Status of juvenile Wild Atlantic Salmon in Wester Ross, Northwest Scotland

Report following 2021 field season

Abhainn Gleann na Muice (Gruinard River headwaters), August 2021

Peter Cunningham and Colin Simpson,

Wester Ross Fisheries Trust, February 2022

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Summary information for major salmon rivers in area covered by the Wester Ross Area Salmon Fishery Board, as at December 2022

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River system	Estimated potential smolt output[1]	Conser-vation grade 2022[2]	Genetic status 2021[3]	River system	Sub-catchment	Juvenile fish survey - number of electro-fishing sites surveyed by WRFT in 2021					Comments & Actions needed
						NEPS	WRASFB	Contract	Other	Status[4]	
Kanaird	10500	2	mod	**Kanaird**	mainstem			4		mod	**Langwell falls!**
				Kanaird	Runie		3			good?	
Ullapool	9700	2	good	**Ullapool**	below loch						
				Ullapool	Rhidorroch	2				mod	**Catchment sediment management**
Lael	1500			**Lael**			1				
Broom	6900	1		**Broom**			4			good	
Dundonnell	3100	3	mod	**Dundonnell**							2020 survey fry high; 2019 survey fry low
Gruinard	19700	1	good	**Gruinard**	mainstem	2	2		(2 SEPA sites)	good?	Impoverished (not enough food . . .)
				Gruinard	ab've L n' Sealga	1	1			mod	**Riparian habitat!** Impoversished
Little Gruinard	14600	3		**Little Gruinard**	mainstem	1	3			good?	Impoverished (not enough food . . .)
(SAC)				Little Gruinard	above Fionn L.		6			good?	
Allt Beith	800			**Allt Beith**							2020 survey good parr densities
Tournaig	600			**Tournaig**				5		poor	Low water
Ewe	49800	1		**Ewe**	mainstem						Fish eating birds . . .
				Ewe	Kernsary	1	1			good	
			good	Ewe	L. Maree burns	2	2			mod	
			good	Ewe	Kinlochewe		1			good?	**Kinlochewe septic tank?**
				Ewe	Bruachaig upper		3	4		poor	**Bruachaig falls!**
				Ewe	Bruachaig lower	2				good?	
			mod	Ewe	A' Ghairbhe						Spawning activity, Nov 2021
				Ewe	Coulin		5			good?	Impoverished (not enough food . . .)
Sguod	500			**Sguod**							
Sand	500			**Sand**					2	poor	Sea lice!
Kerry	4000	3	good	**Kerry**		1	3			good?	**Sea lice!**
Badachro	3600	3		**Badachro**			3			good?	**Sea lice!**
Torridon	8300	3	good	**Torridon**			6			mod	**Sea lice!**
Balgy	5400	3	poor	**Balgy**							
Cuaig	1600			**Cuaig**							
Applecross	4200	3		**Applecross**		1	2			poor	**Sea lice!** Catchment sediment management
(Carron)	(25000)			**(Carron)**		2	2	5		?	Heavily stocked obscuring wild population

Sources / notes:

1. Potential smolt output estimates from habitat based calcualtions in WRFT Fisheries Management Plans etc.
2. Scottish Government Conservation grading https://www.gov.scot/publications/salmon-fishing-proposed-river-gradings-for-2022-season/
3. From Gilby et al 2021 National assessment of influence of farmed salmon escapes to genetic integrity (based on samples collected by WRFT in 2018)
4. Juvenile fish status based on WRFT e-fishing survey 2021 results and other considerations (e.g. growth rates)

Summary

This report provides a summary of the results of a survey of juvenile salmon in the Wester Ross area in July – September 2021. Over 80 sites were surveyed in 15 rivers using specially designed electro-fishing equipment. Sites were fished under contract for the Scottish Government's National Electro-fishing Programme of Scotland [NEPS], for hydropower scheme monitoring contracts or supported by the Wester Ross Area Salmon Fishery Board [WRASFB]. Data from the SEPA fish survey team for two sites in the Gruinard River was kindly provided. Together with information from a study of genetic introgression of wild salmon populations associated with spawning of escaped farm salmon in the wild (Gilby *et al* 2021), some conclusions can be reached regarding the likely status of wild salmon populations within many of the rivers of the area.

Wester Ross retains relatively strong wild juvenile salmon populations in the major rivers flowing into the Wester Ross Marine Protected Area including the rivers Kanaird (Canaird), Ullapool, Broom, Gruinard, Little Gruinard and Ewe. The rivers Kerry and Badachro also retain strong juvenile salmon populations in terms of juvenile fish densities. In contrast, the status of wild juvenile salmon populations in the rivers to the south of Loch Gairloch (rivers Torridon, Applecross) is fragile, or uncertain due to artificial stocking (River Carron). The River Balgy was not surveyed in 2021.

Our results generally, but not entirely, concur with the Scottish Government's proposed conservation gradings (based on reported rod catches) of salmon rivers for 2022 (see: Summary information on preceding page). They support the contention that wild salmon populations in the south of the area associated with post-smolt migration routes that pass through sea areas exposed to high cumulative emissions of larval sea lice from large, circular open mesh cage salmon farms in the east of Skye and Loch Torridon are at greatest threat of being damaged further or lost in terms of any river-specific genetic adaptations.

The production of wild salmon smolts from some rivers could be higher with greater attention to the protection and restoration of riparian habitat (e.g. alder and other riverside trees), catchment area vegetation (e.g. peatlands) and food availability (e.g. addressing phosphorus deficits at whole catchment scale).

Following several riparian woodland projects around the Wester Ross area in earlier years, since 2020, local landowners have undertaken remedial actions to restore or enhance riparian woodlands along parts of the River Kanaird system, in the River Ewe headwaters, and in the Rhidorroch River (Ullapool River) headwaters where further work is planned for 2022.

Riparian habitat along the Abhainn Gleann na Muice (Gruinard River headwaters) is in urgent need of protection and recovery. The upper Bruachaig River (River Ewe headwaters) represents the largest area of freshwater habitat within the Wester Ross area where juvenile salmon production could be much higher than it has been in recent years. Other rivers where actions are needed to benefit wild salmon include parts of the rivers Kanaird, Little Gruinard, Torridon and Applecross.

Thank you to all funders and many helpers and estates for their support in 2021.

1. Introduction

The Atlantic Salmon (*Salmo salar*) has been in decline across most of its range in recent years. In 2019 NASCO described the Atlantic salmon as a species in crisis. Wild salmon are subject to many pressures that affect survival; these include weather-related events in freshwater and changes in the distribution of food at sea including those associated with climate change.

In Ireland, Norway and in much of the west of Scotland, pressures associated with open cage salmon farming have been a major concern. The threat to populations of wild salmon from open cage salmon farming around Wester Ross and Skye was highlighted in the SWRFT Review September 2020. The most recent review of the Status of wild salmon in Norway 2021 also states that *'Escaped farm salmon, salmon lice and infections related to salmon farming are the greatest anthropogenic threats to Norwegian wild salmon'.*

Wester Ross retains some of the most important wild Atlantic salmon river systems in the northwest mainland of Scotland in terms of the overall size of the accessible 'wetted area' and the diversity of freshwater habitats for salmon. These include the Little Gruinard River (including the Fionn Loch), a Special Area of Conservation [SAC] for Atlantic salmon, formerly protected by European Union legislation; the big Gruinard River system (including Loch na Sealga); and the River Ewe system (including Loch Maree).

As wild salmon numbers fall elsewhere within their range, the need to monitor and to protect wild salmon in Wester Ross has become even greater especially given further recent increases in farm salmon production together with the associated increases in cumulative emissions of parasitic sea lice into surrounding waters.

Since the year 2000, juvenile salmon ('fry' and 'parr') have been found in over 20 river or stream systems within the Wester Ross Area Salmon Fishery Board [WRASFB] area. Of these, twelve of the larger rivers have supported a rod fishery (rivers Kanaird (Canaird), Ullapool, Broom, Dundonnell, Gruinard, Little Gruinard, Ewe, Kerry, Badachro, Torridon, Balgy, Applecross). Further background information can be found in the Wester Ross Fisheries Management Plan 2009.

This report provides a river by river assessment of the status of wild salmon for the rivers of the Wester Ross area, as at the end of 2021, using the best available information.

Results from the WRFT electrofishing survey during the summer and autumn of 2021 are summarised together with information from other sources, including the Scottish Government's proposed conservation gradings for rivers within the Wester Ross for 2022 (these are based on reported rod catches of adult salmon in earlier years), and reference to a recently published study of the genetic status of wild salmon in Scotland (Gilby *et al*, 2021) which for wild salmon populations in Wester Ross rivers was largely based on samples of genetic material collected by the fisheries trust's field team for the Scottish Government's Marine Scotland Science in 2018 and 2019.

During preparation of this report, the Scottish Wild Salmon Strategy was published. Section 3 of this report discusses some issues relating to the recovery and protection of wild Atlantic salmon populations in Wester Ross within the context of this strategy.

2. Juvenile fish survey

funded by the Scottish Government via Marine Scotland Science, WRASFB, WRFT members and donors, and hydropower businesses.

2.1 Introduction

Electro-fishing using purpose designed equipment provides the means for monitoring the distribution and relative abundance of juvenile fish. The equipment and protocols used are designed so that all the fish that are captured during a survey can be returned unharmed to where they came from following a period of recovery. Using this method, since 2020, juvenile salmon have been recorded within 20 river or small stream systems within the Wester Ross Area Salmon Fishery Board area (rivers Kanaird to Applecross).

In 2018, the collaborative National Electro-fishing Programme of Scotland **[NEPS]** was launched by the Scottish Government' Marine Scotland Science [MSS] to provide data on the occurrence of juvenile salmon from which trends in the abundance of juvenile salmon can be assessed at the regional level. NEPS electro-fishing survey sites were randomly selected by MSS and widely spread across Scotland. On their own, a survey of these sites is not adequate to provide an assessment of the status of wild salmon populations at individual river or individual salmon population levels. However, NEPS has been a useful step forward by the Scottish Government in support of wild salmon.

The main aim of the WRFT juvenile fish survey in 2021 was to visit as many of the salmon rivers within the Wester Ross area as possible to assess the distribution and abundance of juvenile salmon. Juvenile trout, eels and other fish species were also recorded; however site selection was focussed on learning about salmon. To complement the NEPS survey and to maintain our own information base for local conservation and fisheries management purposes, additional sites were surveyed in many rivers. This was possible only through the support of river proprietors, estate staff and the Wester Ross Area Salmon Fishery Board. Additional surveys were carried out to fulfil monitoring contracts for hydropower companies or for educational purposes.

Surveys were carried out by the WRFT electro-fishing team of Peter Cunningham and Colin Simpson (both SFCC qualified) in July, August and September 2021. Peter and Colin have worked together for over 10 years. Water levels were low throughout most of this period, and progress was good. By the end of the field season (July to end September) over 80 sites in 15 different river or coastal stream systems had been surveyed.

Further background information and summaries of the results of juvenile fish surveys in earlier years can be found in the SWRFT Review September 2020 and other reports on the WRFT website.

Colin by the Badachro River, 19th July 2021, with buckets ready to process fish.

2.2 Results

Overview

Some of the main findings were as follows:

- Juvenile wild salmon of wild origin remain widely distributed within most of the major salmon rivers of the Wester Ross area.
- High densities of juvenile salmon (fry and parr) were recorded at some sites within the rivers Kanaird, Broom, Gruinard, Little Gruinard, Ewe, Kerry and Badachro.
- However, salmon fry were missing from some sites in the Applecross River and Torridon River, and above complex waterfalls in the upper River Kanaird and Bruachaig River (Ewe system).
- Unusually large salmon parr (>150mm in length) were found in the upper Bruachaig River and River Kanaird where they were present at very low densities; and at the tops of the Inveran and Little Gruinard rivers just below loch outflows, associated with unusually good feeding opportunities.
- The highest biomass of salmon fry per unit area was recorded in the Kinlochewe River, 500m downstream from the Kinlochewe sewage works outflow.
- Relatively high densities of very small salmon fry were found at sites in the big Gruinard River, Little Gruinard River and Coulin River (Ewe headwaters), as in previous years. There is very little food for the wee fish at these locations especially during the latter part of the summer.

River by river summaries

Results in terms of fish numbers at respective sites are expressed as numbers of fish per unit fishing time (Catch per Unit Effort [CPUE]) or numbers of fish per unit area or minimum density estimates [numbers of fish per 100m^2). Figure 1 shows the relationship between the area fished and the time fished for sites surveyed by the WRFT electrofishing team in 2021. Conveniently, the team fished at a fairly consistent rate of close to 10 m^2 per minute. Thus, for example, a catch rate of 1 fish per minute is usually close to a minimum density of 10 fish per 100m^2. Three-run (fully quantitative) electro-fishing surveys have indicated that actual fish densities are typically around 50% - 100% higher than the minimum fish densities recorded in the one-run surveys reported here.

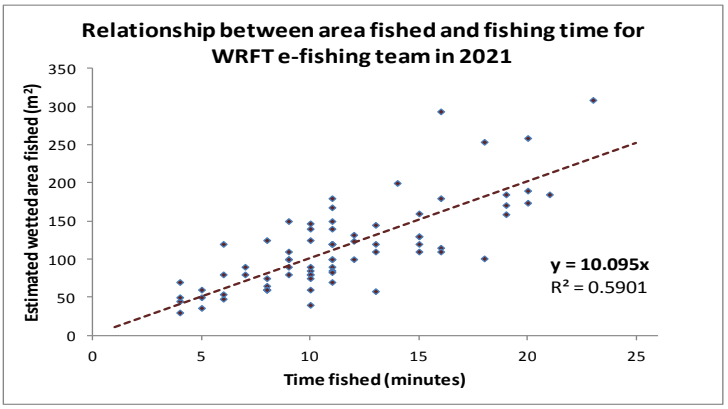


Figure 1 Relationship between the area fished and the fishing time for electro-fishing sites surveyed by the WRFT electro-fishing team in 2021.

The distribution and relative abundance of salmon fry and salmon parr is shown in Figure 2 (a) and Figure 2 (b). Note that these maps present relative abundance as numbers of fish caught per minute (so catch per unit effort, CPUE). Note that the area of each survey site was also estimated to enable minimum estimates of fish density (numbers of fish per square metre).

The following river by river summaries are in order from north to south through the area.

Figure 2a Recorded distribution and relative abundance of salmon fry at sites surveyed within the Wester Ross area in 2021 (and 2020 for Dundonnell River and Docherty Burn). For NEPS sites on the mainland, only the fish in the first run are included.

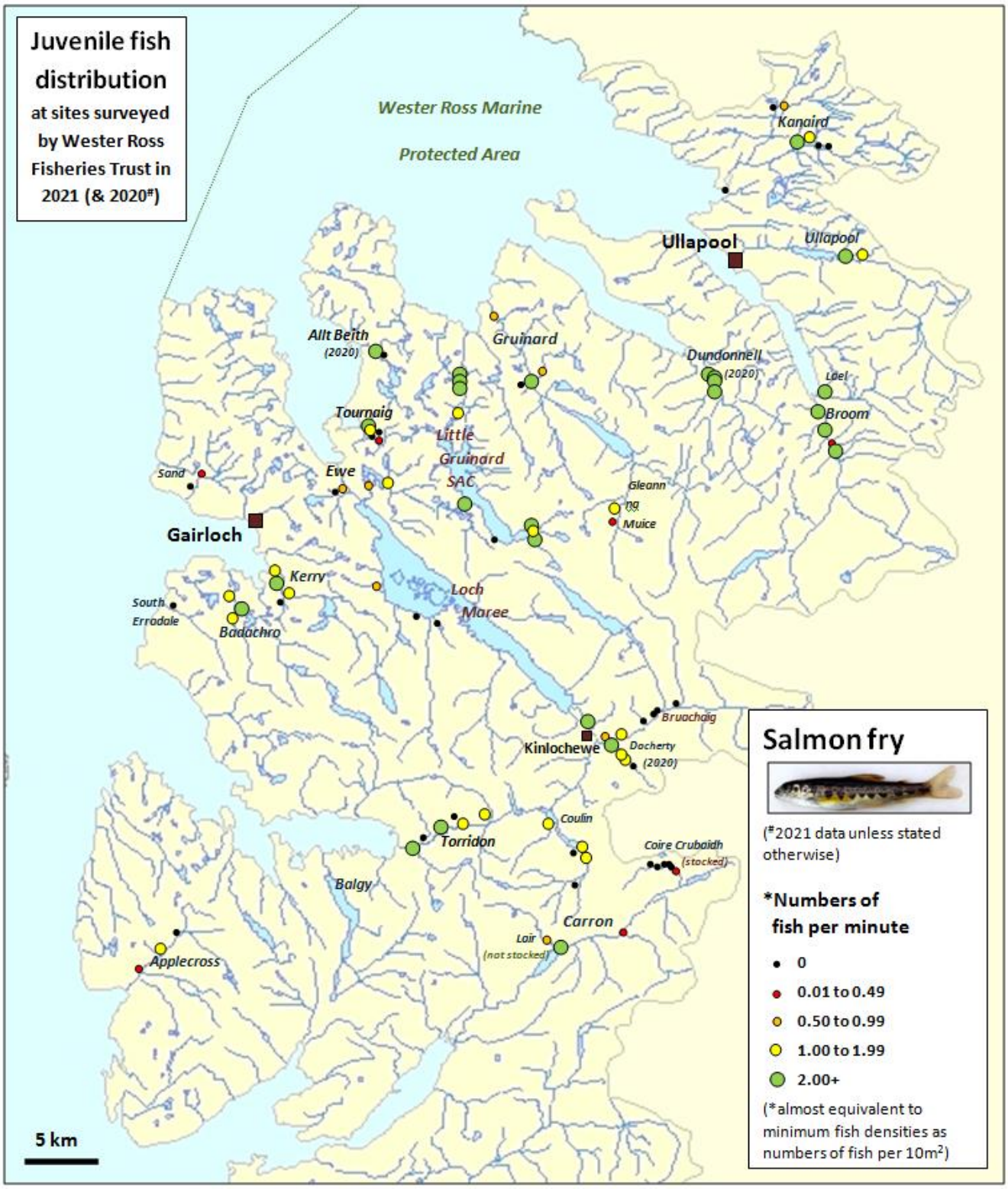
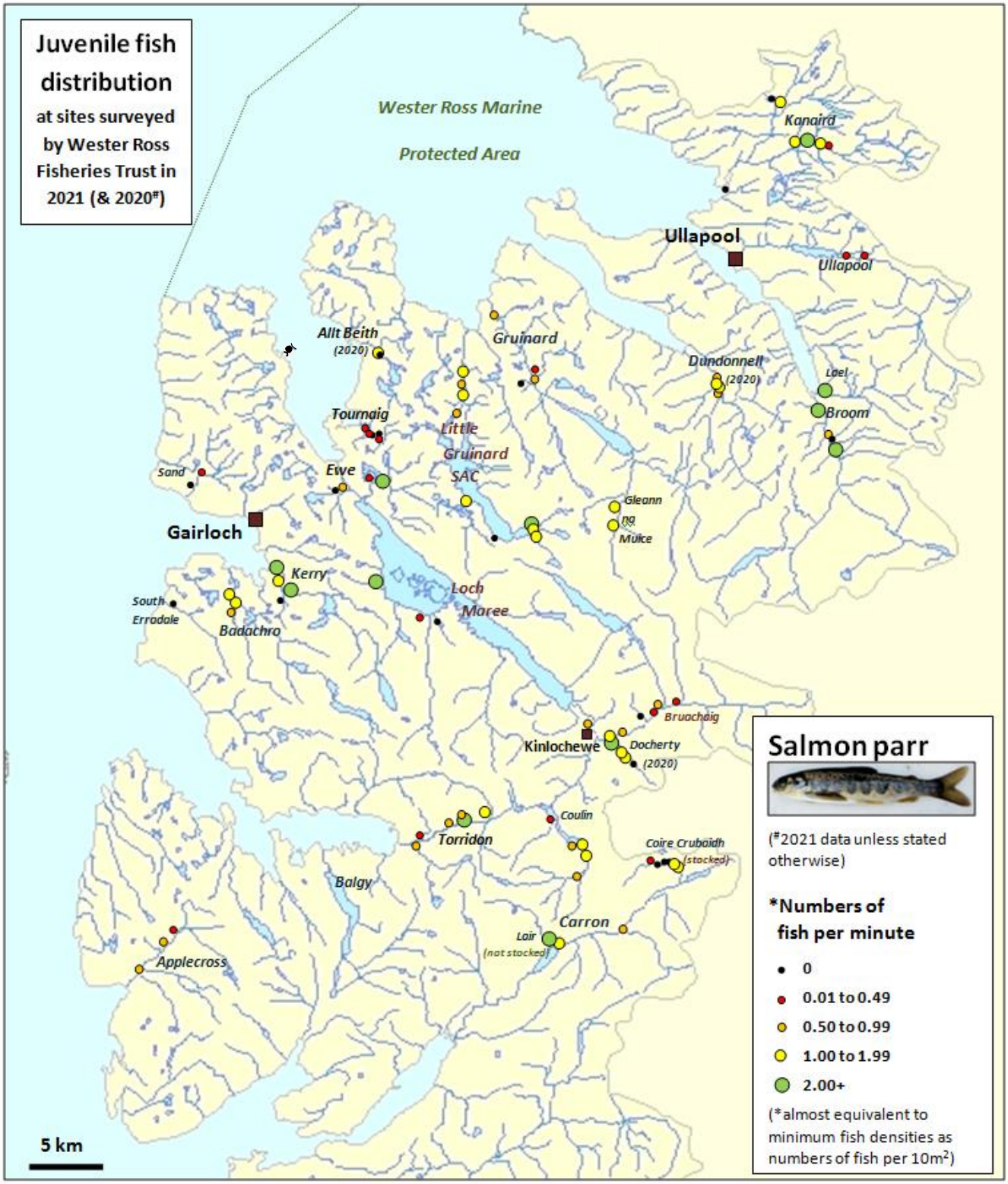


Figure 2b Recorded distribution and relative abundance of salmon parr at sites surveyed within the Wester Ross area in 2021. For NEPS sites on the mainland, only the fish in the first run are included.



River Kanaird (Canaird)

Sites were surveyed in both the upper River Kanaird and the upper River Runie.

Four sites were surveyed in the upper River Kanaird on 1st September 2021; two sites above and two sites below the Langwell falls as part of a contract for DHG Hydro in fulfillment of the CAR license for the Langwell Hydro scheme. Large salmon parr (age 1+) but no salmon fry were found above the Langwell falls. These results indicate that at least one female salmon ascended the Langwell falls and spawned above them in 2019, for the first time since 2015. However there was no evidence of salmon spawning above the Langwell falls in 2020.

In contrast, high densities of salmon parr and salmon fry were recorded at the two sites below the Langwell falls respectively, as in previous years. At both these lower sites, juvenile fish occurrence was considered to be close to the carrying capacity of respective areas of habitat with fish growth (and sizes) corresponding to density dependent feeding opportunities at sites below the falls.

The Langwell falls were modified historically so are an unnatural feature (Figure 3). Further minor modifications would enable adult salmon to more easily access a wetted area of 10,000m^2 – 15,000 m^2 of mostly good salmon parr habitat capable of producing >1000 wild salmon smolts each year.

Figure 3 Langwell falls, River Kanaird on 1st September 2021, suggesting minor modifications required to ease passage to enable adult salmon to more easily access a large area of good nursery habitat above the falls.

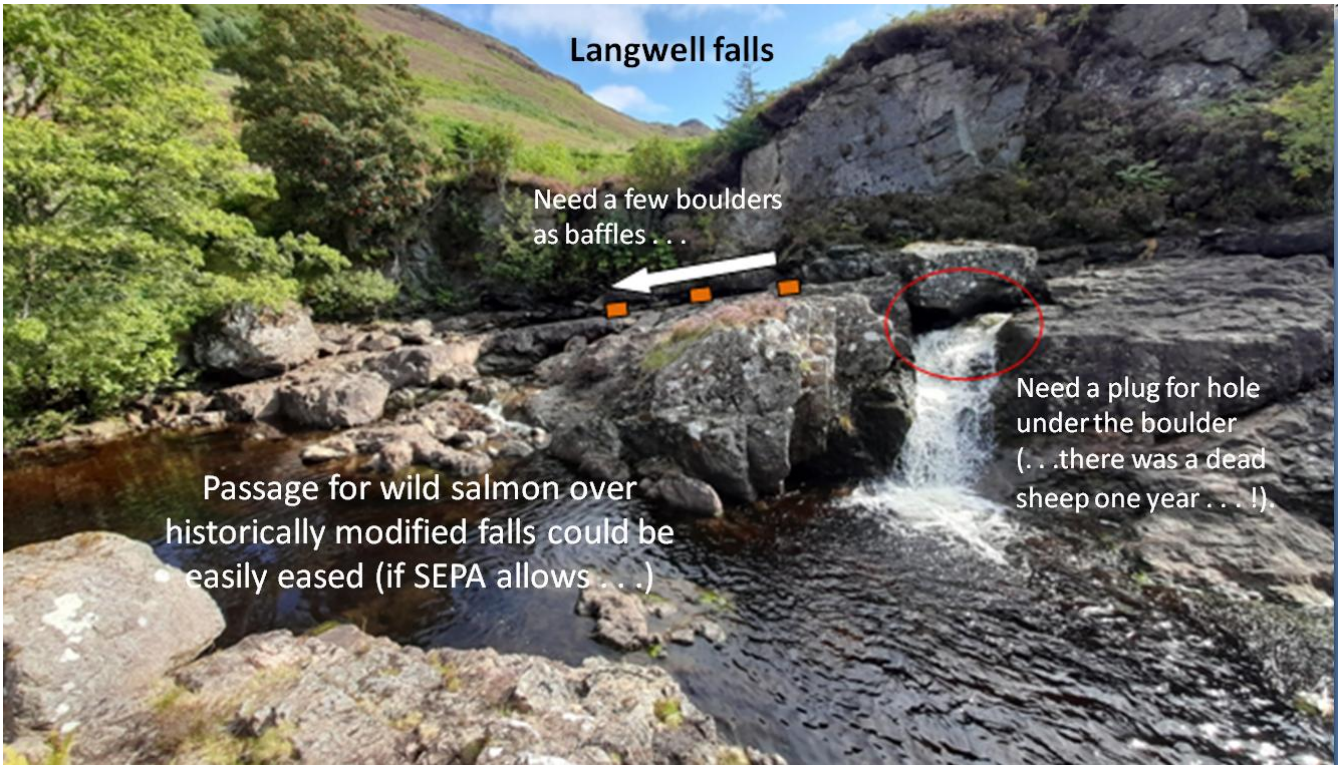


Figure 4 River Kanaird (Canaird), 1st September 2021. All fish in this and other pictures in this report were photographed under sedation prior to recovery and their return to the river. The survey was supported by DHG hydro.

Kan 1 (top site by Glen Cottage, above Langwell falls) A ?trout x salmon hybrid (top) and two juvenile trout.


Kan 2 (500m, upstream from Langwell falls) Large salmon were parr recorded, but no salmon fry. Note trees inside riparian woodland regeneration scheme; planted around 20 years ago, these have mostly grown well.


Kan 3 (150m downstream from Langwell falls) High density of salmon parr recorded.


Kan 4 (channel section below Langwell, between fields) High density of salmon fry.


On the 17th August 2021 a site was surveyed in a tributary of the upper River Runie within a new riparian woodland enclosure (Figure 5). Salmon fry and parr were recorded. Electro-fishing conditions were difficult at the time of the survey with high river level; so the recorded CPUE underestimates the density of fish present compared to other sites. Overall however, there is still a strong wild salmon population in the River Kanaird.

Thank you to Mark MacKenzie, the Bulmer family, and to Nigel and Meryl Carr for support.

Figure 5 Good salmon parr habitat in the River Runie headwaters; Nigel Carr is pointing to a young alder tree within the new woodland enclosure near Tileathdoire. There may be opportunities for several small woodland riparian enclosures further downstream to further support freshwater biodiversity and productivity.



Ullapool River

Two NEPS sites were surveyed in the Rhidorroch River, the principle spawning stream for salmon in the Ullapool River above Loch Achall, on 20th July 2021. Salmon fry were recorded at moderate to high densities; however salmon parr were scarce. Brown trout of ~20cm in length were found in a pool near the top site NEPS 2893 (Figure 6).

Problems associated with streambed instability will be addressed in 2022 as part of a project supported by the Wild Salmonid Support Fund via Fisheries Management Scotland. Riparian tree planting is already underway. There may be potential to greatly reduce the rate of runoff of water and sediment from headwater streams in Glen Douchary. The Ullapool River provides complex habitat for wild salmon and is of high conservation value.



Figure 6 Ullapool River system: sites NEPS 2909 (left) and NEPS 2893 (middle) in the Rhidorroch River, 20th July 2021. Salmon fry (below right) were recorded at moderate to high densities, however parr were scarce. Large brown trout (top right) were found nearby; these are known from investigations in previous years to include salmon parr in their diet.

River Broom and River Lael

Four sites were surveyed in the River Broom on 17th September 2021, two in the main river and two in tributaries (Figure 7). One site was surveyed in the River Lael nearby; the River Lael joins the River Broom in tidal waters. Water levels were low at all sites. High densities of both salmon fry and parr were recorded at both main river sites and in the River Lael. One of the spawning burn sites, the Sawmill Burn had high densities of both salmon fry and trout fry suggesting use by both salmon and sea trout. A riparian habitat improvement project funded by SNH was developed along this burn in 2000, it has been a success. Overall the River Broom and Lael support a healthy population of juvenile salmon within a relatively large area of prime, relatively productive salmon parr habitat.

Figure 7 (right) River Broom at Achindrean bridge, and (far right) the Sawmill Burn on 17th September 2021. High densities of salmon fry were recorded at both sites.

Dundonnell River

The Dundonnell River is somewhat like a slightly smaller version of the River Broom. Both rivers flow between tree-lined banks; and both rivers have had problems with streambed instability over the years. Following a survey in 2019 when very few salmon fry were recorded, the Dundonnell River was surveyed on 27th August 2020. In contrast to 2019, salmon fry were recorded at high CPUE at four main river sites in 2020. The river was not surveyed in 2021. Dundonnell estate has done much work to stabilise the river channel and restore peatlands within the catchment of the Dundonnell River; this follows earlier actions to protect riparian woodlands. This has all helped to stabilise the streambed and support higher production of juvenile salmon.

Figure 8 The Dundonnell River, Gheta Ban Pool, September 2021.

Gruinard River

Figure 9 Gruinard River system: remains of gorge woodland within the Great Wilderness with alder, rowan, birch, aspen, willow, alder at the top of the accessible area for salmon in the Abhainn Gleann na Muice at NH 04177 75764, 19th August 2021. Potential seed sources for riparian woodland enclosure(s) downstream?

The Gruinard River has one of the largest areas of wetted riverine salmon habitat of any river system within the Wester Ross area and supports complex and varied freshwater habitat for wild salmon.

On 19th August, the WRFT e-fish team walked to the top of the area accessible of the Abhainn Gleann na Muice, a headwater stream above Loch na Sealga in the heart of the 'Great Wilderness' for the first time for 10 + years. Two sites were surveyed including a NEPS site; low densities of salmon fry and parr were recorded.

This valuable headwater spawning stream retains sporadic riparian alder trees, the roots of which bind river banks together supporting a fertile corridor of riparian vegetation (Figure 10, individual riparian trees can also be seen on satellite photos via https://gridreferencefinder.com/). However grazing pressures and nutrient deficiency associated with declining numbers of adult salmon and export of deer and livestock from the catchment area is continuing to steadily degrade both the riparian woodland corridor and the biological productivity of the river and catchment area. The Abhainn Gleann na Muice is potentially one of the most important headwater spawning streams of any salmon river in the Wester Ross area for early running salmon; action is now urgently required to protect and restore the existing riparian corridor. Figure 11 illustrates some of the issues relating to riparian alder trees (published in February 2021 by Reforesting Scotland).

Figure 10 Upper Gruinard, riparian alder trees in Gleann na Muice are steadily dying off as a result of grazing and browsing pressure and nutrient deficiency. This headwater salmon spawning stream should be of highest priority for protection and restoration.

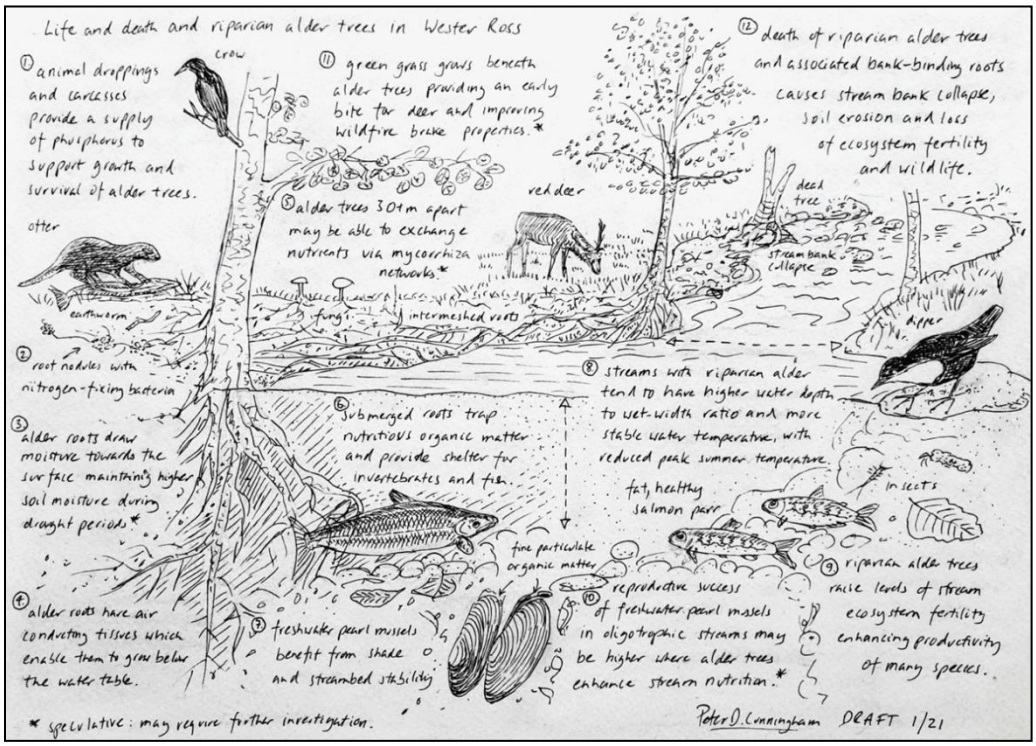
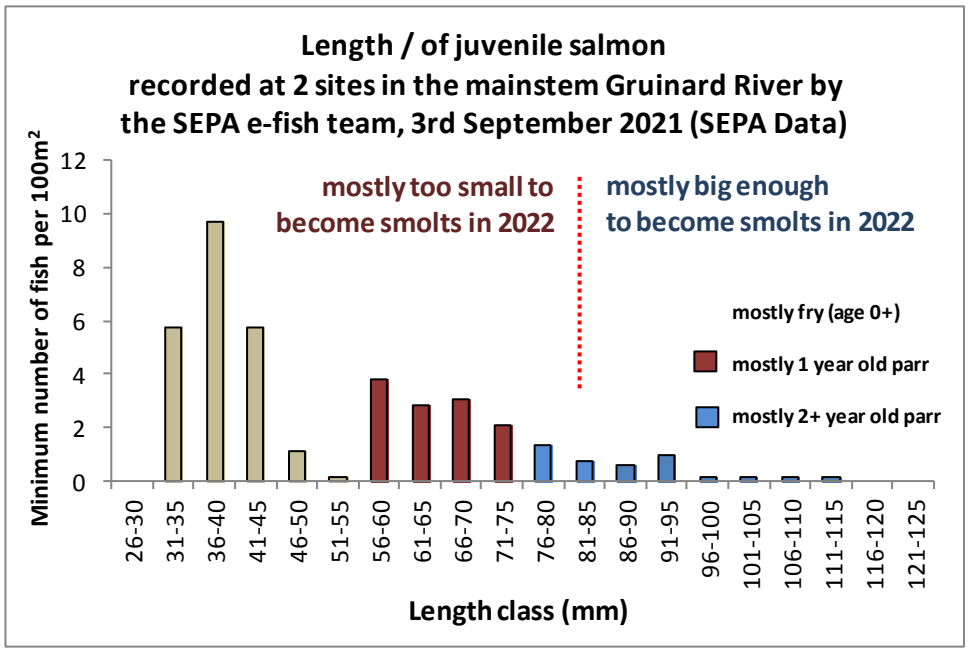


Figure 11 is based on observations from rivers in Wester Ross including the Abhainn Gleann na Muice and was drafted for a Reforesting Scotland Director's blog on riparian woodlands published in February 2021. https://reforestingscotland.org/of-riparian-trees-and-fish-and-fire/

On 30th August 2021, two NEPS sites in small tributaries of the Gruinard River and two main river sites below Loch na Sealga were surveyed. In addition, the SEPA electrofishing team surveyed two main river sites in the Gruinard River on 3rd September 2021.

Both NEPS sites were in marginal habitats for juvenile salmon (one site was slow peaty pools; the other in a partially dried up channel with pools containing trout), so much effort to provide little information about the status of salmon stocks in this part of the Gruinard River catchment area. However, at both the WRFT and SEPA main river sites, salmon fry and parr were recorded at moderate CPUE. Salmon fry were very small, mostly between 32mm and 45mm in length and only 9 of 86 salmon parr recorded by the SEPA electro-fishing team were over 90mm in length so likely to be big enough to 'smolt' in 2022, as shown in Figure 12.

Figure 12 Lengths of juvenile salmon at two electro-fishing sites in the Gruinard River surveyed by the SEPA electro-fishing team on 3rd September 2021.Thankyou to SEPA for data.



Results from the main river sites once again suggest that the food supply is the major factor limiting juvenile salmon and smolt production in the Gruinard River system. Mortality of juvenile salmon due to starvation may be high especially in late summer and during winter months when the water temperature is high. How many dead or emaciated juvenile salmon are washed out to sea representing a loss of nutrients and energy that might otherwise have contributed to salmon smolt production?

The Gruinard River and associated catchment area has much potential to be restored from a state of ecosystem degradation and malnourishment to one of higher levels of biodiversity and biological production including that of salmon and other freshwater biota through restoration of riparian woodlands and other catchment vegetation, and ecosystem refertilisation (addressing phosphorus deficits especially). The Great Wilderness could be revived to support much higher productivity of wildlife, including wild salmon and deer (better quality animals) and for domestic livestock production.

Thank you to Eric Ross (Gruinard Estate) and Iain Allison (Eilean Darach Estate) for providing transportation to fish survey sites and for lots of other information, especially stories from Eric about the former abundance of salmon and sea trout in the 1960s and 1970s. We mustn't forget . . .

Little Gruinard River (Special Area of Conservation [SAC] for Atlantic Salmon)

Four sites were surveyed by the WRFT e-fishing team in the mainstem Little Gruinard River below the lochs on 6th August 2021 including a NEPS site at the outflow of Loch Eileach mhic ille Riabhaich at the top of the river, and five sites were surveyed in streams flowing into the Dubh Loch and Fionn Loch on 10th August 2021.

Salmon fry were found at high CPUE at all main river sites except the top site at the loch outflow; parr were present at moderate CPUE at most sites. At the top main river site parr were much larger than at other sites demonstrating high growth potential of juvenile salmon within the Little Gruinard River where there is more food. In contrast salmon parr at a site near the lower flats were very small like those of the big Gruinard River (see Figure 13).

Figure 13 (top) Little Gruinard River on 6th August 2021: Large one year old salmon parr were caught at the top site, in contrast much smaller salmon parr show together with fry were recorded at the site near the lower Flats; fish shown to scale. All fish were returned to the water after recovering from sedation.

Site NEPS 2892 At the loch outflow. Very big parr; indicative of a steady food supply from the loch.

Site LGD11 Small fry and small parr to same scale. Contrast size of parr with those in above photo.

Ancestral salmon redds in the Little Gruinard River exposed at very low water on 6th August 2021. Water levels in the back channel were too shallow for the usual survey to be undertaken here.

Fionn Loch, Looking towards Carnmore 10th August 2021 (inset: scribe, Colin Simpson & midges . . . !).

Above the Fionn Loch (above Little Gruinard River), salmon fry were found at high CPUE and salmon parr at moderate CPUE in three of five sites surveyed. Densities of juvenile salmon in the three burns flowing into the Dubh Loch were similar to those of previous surveys (Figure 14). At only one site, a small burn flowing into the south shore of the Fionn Loch, were no salmon found; juvenile salmon have not recorded in this burn previously; it supports high densities of trout fry and is probably too small for salmon.

The survey demonstrated that the Little Gruinard River system maintained a widely distributed and healthy wild juvenile salmon population in 2021. Smolt productivity could be higher in the main river if there was more food for juvenile fish. This could be achieved via the restoration of riparian woodlands (see recommendations in Billier, 2014) and through attention to food supply and long-term phosphorus deficits.

Figure 14 (left) Upper Little Gruinard SAC: Salmon spawning stream on north side of Dubh Loch, beyond the Fionn Loch. (below) three year classes of juvenile salmon and trout fry were recorded here.

Allt Beith [Aultbea River] (surveyed in 2020)

Juvenile salmon have been consistently recorded in the little Allt Beith at sites in the 'flats' above the road at high densities. In the early 20th century (or perhaps as early as the 18th Century, Mackenzie, 1803), a fish ladder was made to enable wild salmon and sea trout to ascend to Loch a' Bhaid-luachraich (locally known as 'the Goose Loch'). Following repairs by WRFT and local volunteers in the early 2000s, juvenile salmon were recorded in some years as far upstream as the outflow of the Goose Loch. Much excitement!

In 2020, just two sites were surveyed; one at the bottom of the fish pass and one at the top. Salmon fry were found at high CPUE at the lower site; no salmon fry were found at the top of the fish pass.

The Allt Beith has potential to be developed by the local community for greater amenity value, for wildlife and as a place where local children can learn about nature and fishing. Some of the older people living nearby have exciting stories of salmon and sea trout taken from the river in past years when wild fish were plentiful.

Tournaig River

The Tournaig River system is one of the smallest in the Wester Ross area to have supported juvenile salmon. WRFT has operated an upstream downstream trap to record smolts leaving the system and adult fish returning since 1999. In addition, each year since 2004 the WRFT electro-fishing team has carried out a survey of six sites in the Allt na Coille, the principle spawning stream above Loch nan Dailthean.

Salmon fry were recorded at two of six sites in the Allt na Coille in 2020 and at four of six sites in 2021. The patchy distribution and low numbers of salmon fry and parr recorded in 2020 and 2021 indicate a lack of spawning by adult salmon in the system. Numbers of adult salmon recorded entering the Tournaig system in previous years prior to electro-fishing surveys were also low, with just five adult salmon in 2019 and only two in 2020, so the electro-fishing results were no surprise.

Figure 15 shows how juvenile salmon numbers have fluctuated in the Tournaig system since it was recolonised by straying wild salmon in 2003. It is probably that the Tournaig salmon population is dependent upon straying salmon entering and spawning within the system once every few years.

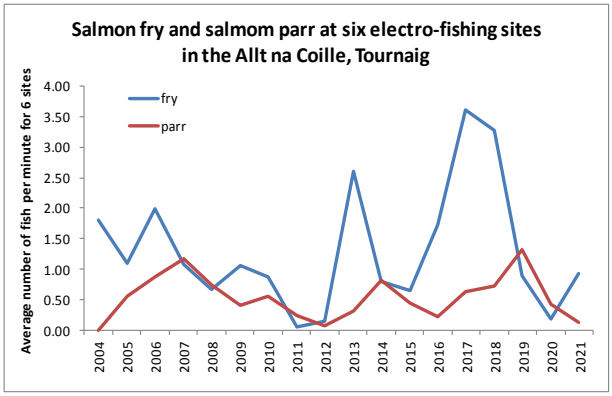


Figure 15 Average numbers of salmon fry caught per minute for 6 electro-fishing sites in the Allt na Coille at Tournaig, 2004 to 2021. Note how parr CPUE tends to follow the same pattern of peaks and troughs as CPUE for fry, but a year later.

In previous years many (around 12%) of the adult salmon entering the upstream trap at Tournaig had bite marks mostly attributed to seal attack. In 2020 and 2021 typically between 10 and 20 common seals could be seen within 500m of the mouth of the Tournaig River. Seals may be a factor in limiting the number of salmon which enter the Tournaig system, or if they chase them, in directing some of them into the river during spate flows?!

Thank you to MOWI and Tournaig Estate for support and permissions; and to Ben Rushbrooke of Tournaig Garden Cottage Nursery for continued enthusiastic support for operating the traps and lots of other help.

River Ewe system

The River Ewe – Loch Maree system is the largest freshwater system within the Wester Ross area and often the most productive river system for rod catches of adult salmon within the WRFT area. Juvenile salmon have been found consistently within several sub-catchment areas in tributaries which flow into Loch Maree.

In 2021, 22 sites were surveyed in the River Ewe system. Nine sites were surveyed in the Bruachaig River above Kinlochewe, including contract sites for the Bruachaig Falls hydro project (Figure 16) and two NEPS sites below the Bruachaig falls.

Figure 16 The hydropower intake weir at Bruachaig falls on 8th July 2021. Note the pile of sediment by the far side of weir near the top of the fish pass following localised flash flood at the beginning of July; plans were in place on the day the photo was taken to remove any sediment in the fish pass.

Sites above the Bruachaig falls were surveyed on 8th July and 16th September. Very large salmon parr were recorded at low densities (Figure 17), but no salmon fry. From scale reading, the parr were aged at two or three years old, assumed to be progeny of salmon spawning above the falls in 2018. No evidence was found of salmon spawning above the falls more recently than 2018.

Figure 17 The Bruachaig River at the Heights of Kinlochewe, above the falls. (inset) lightly sedated salmon parr of 196mm (top), together with trout fry (bottom) and 1+ year old trout (middle) caught at a site 500m further upstream. This spectacularly large, plump, salmon parr, the biggest recorded at any WRFT electro-fishing site in 2021, was aged from scale reading as a fast growing 2+ fish. It was the only salmon parr found at this site.

Status of Wild Atlantic Salmon in Wester Ross 2021

Below the Bruachaig falls, two NEPS sites were surveyed on the 8th July 2021. Salmon parr and fry were recorded at medium to low densities. Thank you to Mairead Murnion (Green Highland) and to Franki Kalinowski, Dr John Ogle, family and friends, and to Kinlochewe Estate for support.

Above Loch Clair (River Ewe headwaters by Coulin), five electro-fishing sites were surveyed on the 25th August 2021. In the Coulin River, small salmon fry and parr were found at moderate densities in main river sites; salmon fry and parr were also recorded at low densities at the highest site in the burn above the stone bridge; fish numbers may have been reduced following a sudden streambed and streambank-scouring spate earlier in the summer. Salmon fry were absent from the upper Coulin Farmhouse burn site (though high densities of trout fry). At the mouth of the Allt na Luib where it flows into Loch Clair, salmon fry were recorded together with many minnows (and midges!). Minnows have spread within the lochs Clair and Coulin area in the past 10 years.

Juvenile salmon grow very slowly in the mainstem Coulin River as there is little riparian vegetation and a very limited supply of food for small fish (Figure 18). The river is unstable and liable to flood out from the channel after heavy rain, so it is not easy to develop riparian woodland schemes or other habitat improvement projects which would require fencing to prevent browsing by deer. In contrast, juvenile salmon and trout grow well in the nearby Coulin Farmhouse burn where Woodland Grant Scheme enclosures developed in the early 2000s are now providing useful additional leaf litter and other nourishment to support juvenile salmon and trout production. Thank you to Philip Smith, family and friends, Neil Morrison and Simon Stewart for support.

Figure 18 (left) Contrasting riparian(river bank) habitats. Coulin River: bare banks; riparian habitat provides little nourishment for the river. Juvenile salmon grow very slowly. (right) Farmhouse burn, Woodland Grant Scheme. Young trees including riparian alders are now well established providing leaf littler and other nourishment to the river. [Could the old water-gate be reused elsewhere, it's a good one with stainless steel frame?]

On 16th September, the highest biomass of salmon fry per unit streambed area for any WRFT site in 2021 was recorded in the Kinlochewe River, ~400m downstream from septic tank discharge (Figure 19)! However, few salmon parr were recorded here. The streambed was a rug of green filamentous algae, over-enriched . . . ?

Figure 19 Kinlochewe River on 18th Sept 2021. Large salmon fry were recorded at high densities here. The site is about 500m downstream from the Kinlochewe septic tank outflow. Low water levels and high temperatures in the summer of 2021 together with high soap and dissolved nutrient levels led to filamentous algae growth.

Contrasting growth of salmon fry above and below the septic tank outflow has also been noted in previous years.

In the Slattadale burn (by Loch Maree) on 20th August 2021, salmon fry were recorded at only low CPUE; however parr were recorded at high CPUE. In 2020 salmon fry were recorded at high CPUE at this site; also in 2020 salmon fry were recorded much further upstream in the Slattadale burn above the forestry bridge for the first time in several years. The Slattadale burn is one of the larger spawning burns on the south side of Loch Maree, mostly for trout (and sea trout); riparian habitat is now good with overhanging alder and other trees.

At a site (NEPS 2891) in a small bouldery burn known locally as the 'hotel burn' near the Loch Maree Hotel, no salmon fry and just one salmon parr was found. However, this site was difficult to fish with large boulders and a fallen tree; marginal habitat for juvenile salmon. No juvenile salmon were found in the weedy Loch na Fideil burn 200m below Loch na Fideil. This burn also enters Loch Maree by Talladale and could be much improved as a sea trout spawning burn if some of the weed and silt was removed and banks protected from cattle.

NEPS sites were surveyed: on 23th August near the bottom of the Tollie Burn (~100m upstream from River Ewe) and on 25th August in the Inveran River (100m below Loch Kernsary) and also a routine fully-quantitative WRFT site in the Kenrsary River above Loch Kernsary.

Fry and parr were recorded at medium densities in the Tollie Burn. Salmon parr were found at high density in the Kernsary River, fry at medium density. At the site in the top of the Inveran River very large fry and parr were recorded at low densities, where many eels were also recorded. Overall, fish densities were roughly what one would expect to find given the characteristics of the habitat at respective sites. Thank you to Andrew Oliver (Letterewe Estate) for loan of boat; and to Dr Michael Aitchison and family for support.

Figure 20 Loch Kernsary area: stop nets were used for the three-run fully quantitative electro-fishing sites in the Kernsary River (top); and at NEPS 2890 in the Inveran River (below left, middle) where eels, minnows and juvenile salmon (including some large parr) were caught.

In summary, at sites surveyed in the River Ewe system in 2021, juvenile salmon were recorded at densities generally considered to be indicative of site specific habitat constraints (e.g. streambed stability, abundance of cover, . . .) rather than inadequate spawning by adult salmon in previous years. The main exception to this was the upper Bruachaig River above the Bruachaig falls where no salmon fry or one year old parr were recorded.

Sand River (Gairloch)

On 22nd June 2021, low numbers of both salmon fry and parr were recorded in this little river by the Sand Archaeology trail as part of an education day supported by Countryside Learning Scotland with pupils from Gairloch High School. The river is noted more for supporting a sea trout population.

River Kerry (Special Area of Conservation [SAC] for Freshwater Pearl Mussel)

The Kerry is a short river, regulated according to discharge from the SSE Kerry Falls power station. However it represents one of the best freshwater habitats and ecosystems of any river in the northwest of Scotland. The River Kerry is a Special Area of Conservation [SAC] for the Freshwater Pearl Mussel [FWPM]. FWPMs thrive in the river due to its stable streambed habitat, relatively stable flows, relatively high biological productivity with a riparian corridor of lush woodland, and perhaps some additional nutrient that enters the river in run-off from the road nearby. The mussels of the Kerry were noted historically for not containing pearls; hence one reason why the mussel beds were not plundered as they were in many of the other rivers in Wester Ross.

Freshwater pearl mussels need healthy populations of juvenile salmon to complete their life cycle. The River Kerry is usually stuffed with salmon fry and parr; and indeed on 24th August 2021 very high salmon fry densities were recorded at the middle site above the road bridge. However fry numbers were lower than in some previous years at the bottom site. Parr were recorded at high density at two of the three sites, so still a good juvenile salmon population (Figure 21).

No fish were found at e-fishing site NEPS 2894 in a very small moorland tributary to the south of the main River Kerry (18 Aug 21); this little stream may have been too small to have sustained flows in which fish could survive during the dry period earlier in the summer of 2021. We enjoyed the expedition through the ancient birch and hazel woods to get there and back (many veteran trees to be recorded . . .).

Figure 21 River Kerry on 24th August 2021: top e-fishing site (and salmon parr), and (right) bottom site (and stonefly larvae).

Badachro River

Three sites were fished in the Badachro River on the 19th of July 2021. The first site was only 100m downstream from the outflow of the new hydropower station, in a braided section of river where densities of juvenile salmon have been high in previous years. The water level was so low (due to drought, not hydro) that it was difficult to pick some of the fish out from between the stones using our nets. Nonetheless both salmon fry and parr were found at moderate to high CPUE. Salmon fry were recorded at high density at the lowest site (just above the loch) and also in the Allt a' Ghuibhais tributary. Our overall assessment is that densities of juvenile salmon were as we would expect to find them given the constraints of habitat and flow at the three sites surveyed.

Figure 22 Electro-fishing sites in the Badachro River

Some of the fish taken at the Allt a' Ghubhais site looked a bit like hybrids, most likely female salmon x male brown trout. Putative salmon x trout hybrids have been found in this tributary in previous years.

Torridon River

Six sites were surveyed in the Torridon River system on 2nd of September 2021. The most notable finding was an absence of salmon fry at a main river site in the lower part of the river (despite much searching) and very few parr at this site (Figure 23). Fry were present at high CPUE at the middle site near Glen Cottage and fry were also recorded in the River Thrail at high CPUE and at moderate CPUE at the top site above Loch an Iasgair, so patchy distribution. However our results suggest inadequate numbers of adult salmon spawning within the Torridon River to populate all available habitat within the system with juvenile salmon, concurring with the SG Conservation Grading of 3. In conclusion, the Torridon River salmon population is fragile.

Figure 23 Torridon River by pine trees; no salmon fry and very few parr were found at this main river site. This should be prime habitat for juvenile salmon.

Applecross River

After a somewhat frustrating drive over the Beallach na Ba single track road (following a cyclist who wouldn't pull in to let the cars pass) we surveyed three sites in the Applecross River on 19th July 2021, including NEPS 2898, the lower most site. Very low densities of salmon fry and low densities of salmon parr were recorded at the NEPS site; moderate salmon fry densities were recorded at a middle site; and just large parr at the top site, some of which had ulcerations on them (Figure 24). Our results suggest that the numbers of adult salmon returning to the Applecross River have been inadequate to populate available habitat with juvenile salmon; that the salmon population is fragile. The river has been stocked by Bob Kindness in some recent years. A grilse was seen in the lowest NEPS site; some fish make it back from the sea. Sea lice may be a major problem affecting smolt survival. There are also habitat problems which should be addressed including active landslips on the hillsides further upstream. However the fish we recorded were large for their age; fast growing in response to low densities. Some of these problems could be fixed. Thank you to David Abrahams and the Applecross Trust for support.

Figure 24 Applecross River, 19th July 2021. (top left) middle site where both parr and fry were recorded [inset]; and lower NEPS site where densities of juvenile salmon were very low. The salmon parr illustrated at bottom of figure had ulcerations on its side, seen more clearly when the fish was held underwater (bottom right). Several other parr in the same bucket were affected in similar way. What pathogens are present?

River Carron

The River Carron is currently out with the area of the new WRFT and that of the Wester Ross Area Salmon Fisheries Board. Nevertheless the Trust was asked to survey two NEPS sites and a series of other contract sites within the river. Two other sites were surveyed in part of the river system where there has not been stocking of juvenile salmon in recent years.

One NEPS site was surveyed on the Allt Coire Crubaidh at the top of the system on 21st July 2021, and another five HP scheme monitoring contract sites on the 14th September 2021. Just one salmon fry was found at the site

nearest the powerhouse; where parr were recorded at high CPUE (Figure 25). 30,000 salmon eggs were stocked into the headwaters of the River Carron earlier in 2021 (including the lower Allt Coire Crubaidh) so it is possible that the one salmon fry recorded was from the stocking and had swum upstream. Indeed, as fry were also stocked within 1km of the lower most electro-fishing site in 2020 and 2019 it is not possible be sure whether any of the juvenile salmon recorded in the Allt Coire Crubaidh were of wild origin (as opposed to stocked fish) (Figure 25). Thank you to Hydroplan for support and to Bob Kindness for information about stocking.

Figure 25 Wild or stocked? The salmon fry (the only one!) and two age classes of parr from the Allt Coire Crubaidh, River Carron on 14th September 2021.

Further downstream within the River Carron system, a NEPS site was fished in the Allt a' Chonais above the forestry bridge in the Achnashellach forest. The site was upstream from a new Hydropower house, within the section of river from which water is abstracted. Fry and parr were recorded at low densities. We are uncertain as to whether they were of stocked or wild origin or both.

By Loch Dughaill (Figure 26), a site was surveyed in the River Lair, about 150m above the loch. Salmon parr were recorded at high CPUE in this productive habitat. In the main River Carron about 200m upstream from Loch Dughaill, salmon fry were recorded at high CPUE and parr at moderate CPUE despite unstable substrate of mostly pebble and small cobble sized sediment (so not ideal for parr). Neither the River Lair nor the main River just above Loch Dughaill have been stocked in recent years. Together, they may therefore represent a core area for the 'wild' salmon population within the River Carron system. Thank you to Richard Wilson for support.

Figure 26 Carron, 14th September 2021. High densities of salmon parr were recorded in the River Lair (left); and high densities of salmon fry were recorded in the River Carron (right); the fish were assumed to be wild.

3. Assessment of pressures affecting wild salmon in Wester Ross area

3.1 Marine pressures

3.1.1 Sea lice infestation of wild post-smolt salmon in local waters

Sea lice from salmon farms continued to plague wild sea trout in coastal waters around parts of Wester Ross in 2021. A sample of sea trout taken by in the Flowerdale estuary, Loch Gairloch in April 2021 demonstrated that cumulative level of infective planktonic sea lice larvae were much too high even 25km+ away from the nearest salmon farms (Figure 27). https://www.wrft.org.uk/news/newsitem.cfm?id=229 . High numbers of sea lice were also recorded on sea trout sampled by the Isle of Skye in early summer 2021 (Moore, pers. comm.).

In contrast, lice levels recorded in 2021 on sea trout further north, near Ullapool, were much lower than in Loch Gairloch. https://www.wrft.org.uk/news/newsitem.cfm?id=231. Since 2015, the relatively small 'hands-on' salmon farms in the Ullapool area operated by Wester Ross Fisheries have been better able to control lice than the much larger and more automated salmon farms in Loch Torridon and further south and around the Isle of Skye, based on SSPO sea lice reports and now Scottish Government sea lice reports.

Sea lice represent an unresolved major threat to post-smolt salmon migrating to sea from the Applecross River, rivers in Loch Torridon, and based on sea trout sampling in Loch Gairloch, to post-smolt salmon from the Badachro River and River Kerry SAC. New regulations are required to protect wild salmon from these areas including more effective controls for sea lice emissions from salmon farms in Torridon, Loch Carron and the east of Skye. At the time of writing, a SEPA consultation on new sea lice regulations is ongoing.

With the closure of the MOWI Isle Ewe salmon farm in 2020 and generally lower lice counts on other farms in the Wester Ross MPA (operated by Wester Ross Fisheries and to a lesser extent Scottish Sea Farms), post-smolt salmon from the River Ewe and rivers north to the River Kanaird migrating through coastal waters have in recent years been subject to reduced pressure from lice infestation. It is important that this remains the case. Note that it is possible (based on sea lice dispersal modeling that infective stage sea lice from salmon farms as far away as the east coast of Skye can infect post-smolt salmon within the Wester Ross MPA 30+ km away.

Figure 27 There were over 800 mostly very small early stage sea lice on this sea trout taken by the WRFT sweep netting team in the Flowerdale estuary, Loch Gairloch in April 2021, over 25km from the nearest salmon farm. Post-smolt salmon from nearby rivers (e.g. rivers Kerry and Badachro) would very likely have been exposed to similar sea louse infection pressures in coastal waters.

3.1.2 Feeding at sea

Changes in far away oceanic feeding areas associated with climate change affect wild salmon; it is beyond the scope of this report to comment further.

Of more local relevance is the occurrence of high densities of fish larvae and other potential post-smolt salmon food in local waters in May and June. Herring were recorded spawning near the mouth of Loch Gairloch in March of 2018 and 2019; and reported to have spawned nearby in March 2020 and 2021. Herring larvae and other fish fry in April and May provide ideal food for post-smolt salmon migrating through coastal waters. https://www.wrft.org.uk/files/WesterRossHerringPoster19June2019reworked.pdf

Figure 28 Sandeels feeding over herring spawning ground near Gairloch in March 2019, from Spring spawning Herring – Gairloch video by Andy Jackson https://vimeo.com/323284761 . By May, herring fry are of ideal size as food for post-smolt salmon.

Protection of herring stocks in the west of Scotland and of their spawning grounds especially those around Wester Ross should be of high priority as a means of supporting salmon populations. This affects post-smolt salmon from all the rivers covered by this report and rivers to the south of Wester Ross.

Initial results from the Atlantic Salmon Trust led West Coast tracking project indicate that some salmon from rivers as far south as SW Scotland (and presumably beyond) migrate through the coastal waters of the west of Scotland. High concentrations of herring fry and other fish fry will benefit post-smolt salmon from many rivers, and may indeed be one of the factors which influence which way the post-smolt salmon tend to go and whether or not they survive.

3.1.3 Predation by marine mammals

Both seals and dolphins may take adult salmon as they return to estuaries through coastal waters. Seals were formerly killed by salmon netsmen around Wester Ross through the 'netsman's defense'. One retired local

netsman has stated that seals very likely now take more salmon in a year from coastal waters by the former netting station at Red Point and nearby than he ever did when he netted salmon there! It is no longer politically acceptable to consider using lethal means to control seal numbers in contrast to red deer where (in the absence of a natural predator) the need for annual culls is widely accepted and indeed encouraged by most wildlife conservation organisations for the purposes of animal welfare and to maintain overall ecosystem health.

In 2021, common seals were particularly evident in Gruinard Bay (esp. Laide to Gruinard beach) and Loch Thurnaig. Four or more seals were reported to have died of starvation or disease in late winter 2020 in Loch Thurnaig; local residents reported a bad smell from far away. Unfortunately the dead seals were not reported until long after they had died. Please report any dead seals to https://strandings.org/ .

More detailed observation of seals may be useful for understanding whether wild salmon and sea trout represent a significant part of their diet and what that might represent in terms of fish numbers returning to nearby rivers.

3.2 Freshwater pressures

3.2.1 Streambed instability and stream habitat washout

Streambed stability is a localised problem affecting some parts of some river systems, but not all. The Rhidorroch River (Ullapool) and Applecross River are two systems which have particularly unstable streambeds with frequent movements and redeposition of bedload sediment, causing undercutting of river banks and erosion, and washout of fish eggs, fry and parr, and invertebrates (food for fish).

Washout tends to be episodic even in the most unstable rivers. So, for example, in some previous years even in the Rhidorroch River when there have been no major spates, high densities of juvenile salmon have been recorded, in contrast to other years following a major river channel-redirecting spate.

In 2022 a project supported by the Wild Salmonid Support Fund will survey the upper catchment of the Rhidorroch River in Glen Douchary to identify actions to greatly reduce sediment discharge. This is a very useful opportunity; and we look forward to working with riparian owners some of whom have already expressed interest in peatland restoration work which may greatly help.

The Applecross River is also subject to streambed instability and washout. In 2017, the fisheries trust field team identified a major active landslip, which if repaired would reduce the amount of sediment entering the river. This is another area where appropriate actions would benefit wild salmon and other interests further down the glen.

Other areas with streambed instability problems include tributaries of the Gruinard River in Strath na Sealga including the upper Abhainn Gleann na Muice (see below).

In contrast, many rivers including the mainstem rivers Gruinard, Little Gruinard, Runie (Kanaird tributary), Ullapool (below Loch Achall), Broom (esp. since new hydro schemes?), A' Ghairbhe [Ewe]), Kerry, Badachro and Torridon have generally stable streambeds where redd washout is not an issue of concern.

These issues were considered in a presentation entitled 'About river banks and juvenile salmon production in Wester Ross' at the SFCC Riparian Woodlands workshop in February 2020.

3.2.2 Riparian woodland

As stated earlier, the most pressing freshwater habitat problem for wild salmon at Wester Ross area scale is the ongoing degradation of riparian woodland along the Abhainn Gleann na Muice in the Gruinard River headwaters. This has been noted by WRFT field teams over many years; the problem has not yet been resolved. Given the potential of the Abhainn Glenn na Muice to support an early running salmon population, this issue is regarded as being of high priority for action in partnership with local land managers.

Other rivers where riparian woodland protection and restoration could be particularly beneficial include parts of the rivers Runie (Kanaird tributary), Rhidorroch (woodland restoration in progress in 2021), Gruinard system (above and below Loch na Sealga), Little Gruinard system (several areas), Coulin (Ewe headwaters), Torridon (localised) and Applecross.

3.2.3 Malnourishment and ecosystem degradation

This pressure is associated with very slow growth of juvenile salmon and is a feature of rivers which drain very oligotrophic catchment areas underlain by Torridonian sandstone and Lewisian gneiss which have been managed for many decades for grazing. Over hundreds of years, catchment denudation, fire, trampling and soil erosion, and the export of sheep, cattle and deer carcasses have led to a deficit of phosphorus and calcium, particularly in animal bone. It particularly affects production of salmon smolts from the Gruinard River, Little Gruinard River and Coulin River (Ewe).

In addition to finding high numbers of very small salmon fry and parr (see Little Gruinard summary), the problem may be so severe in some river that freshwater pearl mussels are inadequately nourished to be able to reproduce successfully.

Historically there was a much larger input of marine derived nutrient via both salmon and sea trout into some rivers. At the very least, this missing amount of nutrient should be replaced. At a catchment level, continued denudation and erosion associated with grazing animals and trampling by red deer, goats and livestock, and export of carcasses, represents a major net export of phosphorus. This phosphorus deficit should also be addressed through appropriate nutrient budgeting and emphasis on restoration of ecosystem fertility and associated biota. These issues have been discussed at length in previous WRFT workshops, for example Refertilising Wester Ross 2016, and reviewed at a workshop at MSS Freshwater Laboratory in February 2020; a presentation entitled 'About ecosystem nutrition and juvenile salmon production in Wester Ross' can be found here.

3.2.4 Pollution

In stark contrast to the foregoing paragraph, in August 2021 the Kinlochewe River was evidently over-enriched due to discharges of phosphorus-rich effluents from the Kinlochewe septic tank; the stream bed was like a rug of filamentous algae when electro-fishing site surveyed. Note that salmon fry densities were high and growth prolific in the Kinlochewe River; but what about the salmon parr, where were they?

Anglers reported that a layer of warm soapy water had formed at the head of Loch Maree in late summer 2021, affecting fishing. A combination of drought and high numbers of people staying at Kinlochewe may have led to some of the highest concentrations of effluents from domestic sources into the Kinlochewe River to date. This should be monitored in 2022.

3.2.5 High water temperatures and drought

Water temperature is not yet considered to be a major factor limiting juvenile salmon production in Wester Ross; however projections by scientists at Marine Scotland Science stress the need to plant riparian trees to provide shade in future years when peak summer temperatures are projected to be several degrees higher. Much information about this can be found on the Scotland River Temperature Monitoring Network website.

The wide shallow rivers listed in 3.2.3 are also the ones where water temperatures may be too high in early July esp. for juvenile salmon. Priority rivers for riparian trees to provide shade include rivers Coulin, Gruinard, (including headwaters), Little Gruinard, Torridon, Applecross. Note that riparian trees have many other benefits as stated earlier.

Not much can be done where rivers run dry. Given the importance of the River Kerry FWPM population, attention has been focused on regulation of low flow discharges from Loch Bad an Sgalaig into the river via the SSE Kerry falls Hydroscheme. All good for juvenile salmon!

There are several other river systems with potential for retention of back up flows from a loch to provide compensation during dry periods; including the Kanaird and Broom. However, currently not enough information to assess whether low flows has resulted in reduced production of juvenile salmon.

Of concern were low flows during the smolt run in May 2021. This was highlighted by the low counts of salmon smolts in the downstream trap at Tournaig (less than 100 in 2021). For most of the smolt migration season in 2021, water levels were inadequate to enable smolts to migrate from Loch nan Dailthean to the sea. Is it worth exploring options for releasing freshets from nearby lochs could be used to aid passage? Some smaller rivers (e.g. Allt Beith) may have options for this; or to look at low flow obstacles to downstream passage of smolts (e.g. shallow transverse fords)?

3.2.6 Predation by fish eating birds and other animals

Smolts tend to migrate downstream at night. However, where smolts set off downstream from a safe holding pool but fail to reach the sea or other safe place by daybreak because of obstructions associated with very low flows, they will be particularly vulnerable. Fish eating birds were considered to be a problem on several rivers in 2021 during low flows at smolt migration time.

Smolts may struggle to migrate downstream especially the smaller rivers at low flows including parts of the river Little Gruinard, Allt Beith, Applecross, Torridon, A'Ghairbhe (Ewe) and tributaries including headwaters of larger rivers where at low flows water tends to percolate through the stones on the streambed. Streams with narrow tree-lined channels (so deeper water) with places for smolts to hide (e.g. among alder roots) provide more secure routes to the sea than wide shallow streams where smolts may 'run aground' or have nowhere to hide should they be intercepted.

3.3 Population health and genetic introgression

Adult salmon tend to home back to where they came from. Because of this natural selection tends to increase the fitness of each salmon population to the particular environmental challenges associated with successfully completing their life-cycle.

Salmon from some populations face many more life-cycle challenges than others.

Within the context of Wester Ross, for example, the salmon smolts from the upper Bruachaig River above the Heights of Kinlochewe must undergo a longer, more hazardous journey as they migrate to sea (including swimming the length of Loch Maree) and as they return to spawning grounds as adult fish over the falls, compared to the smolts from the River Ewe, less than a mile from the sea.

As overall rates of marine survival decline, the salmon populations which occupy marginal habitat above lochs and waterfalls far from the sea, or in small shallow spawning streams, are those one might expect to lose first as rates of whole life-cycle survival fall below the levels where there are enough returning adult fish to keep the population healthy. It's hardly surprising that the upper Bruachaig River salmon population (Ewe headwaters) is fragile.

Gilby et al 2021 looked at the genetic integrity of wild salmon populations in Scotland in relation to introgression with escaped farm salmon, focusing on the occurrence of genetic markers from Norwegian strain farmed fish. This study included genetic samples (very small fin clips from sedated salmon parr) that were collected from some but not all rivers in Wester Ross by fisheries trust biologists in 2018 and 2019 as part of a contract for Marine Scotland Science.

Some of the results for Wester Ross were as follows: a sample from the River Balgy was classified as 'very poor'; samples from parts of the Torridon River (c. lower site in Torridon River where very low densities of juvenile salmon were found in 2021, see p23 of this report), Dundonnell River, River Kanaird and Kinlochewe River were classified as 'poor'. In contrast, samples classified as 'good' were obtained from the rivers Ullapool, Gruinard, Ewe, Kerry and Torridon (upstream site). No samples were obtained from the Broom, Little Gruinard, Badachro, Applecross and Carron rivers for this study. So a mixed picture: no surprise about the poor genetic status of the Balgy sample given that there are two farmed salmon smolt cage units on Loch Damh.

Pritchard *et al* 2021 published a report from analyses of genetic samples from salmon from the River Carron including broodstock and stocked fish. Amongst their finding was that '*genetic material from Norwegian aquaculture fish was identified in varying amounts in the broodstock parents, the smolts, and the returning adults. Although we did not observe any elevated aquaculture ancestry in the 2014 broodstock offspring compared to the population as a whole, we note that many of the other smolts and returning adults tested are likely to be stocked fish from other years. Therefore, at this time we cannot draw any conclusions about whether the supplementary stocking is maintaining or increasing the amount of Norwegian aquaculture material in the wild population'.*
https://static1.squarespace.com/static/6011565a6d3d7619bc09e764/t/617914ce62c22f532e4d5e27/1635325135657/River_Carron_Restoration_Phase_IIa_Report_FINAL.pdf

Note that the Carron stocking programme is based on the collection each year of adult salmon that have completed their migration to sea and back to be used as broodfish, so these broodstock fish have been subject to selective pressures during the marine phase and in that respect are no different from wild fish. However, as these fish are not able home back and spawn in the specific reach of river from where they came, their progeny

may end up being stocked into the river somewhere far away, limiting their ability to adapt to some of the pressures within the freshwater environment.

There are still wild spawning salmon in the River Carron, though it is uncertain whether there are still parts of the River Carron system where a majority of juvenile salmon are not either of stocked origin or are the progeny of salmon that were stocked as eggs or fry. There is therefore uncertainty as to whether any stock structuring within the river (for example, genetic differences between the salmon which spawn above Glencarron Falls and the ones which spawn below Loch Dughaill) might remain.

Gilby et al 2021 state that *'Enhancing the understanding of observed patterns of introgression through the various measures outlined above will provide powerful tools to better inform knowledge-based management of the aquaculture industry. Hybridisation and introgression have implications for the fitness and long-term viability of populations (McGinnity et al., 2003; Glover et al. 2017; Castellani et al., 2018)'.*

Currently, salmon smolts migrating to sea from the River Carron must pass many salmon farms where sea lice numbers have been high in recent years, and rates of mortality of post-smolt salmon are likely to have been high in some years (see WRFT Review 2018). Until sea lice are adequately managed on salmon farms along the post-smolt migration route, the River Carron salmon stocking programme may still have value in sustaining juvenile salmon production in some parts of the river system which would otherwise have inadequate numbers of returning adult salmon to sustain a wild salmon population, for example above the Glencarron Falls.

Within the context of Wester Ross, wild salmon populations which may have been lost in previous years (no juvenile salmon were found in surveys) include those of the upper Balgy salmon population (above Loch an Loin – surveyed in earlier years), the upper Bruachaig above Leckie.

Salmon populations hanging on in 2021 were in the rivers Tournaig, Bruachaig (above the falls), upper Kanaird (above Langwell falls), Applecross and possibly parts of the upper Carron (above Glencarron Falls; the River Carron stocking programme obscured any recruitment from natural spawning).

Some of these salmon populations may have been weakened by introgression. Another finding by Gilby et al 2021 was that some samples contained 'full sibling crosses' (i.e. parent salmon were brother and sister).

4. Recommendations

Since starting to draft this report, the Scottish Wild Salmon Strategy has been published. This document provides a summary of legislation to protect wild salmon in Scotland, pressures that affect wild salmon populations in Scotland, and outlines a series proposed actions at national government level.

Recommendations proposed here focus on issues affecting wild salmon populations in the Wester Ross area.

4.1 Improve control of sea lice on salmon farms around Wester Ross

The Scottish Government, through Marine Scotland Science and SEPA, could have moved much faster in recent years to ensure that discharges of sea lice from salmon farms and their impacts to wild fish were understood, monitored and that regulations were fit for purpose to protect wild salmon and sea trout.

At the time of writing, a consultation from SEPA proposes to strengthen protection for wild salmon and sea trout through improved regulation of sea lice emissions from salmon farms and a consultation is underway. That there is to be regulation of sea lice emissions to protect wild fish is a step in the right direction; the challenge is to ensure that the new regulations are adequate. https://media.sepa.org.uk/media-releases/2021/protecting-scotlands-wild-atlantic-salmon-a-national-priority-as-protection-zones-and-sea-lice-thresholds-proposed-by-sepa.aspx

Also at the time of writing (February, 2022) many salmon farms in Loch Torridon and on the east coast of Skye are either fallow or recently stocked, so sea lice levels in Loch Gairloch and beyond should not be as high as in 2021. However there are still some farms not so far away (i.e. Portree, West Strome (Loch Carron), Loch Duich farms) which reported high on-farm sea lice counts in January 2022. These farms may need to greatly reduce their total sea lice numbers by March 2022 to protect migrating post-smolts from the rivers Carron and Applecross.

Meantime, the Trust should continue to record levels of sea lice on sea trout close to the areas through which post-smolt salmon migrate, and to publish sea lice monitoring results in a timely manner especially where they are of particular concern.

4.2 Add wild salmon to the list of 'protected features' for Marine Protected Areas

The Little Gruinard River Special Area of Conservation [SAC] has been of value to wild salmon conservation within the Wester Ross area more widely than for just protecting Little Gruinard salmon. Post-smolt salmon from neighboring rivers (e.g. Gruinard River) received the same level of protection as Little Gruinard salmon as they very likely go the same way through coastal waters, most notably when planning permission for a proposed large salmon farm at Annat Bay near Ullapool was not granted in 2005, partly because of concerns for wild salmon post-smolt from the Little Gruinard River. Can the Scottish Government commit to giving post-smolt salmon migrating through coastal waters from the Little Gruinard River SAC the same level of protection as prior to leaving the EU?

The Little Gruinard River SAC is much smaller than the SACs for Atlantic salmon in the north and east of Scotland. The rivers and wild salmon of northwest Scotland are different from those in the north and east of Scotland. To protect a useful genetic diversity of wild salmon in northwest Scotland, special protection measures could be extended at least to all salmon rivers which enter the Wester Ross Marine Protected Area, including those of the Gruinard River and River Ewe system. Much of the River Ewe system is already protected under Natura 2000 legislation; Loch Maree is a Special Protected Area for Black-throated diver. Wild salmon are iconic to the Wester Ross area and to Gairloch Parish in particular: the logo of the award winning Gairloch Museum is a

wild salmon depiction from a Pictish stone recovered from nearby. The freshwater pearl mussels of the River Kerry SAC are also dependent upon a healthy population of juvenile salmon.

There are other important fish species of conservation concern which could be added to the list of protected features for the Wester Ross MPA (e.g. Flapper skate). Giving protection to wild fish would not preclude aquaculture developments or other appropriate developments within the MPA where it could be certain that the development presented no threat to wild fish populations or other protected features.

These ideas are in line with the recently published Scottish Salmon Strategy actions which will include:

'Protecting and enhancing marine biodiversity, including salmon and the habitats they depend on, through a well-managed network of Marine Protected Areas, proposed Highly Protected Marine Areas and other conservation measures.'

Outer Loch Carron has also become a Marine Protected Area, adding Atlantic salmon to the list of protected features might provide additional incentive for salmon farms in Loch Carron and Loch Kishorn to control on-farm sea lice levels.

4.3 Protect sea bed habitats (especially maerl and maerl gravel) where they may be used as herring spawning grounds

Wester Ross is surrounded by diverse seabed habitats including priority marine features, maerl and maerl gravel. Some of these features remain outwith marine protected areas and are still vulnerable to further damage by scallop dredging. Maerl gravel is known to be used by herring as a spawning ground (Jackson, 2019). Is hatching success of spring spawning herring eggs is highest where the seabed habitat is in good condition where there is more gravel, including shell and maerl gravel and less sand?

Many other fish species benefit at different stages of their life-cycle from maerl and other seaweed habitats in relatively shallow water, including juvenile cod and flatfish. Many of these species spawn in the spring time; eggs and tiny fish larvae all add to the abundance of post-smolt-sized food that can all help to ensure that wild salmon grow well in their first few weeks at sea.

WRFT will support the forthcoming West of Scotland Herring Hunt project (led by Napier University) in seeking to learn more about the spawning grounds of herring around Wester Ross and nearby areas.

4.4 Whole catchment-scale river ecosystem restoration project(s) for Wester Ross?

The focus here, as it has been for many years, is to revive the productivity of some of the larger salmon producing rivers. Estates owned by private landowners in other parts of Scotland have sought investments for 'rewildling' projects including large scale tree planting. One landowner in northwest Scotland has already made the restoration of wild salmon a principle objective of a large-scale restoration project. https://atlanticsalmontrust.org/ast-grosvenors-reay-forest-estate-launch-salmon-restoration-project-in-the-scottish-highlands/

A similar ambitious catchment-scale project to take in the big Gruinard River, Little Gruinard River and River Ewe – Loch Maree catchments to revive the great wilderness would be very beneficial for wild salmon. The most urgent priority, to protect riparian habitat along the Abhainn Gleann na Muice (Gruinard River), has already been highlighted earlier in this report. Much more besides wild salmon would benefit from catchment-scale ecosystem recovery initiatives.

4.5 Encourage and support local community groups to look after wild salmon

There are many opportunities for local communities to become more actively involved with wild salmon and sea trout conservation. Active interest should be encouraged; many landowners lack the resources to be able to look after all the things that need looking after on their land on their own. Several opportunities may arise later in 2022.

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6. References and some useful links to further information

Atlantic Salmon Trust (2021) The West Coast Tracking Project https://atlanticsalmontrust.org/our-work/the-west-coast-tracking-project/

Atlantic Salmon Trust (2021) AST & Grosvenor's Reay Forest Estate Launch Salmon Restoration Project in the Scottish Highlands https://atlanticsalmontrust.org/ast-grosvenors-reay-forest-estate-launch-salmon-restoration-project-in-the-scottish-highlands/

Billier, G. (2014) A study of macro-invertebrates and the feeding behaviour of juvenile salmon in the Little Gruinard River SAC, 2014 Engineering Student at Ecole Nationale Supérieure Agronomique de Toulouse 'ENSAT' https://www.wrft.org.uk/files/Little%20Gruinard%20Macroinvertebrate%20Study%202014%20BILLIER%20Geoffrey%20v1.pdf

Cunningham, P. (2011) Little Gruinard River Fisheries Management Plan April 2011 Wester Ross Fisheries Trust https://www.wrft.org.uk/files/Little%20Gruinard%20FMP%20April%202011%20Part%201%20&%2021.pdf

Cunningham, P. (2019) Wester Ross Spring Spawning Herring: Life Cycle and Ecology Poster https://www.wrft.org.uk/files/WesterRossHerringPoster19June2019reworked.pdf

Cunningham, P. (2020) About river banks and juvenile salmon production in Wester Ross. Presentation given at the SFCC meeting at workshop on Riparian Woodlands on 5th February 2020 https://fms.scot/wp-content/uploads/2020/03/200205-SWRFT-Riparian-Peter-C.pdf

Cunningham, P (2020) About ecosystem fertility and juvenile salmon production in Wester Ross. Presentation given at the nutrient additions workshop at the Marine Scotland Freshwater laboratory on 6th February 2020. https://www.wrft.org.uk/files/Peter%20Cunningham%206%20Feb%2020%20Eco%20fertility1.pdf

Cunningham, P. (2021) Of Riparian trees and fish and fire. Published by Matt Hay, Reforesting Scotland Director's blog https://reforestingscotland.org/of-riparian-trees-and-fish-and-fire/

Gilbey, J, J Sampayo, E Cauwelier, I Malcolm, K Millidine, F Jackson & D J Morris (2021) A national assessment of the influence of farmed salmon escapes on the genetic integrity of wild Scottish Atlantic salmon populations. Scottish Marine and Freshwater Science Vol 12 No 12, 70pp. DOI: 10.7489/12386-1 https://data.marine.gov.scot/dataset/national-assessment-influence-farmed-salmon-escapes-genetic-integrity-wild-scottish-atlantic

Jackson, A (2019) Spring spawning herring - Gairloch video. https://vimeo.com/323284761

Mackenzie, John (1803) Extracts from an Essay on the Natural History of Salmon. Trans. Of Highland Society of Scotland, Vol. 11 p 377.

NASCO (2019) State of North Atlantic Salmon https://nasco.int/atlantic-salmon/state-of-salmon/#:~:text=A%20Species%20in%20Crisis&text=Between%201983%20and%202016%20%E2%80%93%20a,fell%20by%20more%20than%20half.

Norwegian Advisory Committee for Atlantic Salmon (2021) Status of Wild salmon in Norway 2021 https://www.vitenskapsradet.no/Portals/vitenskapsradet/Status%20of%20wild%20Atlantic%20salmon%20in%20Norway%202021.pdf

Pritchard, V. and others (2021) River Carron Catchment Scale Restoration Programme Phase IIa: Assessment of the Proportion of Offspring from the 2014 Carron Atlantic Salmon Broodstock among Smolts and Returning Adults.
https://static1.squarespace.com/static/6011565a6d3d7619bc09e764/t/617914ce62c22f532e4d5e27/1635325135657/River_Carron_Restoration_Phase_IIa_Report_FINAL.pdf

Rabe, B, A Gallego, J Wolf, R O Murray, C Stuiver, D Price, H Johnson (2020) Applied connectivity modelling at local to regional scale: The potential for sea lice transmission between Scottish finfish aquaculture management areas, Estuarine, Coastal and Shelf Science, Volume 238, 2020, 106716, ISSN 0272-7714, https://doi.org/10.1016/j.ecss.2020.106716

Scottish Government (2021) Salmon fishing: proposed river gradings for 2022 season
https://www.gov.scot/publications/salmon-fishing-proposed-river-gradings-for-2022-season/

Scottish Government (2021) National Electrofishing Programme of Scotland
https://www.gov.scot/publications/national-electrofishing-programme-for-scotland/

Scottish Government (2021) New Reports Looking at Sea lice dispersal around Scotland
https://blogs.gov.scot/marine-scotland/2020/03/30/new-reports-looking-at-sea-lice-dispersal-around-scotland/

Scottish Government (2022) Scottish Wild Salmon Strategy https://www.gov.scot/publications/scottish-wild-salmon-strategy/

Scottish Government (2022) Scotland's aquaculture – sea lice data
https://scottishepa.maps.arcgis.com/apps/webappviewer/index.html?id=2218824350e5470e8026076d4138da58

Scottish Government (2022) Scotland River Temperature Monitoring Network (including papers by Jackson and others) https://www.gov.scot/publications/scotland-river-temperature-monitoring-network-srtmn/pages/overview/

SEPA (2021) Protecting Scotland's wild Atlantic salmon 'a national priority' as protection zones and sea lice thresholds proposed by SEPA https://media.sepa.org.uk/media-releases/2021/protecting-scotlands-wild-atlantic-salmon-a-national-priority-as-protection-zones-and-sea-lice-thresholds-proposed-by-sepa.aspx

Skye and Wester Ross Fisheries Trust (2018) SWRFT Review February 2018
https://www.wrft.org.uk/files/SWRFT%20Review%20February%202018%20Final%20for%20web%20V2.pdf

Skye and Wester Ross Fisheries Trust (2020) SWRFT Review September 2020
https://www.wrft.org.uk/news/newsitem.cfm?id=227

Wester Ross Fisheries Trust (2009) WRFT Fisheries Management Plan
https://www.wrft.org.uk/downloads/files.cfm?id=17

Wester Ross Fisheries Trust (2016) Refertilising Wester Ross workshop presentations and report
https://www.wrft.org.uk/downloads/files.cfm?id=39

WRFT (2021) Are lice levels too high to safeguard wild salmon migrating through coastal waters around Wester Ross? https://www.wrft.org.uk/news/newsitem.cfm?id=229

WRFT (2021) Just four sea lice on 20 sea trout caught in the Kanaird estuary
https://www.wrft.org.uk/news/newsitem.cfm?id=231