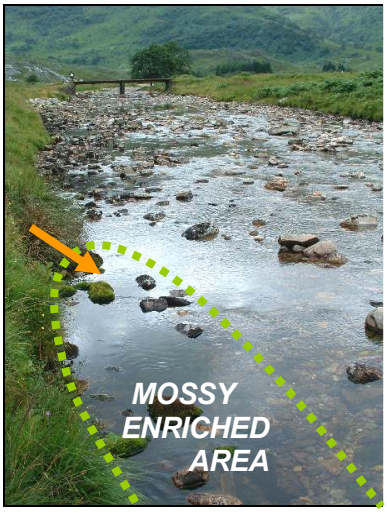
The health of riparian and catchment soils affects the stability of rivers by providing a medium for growth of strongly rooted vegetation, the fertility of streams and food availability, and their ability to resist acid flushes. Across much of Wester Ross, soils are thin, peaty, or poorly developed, reflecting an impoverished ecosystem.

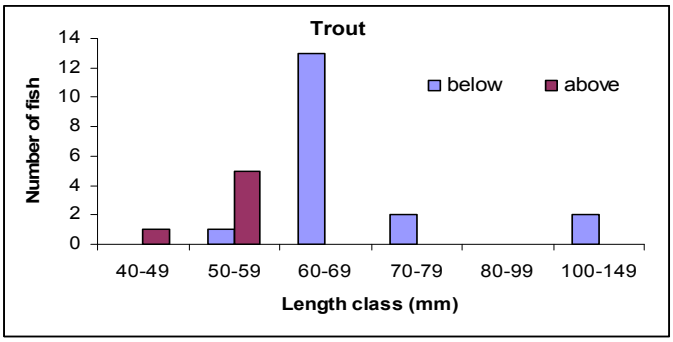
Indicators of healthy, fertile soils include earthworms and moles. WRFT is currently mapping the distribution of these, and of invasive New Zealand flatworms.

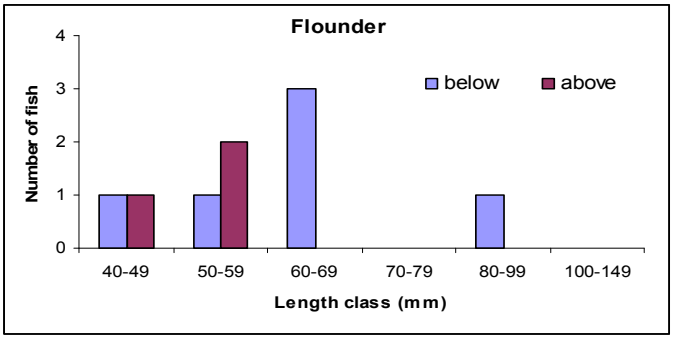
One of the most exciting developments for habitat restoration in recent years has been the establishment of Woodland Grant Schemes [WGSs] to restore native woodlands. By reducing grazing pressures (there are still voles and hares in some WGS schemes), planting trees and applying phosphorus fertilizer, soils are given a chance to recover. The largest WGS in Scotland, the Balle Mor woodland, is located between Gairloch and Loch Maree. There are trout lochs in the new woodland area and these may become more productive as the trees become established.

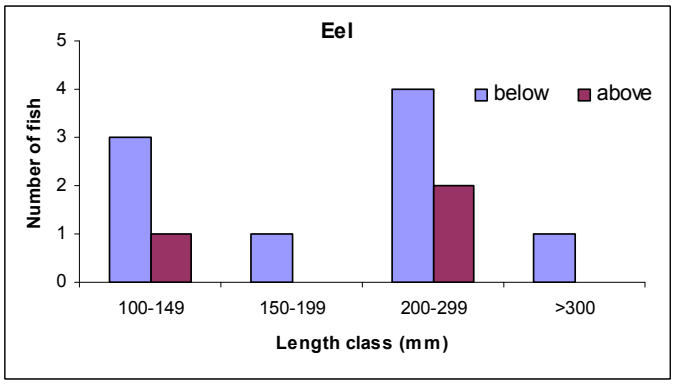
Box 4.3.1 *Observations around septic tank discharge.*

Across much of Wester Ross, **biologicial productivity is limited by the availability of nutrients and food**. Many streams are highly oligotrophic and juvenile salmon and trout have to survive and grow with a very limited food supply. In some places the relationship between nutrient levels and fish abundance is easily recorded in the field. The figure below contrasts the numbers and size of fish taken around a septic tank inflow into a river in the southern part of the WRFT area. Below the outflow, the streambed was mossy. Above the outflow, the streambed was of bare stones. In ten minutes of electrofishing at sites below and above the outflow respectively, we found the following. Below the outflow there were more fish and trout fry were on average more than 5mm longer than above the outflow.









Number and size of trout, flounder and eel caught in 10 minutes fishing at a site immediately downstream from ('below') a septic tank outflow and 10 minutes fishing at a comparable site upstream ('above') the septic tank outflow. There were more fish in the enriched area and most were larger!

SEPA may have concerns about the levels of nutrient discharged at this point! However, if there is a shortage of nutrient in the river which, in part, is a consequence of anthropogenic changes within the catchment area associated with long-term land management practices, one might argue that the septic tank outflow is merely supplying supplementary nutrients into the water that under more natural circumstances would have been fed into the river in any case. Wild fish in the impact zone, it appeared, were thriving!

4.3.4 Obstacles

4.3.4.1 Natural waterfalls

There are many natural waterfalls in Wester Ross, some of which are passable to salmon and trout, others are passable only occasionally to salmon, or sea trout. Historically, some have been eased to enable upstream fish passage upstream. These include falls on the Runie (Kanaird) and Bruachaig (Ewe).

Fish ladders were constructed around falls on the Allt Beith and the Tournaig River during the early 20th century. The Allt Beith fish ladder was partially repaired by WRFT in 2003 and 2004, restoring salmon access up to Loch a' Bhaid Luachraich. There is still some work to do to prevent leakage at lower flows and to ensure salmon smolts are able to migrate down the fish ladder to the sea.

The WRFT Tournaig trap is situated in the fish ladder around the falls at the bottom of the Tournaig River system. This fish ladder has also been repaired in the past and will require further maintenance in the future.

4.3.4.2 Road culverts

(c. SEPA pressure 3: abstraction and flow: electricity, water supplies, agriculture
4. changes in morphology: river engineering, agriculture, land claim, urban)

Actions have already been taken to ease fish passage through road culverts on spawning burns around Loch Maree and the River Kerry. However, there are still a number of road culverts which should or could be improved to enable fish passage.

Offending culverts are situated as follows (none of these require digging up the road: solutions can be found by attaching concrete baffles inside the pipes or on the concrete apron):

1. **Allt Bad an Luig** (near Second Coast): culvert beneath A832 at NGR 193050 890300 is impassable to salmon and – pipes too steep, and pool required below culvert to allow access. The area pf habitat for salmon and sea trout above this culvert includes 15,000m^2 of riverine habitat and at least one loch (Loch na h-Uidhe) of area 8-10 ha. I've yet to check whether Loch Fada might also be accessible, if so the, culvert is potentially obstructing access to a large sea trout system.

2. **Sand Burn (Laide):** culvert at NGR 190350 891800 is possibly impassable to salmon and sea trout which were formerly able to access as far upstream as loch na Greige in Laide wood.

3. **River Sguod** (below Loch Sguod): the culvert beneath B8057 at NGR 181800 887800 is difficult for salmon and sea trout to get over: too wide and smooth so water shallow and difficult for fish to jump on to culvert. This could be relatively easily improved.

4. **Glen Docherty Burn**: new culvert beneath A832 at NGR 205750 860250 to a small trout spawning stream is impassable – pipe too long and steep. There is possibility for diverting the stream into a ditch (will need excavated) to the next culvert downstream which is shorter and could be more easily made passable, thereby creating a trout (and sea trout) spawning channel of several hundred metres.

4.3.4.3 Other man made blockages

There is also an old water intake weir (marked as a 'Dam' on OS Explorer [1:25,000] sheet 434) at NGR 180900 880400 which is no longer in use (and unlikely to be used again – check with Scottish Water) which should be made passable. Gairloch Angling Club members could make the weir passable in an afternoon using sledgehammers! Or else, a simple fish pass could be provided if the structure is to be retained.

Figure 4.3.1 *Impassable culvert near Second Coast*

- **Proposed actions for WRFT:** WRFT will seek to ensure that obstructions are made passable, by working with SEPA, The Highland Council, Scottish Water and other agencies responsible for them.

4.3.5 Predators

4.3.5.1 Fish-eating fish

Trout are natural predators of salmon and arctic charr. The extent to which they affect levels of production of prey species has not been studied within the WRFT area. Estimates of predation by trout of salmon smolts from the River Bran (Conon system) suggest significant losses to trout (?10%+). Trout as small as 25cm can take large parr (*pers obs.* thanks to 13 year old Dougie Williams!).

Trout predation of juvenile salmon is likely to be most significant in systems where salmon smolts have to pass through a large freshwater loch to reach the sea. Such systems include the Ullapool River (Loch Achall), the Gruinard (Loch na Sealga), the Ewe (Loch Maree), and the Balgy (Loch Damh).

Trout also take charr and the eggs of charr and salmon. Like other predators, if fish populations are subject to other pressures (for example poor marine survival, habitat deterioration), trout may contribute to local extirpations of some populations.

Eels may take juvenile salmon, and trout; and in Loch Maree at least, they seem to particularly fond of small benthic-morph Arctic charr (from gill net studies). Conversely, trout have been found with small eels inside them.

In the marine environment, very little is known about what eats what. Pollack are possibly a significant fish-predator of sea trout in the late spring and summer.

- **Proposed actions for WRFT:** Where possible, data should be collected to clarify the extent to which trout take smolts; and perhaps also the diet of Pollack. It has also been suggested that minnows may take charr eggs in some lochs; this possibility requires further investigation.

4.3.5.2 Fish eating birds

These include Black-throated diver, Cormorant, Red-breasted merganser, Goosander, Heron, Herring gull, Osprey, White-tailed eagle and Dipper. Fish or fish eggs are an important source of food for these species. Note that one of the aims of the fisheries management plan is to restore food supplies for birds and other wildlife.

Where juvenile fish populations are healthy, bird predation is likely to make little impact on overall levels of production. Birds tend to feed in areas where fish densities are highest. This is because juvenile fish are most vulnerable to predation when out-competed / displaced by other fish; when they are loosing condition.

Saw bills ducks are seen as a problem by some estates particularly during the smolt migration period when a loss of productivity can be understood. Strong, well-fed smolts are likely to be less vulnerable than those that are in poor condition. WRFT in collaboration with RSPB studied fish-eating birds in the River Ewe catchment in 2003. Numbers were recorded through summer months; there is little information describing local congregations of birds during the smolt migration period.

Fish eating birds are often present in areas where lice infested early returned post-smolt sea trout gather. Heron and Herring gulls were seen taking small sea trout from the River Ewe in May and June 2007 during a sea lice epizootic

- **Proposed actions for WRFT:** Numbers of fish eating birds should be recorded during smolt migration periods in the River Ewe and other major salmon and sea trout rivers. Studies of the feeding behavior of Black-throated divers in Loch Maree may help to clarify whether they are able to find an adequate food supply.

4.3.5.3 Otters

In 2001, WRFT radio-tracked 12 salmon in the Kinlochewe area during the period up to and following spawning (Cunningham *et al* 2002). Of six tagged male salmon, the tags of 5 were recovered on the river bank, and it was assumed based on nearby spraints and other evidence that the salmon had been taken from the water by an otter. Of six female salmon, one was taken by an otter although the other 5 survived the spawning period.

Other evidence of otter predation includes the discovery of salmon scales and a backbone near the Runie Falls in 2006, and evidence of salmon taken by an otter from the Docherty burn in 2006. Sometimes salmon eggs pass through the gut of an otter without being digested.

Predation by otters is judged to be a significant factor limiting numbers of spawning salmon towards the headwaters of some systems. As spawning time approaches, adult salmon become increasingly vulnerable as may move into shallower water to spawn. Studies elsewhere also show that during the spawning period more male salmon are taken than female salmon.

Otter predation is an entirely natural and important part of the food web along spawning burns. By removing salmon or salmon carcasses from the water, nutrients of marine origin become accessible to the terrestrial ecosystem. Formerly, there were also bears, and wolves – both of which are known to take salmon from spawning streams in N. America.

However, in the context of diminishing adult salmon returns, otters may have played a role in the extirpation of juvenile salmon populations especially from some of the smaller more marginal areas.

4.3.5.4 People: poaching and illegal netting

Over the years, fish have been taken illegally in gill nets, by rod and line without permission, and though other means. In the 1970s several rivers were poised by thieves using cymag.

Current levels of poaching are difficult to establish; since the removal of legal netsmen, some have suggested that illegal netting operations have become more prevalent in some areas. The tradition of taking a fish ‘for the pot’ is still part of crafting culture; there is still no system of tracing the origin or destination of wild salmon served in local and distant restaurants. This is a poor state of affairs.

Much (most) of the Wester Ross coastline is not covered by a bailiff. Appointed bailiffs tend to be ghillies and keepers who patrol their local patch. The Scottish Fisheries Protection Agency carries out random searches for illegally set nets.

4.3.5.5 People: overexploitation by anglers

Salmon

Anecdotes suggest overexploitation in the past by anglers may have also contributed to the decline of some fish populations. Spring salmon have been shown in studies elsewhere to be particularly vulnerable to capture by anglers. Catches salmon from the falls pool of the River Bruachaig are said to have peaked in the years prior to the sale of the fishery in the 1970s, and it is possible that this was a factor in the decline of the sub-populations.

The Little Gruinard River has extensive areas of naturally good juvenile salmon habitat. The river first adopted a catch and release policy for salmon in 1991 and this policy remains in place. The Little Gruinard River has retained the healthiest salmon population of any river within the WRFT area.

Nearly all fisheries now have a compulsory or voluntary catch and release policy, and the majority of salmon in all rivers are returned. The WRFT River Ewe radio-tracking project (2001 -2002) demonstrated that a high proportion of rod caught salmon, when returned to the river, can survive until the spawning season and beyond (for females at least). Bob Kindness has demonstrated a high rate of survival of released fish some were recaptured three times (including as kelts).

The WRASFB leaves each river to set its own policy for C&R; WRFT recommends that at least all early fish salmon and 2SW female fish are returned.

Sea trout

Formerly, there were so many sea trout that even finnock were taken by anglers for the table. The WRFT currently strongly recommends that all sea trout are returned in the WRFT area, and this policy is adopted in all fisheries. The only possible area where more work may need to be done is with sea anglers who fish for sea trout, particularly in the Ullapool area.

As for salmon when stocks recover, the need for a catch and release policy may change. Our long term target is for fish populations to be healthy enough in the future to provide an exploitable yield as they did in the past.

Brown trout

Most hill lochs are populated by large numbers of relatively small trout. A few lochs and lochans have relatively small numbers of large trout. If some of these lochs were managed as ‘catch and release’ fisheries (perhaps like carp ponds), the WRFT area could become a venue for fishing for spectacular, big trout in spectacular natural surroundings. Please refer to Cunningham, 2007 for background info and discussion.

- **Proposed actions for WRFT:** WRFT can raise awareness of the need to protect wild fish and responsibly manage fisheries within the local area through provision of information (e.g. juvenile fish surveys; catch assessments) and education. Bailiffing is largely a matter for estates and the area district salmon fishery board.

4.3.6 Genetic integrity

4.3.6.1 Genetic continuum: native – non-native populations

Compared to the threatened fish populations of tropical rivers like the Mekong (where the WRFT biologist became familiar with over 100 freshwater fish species in the 1990s some of which were threatened and have not been recorded since), the freshwater fish populations of Scotland and Wester Ross are all relatively young. Even so, during the 10,000 years since the wild salmon, trout and charr initially colonized the freshwaters of Wester Ross the genetic make up of different populations has diverged. There has been much recent interest in finding out more about population structuring within salmon, trout and charr population. It is clear that there is much genetic biodiversity within species, and WRFT is currently collecting DNA samples from salmon and trout (e.g. Loch Maree Wild Trout Project) to learn about population structuring. WRFT has also provided support for other workers learning about charr population structuring.

At one end of the spectrum are fish populations which have retained their original genepool, or evolved without interference from man, for example Arctic charr populations in the larger lochs. At the other end of the genetic spectrum are fish populations which are of stocked origin, for example the Brook trout population in Loch an Uaine which was stocked over 100 years ago.

4.3.6.2 Stocking

The extent to which fish of non-native origin are able to establish new viable populations varies. The spread of minnows within the WRFT area in recent years demonstrates how easily some species are able to colonise new habitat.

Some angling clubs still buy in trout from fish hatcheries out with the area to stock their local waters. The risks of introducing new parasites (e.g. the freshwater louse *Argulus*) or diseases to stocked waters are also poorly understood.

In the past salmon of non-native origin were also stocked into rivers in Wester Ross. However, this practice has now ceased within the area. To the best knowledge of the WRFT biologist, all salmon currently used for stocking since 2000 have been of native (to the local area) origin.

Rivers where non-native salmon have been stocked in past years include the Kanaird & Ullapool rivers (both with Kyle of Sutherland origin fish) and the Arnisdale (North Esk salmon)

- **Proposed actions for WRFT:** WRFT can raise awareness of the need to protect wild fish and responsibly manage fisheries within the local area through provision of information about the genetic integrity of fish populations; and by fostering greater awareness of the need to protect native ‘gene pools’. WRFT in collaboration with FRS should assist river proprietors and fishery managers as much as possible in making decisions as to whether to stock or not (e.g. in light of juvenile fish and river habitat surveys). Such decisions should not be influenced by salesmen.

4.3.6.3 Escaped farm salmon

Escapes of salmon from farms within and around the WRFT area are reported most years. In 2005 over 20,000 salmon were lost from a farm in Loch Carron due to storm damage. In 2007, 24,000 salmon were reported to have escaped from a farm in Loch Ewe when a net split open; within the same area 25,000 salmon escaped from nearby farms in 2003 (fire melted cage; fish transferred to a holed net); the catalogue of other escapes is presented in the WRFT River Ewe FMP.

Escaped farm salmon have been recorded in WRFT rivers for almost 20 years. During the early 1990s, progeny of escaped female farm salmon were recorded in many of the rivers in the area demonstrating that female farmed salmon had successfully spawned (Webb *et al* 1993). Since then up to 30% of the rod catch of salmon from some rivers in some years has been ascribed as 'escaped farm salmon'. Escaped farm salmon may be under-represented in some catch figures, especially when they escape as smolts and subsequently grow to look like wild fish. Salmon that have escaped from marine cages may be hard to recognise by their general appearance after six months or more in the wild.

The extent to which genes from salmon of farm origin are present within salmon populations in Wester Ross has yet to be fully quantified. Systems which have had freshwater 'smolt' production units may have been subject to higher degree of genetic introgression than other rivers. Such systems include the Balgy (Loch Damh), the Carron (Loch Sgamhain) and the Ewe (Loch Tollie cages). There are also smolt production units at the mouth of the Kerry (near Gairloch), the mouth of the Russel Burn (near Kishorn) and Tulloch burn (Lochcarron). WRFT monitored numbers of escaped farm salmon smolts leaving Loch Damh in 2000 and carried out studies of escaped farm smolts in Loch Tollie in 1999. More recently, scientists from FRS have conducted further investigations of the origin of salmon smolts leaving the River Balgy system (Middlemas and Stewart, 2008).

Smolt production cages have recently been removed from Loch Sgamhain (2007); and cages in Loch Tollie have been fallow since ?2005.

- **Proposed actions for WRFT:** WRFT can raise awareness of the need to identify and remove escaped farm salmon where possible. Unfortunately, often the only way to do this is through scale reading. WRFT in collaboration with other fisheries trusts through RAFTS should seek funding to develop a means of identifying escaped farm fish through genetic screening. All farmed salmon should be tagged.

4.3.7 Alien species

(c. SEPA Pressure 5: invasive alien species)

4.3.7.1 Non-native fish

Pike and minnow are considered to be non-native species within Wester Ross. Their distribution is described in Part 3. Pike are currently known from only two loch systems in Wester Ross. To date they have not been recorded in any of the major lochs. They are widely distributed within the River Conon System to the east of the WRFT area. Minnows have become established in many system. The general pattern of colonization suggests that many populations originated from discarded anglers' live bait.

- **Proposed actions for WRFT:** WRFT can raise awareness of the need to protect native wild fish populations and to prevent the spread of non-native species in the area, in collaboration with other organisations and agencies (including SEPA, SNH and FRS)

4.3.7.2 Other non-native fauna and flora

Mink

Mink are seen from time to time within the WRFT area most recently near Loch Maree and in Feb 2008 by River Attadale. There is no evidence that they have affected juvenile fish populations in the area in the same way that juvenile fish production in the Wester Isles has been impacted. The WRFT Biologist feels that mink may be deterred from some areas by the presence of Pine martens which are also good swimmers and feed on fish carrion, foxes and badgers. However, the distribution of mink in Wester Ross is poorly known.

- **Proposed action for WRFT:** WRFT is to help SNH investigate the occurrence of mink within its area through distribution mink recording rafts and traps to keepers and other land managers.

Rhododendron ponticum

The problem of invasive spreading along water courses was highlighted in the WRFT River Broom FMP, WRFT River Carron FMP, WRFT Ullapool River FMP (see references under Cunningham *et al*). Rhododendron leaves contain toxins so are less palatable than the leaves of native trees for instream invertebrates. Furthermore, the dense shade created may restrict autochthonous productivity.

- **Proposed actions for WRFT:** Further work is required to find out whether Rhododendron leaves and woody debris contributes anything to instream productivity once toxins have been leached out.

4.3.8 Parasites and diseases

The primary parasite issue in the WRFT area concerns epizootics of **sea lice** (*Lepeophetheirus salmonis*) affecting sea trout and to a lesser degree, salmon (see 4.2.4 above).

Other health problems have affected fish: during the 1970s **Ulcerative Dermal Necrosis** (UDN) affected salmon and sea trout in many rivers within the area. In 2007, many salmon and grilse had **'bleeding vent syndrome'** associated with infection by parasitic nematode worms at sea.

Farm fish in Loch Damh were reported to be infected with the viral disease **Infectious Pancreatic Necrosis** (IPN) on several occasions until the disease was removed from the 'notifiable' diseases list (?in 2005). The disease can cause high mortality of farmed salmon smolts following transfer to saltwater. Whether the virus has caused any direct (or indirect) mortality of wild salmon or sea trout smolts that carry the virus following entry to saltwater is unknown.

WRFT has assisted FRS Fish Health inspectors in collecting samples of salmon parr from the Dundonnell River, Docherty Burn (River Ewe), River Croe and River Elchaig in recent years. Reports obtained have all indicated that no bacterial or viral diseases were detected.

In freshwater, Brown trout are often infected with **nematode worms** and **tape worms**. In 2003, WRFT concluded that a principle factor for a lack of larger brown trout in Lochan nam Breac near Gairloch was parasitic infection leading to premature mortality of trout, associated with the seagulls which are attracted to a nearby waste disposal area.

The WRASFB has distributed leaflets and notices wildly within the area it covers warning anglers to take care not to introduce ***Gyrodactylus salaris***. WRFT has distributed information to river areas to the south of the WRASFB area.

Minnows in Loch Maree are infested with tapeworms (***Ligula*** sp.); larger minnows are commonly disfigured. The parasitic tapeworm in question does not appear to infect trout.

- **Proposed actions for WRFT:** WRFT should continue to work closely with the FRS Fish Health Inspectorate, and encourage fisheries managers and anglers to notify the trust if they come across problems. WRFT should ensure that all equipment is disinfected following field work in a river system where there is a possibility of disease transfer. For example, diseases such as IPN are known to occur in some systems with salmon smolt units; care should be taken not to transfer this disease to other systems.

- The Trust should continue to actively support efforts to prevent ***Gyrodactylus salaris*** from entering the country.

4.3.9 Ecosystem integrity

4.3.9.1 Freshwater areas

Atlantic salmon and sea trout can be regarded as ecological keystone species within the river systems in which they are found. Many other animals are partly dependent upon juvenile or adult fish as part of their diet; formerly a relatively large proportion of the annual import of phosphorus into some oligotrophic catchment areas would have been of marine-derived origin, via salmon or sea trout.

For several thousand years after the last period of glaciation, salmon are understood to have been part of an ecosystem which included bears, wolves and lynx, as well as herbivorous animals such as elk and beaver. Until a few hundred years ago, people living in river valleys including headwaters of most of the major river systems (examples: the Ullapool, Gruinard, Little Gruinard and Ewe) would have performed a similar ecosystem role so far as nutrient retention and recycling is concerned.

Over the past 100 years, headwater areas have been depopulated, and grazing pressures have increased. So far as the productivity of rivers and lochs is concerned, the loss of fertility (see 3.3.3) is closely associated with ecosystem breakdown.

Salmon thrive in habitats where predators and scavengers remove and ingest carcasses, and nutrients are recycled back into the river ultimately contributing food for juvenile fish.

- **Proposed actions for WRFT:** WRFT can raise awareness of the need to adopt an ecosystem approach to land and river management. This does not mean reintroducing large predatory animals. What is important is to understand how ecosystems, regardless of whether they are wild-, human- or agri-ecosystems can cycle and retain nutrients and generate higher fertility and productivity.

4.3.9.2 Marine ecosystems

Damage to inshore habitats and overexploitation of coastal fisheries has also led to ecological changes. There are more seals and less fin fish in coastal waters than 100 years ago. In 2005 and 2006 there were prolific jellyfish (*Aurelia*) blooms in local sea lochs; fewer jelly fish were seen in 2007.

Aquafarms discharge large amounts of nutrient into coastal waters, possibly more than from combined domestic and natural sources in the past (dissolved and particulate matter). Relationships between nutrient levels, plankton diversity, and densities and other fauna (e.g. jelly fish blooms) are not clearly understood by WRFT biologist, but are of much interest.

Ullapool was founded on the herring fishery which developed in the area at the end of the 18th century, but within 50 years, stocks had collapsed. It seems they have never recovered to former levels.

The integrity and natural productivity of the inshore marine ecosystem is clearly of importance for sea trout populations and fisheries. Much more collaborative work (e.g. with wildlife tourism interests) needs to be done to better monitor, understand and manage marine habitats and wildlife. WRFT is well positioned to take a lead or help facilitate some of this.

- **Proposed actions for WRFT:** Although largely out-with WRFT remit, there is much to do to learn more about the health and productivity of the coastal environment, particularly in relation to sea trout feeding opportunities.

4.3.10 Lack of information / awareness about fish populations and their habitats

4.3.10.1 Knowledge continuum

WRFT has collected detailed information describing riverine habitats for many systems in the area, and particularly juvenile salmon populations. At the other end of the continuum, WRFT has little knowledge of fish populations (e.g. charr) and important habitats in all but a few lochs.

- **Proposed actions for WRFT:** Gaps in our knowledge of fish populations need to be filled. One of the key areas of current work is genetic sampling and profiling of salmon and trout populations, for fisheries management purposes, within the WRFT area in collaboration with FRS.

4.3.10.2 Fish populations including Arctic charr in lochs

There is very little knowledge about the fisheries ecology of lochs in Wester Ross and in particular the ecology and status of the many populations arctic charr. Formerly, residents were more knowledgeable than they are now; much traditional ecological knowledge [TEK] has been lost.

- **Proposed actions for WRFT:** WRFT has recently worked in partnership with / facilitated survey teams to investigate fish populations in lochs through inventory gill netting. This work has already increased out understanding of the relative abundance of different fish species in different lochs.

Figure 4.3.2 *'Pelagic' and 'benthic' arctic charr from Loch Maree, taken in gill nets in 2005. Virtually nothjng is known about the status of respective populations. Spawning locations are unknown. Historically, charr were netted from Loch Maree.*

4.3.10.3 Fish populations in coastal areas and marine ecosystems

Many fish (including sandeels, herring and small gadids) and invertebrates (including shrimps and prawns) are eaten by sea trout. There is little knowledge about the current status of wildlife, including fish populations and the habitats that they depend upon within coastal seas. Formerly, local fishermen had more intimate knowledge of different fish and shellfish populations; traditional ecological knowledge [TEK] about herring populations (herring are no longer fished for locally) has been, and is being lost.

- **Proposed actions for WRFT:** WRFT should work with other local fishing organisations and marine wildlife conservation interests to develop projects to research and monitor wild fish populations – for example local spawning herring.

4.3.11 Communication and information exchange

4.3.11.1 Communication continuum

A common fisheries management problem is ensuring that fisheries managers, fisheries scientists and fishers communicate effectively with each other. WRFT has good communication with many ghillies, fisheries proprietors and fisheries scientist in FRS and other agencies. Two newsletters and an annual review are prepared each year. The WRFT website was redeveloped in 2008.

4.3.11.2 Whole river management groups

Following the formation of the Wester Ross Area Salmon Fishery Board in 2005, several smaller fishery boards were disbanded (Kanaird, Broom, Gruinards, Ewe). The revival of annual meetings to address rive specific issues might help to facilitate actions toward more productive fisheries.

4.3.11.3 Government agencies

WRFT has a good working relationship with SNH, particularly local area officers, and with many scientists in FRS. The local SNH area officer attends WRFT meetings. WRFT seeks to progress closer working relationship with SEPA especially with respect to the CAR regulations and monitoring and the Area Advisory Group.

4.3.11.4 Informing youngsters: school children and students

WRFT has carried out 'Salmon in the Classroom projects' over recent years at 16 primary schools, and a new 'life in lochs project' in collaboration with The Highland Council was launched at 4 schools in 2007. These projects have been successful in providing children with an introduction to the world of fish, and in communicating messages about conservation.

WRFT is keen to encourage closer links with universities to try to initiate collaborative studies suitable as student projects.

4.3.11.5 Informing anglers

Some good anglers' guides to the local area have been produced in recent years, for example Davis *et al,* (2001). However, some anglers especially those heading into the hills to fish, may still be unaware of management needs for wild trout and other wildlife that they pass en route. Some of the problems relating to management of trout lochs are discussed in Cunningham (2007) Wild Trout Project Report. Many of them are about providing the right guidance to anglers: a good angling guide would earn his keep in the Gairloch area – helping to ensure that his clients were knowledgeable enough to catch good fish and to do so in a responsible manner.

- **Proposed WRFT actions:** WRFT will update the website with news items, river reports, project reports and minutes of meetings. WRFT will offer support to local river management groups, and encourage them to be guided by the best available scientific information. Funding will be sought to carry out the Salmon and Trout in the Classroom project at 4 primary schools in 2008-9. WRFT will continue to attend local 'community gatherings' and open days.

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