Beauly
Fishery Board

RW 16/02/2022

2021 Smolt Run Monitoring for Flow Management and Smolt Survival

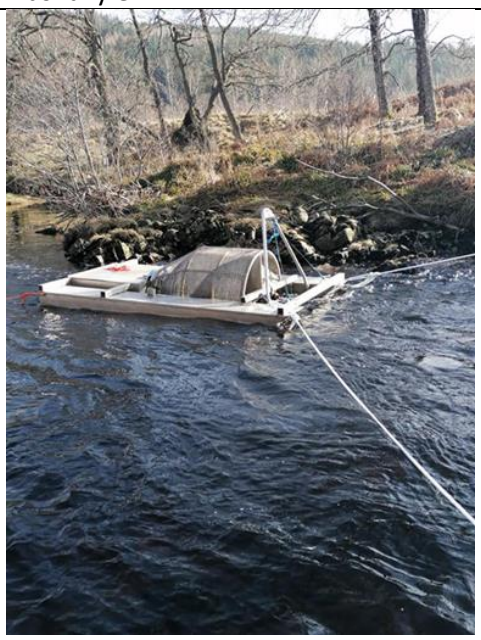
1. INTRODUCTION

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 further improve smolt survival when negotiating Aigas and Kilmorack turbines.

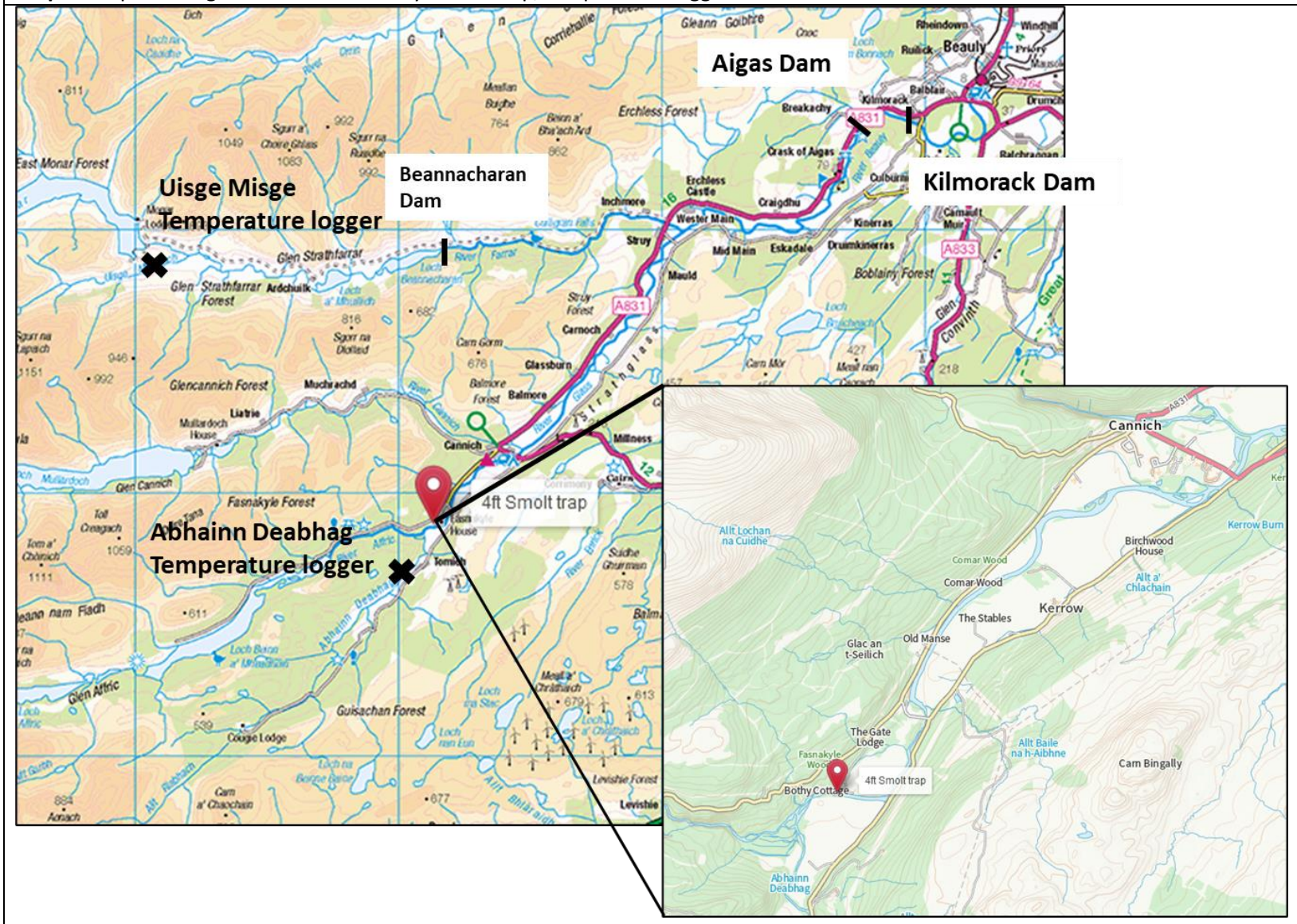
Between 17 March- 30 May a four-foot rotary screw trap provided by SSE was operated when flows allowed. It was sited at the top of Home pool at Fasnakyle house on the Abhainn Deabhag to monitor smolt run timing at the top of the R. Glass (a main tributary of the R. Beauly) See photos 1 and 2, and Map 1 for location. Temperature loggers were also installed further upstream and at the top of the Farrar (on the Uisge Misge) to aid potential future predictions of smolt run timing based on temperature alone.

Staff and volunteers were used to check the trap every day the trap operated and to move the trap ahead of forecast high rainfall. The board reported smolt numbers to SSE on a daily basis, and as a result, enhanced smolt flows were in place between 22 April- 1 June.

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.

Photo 1: Smolt captured 16 April	**Photo 2:** smolt trap in position at Fasnakyle
	

Map 1: Map showing location of 4ft Rotary Screw Trap, temperature loggers and Dams

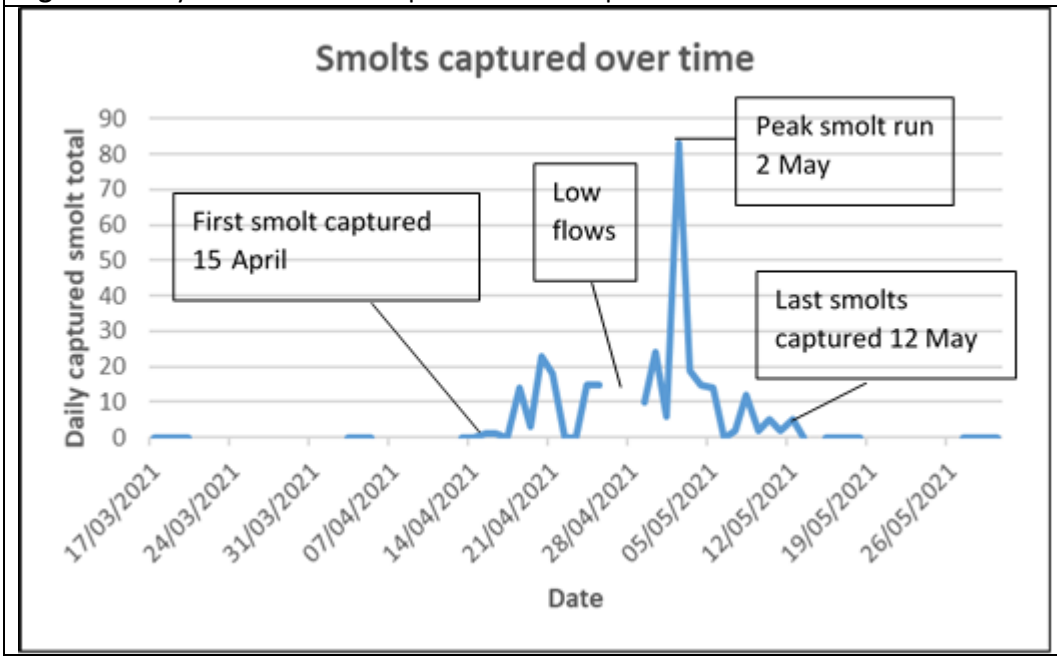


2. FINDINGS

2.1 Smolt run timing

The timing of the smolt run at the top of the R. Glass was found to be 15 April- 12 May (Figure 1).

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



The timing on the neighbouring Ness is consistently 1 April- 15 May (comms C. Conroy). In 2021 it was similar and started from 6 April with the peak a bit later than normal.

It is possible that we missed smolts between 5 April-12 April as flows were initially too low, then too high for trap operation. There is also a possibility that smolts may have migrated after May 12. However from the pattern of smolt numbers appearing in the trap and from observations in the neighbouring Ness catchment it would appear we captured the smolt run timing.

2.2 Smolt numbers

A total of 289 salmon smolts were captured which was many less than initially expected. Originally, based on the neighbouring Conon catchment (output of 3 smolts produced per 100m^2) and electro-fishing surveys that had shown the A. Deabhag to be below parr carrying capacity (in 2018 and 2019), it had been predicted that an output of 2 smolts per 100m^2 would result in 10,827 smolts descending past the trap during the smolt run.

The reasons for the lower-than-expected numbers is unknown as capture efficiency was not assessed. It is hoped in future years to assess this so that an estimate of total smolt output can be made. The site seemed to be good with flow channelled into the drum. Low flows may have been a factor and it is possible that some smolts were missed on 28 April (see 'Effect of Flows on Smolt Run Timing') or after 12 May.

1 trout smolt was also captured.

2.3 Effect of Temperature on smolt run timing

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

Temperature was recorded using a calibrated, hand-held probe at around 10am each morning. **The smolt run started properly on 18 April after water temperature rose sharply from 2.3°C (13 April) to 7.1°C on 17 April** (4.8°C over four days). See Figure 2a.

Figure 2a: Water temperature at smolt trap using hand held probe and smolt numbers.

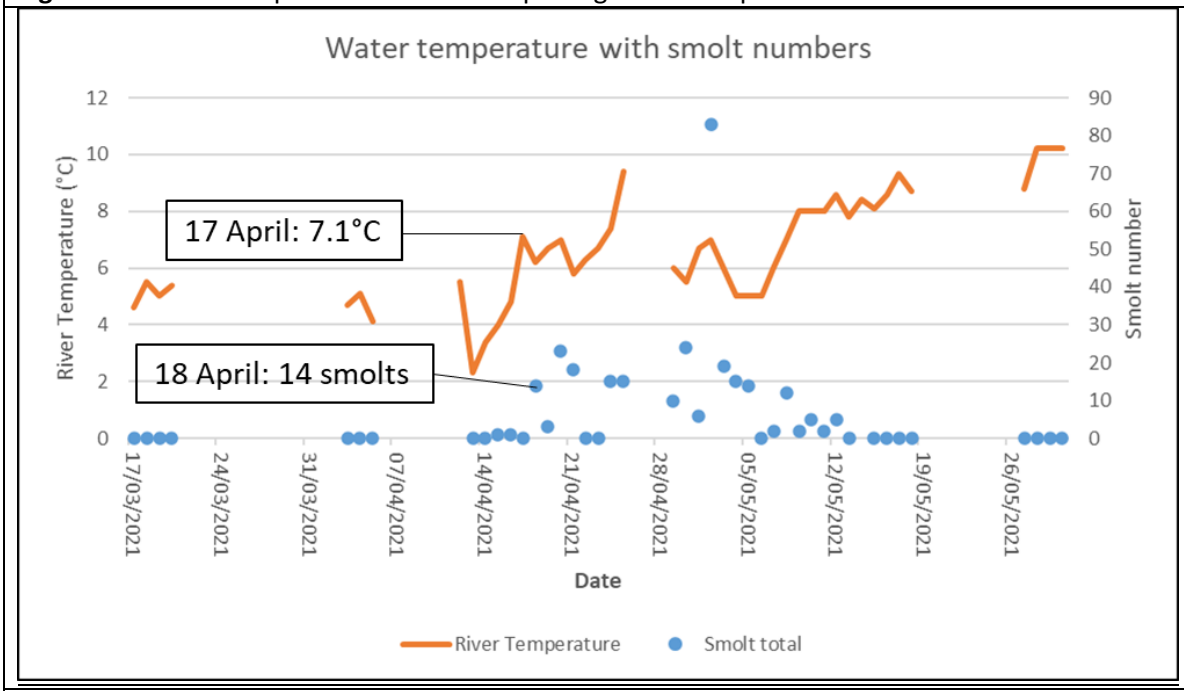
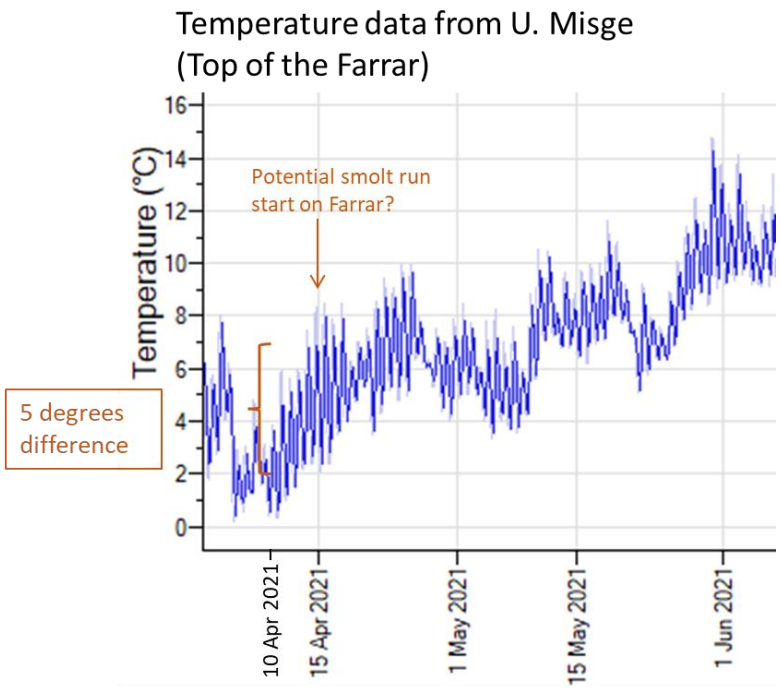


Figure 2b: Tiny tag logger data from the Top of the Farrar for the smolt run period on the Upper Glass.



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 [****] . **The cold spring seems to have delayed smolt migration and meant that smolts ended up migrating at a relatively low temperature** (there was snow on the ground at the trap until at least 7 April).

Temperatures over the preceding weeks may have had an effect too.

Temperatures experienced on the Farrar appear to be similar to those at Fasnakyle (Figure 2b) so smolt migration may have taken place around the same time, perhaps commencing on 15 April.

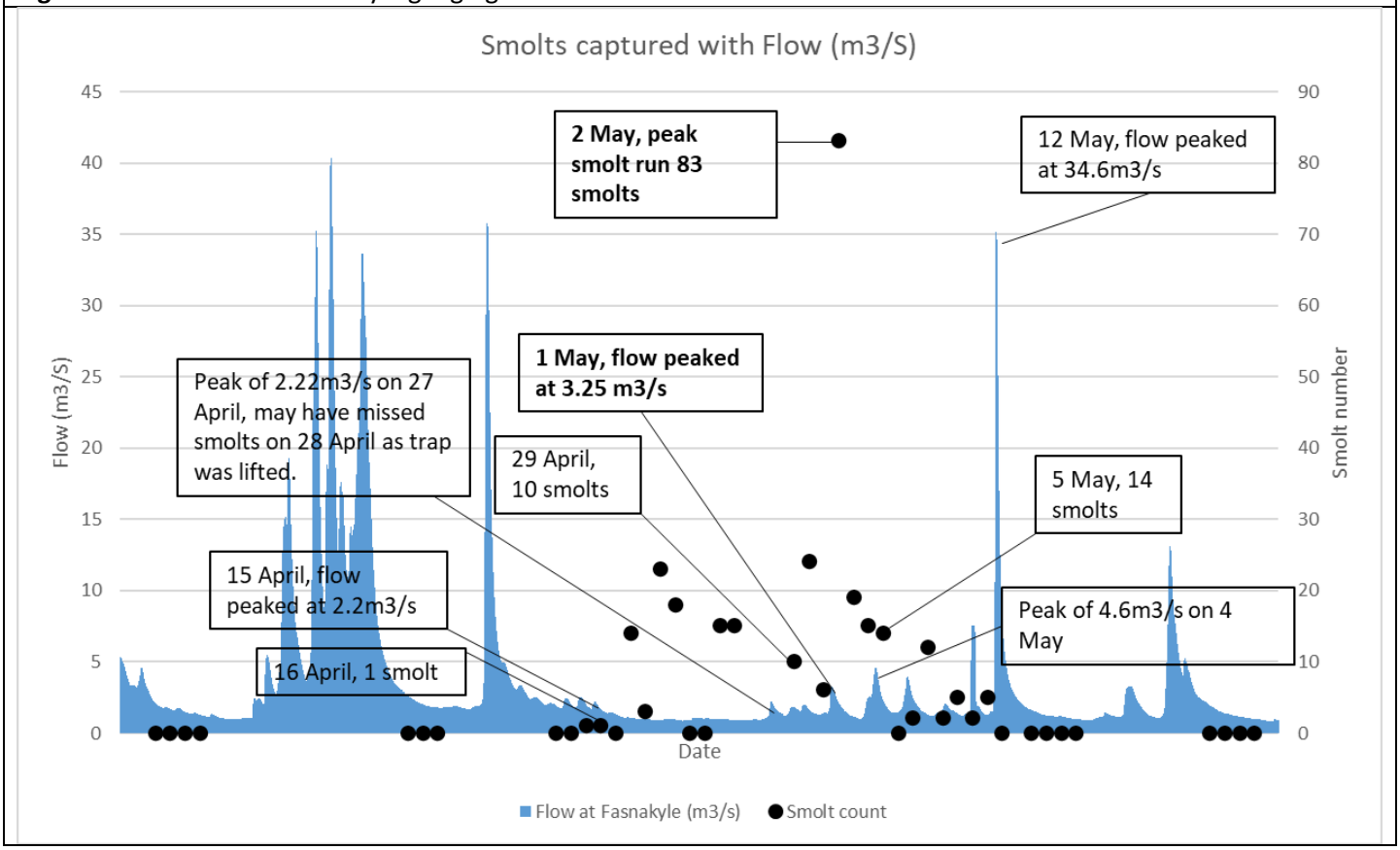
2.4 Effect of Flows on Smolt run timing

SEPA have a gauging station that was measuring flow rate at Fasnakyle during the smolt monitoring work.

Rises in flow did not appear to trigger the smolt run, although **the relatively large rise from 1.3m^3/s to 3.25m3/s on 1 May appeared to have an effect on peak smolt numbers**. The trap had been lifted as the drum was not turning due to low flows on 25 April so we missed a potential peak of smolts after flows went up to 2.22m^3/s on 27 April (Figure 3).

Please note these are SEPA flows not water levels.

Figure 3: SEPA flows at Fasnakyle gauging station with smolt numbers.

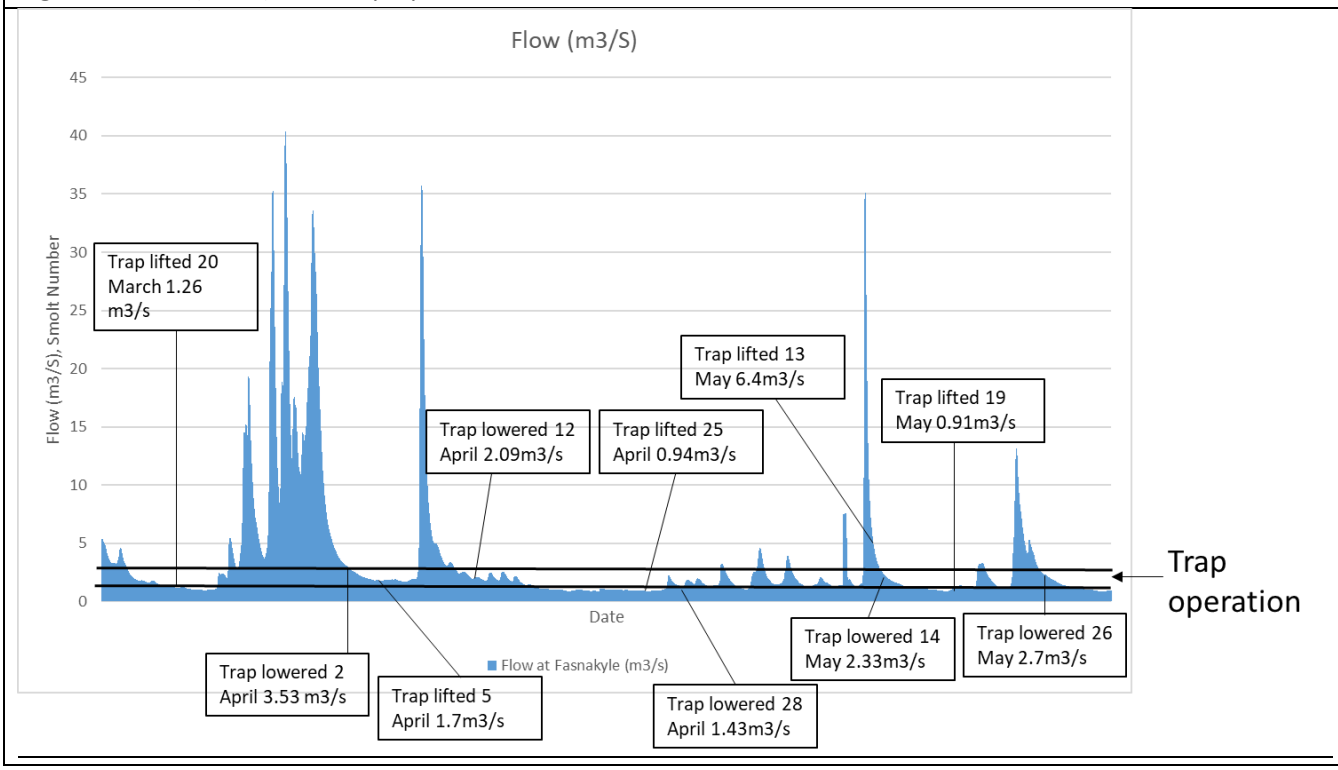


Other catchments show smolts run after a relative rise in levels (irrelevant of size of peak flow) and this would appear to be the case here.

2.5 Trap operation flow thresholds

With some daily trap adjustment, **the 4ft trap operated (the drum span) at between 3.5m3/s-1.26m3/s** (Figure 4).

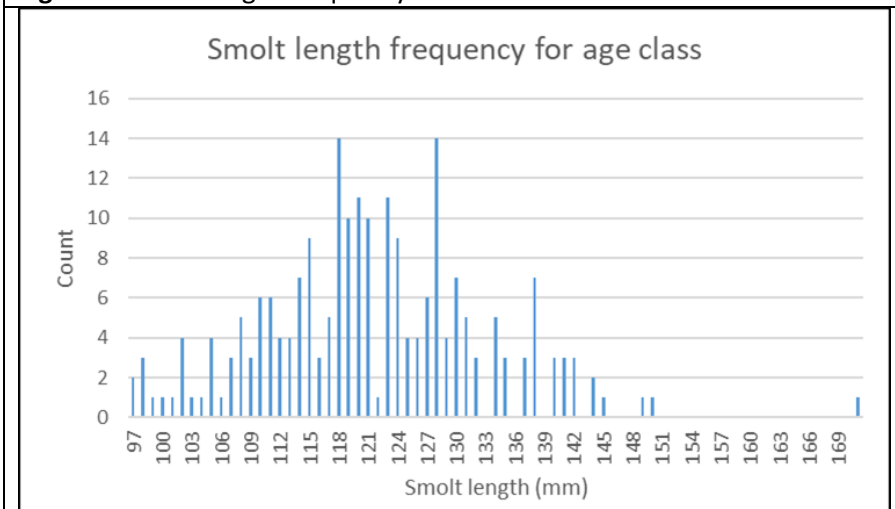
Figure 4: Flow (m3/s) with trap operation notes.



2.6 Smolt age

Smolts ranged from 97mm-150mm with a single outlier of 171mm. There were numerous age classes of smolts captured in the trap. Scale reading has not been completed but based on past electro-fishing data these are likely to be predominantly 2+ smolts (Figure 5).

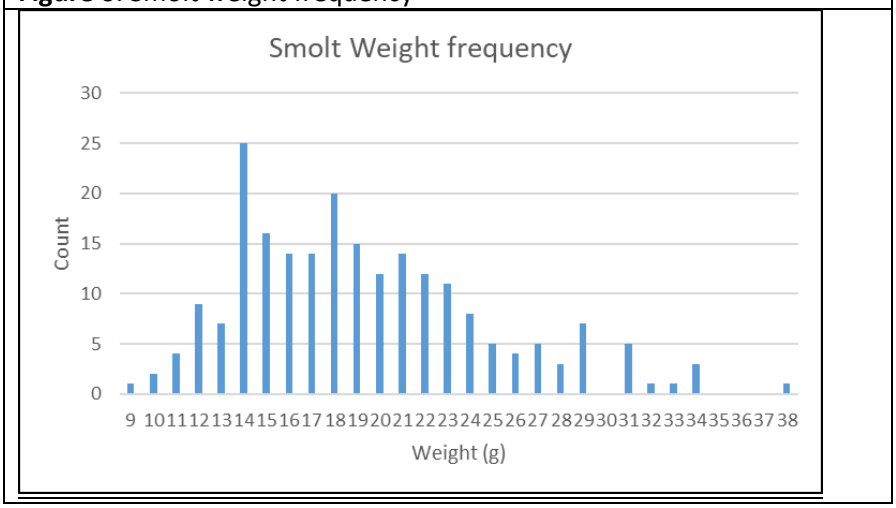
Figure 5: Smolt length frequency



2.7 Smolt weight

Smolt weight averaged 19.2g (Standard deviation 5.5g). Range was between 9-38g (Figure 6).

Figure 6: Smolt weight frequency



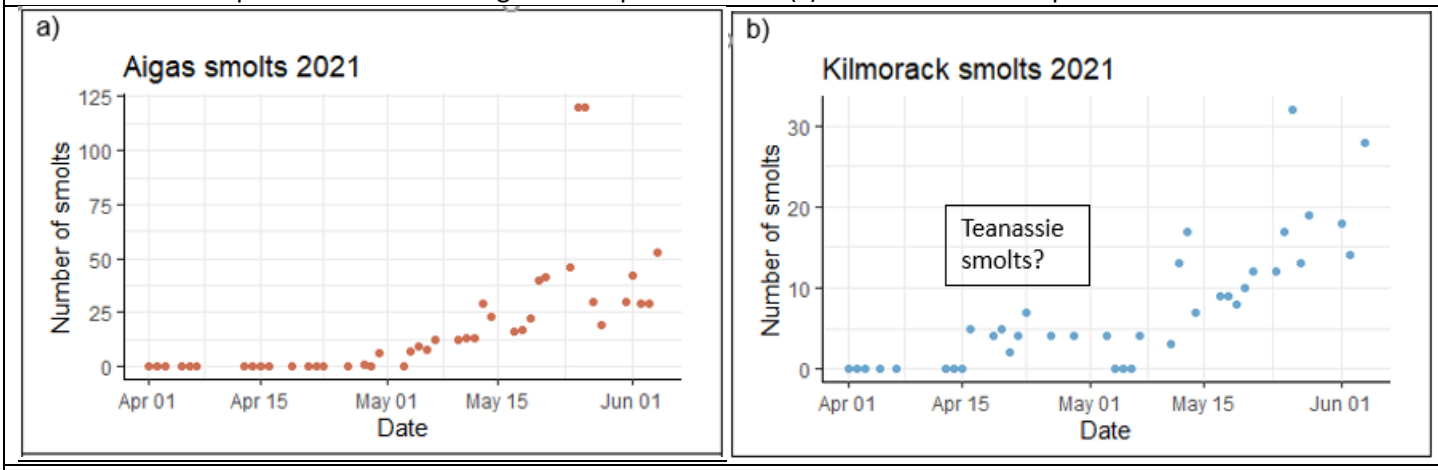
In England, work done on the R. Frome showed that larger smolts have better sea survival. Large smolts were more than three times more likely to return after their first winter at sea (16 cm long, 3.5% return rate) compared to small smolts (12cm long, 0.95% return rate) [*].

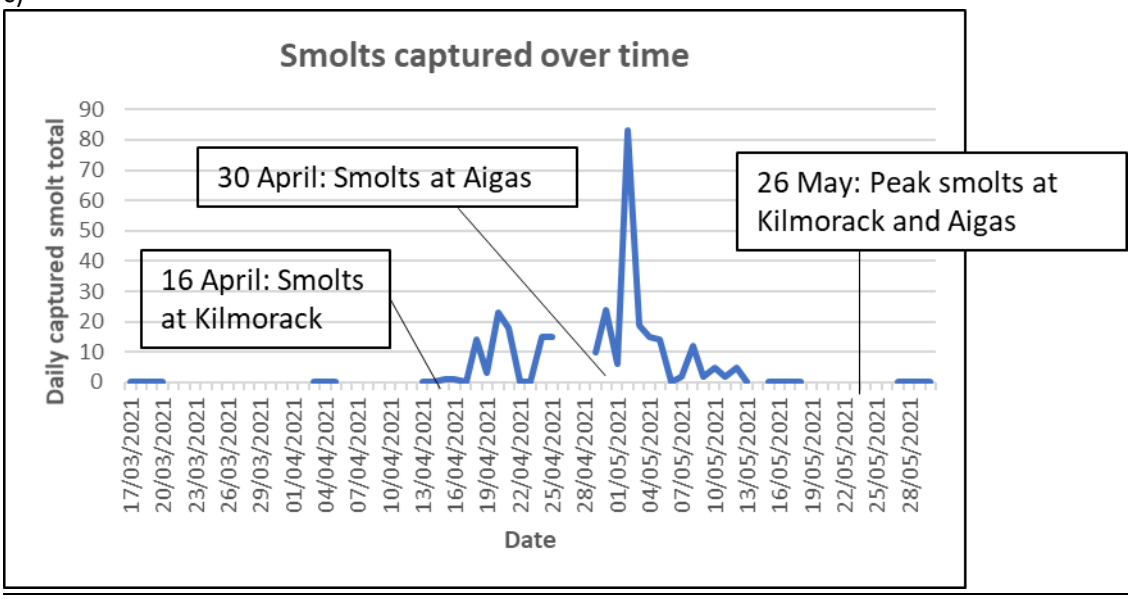
This may be due to their stronger swimming abilities to avoid predators, or just general better physical condition.

2.8 Smolts at Aigas and Kilmorack gate slots

Experienced operatives at Aigas and Kilmorack dams checked for smolts in the gate slots most days. No smolts were spotted by operatives at Beannacharan dam on the Farrar. 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 (Figures 6 a, b, c).

Figure 6: Daily numbers of smolts observed in intake gate slots at Aigas (a) and Kilmorack (b) in 2021, data provided by SSE. How this compares to the run timing at the top of the Glass (c). Please note Incomplete data.





At Aigas, smolts were observed between 28 April and 4 June. A maximum of 120 smolts were seen on 26 and 27 May (**Fig 6a**). At Kilmorack, smolts were observed between 16 April and 4 June. A maximum of 32 smolts were seen on 26 May **(Fig. 6b**).

Compared to the smolt monitoring work at the top of the Glass, **peak smolts were trapped twenty six days after peak run at the top of the R. Glass** (Figure 6c), these smolts could have been from various parts of the catchment and it is not clear if this is the result of smolts being delayed on their migration. Water takes around 6 hours to flow from Fasnakyle to Aigas, but monitoring was not in place after 12 May. On the Conon, smolts tend to head straight out once below the dam. Dimpling on the surface of the water (often associated with smolts) was seen downstream of Cruives at some point in May (date unconfirmed).

2.9 Comparison with previous years and SSE mitigation measures

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 beauly 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) was updated in 2021 with input from SEPA and the board. The protocol improved on the previous year and introduced a two-stage regime.

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

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".

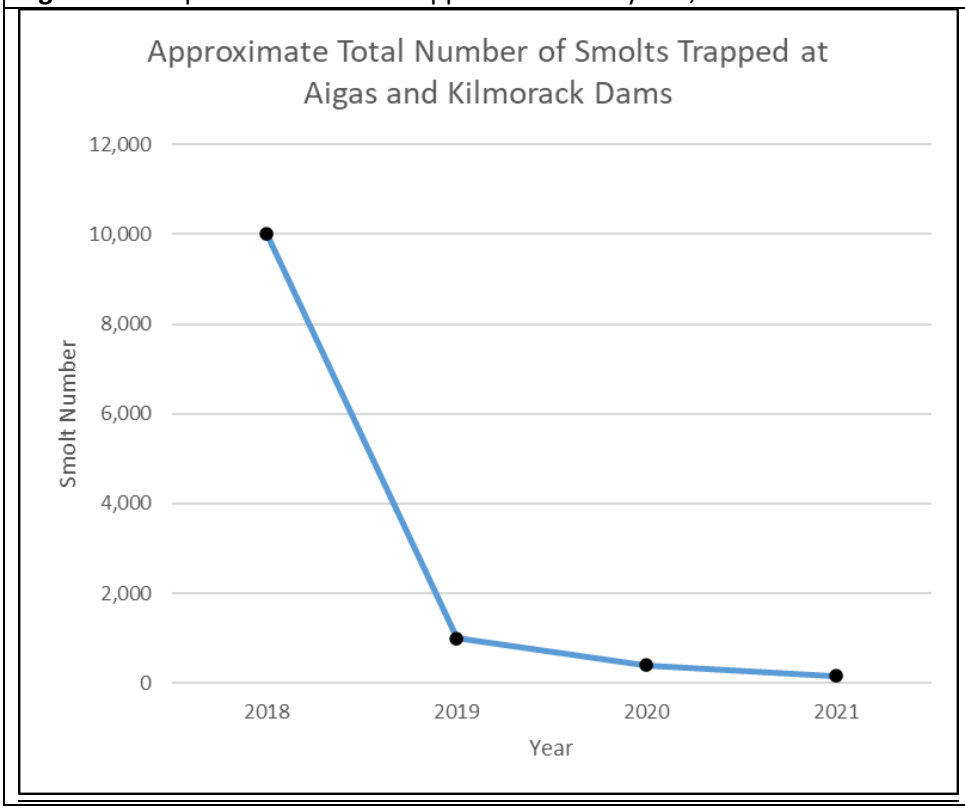
SSE report that the protocol and work instructions were followed at all times during the smolt season, i.e. between 1 April and 31 May 2021:

- *"Between 1 April and 4 June (inclusive), the intake gate slots were checked every day (except weekends) for smolts. The total numbers observed at Kilmorack were >20 until 26 May when they peaked at 32. The total numbers at Aigas were >50 approx, except for 25 & 26 May when they peaked at 120.*
- *Between 1 April and 4 June (inclusive), all unavoidable stopping and starting of the machines was prevented. This was crucial to protect smolts from being drawn into and entrained in the intake gate slots.*
- *Between 1 April and 4 June (inclusive), where possible, use of machine G1 was favoured. As the smolts tend to favour the side of the river where machine G1 is situated, this encourages them to pass through the machines and dam safely.*
- *Between 20 April and 31 May (inclusive), generation at Culligran and Fasnakyle was managed to ensure that the load at Aigas did not reduce during the hours of darkness. This supports the migration and escapement of smolts to the sea during the height of the smolt run.*

For the sake of clarity and for maximum protection of the smolts, unnecessary stopping and starting of the machines was prioritised over use of machine G1."

A peak of a total of 152 smolts were seen on 27 May. This compares to a peak of approximately 310 smolts seen by operatives on 15 May 2020, c1,000 trapped in 2019, and c10,000 in 2018.

Figure 7: Comparison of smolts trapped across the years, 2018-2021.



To give some context to these figures it is estimated that the total smolt output for the Beauly is 80-90,000 smolts. Assuming a 5% marine survival, out of a total of 4,500 returning adults the numbers of potential lost adults have gone down from 500, to just 8 with SSE and the board's work.

3. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

-The timing of the smolt run at the top of the R. Glass was likely to have been 15 April- 12 May and flows for smolts were in place between 20 April- 31 May.

-Smolt monitoring work to inform SSE flows and turbine operation at Fasnakyle, and through Aigas and Kilmorack dams appears to have reduced the number of smolts stuck at the Aigas and Kilmorack gate slots, and should have improved smolt survival in the catchment during the 2021 smolt run.

-There was a 26 day delay in peak smolts seen at the top of the R. Glass and peak smolts observed at the Aigas and Kilmorack gate slots.

-A total of 289 salmon smolts were captured (many less than expected).

-Although temperature appears to have triggered smolt migration, flow appears to have dictated the peak of the smolt run. The relatively large rise from 1.3m^3/s to 3.25m^3/s on 1 May appeared to have an effect on peak smolt numbers.

-Smolt migration commenced properly at a relatively low temperature of 7.1°C (having risen sharply) and appeared to be delayed due to the cold spring.

-Temperatures experienced on the Farrar appear similar to those at Fasnakyle. This may indicate smolt migration occurred at a similar time on the Farrrar but further work is needed to confirm this.

-The trap drum turned at flows between 3.5m3/s-1.26m3/s.

-A range of ages and condition of smolts were found, likely due to smolts migrating from a range of small burns and altitudes above Fasnakyle.

RECOMMENDATIONS FOR FUTURE SMOLT WORK

SSE: 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 re Affric spilling to ensure the smolt trap is not swept away. Support the updating and refinement of SSE work protocols as knowledge improves.

-Continue to request specific generation/ operational information from SSE to enable comparison of operations between years and further refinement of flows.

-Request operatives to report any sightings of smolts at Beannacharan dam.

Strategy: For future, smolt run timing should be monitored on the Farrar up and downstream of Beannacharan dam to get an idea of smolt run timing on the Farrar (e.g. box trapping), or a 6 ft trap on the mainstem Beauly below the Farrar confluence to get an idea of total smolt run timing to refine flows further for smolts at Aigas and Kilmorack dams.

-Continue operating the trap for a longer period, to ensure smolts are not missed in mid-May.

-Continue temperature monitoring on both the A. Deabhag and U. Misge to improve smolt run timing predictions for future years.

-A seasonal member of staff is required to operate even a single trap as it is a 2 person job each day, every day.

-Seek out specific observations from anglers/ ghillies during the smolt run etc

-**Improving trap efficiency**: Do mark-recapture work to assess trap efficiency. If drum can continue to turn at low flows this could improve trap efficiency. Consider a motorised trap for future years. Keep the 4ft trap drum lowered even if it is not turning so that any increase in flows (however small) may capture smolts if drum starts to turn.

Thanks to SSE, Ali Skinner, Bob Smart and the 13 volunteers who gave up their time to help us check the smolt trap, namely Dennis Ross who gave us 11 mornings. 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.