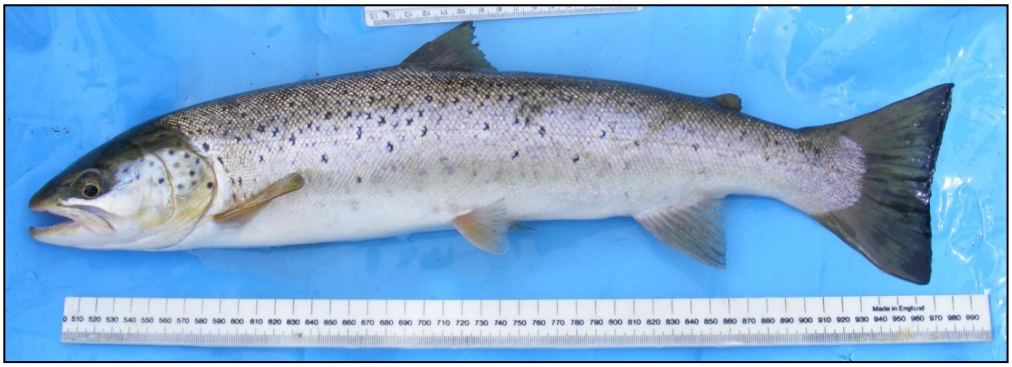
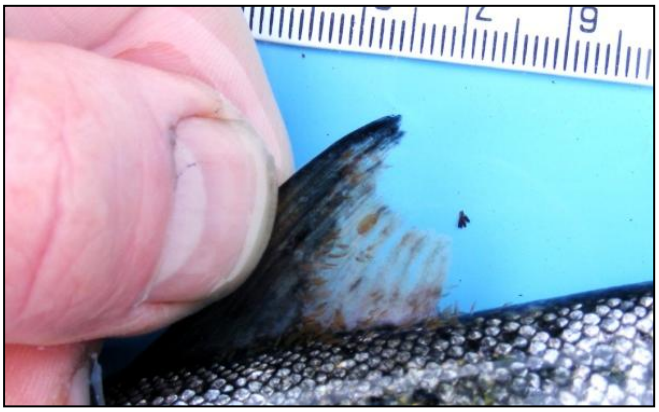
About the wild trout of the River Torridon

and other nearby stream systems in relation to an infestation of the sea louse *(Lepeophtheirus salmonis)* on salmon farms within Loch Torridon in 2015





Peter Cunningham, Charlie Hill, Les Bates and Colin Blyth **January 2016**

info@wrft.org.uk

On the wild trout of the River Torridon, 2015

Summary

This report presents some of the results of investigations to gather information about sea trout around the Loch Torridon area in 2015 following reports of exceptionally high concentrations of parasitic sea lice (*Lepeophtheirus salmonis*) on salmon farms within the area during the first six months of 2015[1].

Sea trout were sampled by Wester Ross Fisheries Trust during the period May – July 2015 using sweep netting, rod and line and electro-fishing. In October and early November 2015 a fyke net trap was operated in a tributary of the River Torridon to learn more about the spawning population of trout within that river system.

Sea trout carrying high or very high sea lice burdens (100 lice to 400+ lice per fish) were sampled from the River Balgy sea pool, Inverbain river estuary, Sand (by Gairloch) river estuary and Flowerdale River estuary. The most heavily infested fish were between 250mm and 350mm in length and were caught between late May and early July. The majority of lice on heavily infested fish were 'chalimus' (juvenile) stage lice.

Some samples included thin post-smolt sea trout carrying no lice or very few lice. Some of these samples may have included trout that had remained in brackish water and not been exposed to the high lice infestation pressures experienced by other trout in respective samples. They may have also included sea trout which by returning 'early' to freshwater shortly after becoming infested, had been able to rid themselves of lice before significant external physiological damage associated with lice infestation had occurred.

Sea trout with severely damaged dorsal fins associated with sea lice infestation were taken from the Flowerdale River in July 2015. Evidence that some trout which experienced damaging levels of sea lice infestation had shed their lice and recovered was recorded as follows. In August, three maturing female sea trout with damaged but healing dorsal fins were taken in the South Erradale River. In September two sea trout with damaged but healing fins were taken in the Flowerdale river estuary; one of these trout had a condition factor of >1.3 and was the fattest trout sampled during the 2015 season. On 1st October, 23 sea trout (including both maturing female trout and finnock) were taken in the Flowerdale estuary; most of these fish had damaged but healing dorsal fins associated with earlier sea lice infestation.

The fyke net trap was set on 12th October 2015 and operated almost continuously until 9th November. There were 212 captures of trout in the trap. Of these 76 were recorded as sea trout, and the remainder were brown trout. Five of the sea trout were identified as 'recaptured fish'; several male brown trout were also recaptured (a few other recaptured trout may have been overlooked). Most of the sea trout were fish which had returned to freshwater after their second summer at sea and were between 310mm and 340mm in length. The oldest sea trout was a 9+ (or 10+) year old female fish of 520mm in length which had returned to freshwater after a 6th (or possibly 7th) summer in the sea. In contrast (r. size), the oldest brown trout, aged at 10+ years, was a fish of only 352mm in length.

The occurrence of heavily lice-infested sea trout in samples taken during the period May – July 2015 around Loch Torridon and at sites as far away as Loch Gairloch can most easily be explained by proximity to a very large adult female sea lice population on the salmon farms in the Loch Torridon area during the period January to June 2015.

Levels of lice infestation on sea trout in some samples were in excess of potentially lethal thresholds discussed in published literature. The marine survival rate, especially of smaller trout in systems such as the River Balgy, may have been reduced by 50% or more as a result of sea lice infestation.

[1] Data for sea trout sampled by MSS Shieldaig Project in Loch Torridon in 2015 may be reported elsewhere.

However, many mature sea trout were caught in the Torridon River fyke net trap in October and November 2015. These fish had survived and grown despite close proximity to sources of larval sea lice (i.e. nearby salmon farms). Some of these fish were older and larger than any of the sea trout sampled during the period 2007 – 2015 in the River Shieldaig system by Marine Scotland Science.

It is suggested that the overall impact of the Loch Torridon sea lice infestation in 2015 on sea trout populations around and beyond Loch Torridon varied according to geographic factors. The extensive intertidal area and west facing characteristics of the Torridon River estuary may provide River Torridon 'sea trout[2]' with better prospects of survival than sea trout entering the sea from other nearby stream systems (e.g. sea trout from the Shieldaig River).

In conclusion, this study suggests that the consequences of a severe sea lice infestation (associated with salmon farming) on wild trout populations varies according to whether or not sea trout from respective river systems have opportunities for finding fresh or brackish water areas where they can evade or rid themselves of parasitic sea lice, find food, and evade capture by seals and other potential predators of lice-infested fish.

Therefore, the threat from sea lice infestations associated with salmon farming to the productivity of respective sea trout fisheries will also vary according to geographic factors associated with the areas into which respective rivers discharge.

Cover photos *(clockwise from top right): 9+ year old sea trout taken from the Torridon River estuary on 15 June 2015; the sweep netting sampling team (l-r: Tom Barlow, Katherine Kinloch, Ruaraidh MacNally, Charlie Hill, Seamus MacNally, Jamie Barlow, Colin Simpson, Henry Barlow and Ed Barlow) by the mouth of the Torridon River estuary on 16th July 2015 [just one flounder was caught that day!]; Charlie Hill, Les Bates and Colin Blyth by the Torridon River fyke net trap in October 2015; mature male and female sea trout from the Torridon River fyke net on 27th October 2015; sea lice on dorsal fin of sea trout taken in the estuary of the Balgy River on 25th May 2015; Liam Perks and the 9+ year old sea trout taken from the Torridon River estuary on 15 June 2015.*

[2] One might argue that some of the Torridon river trout would be better described as estuarine trout rather than sea trout. However, their appearance and scale growth (especially following smoltification) was characteristic of sea trout sampled elsewhere.

1. Introduction

1.1 Aims

This report presents the initial results of investigations to gather information about sea trout around the Loch Torridon area in 2015 following reports of exceptionally high concentrations of parasitic sea lice (*Lepeophtheirus salmon*) on salmon farms within the area.

Sea trout were sampled in several river estuaries and around the area during the period May – July 2015 using sweep netting, rod and line and electro-fishing. In October and early November 2015 a fyke net trap was operated in a tributary of the River Torridon above Loch an Iasgair, to learn more about the spawning population of trout within that river system. Figure 1.1 shows the locations of salmon farms and sampling sites.

Investigations attempted to answer two questions:

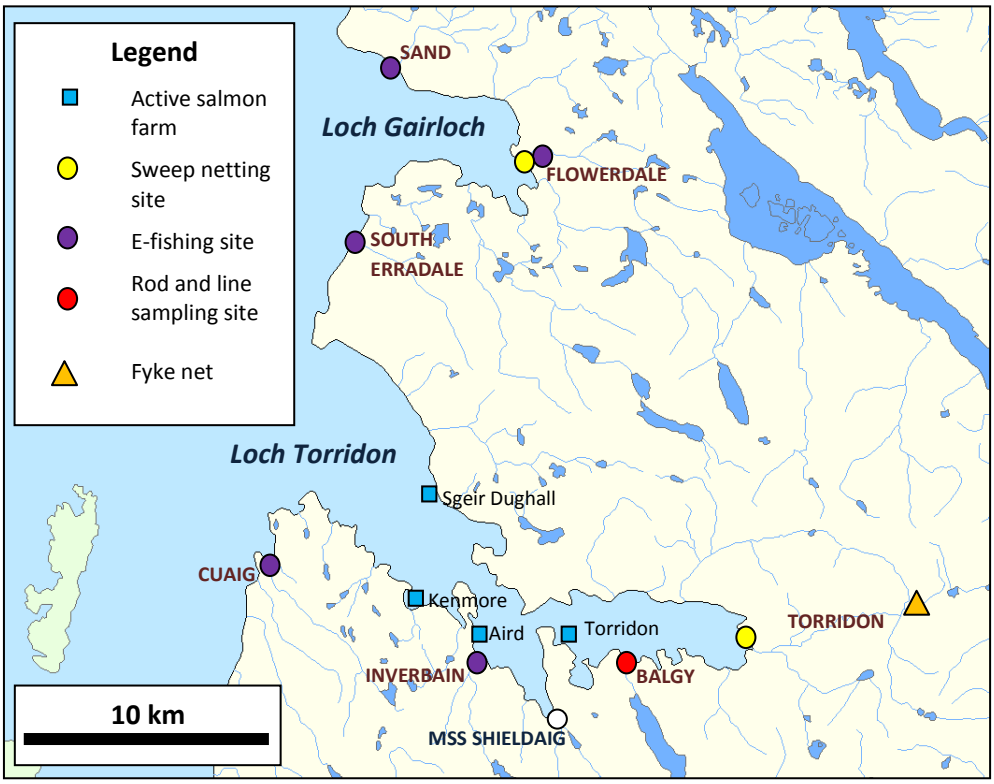
1. What was the distribution of heavily lice-infested sea trout within and beyond the Loch Torridon area?

2. What was the impact of the sea louse epizootic on sea trout populations around Loch Torridon?

This report has been written to inform the Wester Ross Area Salmon Fishery Board, fisheries managers, farm salmon producers, scientists working for at the MSS Shieldaig Field station, and anyone else with an interest in the management and welfare of wild sea trout and salmon populations within the Wester Ross area.

Together with long-term datasets from monitoring at the MSS Shieldaig field station, the investigations described here can also contribute to a better understanding of how a very large on-farm sea louse population can affect wild sea trout populations around and beyond a lice-infested area.

Figure 1.1: Map of the study area, showing the locations of salmon farms and sea trout sampling sites



1.2 Background information

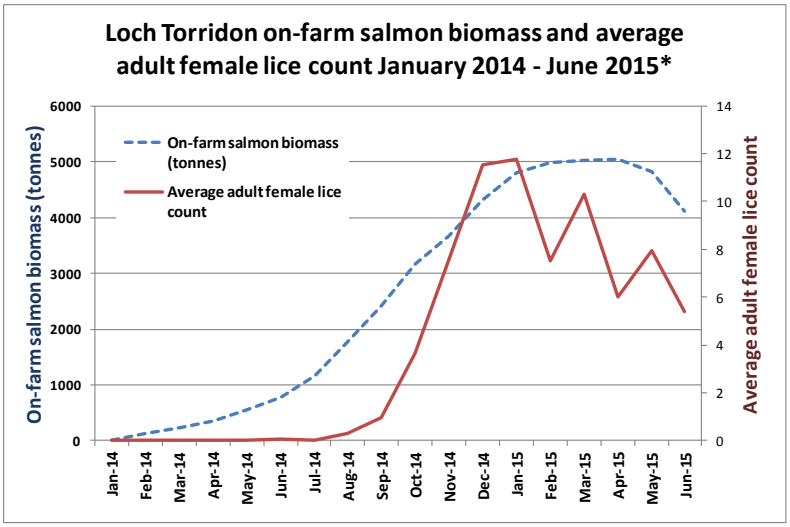
1.2.1 On-farm sea louse populations in the Loch Torridon area in spring 2015

The Scottish Government and Scottish Salmon Producers Organisation publish information from which an estimate of the scale of the on-farm sea louse population in the Loch Torridon area can be made. Figures are published by the Scottish Government on the 'Scotland's Aquaculture' website for the biomass of salmon held at respective salmon farms; and by the Scottish Salmon Producers Organisation in quarterly Fish Health Management Reports for the average number of adult female sea lice count per fish in each salmon farming district.

During the period January 2014 to June 2015, there were 4 active salmon farms in Loch Torridon: Sgeir Doughall, Kenmore and Aird (all operated by the Scottish Salmon Company) and the Loch Torridon farm operated by Marine Harvest. Production was synchronised in so far as three farms were stocked together in February 2014 following a fallow period.

Figure 1.2 shows the cumulative on-farm biomass and average adult female lice count per fish for the Loch Torridon area for the period January 2014 to June 2015.

Figure 1.2: Cumalitve on-farm biomass and average adult female lice count per fish for the Loch Torridon area for the period January 2014 to June 2015.



*from data published in SSPO fish health management reports and on the Scotland's Aquaculture website.

The SSPO Code of Good Conduct treatment threshold levels for average adult female lice is set at 0.5 lice per fish for the period February to June, then 1 louse per fish for the period July to January. From October 2014, reported average lice levels were above SSPO treatment threshold levels, peaking at just over 20 times the threshold level.

Estimates of actual on-farm numbers of adult female lice can be made by multiplying the average adult female lice count by an estimate of the number of farmed salmon in the area. If the farm salmon were of average weight 4kg, then during the peak biomass period from November 2014 to March 2015, the total on-farm adult female louse population within the Loch Torridon area would have been in the order of 10 million lice.

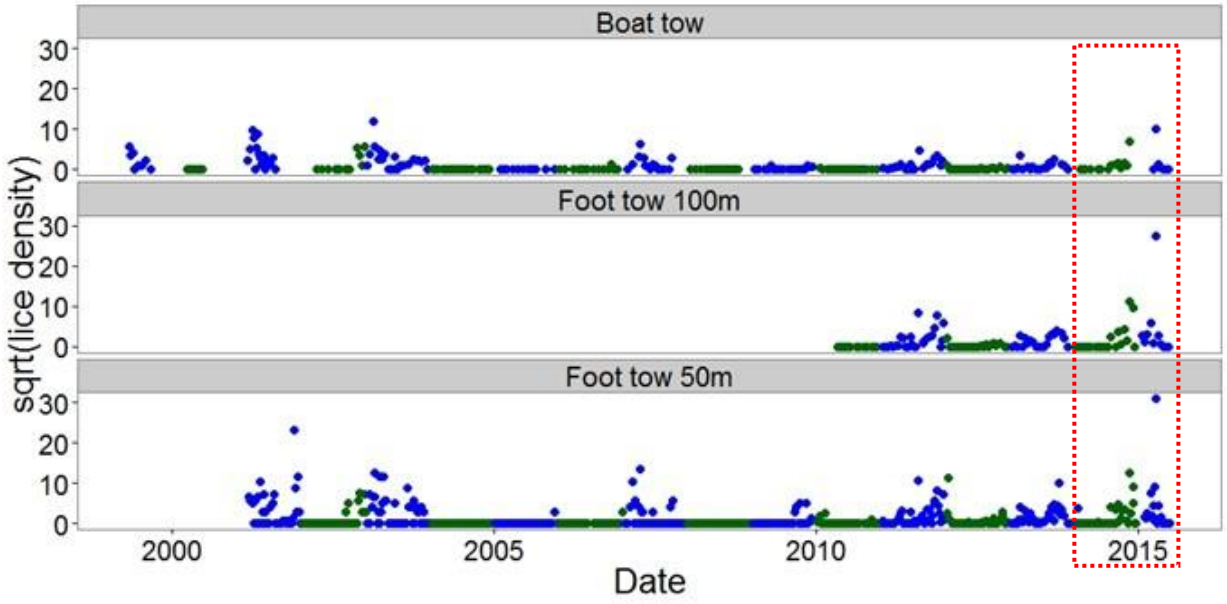
For comparison, during this period it is almost inconceivable that there could have been more than 10,000 wild salmon and sea trout in the area at any time, and inconceivable that each wild salmonid could have had more than an average of 10 adult female lice per fish. Therefore, it is also inconceivable that the adult female louse population

on wild fish within the Loch Torridon area at any time during the period November 2014 to March 2015 could have exceeded 100,000 adult female lice.

1.2.2 Plankton lice sampling in Loch Torridon

The Scottish Government also publishes data collected and recorded by Marine Scotland [MS] scientists based at the Shieldaig Field Station. Figure 1.3 is reproduced from the Scottish Government's Shieldaig Project website[3] and shows planktonic sea lice densities recorded in the Loch Shieldaig area for the period 1999 – 2015.

Figure 1.3: Density of sea lice (square root transformed) measuring by plankton tows in Loch Shieldaig 1999-2015. Green points are those in the first year of production, blue are in the second year. This graph has been reproduced from the Scottish Governments Shieldaig Project website. The period January 2014 – June 2015 is indicated by the box outlined in red which has been added to the published graph.



Lice were detected in the plankton in the autumn of 2014 at some of the highest levels on record before the end of the 1st year of a salmon farm production cycle within the Loch Torridon area. During the first half of 2015 (2nd year of fish farm production cycle) lice were detected at some of the highest densities of planktonic sea lice on record.

Note that the timing of high lice counts in the plankton presented in Figure 1.3 correlates with the two-year farm salmon production cycle within Loch Torridon and; recorded lice densities in the plankton in Loch Shieldaig correlate with estimates of on-farm adult female sea louse populations in the Loch Torridon area based on the data presented in Figure 1.2.

[3] Data from the MSS Shieldaig project can be found at http://www.gov.scot/Topics/marine/Salmon-Trout-Coarse/Freshwater/Research/Aqint/Shieldaig .

2. Sea trout sampling during period May – August 2015

2.1 Background to sea trout sampling and sea louse recording

To gather information about levels of infestation of sea trout by the sea louse *Lepeophtheirus salmonis* in and around the Loch Torridon area in 2015, samples of fish were caught using a sweep net, using rod and line, and by electro-fishing the lower pools of some of the rivers in the area.

The Wester Ross Fisheries Trust [WRFT] has sampled sea trout in coastal waters and river estuaries since 1996, and has recorded a wide range of levels of lice infestation. Data presented in reports published on the WRFT website show that sea louse infestation levels on sea trout caught in the sea or estuarine waters has varied from 0 lice to over 200 lice per sea trout. Cunningham 2009 and Cunningham 2013 explored the links between lice infestation on sea trout, sea trout size and proximity to salmon farms. Various other studies, including Middlemas *et al* 2013 and Thorstad *et al* 2015, have also concluded that there is a link between high levels of infestation by sea lice on wild sea trout and proximity to salmon farms.

Different authors have proposed different threshold levels of what constitutes a potentially 'harmful' sea louse burden on a sea trout. Some authors have proposed a threshold level for 'post-smolt' sea trout of less than 260mm (e.g. Wells *et al,* 2006); others (e.g. Taranger *et al.* 2015) have proposed that harmful threshold levels vary according to the size of the fish, acknowledging that larger sea trout are able to survive with larger lice burdens than smaller sea trout.

Taranger *et al.* 2015 assessed the risk to sea trout stocks in Norway from sea louse infection. Louse infection levels (referred to in this report as 'infestation levels'[4]) were expressed as the number of lice on the fish / weight of fish (g); and the risk of harm to the fish based on this level. Sea trout which carried louse burdens in excess of 0.3 lice per g bodyweight of sea trout (for example, more than 60 lice on a 200g fish) were assumed (for the purposes of the risk assessment) to be subject to 100% mortality. They provide a formula for calculating the overall 'stock regulating effect', based on the proportions of fish in each infection group.

For the purposes of describing sea lice infestation observed in 2015, and to put the figures into some sort of context, I'll refer to the following infestation levels all of which are far above the potentially 'harmful' levels proposed by all authors.

Small sea trout (of less than 30cm in length) which carry over 50 lice represents a 'high' sea louse burden (c. Taranger *et al.* 2015's '50% mortality' group). Small sea trout (of less than 30cm length) carrying over 100 lice are represents a 'very high' sea louse burden (c. Taranger *et al.* 2015's '100% mortality' group). Any sea trout which carries over 200 lice is exceptionally heavily infested; such fish are all within Tarranger *et al.* 2015's '100% mortality' category unless they are large fish of over 667g in weight.

This approach is discussed again later in this report.

[4] There is some variance in the literature as to whether parasitic lice 'infest' or 'infect' a fish. For this report I've chosen to use the word 'infest' on the basis that lice are external parasites. Google infest vs. infect for related discussion!

2.2 Results of sea trout sampling in the sea or lower reaches of rivers

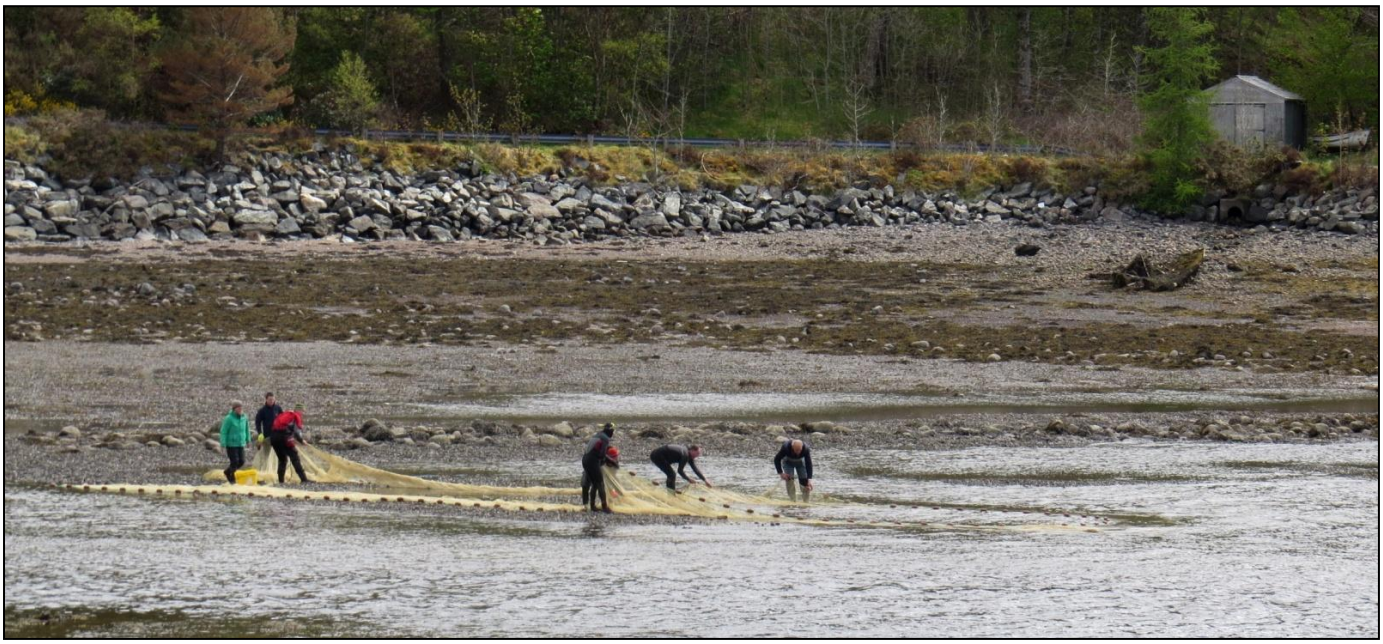
These are presented in full in Appendix 1.

2.2.1 Sweep netting samples

- Loch Gairloch, Flowerdale River estuary, 19th May 2015

Ten sea trout were taken using the sweep net. Some of the fish were heavily infested with lice; others were not. One of the largest fish, a sea trout of 281mm carried an estimated 500 lice; a record louse burden for any fish in Loch Gairloch since sampling began in 2007. Two other smaller sea trout of 203mm and 171mm respectively carried 60 and 65 lice respectively. Lice counts for the other 7 fish ranged from 0 (on a sea trout of 281mm, which weighed 310g) to 40 (sea trout of 150mm). All the lice were early stage chalimus and copepodid stage lice.

Pulling in the sweep net at Flowerdale on 19th May 2015 (photo by James Merryweather).

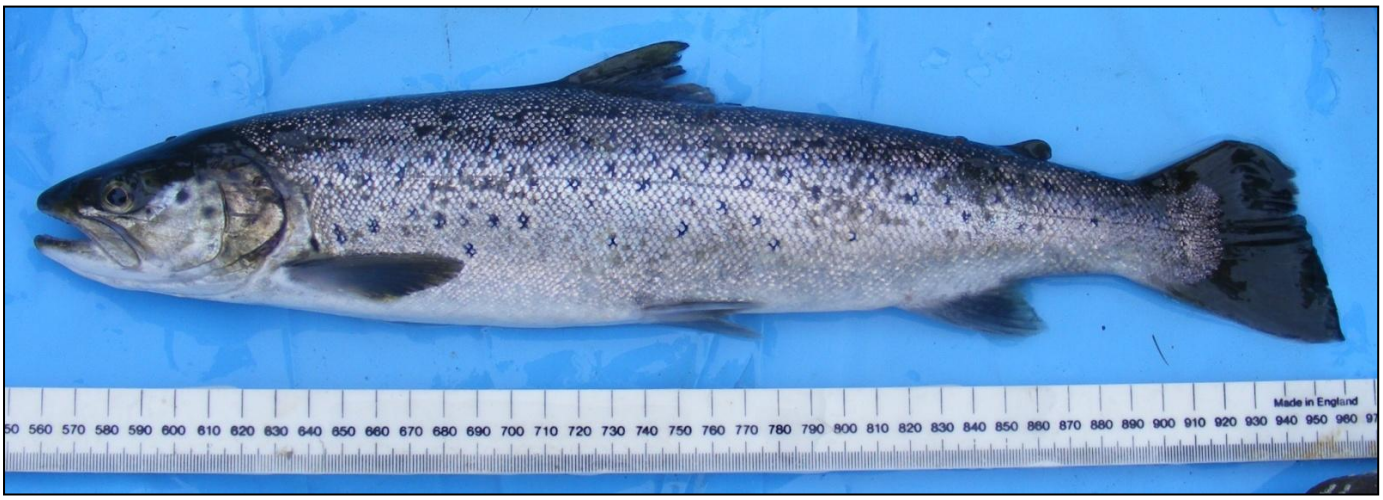


Sea trout of 281mm taken in the sweep net at Flowerdale on 19th May 2015. This fish carried an estimated 500 mostly chalimus stag lice. Note the descaled area below the dorsal fin associated with a bird attack (photo by James Merryweather).

- Loch Gairloch, Flowerdale River estuary, 18th June 2015

Four sea trout were caught of 170mm, 325mm, 380mm and 400mm in length respectively in a single sweep of the estuary. The three larger fish carried sea lice; however this time, the lice counts were much lower (all less than 20 lice per fish) and the lice were mostly pre-adult or adult lice. Some of the fish had damaged dorsal fins indicative of higher louse burdens previously.

Sea trout of 400mm taken on 18th June 2015 in the Flowerdale River estuary. This fish carried only 17 lice. However note that it has a damaged dorsal fin indicative of higher lice burdens at some earlier though recent point in time.



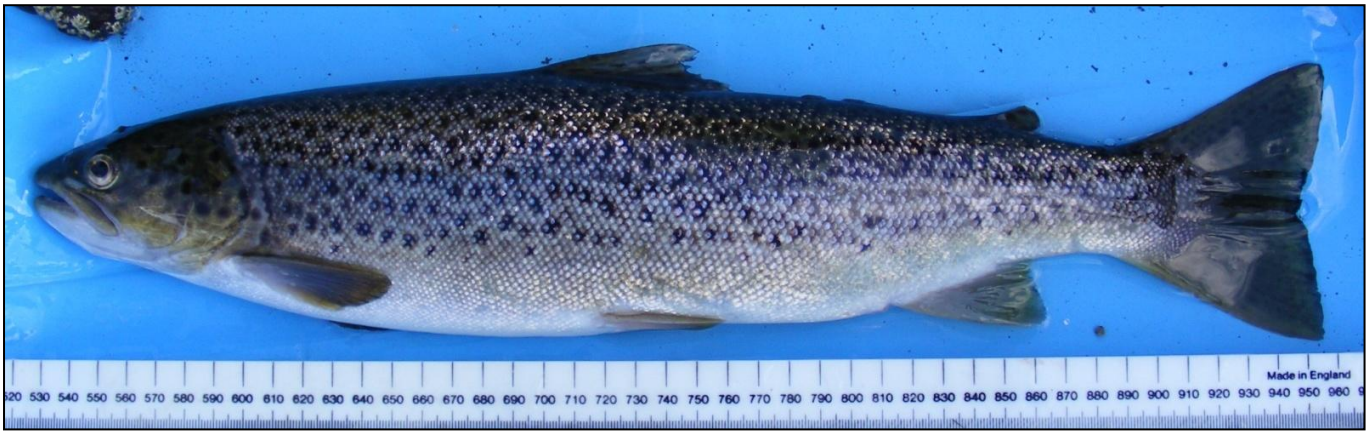
Some members of the sweep netting team at Flowerdale on 18th June 2015.

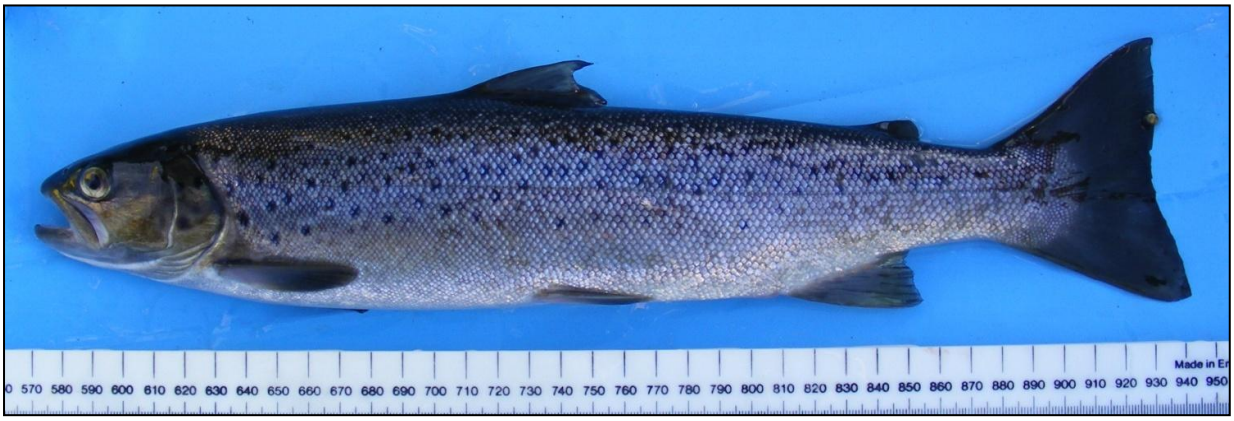
- Loch Gairloch, Flowerdale River estuary 1st October 2015

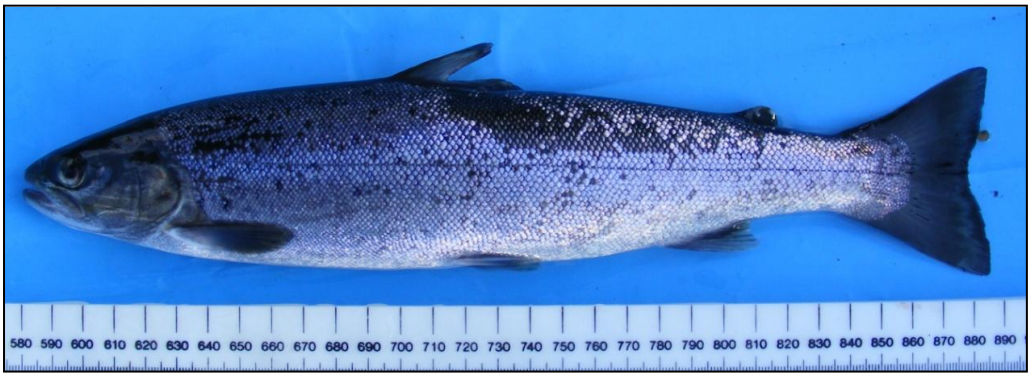
This was the most successful sweep of the season, with a catch of 23 sea trout. Thirteen of the fish were of less than 260mm (small finnock); 8 fish were between 260mm and 310mm (inclusive); and the two largest trout (maturing females) were 365mm and 432mm (843g). Twenty of the fish had condition factors between 0.95 and 1.12 indicative of modest summer growth.

Lice levels were generally low. Only one of the fish had more than 10 lice; a trout of 275mm with 62 lice. These were mostly pre-adult and adult lice; this fish also had 25 chalimus lice. The total count of chalimus lice, and pre-adult and adult lice on all the other (22) trout added together (respectively) was 11 chalimus lice and 60 pre-adult and adult lice; an average total lice count of less than 4 lice per fish. Seventeen of the trout had dorsal fin damage, associated with higher levels of louse infestation; this was noted as 'healed' or 'healing' on a majority of the trout.

(top to bottom) Sea trout of 432mm, 365mm and 305mm(respectively) taken at Flowerdale on 1st October 2015. Note the 'healed' dorsal fins.



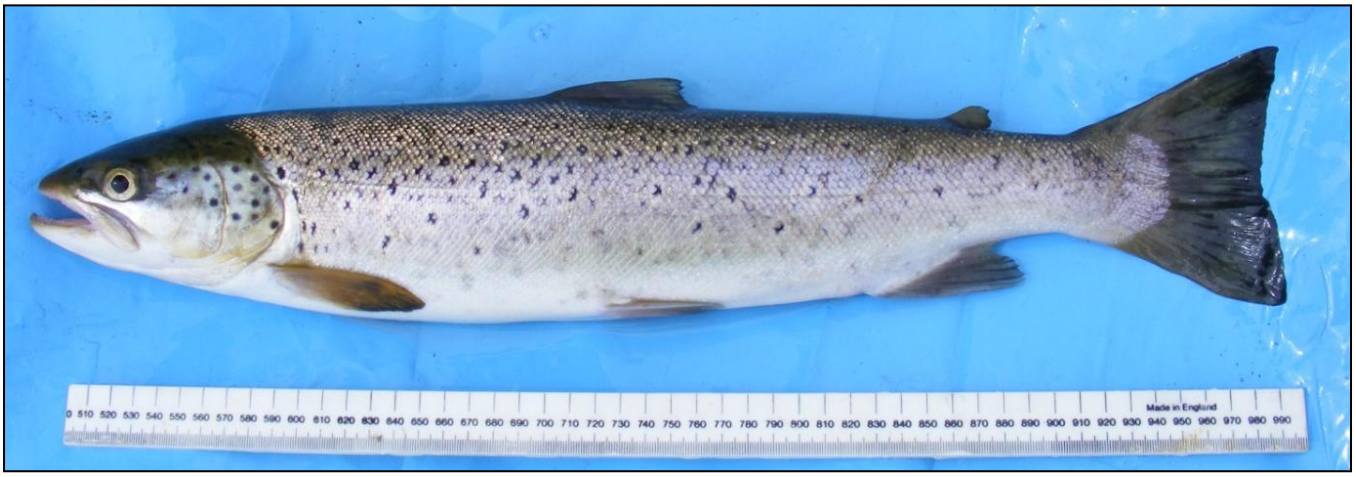




- Torridon river estuary, 15th June 2015

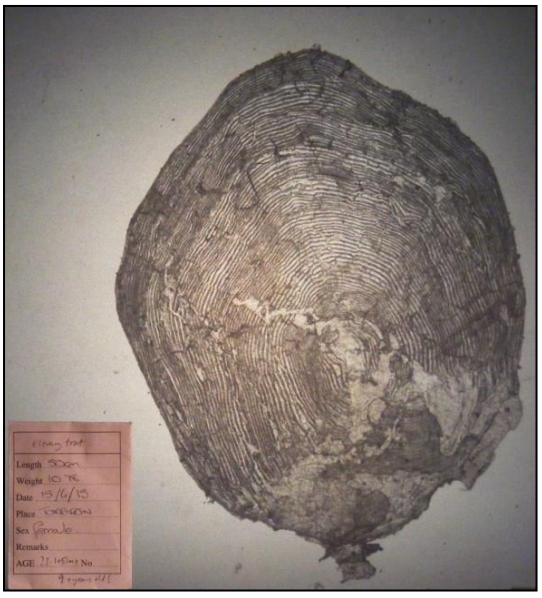
Just one trout was caught. This was a large fish of 500mm, with no sea lice on it. The dorsal fin was a bit ragged, probably associated with louse damage previously.

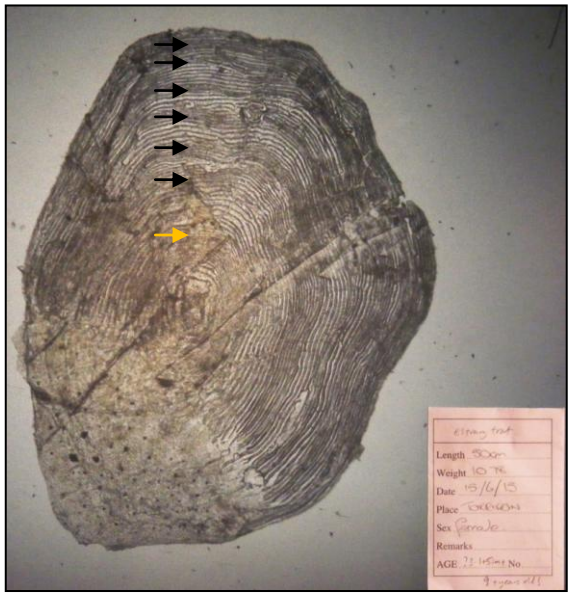
Sea trout of 500mm taken on 15th June 2015 in the Torridon River estuary. This fish had no lice on it. However note that it has a damaged dorsal fin (right) indicative of higher lice burdens at some earlier point in time.



Scale reading suggests this fish was at least 9 years old, and was spending a 6th or 7th summer in the river estuary or sea. It is one of the longest-lived trout to have been caught to date by the WRFT sweep netting team (since 2007).

Two scales from the sea trout of 500mm that was taken in the Torridon River estuary on 15th June 2015. Both of these scales are 'replacements' of scales lost by the fish during its first or second year in freshwater. The black arrows denote winter growth checks following an initial migration to sea (orange arrow).





- Torridon River estuary, 16th July 2015

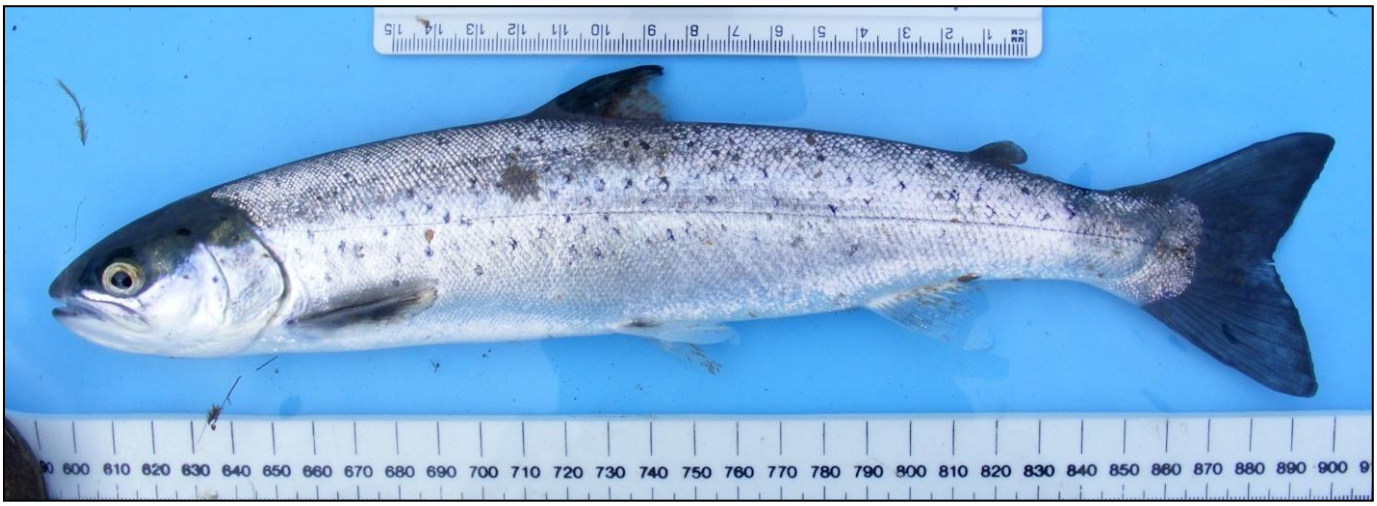
Assisted by many enthusiastic volunteers, a further attempt was made to sample sea trout using a sweep net in the estuary of the Torridon River. Despite much strenuous effort, our only catch was a flounder!

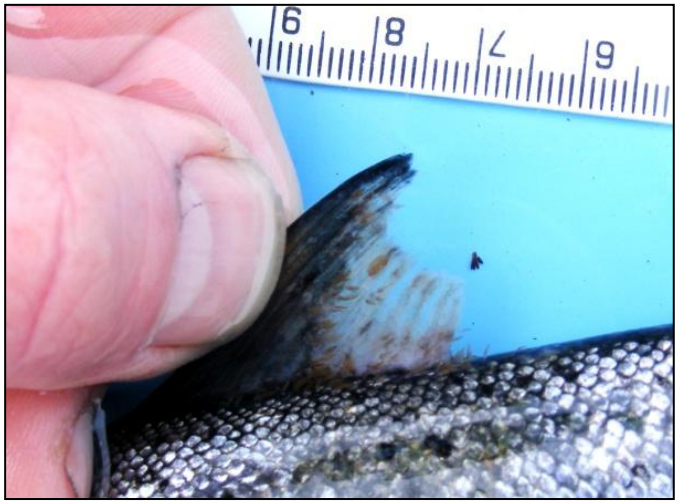
2.2.2 Samples of sea trout taken by rod and line in river estuaries and adjacent areas.

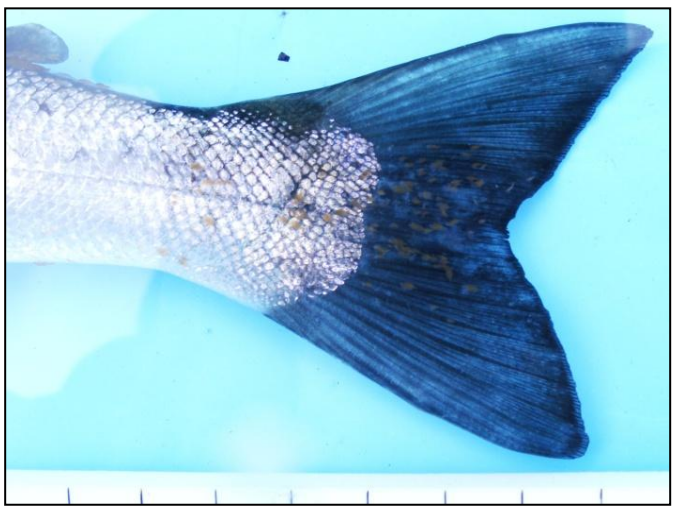
- River Balgy sea pool 25th May 2015

Eight sea trout ranging in length from 173mm to 295mm were caught using rod and line. All fish were still thin; the average condition factor of this sample was just 0.76. Two fish carried sea lice, including a trout of 295mm which had at least 475 lice.

Sea trout of 295mm caught in the River Balgy sea pool using rod and line on 25th May 2015, with close ups of lice infestation and associated dorsal fin damage.



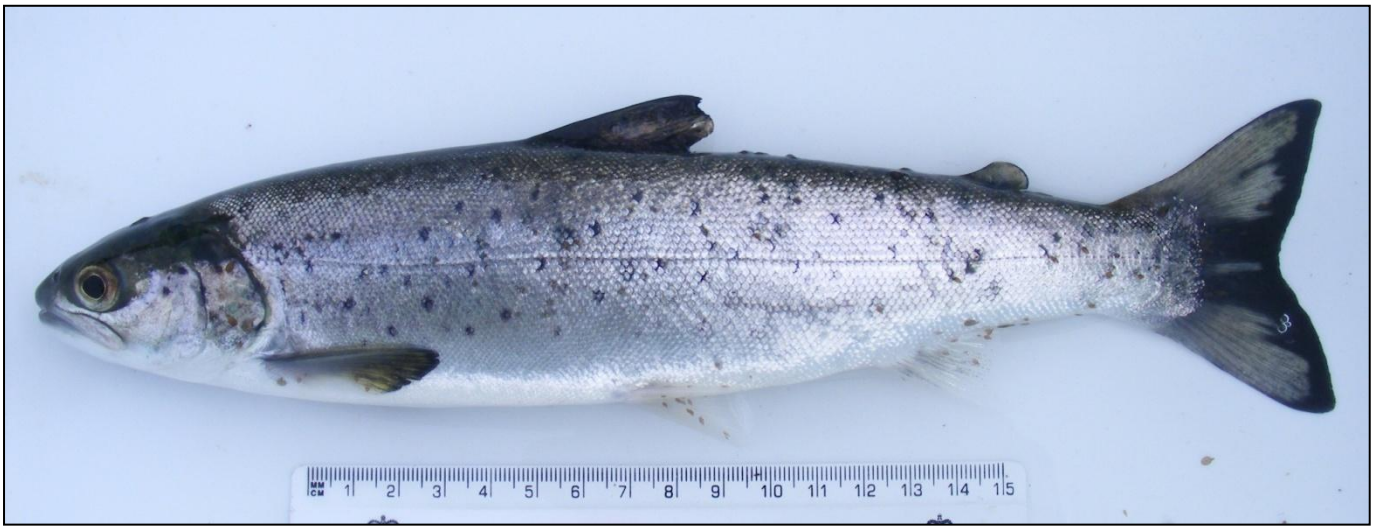




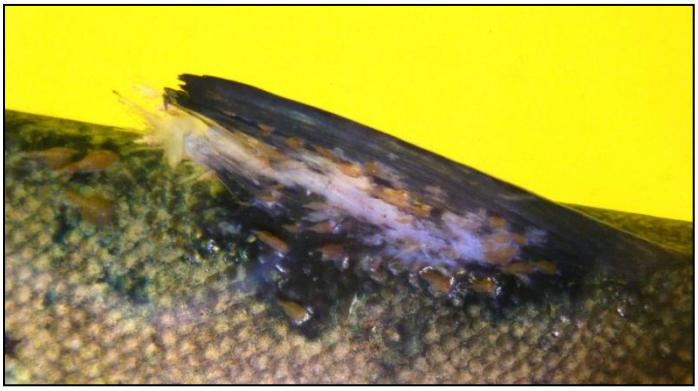
- River Balgy sea pool 25th June 2015

Six sea trout were caught ranging in length from 185mm to 275mm. All fish carried sea lice. The largest fish of 275mm carried 175 lice (150 chalimus and 25 adult and pre-adult lice). The smaller trout carried 20, 43, 43, 74 and 80 lice respectively. The average condition factor of fish in this sample was 1.00; fish were therefore in better condition than those sampled one month earlier.

Sea trout of 275mm taken in the River Balgy sea pool on 25th June 2015. Note the dorsal fin damage associated with sea louse infection. However the fish has been feeding: compare its profile with the 295mm trout taken on 25th May 2015.



Close up of the dorsal fin of the 275mm trout taken in the River Balgy sea pool on 25th June 2015.



2.2.3 Samples taken using electro-fishing equipment from the lower reaches of rivers

- Inverbain River, 25th June 2015

Six trout were caught in the river within 100m of the top of the tide. Three of these trout were silvery and were recorded as 'sea trout', the other 3 were recorded as brown trout. Two of the sea trout carried lice; a fish of 175mm carried 150 lice (all small chalimus stage lice); the fish of 170mm carried 58+ lice, mostly small chalimus stage lice.

Small sea trout of 175mm (top) and 170mm (below) taken in the Inverbain River on 25th June 2015. These fish carried 150 and 58+ sea lice respectively. Note that the top fish has been adipose fin clipped; the Inverbain river is located close to the Shieldaig river from where this fish is thought to have originated.

- Cuaig river, 25th June 2015.

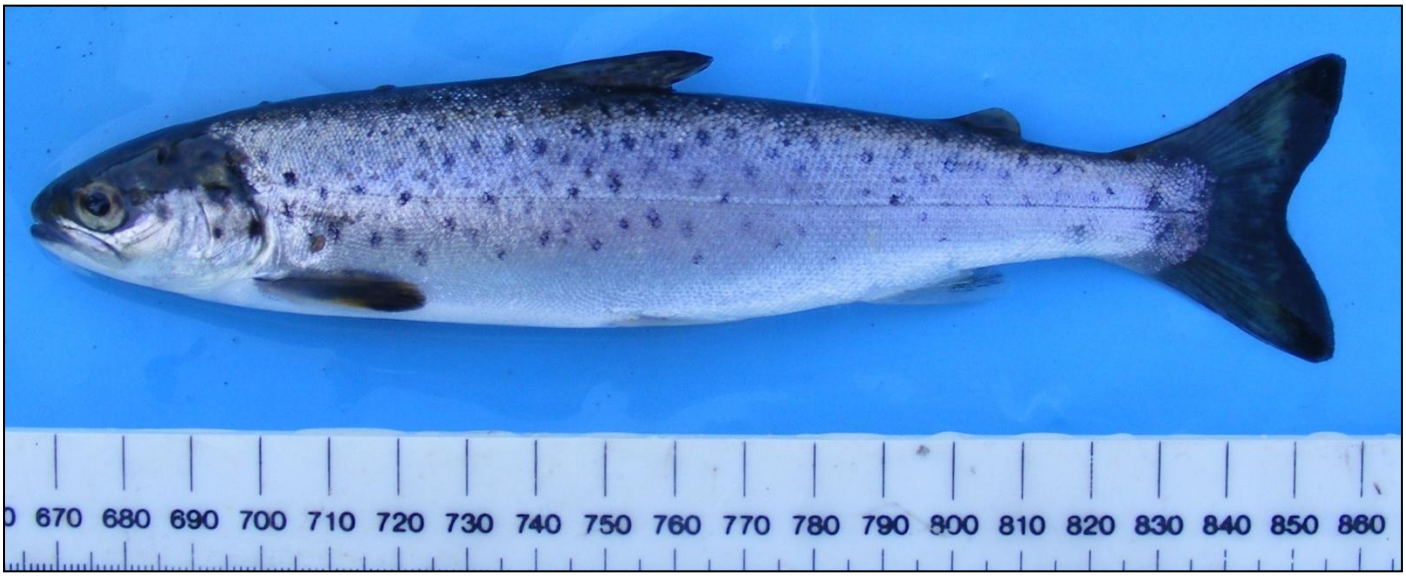
Seven trout were caught in the Cuaig river from between the sea pool and 100m upstream. Three of these fish were small silvery trout of 130mm, 140mm and 158mm in length respectively. No lice were present on any of these fish.

- Sand River (by Loch Gairloch), 26th May and 1st July 2015

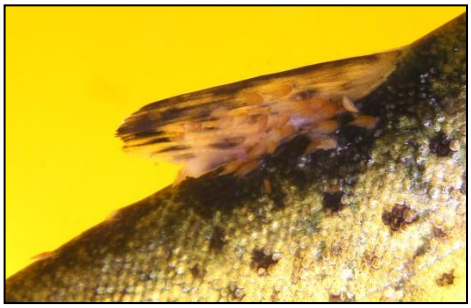
On **26th May**, nine trout were taken in the sea pool of the Sand River ranging in size from 105mm to 185mm in length. Eight of these fish were silvery; however none of them had sea lice. One possibility is that the sample was primarily of smolts still on their way out to sea.

On **1st July**, twelve silvery trout (153mm to 231mm), one brown trout and a salmon parr were taken in the sea pool of the Sand River. On this occasion, five of the trout were infested with sea lice, with numbers ranging from 22 to 109 lice. Nearly all of the lice were small chalimus stage lice.

Sea trout of 191mm (top) and 153mm (below) taken in the Sand River on 1st July 2015. These fish carried 44 and 109 sea lice respectively.



Chalimus lice on the dorsal fin of the 153mm trout (shown above) taken in the Sand River on 1st July 2015.



- Flowerdale River, 6th July 2015

Seven sea trout were caught in the sea pool of the Flowerdale River *(right)* using electro-fishing equipment. These fish ranged in size from 139mm to 279mm. All carried sea lice, with infestation levels ranging from 2 to 85 mostly chalimus stage lice.

The three largest fish had damaged dorsal fins associated with high levels of sea louse infestation. Condition factors were all around 1.0.

Peter Cunningham and Dr Steve Kett electro-fishing a pool at the top of the Flowerdale river estuary (photo by Andy Vicks).

Sea trout of 279mm taken in the Flowerdale River on 6th July 2015. This fish had 81 lice on it and a freshly damaged dorsal fin associated with sea louse infestation (photo by Andy Vicks)

- South Erradale Burn, 20th August 2015

Five sea trout were taken in the South Erradale burn on 20th August 2015. The fish were caught in freshwater in a pool about 300m upstream from the top of the estuary. These included three larger, maturing female trout and three thin finnock. The condition factor of the two largest fish was over 1.1; these fish were relatively 'fat'. None of the fish carried sea lice; however dorsal fins had been damaged indicating sea louse infestation previously.

Three mature female sea trout taken in the South Erradale burn on 20th August 2015 by the WRFT e-fishing team. The largest fish was 350mm in length and 495g in weight.

The dorsal fin of a 350mm sea trout taken in the South Erradale burn on 20th August 2015. The fin has been damaged but has healed.

Sea trout had not previously been recorded in the South Erradale burn by the WRFT e-fishing team so this catch has added to our recorded knowledge of the distribution of sea trout in the WRFT area.

Two finnock (192mm & 21mm) and a brown trout (202mm) from the South Erradale burn on 20th August 2015. The two finnock were not weighed; however note that they are thin (even compared to the brown trout), with estimated condition factors of around 0.9 or less (based on comparison with pictures of other finnock, e.g. fish of 255mm taken on 1st Sept 2015 in Flowerdale estuary). Note the black marks on the tail of both fish which may be associated with sea louse attachment. However the dorsal fins were not notably damaged.

- Flowerdale River, 1 Sept 2015

Two sea trout of 255mm and 345mm, of condition factors 1.31 (=fat) and 1.05, respectively were taken in the sea pool upstream from The Old Inn. These fish carried 3 and 11 lice respectively; the majority of the lice were adult and pre-adult lice. Both fish had damaged, though healing, dorsal fins.

2.3 Summary of results of sea trout sampling in the sea & lower reaches of rivers in chronological order

- In May, 10 sea trout were taken in the Flowerdale estuary using a sweep net. Some of these fish were infested with very high sea louse burdens (to over 500 lice / fish); others carried few lice. Eight thin sea trout were caught in the Balgy sea pool using rod and line including a fish with over 400 lice.

- In June, trout sampled in the Flowerdale river estuary had lower levels of lice .These were mostly pre-adult and adult lice. On 25th June six sea trout were caught in the River Balgy estuary carrying up to 175 lice. These fish were in better condition than trout in the sample taken at the same location in May. Several small sea trout (length <25cm) were recorded in the Inverbain river with very high numbers of chalimus lice.

- In early July small sea trout (length <25cm) with high sea louse burdens were recorded in the Sand River. Larger sea trout with up to 80 lice and severely damaged dorsal fins associated with high sea louse infestation were caught in the Flowerdale burn.

- In August, three small thin sea trout and three larger maturing female sea trout of higher condition factor were taken in the South Erradale River. These fish were several hundred metres upstream from the top of the tide. No lice were present on these fish. The three larger sea trout had damaged, but healing dorsal fins.

- In September two sea trout were taken in the Flowerdale river estuary carrying low numbers of lice (max 11). Both fish had damaged but healing fins. One of the trout had a condition factor of >1.3 and was the fattest trout sampled during the 2015 season.

- On 1st October, 22 sea trout were taken in the Flowerdale estuary. Lice levels were generally low, with only one of these fish having more than 10 lice. Most of these fish had damaged but healing dorsal fins associated with sea lice infestation.

3. The River Torridon fyke net project

3.1 Objectives of fyke net project

To learn more about the Torridon River trout population, a fyke net trap was set in the Feith Ghlas, a principal trout spawning burn above Loch an Iasgair on 12th October 2015 and operated until the 9th of November 2015. The trap was operated throughout this period except for two breaks over the weekends of 24th to 26th October and 30th October to 2nd November when the trap was lifted either because there was no-one able to check the trap, or water levels were judged likely to be too high for the trap to operate safely.

The objectives were as follows:

1. To record the occurrence of sea trout and other fish entering the trap.

2. To obtain measurements of all fish, and take photographs and scale samples to provide additional information from which an interpretation of life history (brown trout or sea trout) could be made.

3. To estimate the ages of brown trout and sea trout from reading of scales.

4. To describe the characteristics of the trout population.

5. To record damage associated with louse infestation or predation

3.2. Materials and methods

The fyke net was of standard design (5 hoop, small mesh 'D' front hoop, with 16ft leader made by Collins Nets) and was fitted with an otter guard (Figure 3.1). It was set in a pool with its entrance facing downstream and the leader set at a diagonal across the river to guide fish heading upstream towards the trap entrance. Gaps on either side of the trap were left to enable fish heading downstream to bypass the trap and to enable any large fish that was too big to enter the trap to find a way around it. The trap was set to fish at all water levels.

After three weeks of operation, on the 5th of November a new fyke with an otter guard with grid spaces of 16cm (high) by 7cm (wide) was set to enable slightly larger fish to enter the trap should they be present; whilst ensuring the trap remained effectively otter proof.

The trap was set up by WRFT Biologist Peter Cunningham, and checked each morning between 9am and 10am. After the trap was up and running, local residents Les Bates and Colin Blyth (both of whom have much previous fish handling experience from employment in fish farming or fisheries research) together with estate manager Charlie Hill carried out day to day operation of the trap, with the WRFT Biologist providing occasional support. Special licences were obtained from the Scottish Government to enable all the above to operate the fyke net outwith the fishing season without committing an offence.

Upon arriving at the trap each morning, water levels and temperatures were recorded. Fish were then transferred into buckets or tubs; anaesthetised in a solution of eugenol in ethanol; length and weight measurements were taken; scale samples were taken; and a photograph was taken. Following recovery in fresh water, all fish were released above the trap; except on the 9th November, following a night with very high water, when a sample of small trout which were dead inside the trap were retained for dissection (see Appendix 3!).

An assessment of the type of trout (sea trout or brown trout) was made based on their appearance. To provide further confirmation, a scale sample and a photograph was also taken. The photographs were also used to confirm the recapture of some trout. However, as fish were not marked other than to take a sample of scales, a small

proportion of fish especially of smaller trout may have been captured more than once without being recorded as 'recaptured'.

Figure 3.1: The fyke net set in the Feith Ghlas on 6th November 2015

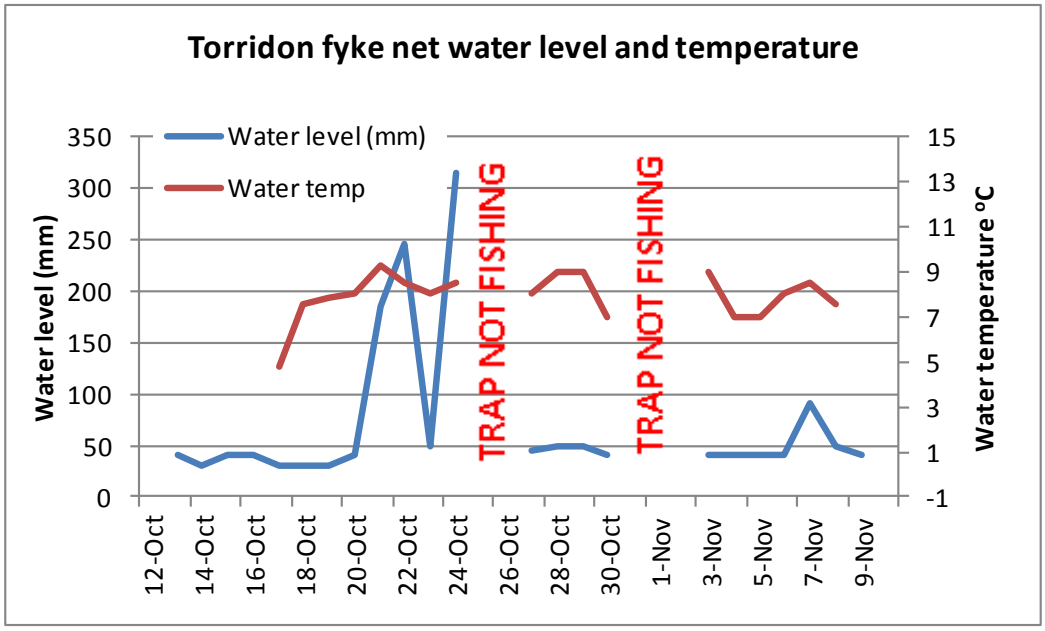
3.3 Results

3.3.1 Water levels and water temperature

Stream levels rose and fell quickly according to rainfall. After an initial week with little rainfall, water levels rose on the 23rd October to over 30cm above the 'base' level; and again on 8th November. Water temperatures rose from around 5C to over 8C on 19th October and remained at around 8C for the remainder of the period when the trap was in operation.

Figure 3.2 shows water levels and water temperatures recorded at the trap.

Figure 3.2: Water levels and water temperatures recorded at the Torridon fyke trap



3.3.2 Numbers and sizes of fish caught

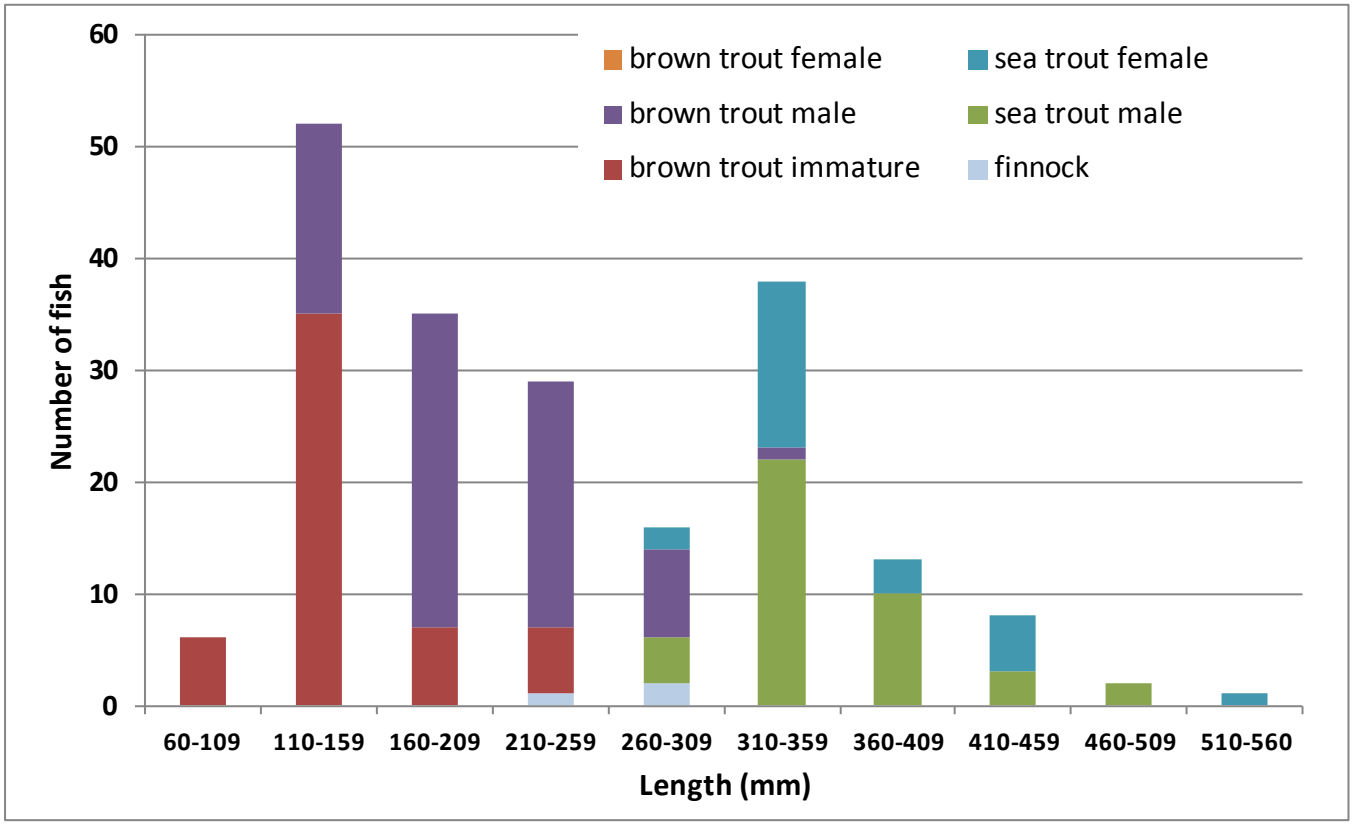
There were 211 captures of fish in the trap. 133 of these were recorded as brown trout, 76 were recorded as sea trout, one was recorded as a possible sea trout, and a salmon parr was also recorded. A small proportion of these fish were recorded as recaptures. Some of the smaller brown trout may have been captured more than once without being recorded as a 'recapture'.

There were 54 captures of immature brown trout, and 76 captures of mature male brown trout. No mature female brown trout were captured.

There were 3 captures of immature sea trout (finnock) and 26 captures of mature female sea trout. None of these fish are thought to have been caught more than once. There were 47 captures of male sea trout, including 5 that were recognised as recaptures; a few others may have been overlooked.

Immature brown trout were 64mm to 157mm in length; mature male brown trout ('running milt') were 115mm to 352mm in length; immature sea trout (finnock) were 245mm to 260mm in length; mature male sea trout 260mm to 488mm in length; and mature female sea trout 300mm to 520mm in length. Figure 3.3 is a size – frequency graph showing the number of fish caught vs. respective length categories. Known recaptured fish were removed from the data set used to produce this graph.

Figure 3.3: Size – frequency graph showing the number of fish caught vs. respective categories.



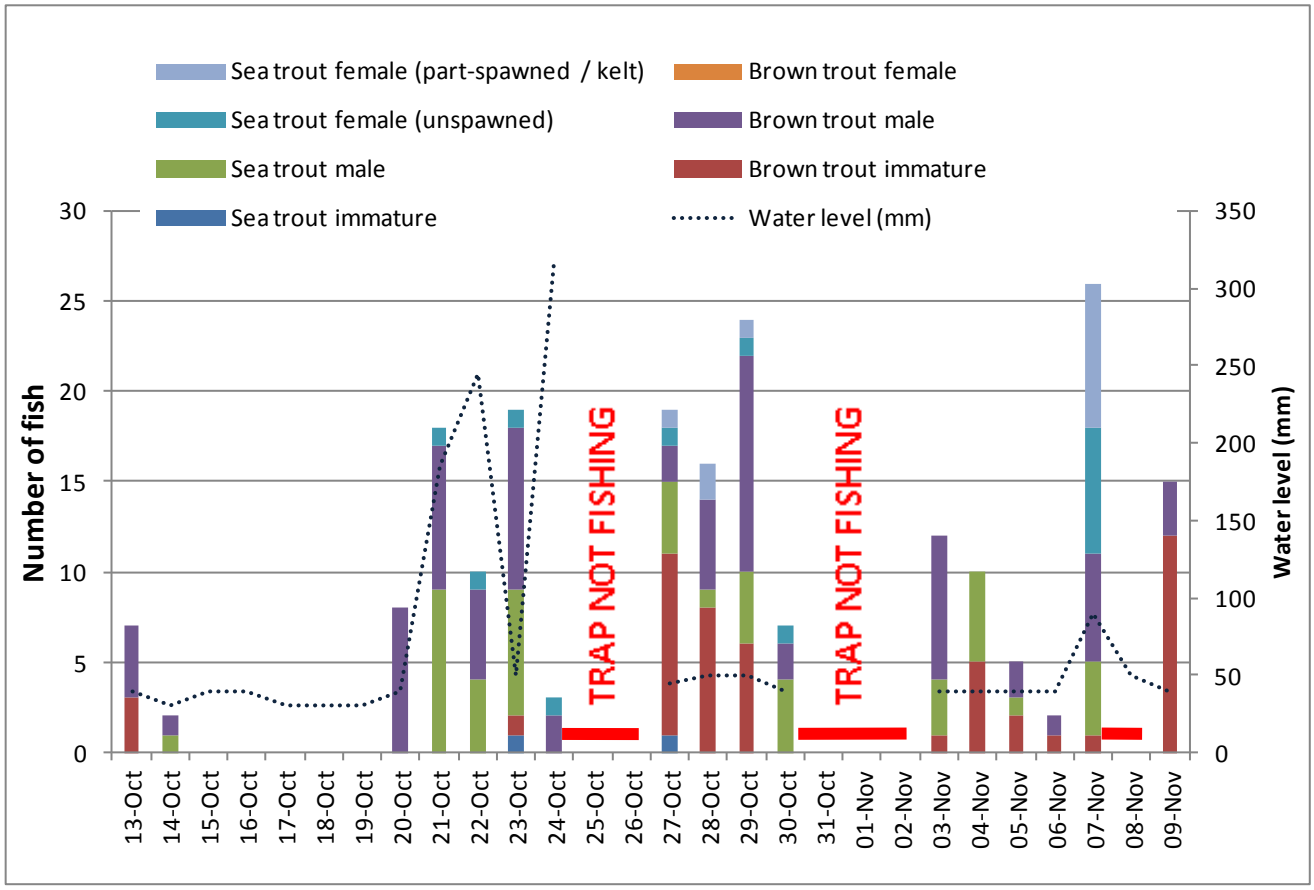
Note that it was not the intention to catch the entire spawning run of trout in the burn. The trap was not set on 25th and 26th of October when water levels were relatively high; and on 31st October, 1st November and 2nd November. On 8th November the catch of trout (including two '~50cm+ spotty fish') was accidentally released back into the river prior to processing and data collection! The trap was removed on 9th November, after being lifted during a large spate following a weekend when many partially or fully spawned female trout had been caught.

Trap catches provide an indication of the composition of the wild trout population ascending the burn towards spawning areas. The objectives were all largely achieved.

3.3.3 Timing of fish catches

Figure 3.4 shows the recorded fish catches at the fyke trap.

Figure 3.4: Timing of recorded fish catches.



The first fish (male sea trout and brown trout) were caught on 13th October, the day after the trap had been put in. Only two fish were caught in the trap the following day; and there were no more fish until water levels rose on 20th October.

From the 20th of October until the 8th of November, sea trout were recorded in the trap each day, along with mature male brown trout in spawning condition. The majority of the sea trout captured were males.

Unspawned female sea trout were recorded on the 21st, 22nd, 23rd, and 24th October. Part-spawned female sea trout or kelts were recorded from 27th October. The biggest catch of female sea trout was on the 7th November when the trap contained 15 female sea trout; these were recorded as a mix of unspawned fish, part-spawned fish and kelts.

Small numbers of immature brown trout were taken throughout the operation of the trap.

On 9th November, the trap had been lifted out of the water during high spate flows the previous night, killing the fish inside. There were 15 small trout inside; these were dissected. Only 3 of these fish were mature the others were immature. Dissection of stomach contents demonstrated that some of these fish had been feeding on trout eggs (see Appendix 3).

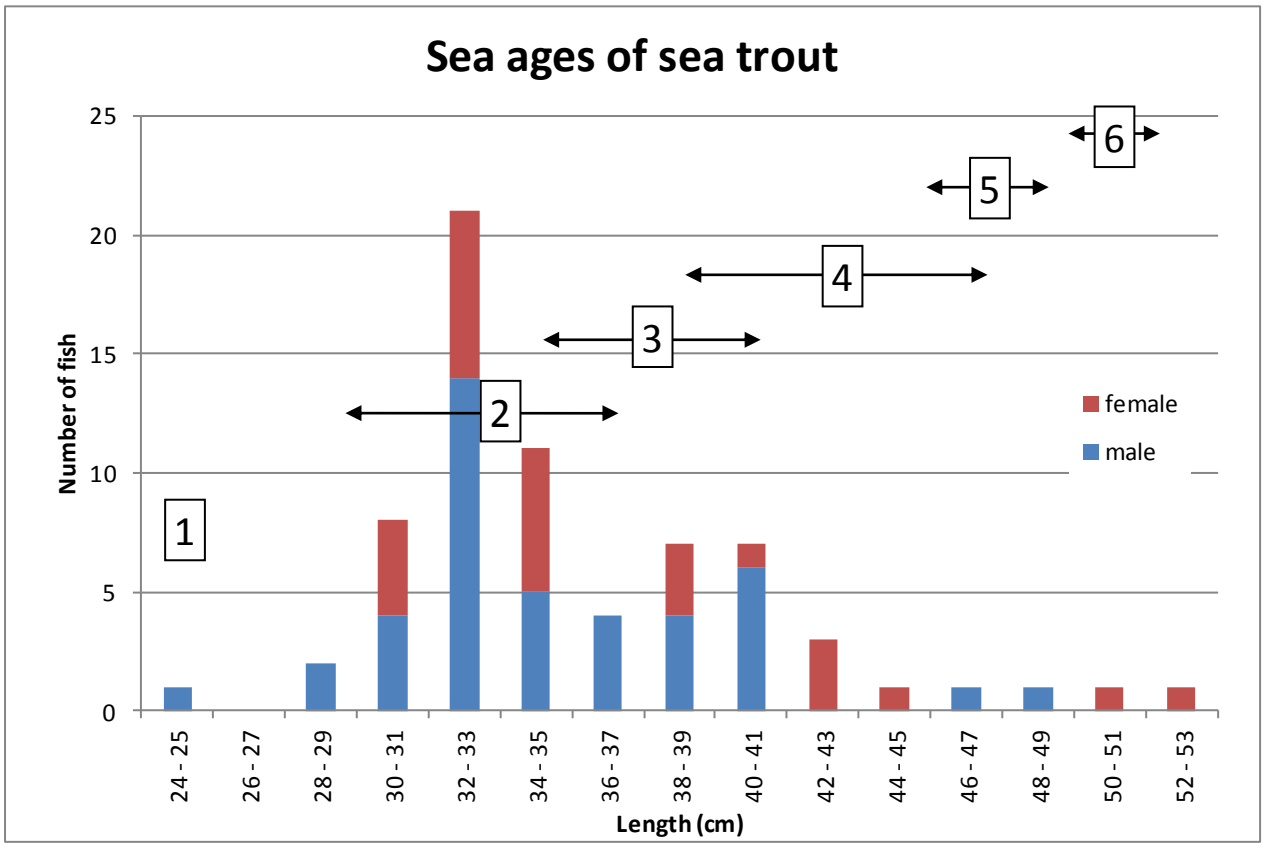
3.3.4 Ages of trout caught

Initial reading of sea trout scales indicates that the majority of the mature sea trout were fish which had returned to freshwater after their second summer at sea and were on their first spawning run, after an initial smolt migration aged 3 winters.

A female sea trout of 430mm had spent 4 summers at sea, and had just spawned for the third time. The largest fish, a female sea trout of 520mm had spent 6 summers in the sea, and was about to spawn for either the third or fourth time. She is one of the longest lived sea trout seen in the WRFT area in recent years. [The sea trout of 500mm taken in June in the estuary (shown on page 11 of this report) was also in its 6th or 7th summer in the sea].

Figure 3.5 shows the ages of the sea trout from which scales could be read.

Figure 3.5: Length distribution of mature (or maturing) sea trout taken in the Feith Ghlas; all fish taken in the fyke net in October – November, except a female fish of 50cm which was taken in the Torridon River estuary earlier in June. The arrows show the sea age ranges in numbers of sea summers, based on scale reading.

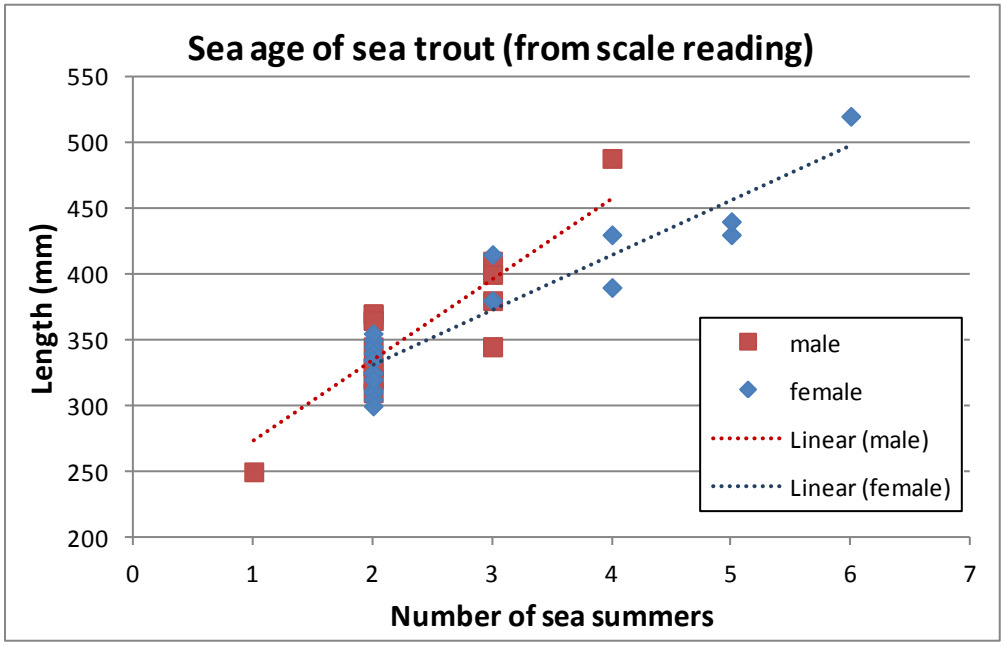


Scale reading and the size frequency graph suggests that most of the 2 sea summer fish were between 300mm and 360mm in length, 3 sea summer fish from 340mm to 410mm; 4 sea summer fish from 380mm to 470mm, 5 sea summer fish 460mm to 490mm; and 6 sea summer fish from 500mm – 520+mm in length.

Therefore, after maturing for the first time typically at around 300mm to 360mm in length at an age of 4.5 years (except for one male 3.5 year old finnock) , annual growth increments were somewhere between an additional 40mm to 50mm in length. The oldest trout, of 520mm, had a total estimated age of 8.5 years.

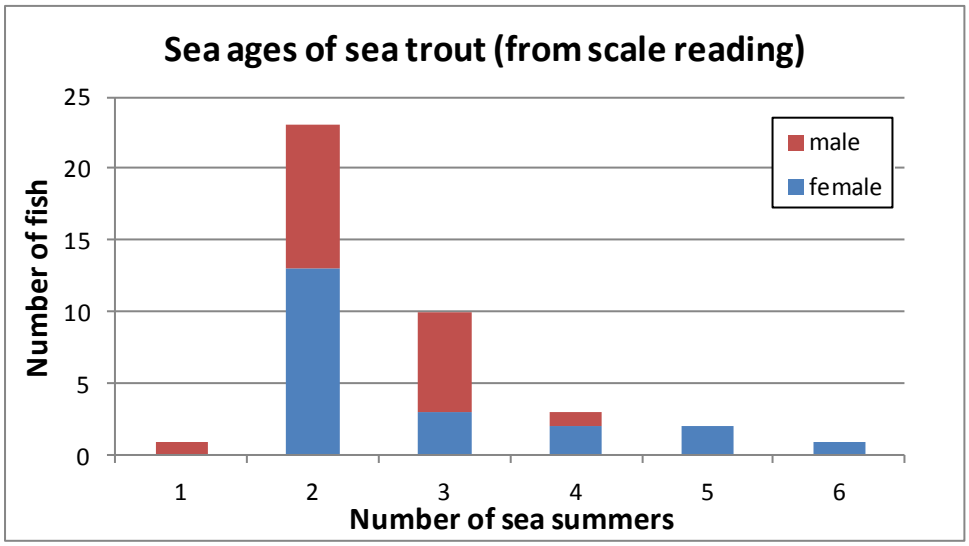
Figure 3.6 shows the range in size of male and female sea trout from which scales have been read. The graph suggests that after maturing for the first time / 2nd summer at sea, the female sea trout grew more slowly than the male sea trout. This can be investigated further in future.

Figure 3.6: Length of male and female sea trout in the Feith Ghlas vs. their sea age (in numbers of sea summers)



When the two sets of age data are combined, a graph can be produced which shows the composition of the sea trout population in the spawning burn in terms of the numbers of fish of respective sea ages.

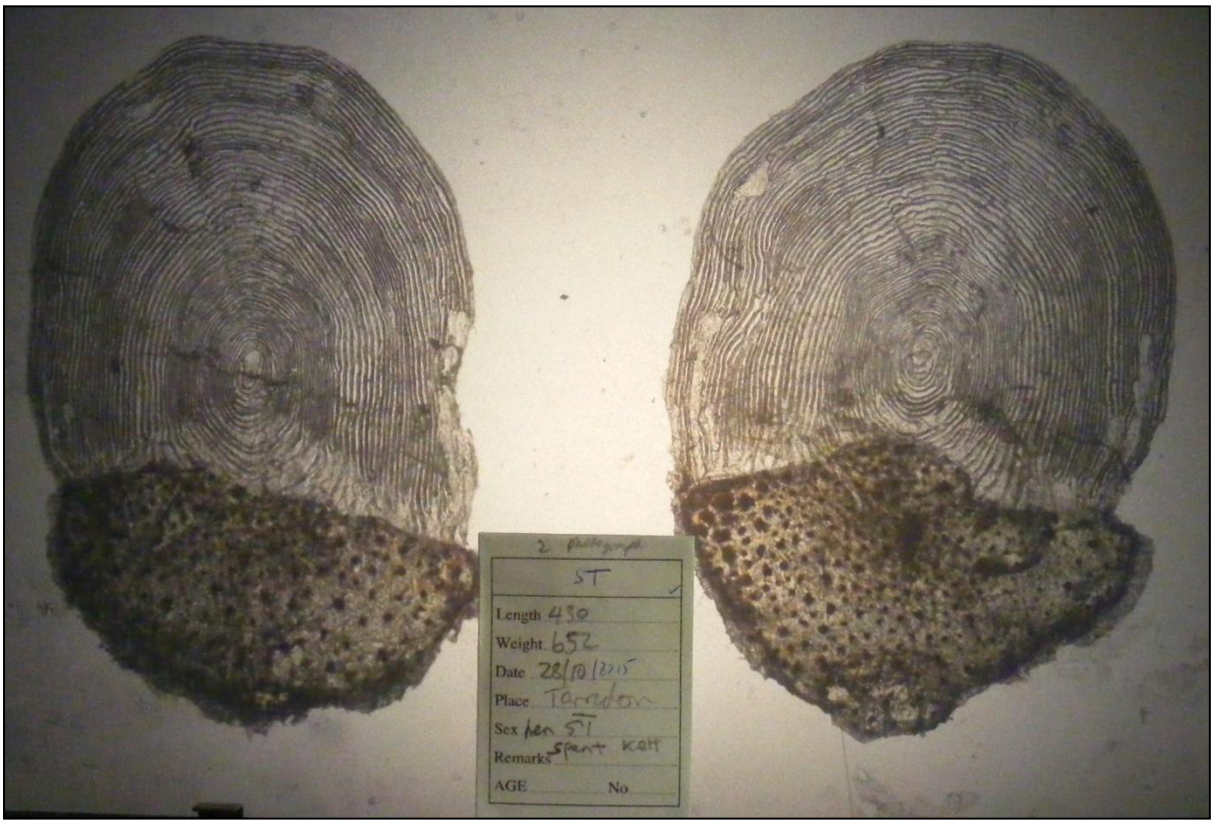
Figure 3.7: The sea age distribution of sea trout in the Feith Ghlas from scale reading of samples from which suitable scales were obtained.



The oldest brown (non-sea going) trout and oldest fish in the fyke net sample was a male trout of 352mm in its 11th year. This old warrior looked like it had fought a few battles over the years (see page 33)! Photographs of this trout and some of the sea trout together with their scales are shown in the following pages.

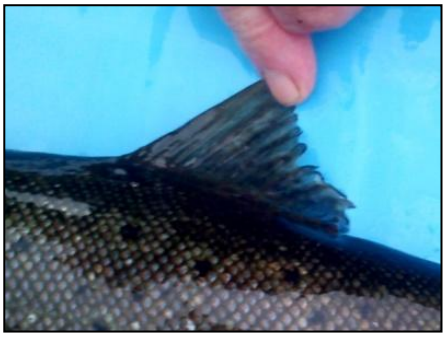
- Sea trout, female, 430mm. Torridon fyke net 28 October 2015.

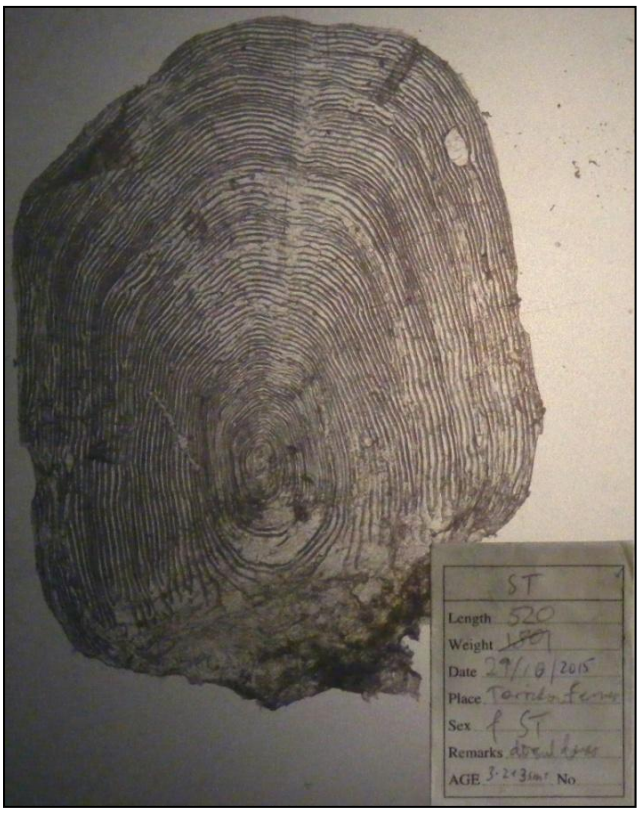
3 years in freshwater then 4 summers at sea. Spawned for first time after 2nd summer at sea; has just spawned for her third time. 3.1+2SM+(.SM)

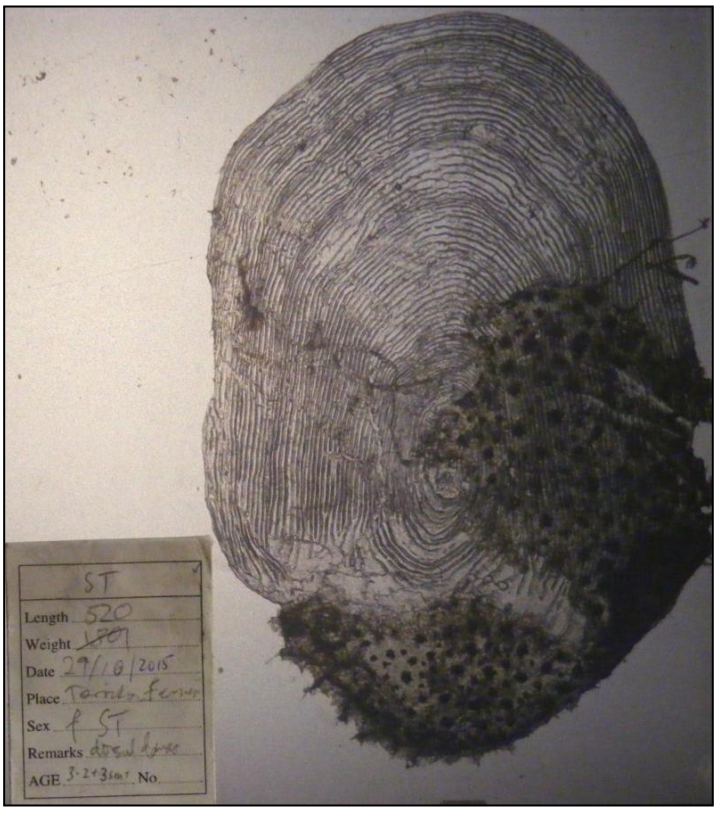


- Sea trout 520mm, female, Torridon fyke net 29th October 2015

The recorded weight for this fish was incorrect (wobbly scales!); the fish is likely to be around 3lb (1350g) in weight. The dorsal fin is partially eroded, though healed; typical of sea louse damage in earlier years. The scale photographs indicate that this fish had spent six summers at sea, after three summers in freshwater. She had spawned on two or possibly three previous occasions prior to 2015. Total age ?8.5 years; 3.2+?3SM+

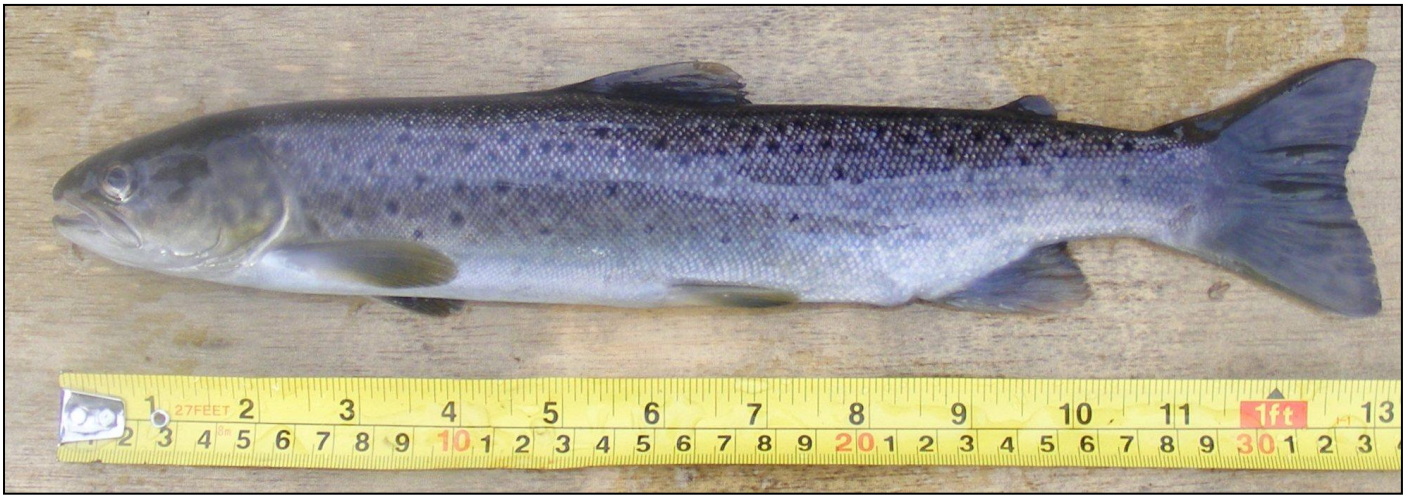






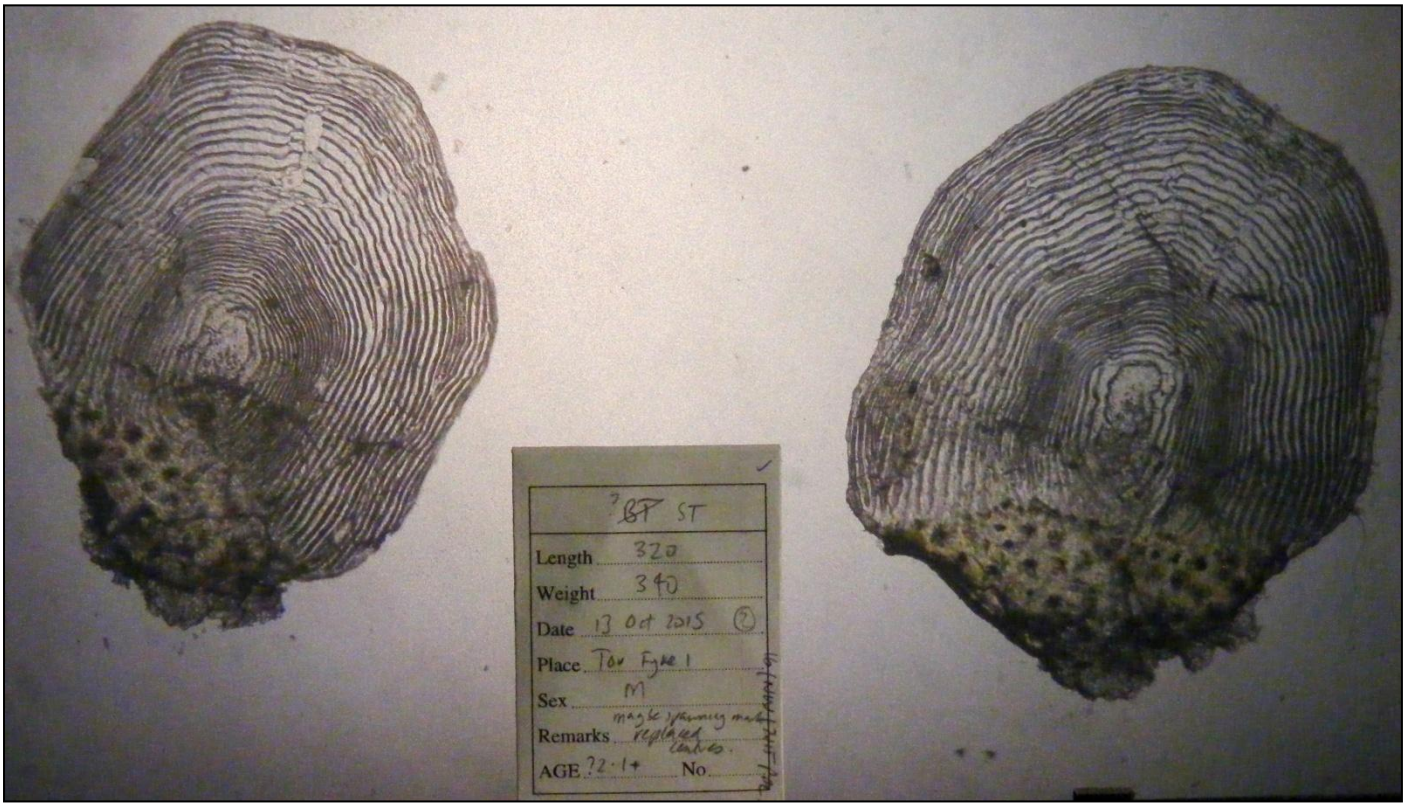
- Sea trout, female kelt of 325mm, 27th October 2015

This fish had just spawned for the first time (in 2015), after her second summer at sea. 3.1+(SM)



- Sea trout male, 320mm; 13th and 14th October 2015 Torridon fyke net

One of the trout caught on more than one occasion. From scale reading, I think that this fish spawned after its first summer at sea and had returned to freshwater after a second summer at sea.



- Sea trout male, 405mm, 27th October 2015, Torridon fyke net

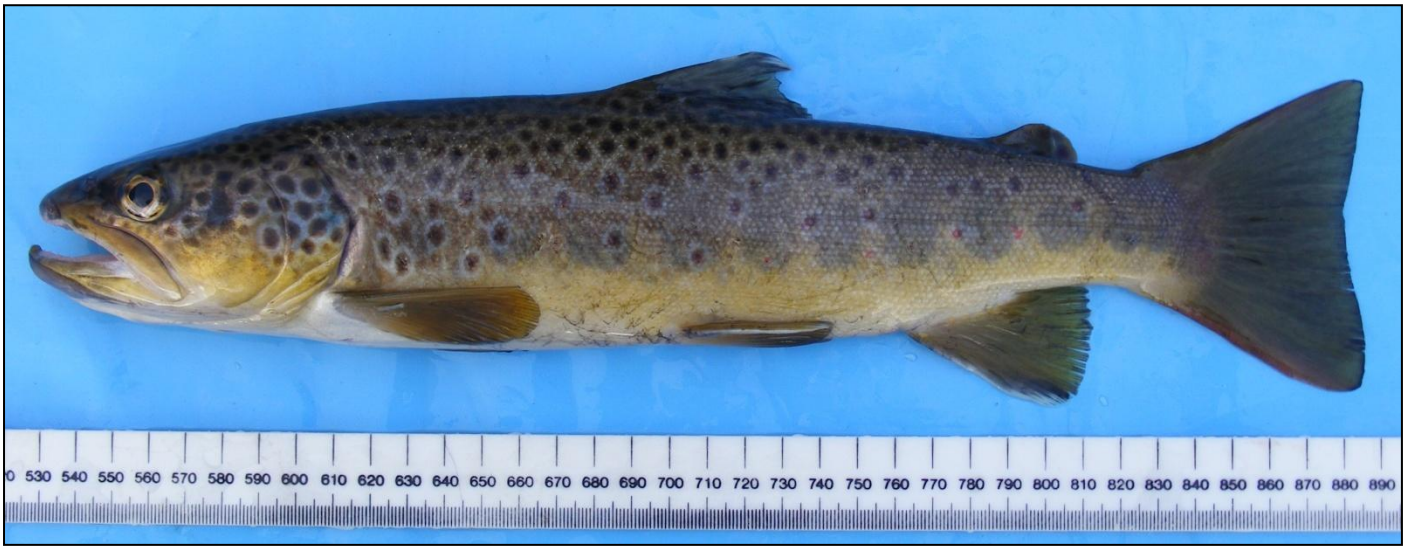
(below) The male sea trout is the one at the top in the picture (above an unspawned female sea trout). Scale reading suggest it has spent just 3 summers at sea so was a relatively fast growing trout! Possibly it was maturing for the first time.

(below) Photograph of the scales of the male trout shown at the top of the picture above. This trout has a very small summer 2015 growth increment.

- Sea trout male, 330mm, 27th October 2015; Torridon fyke net

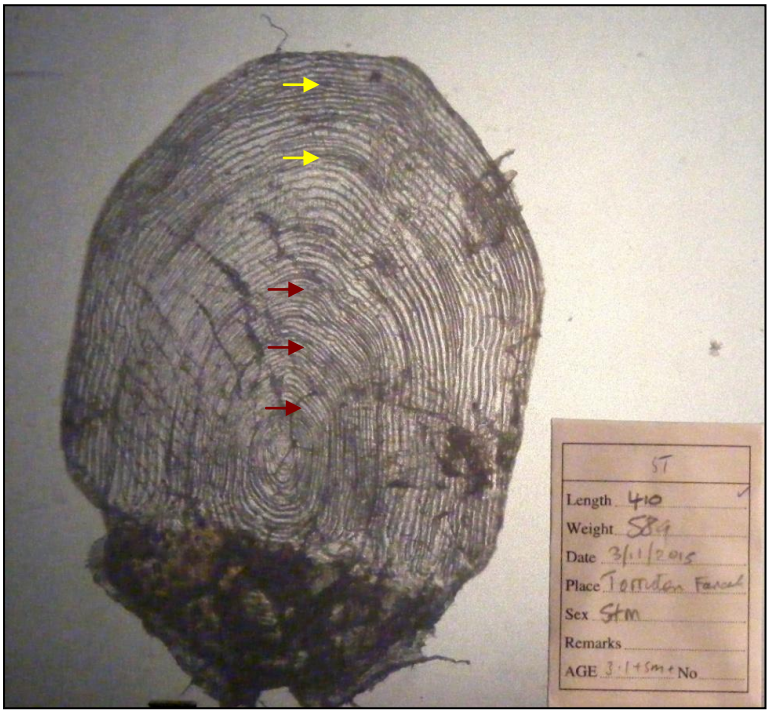
This fish had a slightly eroded but healed dorsal fin, and a caudal fin deformity (sea lice damage?). Scale reading shows it had spent two summers in the sea; however there is not so much summer growth in 2015.

- Brown trout of 352mm taken in the fyke net on 3rd November 2015; 10+ years old. Some interesting colour markings: note the white tips to dorsal fin, pelvic fins and ventral fin. Old charr have similar markings!



(below) Scales of the 352mm brown trout shown above. The scale on the left shows all 10 winter growth checks; the outermost winter check is slightly easier to see in the scale on the right which is missing its inner most winter check.

- *Recaptured male sea trout of 410mm (top) shown together with the 10 year old 'warrior' trout of 352mm (below) taken in the fyke net 3rd November 2015 (see previous page). [Photos show that the male sea trout is the same one that was caught on 27th October (when recorded as a 405mm trout!)]. Note difference in head length: total length ratios. The brown trout has a longer head than the male sea trout, however its total length is 6cm shorter than the sea trout, giving it a slightly stunted appearance.*

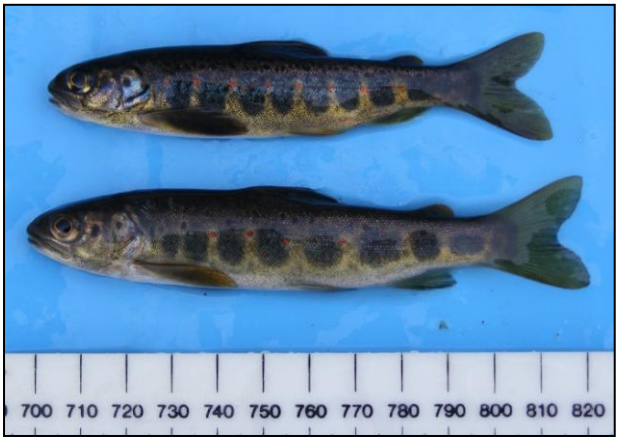


(left) another scale of the recaptured 410mm sea trout taken in the Torridon fyke net on 3rd November 2015. I've indicated freshwater winter growth checks with red arrows, and the two winter growth checks following an initial summer at sea with the yellow arrows.

Compare the growth of this sea trout with that of the 352mm brown trout (scales of which are shown on the previous page).

(below) Genetic mix?: all the trout in the picture below from the 3rd November 2015 Torridon fyke net catch are mature male brown trout and were running milt. The fish at the top is a sea trout; the other trout had not been to sea. The smallest mature male was only 115mm long!

A 'precocious' male salmon parr (top) and mature male brown trout, taken in the trap on 28th October 2015. What was the salmon parr doing? Youngson et al 1993 recorded an unusually high proportion of trout salmon hybrids in the Torridon River; however, this was associated with male trout fertilising female salmon eggs rather than vice versa.



3.3.4 Summary of results of fyke net operation in the Feith Ghlas in 2015

- The fyke net trap was set in the Feith Ghlas on 12th October 2015 and operated continuously except for two weekend breaks until 9th November when the trap was lifted.
- There were 212 captures of trout in the trap. Of these 76 were recorded as sea trout, and the remainder were brown trout. Five of the sea trout were identified as 'recaptured fish' several male brown trout were also recaptured.
- 42 of the sea trout were mature males (260mm – 488mm); 26 were females (300mm – 520mm); and 3 were immature 'finnock' (245mm – 260mm).
- 76 of the brown trout were mature male fish 'running milt' (115mm – 352mm); the remainder were immature or were males that were not identified as such (64mm – 157mm).
- No mature female brown trout were recorded.
- The first sea trout kelts were recorded on 27th October; unspawned & partly spawned female sea trout were recorded until 7th November.
- Most of the sea trout were fish which had returned to freshwater after their second summer at sea. Most of these fish were between 310mm and 340mm in length.
- The oldest sea trout was a female fish of 520mm which had returned to freshwater after a 6th (or possibly 7th) summer in the sea.
- The oldest brown trout was a fish of 352mm, aged at 10+ years.

Charlie, Les and Colin with male sea trout (from the anaesthetic bucket)!

4. Discussion

4.1 What was the distribution and timing of heavily lice-infested sea trout around Loch Torridon?

The very high levels of sea lice recorded on some of the sea trout sampled around Loch Torridon and as far away as the Flowerdale estuary (Loch Gairloch) in May – early July were unusual.

In May and June 'early returned' sea trout with sometimes very high numbers of mainly small chalimus stage sea lice were recorded around Loch Torridon: in the River Balgy estuary and lower pools of the Inverbain river. Early returned sea trout were also recorded in the lower pools of the Shieldaig River by Marine Scotland scientists (Raffell, *pers comm*.). All these sampling sites are within 5km of the nearest salmon farm within the Loch Torridon production area (referred to as 'Badachro – Applecross'), and their occurrence can most easily be explained by the prevalence of high numbers of adult female sea lice recorded on farm salmon at sites within the area.

The high numbers of sea lice recorded on some of the sea trout in the Sand River (by Loch Gairloch) on 1st July, in the Flowerdale estuary on 19th May and the occurrence of louse-damaged sea trout in the sea pool of the Flowerdale burn on 6th July can also be most easily explained by proximity to the Loch Torridon salmon farms. The Sand River is 20km from the Sgeir Dughall salmon farm; the Flowerdale estuary is 24km from the Sgeir Dughall salmon farm. To the north, the nearest active salmon farm was the Isle Ewe salmon farm (>30km around the coast from the Sand River Estuary); at its peak, the adult female sea louse population in Loch Ewe was around 1 order of magnitude lower than that in the Loch Torridon area. To the southwest the nearest salmon farms are near Portree, about 50km away; adult female lice levels on these farms, in the first year of their production cycle, were reported as close to zero.

Further afield, a 294mm sea trout carrying an estimated 412 lice was recorded in a sweep netting sample at Boor Bay in Loch Ewe on 4th June. This is the most heavily infested sea trout recorded at this site in Loch Ewe to date. This fish was an 'odd one out' in a sample of 41 sea trout; only one other fish in the sample carried more than 10 sea lice (a fish of 308mm with 67 lice); and all of the other fish in this sample were lice free or carried 4 or less lice (all except another 2 fish were small post- smolt sea trout of less than 250mm). It is considered possible that the lice on the very heavily infested fish of 294mm were derived from the Loch Torridon salmon farming area; as other similar sized sea trout in the sample carried much less lice at that time. However this is less clear than for the trout sampled around Loch Gairloch and Loch Torridon.

On 7th July, 21 sea trout of average length 250mm (range 207mm – 368mm) were taken in the River Ewe using rod and line. These fish carried up to 261 lice per fish; four of these fish were lice-free; the 17 infected fish carried an average of 61 lice. Some of these lice may have been derived from the Loch Torridon farm or perhaps more likely from the nearest farm at Isle Ewe which carried high numbers of adult female lice (possibly up to 500,000 adult female lice based on estimates of fish numbers multiplied by the average reported adult female lice count).

It is thought possible that sea lice from the Loch Torridon farms could have infested farmed salmon on the Isle Ewe farm (just less than 50km by sea away); however it is beyond the scope of this report to examine the possibility of a knock-on effect of louse infestation from Loch Torridon farms via the Isle of Ewe farm to sea trout in the Loch Ewe area.

Not all the sea trout sampled at any of the sites were heavily lice infested. In May and June, some of the 'silvery' trout taken in the Balgy estuary, Flowerdale estuary and Cuaig River were lice free. Some of these fish may not have experienced fully marine water having lingered in freshwater or the brackish water of the estuary en route to the sea. In August, September and October, sea lice levels on sea trout sampled at all sites were much lower than earlier in the year. By this time, the farmed fish in the Loch Torridon area had been harvested.

4.2 What were the consequences of heavy louse infestation on sea trout populations around Loch Torridon?

This is the question that is most difficult to answer. The Scottish Government acknowledges that at the individual fish level there is an impact to sea trout from sea lice emanating from salmon farms; however, from published information the influence of aquaculture on sea trout populations in the West of Scotland is 'not clear'[5].

In terms of rates of marine survival, there is evidence from Norway of an impact to sea trout at population level associated with sea lice. In the Hardangerfjord, Norway, Skaala *et al* 2014 found that twice as many sea trout that had been treated with Substance EX to prevent sea louse infection survived to return to their rivers of origin than in the untreated control group, and suggested that salmon lice infection was an important contributor to the high mortality of anadromous trout in that study area. However, our results suggest complex relationships.

4.2.1 Proportions of samples carrying potentially lethal sea louse infestation levels

Taranger *et al* 2015 proposed that the risk to sea trout stocks from sea louse infection would vary according to the size of infested fish, how many lice they carried, and the proportions of the population in each infection group. Figure 4.1 is shows an example of how a calculation can be made using this formula for the 'stock regulating effect' for any area based on sampling of the population.

Figure 4.1: Risk assessment for salmon and sea trout populations: an example of an assessment of stock regulating effects based on the proportion of the populations subject to varying levels of louse infection.

Taranger et al. 2015

Risk assessment of sea lice on wild salmonids in Norway

Assessment on **Stock regulating effects** of salmon lice on wild salmon and sea trout populations

Infection group (number of lice/fish weight, g)	Proportion of population (%)	Expected mortality	Index
< 0,1	50	0%	0
0,1 - 0,2	20	20%	4
0,2 - 0,3	20	50%	10
> 0,3	10	100%	10
Estimated stock reduction (%)			24

Increased Mortality Risk at Population Level	Stock Regulating Effect
>30%	High
10%-30%	Moderate
<10%	Low

In the current study, all 6 sea trout taken in the Balgy sea pool on 25th June 2015 were heavily louse-infested; these were of average length 221mm, average weight 116g and carried an average lice burden of 72.5 lice. 5 out of six of these fish carried more than 0.3 lice per g body weight of fish.

[5] http://www.gov.scot/Topics/marine/Salmon-Trout-Coarse/Freshwater/Research/Aqint/troutandlice

At Flowerdale, the fish with 500 lice was the most heavily infested fish sampled in the Loch Gairloch since sampling began in the loch in 2007; the previous record was a fish with just over 200 lice. These fish, together with some of the fish sampled in the sea pool of the Flowerdale River and in the Sand River in early July were in the '100% expected mortality group'.

However, because all samples of sea trout, especially those taken in estuarine areas or lower pools of rivers (by whatever means), are unlikely to be representative of the whole of the respective populations, it is still difficult to measure the overall impact of the sea lice epizootic on respective trout populations.

This is not the same as stating that it is not possible to say or not whether there has been an impact at population level. Many sea trout were recorded carrying sea lice burdens far above the 'expected mortality' threshold levels described by Taranger *et al* 2015. Given the very high levels of lice seen on some fish in the Loch Torridon area, the figures presented in Skaala *et al's* paper suggesting a reduction in rates of marine survival of sea trout of around 50% where there is a severe sea lice infestation do not seem unreasonable.

4.2.2 To what extent did the sea lice infestation affect sea trout egg deposition?

Despite high and potentially 'lethal' levels of sea lice in some samples of sea trout from around and beyond Loch Torridon in May to July 2015, evidence that sea trout survived to maturity was collected from the Flowerdale estuary, South Erradale River and particularly from the River Torridon (closest to infested farms).

Samples of sea trout taken in the South Erradale burn on 20th August (6 fish) and Flowerdale on 1st October (23 fish) suggested that many sea trout which had become infested with sea lice had managed to rid themselves of the lice by then [the South Erradale burn mouth is about 12km from the Sgeir Dughall farm]. Three of the South Erradale sea trout were maturing female fish in reasonable condition; having survived a second summer at sea. Two or more of the sea trout in the October sample at Flowerdale were maturing female sea trout. These fish were recorded as having 'damaged but healing' dorsal fins, indicative of earlier sea lice infestation.

Perhaps the most interesting finding of this investigation was of the sea trout captured in the Torridon River (Feith Ghlas) fyke net in October and November. The mouth of the Torridon River is only 8km form the Torridon salmon farm; and sea trout entering the sea around the River Torridon area were therefore likely to have been close to areas where there was high infestation pressure from larval sea lice emanating from the nearby salmon farms.

Despite this, the fyke net sample included many sea trout which had grown in the sea in 2015 and survived to return to freshwater as mature fish. Some of these sea trout had dorsal fins which were noted as damaged but healing, indicative of infection by sea lice at some earlier time in their lives. None of the fish had dorsal fins as stunted as those sampled in the South Erradale burn (or some of those seen in Loch Gairloch in previous years).

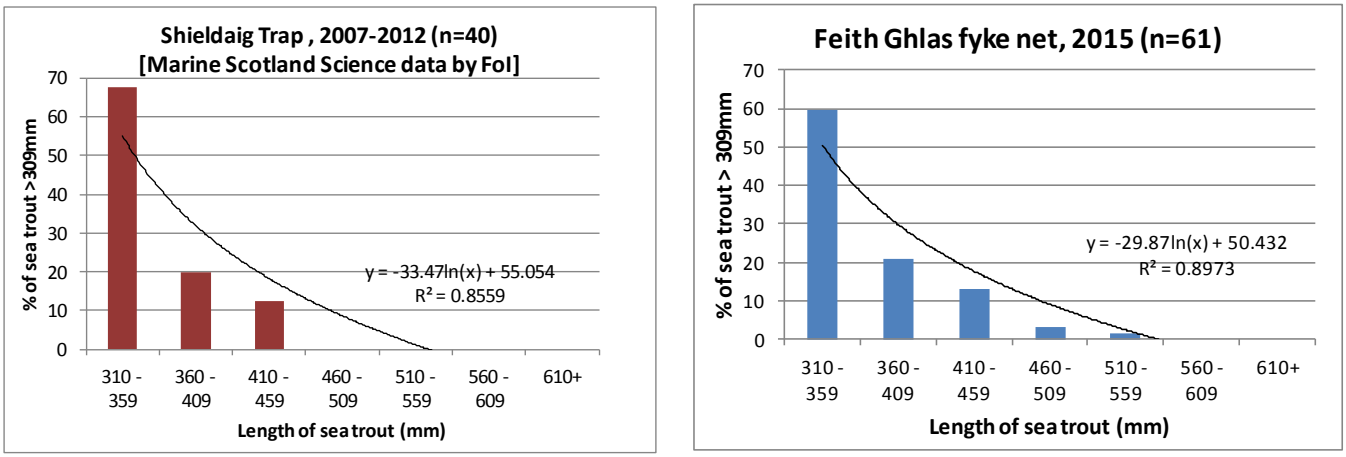
Therefore, the Feith Ghlas fyke net sample provided strong evidence that in terms of egg deposition, the Torridon River sea trout population remained healthy enough to recruit the next generation.

4.2.3 To what extent did the sea louse infestation affect sea trout growth rates?

Initial analyses suggests that the overall range in growth rates for Torridon River sea trout was similar to those for similar sized sea trout sampled elsewhere in Wester Ross in other recent years (since year 2000). The scales of some Torridon sea trout had small summer 2015 growth increments; others had larger growth increments. Growth rates for sea trout in the Flowerdale estuary and other areas around Scotland are discussed in Cunningham, 2013.

Figure 4.1 compares proportions of sea trout in different size classes taken in the Torridon River (Feith Ghlas) fyke net in 2015 with those taken in the Shieldaig trap during the period 2007 to 2012. The graph for the Shieldaig trap sea trout is taken from Cunningham 2013 which investigated the occurrence of larger sea trout around the West of Scotland in relation to salmon farming.

Figure 4.1: Proportions of sea trout in size classes above 309mm in the Shieldaig River system (2007 to 2012) compared to the Torridon River Feith Ghlas fyke net in 2015.

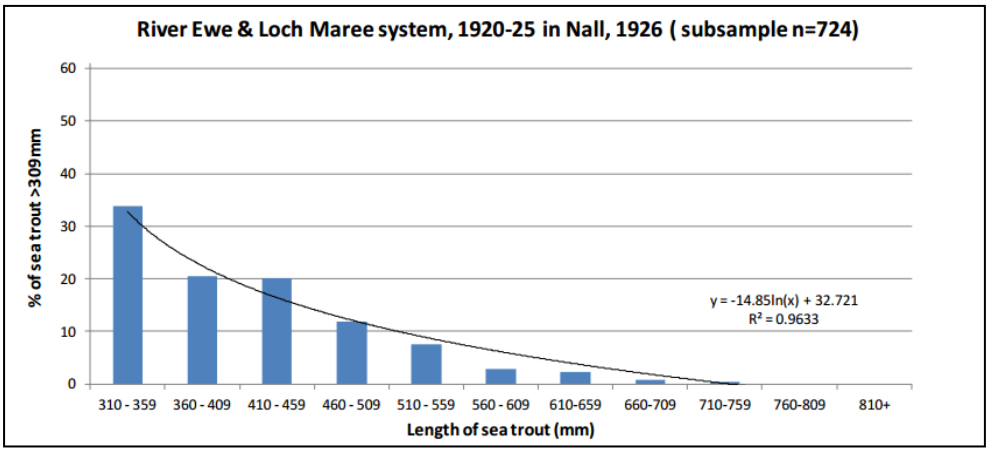


The graph shown in Figure 4.1 for the Torridon River fyke net is not quite so steep as for the Shieldaig Trap; note that at Shieldaig, during the period 2007 to 2012, sea trout larger than 460mm were not recorded. In 2015, the largest sea trout recorded entering the Shieldiag trap was a fish of 343mm (Raffell *pers comm*.). Therefore in recent years, some River Torridon sea trout have grown bigger and have lived longer than those that have lived in the Shieldaig river system.

Also remember that the Torridon fyke net was fitted with an otter guard and some larger sea trout may have been unable to enter the trap; at least two large trout were seen in the Feith Ghlas but not recorded.

All said however, both graphs show a relatively steep decline in the proportions of sea trout of over 359mm in both the Shieldaig trap and Torridon River Feith Ghlas fyke net samples compared to sea trout samples from the past (1980s and earlier). For both systems, the majority of sea trout were less than 360mm in length. Contrast this with a River Ewe – Loch Maree system sample of sea trout taken during the years 1920-25 (Figure 4.2).

Figure 4.2: Proportions of sea trout in size classes above 309mm in the River Ewe system (1920-1925). Note that larger proportions of the overall sample were in the higher length classes.



4.2.4 Other factors may determine whether a sea trout 'population[6]' can survive in a sea lice infested area

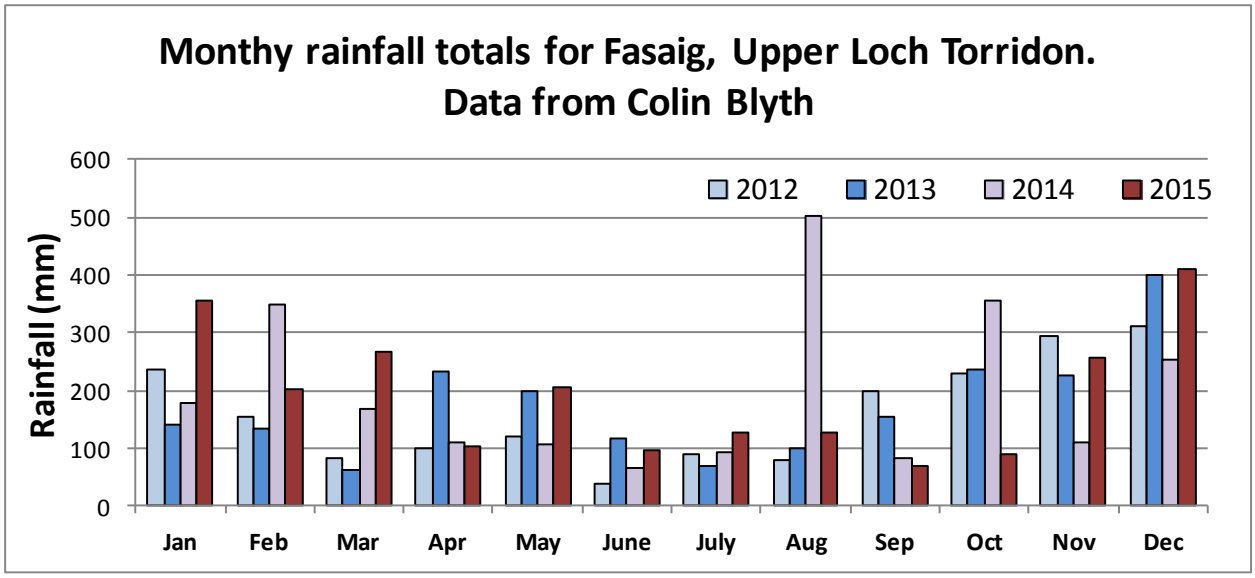
Even when sea trout have a burden of lice that is potentially harmful to their wellbeing; whether they survive or not is dependent upon other factors. Sea trout with potentially harmful burdens of parasitic marine sea lice are known to seek freshwater (Birkelund & Jakobsen, 1997). The sea louse (*Lepeophtheirus salmon*) is unable to tolerate freshwater for long; so by 'returning early' to freshwater, sea trout are able to rid themselves of some or all of the lice over a period of days (e.g. Wells *et al*, 2006).

In the context of the current investigation, the following factors are likely to have affected prospects of survival for sea trout subjected to lice infestation:

1. Opportunities for finding freshwater to return to when subject to high sea louse infestation pressure

The geography and catchment area of upper Loch Torridon is such that, except during periods of drought, a freshwater layer is likely to be present around much of the sea loch providing many places where lice-infested trout can seek to rid themselves of these troublesome parasites. In comparison, sea trout from the Sguod, Tournaig and Shieldaig systems enter sea lochs with slightly different geography and hydrology and may have fewer 'safe' options for finding suitable freshwater areas for delousing.

Figure 4.3: Monthly rainfall totals for Fasaig, upper Loch Torridon for years 2012 to 2015 (figures from Colin Blyth). Even 'normal' rainfall during the summer months may be enough to maintain a sizable freshwater layer around part of upper Loch Torridon.



2. Access from fresh or brackish water to marine food sources

Trout from the Torridon River are likely to able to feed on a wide variety of marine or intertidal food sources over an extensive intertidal area around the head of Loch Torridon without the need to remain in water of high salinity (where the sea lice infestation pressure will be highest) for long. Compared to trout from the Shieldaig and Tournaig systems (and to a lesser extent trout from other systems), Torridon River sea trout appear to have a much larger area of fresh & brackish water habitat in which to find food, or from which to move in and out of saltwater. This could be investigated further through sampling.

[6] Here I use the word 'population' to mean a group of related trout with sea-going tendency inhabiting the same area.

3. An ability to avoid predation by seals and birds

As the tide ebbs and flows, sea trout gathered in an estuary are forced to move about. A seal is only able to catch a lice-infested sea trout if the water is deep enough for it to swim in. Where the estuary is wide with shores of low gradient, trout may be able to follow the tide without the need to move through deep water where a seal would be able to catch them. By staying within shallow water (less than about 0.6m deep), a sea trout, no matter how heavily infected with lice, will be virtually impossible for a seal to catch. For the reasons described above, the Torridon river estuary appears to provide much greater opportunity for a lice-infested sea trout to linger safely in freshwater out of the reach of seals around the head of Loch Torridon compared to a sea trout in, for example, Loch Shieldaig or Loch Thurnaig where shoreline gradients are generally steeper and there are many seals. In March 2013, larger sea trout (to 500mm+) were caught by the WRFT sweep netting team in shallow water at the head of Little Loch Broom, with several common seals looking on from less than 50m away (I don't think they were admiring our fish catching prowess . . .)!

However smaller River Torridon sea trout, if infested with sea lice which remain in shallow water, may be just as vulnerable to predation by fish eating birds including heron, gulls, cormorants as small trout from other river systems (c. Middlemas *et al*., 2009). Very few finnock were recorded in and around the Torridon river in 2015 (sweep netting, rod and line, fyke net trap), and it is possible that lice infested post-smolt sea trout from the Torridon River were subject to proportionally higher rates of mortality than larger fish. This is possibly something to investigate further by setting the fyke net in the burn again in autumn 2016.

4. Occurrence of freshwater lochs within the river system

The absence of mature female brown trout in the Feith Ghlas fyke net sample suggests that there is still a strong selective advantage for a female Torridon River trout to go to sea despite the threat of sea lice infestation. In contrast to the Torridon River system, the Sguod, Tournaig and Ewe systems all have larger freshwater lochs and mature female brown trout. Female trout in systems with larger lochs may have more opportunity to grow to maturity in freshwater than those inhabiting the Torridon river system. These systems are capable of producing larger numbers of brown trout relative to the sea trout population.

Where there are larger numbers of mature female brown trout, a reduction in survival of female sea trout may have a disproportionate impact on the overall sea going tendency of the trout populations; because progeny of remaining female sea trout will face greater competition from higher numbers of progeny of female brown trout. This is discussed by Thorstad *et al* 2015, who suggest that for some systems, there may be a genetic shift in a trout population away from anadromy (a tendency to go to sea) towards non-migratory brown trout if few female sea trout survive to maturity. Note that the Shieldaig system is heavily stocked with juvenile trout of 'Coulin origin' which is likely to obscure any genetic changes associated with differential survival of sea-going and non sea-going trout.

For the Torridon River trout population, all these factors may interact in such a way as to favour continued survival of the sea-going tendency of especially female trout within the system, despite the occurrence of sea louse infestations in nearby waters.

This is in contrast to many other stream systems round Wester Ross, particularly those where trout have greater opportunity to complete their life-cycle in larger freshwater lochs without exposing themselves to the higher risks associated with sea lice infestation in the sea, for example the Sguod river system (spawning burn sampled by WRFT using a fyke net in 2012), Tournaig river system (WRFT upstream & downstream traps since 1999) and the River Ewe

- Loch Maree system (various WRFT studies of adult trout populations in spawning burns since 1997 using fyke nets and electro-fishing).

Other places within the WRFT where sea trout populations appear from anecdotal reports to remain relatively healthy (in so far that sea trout of 1kg are recorded regularly in rod catches) despite proximity to salmon farms with a history of high sea louse populations, include: Loch Hourn (Fison, *pers comm*.[7]) and Loch Long, near Dornie (Holland, *pers comm*.[8]). Both these sea lochs are characterised by the presence of 'narrows' enabling the formation and retention of a freshwater layer on top of the saltwater within the upper parts of respective sea lochs; sea trout which live in these places can grow in the sea without spending so much time in water of fully marine salinity.

5. Conclusions

- The occurrence of heavily lice-infested sea trout in samples taken around Loch Torridon and at sites as far away as Loch Gairloch during the period May – July 2015 can most easily be explained by proximity to a very large sea lice population on the salmon farms in the Loch Torridon area during the period January to June 2015 as inferred from figures reported on SSPO and the Scottish Government websites.

- Levels of lice infestation on sea trout in some samples were in excess of lethal threshold levels described in published literature. The marine survival rate, especially of smaller trout in systems such as the River Balgy, may have been reduced by 50% or more as a result of sea lice infestation.

- However, many mature sea trout were captured in the Torridon River system in the fyke net trap in the Feith Ghlas spawning burn in October and November 2015. These fish had survived and grown, presumably mainly within the upper Loch Torridon area despite close proximity to sources of larval sea lice (i.e. nearby salmon farms).

- It is suggested that the overall impact of the Loch Torridon sea lice infestation on sea trout populations around and beyond Loch Torridon in 2015 varied according to geographic factors, including the topography and hydrology of the areas into which rivers discharge. The extensive intertidal and west facing characteristics of the Torridon River estuary and upper Loch Torridon may provide River Torridon 'sea trout' with greater opportunities for finding freshwater or brackish water areas where they are better able to evade or rid themselves of sea lice as well as finding food and evading capture by seals than sea trout from some other systems (e.g. Shieldaig).

- These things could be clarified by further study of the movements of tagged trout in Loch Torridon in relation to salinity, depth and other factors.

- This investigation has focussed on the survival of sea trout around Loch Torridon in 2015. The Torridon River also supports **a salmon population**. In spring 2015 salmon smolts from the Torridon River will have migrated to sea past the lice-infested salmon farms. How has the 2015 Loch Torridon lice infestation affected the survival of salmon smolts?

[7] Thank you to Tim Fison for regular reports and samples of rod caught sea trout from around Kinlochhourn.
[8] Thank you to David Holland for reports of rod caught sea trout taken in the estuary of the River Ling / Elchaig at the head of Loch Long.

6. Acknowledgments

For permission to carry out sampling, thank you to Estate of Gairloch, Ben Damph Estate, Applecross Estate and Kinloch Woodland Trust. Sea trout sampling was carried out with much help from Colin Simpson, Gary Bulmer, Jim Buchanan, Cory Jones, Dr James Merryweather, Reuben Brown, Lucy Robison, Cara Allison, Prof Dave Barclay; Bill, Irene and Fraser Anderson; Rob Adams, Dr Steve Kett, Dr Andy Vicks, Vu Dang, Toby Landeryou, Nick Oliver, Liam Perks, Seamus and Ruaraidh MacNally (NTS Torridon), Will Gray and friends, Katharine Kinloch; Tom, Ed, Henry and Jamie Barlow; Les Bates and Colin Blyth; thank you to everyone. Thank you to Jim Raffell at MS Shieldiag field station for information, discussion and interest, and to Mark Williams and Keith Dunbar for comments on an earlier draft.

Sea trout sampling was funded by the Scottish Government via RAFTS, the Wester Ross Area Salmon Fishery Board, and by generous donations from other sources.

Loch an Iasgair, at the top of the Torridon River, December 2015 by Les Bates.

7. References

Birkeland, K. & Jakobsen, P.J. 1997. Salmon lice, *Lepeophtheirus salmonis*, infestation as a causal agent of premature return to rivers and estuaries by sea trout, Salmo trutta, ju-veniles. Environmental Biology of Fishes 49, 129-137.

Butler JRA (2002) Wild salmonids and sea louse infestations on the west coast of Scotland: sources of infection and implications for the management of marine salmon farms. Pest Manag Sci 58: 595−608

Butler JRA, Walker AF (2006) Characteristics of the sea trout *Salmo trutta* (L.) stock collapse in the River Ewe (Wester 109 Aquaculte Environ Interact 7: 91–113, 2015 Ross, Scotland), in 1988-2001. In: Harris G, Milner N (eds) Sea trout:biology, conservation and management. Blackwell, Oxford, p 45−59

Cunningham, PD (2009) WRFT sea lice monitoring Report 2007 - 2008 http://www.wrft.org.uk/files/WRFT%20Sea%20lice%20monitoring%20report%202007-2008%20for%20web.pdf

Cunningham, PD (2013) Wester Ross Sea Trout Monitoring Report April 2013: On the Occurrence of Larger sea trout. http://www.wrft.org.uk/files/wrft%20sea%20trout%20monitoing%20report%20April%202013%20v5.pdf

Middlemas SJ, Stewart, DC, Mackay S, Armstrong JD (2009) Habitat use and dispersal of post-smolt sea trout *Salmo trutta* in a Scottish sea loch system. Journal of Fish Biology Volume 74, Issue 3, pages 639–651, February 2009

Middlemas SJ, Fryer RJ, Tulett D, Armstrong JD (2013) Relationship between sea lice levels on sea trout and fish farm activity in western Scotland. Fish Manag Ecol 20: 68−74

Penston MJ, Davies IM (2009) An assessment of salmon farms and wild salmonids as sources of *Lepeophtheirus salmonis* (Krøyer) copepodids in the water column in Loch Torridon, Scotland. J Fish Dis 32: 75−88

Pert CC, Raffell J, Urquhart K, Weir SJ, Kantola KMH, Bricknell IR (2009) The pathogen burden of early returning sea trout (*Salmo trutta* L.) infected with *Lepeophtheirus salmonis* (Krøyer, 1837), in the River Shieldaig, Scotland. Bull Eur Ass Fish Pathol 29: 210−216

Skaala Ø, Kålås S, Borgstrøm R (2014a) Evidence of salmon lice-induced mortality of anadromous brown trout (*Salmo trutta*) in the Hardangerfjord, Norway. Mar Biol Res 10: 279−288 [survival to return to river of 'x' treated smolts 3.41%; survival of control group 1.76%] http://www.tandfonline.com/doi/pdf/10.1080/17451000.2013.810756

Taranger GL, Karlsen Ø, Bannister RJ, Glover KA and others (2015) Risk assessment of the environmental impact of Norwegian Atlantic salmon farming. ICES J Mar Sci 72: 997−1021

Thorstad, E. B. , Christopher D. Todd, Ingebrigt Uglem, Pål Arne Bjørn, Patrick G. Gargan, Knut Wiik Vollset, Elina Halttunen , Steinar Kålås, Marius Berg , Bengt Finstad (2015) Effects of salmon lice *Lepeophtheirus salmonis* on wild sea trout *Salmo trutta*—a literature review. Aquacult Environ Interact Vol. 7: 91–113, 2015 doi: 10.3354/aei00142 Published online August 20 2015

Vollset KW, Barlaup BT (2014) First report of winter epizootic of salmon lice on sea trout in Norway. Aquacult Environ Interact 5:249−253

Youngson, A.F., Knox, D. & Johnstone, R. (1992). Wild adult hybrids of *Salmo salar* and *Salmo trutta* L.. Journal of Fish Biology 40, 817-820.

Youngson, A.F., Webb, J.H., Thompson, C.E. & Knox, D. (1993). Spawning of escaped farmed salmon (*Salmo salar*): Hybridisation of females with brown trout (*Salmo trutta*).Canadian Journal of Fisheries & Aquatic Sciences 50, 1986-1990.

Wells A, Grierson CE, MacKenzie M, Russon IJ and others (2006) Physiological effects of simultaneous, abrupt seawater entry and sea lice (*Lepeophtheirus salmonis*) infestation of wild, sea-run brown trout (*Salmo trutta*) smolts. Can J Fish Aquat Sci 63: 2809–2821

Appendix 1: Summary data from sea trout sampling around the Loch Torridon area during the period May – October 2015

No.	Location	Date	Method	River / Estuary / Beach	Fish	Length (mm)	Weight (g)	Condition factor	*Caligus* total	*Lepeophtheirus salmonis*				Dorsal fin damage	Lice spots	*Crypto-cotyle* (spots/cm ^{3})	Predator damage	Photo	Comments
										Copepodid & Chalimus	Pre-adult & adult	Ovigerous female	Total *L. s*						
1	Flowerdale	19-May-15	Sweep net	Estuary	ST	281	200	0.90		500 est.	0	0	500 est.	1.5	-	-	Bird	N	
2	Flowerdale	19-May-15	Sweep net	Estuary	ST	203	70	0.84		60	0	0	60	0	-	40	N	N	
3	Flowerdale	19-May-15	Sweep net	Estuary	ST	171	75	1.50		65	0	0	65	0	-	-	N	N	
4	Flowerdale	19-May-15	Sweep net	Estuary	FL	281	310	1.40		0	0	0	0	0	-	-	N	N	
5	Flowerdale	19-May-15	Sweep net	Estuary	ST	175	60	1.12		7	0	0	7	0	-	-	N	N	
6	Flowerdale	19-May-15	Sweep net	Estuary	ST smolt	149	36	1.09		0	0	0	0	0	-	-	N	N	
7	Flowerdale	19-May-15	Sweep net	Estuary	ST	160	25	0.61		20	0	0	20	0	-	-	N	N	
8	Flowerdale	19-May-15	Sweep net	Estuary	ST	150	-	-		40	0	0	40	0	-	-	N	N	
9	Flowerdale	19-May-15	Sweep net	Estuary	ST	155	-	-		16	1	0	17	0	-	-	N	N	
10	Flowerdale	19-May-15	Sweep net	Estuary	ST	148	-	-		4	0	0	4	0	-	-	N	N	
11	Balgy	25-May-15	Rod & Line	Estuary	ST	230	113	0.93		0	0	0	0	0	N	N	old	Y	
12	Balgy	25-May-15	Rod & Line	Estuary	ST	230	98	0.81		0	0	0	0	0	N	N	N	Y	
13	Balgy	25-May-15	Rod & Line	Estuary	ST	230	87	0.72		0	0	0	0	0	N	N	N	Y	
14	Balgy	25-May-15	Rod & Line	Estuary	ST	295	140	0.55		450+	24	0	474+	2	N	Y	N	Y	
15	Balgy	25-May-15	Rod & Line	Estuary	ST	173	38	0.73		0	0	0	0	0	N	N	N	Y	
16	Balgy	25-May-15	Rod & Line	Estuary	ST	290	187	0.77		24	2	0	26	0.5	N	?	Y bird	Y	
17	Balgy	25-May-15	Rod & Line	Estuary	ST	203	64	0.77		0	0	0	0	0	N	N	N	Y	
18	Balgy	25-May-15	Rod & Line	Estuary	ST	195	60	0.81		0	0	0	0	0	N	N	N	Y	
19	Balgy	25-May-15	Rod & Line	Estuary	ST	230	113	0.93		0	0	0	0	0	N	N	old	Y	
20	Balgy	25-May-15	Rod & Line	Estuary	ST	230	98	0.81		0	0	0	0	0	N	N	N	Y	
21	Balgy	25-May-15	Rod & Line	Estuary	ST	230	87	0.72		0	0	0	0	0	N	N	N	Y	
22	Balgy	25-May-15	Rod & Line	Estuary	ST	295	140	0.55		450+	24	0	474+	2	N	Y	N	Y	
23	Balgy	25-May-15	Rod & Line	Estuary	ST	173	38	0.73		0	0	0	0	0	N	N	N	Y	
24	Balgy	25-May-15	Rod & Line	Estuary	ST	290	187	0.77		24	2	0	26	0.5	N	?	Y bird	Y	
25	Balgy	25-May-15	Rod & Line	Estuary	ST	203	64	0.77		0	0	0	0	0	N	N	N	Y	
26	Balgy	25-May-15	Rod & Line	Estuary	ST	195	60	0.81		0	0	0	0	0	N	N	N	Y	
27	Sands River	26-May-15	E-fishing	River	ST smolt	145	-	-		0	0	0	0	0	-	-	-	-	
28	Sands River	26-May-15	E fishing	River	ST smolt	152	-	-		0	0	0	0	0	-	-	-	-	
29	Sands River	26-May-15	E fishing	River	ST smolt	149	-	-		0	0	0	0	0	-	-	-	-	
30	Sands River	26-May-15	E fishing	River	ST smolt	155	-	-		0	0	0	0	0	-	-	-	-	
31	Sands River	26-May-15	E fishing	River	ST smolt	165	-	-		0	0	0	0	0	-	-	-	-	
32	Sands River	26-May-15	E fishing	River	ST smolt	142	-	-		0	0	0	0	0	-	-	-	-	
33	Sands River	26-May-15	E fishing	River	ST smolt	135	-	-		0	0	0	0	0	-	-	-	-	
34	Sands River	26-May-15	E fishing	River	ST smolt	185	-	-		0	0	0	0	0	-	-	-	-	
35	Torridon	15-Jun-15	Sweep Net	est	ST	500	1078	0.86		0	0	0	0	0	-	5	N	N	
36	Flowerdale	18-Jun-15	Sweep Net	est	ST	400	580	0.91		2	14	1	0	2	-	0	N		
37	Flowerdale	18-Jun-15	Sweep Net	est	ST	380	500	0.91		3	16	0	0	0.5	-	0	N		
38	Flowerdale	18-Jun-15	Sweep Net	est	ST	325	320	0.93		3	7	0	0	0.5	-	0	N		
39	Flowerdale	18-Jun-15	Sweep Net	est	ST	170	-	-		0	0	0	0	Bird	-	0	N		
40	Balgy	25-Jun-15	Rod & line	est	ST	185	63	1.00		20	0	0	20	0	Y		N	Y	
41	Balgy	25-Jun-15	Rod & line	est	ST	203	85	1.02		57	17	0	74	0.5	Y		N	Y	

Appendix 1 (continued): Summary data from sea trout sampling around the Loch Torridon area during the period May – October 2015

No.	Location	Date	Method	River / Estuary / Beach	Fish	Length (mm)	Weight (g)	Condition factor	*Caligus* total	*Lepeophtheirus salmonis*				Dorsal fin damage	Lice spots	*Crypto-cotyle* (spots/cm^3)	Predator damage	Photo	Comments
										Copepodid & Chalimus	Pre-adult & adult	Ovigerous female	Total *L. s*						
42	Balgy	25-Jun-15	Rod & line	est	ST	230	130	1.07		40	40	0	80	0	Y		N	Y	quite fat
43	Balgy	25-Jun-15	Rod & line	est	ST	229	115	0.96		40	3	0	43	0.5	Y		N	Y	tatty dorsal fin
44	Balgy	25-Jun-15	Rod & line	est	ST	208	82	0.91		43	0	0	43	0	Y		N	Y	thin
45	Balgy	25-Jun-15	Rod & line	est	ST	275	221	1.06		150	25	0	175	1	Y		N	Y	fat, ragged dorsal fin
46	Cuaig	25-Jun-15	E fishing	River	BT	162	-	-		-	-	-	-	-	-	-	-	-	
47	Cuaig	25-Jun-15	E fishing	River	BT	110	-	-		-	-	-	-	-	-	-	-	-	
48	Cuaig	25-Jun-15	E fishing	River	BT	105	-	-		-	-	-	-	-	-	-	-	-	
49	Cuaig	25-Jun-15	E fishing	River	BT	145	-	-		-	-	-	-	-	-	-	-	-	
50	Cuaig	25-Jun-15	E fishing	River	BT	185	-	-		-	-	-	-	-	-	-	-	-	
51	Cuaig	25-Jun-15	E fishing	River	BT	153	-	-		-	-	-	-	-	-	-	-	-	
52	Cuaig	25-Jun-15	E fishing	River	BT	115	-	-		-	-	-	-	-	-	-	-	-	
53	Cuaig	25-Jun-15	E fishing	River	BT	133	-	-		-	-	-	-	-	-	-	-	-	
54	Cuaig	25-Jun-15	E fishing	River	ST	158	-	-		0	0	0	0	0	-	-	-	-	
55	Cuaig	25-Jun-15	E fishing	River	BT	138	-	-		-	-	-	-	-	-	-	-	-	
56	Cuaig	25-Jun-15	E fishing	River	BT	140	-	-		-	-	-	-	-	-	-	-	-	
57	Cuaig	25-Jun-15	E fishing	River	BT	145	-	-		-	-	-	-	-	-	-	-	-	
58	Cuaig	25-Jun-15	E fishing	River	BT	108	-	-		-	-	-	-	-	-	-	-	-	
59	Cuaig	25-Jun-15	E fishing	River	BT	99	-	-		-	-	-	-	-	-	-	-	-	
60	Cuaig	25-Jun-15	E fishing	River	ST	130	-	-		0	0	0	0	0	-	-	-	-	
61	Cuaig	25-Jun-15	E fishing	River	ST	140	-	-		0	0	0	0	0	-	-	-	-	
62	Inverbain	25-Jun-15	E fishing	Estuary	BT	203	87	1.04		-	-	-	-	-	-	-	-		
63	Inverbain	25-Jun-15	E fishing	Estuary	ST	170	47	0.96		48+	10	0	58+	0.5	-	-	-		
64	Inverbain	25-Jun-15	E fishing	Estuary	ST	175	56	1.04		150	0	0	150	0.5	-	-	-		
65	Inverbain	25-Jun-15	E fishing	Estuary	ST	203	71	0.85		0	0	0	0	0	-	-	Y		
66	Inverbain	25-Jun-15	E fishing	River	BT	100	-	-		-	-	-	-	-	-	-	-		
67	Inverbain	25-Jun-15	E fishing	River	BT	130	-	-		-	-	-	-	-	-	-	-		
68	Sands River	01-Jul-15	E fishing	River	ST	231	140	1.14		62	8	0	70	2	-	1	N	Y	
69	Sands River	01-Jul-15	E fishing	River	ST	191	72	1.03		41	3	0	44	0.5	-	0	N	Y	
70	Sands River	01-Jul-15	E fishing	River	BT	185	66	1.04		0	0	0	0	0	-	0	Y	Y	
71	Sands River	01-Jul-15	E fishing	River	ST	172	49	0.96		19	3	0	22	0	-	0	N	Y	
72	Sands River	01-Jul-15	E fishing	River	ST	166	45	0.98		0	0	0	0	0	-	0	Old	Y	
73	Sands River	01-Jul-15	E fishing	River	Salmon	88	-	-		-	-	-	-	-	-	-	-	-	
74	Sands River	01-Jul-15	E fishing	River	ET	158	37	0.94		0	0	0	0	0	-	0	N	Y	
75	Sands River	01-Jul-15	E fishing	River	ST	165	42	0.93		0	0	0	0	0	-	0	N	Y	
76	Sands River	01-Jul-15	E fishing	River	ST	186	68	1.06		47	5	0	52	1	-	0	N	Y	
77	Sands River	01-Jul-15	E fishing	River	ST	153	38	1.06		109	0	0	109	0	-	0	N	Y	
78	Sands River	01-Jul-15	E fishing	River	S/ET	164	46	1.04		0	0	0	0	0	-	0	N	Y	
79	Sands River	01-Jul-15	E fishing	River	ST	165	40	0.89		0	0	0	0	0	-	0	N	Y	
80	Sands River	01-Jul-15	E fishing	River	ST	170	46	0.94		0	0	0	0	0	-	0	N	Y	
81	Sands River	01-Jul-15	E fishing	River	ET	176	50	0.92		0	0	0	0	0	-	0	N	Y	
82	Sands River	01-Jul-15	E fishing	River	ST	170	50	1.02		0	0	0	0	0	-	0	N	Y	
83	Flowerdale	06-Jul-15	E fishing	River	BT	168	55	1.16		0	0	0	0	0	-	0	N	Y	

Appendix 1 (continued): Summary data from sea trout sampling around the Loch Torridon area during the period May – October 2015

No.	Location	Date	Method	River / Estuary / Beach	Fish	Length (mm)	Weight (g)	Condition factor	*Caligus* total	*Lepeophtheirus salmonis*				Dorsal fin damage	Lice spots	*Crypto-cotyle* (spots/cm^3)	Predator damage	Photo	Comments
										Copepodid & Chalimus	Pre-adult & adult	Ovigerous female	Total *L. s*						
84	Flowerdale	06-Jul-15	E fishing	River	BT	228	121	1.02		0	1	0	1	0	-	1	N	Y	
85	Flowerdale	06-Jul-15	E fishing	River	ST	203	85	1.02		40	11	1	52	0.5	-	4	N	Y	
86	Flowerdale	06-Jul-15	E fishing	River	ST	279	232	1.07		75	5	1	81	2	-	1	Aves	Y	
87	Flowerdale	06-Jul-15	E fishing	River	ST	260	184	1.05		12	3	1	16	1	-	2	?	Y	
88	Flowerdale	06-Jul-15	E fishing	River	ST	200	77	0.96		45	9	0	54	1.5	-	0	N	Y	
89	Flowerdale	06-Jul-15	E fishing	River	ST	162	44	1.03		85	0	0	85	0	-	4	Scratch	Y	
90	Flowerdale	06-Jul-15	E fishing	River	ST	168	46	0.97		75	6	0	81	1	-	4	?	Y	
91	Flowerdale	06-Jul-15	E fishing	River	ST	139	22	0.82		0	2	0	2	0	-	2	N	Y	
92	South Erradale	20-Aug-15	E fishing	River	ST	192				0	0	0	0		-	-	-		
93	South Erradale	20-Aug-15	E fishing	River	ST	211				0	0	0	0		-	-	-		
94	South Erradale	20-Aug-15	E fishing	River	ST	167				0	0	0	0		-	-	-		
95	South Erradale	20-Aug-15	E fishing	River	ST	290	261	1.07		0	0	0	0						
96	South Erradale	20-Aug-15	E fishing	River	ST	350	495	1.15		0	0	0	0						
97	South Erradale	20-Aug-15	E fishing	River	ST	325	386	1.12		0	0	0	0						
98	Flowerdale	01-Sep-15	E fishing	River	ST	255	217	1.31		1	2	0	3	1.5	Y	5	N	Y	
99	Flowerdale	01-Sep-15	E fishing	River	ST	320	345	1.05		5	6	0	11	1	Y	1	N	Y	
100	Flowerdale	01-Sep-15	E fishing	River	Sal	135												Y	
101	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	300	268	0.99	0	1	2	0	3	0	-	20	N	Y	
102	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	242	150	1.06	0	0	2	1	3	0.5		5	N	Y	
103	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	236	140	1.07	0	1	1	2	4	0.5		5	N	Y	
104	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	275	215	1.03	1	25	36	1	62	2		1	N	Y	
105	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	250	152	0.97	0	0	1	0	1	0		30	N	Y	
106	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	365	495	1.02	0	0	1	0	1	1 healing		0	N	Y	
107	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	273	212	1.04	0	0	0	0	0	1 healing		1	N	Y	
108	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	252	157	0.98	0	0	0	0	0	1 healing		2	N	Y	
109	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	305	197	0.69	0	0	1	0	1	1 healing		0	old	Y	
110	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	310	335	1.12	0	4	3	0	7	1 healing		0	Y	Y	Top of caudal fin damaged
111	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	292	260	1.04	0	0	6	0	6	2 healing		1	flank	Y	
112	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	240	150	1.09	0	0	1	0	1	1 healing		4	N	Y	
113	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	432	843	1.05	0	0	6	3	9	1.5 healing		30	N	Y	
114	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	268	185	0.96	0	0	4	2	6	0		0.5	N	Y	
115	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	225	115	1.01	0	0	0	0	0	0		0	N	Y	
116	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	251	160	1.01	0	5	5	0	10	1 healing		0	N	Y	
117	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	250	150	0.96	0	0	4	4	8	1 healing		1	N	Y	
118	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	226	125	1.08	0	0	2	1	3	1 healing		5	N	Y	
119	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	241	148	1.06	0	0	1	1	2	0.5 heal		10	N	Y	
120	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	270	165	0.84	0	0	1	1	2	0.5 heal		2	N	Y	
121	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	240	130	0.94	0	0	1	1	2	1 healing		0	N	Y	
122	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	234	128	1.00	0	0	1	0	1	0		0	N	Y	
123	Flowerdale	01-Oct-15	Sweep Net	Estuary	ST	214	100	1.02	0	0	1	0	1	0		1	bird	Y	

Appendix 2: Summary of fish data from the Feith Ghlas (Torridon River) fyke net

Fish No.	Date	Fish	Length (mm)	Weight (g)	Condition factor	Sex (M/F)	Dorsal fin damage	Scale reading	Sea summers	Comments
1	13-Oct-15	BT	272	205	1.02	M	N	6+ or 7+		
2	13-Oct-15	ST	320	340	1.04	M		2or3.0+sm+ or 2or3.1+	2	
3	13-Oct-15	BT	235	115	0.89	M				
4	13-Oct-15	BT	115							moribund
5	13-Oct-15	BT	220	100	0.94	M				
6	13-Oct-15	BT	225	120	1.05	M				
7	13-Oct-15	BT	192	78	1.10					
8	13-Oct-15	BT	140	28	1.02					
9	14-Oct-15	ST	320	350	1.07					recapture
10	14-Oct-15	BT	270	190	0.97	M		?		
11	20-Oct-15	BT	250	144	0.92	M				
12	20-Oct-15	BT	250	147	0.94	M				
13	20-Oct-15	BT	240	135	0.98	M				
14	20-Oct-15	BT	210	87	0.94	M				
15	20-Oct-15	BT	203	79	0.94	M				
16	20-Oct-15	BT	175	49	0.91	M				
17	20-Oct-15	BT	180	61	1.05	M				
18	20-Oct-15	BT	200	68	0.85	M				
19	21-Oct-15	ST	340	428	1.09	F				unspawned
20	21-Oct-15	ST	260	183	1.04					finnock
21	21-Oct-15	BT	275			M				
22	21-Oct-15	BT	250							
23	21-Oct-15	ST	410			M		?		kype large fish, no scales in packet
24	21-Oct-15	BT	180			M				
25	21-Oct-15	BT	235			M				
26	21-Oct-15	ST	350			M				
27	21-Oct-15	BT	210	79	0.85	M				
28	21-Oct-15	BT	195	66	0.89	M				
29	21-Oct-15	ST	380	559	1.02	M				
30	21-Oct-15	ST	380	575	1.05	M				
31	21-Oct-15	ST	310	323	1.08	M				
32	21-Oct-15	ST	340	369	0.94	M				
33	21-Oct-15	ST	320	339	1.03	M				
34	21-Oct-15	ST	330	365	1.02	M				
35	21-Oct-15	BT	210	89	0.96	M				
36	21-Oct-15	BT	230	104	0.85	M				
37	21-Oct-15	BT	175	49	0.91	M				
38	22-Oct-15	ST	488	984	0.85	M		?3.2+sm+	4	
39	22-Oct-15	ST	390	636	1.07	M				
40	22-Oct-15	ST?	330	358	1.00	M				
41	22-Oct-15	ST	340	397	1.01	F		?3.1+	2	
42	22-Oct-15	ST	320	317	0.97	M				
43	22-Oct-15	BT	270	208	1.06	M				
44	22-Oct-15	BT	230	106	0.87	M				
45	22-Oct-15	BT	225	106	0.93	M				
46	22-Oct-15	BT	265	178	0.96	M				
47	22-Oct-15	BT	243	133	0.93	M				
48	23-Oct-15	ST	410	595	0.86	M	N			
49	23-Oct-15	ST	345	357	0.87	M	N	?3.1+sm+	3	
50	23-Oct-15	ST	330	346	0.96	M	N			
51	23-Oct-15	ST	320	286	0.87	M				
52	23-Oct-15	BT	215	88	0.89	M				
53	23-Oct-15	ST	260	128	0.73	imm			1	finnock
54	23-Oct-15	BT	175	54	1.01					
55	23-Oct-15	BT	200	75	0.94	M				
56	23-Oct-15	BT	130	28	1.27					
57	23-Oct-15	ST	435	666	0.81	F				
58	23-Oct-15	ST	340	357	0.91	M				
59	23-Oct-15	ST	320	256	0.78	M				
60	23-Oct-15	BT	215	89	0.90	M				

Appendix 2 (cont.): Summary of fish data from the Feith Ghlas (Torridon River) fyke net

Fish No.	Date	Fish	Length (mm)	Weight (g)	Condition factor	Sex (M/F)	Dorsal fin damage	Scale reading	Sea summers	Comments
61	23-Oct-15	BT	190	63	0.92	M				
62	23-Oct-15	BT	205	79	0.92	M				
63	23-Oct-15	BT	180	49	0.84	M				
64	23-Oct-15	BT	170	43	0.88	M				
65	23-Oct-15	BT	160	42	1.03	M				
66	23-Oct-15	BT	140	32	1.17					
67	23-Oct-15	BT	195	72	0.97	M				
68	23-Oct-15	ST	475	939	0.88	M	N			clean fish - no damage tough skin
69	24-Oct-15	ST	320	276	0.84	F				unspawned
70	24-Oct-15	BT	210	86	0.93	M				
71	24-Oct-15	BT	180	63	1.08	M				
72	27-Oct-15	ST	330	364	1.01	M	1	?3(or4).1+	2	Tail damage from predator
73	27-Oct-15	ST	380	540	0.98	M	0.5	3.1+sm+	3	
74	27-Oct-15	ST	330	322	0.90	M	0.5	2.1+	2	
75	27-Oct-15	ST	325	282	0.82	F	0.5	3.1+	2	kelt
76	27-Oct-15	ST	245	142	0.97	imm	0.5	3.+	1	
77	27-Oct-15	BT	220	110	1.03					interesting markings
78	27-Oct-15	BT	200			M				
79	27-Oct-15	BT	140							
80	27-Oct-15	BT	142							
81	27-Oct-15	BT	115							
82	27-Oct-15	ST	405	630	0.95	M	0	?3.1+sm+	3	mouth damage (?hook)
83	27-Oct-15	ST	325	340	0.99	F	0.2	3.1+	2	unspawned
84	27-Oct-15	BT	180							
85	27-Oct-15	BT	185			M		3+		
86	27-Oct-15	BT	95							
87	27-Oct-15	BT	115							
88	27-Oct-15	BT	132							
89	27-Oct-15	BT	113							
90	27-Oct-15	BT	115							
91	27-Oct-15	BT	160			M				
92	28-Oct-15	ST	365	440	0.90	M	1	?3.1+	2	
93	28-Oct-15	ST	430	652	0.82	F	0	?3.1+2sm+	4	kelt
94	28-Oct-15	ST	350	346	0.81	F	0.5	3.1+	2	kelt; dorsal fin slightly recovered
95	28-Oct-15	salmon	100			M				precocious parr
96	28-Oct-15	BT	128			M				
97	28-Oct-15	BT	146			M				
98	28-Oct-15	BT	125							
99	28-Oct-15	BT	125							
100	28-Oct-15	BT	125							
101	28-Oct-15	BT	143			M				
102	28-Oct-15	BT	142							
103	28-Oct-15	BT	152			M				
104	28-Oct-15	BT	120							
105	28-Oct-15	BT	148							
106	28-Oct-15	BT	130							
107	28-Oct-15	BT	118			M				
108	28-Oct-15	BT	215	111	1.12			3+		photos with larger males
109	29-Oct-15	ST	312	328	1.08	F	0.5	3.1+	2	semi-spent
110	29-Oct-15	ST	370	382	0.75	M	3	3.+sm+	2	?spawned as large finnock
111	29-Oct-15	ST	320	309	0.94	M	0.2	?3(or2).1+	2	
112	29-Oct-15	BT	270	180	0.91	M		5+		
113	29-Oct-15	BT	195	98	1.32	M				
114	29-Oct-15	BT	170	48	0.98	M				
115	29-Oct-15	BT	210	106	1.14	M				
116	29-Oct-15	BT	225	98	0.86	M				
117	29-Oct-15	BT	190	65	0.95	M	1			fin damage
118	29-Oct-15	BT	180	58	0.99	M				
119	29-Oct-15	BT	170	51	1.04	M				caudal fin damage
120	29-Oct-15	BT	145	35	1.15	M				

Appendix 2 (cont.): Summary of fish data from the Feith Ghlas (Torridon River) fyke net

Fish No.	Date	Fish	Length (mm)	Weight (g)	Condition factor	Sex (M/F)	Dorsal fin damage	Scale reading	Sea summers	Comments
121	29-Oct-15	BT	145	31	1.02	M				
122	29-Oct-15	BT	140	28	1.02	M	0.1			
123	29-Oct-15	BT	115	17	1.12	M				
124	29-Oct-15	BT	125	19	0.97	imm				
125	29-Oct-15	BT	95	8	0.93	imm				
126	29-Oct-15	ST	520		0.00	F	1	3.2+3SM+ or 3.1+4SM+	6	large female fish, spent
127	29-Oct-15	ST	250			M	0	3.+	1	possibly caught before
128	29-Oct-15	BT	260	196	1.12	M		5+		a brown trout from scale reading
129	29-Oct-15	BT	220	116	1.09		1	emty packet		dorsal damage
130	29-Oct-15	BT	180	71	1.22					possible recapture
131	29-Oct-15	BT	155							
132	29-Oct-15	BT	220							
133	30-Oct-15	BT?	255	163	0.98	M				
134	30-Oct-15	ST	345	366	0.89	F		?3.1+	2	semi-spent
135	30-Oct-15	ST	410	618	0.90	M		3.1+sm+	3	
136	30-Oct-15	ST	290	229	0.94	M				
137	30-Oct-15	BT	305	280	0.99	M				
138	30-Oct-15	ST	335	322	0.86	?				
139	30-Oct-15	BT	235	128	0.99	M				
140	30-Oct-15	ST	330	345	0.96	M				
141	03-Nov-15	ST	400	555	0.87	M	0.2	?.1+sm+	3	
142	03-Nov-15	ST	410	589	0.85	M	0	3.1+sm+	3	
143	03-Nov-15	BT	352	405	0.93	M		10+		warrior fish; white top to dorsal fin
144	03-Nov-15	ST	370	472	0.93	M	0.1	?.1+	2	[few spots]
145	03-Nov-15	BT	282	231	1.03	M		6+		
146	03-Nov-15	BT	120			M				
147	03-Nov-15	BT	116			M		2+		
148	03-Nov-15	BT	191			M				
149	03-Nov-15	BT	202							
150	03-Nov-15	BT	140			M				
151	03-Nov-15	BT	150			M		3+		
152	03-Nov-15	BT	196			M				
153	04-Nov-15	ST	400	599	0.94	M	1	?2.1+sm+	3	nose damage
154	04-Nov-15	ST	315	276	0.88	M	1			dorsal damage
155	04-Nov-15	ST	345	379	0.92	M	1.1	3.1+	2	bad dorsal damage; recapture
156	04-Nov-15	ST	330	303	0.84	M	0.5			nose damage
157	04-Nov-15	ST	300	255	0.94	M	0.3			dorsal damage
158	04-Nov-15	BT	125			imm				
159	04-Nov-15	BT	135			imm				
160	04-Nov-15	BT	115			imm				
161	04-Nov-15	BT	125			imm				
162	04-Nov-15	BT	123			imm				
163	05-Nov-15	ST	345	391	0.95	M	2	4(or3).1+sm+	3	possible recapture
164	05-Nov-15	BT	215	99	1.00	M				
165	05-Nov-15	BT	165	43	0.96	M				
166	05-Nov-15	BT	126	21	1.05	imm				
167	05-Nov-15	BT	64	3	1.14	imm				
168	06-Nov-15	BT	230	111	0.91	?M				spent
169	06-Nov-15	BT	282	222	0.99		0.1			recapture
170	07-Nov-15	ST	430	561	0.71	F	0.2	?.1+3sm+	5	no tag, still has eggs
171	07-Nov-15	ST	340	311	0.79	F	0.2	3.1+	2	no tag
172	07-Nov-15	ST	335	390	1.04	F	0.1	3.1+	2	no tag dorsal damage
173	07-Nov-15	ST	335	341	0.91	F	0.5	?3.1+	2	no tag
174	07-Nov-15	ST	345	308	0.75	M	1.5			no tag, milt photo dorsal
175	07-Nov-15	BT	150			M				
176	07-Nov-15	BT	115							
177	07-Nov-15	BT	145			M				
178	07-Nov-15	BT	160			M				
179	07-Nov-15	BT	135			M				
180	07-Nov-15	ST	380	498	0.91	F	1.5	3.2+sm+	3	no tag; eggs

Appendix 2 (cont.): Summary of fish data from the Feith Ghlas (Torridon River) fyke net

Fish No.	Date	Fish	Length (mm)	Weight (g)	Condition factor	Sex (M/F)	Dorsal fin damage	Scale reading	Sea summers	Comments
181	07-Nov-15	BT	300	262	0.97	M	0.5			no tag, recapture
182	07-Nov-15	ST	365	431	0.89	M	0.5	3(or4).1+	2	no tag
183	07-Nov-15	ST	440	674	0.79	F	2	6.1+sm+ or 4.3+sm+	5	no tag, spent
184	07-Nov-15	ST	390	543	0.92	F	0.5	3.2+sm+	4	no tag, spent
185	07-Nov-15	ST	355	369	0.82	F	1	3.1+	2	no tag, spent, dorsal damage
186	07-Nov-15	ST	415	688	0.96	F	0.5	?3(or4).1+sm+	3	no tag, gill & jaw damage, eggs
187	07-Nov-15	ST	380	519	0.95	F	0.5	?.1+sm+	3	no tag, eggs
188	07-Nov-15	ST	310	256	0.86	F	0.1	?.1+	2	no tag, kelt, tail damage
189	07-Nov-15	ST	325	333	0.97	M	1.5			no tag tail and fin damage
190	07-Nov-15	ST	335	345	0.92	F	0			no tag, spent
191	07-Nov-15	ST	305	257	0.91	F	1	?4.1+	2	no tag, spent
192	07-Nov-15	ST	320	298	0.91	F	2	?2(or3).1+	2	no tag, spent
193	07-Nov-15	ST	300	239	0.89	F	1	?.1+	2	no tag, spent
194	07-Nov-15	ST	310	276	0.93	M	0.5	?2.1+	2	no tag pectoral fin & anal fin damage
195	07-Nov-15	ST	295	136	0.53	M				no tag pectoral fin & anal fin damage
196	07-Nov-15	BT	200	101	1.26	M	0.3			
197	09-Nov-15	BT	118			imm				see appendix 3
198	09-Nov-15	BT	133			M				see appendix 3
199	09-Nov-15	BT	196			M				see appendix 3
200	09-Nov-15	BT	104			imm				see appendix 3
201	09-Nov-15	BT	157			imm				see appendix 3
202	09-Nov-15	BT	122			imm				see appendix 3
203	09-Nov-15	BT	125			imm				see appendix 3
204	09-Nov-15	BT	144			imm				see appendix 3
205	09-Nov-15	BT	109			imm				see appendix 3
206	09-Nov-15	BT	123			imm				see appendix 3
207	09-Nov-15	BT	112			imm				see appendix 3
208	09-Nov-15	BT	116			imm				see appendix 3
209	09-Nov-15	BT	119			imm				see appendix 3
210	09-Nov-15	BT	92			imm				see appendix 3
211	09-Nov-15	BT	181			M				see appendix 3

Appendix 3: Juvenile trout feed on sea trout eggs

The heavy rainfall on 8th November was too much for the Torridon fyke net leader which pulled itself free from its anchor point on the far bank. The trap lifted and rolled itself up onto the bank (it has now been removed).

There were 15 small trout in the net, all dead; fortunately there were no larger ones. These are the only fish that were killed as part of the project. So that evening I decided to open them up to find out more about them.

There were two questions I was interested in finding out about:

Q1. What % of the sample of trout was mature (in spawning condition)?

Q2. Had any of them been feeding on trout eggs?

Here's a table with the results (sorted from shortest to longest fish in descending order):

No	Length (mm)	Sex		Stomach % full	Stomach contents		Comments
					trout eggs	other food	
14	92	Imm		25%		Y	
4	104	Imm		100% (+!)	6	Y	
9	109	Imm		empty		N	
11	112	Imm		25%		Y	
12	116	Imm		25%		Y	
1	118	Imm		empty		N	
13	119	Imm		50%	2	N	
6	122	Imm		25%	1	Y	
10	123	Imm		50%		Y	
7	125	Imm		25%		Y	
2	133	Male	milt	25%	1	Y	
8	144	Imm		25%	1	Y	
5	157	Imm		25%		Y	includes caddis
15	181	Male	milt	empty		N	
3	196	Male	milt	empty		N	

So, in answer to:

Q1. Only three of the trout were mature males: the two largest ones, both of which had predator damage associated with bird (or possibly a larger trout?) and a smaller trout of 133mm. The other fish were immature trout with no development of gonads.

Q2. Five of the trout had eaten eggs. A trout of 104mm had eaten at least six eggs. Some of the eggs had burst (so were recognised only by their shells, others were intact). An interesting finding was that one of the mature male trout (running milt) had also eaten an egg.

In conclusion, I'd suggest that some of the trout were heading upstream to spawn; and others were heading upstream following the run of mature sea trout over the weekend to feed on trout eggs. For a small fish, trout eggs represent a very large meal. For the 104mm trout, the 6+ eggs may have represented the largest meal it had ever eaten!

So, more questions: a large meal of eggs would presumably improve prospects of over-winter survival? Would that have any effect on whether or not that wee fish would become a sea trout itself one day? Would sea trout smolt production increase if there were more trout eggs available for smaller trout to eat?

(below) The 15 trout, in order (top to bottom), 1 to 13, trout 14 is bottom left; trout 15 is bottom right.

(below) The dissected trout in which trout eggs were found in their stomachs. They are in the following order (top to bottom): fish 13, fish 8, fish 6, fish 4 and fish 2.

Thank you to Les Bates, Colin Blyth and Charlie Hill for lots of enthusiastic help with running the Torridon fyke net project, to Jim Raffell (Marine Scotland) for discussion and loan of PIT tag recorder, to the river and fishery proprietors for permissions to operate the trap, and to the Wester Ross Area Salmon Fishery Board for supporting the project!