

2022 Smolt Run Monitoring for Flow Management and Smolt Survival

1. INTRODUCTION

Based on relative numbers of smolts seen trapped in gate slots between 2018-2020 it was identified between the board and SSE that pinning down precise smolt run timing could help SSE further refine flows for smolts in the catchment and could improve smolt survival when negotiating Aigas and Kilmorack turbines. In 2021 a four-foot rotary screw trap (rst) provided by SSE was successfully operated close to Fasnakyle House on the Upper Glass. Temperature loggers were also installed at the top of the catchment to potentially aid future predictions of smolt run timing. One on the main tributary of the R. Farrar (Uisge Misgeach) and the other on the A. Deabhag above Tomich, a main tributary of the Glass. A cold spring resulted in smolts being recorded in the trap between 15 April-12 May 2021. See [2021 Smolt Report](#).

In spring 2022 temperature loggers were in place again. The 4ft rst was re-installed at the **Fasnakyle** site to monitor run timing and also to assess trap efficiency to get an idea of smolt output for the A. Deabhag.

With the help of Strath Conon estate (who lent us two box traps), Kyle of Sutherland Fishery Trust (who lent us a lighter box trap), and Braulen estate (who helped with installation), trial box trap monitoring also occurred on the **R. Farrar** for the first time. The purpose of this monitoring was to trial possible box trapping sites up and downstream of Beannacharan dam, and if possible, start to look at whether Beannacharan dam may have any impact on smolt migration.

See [Map 1](#) of sites.

Fasnakyle: Installation of the 4ft rst took place on 4 April (slightly delayed due to a combination of mechanical failure and COVID). 128 smolts were found in the trap the next morning on 5 April. Unfortunately river levels rose sharply overnight and by 6 April the trap was damaged and out of action.

Farrar: Installation of the 'Farrar downstream', and a single 'upstream' box trap (on the E arm of the island at Piper's memorial) occurred on 1 April. A third box trap was installed on the 'W arm' of the island on 4 April. All box traps were actively monitoring until 24 May, with the exception of 17-19 May due to other work commitments and to allow for a release of water from Beannacharan dam.

Staff (including Working with Rivers trainee, Louise) and volunteers were used to check the traps. Due to the nature of box trapping, box traps stayed in place despite high flow events. **The board reported smolt numbers to SSE on a daily basis, and as a result, phase 1 smolt flows were in place from 1 April with phase 2 flows being in place between 25 April-28 May.** See [Photos 1-6](#).

The timing of the smolt run is important in determining smolt survival at sea and it is essential that smolts are not impeded on their migration.

Map 1: Map showing location of 4ft Rotary Screw Trap (Fasnakyle), Box traps (Farrar), temperature loggers and Dams

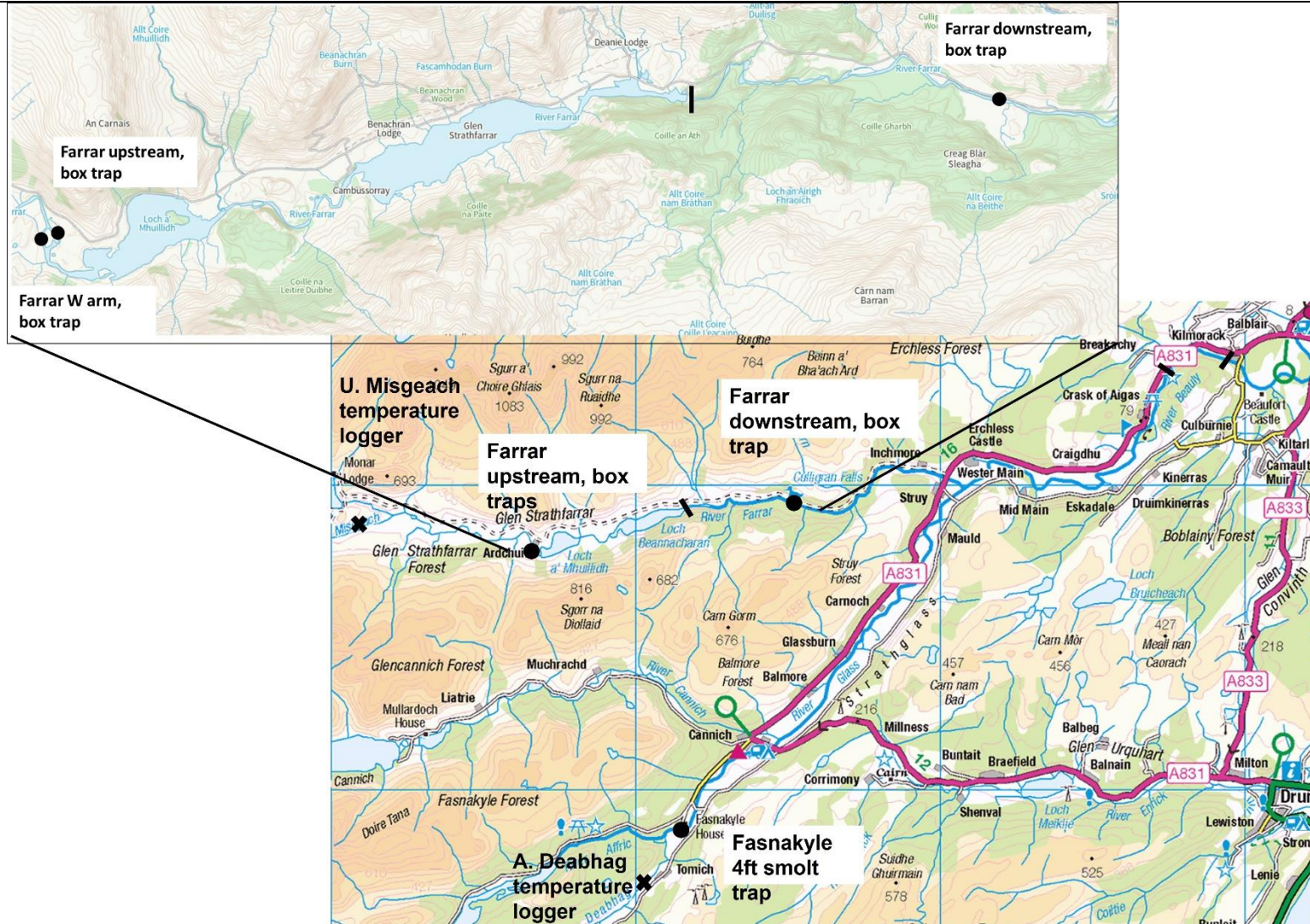


Photo 1: Fasnakyle NH31247 28785. 4ft rst installed



Photo 2: Fasnakyle, 4ft rst damaged (6 April).



Photo 3: Farrar downstream box trap (KOS), NH35556 39332 With extra guide rope on surface.



Photo 4: Farrar upstream box trap (Strathconon). NH 26625 38012.



Photo 5: Farrar West Arm box trap (Strathconon), NH 26484 38037. Double wing intercepting flow.



Photo 6: The first Farrar pre-smolt captured 3 April



2. FINDINGS

2.1 Smolt run timing

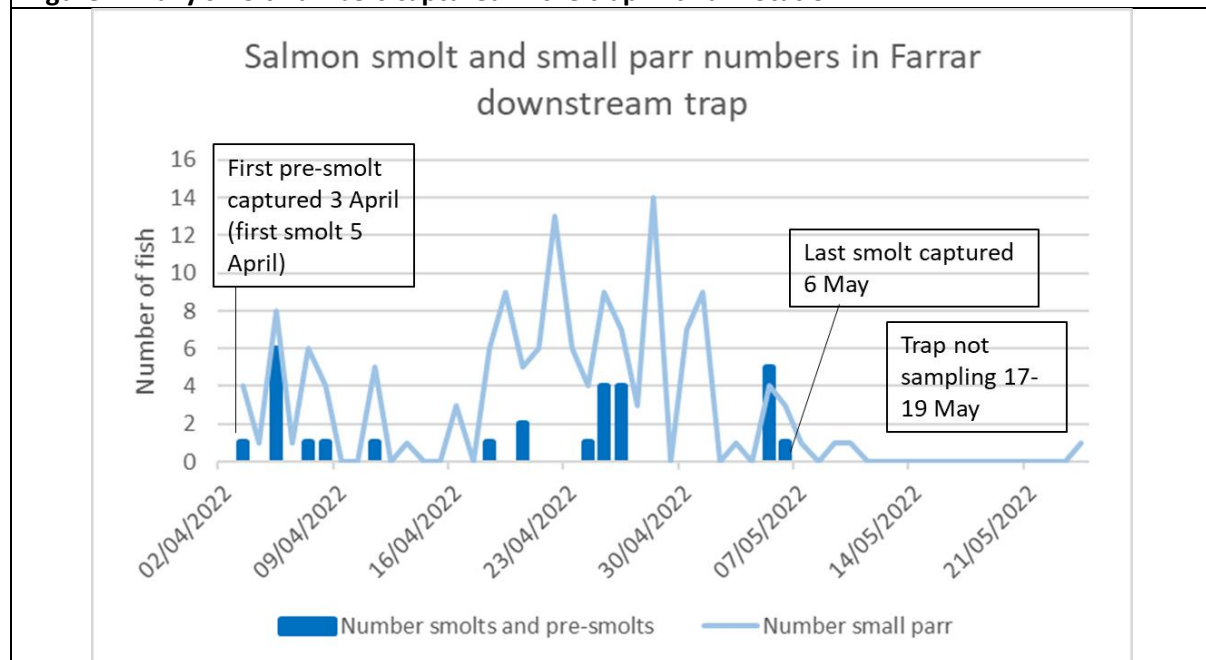
The Box trap sampling on the Farrar showed smolts and pre-smolts to be running between 3 April-6 May. A total of 31 salmon smolts and pre-smolts were detected, 29 were in the box trap downstream of Beannacharan dam. See [Figure 1](#).

At the other two traps upstream of Beannacharan dam and Loch a' Mhuilidh, a pre-smolt was detected on 4 April and a smolt detected on 23 April. One possible sea trout smolt was detected in the W arm trap 6 May. No other smolts were detected although the traps were successful at capturing small parr. This may suggest smolts had already migrated downstream ahead of the traps being in place. This is supported anecdotally by an SSE operative at Beannacharan dam who mentioned he thought he had seen smolts above the dam at the end of March.

Due to the nature of the sampling it is not possible to say if 3 April-6 May was the definitive smolt run timing on the Farrar as trapping will have only caught a very small proportion of the total smolt run and smolts may well have been running before and after these dates.

On the Upper Glass (Fasnakyle), smolts were running on the night of 4 April with 128 smolts and 3 pre-smolts caught. Several trout parr were caught with one being a sea trout smolt. ([Figure 1](#)).

Figure 1: Daily smolt numbers captured in the trap with annotation.



On the neighbouring Conon system, smolt trapping for mitigation purposes occurs on two tributaries- the Meig and the Bran. At the Meig, smolts were recorded as running from 9 April- 21 May, with peak migration occurring 28 April and 1 May.

On the neighbouring Ness system, smolt trapping occurred for tagging purposes at the Invergarry 6ft smolt trap and smolts were caught from 5 April, with the peak run being 22 April, although it is not known what happened after the 23 April as smolt trapping ceased. See [Appendix 1](#) for neighbouring catchment data summaries.

2.2 Temperature

Temperature data was downloaded from the loggers in June and showed that the Tomich logger had unfortunately been removed from the water on 28 April, the Farrar logger was in for the entire smolt run.

The environmental factors cuing downstream smolt migration are mainly water discharge and water temperature [*****].

Due to the nature of the monitoring in place we cannot precisely tell when the smolt run started in the Beaully catchment in 2022, however we know smolts were running when water temperature reached 7.2°C on both rivers. See [Figure 2A](#) and [2B](#).

Figure 2A: Water temperature logger data with Farrar smolt run notes for R. Farrar for 2021 and 2022

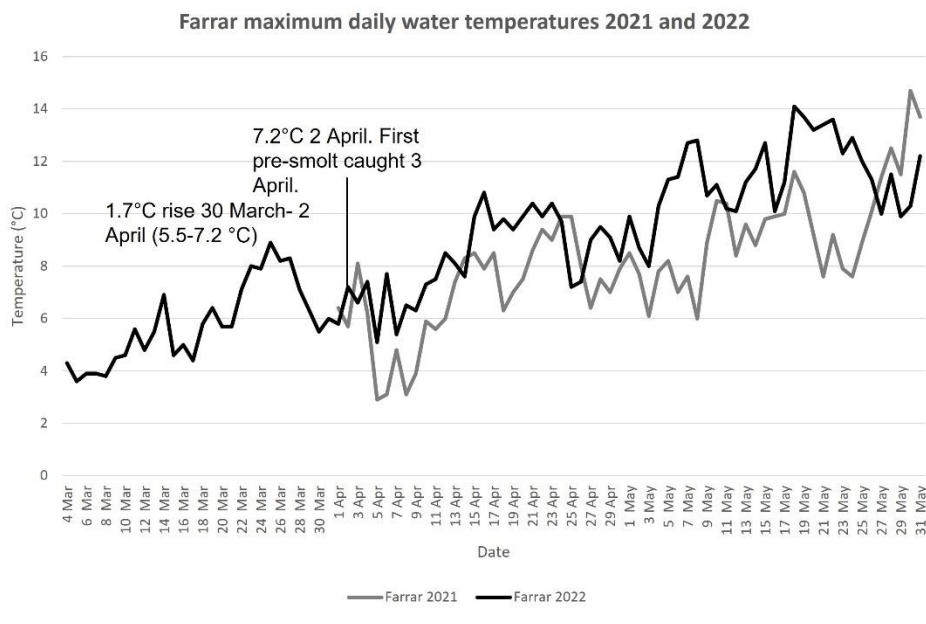
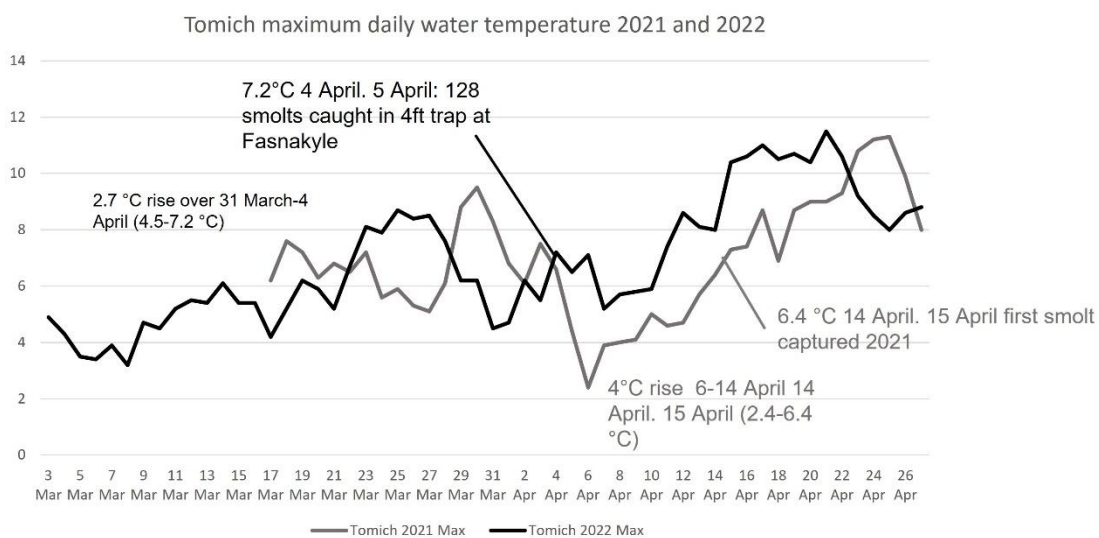


Figure 2B: Water temperature logger data for A. Deabhog (top of River Glass) with Fasnakyle smolt run notes for 2021 and 2022



Smolts are generally adapted to time their migration so that when they reach the sea, sea surface temperatures are warm enough for feeding, growth, and movement to avoid predation [****] .

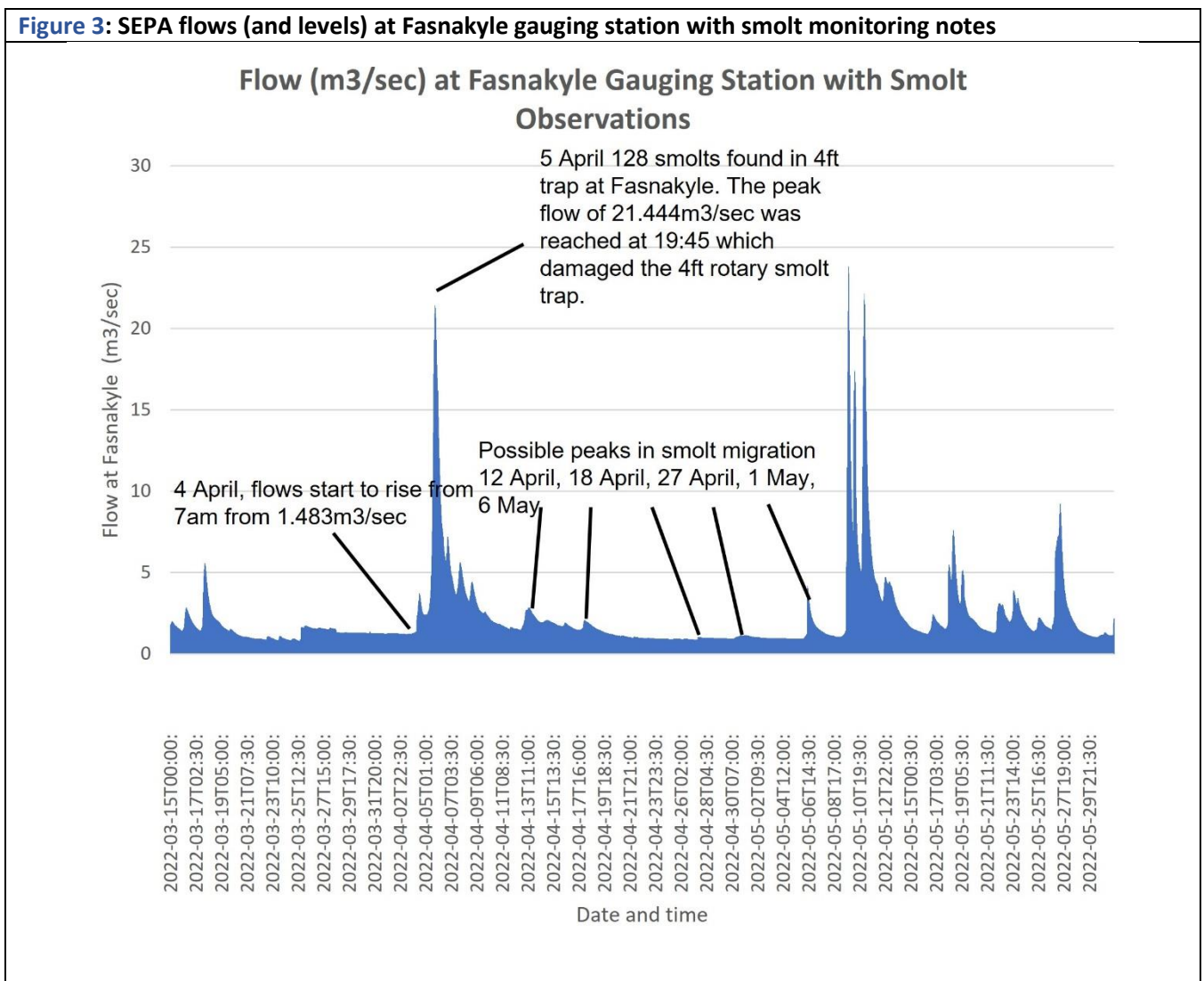
Water temperatures for most of April were above those experienced in 2021. There is a lack of preceding data for comparison although it is generally thought that air temperature in 2022 was generally warmer than 2021. The run occurred at least 10 days earlier when compared to 2021.

Temperatures recorded by a hand-held temperature probe do not suggest any consistent temperature difference between the US and DS box trap sites on the Farrar. The temperature at the DS Farrar box trap was on average 0.4 °C warmer, with a very similar range (9 degrees compared with 9.3 degrees found upstream. This may be due to actual climatic difference (being further down the catchment and slightly warmer) or simply because we were in the habit of checking the top traps first and the bottom trap last when air temperatures would have been higher slightly later in the morning. This may suggest that Loch Beannacharan is not having much of a thermal impact on water temperature at this time of year. This would make sense as at Beannacharan dam, water is abstracted from the top of the water column, it goes through a comp set to generate a small amount of electricity before being returned downstream to the river.

2.3 Effect of Flows on Smolt run timing

Flow rate and water level data is available from SEPA’s gauging station at Fasnakyle and is recorded every 15 minutes.

As we only have one night’s worth of smolt monitoring data at Fasnakyle, it is impossible to say whether or not the elevated flows seen on the night of the 4 April triggered the start of the smolt run. It is likely that the elevated flows encouraged smolts to migrate. Last year, rises in flow did not appear to trigger the smolt run although a rise in flow did correspond with peak smolt numbers caught. This may also have been down to improved trap efficiency. Smolt monitoring observations are shown with flow data in [Figure 3](#) below. Please see [Appendix 2](#) for the equivalent water level data.



A rise in flow and levels occurred from 7am on 4 April, with a peak flow of 21.433m³/sec being reached at 19:45 on 5 April (peak level 0.889m at 20:45 on 5 April. This was the spate which damaged the rotary screw trap.

Smolt monitoring on the Farrar showed smolts to be running until at least 6 May. If the run timing was similar on the Glass then rises in flow and possible peaks in smolt migration may have occurred on 12, 18, 27 April and 1 and 6 May.

2.4 Smolt age

Last year smolts caught at Fasnakyle ranged from 97mm-150mm with a single outlier of 171mm and were likely to have been predominantly 2+ smolts.

The length data for the smolts captured in 2022 is shown below (Figures 4A and 4B).

Figure 4A: Smolt length frequency, for 34 smolts measured on 5 April, Fasnakyle

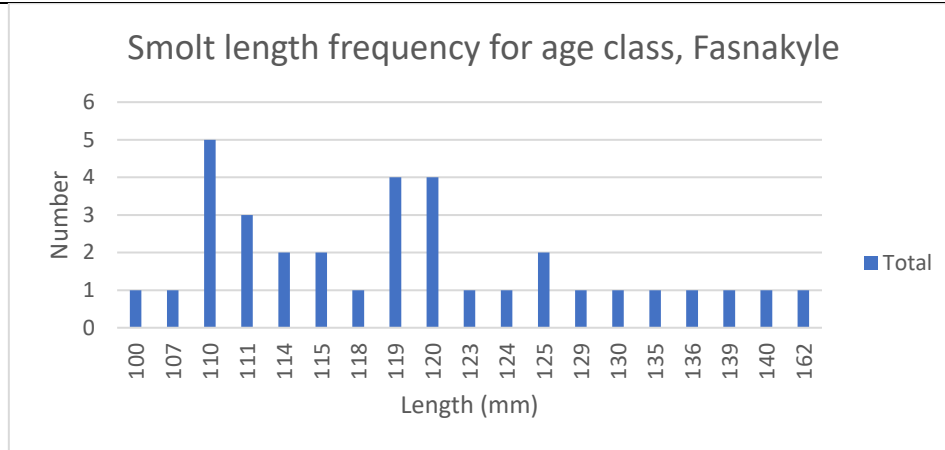
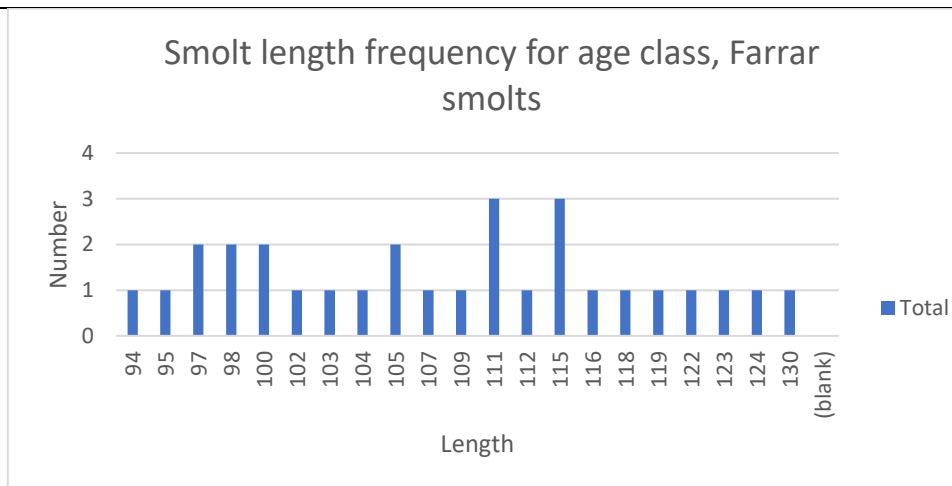


Figure 4B: Smolt length frequency for 29 smolts measured throughout the smolt run, DS trap Farrar.



Sub-sampled smolts caught at Fasnakyle ranged from 100-162mm with the average size being 120mm. Smolts sampled on the Farrar ranged from 94-130mm with the average size of smolts being 109mm. Scales have not been analysed but electro-fishing data would suggest that the majority of smolts are 2+ fish from both of these main tributaries of the Beaully.

On the Ness, for 2022 the smolts captured at the Invergarry trap averaged 122mm.

2.5 Smolt weight

Last year smolt weight averaged 19.2g (Standard deviation 5.5g) with a range between 9-38g at Fasnakyle.

In 2022 smolt weight averaged 20.1g at Fasnakyle (range 14-31g). See [Figure 5A](#).

On the Farrar, smolt weight averaged 12.2g (range 6-27g). See [Figure 5B](#). It is unclear if the finding of there being lighter smolts on the Farrar is genuine as the weighing method varied slightly between the two sites i.e. smolts were sometimes weighed on the back of the truck tailgate for convenience at the Farrar DS site.

Figure 5A: Smolt weight distribution for 34 smolts measured on 5 April, Fasnakyle

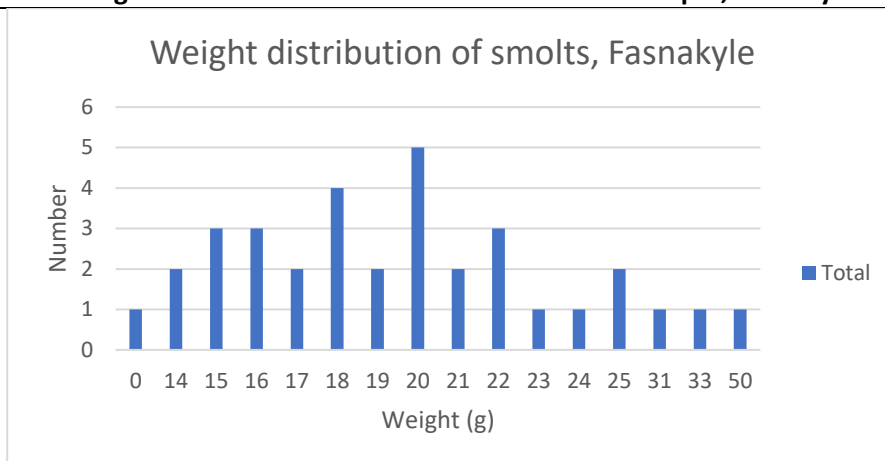
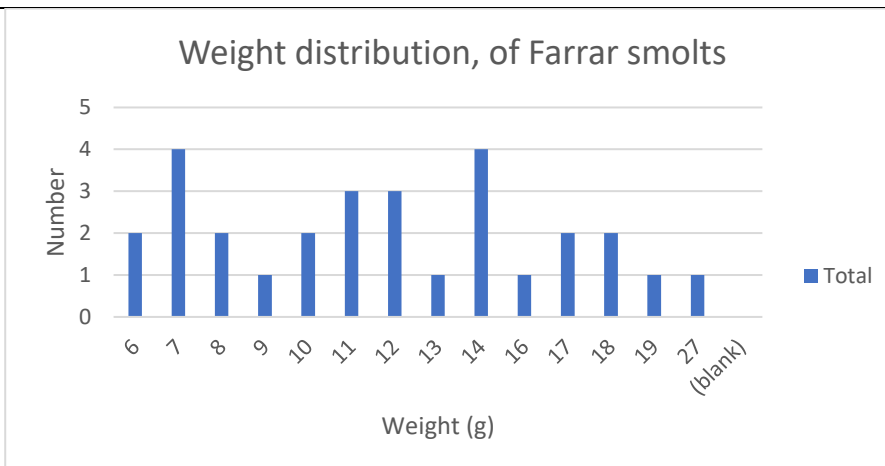


Figure 5B: Smolt weight distribution for 29 smolts measured throughout the smolt run, DS trap Farrar



In England, work done on the R. Frome showed that larger smolts have better sea survival. Large smolts were more than three times more likely to return after their first winter at sea (16 cm long, 3.5% return rate) compared to small smolts (12cm long, 0.95% return rate) [*].

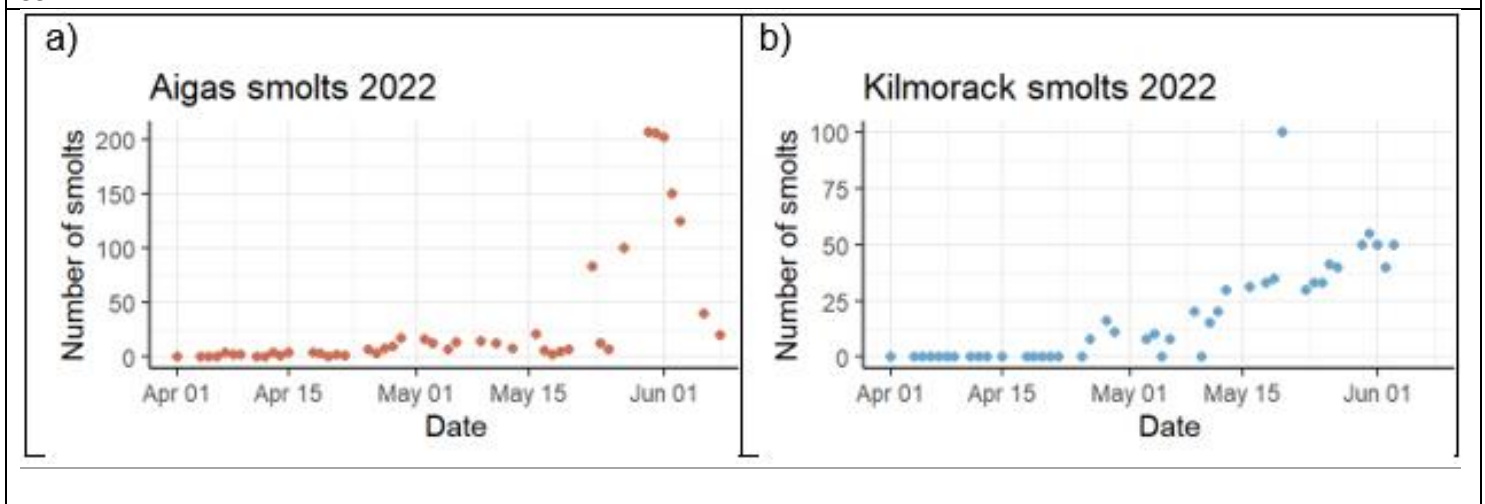
This may be due to their stronger swimming abilities to avoid predators, or just general better physical condition. It is an example of how the freshwater phase interacts with the marine phase of a salmon's life and may influence its resultant survival and behaviour at sea.

2.6 Smolts at Aigas and Kilmorack Gate Slots and Comparison with Previous Years

As done last year, experienced operatives at Aigas and Kilmorack dams checked for smolts in the gate slots during the smolt run and estimated how many smolts were stuck. These figures are indicative only as due to the depth and complexity of the gate slots it is very difficult to count smolt numbers accurately.

Last year smolts were observed at Aigas dam between 28 April and 4 June, with a maximum of 120 smolts seen on 26-27 May. At Kilmorack, smolts were observed between 16 April and 4 June. A maximum of 32 smolts were seen on 26 May. The results for this year are included below and are provided by SSE (Figures 6A and 6B).

Figure 6: Daily numbers of smolts observed in intake gate slots at Aigas (a) and Kilmorack (b) in 2022, data provided by SSE.

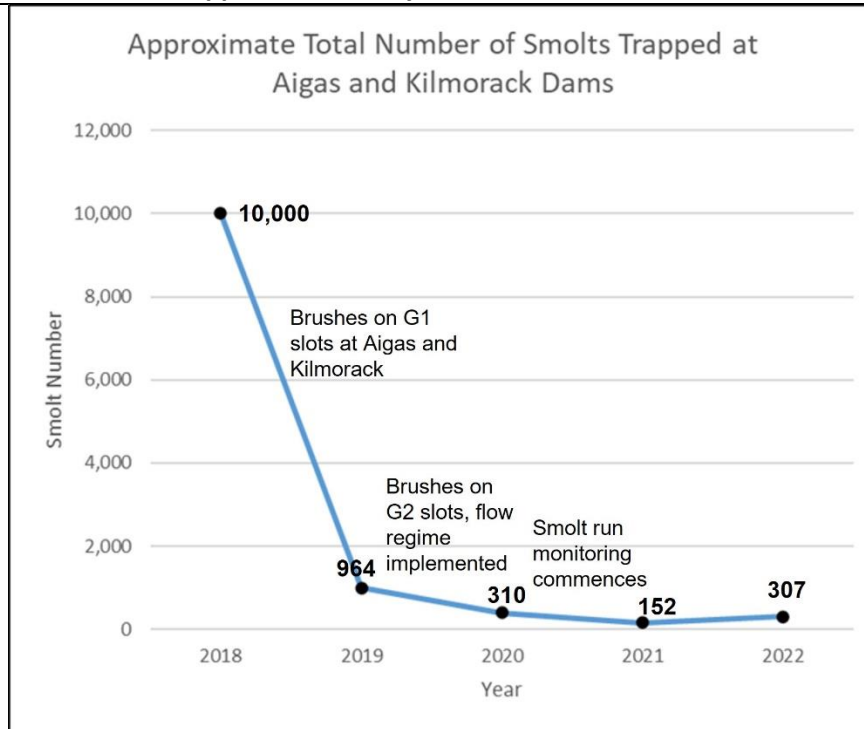


At Aigas, smolts were observed between 7 April and 8 June, with an average of 18 smolts and **maximum of 207** smolts on 30 May. At Kilmorack, smolts were observed between 26 April and 3 June, with an average of 7 smolts and **maximum of 100** smolts on 20 May (Fig. 1b). Aigas and Kilmorack dams were visited by Fishery board staff on 23 May to check the numbers of smolts in the gate slots and it was estimated that there were approximately 40 smolts at Kilmorack and 150 at Aigas.

Although smolt numbers are up from last year (peak of 307 smolts in 2022 compared to a peak of 152 last year) this is still many less than pre 2020 (see Figure 7), but **it suggests that the flow mitigation was less successful than last year. Phase 1 flows were implemented as per the protocol, however there was a delay in the implementation of the Phase 2 flow mitigation.** See Appendix 3 for more information on the protocol. Smolts were recorded in the upper catchment between 5 April- 6 May but Phase 2 of the protocol was in place 25 April- 28 May 2022. Last year we recorded smolts running between 15 April-12 May and SSE operated Phase 2 of the protocol between 20 April- 31 May.

The delay in implementation may have been down to the less comprehensive quality of the data collected this year in the Beaulay catchment and a resulting reliance on information from neighbouring catchments.

Figure 7: Comparison of smolts trapped across the years, 2018-2022. For more information see Appendix 3



To give some context to these figures it is estimated that the total smolt output for the Beaully is 80-90,000 smolts. Assuming a 5% marine survival, out of a total of approximately 4,500 returning adults the numbers of potential lost adults have gone down from 500, to just 15 with SSE and the board's work.

3. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- Trial Box trap sampling on the Farrar showed **smolts and pre-smolts to be running between 3 April- 6 May on the Farrar**. Due to the nature of the trapping it was not possible to detect precise run timing so smolts were likely to have been running either side of these dates.

- **Smolts were running at the top of the R. Glass (A. Deabhag) on the night of 4 April. This is at least 10 days earlier than in 2021** (15 April-12 May). This is likely to have been down to warmer preceding temperatures.

- Smolt run timing from neighbouring catchments (as well as our own monitoring) was used to judge when Phase 2 smolt flows were to be implemented. On the Conon, smolts were recorded as running 9 April- 21 May (peak migration 28 April and 1 May). On the Ness, smolts were recorded from 5 April (possible peak on 22 April).

- Smolts were running when water temperatures reached **7.2°C** on both the R. Farrar and R. Glass (A. Deabhag) after rises in temperature. This compares to 6.4°C in 2021 on R. Glass.

- It is likely that the elevated flows on 4 April encouraged smolts to migrate. Rises in flow and water level at Fasnakyle occurred on 12, 18, 27 April and 1 and 6 May and may have resulted in possible peaks in smolt migration but this was not monitored.

- Sampled smolt length at Fasnakyle ranged from 100-162mm with the average size being 120mm. Smolts sampled on the Farrar ranged from 94-130mm with the average size of smolts being 109mm. The majority of smolts are 2+ fish from both of these main tributaries of the Beaully.

- Sampled smolt weight averaged 20.1g at Fasnakyle (range 14-31g) and 12.2g (range 6-27g) on the Farrar. **Further monitoring is required to see if this difference in condition of smolts between the two rivers is genuine or not as it may have implications for ongoing marine survival of smolts.**

- At Aigas dam gate slots, smolts were observed between 7 April and 8 June, with an average of 18 smolts and **maximum of 207** smolts on 30 May. At Kilmorack, smolts were observed between 26 April and 3 June, with an average of 7 smolts and **maximum of 100** smolts on 20 May. The peak of 307 smolts observed at the gate slots suggests **that the flow mitigation was less successful than last year. This may have been down to the delay in the Phase 2 flow mitigation being implemented.**

- As the upstream box traps on the Farrar successfully captured small parr, this suggests that the placement of the traps was ok, but smolts may have dropped into the lochs ahead of sampling being in place.

- The spatey nature of the site at Fasnakyle has led us to re-consider whether this is really a suitable site for running a rotary screw trap unless site alterations are made.

- Trap efficiency was not assessed on either river due to the small number of smolts captured on the Farrar and the unfortunate damage to the 4ft RST at Fasnakyle.

RECOMMENDATIONS

- Continue to work with SSE to help improve flows for smolts whilst this improves smolt survival in the catchment. Ensure good communication between SSE and Board staff. Support the annual updating and refinement of SSE work protocols as knowledge improves.

-It has been highlighted to SSE that the board would have preferred Phase 2 smolt flows to have been in place sooner. With the existing data now gathered from 2021-2022 and improved monitoring planned to be in place in 2023 this should mean a quicker response to implementing Phase 2 of the protocol.

-Better weighing scales/ more reliable measuring method to be used next time on the Farrar.

-Temperature loggers need to be back in the river from 1 January to enable three months of temperature monitoring prior to the smolt run to enable long term data analysis to be conducted in due course.

-Improve the reporting of smolt observations from ghillies and SSE operatives (including at Beannacharan dam and below Kilmorack) to the board.

Monitoring in 2023 will hopefully be lower down the catchment in the form of a large 6ft smolt trap placed closer to Aigas dam to enable better information as to when smolts are about to go through the turbines (to enable more effective mitigation flows). It is hoped to also run box traps at the start of the smolt run (one on the Farrar, and another on the Glass) to see if monitoring can detect the start of the smolt run further up the catchment. Trap-efficiency of the 6ft rotary screw trap will hopefully be assessed.

Thanks to SSE, Fishery board staff (Ali Skinner, Bob Smart, Louise Senior) and volunteers Jim, Steve and Tim who gave up their time to help us check the smolt traps, and to Strath Conon estate, Braulen estate, Kyle of Sutherland Fisheries and Miranda at Fasnakyle house. Your help is much appreciated.

References

[*] Gregory, S.D. et al (2019). Atlantic salmon return rate increases with smolt length. *ICES Journal of Marine Science* 76 (6): 1702-1712.

[**] Heisey Balloon Tagging technique used to investigate salmon smolt survival rate at hydro facilities in Scotland. SSE presentation (2014).

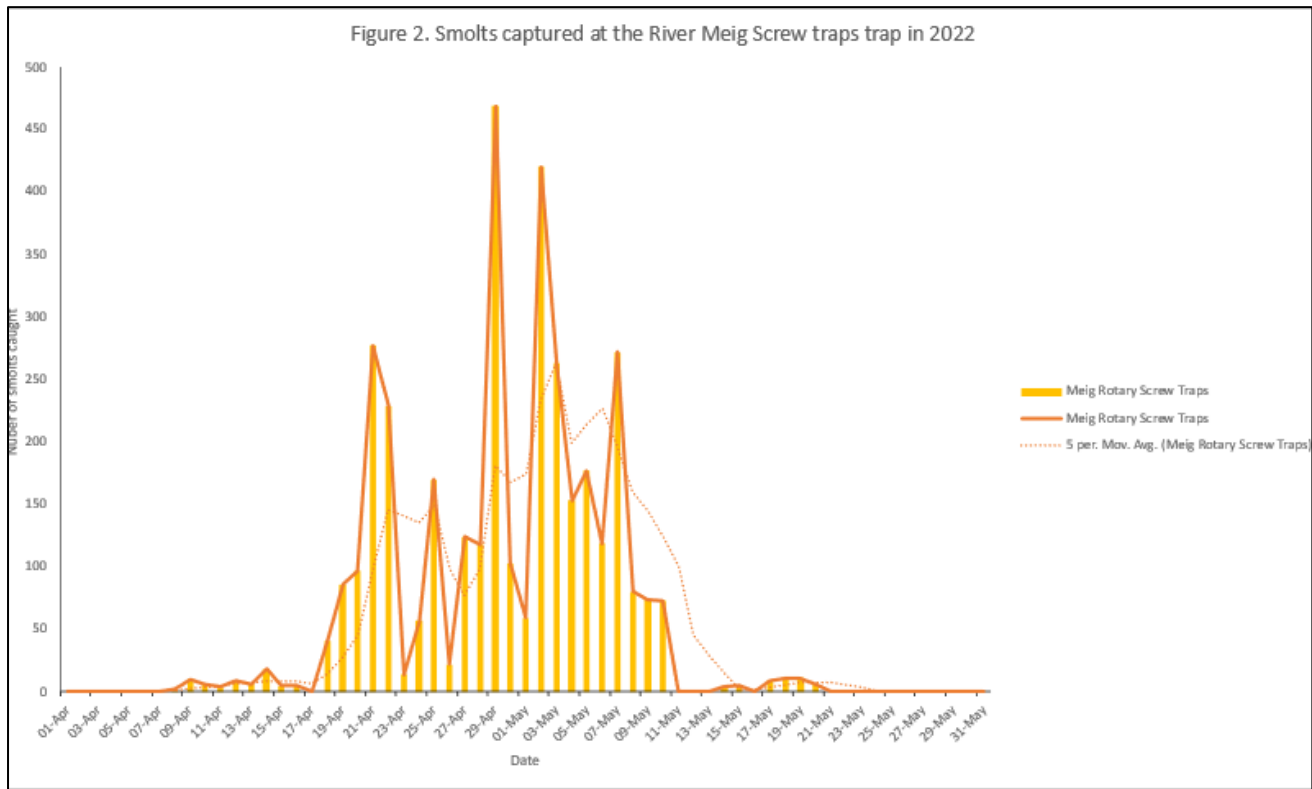
[***] Malcolm I.A et al (2015) Spatio-temporal variability in Scottish smolt emigration times and sizes *Scottish Marine and Freshwater Science* Vol 6 No 2

[****] Solomon D.J and Lightfoot G.W (2008) The thermal biology of brown trout and Atlantic salmon. Environment Agency Guidance.

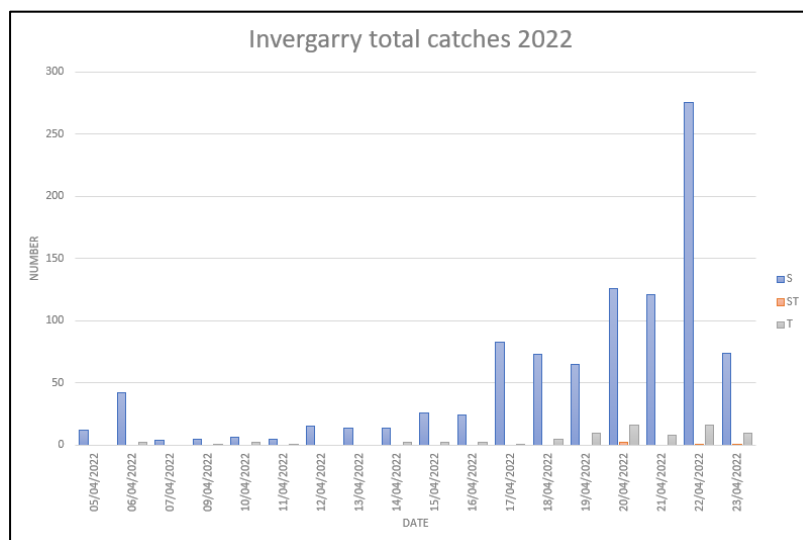
[*****] Thorstad E. B et al (2021) A critical life stage of the Atlantic salmon *Salmo salar*: behaviour and survival during the smolt and initial post-smolt migration. *Journal of Fish Biology* 81, 500-542.

APPENDIX 1- Smolt run timing on neighbouring catchments 2022

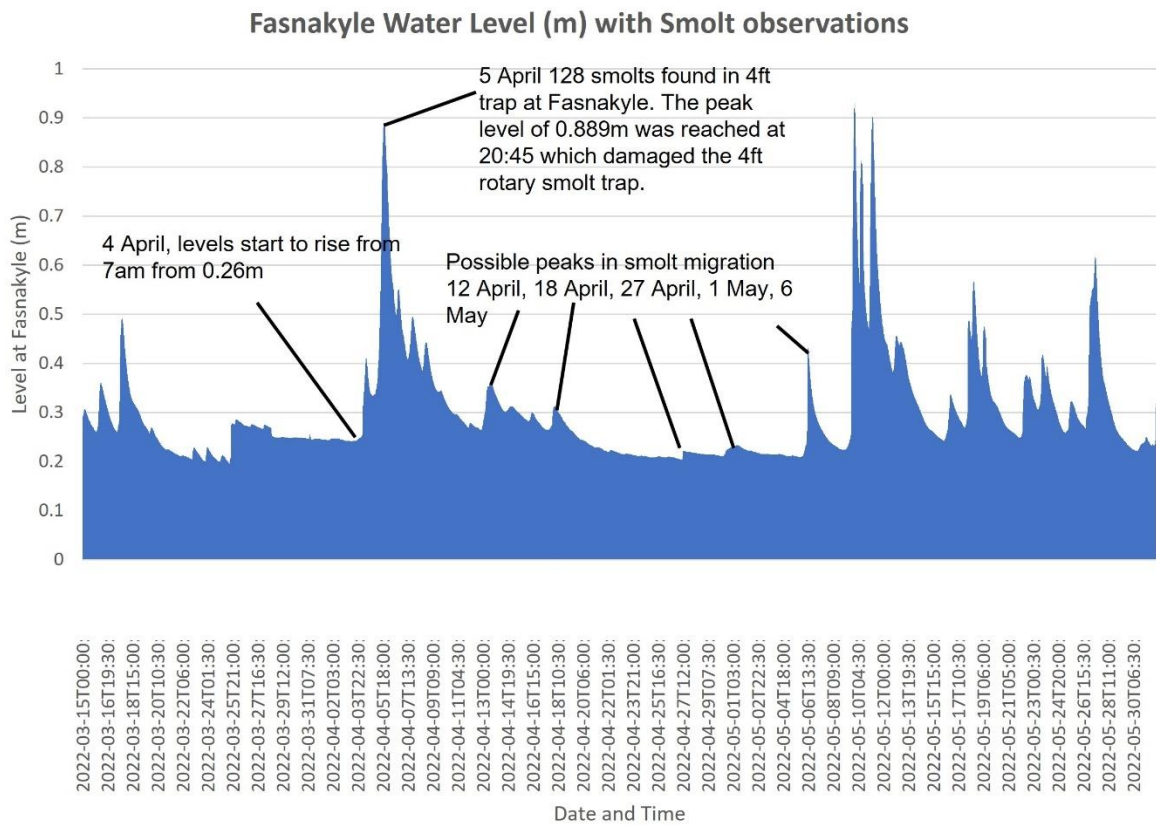
Conon: Comms with Biologist Sunny Bradbury, “With regards smolt run timing, we tagged fish on two tribes of the Conon – Meig and Bran.....Excluding small numbers (<50) of early and late running fish, the smolt migration took place over a 22 day period between 17th April and 11th May. There was a distinct peak in migration on the nights on the 28th April and 1st May, with 469 and 420 smolts caught, respectively. I have included a graph of the migration below.”



Ness (Ness District Salmon Fishery Board): Comms with Director Brian Shaw, “This is our graph for the Garry smolt run 2022. As you noted we stopped trapping once we had enough fish for tagging. Our peak was on the 22nd April, but we don’t know what happened after that. Our trapping site is influenced by freshets (7th/14/16/21/22nd April) but, unlike in previous years, we were catching as many during non-freshets flows. Certainly during the first few freshets the trap was becoming blocked, with moss and other debris, washed downstream....We caught 869 salmon smolt and presmolt, the average size was 122mm. We also caught 114 salmon parr, the mean length of which was 73mm. Of the 869 salmon smolts we tagged 125, size distribution below....All caught in a 6ft diameter RST.”



APPENDIX 2- SEPA flow level data with Smolt notes, Fasnakyle 2022



APPENDIX 3- SSE MITIGATION MEASURES AND PROTOCOL

In 2018 it became apparent that there was a problem with smolt migration through the Aigas and Kilmorack turbines in low flows when >8,000 smolts were rescued by SSE and the Ness and Beaully Fishery Trust. In 2019 SSE installed brushes on the entrance to the G1 gate slots at Aigas and Kilmorack ahead of the smolt run to deter smolts from entering. 2019 864 were rescued (with a further 100 found during a dive survey). Further brushes were fitted to the G2 turbines at Aigas and Kilmorack in 2020 ahead of the smolt run. In 2020 a total of 310 smolts were observed as being trapped at the gate slots. Work done by SSE suggests that Kaplan turbines run at higher load improve smolt survival [**].

SSE's 'Hydro Aigas and Kilmorack Salmon Smolt Protection protocol' (WI-HYDR-COMN-007 3.01) protocol was updated with input from the board and was similar to last year. It includes a two-stage regime and includes the following:

Phase 1) April-May: "Renewable Operations Control Room shall avoid all unnecessary machine changes and stop / starts between G1 and G2 units. Where reasonably practicable, unavoidable stop / starts shall take place during daylight hours

- ...where reasonably practicable, only the G1 machines shall be run if the load is less than 10MW".

Phase 2) During the smolt run as identified by the board, enhanced smolt flows: "where reasonably practicable, if either Culligran or Fasnakyle main machines are generating into the evening then they must maintain generation such that the load at Aigas is not reduced during the hours of darkness".