Viking Energy Wind Farm, fish population monitoring: Construction phase, 2024

Commissioned Report to Viking Energy Wind Farm LLP

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Waterside Ecology
Druimindarroch
Arisaig
Inverness-shire
PH39 4NR
T: 01687 450298
M: 07788 717605
jon@watersideecology.co.uk

www.watersideecology.co.uk

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SUMMARY

Background

This report provides an assessment of fish populations in streams draining the Viking Energy Wind Farm. A pre-construction baseline was set for most (n = 31) sites in 2019. The first round of construction phase monitoring took place in 2020 at a limited series of sites where construction had commenced. Baseline data were collected from three new sites (CR2, CR3 and WE1a) in the same year.

The first full round of construction phase monitoring took place in 2021 and all sites were re-surveyed in 2022 and 2023. The current survey took place at the end of the fourth year of the construction phase for the site. The aim was to assess fish populations in potentially impacted streams and to compare current densities with baseline data. A series of control sites has been included each year in order to determine temporal trends in streams outside the wind farm site.

Methods

Electric fishing surveys were carried out at 34 sites in 22 streams across 11 catchments. This comprised 28 impact monitoring sites spread over 9 catchments and 6 control sites in 3 catchments. Sites are harmonised with those used for monitoring of freshwater macroinvertebrates and hydrochemistry, as set out in the Water Quality Monitoring Plan (Viking Energy 2018).

Trout and salmon were the main target species for survey, but all fish caught were recorded. The survey used fully-quantitative methods according to the SFCC (2014) protocol.

Main findings

- Trout were present at 33 out of 34 survey sites. Densities remain highly variable across the site, as they have been during past surveys. However, relative abundances in the various streams broadly matched those observed during the baseline and previous surveys.
- As in 2022 and 2023, trout were absent from survey site LU1 and adjacent reaches in Burn of Lunklet.
- There was an increase in trout fry density at 23 of 28 impact monitoring sites. Mean density increased from 18.3 per 100 m^2 during baseline to 38.1 per 100 m^2 in 2024. A paired T-test showed that the change in mean fry density was significant ($T = 4.07$, $df = 27$, $p < 0.001$). Fry densities in the control streams showed a similar trend and also increased significantly.
- Trout parr densities declined at the majority of impact monitoring sites when compared with baseline and the mean density changed from 11.0 during baseline to 6.9 per 100 m^2 in 2024 ($T = 2.65$, $df = 27$, $p = 0.013$). Parr densities were also lower at all six control sites with a decline in mean density from 23.3 per 100 m^2 during baseline to 9.7 in 2024 ($T = 2.42$, $df = 5$, $p = 0.06$).
- Overall, the similarity of trends at impact and control sites suggests that regional factors, perhaps related to climate, are likely to be the main drivers of wide-scale fluctuations in juvenile trout numbers.
- Atlantic salmon remain scarce in Laxo Burn and South Burn of Burrafirth. Small numbers of salmon parr were present in both watercourses but no fry were present in samples. Salmon presence in these watercourses was sporadic prior to construction and no trends have been apparent since construction started.

- Salmon fry and parr were present in Burn of Weisdale, as they have been every year since the 2019 baseline. Salmon parr were present in Burn of Droswall, a tributary of Burn of Weisdale.
- Trout densities were considered in relation to hydrochemical and freshwater invertebrate data in order to assess whether any observed declines may be related to construction activities. The chemical changes that have been identified in Burn of Lunklet, along with impacts on physical habitats, appear to have left this stream unsuited to trout production. Some downstream impact into site BF1 in Burn of Burrafirth may also have occurred, but due to the historically low fish density at this site this is uncertain. Watercourses linked to Burn of Lunklet continue to sustain trout, providing potential sources for recolonisation should conditions improve.
- Trout numbers increased at WE3 in Burn of Weisdale, where observed declines in 2023 may have been related to construction impacts due to runoff.
- Due to the high degree of variability in time series data prior to any observed changes in water chemistry, it is uncertain whether observed declines in trout densities in Burn of Flamister or Burn of Marrofield Water are related in any way to construction. No substantial changes have been observed in freshwater invertebrate populations at these locations that would confirm impacts.

The findings are discussed in relation to the wind farm development. It is recommended that efforts to mitigate the impact from runoff from Scallafield Scord into Burn of Lunklet and Burn of Weisdale should continue. In addition, it is recommended that monitoring of the success or otherwise of mitigation measures should continue and be subject to ongoing assessment and review.

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1 Introduction

A series of water quality monitoring programmes has been put in place to assess any impacts from construction or operation of Viking Energy Wind Farm on the watercourses draining the site. The identified sensitive ecological receptors are aquatic macro-invertebrates and fish. Stream hydrochemistry is monitored monthly and aids interpretation of the biological data as well as providing direct measures of water quality. The monitoring programme and sampling locations were agreed with statutory consultees during early 2019, as part of the overall Water Quality Monitoring Plan for the site (Viking Energy 2018).

Baseline data on fish were collected at 31 sites, including six control sites, prior to construction (Waterside Ecology 2020). The construction phase of the Viking Energy Wind Farm started in June 2020, in a limited area. Fish populations in potentially impacted streams and appropriate control sites were surveyed in 2020 (Waterside Ecology 2021a & 2021b) and construction phase monitoring of fish across the full wind farm site was completed in 2021, 2022 and 2023 (Waterside Ecology 2021c, 2022, 2023). This report presents results of monitoring in late summer 2024.

2 Objectives

The aim was to assess fish populations across the Viking Energy Wind Farm site for comparison with baseline data gathered at the same sites before development works commenced. Most baseline data were collected in 2019. Specific aims were to:

- Re-survey impact monitoring sites in watercourses draining the site;
- Re-survey the control sites, unaffected by construction;
- Assess densities and temporal trends in trout and salmon numbers at impact monitoring and control sites;
- Identify any evidence of changes in fish populations, especially where these might be attributable to construction work at the site or associated changes in water quality.

3 Methods

3.1 Survey area and survey conditions

All sites were surveyed during late August and early September 2024 by a single SFCC-qualified electric fishing team from Waterside Ecology. Survey conditions were generally good with low or moderate water levels at all sites with the exception of Burn of Laxobigging, a control stream, where water level was moderate to high.

Water temperatures during the surveys ranged from 11.5°C to 15°C (Appendix 8.2).

3.2 Electric fishing methods

Electric fishing was used to assess the densities of salmonids and eels at all survey sites. Sites that had been surveyed in previous years were identified from markers, grid references, site descriptions and site photographs. Multi-run (fully quantitative) electric fishing was conducted at all sites, based on Scottish Fisheries Co-ordination Centre protocols (SFCC 2014). Details of fully quantitative methods are provided by Waterside Ecology (2020), but in essence provide an estimate of total fish numbers based on depletions in catch attained during three or more consecutive survey runs through a site.

3.3 Nomenclature and data presentation

Throughout this report, the term fry is used to describe young of the year salmonid fish. This cohort is also referred to as 0+ (i.e. fish in their first year of life). The term parr is used to describe fish of more than one year and at some sites may include one or two mature fish. The shorthand terms 1+ and 2+

refer to parr in their second and third years of life respectively.

For ease of description and consistency with earlier reports the density classifications provided by Godfrey (2006) are used as a guide to relative abundance of salmon fry and parr. The density classification scheme, based on single run electric fishing, is set out in Table 1. As Godfrey did not have access to any density data from Shetland the Scotland-wide scheme is used. Most of the streams included in the current survey are small, so the relative classification for streams of less than 4 m wide is used throughout this report.

Table 1 Quintile range of salmonid densities for rivers up to 4 m in width throughout Scotland (from Godfrey 2006)

	Density (fish.100 m^{-2})			
	Salmon 0+	*Salmon 1++*	*Trout 0+*	*Trout 1++*
Min	0.2	0.7	0.6	0.7
20th percentile	4.3	2.5	4.5	4.5
40th percentile	8.7	5.1	11.0	5.0
60th percentile	15.2	8.3	22.9	8.3
80th percentile	35.2	15.8	49.9	15.3
Max	497.7	79.0	415.7	174.2

Table 2 Descriptive categories for density used in text (see Table 1 for quintile ranges)

Density in regional classification	**Description used in text**
< 20th percentile	Very poor
20th to 40th percentile	Poor
40th to 60th percentile	Fair
60th to 80th percentile	Good
80th to 100th percentile	Excellent

3.4 Analyses

Depletion estimates were calculated for fully quantitative sites using the *Removal Sampling 2* software (Pisces Conservation Ltd., 2007). The estimator used was Maximum Likelihood (ML) also known as the Zippin estimate. *Removal Sampling 2* provides test statistics to determine whether the data depart significantly from the assumption of constant capture efficiency, inherent in the estimate. All fish densities are expressed as fish per 100 square metres (fish.100m^{-2}). Upper and lower 95% confidence intervals are provided for Zippin estimates. These are often asymmetric. Densities are based on wetted areas as measured during the baseline, since wet width can vary depending on water level.

3.5 Survey sites

A total of 34 sites were surveyed, 28 impact sites and a further 6 control sites, distributed over 22 streams and 11 catchments (Tables 3 and 4). Thirty-one of these sites were included in the baseline fish survey, conducted during 2019.

Baseline data from additional sites CR2 and CR3 on Burn of Crookadale and WF2 Wester Filla Burn were collected in 2020 (Waterside Ecology 2021). Site WF1 was replaced by WF1a in 2021 as the original had scoured down to such a depth (presumably due to spates) that it was no longer surveyable. WF1a is a short distance upstream of the original location in similar habitat.

Construction work had extended into the catchments of all watercourses by 2020 or 2021. Therefore all sites, with the exceptions of those in control streams, can be viewed as potentially impacted by construction work.

Table 3 Locations of electric fishing sites (impact sites)

Site	Watercourse	Catchment	NGR	Survey method
LA1	Laxo Burn	Laxo	HU 43942 63020	Fully quantitative
GO1	Gossawater Burn	Laxo	HU 43712 62535	Fully quantitative
CO1	Corgill Burn	Laxo	HU 43551 60235	Fully quantitative
EF1	Easter Filla Burn	Laxo	HU 42424 62324	Fully quantitative
GR1	Burn of Grunnafirth	Grunnafirth	HU 45748 58851	Fully quantitative
GR2	Burn of Grunnafirth	Grunnafirth	HU 45258 58134	Fully quantitative
QU1	Burn of Quoys	Quoys	HU 44688 55292	Fully quantitative
CR1	Burn of Crookadale	Crookadale	HU 43360 53944	Fully quantitative
CR2	Burn of Crookadale	Crookadale	HU 2839 54059	Fully quantitative
CR3	Burn of Crookadale	Crookadale	HU 42839 54059	Fully quantitative
GI1	Gill Burn	Crookadale	HU 43558 54625	Fully quantitative
FL1	Burn of Flammister	Crookadale	HU 43787 55037	Fully quantitative
PW1	Burn of Pettawater	Stromfirth	HU 41593 55531	Fully quantitative
PW2	Burn of Pettawater	Stromfirth	HU 41693 56975	Fully quantitative
WE1	Burn of Weisdale	Weisdale	HU 40128 54283	Fully quantitative
WE2	Burn of Weisdale	Weisdale	HU 40215 55242	Fully quantitative
WE3	Burn of Weisdale	Weisdale	HU 40511 56722	Fully quantitative
WE4	Burn of Weisdale	Weisdale	HU 40526 57788	Fully quantitative
DR1	Burn of Droswall	Weisdale	HU 39956 54987	Fully quantitative
BF1	Burn of Burrafirth	Burrafirth	HU 36687 57505	Fully quantitative
BF2	South Burn of Burrafirth	Burrafirth	HU 36705 56895	Fully quantitative
BF3	South Burn of Burrafirth	Burrafirth	HU 36469 55055	Fully quantitative
LM1	Burn of Lamba Water	Burrafirth	HU 37448 57107	Fully quantitative
LU1	Burn of Lunklet	Burrafirth	HU 37400 57302	Semi quantitative
MA1	B. of Marrofield Water	Burrafirth	HU 37348 57296	Fully quantitative
KI1	Burn of Kirkhouse	Kirkhouse	HU 39830 61701	Fully quantitative
WF1a	Wester Filla Burn	Voe	HU 41561 62202	Fully quantitative
WF2	Wester Filla Burn	Voe	HU 41529 61165	Fully quantitative

*Original site WF1 was moved slightly upstream in 2021

Table 4 Locations of electric fishing sites (control sites)

Site code	Watercourse	Catchment	NGR	Survey method
SE1	Seggie Burn	Laxo	HU 43948 63767	Fully quantitative
SE2	Seggie Burn	Laxo	HU 43642 64667	Fully quantitative
LB1	Burn of Laxobigging	Laxobigging	HU 41710 07271	Fully quantitative
LB2	Burn of Laxobigging	Laxobigging	HU 41421 72398	Fully quantitative
SA1	Burn of Sandgarth	Sandgarth	HU 40796 68070	Fully quantitative
SA2	Burn of Sandgarth	Sandgarth	HU 40869 67447	Fully quantitative

4 Results

4.1 Impact monitoring sites

4.1.1 Laxo catchment

Trout fry were present at all sites in the Laxo catchment (Table 5). Fry densities ranged from poor to excellent by national standards, with the highest density at CO1 in Corgill Burn, which runs into Gossa Water. This stream appears to provide good spawning opportunities and high trout fry densities have been recorded here during past surveys. Fry density at GO1 in the outflow stream from Gossa Water was good. Fry density at EF1, in Easter Filla Burn was also good; this is another small stream that provides good spawning habitat close to the monitoring site. Trout parr were present at all sites. Numbers were quite low at three sites but the density at CO1 was excellent.

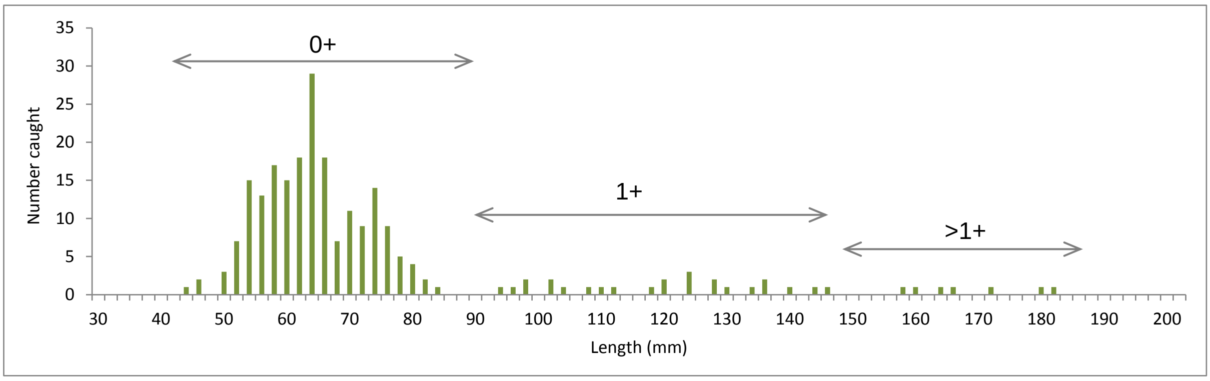
Table 5 Trout densities (fish.100 m^{-2}) and total number of eels, Laxo catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
LA1	7.9	1.4	Poor	Very poor	8.6 (8.6 – 8.7)	5.0 (N/A)	6
GO1	39.5	3.0	Good	Very poor	63.5 (60.3 – 68.7)	5.8 (4.9 – 9.8)	5
CO1	72.3	19.8	Excellent	Excellent	100.2 (97.8 – 105.0)	19.8 (N/A)	2
EF1	24.5	3.7	Good	Very poor	38.9 (37.8 – 41.0)	4.6 (4.6 – 4.7)	0

*Data are Zippins with 95% confidence limits or, if italicised, based on single run data and correction factors

Trout size distribution in the Laxo catchment (Figure 1) shows a clear fry year class with lengths ranging from 45 mm to 85 mm (mean 69.1, σ = 11.1). Length frequencies for each site are provided in Appendix 8.4. Parr ranged in length from 95 mm to 186 mm and scale readings suggested most were aged 1+ with small numbers of older fish also present.

Figure 1. Trout size distribution, Laxo catchment



Salmon were present only at LA1, where three salmon parr were caught. These ranged in length from 109 to 118 mm in length and all were aged 1+ year. No salmon were seen or captured at other sites in the Laxo catchment (Table 6).

Table 6 Salmon densities (fish.100 m^{-2}) Laxo catchment

Site	Salmon density single run		Density classification		Salmon density Zippin with 95% confidence limits	
	Fry	Parr	Fry	Parr	Fry	Parr
LA1	0.0	0.7	-	Very poor	0.0	2.1 (N/A)
GO1	0.0	0.0	-	-	0.0	0.0
CO1	0.0	0.0	-	-	0.0	0.0
EF1	0.0	0.0	-	-	0.0	0.0

European eels were present at three of four sites (Table 5). No other fish species were seen or caught at sites in the Laxo catchment.

4.1.2 Grunnafirth catchment

No salmon were recorded in Burn of Grunnafirth but trout were present at both monitoring sites (Table 7). Single-run fry densities were classified as good and fair at GR1 and GR2 respectively. The Zippin estimates of true density suggest over 30 fry per 100 m^2 were present at both sites. These data suggest relatively good spawning success after a poor year in 2023 (Waterside Ecology 2023). Parr density was classified as very poor at GR1 and good at GR2, but densities were much lower than for fry.

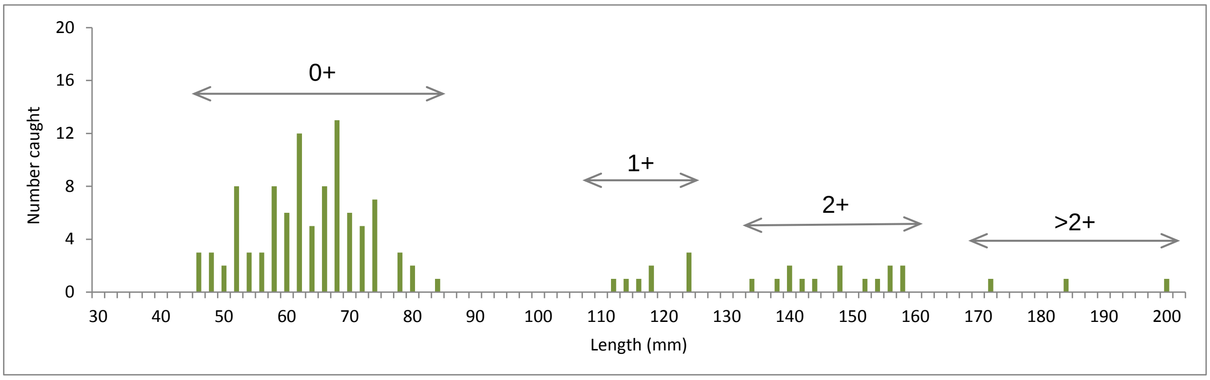
Trout fry ranged in length from 54 mm to 86 mm (mean = 62.8 mm, σ = 8.5 mm) and there was no length overlap with the 1+ year class. Few 1+ trout were present, reflecting the low fry density in 2023. Scale readings showed that trout aged 2+ and older were present in small numbers. This stream is accessible from the sea and it is probable that a proportion of older parr will migrate to sea as sea trout smolts.

Eels were present in small numbers at both sites. No other fish species were seen or captured.

Table 7 Trout densities (fish.100 m^{-2}) and total number of eels, Grunnafirth catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
GR1	24.4	3.3	Good	Very poor	38.0 (36.2 - 41.2)	5.5 (5.3 – 6.4)	1
GR2	16.3	9.8	Fair	Good	30.7 (28.0 – 35.4)	11.1 (11.1 – 11.3)	3

Figure 2. Trout size distribution, Grunnafirth catchment



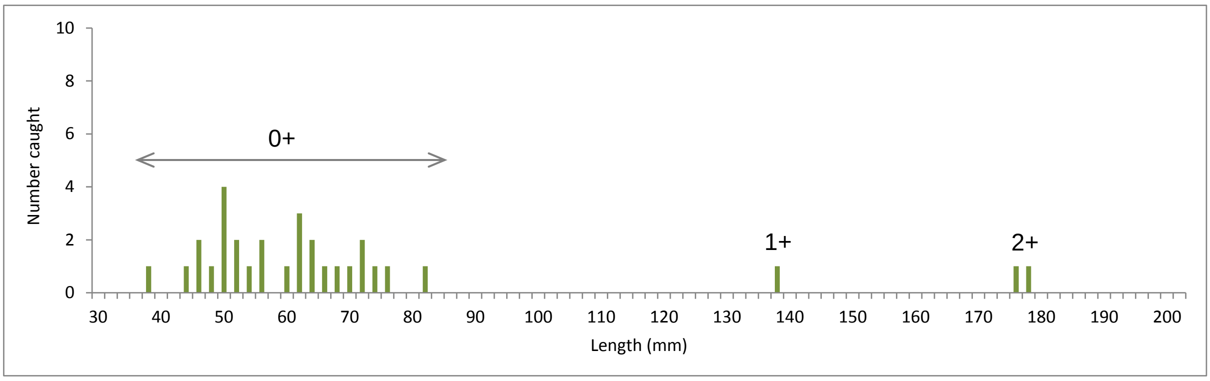
4.1.3 Quoys catchment

As in previous surveys, no salmon were recorded at QU1. Trout fry and parr were present. Fry density was classified as fair but very few parr were present with only one 1+ and two older parr (Figure 3). Four European eels were captured. No other fish species were seen or caught.

Table 8 Trout densities (fish.100 m^{-2}) and total number of eels, Quoys catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
QU1	13.0	1.5	Fair	Very poor	22.8 (21.3 – 26.2)	2.3 (2.3 – 2.9	4

Figure 3. Trout size distribution, Quoys catchment



4.1.4 Crookadale catchment

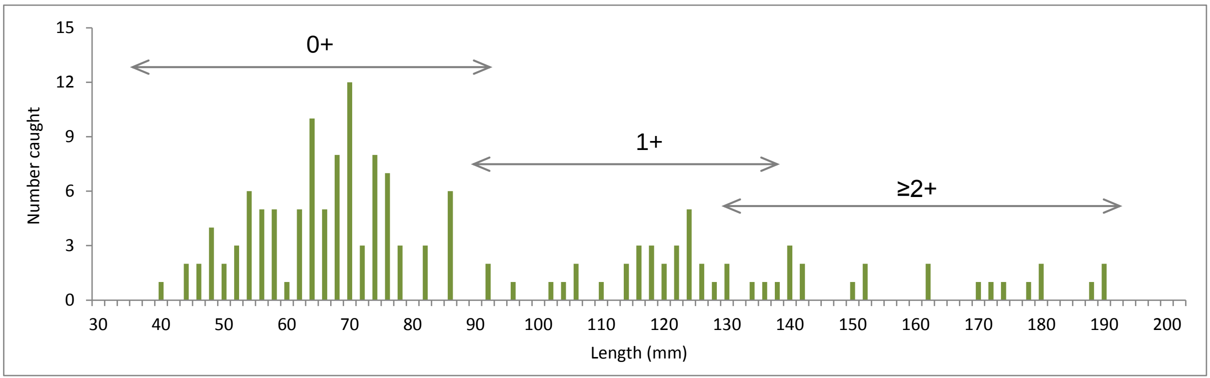
Five sites were surveyed in the Crookadale catchment, three in Burn of Crookadale, one in Gill Burn and one in Burn of Flamister (Table 9). Trout fry were present at all sites, with density classifications ranging from poor at CR2 to good at GI1. Parr densities were good or excellent at all three sites in Burn of Crookadale but few were present in Gill Burn or Burn of Flamister.

Table 9 Trout densities (fish.100 m^{-2}) and total number of eels, Crookadale catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
CR1	20.2	11.4	Fair	Good	27.6 (27.2 – 29.1)	16.0 (15.8 – 17.1)	1
CR2	5.8	16.2	Poor	Excellent	8.2 (8.1 – 9.1)	17.3 (16.7 – 18.0)	0
CR3	14.4	12.2	Fair	Good	21.1 (20.0 – 24.1)	16.9 (16.7 – 18.0)	3
GI1	30.6	1.4	Good	Very poor	40.9 (40.3 – 43.1)	3.0 (2.8 – 5.0)	3
FL1	17.5	2.3	Fair	Very poor	19.8 (19.8 – 20.2)	2.3 (N/A)	1

Trout fry in the Crookadale catchment ranged in length from 40 mm to 92 mm (mean 65.3, σ = 11.1). Growth of parr was quite variable. The 1+ class had lengths ranging from 92 to at least 136 mm, confirmed by scale readings. The smallest 2+ parr from which scales were taken was 130 mm long.

Figure 4. Trout size distribution, Crookadale catchment



The waterfall near the tidal limit on Burn of Crookadale has not been fully assessed. It is uncertain whether it is passable to salmon or sea trout. As such it is not known if the trout population has a sea trout component or not. Small numbers of European eels were captured at four of the five sites, demonstrating that the waterfall is passable for this species. No other fish species was captured.

4.1.5 Stromfirth catchment

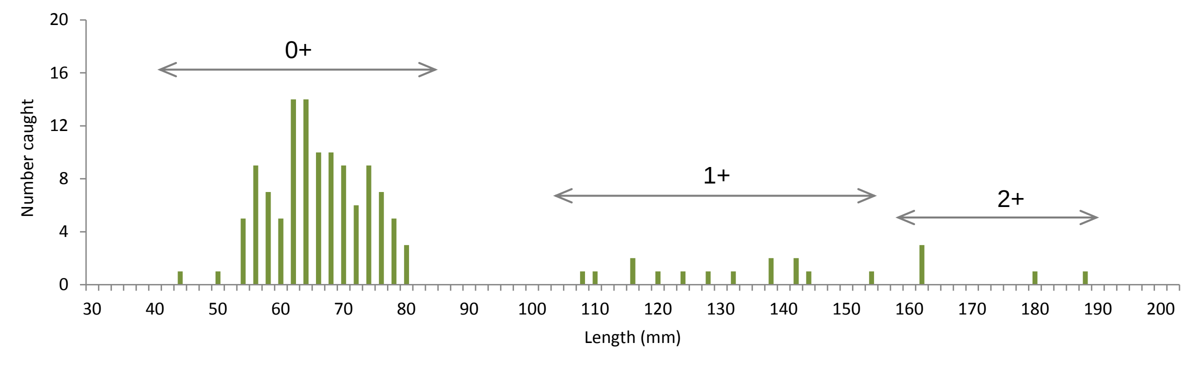
Trout and European eels were recorded in Burn of Pettawater (Table 10). Trout fry density was classified as good at PW1 and fair at PW2. Capture efficiency was not particularly good at PW2 (see Appendix 8.3) and the Zippin estimate of total density was over twice the single-run figure. Trout parr density was fair at PW1 but very poor at PW2, with only 6 captured over the three electric fishing runs. PW1 is known to be accessible to sea trout and salmon. A waterfall just downstream of PW2 may present a partial or full barrier to one or both of these species.

Table 10 Trout densities (fish.100 m^{-2}) and total number of eels, Stromfirth catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
PW1	38.3	5.4	Good	Fair	54.0 (52.6 – 56.4)	7.9 (7.8 – 8.7)	12
PW2	11.3	3.8	Fair	Very poor	24.2 (21.1 – 30.3)	4.5 (4.5 – 4.8)	4

Trout fry in the Burn of Pettawater were between 43mm and 80 mm in length and there was no size overlap with the 1+ year class (Figure 5). Scale reading indicated that some of the parr were very fast growing and the largest 1+ parr was 153 mm long.

Figure 5. Trout size distribution, Stromfirth catchment, Burn of Pettawater



European eels were present at both sites, with the highest density at PW1 where macrophytes provide good cover. In addition, a single three-spined stickleback was caught at PW1.

4.1.6 Weisdale catchment

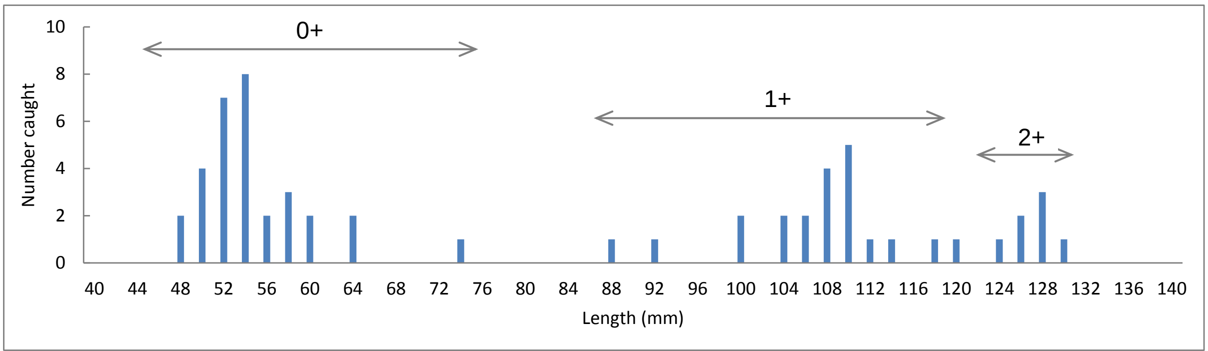
Salmon were caught at the two most downstream sites in Burn of Weisdale (WE1 and WE2) and at DR1 in Burn of Droswall[1] (Table 11). Fry were caught mainly at WE1, where the single-run density was good. Fry were very scarce at WE2 and absent at DR1. This suggests little or no spawning took place in the reaches immediately adjacent to the wind farm. Salmon parr densities at WE1 and WE2 were classified as good and fair respectively. Salmon fry ranged in length from 47 mm to 74 mm (Figure 6). Scale readings found that two parr year classes, 1+ and 2+ were present in the samples.

Table 11 Salmon densities (fish.100 m^{-2}), Weisdale catchment

Site	Salmon density single run		Density classification		Salmon density Zippin with 95% confidence limits	
	Fry	Parr	Fry	Parr	Fry	Parr
WE1	23.2	10.0	Good	Good	34.0 (33.2 - 36.5)	16.6 (16.6 – 33.0)*
WE2	0.9	5.1	Very poor	Fair	0.9 (N/A)	6.9 (6.9 – 9.9)*
WE3	0.0	0.0	-	-	0.0	0.0
WE4	0.0	0.0	-	-	0.0	0.0
DR1	0.0	6.6	-	Fair	0.0	6.6 (N/A)

*Poor depletion model rejected

Figure 6. Salmon size distribution, Weisdale catchment



[1] This stream is more accurately called Burn of Scallafield and the error is acknowledged. We have retained the name Burn of Droswall and site code DR1 for consistency with earlier reports.

Trout fry were present at all five sites in the Weisdale catchment (Table 12). Densities varied widely and classifications ranged from poor at two sites in Burn of Weisdale to good at DR1. Parr densities were generally low. The highest trout parr density was at WE4, which has some long deep glides with undercut banks that are suited to 1+ and older trout.

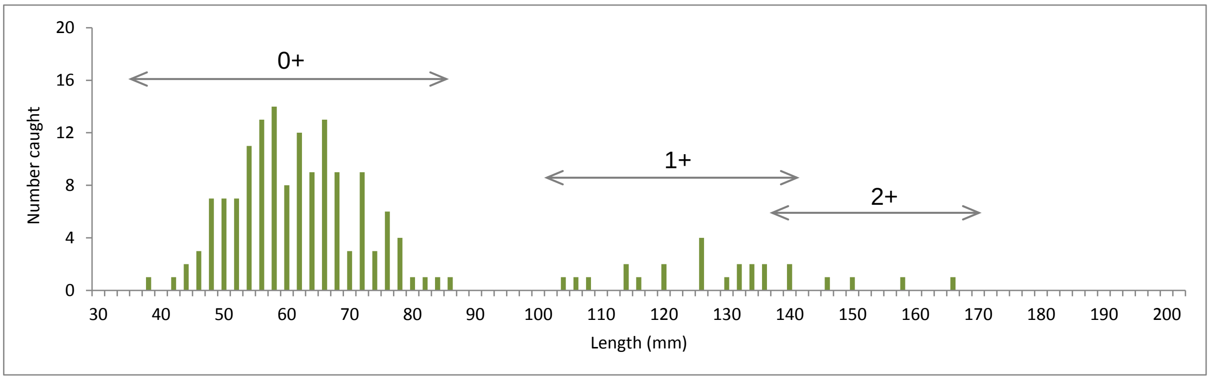
Table 12 Trout densities (fish.100 m^{-2}) and total number of eels, Weisdale catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
WE1	11.1	1.1	Fair	Very poor	29.4 (23.2 – 43.6)	3.3 (N/A)	8
WE2	7.7	1.7	Poor	Very poor	9.5 (9.4 – 9.9)	5.0 (3.4 – 14.1)	16
WE3	22.2	2.2	Fair	Very poor	42.0 (37.1 – 49.5)	2.2 (N/A)	2
WE4	8.7	6.8	Poor	Fair	22.0 (17.4 – 33.6)	12.7 (11.6 – 16.1)	2
DR1	48.6	5.3	Good	Fair	60.9 (60.4 – 62.6)	6.6 (6.6 – 8.6)	7

The relatively strong 0+ cohort is clear in Figure 7, with lengths ranging from 38 mm to 85 mm (mean 59.5 mm, σ = 10.1). Two parr year classes were present in the sample. As in other streams accessible from the sea it is likely that many juvenile trout migrate to sea as 'sea trout' smolts.

European eels were present at all sites and were quite abundant at WE2. Good cover is present here in macrophytes and stones. No other fish species were seen or caught.

Figure 7. Trout size distribution, Weisdale catchment



4.1.7 Burrafirth catchment

Juvenile salmon were present only at BF3, where a single parr of 126 mm in length was caught. Scales showed this fish to be aged 1+, with very rapid growth apparent during 2024.

Trout were present at all sites in the Burn of Burrafirth catchment with the exception of LU1 on Burn of Lunklet (Table 14). Trout fry density varied greatly, with classifications ranging from very poor in Burn of Burrafirth at BF1, through fair at BF2 to good at LM1 in Burn of Lambawater. Trout parr were generally scarce and the highest density recorded was only 4.0 per 100 m^2, at LM1. Parr density was classified as very poor at all sites where they were present. The scarcity of 1+ parr reflects the very low fry densities recorded in 2023.

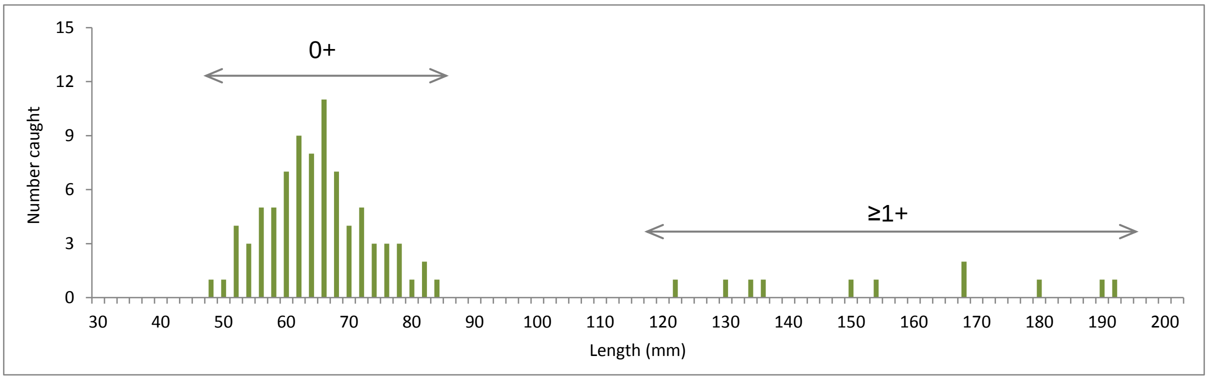
The trout fry cohort in 2024 (Figure 8) was clearly identifiable and lengths did not overlap with the 1+ year class (Figure 8). Mean length of fry across all sites was 64.3 mm (σ = 7.9 mm). Too few scales were taken to separate parr age groups but it seems probable that at least two parr age classes were present.

Eels were present at all six sites. The presence of eels at LM1, LU1 and MA1 suggests that eels can ascend the waterfall in the lower reaches of Burn of Lunklet, but the low numbers indicate this may be difficult. Most of the eels at BF1 and BF2 were quite small and some undoubtedly migrated into the stream in the months before sampling took place.

Table 13 Trout densities (fish.100 m^{-2}) and total number of eels, Burrafirth catchment

Site	**Trout density** single run		**Density classification**		**Trout density** Zippin with 95% confidence limits		**European eels** (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
BF1	1.9	0.6	Very poor	Very poor	1.9 (N/A)	0.6 (N/A)	2
BF2	6.3	3.6	Poor	Very poor	7.2 (7.1 – 7.4)	3.6 (N/A)	12
BF3	17.2	0.9	Fair	Very poor	27.0 (25.9 – 29.8)	0.9 (N/A)	11
LM1	33.0	4.0	Good	Very poor	42.3 (42.0 – 43.8)	4.0 (N/A)	2
LU1	0.0	0.0	-	-	0.0	0.0	1
MA1	3.4	2.2	Very poor	Very poor	3.4 (N/A)	3.4 (3.4 - 4.2)	2

Figure 8. Trout size distribution, Burrafirth catchment



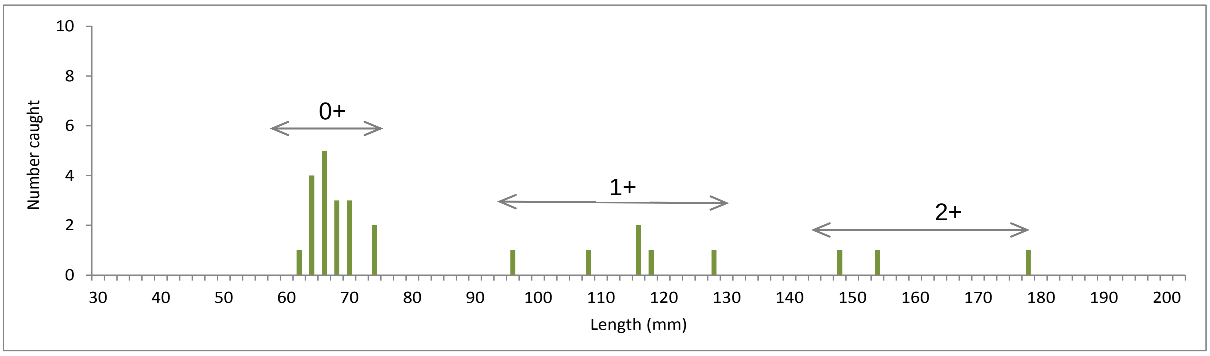
4.1.8 Kirkhouse catchment

Trout fry and parr were present at KI1. The site is inaccessible to salmon or sea trout due to waterfalls and a man-made obstacle, both a short distance upstream of the tidal limit. Single run trout fry and parr densities were both classified as fair (Table 15). True densities, based on correction factors, were estimated to be 16.4 fry and 8.3 parr per 100 m^2. Three year classes, 0+, 1+ and 2+ were present in the sample (Figure 9). A single eel was captured but no other fish species were seen.

Table 14 Trout densities (fish.100 m^{-2}) and total number of eels, Kirkhouse catchment

Site	**Trout density** single run		**Density classification**		**Trout density** Zippin with 95% confidence limits		**European eels** (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
KI1	12.1	5.2	Fair	Fair	16.4 (15.6 – 19.6)	8.3 (7.8 – 10.2)	1

Figure 9. Trout size distribution, Kirkhouse catchment



4.1.9 Manse Burn (Voe) catchment

Trout fry were abundant at both sites on the Wester Filla Burn, with densities classified as excellent by national standards (Table 16). The single-run and total density estimates for trout fry were the highest recorded during the current survey. Total trout density at WF1a was almost 2 fish per m^2. High fry densities are consistently found in this watercourse, reflecting the quality of spawning habitats. Trout fry lengths ranged from 38 mm to 83 mm, with a mean of 58.0 mm (σ = 10.3 mm).

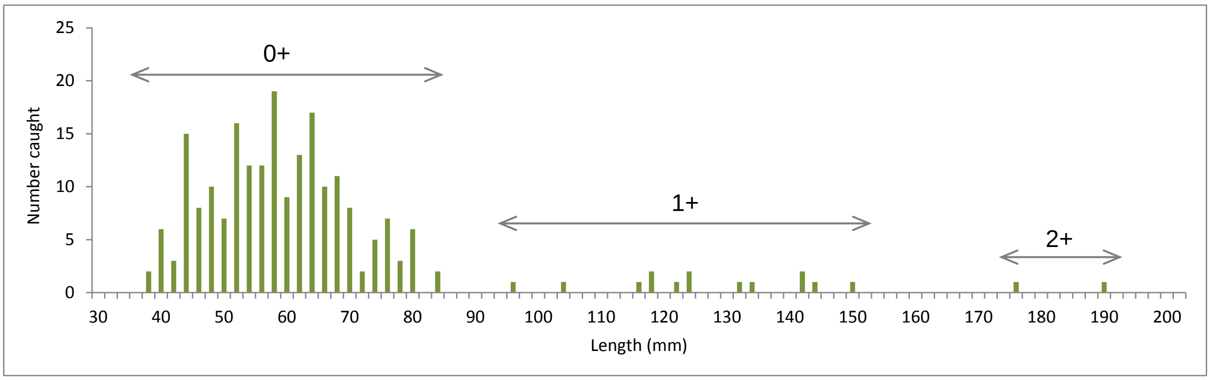
Small numbers of 1+ and 2+ parr were also present, ranging in length from 96 mm to 190 mm. It is thought that trout drop downstream out of this burn into Loch of Voe as they grow and develop, so the low relative parr densities at survey sites are expected.

European eels were present at both sites. Salmon and sea trout are not found in this watercourse, as access is not possible due to cascades downstream of Loch of Voe. Due to their ability to climb over suitable wet substrates, eels may often be found where migratory salmonids are not.

Table 15 Trout densities (fish.100 m^{-2}) and total number of eels, Manse Burn (Voe) catchment

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
WF1a	80.0	7.4	Excellent	Fair	183.1 (150.3 - 215.8)	11.4 (11.1 - 12.9)	2
WF2	73.8	3.3	Excellent	Very poor	122.3 (114.5 - 131.6)	10.5 (7.7 – 22.0)	1

Figure 10. Trout size distribution, Manse Burn (Voe) catchment



4.2 Control sites

4.2.1 Seggie Burn (Laxo catchment)

Trout were present at both sites on Seggie Burn but salmon were absent, consistent with previous surveys. The burn is accessible from the sea via Laxo Burn so some sea trout may be present in the trout population. Trout fry density was fair at both sites. Zippin estimates of true densities were 23.0 and 27.9 at SE1 and SE2 respectively. Single-run parr densities were classified as fair at SE1 and good at SE2. Capture efficiency was high at both sites (Appendix 8.3), so the Zippin density estimates did not greatly exceed the single-run densities.

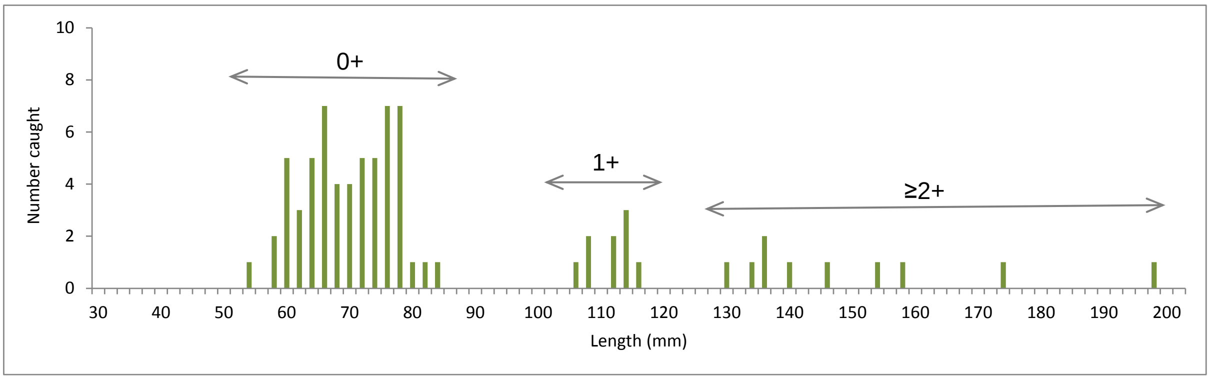
Table 16 Trout densities (fish.100 m^{-2}) and total number of eels, Seggie Burn

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
SE1	17.7	5.1	Fair	Fair	23.0 (22.7 – 24.1)	5.9 (5.9 – 6.6)	4
SE2	21.3	9.8	Fair	Good	27.9 (27.6 – 29.1)	11.6 (11.6 – 11.9)	3

Mean fry length was 69.2 mm (σ = 7.0, range 53 mm to 83 mm). At least two older age classes of trout were present. Trout of 134 mm and 140 mm were aged as 2+ on scale reading, suggesting relatively slow growth in 2024.

Eels were present in small numbers at both sites and no other fish species was seen.

Figure 11. Trout size distribution, Seggie Burn



4.2.2 Laxobigging catchment

Small numbers of salmon parr have occasionally been caught at LB1, but salmon were absent during the current survey. LB2 is inaccessible to salmon or sea trout due to an old water intake dam.

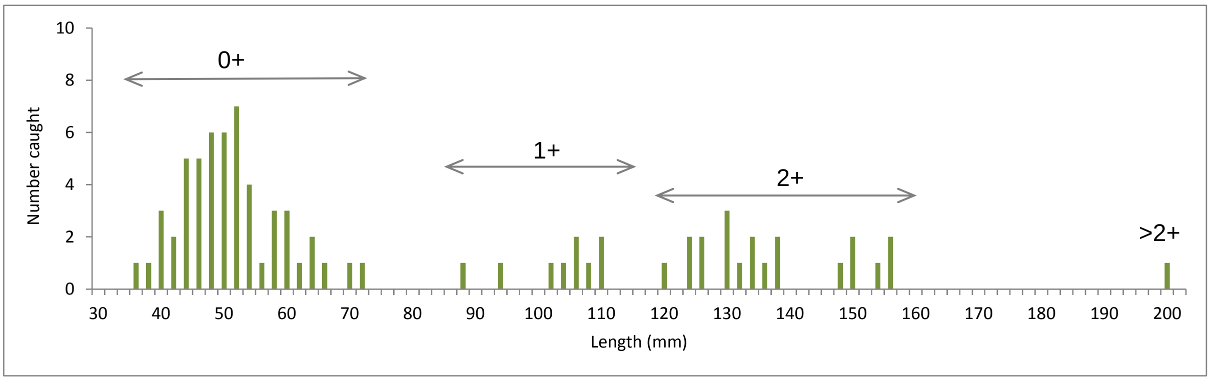
Trout fry and parr were found at both sites (Table 17). Fry densities were both classified as fair and the Zippin estimates of true density were very similar at both sites, at just over 20 fry per 100 m^2. Parr densities were lower than fry densities and were classified as good and fair at LB1 and LB2 respectively. As LB1 is accessible from the sea, it is probable that the trout population at LB1 has a migratory component while that at LB2 is resident.

Table 17 Trout densities (fish.100 m^{-2}) and total number of eels, Burn of Laxobigging

Site	Trout density single run		Density classification		Trout density Zippin with 95% confidence limits		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
LB1	14.7	9.8	Fair	Good	22.4 (21.7 – 24.2)	14.6 (14.0 – 16.5)	8
LB2	13.9	5.5	Fair	Fair	21.3 (20.3 – 24.0)	11.4 (10.2 – 15.4)	3

Trout fry ranged from 35 mm to 72 mm in length (mean 50.5 mm, σ = 8.0). Scale readings suggested that 1+ parr ranged from 86 mm long to 109 mm. Scales taken from five trout ranging in length from 120 mm to 149 mm were all clearly aged at 2+. The parr cohorts were therefore quite small for their age, indicating low growth rates during 2024.

Figure 12. Trout size distribution, Laxobigging catchment



European eels were present in moderate numbers at LB1 and were also present at LB2. Their presence at LB2 demonstrates that eels are able to climb the rough, moss-covered face of the dam upstream of LB1.

4.2.3 Sandgarth catchment

Trout were present at both sites but salmon were absent. Both sites are accessible from the sea and a finnock (small sea trout) with sea louse damage was present in the sample from SA1.

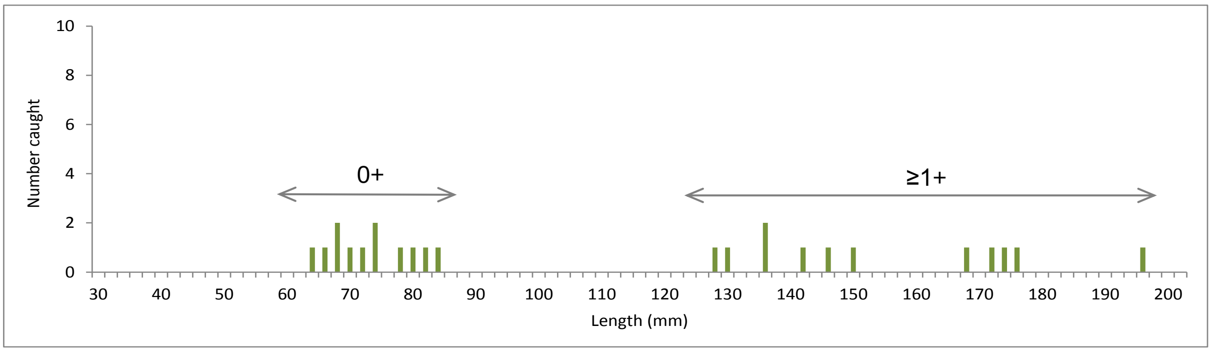
Trout fry and parr densities at SA1 were very poor and poor respectively (Table 18). Over the three electric fishing runs the total catch at SA1 was one trout fry and four parr. Trout were more abundant at SA2, where fry and parr densities were classified as fair and good respectively. Capture efficiencies in the stream were high, so Zippin density estimates were not much greater than the single run densities.

Table 18 Trout densities (fish.100 m^{-2}) and total number of eels, Burn of Sandgarth

Site	Trout density single run		Density classification		Trout density Total density estimate		European eels (n)
	Fry	Parr	Fry	Parr	Fry	Parr	
SA1	1.2	4.7	Very poor	Poor	1.2 (N/A)	4.7 (N/A)	15
SA2	12.5	8.8	Fair	Good	13.8 (13.8 – 14.0)	10.0 (10.0 – 10.3)	3

The trout had a mean length of 72.5 mm (σ = 8.0), which is relatively large compared with some of the other watercourses. However parr growth rates were not particularly high; a trout of 149 mm was found to be 2+ years old and one of 172 mm was aged 3+. Too few scales were taken to determine if 1+ parr were present. Fry were very scarce in 2023 so this cohort may have been absent from samples.

Figure 13. Trout size distribution, Sandgarth catchment



European eels were found at both sites and they were quite abundant at SA1. No other fish species were seen or captured.

5 Discussion

5.1 Data quality and data interpretation

Survey conditions were good at most sites, but due to elevated flows stop nets could not be deployed at LB1 and LB2. Despite the difficult netting conditions at these sites, good depletions were attained during consecutive runs. Nevertheless it is possible that some fish may have moved out of the site due to lack of enclosures, in which case the Zippin density estimates may under-estimate actual fish densities. At almost all other sites, the consistent depletions in fish numbers during consecutive electric fishing runs suggest reliable density estimates from the enclosed sites.

Baseline fish data were collected at some sites for more than one year prior to construction. These data are summarised by Waterside Ecology (2020). An important finding in relation to impact detection was that substantial changes in fish abundance occurred at many sites before any perturbation took place from construction or any other identifiable anthropogenic activity. This natural background variability strongly suggests that changes in fish numbers are to be expected during the monitoring period and that these should not be interpreted as “impacts” unless corroborating evidence from other sources is available. Such evidence would include data from control sites, hydrochemical monitoring data, assessments of other stream biota (primarily freshwater invertebrates) or direct observations of pollution incidents or dead fish by an Ecological Clerks of Works or others.

Taking the above into account, the following sections first look at overall (site-wide) changes in trout abundance compared to baseline. Trout are the main focus of such assessments as salmon presence in streams has already been shown to be patchy and sporadic (Waterside Ecology 2020). Section 5.4 then goes on to look in more detail for any identifiable shifts in fish populations in those streams where it is known from existing data that potentially damaging changes to water quality have occurred.

5.2 All sites comparisons with baseline

5.2.1 Trout fry

Trout fry densities during the baseline (mainly 2019) and current surveys are shown on Figure 14. Data are total density estimates with 95% confidence intervals. In general, 2024 was a good year for trout fry with increases in density at 28 of 34 sites when compared with baseline, suggesting good spawning success and over-winter survival of ova. Mean fry density at impact monitoring sites increased from 18.3 during baseline to 38.1 per 100 m^2 in 2024, a significant change (paired sample T-test, $T = 4.07$, $df = 27$, $p < 0.001$). A similar trend was observed at control sites and this change was also statistically significant ($T = 4.22$, $df = 5$, $p = 0.008$). Declines in trout fry numbers compared with baseline were recorded at 5 impact monitoring sites: LA1, CR2, KI1, LU1 and MA1.

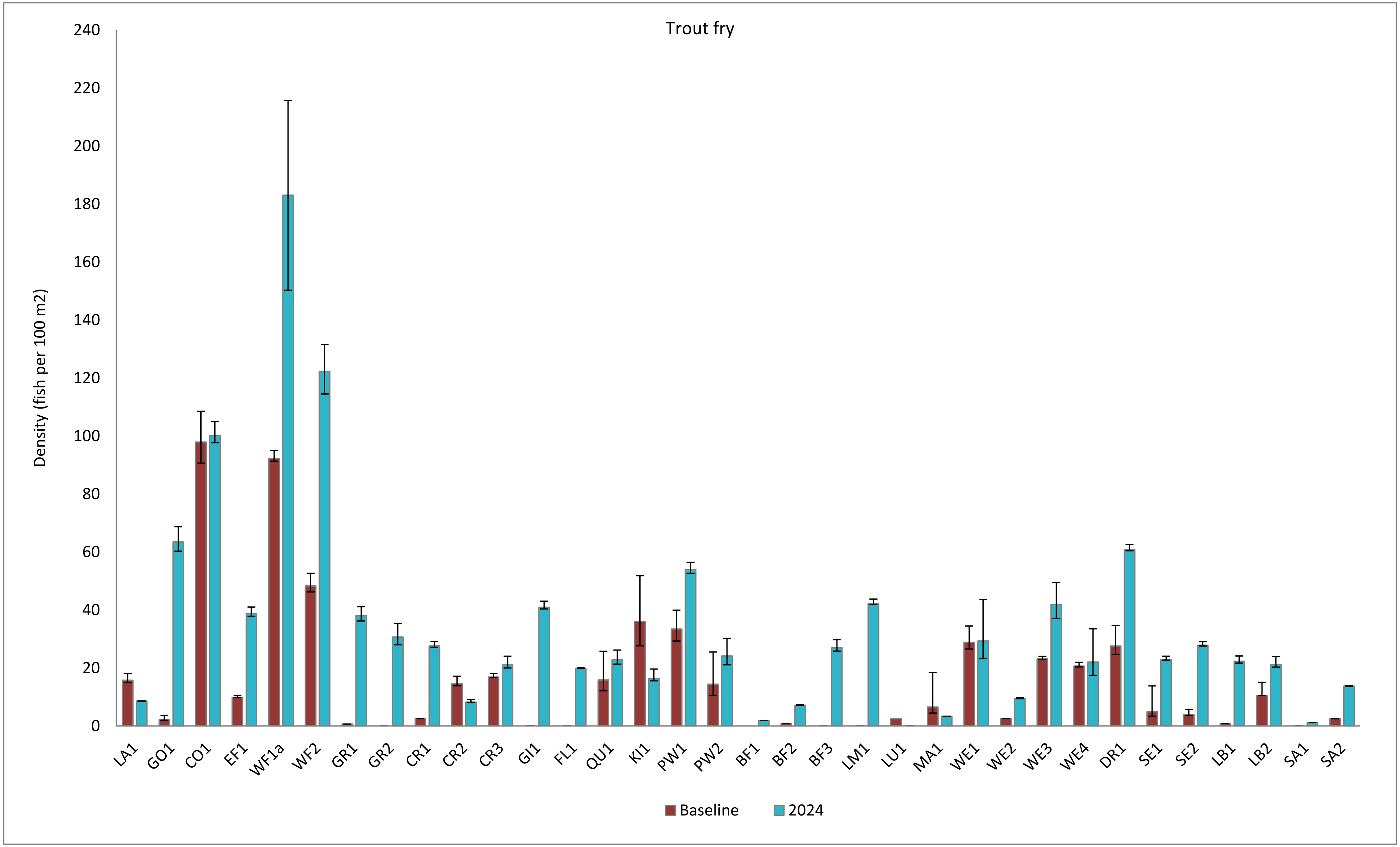
5.2.2 Trout parr

Densities during baseline and 2024 are shown on Figure 15. Trout parr densities in 2024 were lower than baseline at 24 sites and higher at only 3. Mean parr density at impact monitoring sites decreased from 11.0 during baseline to 6.9 per 100 m^2 in 2024. The change was significant ($T = 2.65$, $df = 27$, $p = 0.013$). A similar trend was observed at control sites with a decline in mean density from 23.3 per 100 m^2 during baseline to 9.7 in 2024 ($T = 2.42$, $df = 5$, $p = 0.06$). The decline compared with baseline was observed at all 6 control sites suggesting that, at most sites at least, the observed changes in parr density were probably unrelated to wind farm construction.

5.3 Trends in trout numbers during construction

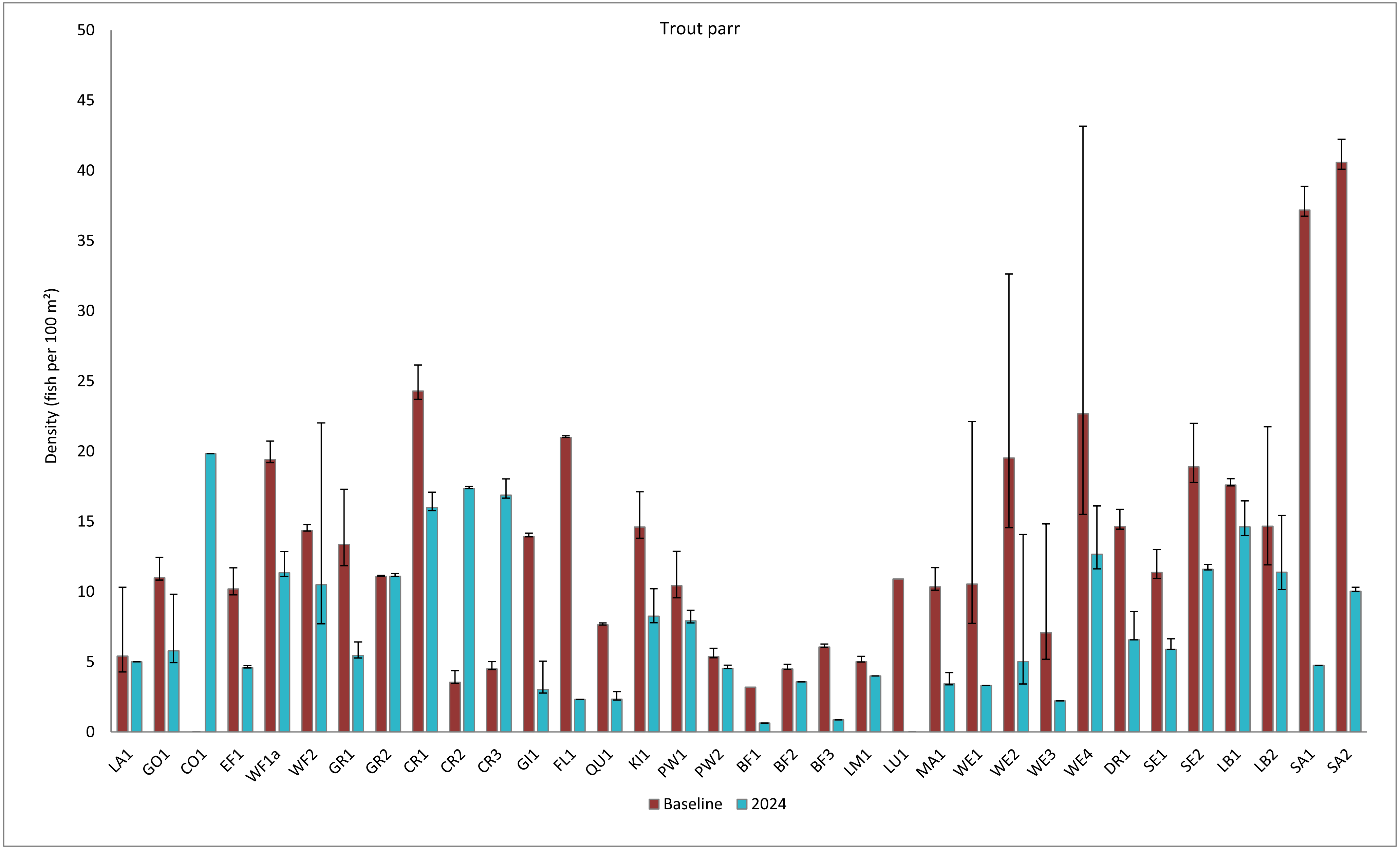
There has been substantial year-to-year variation in juvenile trout densities at many impact and control sites over the course of the monitoring period (Figures 17 & 18). These suggest that the baseline surveys of 2019 probably took place in a year of relatively low trout fry abundance. Increases in fry density occurred at many sites in 2021 and 2022 (see Waterside Ecology 2022a) and it is likely that most of the observed fluctuations are driven largely by regional factors, such as the severity of winter spates when ova may be washed out, or spates during the early post-hatch period when young fry have poor swimming ability. Conversely, trout parr densities during the baseline year were relatively high, with a strong 1+ year class. Slight declines in parr populations compared to baseline are not of themselves a cause for undue concern, unless they can be clearly linked to changes in environmental quality. The very substantial fluctuations observed in parr densities at control sites such as SE2 and SA2 show the degree to which fish densities can shift in the absence of any apparent change to habitat or water quality. Changes in fish densities in streams where water quality has changed are considered further in section 5.4 below.

Figure 14. Trout fry Zippin densities baseline and 2024



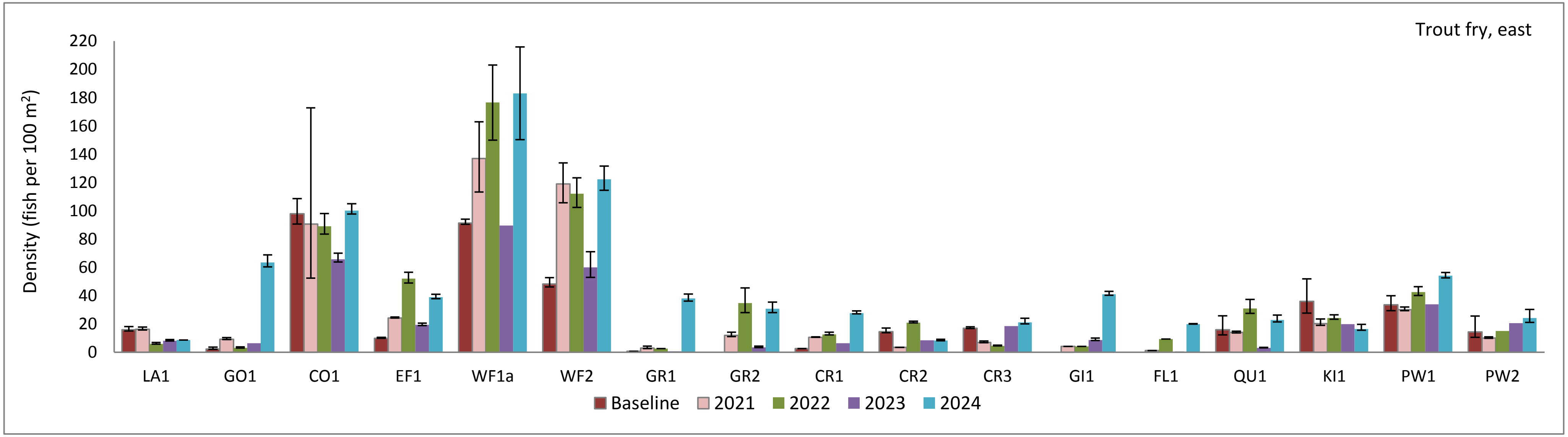
Baseline surveys conducted 2019 except for CO2, CO3 and WF2 (2020)

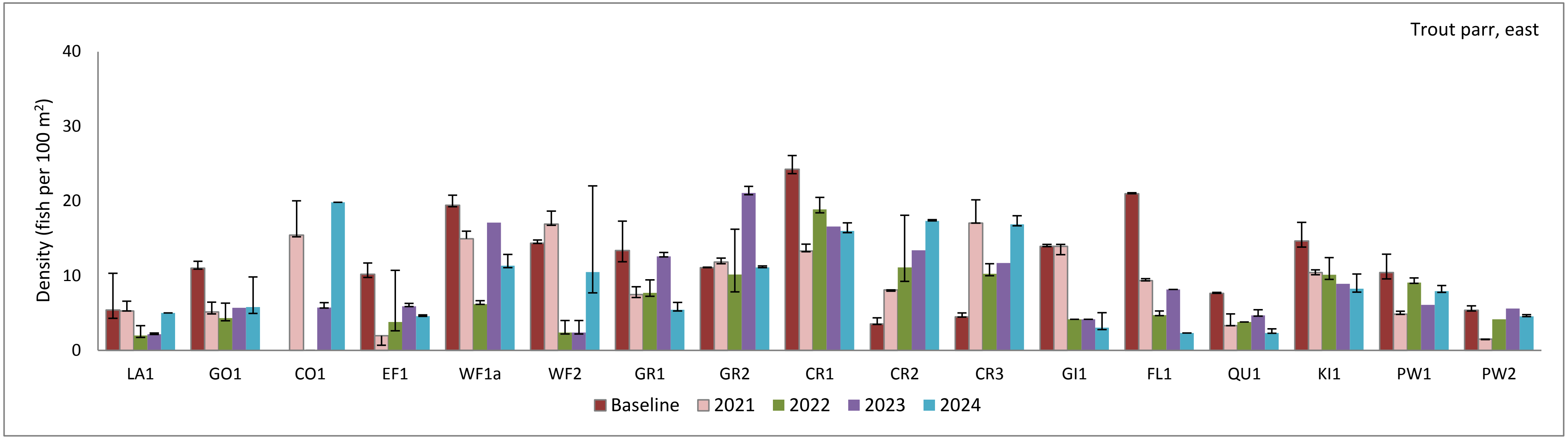
Figure 15. Trout parr Zippin densities baseline and 2024



Baseline surveys conducted 2019 except for CO2, CO3 and WF2 (2020)

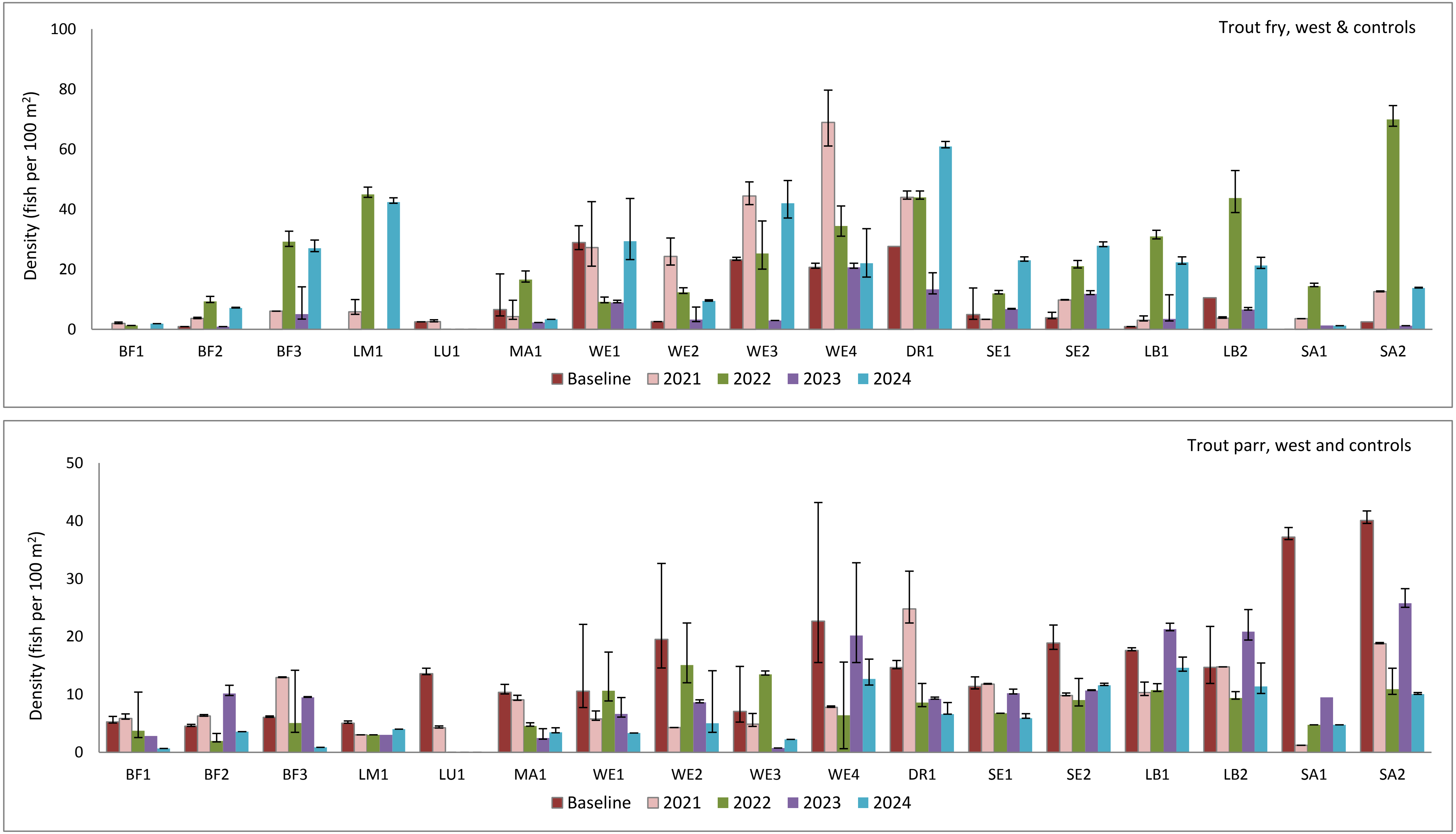
Figure 16. Juvenile trout densities eastern streams, baseline to present





Control sites are: SE1, SE2, LB1, LB2, SA1 and SA2.
Baseline surveys conducted 2019 except for CO2, CO3 and WF2 (2020)

Figure 17. Juvenile trout densities western streams and control streams, baseline to present



Control sites are: SE1, SE2, LB1, LB2, SA1 and SA2.
Baseline surveys conducted 2019 except for CO2, CO3 and WF2 (2020)
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5.4 Trout populations in potentially impacted watercourses

5.4.1 Potential impacts

Table 19 summarises the main changes in water quality that have been identified during the construction period. These data are extracted from quarterly hydrochemical monitoring reports that have been produced throughout the construction period.

Table 19 Changes in water quality prior to survey

Watercourse	Identified impacts	Potentially affected monitoring sites
Easter Filla	Maximum total oxidised nitrogen (TON) over last 12 months above baseline maximum and mean iron (Fe) concentration above baseline mean. Earlier silt episodes (2022-23).	EF1
Wester Filla	High peaks in TON over the last 12 months and changes to iron concentrations.	WF1a, WF2
Burn of Crookadale	Impacts from excavation of construction compound. Nutrients. Visible ochre deposition (CR2 only).	CR1, CR2
Burn of Flamister	Impacted by borrowpit – elevated TON, manganese (Mn) and calcium (Ca).	FL1
Burn of Lunklet and Burn of Burrafirth	Impacted by the waters coming from Scallafield Scord. Increased dissolved and bioavailable heavy metals and aluminium. Reduced dissolved organic carbon (DOC), increased acidity (low pH) and reduced acid neutralising capacity (ANC). Substrates impacted by metal-rich deposition.	LU1, BF1
Burn of Lambawater	Low pH, reduced DOC resulting in lowered ANC.	LM1
Burn of Marrofield Water	Metals (Fe, Mn, zinc). Reduced DOC.	MA1
Burn of Weisdale	Impacted by the waters coming from Scallafield Scord. Increased dissolved and bioavailable heavy metals. Changes to aluminium, DOC, pH and ANC. Substrates show some impact from ochre deposition.	WE3 and WE4
Burn of Droswall	Reduced DOC resulting in lowered acid neutralising capacity. Silt control issues.	DR1

5.4.2 Easter Filla Burn

Fry density has remained significantly above baseline throughout the monitoring period (Figure 16). Parr densities were lowest in 2021, prior to any observed changes in water quality. Since then, parr densities have increased. The data suggest that observed changes in water quality have not affected trout densities. This is consistent with invertebrate monitoring data, which suggest ongoing good water quality (Emes & Watt 2023, 2024).

5.4.3 Wester Filla Burn

Trout fry densities at WF1/1a and WF2 were significantly above baseline in three of the four construction years including 2024 (Figure 16). The high fry densities suggest good water quality. Parr densities were low at both sites in 2022 but recovered at WF1a in 2023. Parr density was slightly below baseline at both sites in 2024, but as this was also the case at the control sites (Figure 17) it is not compelling evidence of impact. Light deposition of silt/ochre was observed at WF2 during the 2023 fish survey, but substrates in 2024 appeared clean. Invertebrate populations remain healthy without evidence of impact (Emes & Watt 2024).

5.4.4 Burn of Crookadale

Sites CR1 and CR2 are both downstream of the main compound while CR3 is upstream. Trout fry density at CR1 has increased compared to baseline while fry densities at CR2 and CR3 have fluctuated without any clear trend (Figure 16). Trout parr densities at CR2 and CR3 have increased compared with the baseline, which was set in 2020. Parr density at CR1 has remained relatively stable but a little below the 2019 baseline. As noted above (sections 5.2 and 5.3) parr were generally abundant in 2019 and numbers at most control sites are currently below baseline (Figure 17). Overall, the data do not suggest any detrimental impact on the trout population in Burn of Crookadale as a result of changes to water quality.

5.4.5 Burn of Flamister

Data from the single site Burn of Flamister are difficult to interpret. The single monitoring site (FL1) is in the upper reaches of the stream where trout numbers are expected to be naturally variable. Fry have not been present in substantial numbers during any of the surveys, but the density in the current survey was the highest to date (Figure 17). Trout parr density at FL1 suggests a steady decline since baseline. Whether this is related to construction effects on water quality is uncertain, but recent monitoring suggests little discernible impact on invertebrate populations (Watt & Emes 2024).

5.4.6 Burn of Lunklet and lower Burn of Burrafirth

This stream has been substantially impacted by very low pH and high concentrations of a number of metals. Heavy ochreous deposits have been present in Burn of Lunklet since summer 2022 and invertebrate populations were severely impacted by spring 2023 (Watt & Emes 2023). No trout were found at LB1 during the current survey or that of 2023. Both surveys continued the search for trout well upstream of the original monitoring site, but none could be found. This is consistent with the data from the 2022 fish surveys (Waterside Ecology 2022a, 2022b) and indicates that the changes to water and habitat quality still make the stream unsuitable for trout.

Trout fry have been scarce in all surveys at BF1 (Figure 17). Trout parr densities have declined fairly steadily since 2019 and in the current survey were the lowest on record. Further upstream at BF2 and BF3 (both well upstream of the Burn of Lunklet confluence) fry densities in 2024 were well above baseline, but parr densities were lower. As trout have been scarce at BF1 in all surveys to date, it is difficult to assess whether contamination from Burn of Lunklet plays a role in the current very low densities, although it is worth noting that some impacts on invertebrates seem to have occurred (Emes & Watt 2024).

5.4.7 Burn of Lambawater

There has been a long term decline in dissolved organic carbon (DOC) in Burn of Lambawater, making it more sensitive to fluctuations in pH (Headley 2023). Trout fry were absent from LM1 during the baseline and again in 2023. However they were quite abundant in 2022 and 2024. Trout parr densities have remained stable. Overall, there is no clear evidence of negative impacts on fish as a result of observed changes in hydrochemistry. It is worth noting that over 25% of the trout fry at LM1 appeared to be suffering from an unknown disease or condition, resulting in a distended belly with prominent venation. A small proportion of affected fish died in the anaesthetic. Photographs of affected fish have been sent to Marine Scotland Science to see if the condition can be identified.

5.4.8 Burn of Marrofield Water

Burn of Marrofield Water has experienced periodic increases in concentrations of some metals and a reduction in DOC. Trout fry and parr at MA1 were scarce during 2023 and the current survey. It is not clear whether changes to water quality have contributed to this. Fish data were collected in 2008 from a site some 0.8 km upstream of MA1 (Waterside Ecology 2008) and no trout fry were present, suggesting that recruitment in this stream may be poor in some years for reasons unrelated to wind farm construction. Spring and autumn sampling of freshwater macroinvertebrates showed no discernible impacts on invertebrate communities since baseline (Aquaterra Ecology 2023, Watt & Emes 2023. It may be that the low fish density is simply a result of year-to-year variability in fish numbers. If access permission can be obtained, it may be worth sampling an additional site further upstream in 2025. Only three fry were captured in the stream. All showed signs of the same condition noted in Burn of Lambawater.

5.4.9 Burn of Weisdale

Some deterioration of water quality has been noted at WE4 and WE3 and potential impacts on freshwater invertebrates were evident in spring and autumn 2023, particularly at WE3 (Emes & Watt 2023, Watt & Emes 2023). These impacts may have been associated with visible ochre and silt deposition at these sites. Fish monitoring in 2023 found very low trout densities at WE3. Fry densities at WE3 recovered during the current survey and exceeded baseline while density at WE4 remained at baseline (Figure 17). Sampling of freshwater invertebrates in autumn 2024 (Watt & Emes 2024) also suggested improvements and recovery towards baseline conditions.

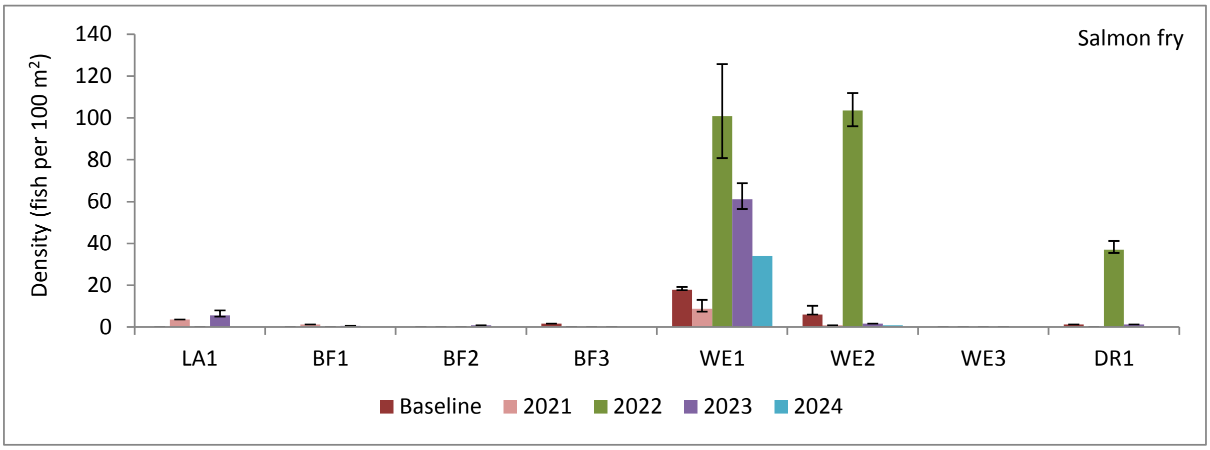
5.4.10 Burn of Droswall

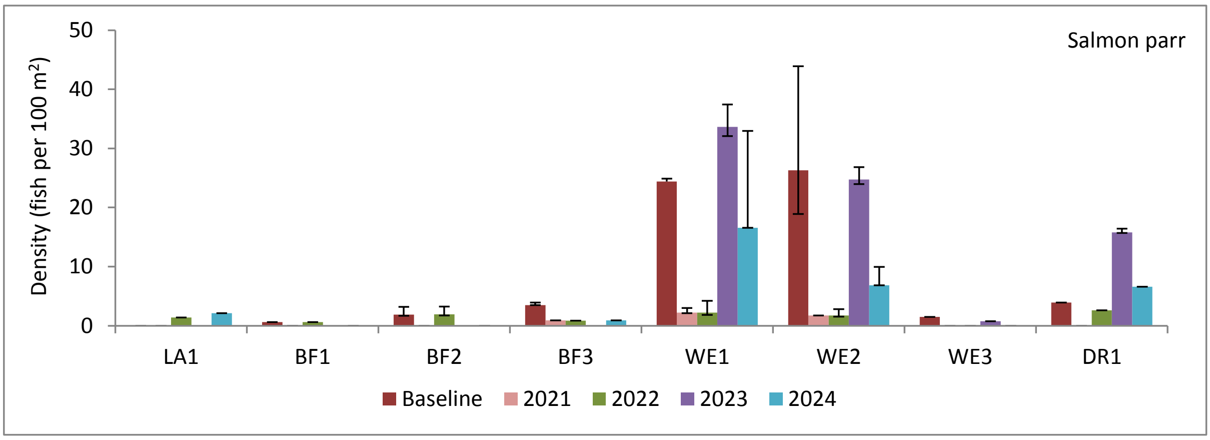
Freshwater invertebrate sampling in spring 2024 suggested some decline in water quality indices, although by autumn 2024 these did not differ significantly from baseline (Emes & Watt 2024, Watt & Emes 2024). Trout fry numbers in late summer 2024 were well above baseline indicating successful spawning in this watercourse. Parr densities were lower than baseline, as they were at the majority of control sites. The fish data and autumn invertebrate sampling suggest that fauna in Burn of Droswall are largely un-impacted by any changes to water quality.

5.5 Salmon

Salmon presence and abundance has been highly variable in the years since monitoring began. Salmon fry and/or parr have been intermittently present in Laxo Burn, Burn of Pettawater, Burn of Burrafirth and Burn of Droswall. However, the only watercourse where salmon have been recorded in each year of survey since 2019 is Burn of Weisdale.

Figure 18. Salmon fry and parr Zippin densities, baseline to 2024





During the current survey, salmon fry were present only at sites WE1 and WE2 in Burn of Weisdale

(Figure 18). Parr were present at these sites and in Laxo Burn (LA1), Burn of Burrafirth (BF3 only) and Burn of Droswall (DR1). Parr densities at LA1 and BF3 were extremely low. Given the sparse data and degree of year-to-year variation the data are not particularly useful for impact detection. Nevertheless, they suggest that water quality in Burn of Weisdale remains sufficiently good to support this species.

5.6 Conclusions

The fish monitoring data from 2024 are consistent with those from previous years and indicate there have been no site-wide impacts on fish populations due to construction works. In general, trout fry densities in 2024 were at or above baseline levels. Densities of trout parr declined at many sites compared to baseline, but as this trend was apparent at control sites it is unlikely to be related to construction. The data continue to indicate that year-to-year variation in trout densities result largely from regional effects, possibly climatic, that are unrelated to construction.

Juvenile salmon presence and abundance remains highly variable. Small numbers of parr were recorded at sites in Burn of Burrafirth and Laxo Burn but no fry were found in these watercourses. This is consistent with past data, which suggest sporadic spawning in these watercourses and/or very few spawning adults resulting in patchy distribution of juveniles. Salmon fry and parr were once again present in Burn of Weisdale. This suggests that water chemistry in the lower Burn of Weisdale remains suited to the maintenance of sensitive salmonid species.

The hydrochemical impacts that have been of greatest concern in relation to fish have occurred in the middle to upper reaches of Burn of Weisdale (WE3 and WE4) and in Burn of Lunklet (LU1). The 2024 fish and invertebrate data both suggest improvements around WE3 and WE4, consistent with a visible reduction in ochre and fine sediment deposition. Hydrochemical data show a reduction in levels of contamination from the east side of Scallafield Scord (Headley 2024), which may help sustain the observed positive trends.

Trout remain absent from the sampled reach of Burn of Lunklet. This is consistent with the known decline in invertebrates and observable impacts on streambed habitats as a result of contaminated runoff from the west Scallafield Scord area.

6 Recommendations

- The suite of fish survey sites should be reviewed in 2025 based on hydrochemical data and the results of the spring invertebrate sampling. It may be possible (with agreement of consultees) to omit some sites where a) no changes in water quality, fish or invertebrate populations have been observed and b) no further works are ongoing or proposed.
- As a minimum, all watercourses listed in Table 19 above should continue to be monitored along with the six control sites.
- Due to substantial between-site variations in capture efficiency resulting from physical conditions, all ongoing monitoring should use fully quantitative methods, where possible.
- Given the observed range of fluctuations in fish densities (in particular substantial variation in annual recruitment), changes in fish numbers are unlikely to provide reliable evidence of impact unless some causal mechanism can be identified. This mechanism would primarily be a change in water quality of sufficient magnitude to impact on one or more salmonid life stage. Therefore interpretation of fish data must continue to be guided by the results of hydrochemical and/or invertebrate monitoring.
- Efforts to raise the pH and reduce the amount of metals reaching biologically valuable watercourses (Burn of Weisdale and Burn of Lunklet) should continue. Runoff towards Burn

of Weisdale has shown recent improvements but metals contamination of Burn of Lunklet remains a pressing concern.

- The efficacy of mitigation measures must be assessed on an ongoing basis aided by the monthly water chemistry data and additional information collected by the on-site environmental team. Regular inflow and outflow sampling of treatment ponds should take place to assist in this process.

7 References

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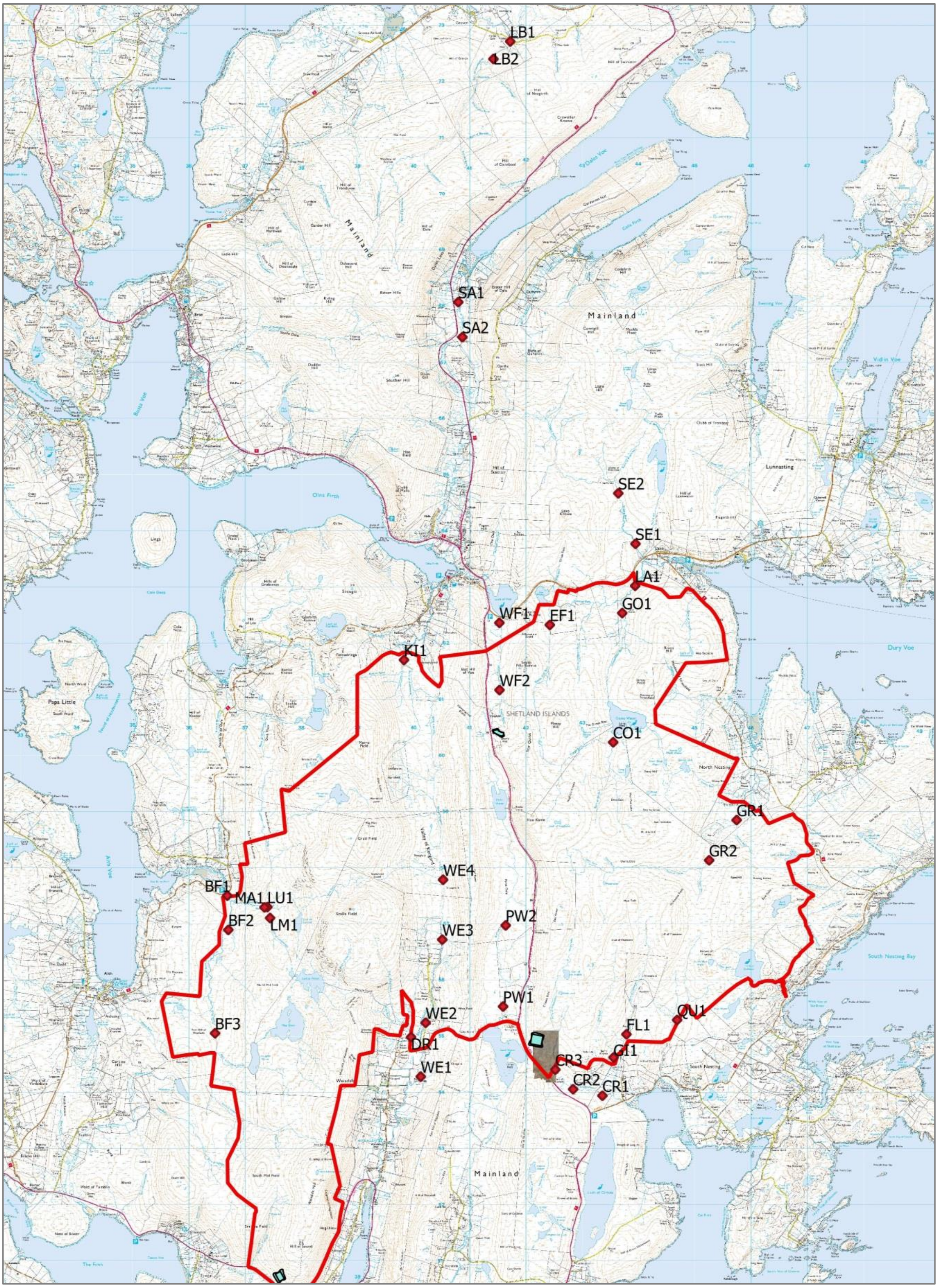
8 Appendices

8.1 Monitoring sites



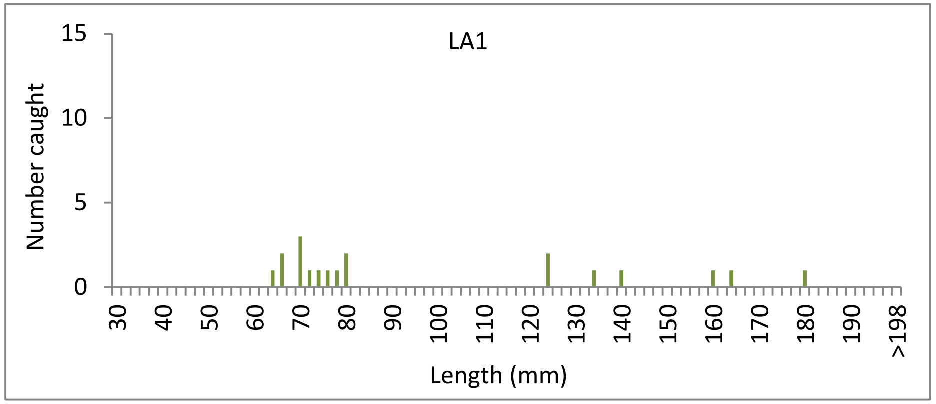
8.2 Electric fishing survey site locations and survey event details: impact sites

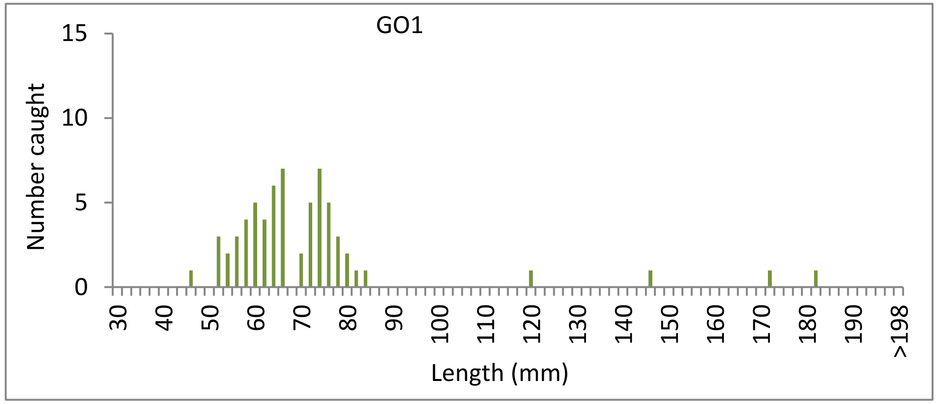
Site	Watercourse	NGR	Length (m)	Width (m)	Area (m^2)	Voltage	Conductivity ($\mu S.cm^{-1}$)	Temp. (°C)	Level	Colour
LA1	Laxo Burn	HU 43942 63020	27	5.2	140.0	240	141	14	low	coloured
GO1	Gossawater Burn	HU 43712 62535	44	2.3	101.2	240	106	13.5	low	coloured
CO1	Corgill Burn	HU 43551 60235	61	1.2	70.6	150	125	13	low	coloured
EF1	Easter Filla Burn	HU 42424 62324	59	2.6	153.4	180	132	13	medium	coloured
WF1a	Wester Filla Burn	HU 41561 62202	73	1.1	81.2	170	165	15	medium	coloured
WF2	Wester Filla Burn	HU 41529 61165	75	1.2	90.8	170	150	13	medium	coloured
GR1	Burn of Grunnafirth	HU 45748 58851	49	3.1	151.9	260	122	13	medium	coloured
GR2	Burn of Grunnafirth	HU 45258 58134	52	3.0	153.4	260	120	12.5	medium	coloured
CR1	Burn of Crookadale	HU 43360 53944	66	1.7	114.1	160	190	12	low	coloured
CR2	Burn of Crookadale	HU 42839 54059	78	1.1	86.5	170	168	11.5	medium	coloured
CR3	Burn of Crookadale	HU 42522 54408	80	1.1	90.0	170	136	12	medium	coloured
GI1	Gill Burn	HU 43558 54625	81	0.9	71.9	180	145	13.5	low	coloured
FL1	Burn of Flammister	HU 43787 55037	71.5	1.2	85.8	180	160	12.5	low	coloured
QU1	Burn of Quoys	HU 44688 55292	64	2.1	131.2	200	133	12	medium	coloured
KI1	Burn of Kirkhouse	HU 39830 61701	51	2.3	115.6	190	128	13.5	medium	coloured
PW1	Burn of Pettawater	HU 41593 55531	63.5	2.6	167.2	200	170	14	medium	coloured
PW2	Burn of Pettawater	HU 41693 56975	50	2.7	132.5	220	156	13	medium	coloured
BF1	Burn of Burrafirth	HU 36687 57505	23	6.9	157.8	220	123	16	medium	coloured
BF2	Burn of Burrafirth	HU 36705 56895	28	4	112.0	250	120	13.5	medium	coloured
BF3	South Burn of Burrafirth	HU 36469 55055	48	2.4	116.0	220	135	15	medium	coloured
LM1	Burn of Lamba Water	HU 37448 57107	77	1.3	100.1	220	128	14.5	medium	coloured
LU1	Burn of Lunklet	HU 37400 57302	55	2.2	119.2	180	178	15	medium	coloured
MA1	Marrofield Water	HU 37348 57296	33	2.7	89.1	220	105	15	medium	coloured
WE1	Burn of Weisdale	HU 40128 54283	24	4	90.4	180	224	14.5	medium	coloured
WE2	Burn of Weisdale	HU 40215 55242	34	3.4	116.7	180	182	14.0	medium	coloured
WE3	Burn of Weisdale	HU 40511 56722	43.5	3.1	134.9	200	137	14.0	medium	coloured
WE4	Burn of Weisdale	HU 40526 57788	86	1.2	103.2	180	114	12.0	medium	coloured
DR1	Burn of Droswall	HU 39956 54987	48	1.6	76.1	160	206	13.5	low	coloured
SE1	Seggie Burn	HU 43948 63767	33	3.6	118.8	180	-	-	low	coloured
SE2	Seggie Burn	HU 43642 64667	45	2.5	112.5	180	-	-	low	coloured
LB1	Burn of Laxobigging	HU 41710 07271	42	3.4	142.8	260	122	13.0	mod-high	coloured
LB2	Burn of Laxobigging	HU 41421 72398	38	2.85	108.3	200	141	15	mod-high	coloured
SA1	Burn of Sandgarth	HU 40796 68070	82	1.03	84.3	250	115	11	medium	coloured
SA2	Burn of Sandgarth	HU 40869 67447	65	1.2	79.9	240	98	13	medium	coloured

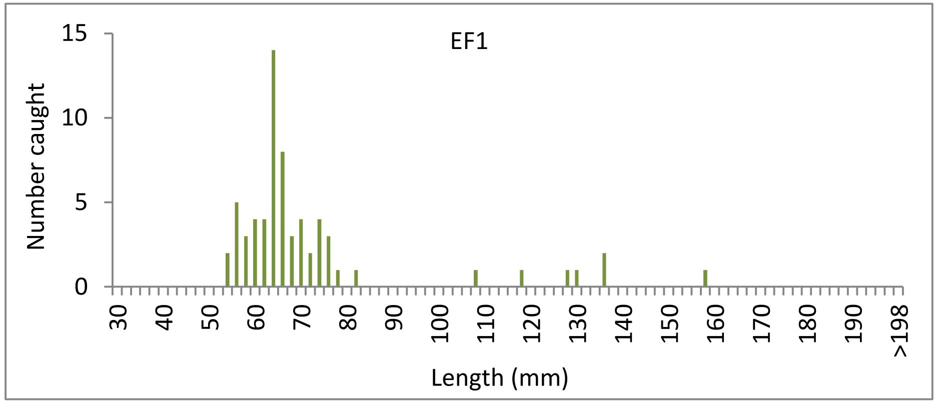
8.3 Depletions attained at fully quantitative electric fishing sites

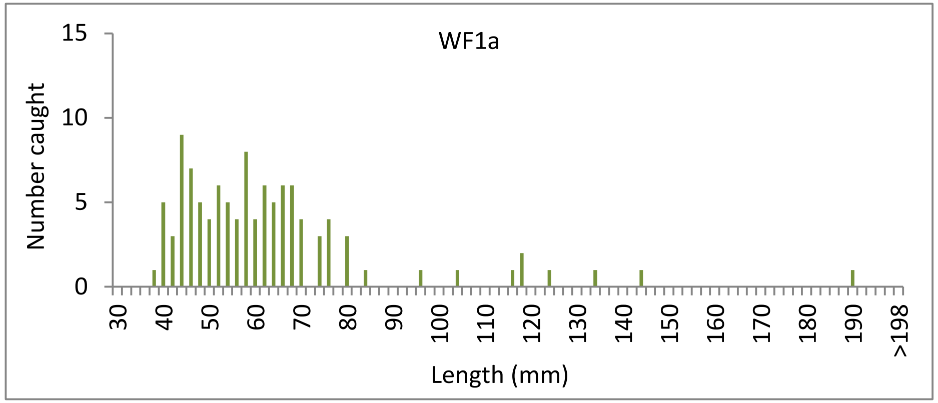
Site	Equipment type	Number trout fry caught			Number trout parr caught			Total trout		
		run 1	run 2	run 3	run 1	run 2	run 3	run 1	run 2	run 3
LA1	Backpack	11	1	0	2	4	1	13	5	1
GO1	Backpack	40	16	5	3	1	1	43	17	6
CO1	Backpack	51	13	5	14	0	0	65	13	5
EF1	Backpack	40	16	2	6	1	0	46	17	2
WF1a	Backpack	65	34	22	6	3	0	71	37	22
WF2	Backpack	67	26	11	3	3	1	70	29	12
GR1	Backpack	37	13	5	5	3	0	42	16	5
GR2	Backpack	25	14	4	15	2	0	40	16	4
CR1	Backpack	23	7	1	13	5	0	36	12	1
CR2	Backpack	5	2	0	14	1	0	19	3	0
CR3	Backpack	13	5	0	11	4	0	24	9	0
GI1	Backpack	22	6	1	1	1	0	23	7	1
FL1	Backpack	15	2	0	2	0	0	17	2	0
QU1	Backpack	17	9	2	2	1	0	19	10	2
KI1	Backpack	14	2	2	6	2	1	20	4	3
PW1	Backpack	64	18	6	9	4	0	73	22	6
PW2	Backpack	15	10	3	5	1	0	20	11	3
BF1	Backpack	3	0	0	1	0	0	4	0	0
BF2	Backpack	7	1	0	4	0	0	11	1	0
BF3	Backpack	20	8	2	1	0	0	21	8	2
LM1	Backpack	33	8	1	4	0	0	37	8	1
LU1	Backpack	0	0	0	0	0	0	0	0	0
MA1	Backpack	3	0	0	2	1	0	5	1	0
WE1	Backpack	10	8	3	1	1	1	11	9	4
WE2	Backpack	9	2	0	2	1	1	11	3	1
WE3	Backpack	30	12	8	3	0	0	33	12	8
WE4	Backpack	9	6	3	7	4	1	16	10	4
DR1	Backpack	37	8	1	4	0	1	41	8	2
SE1	Backpack	21	5	1	6	0	1	27	5	2
SE2	Backpack	24	6	1	11	2	0.0	35	8	1
LB1	Backpack	21	9	1	14	4	2	35	13	3
LB2	Backpack	15	5	2	6	4	1	21	9	3
SA1	Backpack	1	0	0	4	0	0	5	0	0
SA2	Backpack	10	1	0	7	1	0	17	2	0

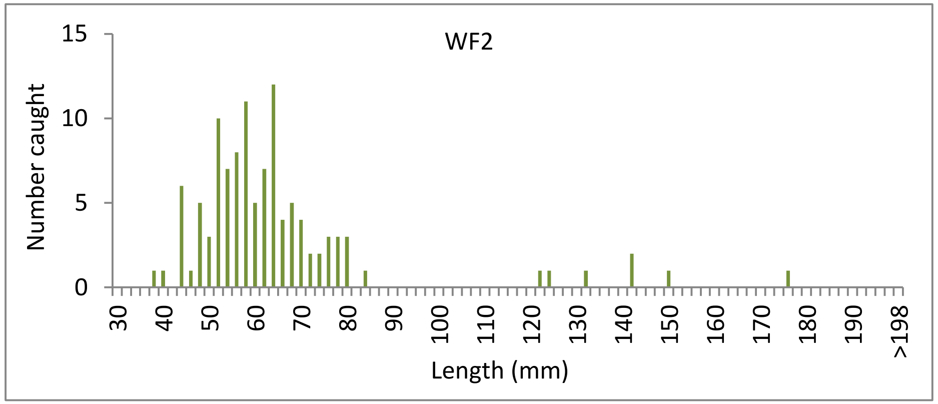
8.4 Trout length frequencies at individual survey sites

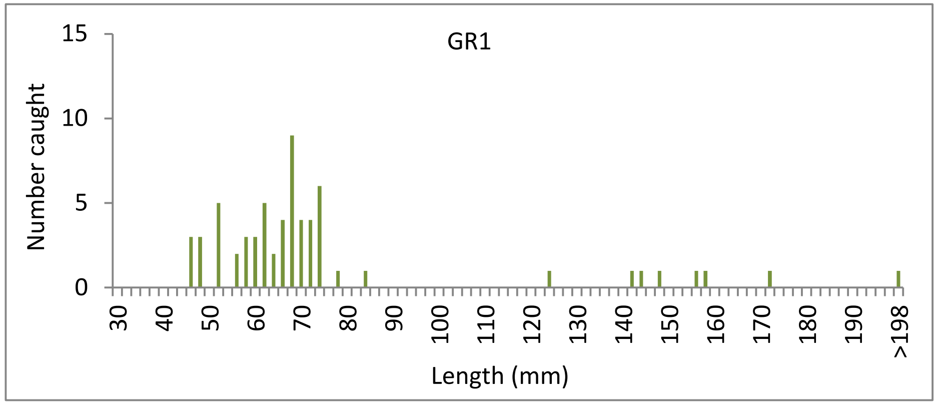


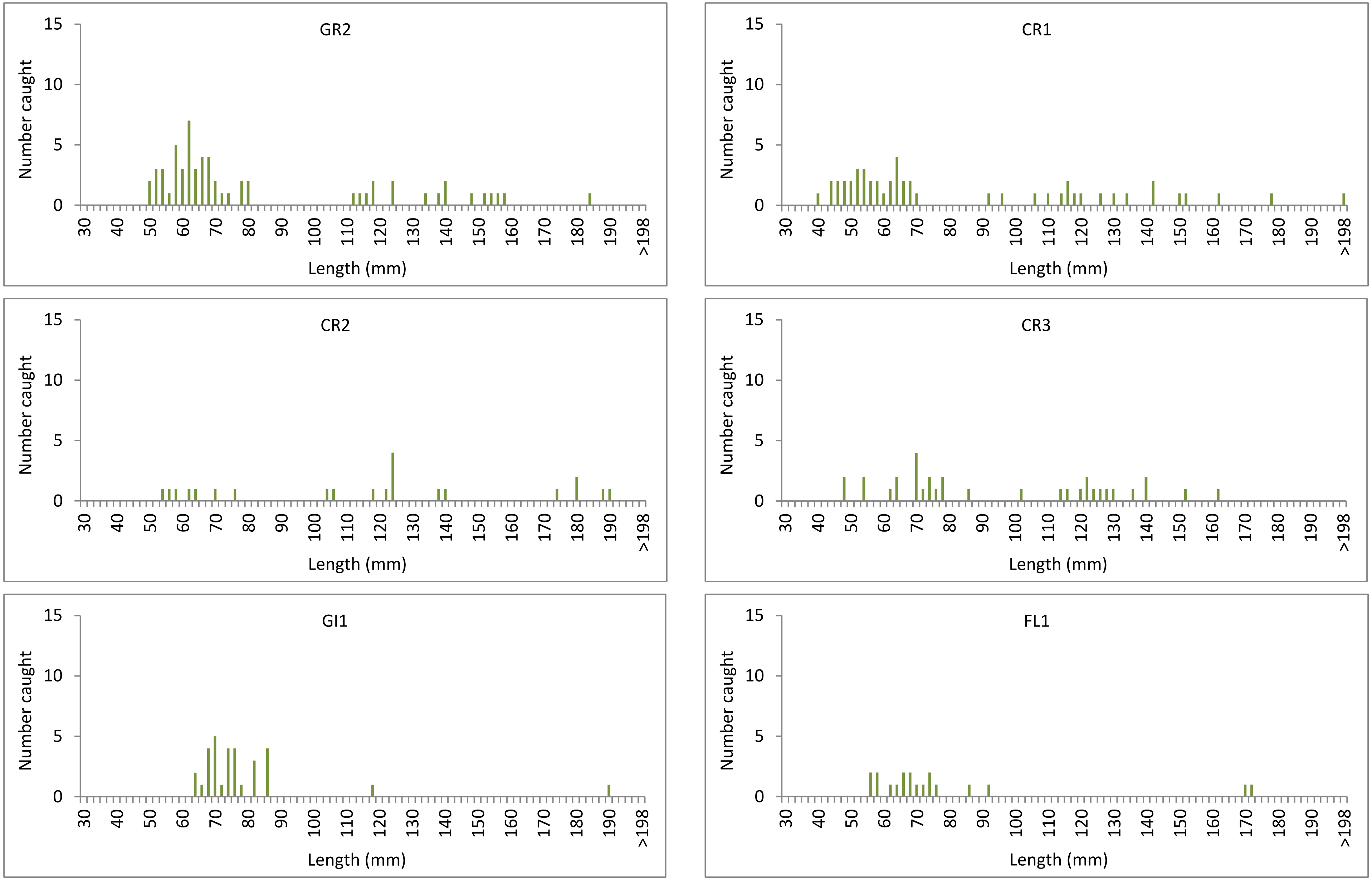




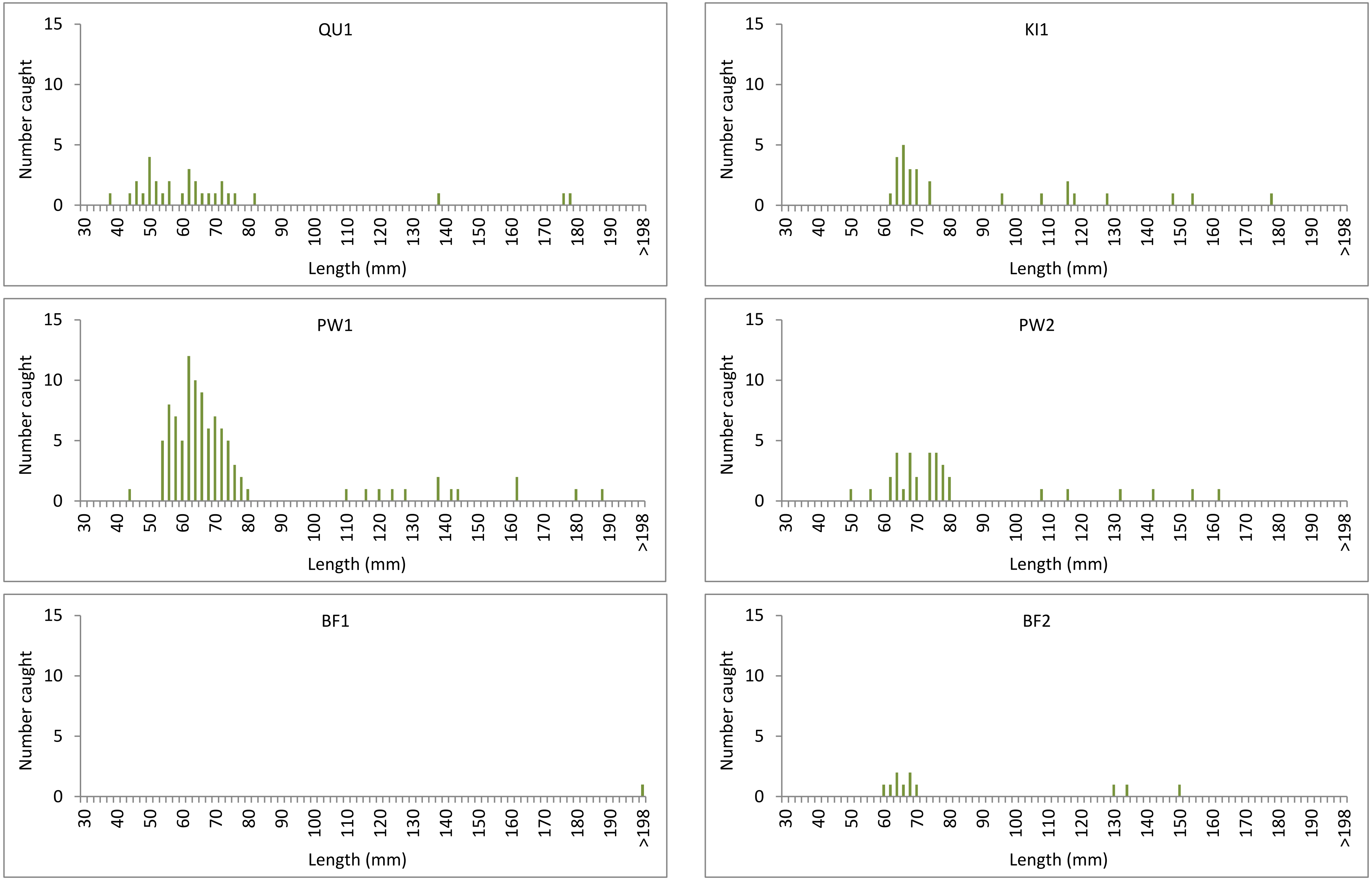


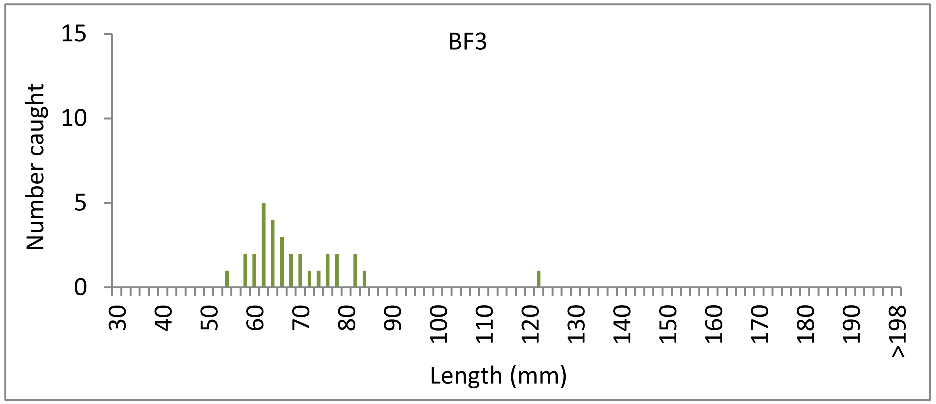


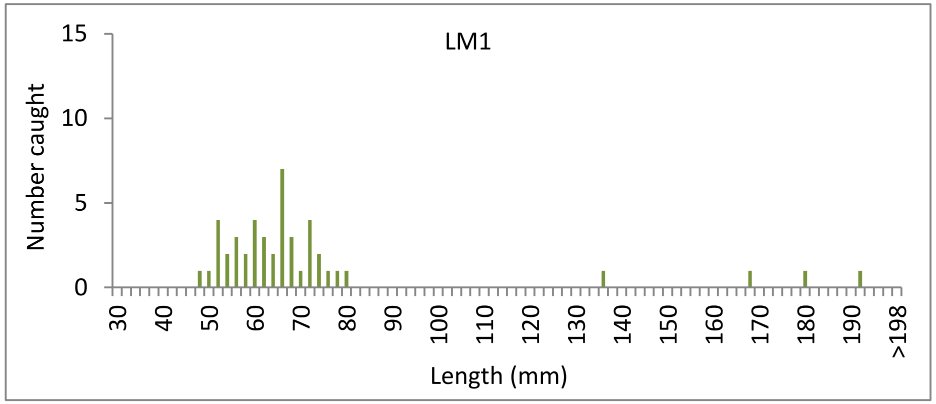


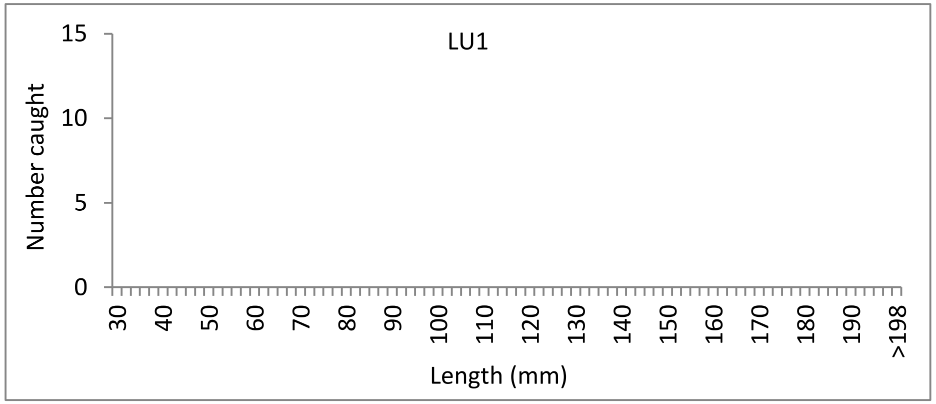


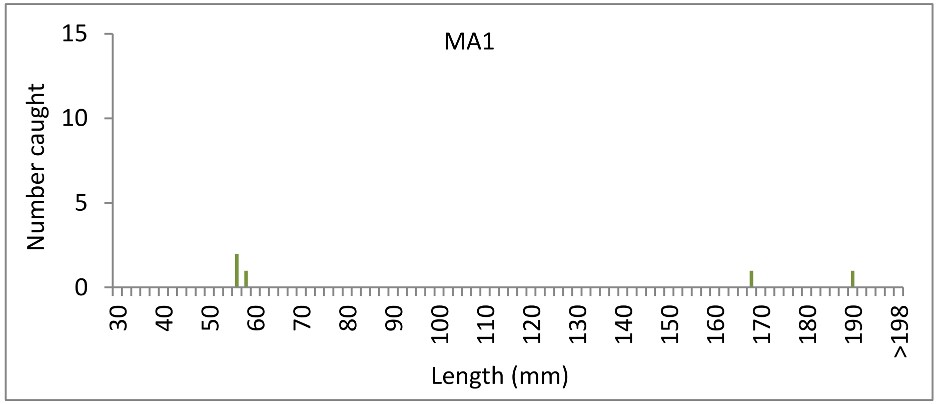
GR2
CR1
CR2
CR3
GI1
FL1
Number caught
Length (mm)

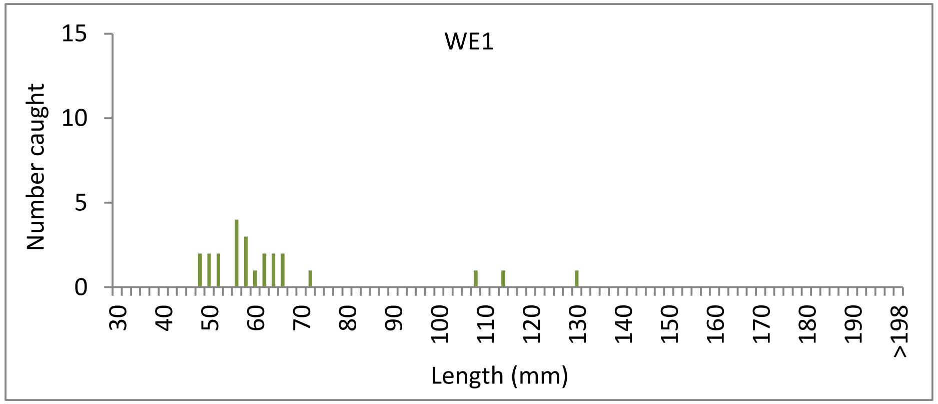

QU1
KI1
PW1
PW2
BF1
BF2
Number caught
Length (mm)
0
5
10
15
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
>198

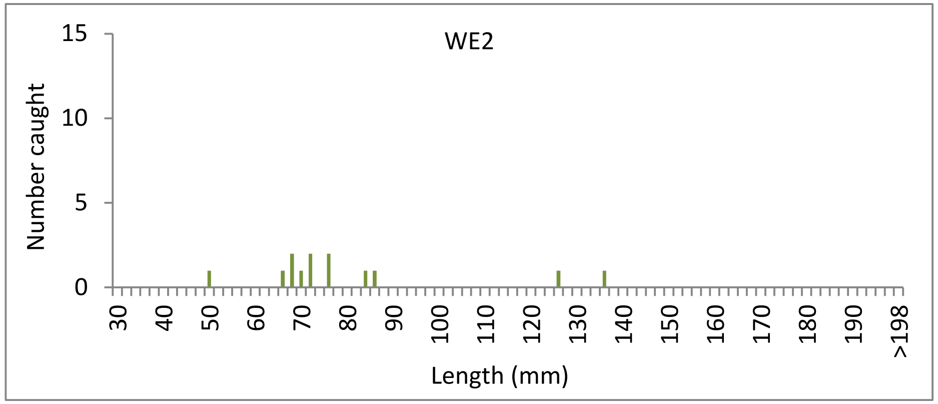

BF3
Number caught
Length (mm)

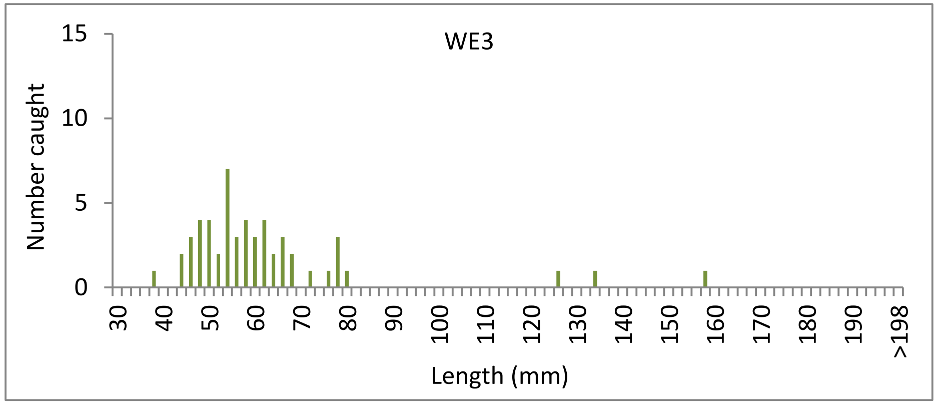

LM1
Number caught
Length (mm)

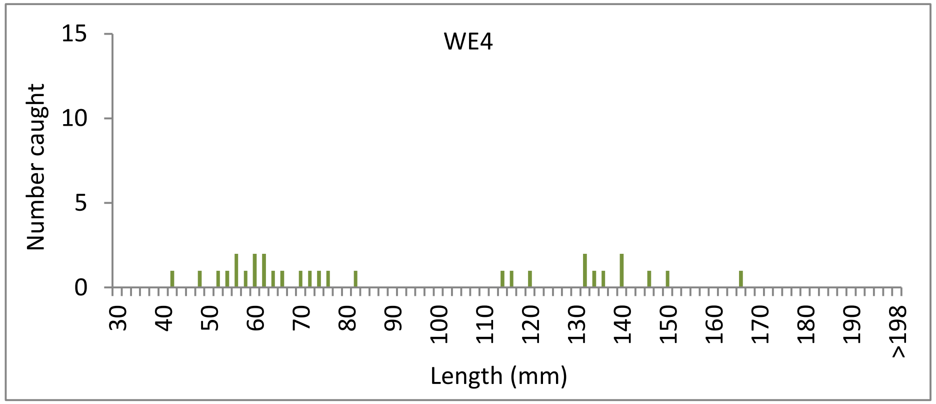

LU1
Number caught
Length (mm)

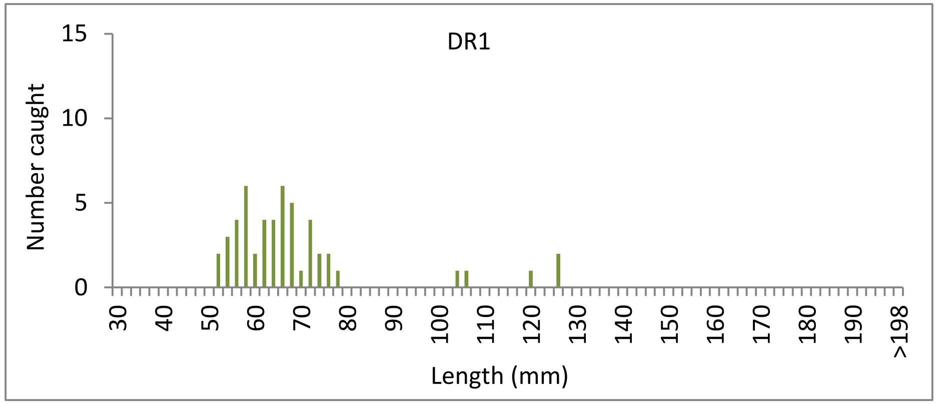

MA1
Number caught
Length (mm)

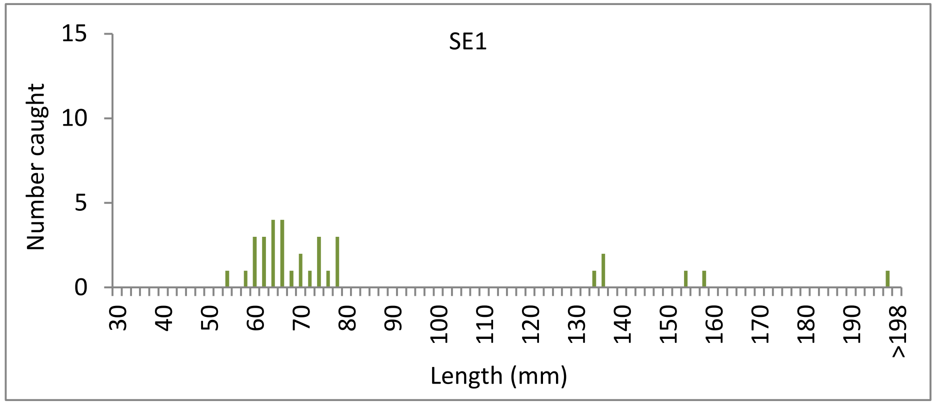

WE1
Number caught
Length (mm)

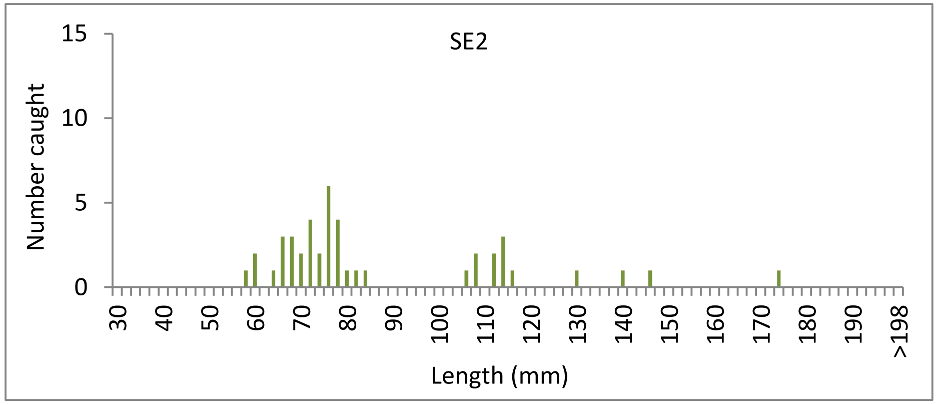

WE2
Number caught
Length (mm)

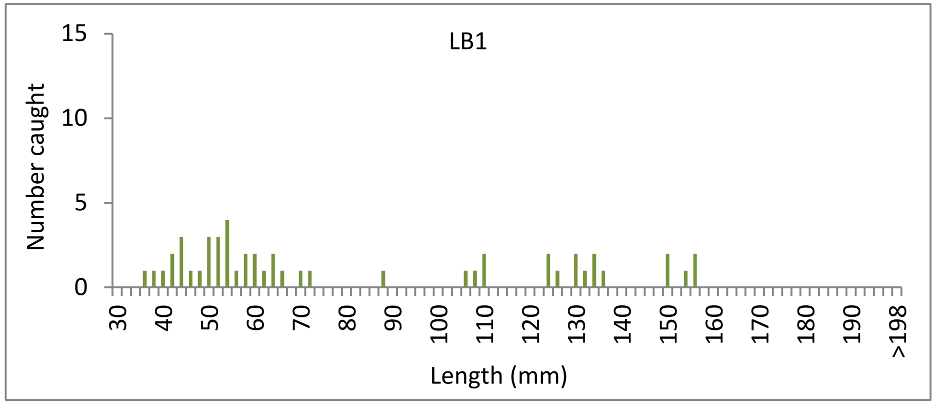

WE3
Number caught
Length (mm)

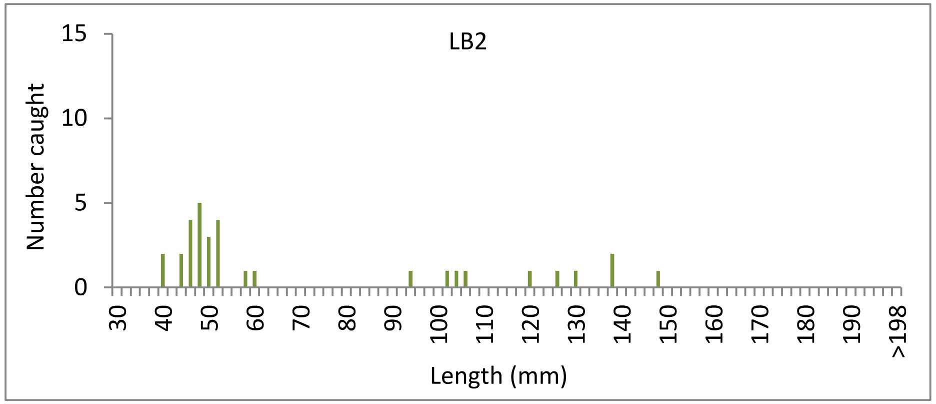

WE4
Number caught
Length (mm)


DR1
Number caught
Length (mm)


SE1
Number caught
Length (mm)


SE2
Number caught
Length (mm)


LB1
Number caught
Length (mm)


LB2
Number caught
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0
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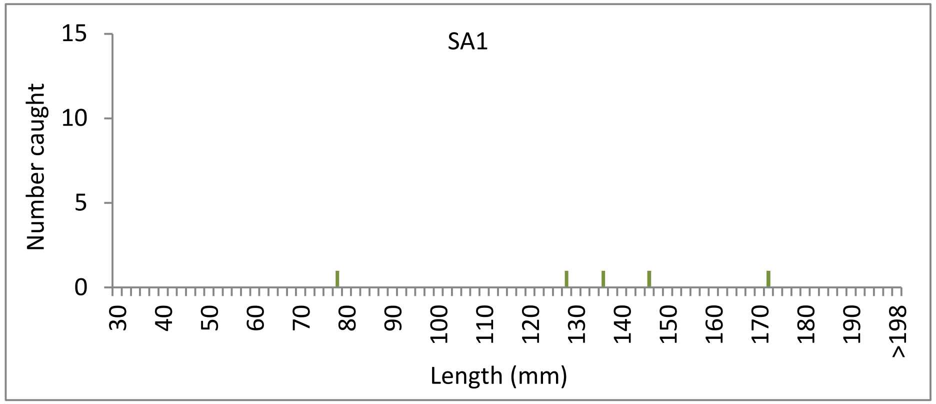
>198
Length (mm)


SA1
Number caught
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0
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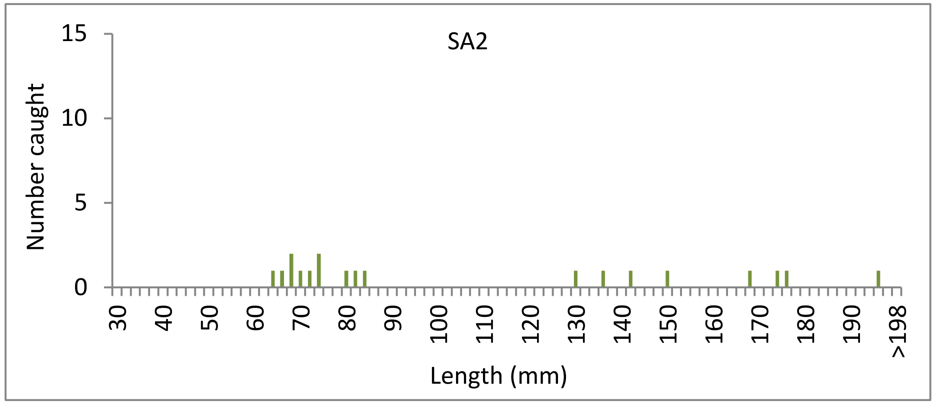
Length (mm)


SA2
Number caught
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50
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80
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100
110
120
130
140
150
160
170
180
190
>198
Length (mm)