Summary of Loch Shin Smolt Trapping and PIT Tagging Data 2005-2020

Kyle of Sutherland Fisheries

1.- Introduction

In the mid-1960s investigations were undertaken in order to assess potential smolt passage issues related to the presence of hydroelectric dams in the upper Shin catchment. The investigations were undertaken in response to concerns raised by the Kyle of Sutherland District Salmon Fishery Board (Kyle DSFB) in relation to the presence of ostensibly landlocked salmon smolts in Loch Shin. At the time the main participants in the research were the Kyle DSFB and the North of Scotland Hyrdo-Electric Board with additional input from other organisations such as the Fisheries (Electricity) Committee and the Freshwater Laboratory at Faskally. The topic was controversial at the time with factors such as predation, damage by turbines and the lack of flow cues cited as possible explanations for the perceived decline in salmon populations post dam construction. It would appear that the fish passage issues were never satisfactorily resolved and the artificial stocking of salmon into Loch Shin tributaries continued to be undertaken by the Kyle DSFB despite evidence of the impingement of smolt passage. Unfortunately meaningful records of the results of the investigations undertaken during this period are not held by Kyle DSFB.

Figure 1. Map of Loch Shin and its tributaries showing the locations of smolt traps, Dams and the location where trapped fish are released.

More recently the issues of smolt passage in the upper River Shin catchment have been revisited. In 2005 rotary screw traps were deployed within tributaries of Loch Shin in order to catch migrating salmon smolts. This was undertaken in response to continuing concerns regarding smolt passage during their downstream migration. Initially, the work was

undertaken jointly by SSE and Kyle DSFB. Passive integrated transponder (PIT) technology has been employed to obtain insights into, amongst other things, the time taken by smolts to migrate through and out of Loch Shin and Little Loch Shin and the ability of smolts to exit the upper Shin catchment. The implementation of the Water Framework Directive in Scotland has resulted in greater involvement from SEPA in relation to the investigations undertaken. In addition to the initial aims of the project, other investigations such as the return rates of released wild smolts as adults have been undertaken. The investigations undertaken have been funded from various sources including Kyle DSFB, Kyle of Sutherland Fisheries Trust (Kyle Trust), Shin system proprietors, SSE and LEADER with additional inputs of expertise into the projects by SEPA and Marine Scotland Science. This document aims to briefly summarise the data holdings currently in the possession of Kyle DSFB and Kyle Trust.

2.- Tagging Data

2.1 – Transit Times and Smolt Exit Rates

Initial investigations undertaken between 2005-2007 utilised smolts caught on the River Tirry to assess the numbers of smolts detected successfully exiting Shin Diversion Dam at the downstream extent of Little Loch Shin. Smolts captured in a rotary screw trap on the River Tirry were PIT tagged and then released a short distance downstream of the trap to continue their migration. PIT tagged fish were automatically detected and their unique number recorded within the Borland fish pass located within Shin Diversion Dam. More recently, ghillies working on the River Shin utilise handheld decoders to check rod caught fish for the presence of tags. The transit period of those smolts successfully exiting was also calculated. A draft report was produced (see appendix) but a final version was never agreed. As such the data and findings remain unpublished in the formal sense. Investigations continued in 2008 but data was unreliable due to decoder failure. In 2011 investigations recommenced. In 2012 SSE deployed measures aimed at improving smolt passage including maximising the operation of the turbines at Lairg Dam in order to attempt to create flow cues plus the installation of guidance curtains in Loch Shin. If successful, these actions presented a possible improvement in the mitigation strategy for the presence of the dams. The 2012 results showed an improvement in the percentage of tagged smolts detected exiting at Shin Diversion compared to the previous years when mitigation measures were not deployed. Table 1 summarises the results of the 2005-2012 investigations which utilised Tirry smolts. Similar investigations were unable to be conducted in 2013 and 2014 due to the refurbishment of turbines which in turn precluded the manipulation of flow levels by SSE. An alternative potential mitigation strategy of capturing smolts in rotary screw traps and releasing them downstream of Shin Diversion Dam was also investigated concurrently. The results of these investigations are considered in Section 2.2.

Table 1 Summary of results of transit time and smolt exit experiments 2005-2012 (A.Watkins, SEPA).

Year	Tag start date	Tag end date	No. fish tagged (A group in 05-07)	Volume of water thru the turbines Apr-June incl. (M m3)	Average transit period (d) - bold figures exclude erroneous data	No. of fish detected D-S	% of fish detected D-S	Volume of water thru the turbines in March (M m3)
2005	7th April	25th May	684		33 **(25)**	63	9.2	
2006	18th April	22nd May	720	152.74	50 (**33**)	56 (*43)	7.8	75.83
2007	2nd April	10th May	1839	231.19	25 (**32**)	225	12.2	98.67
2008*				199.32				108.57
2009				191.28				98.69
2010				110.29				43.65
2011	1st April	13th May	1280	97.66	**24**	54	4.2	35.20
2012	20th March	22nd May	1048	183.80		332	31.7	83.60

* Partial data set due to decoder failure. No smolts were tagged in 2009 and 2010.

In 2012 smolts were also captured in the River Fiag and utilised in a separate investigation. The Fiag smolts were released into Little Loch Shin on the right and left banks in order to ensure that the smolt screening arrangement at Shin Diversion Dam are adequate. The results of the investigations are shown in Table 2.

Table 2 Results of Little Loch Shin screen test utilising Fiag smolts (A.Watkins, SEPA). R = right bank of Little Loch Shin looking downstream; L= left bank of Little Loch Shin looking downstream.

Year	Tag start date	Tag end date	No. fish tagged	No. of fish detected D-S	% of fish detected D-S	Average fish size (cm)
2012	2nd April	18th April	525	401 (R:206; L:195)	76.2	13.9

Attempts at improving smolt passage rates via flow manipulation and associated measures such as guidance curtains close to Lairg Dam resumed in 2015. Both Fiag and Tirry fish were utilised in the 2015 and 2016 investigations. Tables 3 and 4 summarise the results of the investigations in those years. It should be noted that both tables include the numbers and percentages of PIT tagged smolts which were recaptured at the trap operated at the Merkland end of the catchment for illustrative purposes in addition to those detected at Shin Diversion Dam. The results do not include the detection rates of smolts utilised for separate investigations such as the mark-recapture trials aimed at assessing trap efficiency (see Section 2.3).

Table 3 Number and percentages of smolts tagged on the River Fiag with associated detection and recapture rates Excludes fish from mark recapture trials.

Year	Fiag						
	Tag Start Date	Tag End Date	No. Fish Tagged	No. Fish Detected	% Fish Detected at	No. Fish Recaptured at Merkland	% Fish Recaptured at Merkland

				at Decoder	Decoder		
2015	11th April	30th April	748	54	7.2	30	4.0
2016	6th April	3rd May	1100	212	19.27	0	0

Table 4 Number and percentages of smolts tagged on the River Tirry with associated detection and recapture rates. Excludes fish form mark recapture trials.

Year	Tirry						
	Tag Start Date	Tag End Date	No. Fish Tagged	No. Fish Detected at Decoder	% Fish Detected at Decoder	No. Fish Recaptured at Merkland	% Fish Recaptured at Merkland
2015	15th April	20th May	390	27	6.9	17	4.4
2016	6th April	3rd May	137	27	19.7	2	1.5

2.2 – Returning Adults

PIT tagged smolts subsequently returning as adults are detected as they ascend the Borland lift in Shin Diversion Dam. This facilitates an assessment of the adult salmon return rates of the PIT tagged fish that successfully exited the upper Shin catchment during the investigations outlined in Section 2.1. Furthermore, it also facilitates an assessment of alternative potential mitigation activities such as the capture of smolts in rotary screw traps and subsequent release downstream of Shin Diversion Dam.

Return rates of tagged Tirry smolts that had successfully exited Shin Diversion Dam in 2005-2007 were considered low (Table 5). Various potential reasons for such low return rates have been mooted but remain speculative in nature.

Table 5 Return rates as adults after one sea winter (1SW) or multi sea winter fish (MSW) of River Tirry smolts successfully exiting Shin Diversion Dam.

Year	Number Tagged	Smolts Detected at Decoder	1SW Return	MSW Return	% Detected at Decoder Returning as Adults
2005	684	63	0	0	0
2006	720	56	0	0	0
2007	1839	225	1	0	0.4

Similarly, return rates of smolts trapped in the River Tirry and released downstream of Shin Diversion Dam during the same time period were also considered low (Table 6) in comparison with smolts similarly transported to a release site on the Conon system downstream of hydroelectric installations. Typically, transported Conon smolts have a return rate as adults of circa 3-5% (Simon Mckelvey, personal communication).

Table 6 Return rates as adults of River Tirry smolts released downstream of Shin Diversion Dam.

Year	Number Tagged	1SW Return	MSW Return	% Detected at Decoder Returning as Adults
2005	668	4	3	1.0
2006	726	6	1	1.0
2007	1816	3	2	0.3

The return rate as adults of those smolts which were detected successfully exiting Shin Diversion Dam in 2012, however, more closely matched the return rates expected on the Conon system (Table 7). It should also be noted that 50% of the Fiag origin smolts tagged in 2012 returning as adults did so as MSW fish i.e had spent two or more winters at sea prior to returning to the Shin. Typically, the ratio of 1SW to MSW on the Conon system is biased towards the 1SW component although there have been significant changes to this relationship in recent years (Simon Mckelvey, personal communication). It would be expected that MSW salmon would have a lower return rate than their 1SW counterparts due to increased risk of predation at sea etc.

Table 7 Return rates as adults of River Tirry and River Fiag smolts detected exiting Shin Diversion Dam in 2012.

Tagging Location	Release Site	Number Tagged	Smolts Detected at Decoder	2013 Return	2014 Return	2015 Return	% Detected at Decoder Returning as Adults	% Tagged Returning as Adults
Fiag	Little Loch Shin	525	401	7	7	0	3.5	2.6
Tirry	Tirry	1048	332	7	2	1	3.0	1.4

In 2015 smolts were again tagged in both the Tirry and Fiag. A proportion of tagged smolts were released as part of the assessment of downstream passage outlined in Section 2.1 and a proportion were released downstream of Shin Diversion Dam in order to continue to assess the efficacy of utilising the trapping and transportation of smolts caught in the rotary screw traps as a potential mitigation measure. Table 8 summarises the numbers and percentages of fish tagged as smolts in 2015 returning as 1SW adults in 2016.

Table 8 Return rates of smolts tagged in 2015 (excludes smolts utilised in mark-recapture trial as no self exiting smolts from the mark recapture trial returned as adults).

Tagging Location	Release Site	Number Tagged	Smolts Detected at Decoder	2016 Return	2017 Return	2018 Return	% Detected at Decoder as Returning Adults	% Tagged returning as adults
Fiag	Fiag	748	54	0	1	0	1.8	0.13
Fiag	D/S Shin Diversion Dam	750	NA	18	13	0	NA	4.1
Tirry	Tirry	390	27	3	0	0	11.1	0.76
Tirry	D/S Shin Diversion Dam	391	NA	3	0	1	NA	1.02

Table 9. Return rates of smolts tagged in 2016. MR denotes fish that were used in a mark recapture trial and not recaptured. Fish from mark-recapture trials that were recaptured have been

Tagging Location	Release Site	Number Tagged	Smolts Detected at Decoder	2017 Return	2018 Return	% Detected at Decoder Returning as Adults	% Tagged returning as adults
Fiag	Fiag	1100	212	3	4	3.3	0.63
Fiag	D/S Shin Diversion Dam	587	NA	11	11	NA	3.74
Fiag	MR (recaptured)	204	NA	0	3	NA	1.47
Fiag	MR (not recaptured)	146	28	0	0	0	0
Tirry	Tirry	137	27	0	0	0	0
Tirry	D/S Shin Diversion Dam	0	NA	0	0	NA	NA
Tirry	MR (recaptured)	13	NA	0	0	NA	0
Tirry	MR (not recaptured)	74	16	0	0	0	0

In 2017 a total of 437 smolts were tagged from the rotary screw trap on the River Tirry, and 465 on the River Fiag (excluding mark-recapture trials). As smolts were transported directly downstream of the shin diversion dam, there would have been no instances of smolts being recorded passing on the decoder in this instance.

However, there were 7 instances of smolts tagged in 2017 from the mark-recapture trial being recorded at the decoder. One was caught and released on the Fiag, and six were caught and released on the Tirry. The range of days from release to detection was 17-38.

Table 10. Figures from smolts tagged in 2017. MR denotes smolts which were used in mark-recapture trials and not subsequently recaptured in the RST. MR smolts which were recaptured were released below the dam and are included.

Tagging Location	Release Site	Number Tagged	Smolts Detected at Decoder	2018 return	2019 Return	%Tagged returning as adults

Fiag	MR (not recaptured)	34	1	0	0	0
Fiag	MR (Recaptured)	87	NA	2	0	2.29
Fiag	D/S Shin Diversion Dam	465	NA	9	13	4.73
Tirry	MR (not recaptured)	249	6	0	0	0
Tirry	MR (recaptured)	57	NA	0	2	3.5
Tirry	D/S Shin Diversion Dam	494	NA	12	5	3.44

In 2018 some smolts deemed to be wild were tagged with PIT tags supplied by Marine Scotland Science, and released blow the Shin diversion dam. This was in addition to the usual PIT tagging operations on the Fiag and Tirry Rivers.

Table 11. Figures from smolts tagged in 2018. MR denotes smolts which were used in mark-recapture trials and not subsequently recaptured in the RST. MR smolts which were recaptured were released below the dam and are included.

Tagging Location	Release Site	Number Tagged	Smolts Detected at Decoder	2019 Return	2020 Return	%Tagged returning as adults
Fiag	D/S Shin Diversion Dam	1365	NA	43	17	4.39
Fiag	MR (not recaptured)	19	1	1	0	5.26
Fiag	MR (recaptured)	56	NA	2	0	3.57
Tirry	D/S Shin Diversion Dam	477	NA	11	4	3.14
Tirry	MR (not recaptured)	51	2	0	0	0
Tirry	MR (recaptured)	15	NA	0	0	0
Merkland	D/S Shin Diversion Dam	103	NA	2	1	2.91

Table 12. Figures from smolts tagged in 2019. MR denotes smolts which were used in mark-recapture trials and not subsequently recaptured in the RST. MR smolts which were recaptured were released below the dam and are included.

Tagging Location	Release Site	Number Tagged	Smolts Detected at Decoder	2020 Return	%Tagged returning as adults
Fiag	D/S Shin Diversion Dam	1517	NA	12	0.79
Fiag	MR (not recaptured)	43	3	1	2.32
Fiag	MR (Recaptured)	62	NA	1	1.61
Tirry	D/S Shin Diversion Dam	424	NA	1	0.23
Tirry	MR (not recaptured)	89	3	0	0
Tirry	MR (Recaptured)	39	NA	0	0

2.3. – Smolt Trapping Efficiency and Estimates of Smolt Run Magnitude

In addition to the tagging of smolts, the rotary screw traps deployed have been used to provide a rudimentary assessment of the numbers of smolts being produced by individual tributaries although totals caught should be treated with caution given that information regarding trap efficiency, particularly over a range of flow conditions, is presently limited. It is understood that the bulk of the fish captured in rotary screw traps in recent years have been released downstream of Shin Diversion Dam in the belief that the avoidance of potential issues with downstream migration through Loch Shin and Little Loch Shin will increase overall survival rates. Table 9 provides a summary of the numbers of smolts captured at each rotary screw trap location in Loch Shin tributaries in recent years. It should be noted that latterly a box trap has been used at Corriekinloch as a substitute for a rotary screw trap and that in low water conditions box traps have also been deployed on the Tirry and Fiag. Smolts being utilised for the tagging investigations have been sourced from the Tirry and Fiag due to the relative abundance of smolts captured at those sites.

Table 13. Total smolt numbers captured in rotary screw traps and box traps including those used for PIT tagging.

	Corriekinloch		Merkland		Fiag		Tirry	
Year	Putative Farmed	Wild Smolts	Putative Farmed	Wild Smolts	Putative Farmed	Wild Smolts	Putative Farmed	Wild Smolts
2011	19	24	288	217	9	1924	0	1350
2012	1	42	537	507	2	2149	0	1021
2013	0	12	373	553	4	2523	0	604

2014	0	22	301	262	0	726	0	2351
2015	0	32	144	590	2	2261	0	803
2016	0	21	217	441	11	7240	0	238
2017	-	-	-	-	0	2599	0	2049
2018	0	10	148	156	1	4374	1	1449
2019	0	15	30	116	2	6597	0	811
2020	-	-	-	-	8	8131	0	532

2.3.1 - 2015 Mark-Recapture

A single batch of 70 Fiag smolts were PIT tagged and released upstream of the trap at grid reference 246261 923161 on the 12th May 2015. The distance between the Fiag trap site and release point was in excess of 2.5km. Given the considerable migration distance involved any recapture rate is likely to be a conservative estimate of trap efficiency at that time given the increased risk of predation etc. caused by the additional migration length. Of the 70 tagged, 47 (67.1%) were recaptured at the Fiag trap and subsequently re-released downstream of the site. Three of the 70 were subsequently detected by the decoder at Shin Diversion Dam including two of the 47 recaptured smolts that had been re-released at Fiag after recapture. One smolt was recaptured at the Merkland trap after having been recaptured at the Fiag trap and re-released. The range of days between release and recapture was 1-15 with a mean of 3.9 days.

2.3.2 - 2016 Mark-Recapture

Attempts were made to undertake mark-recapture trials on both the Fiag and Tirry during the 2016 smolt run. In the case of the Tirry efforts were hampered by the low numbers of smolts captured. Protocols utilised follow those outlined in *Salmonid Field Protocols Handbook*[1]. In contrast to the 2015 trial, release sites were designated as the first accessible riffle site upstream of the trap location. Release sites were mutually agreed by representatives of Kyle DSFB/ Kyle Trust, SEPA and SSE. All smolts recaptured at the Fiag trap during the trial were transported downstream of Shin Diversion Dam and re-released into the main stem of the River Shin with the exception of a single smolt that was released in error back into the River Fiag. A total of 350 smolts were tagged on the Fiag as part of the mark-recapture trial of which 204 were subsequently recaptured (58.2%). Of those not recaptured 28 were detected by the PIT tag decoder at Shin Diversion Dam (19.1%). The results of the individual trials are shown in Table 14.

Only five releases of smolts for mark-recapture trials was possible on the River Tirry with a total of 87 smolts being tagged, of which 13 were subsequently recaptured (16.7%). Any smolts recaptured at Tirry trap were released downstream of the trap into the River Tirry to

[1] *American Field Protocols Handbook*. Johnson *et al*. 2007. American Fisheries Society.

continue their migration. Of the 87 smolts utilised 16 (18.4%) were subsequently detected by the decoder at Shin Diversion Dam.

Table 14 River Fiag mark-recapture trials undertaken in 2016.

Fiag				Date Range of Recaptures	
Release Date	No. Tagged	No. Recaptured	% Recaptured	From	To
03/04/2016	12	10	83.3	04/04/2016	05/04/2016
05/04/2016	28	7	25.0	06/04/2016	06/04/2015
08/04/2016	20	9	45.0	09/04/2016	10/04/2016
11/04/2016	20	11	55.0	12/04/2016	17/04/2016
13/04/2016	24	17	70.8	14/04/2016	25/04/2016
17/04/2016	20	14	70.0	18/04/2016	27/04/2016
22/04/2016	37	21	56.8	23/04/2016	03/05/2016
25/04/2016	20	13	65.0	26/04/2016	28/04/2016
27/04/2016	20	14	70.0	28/04/2016	03/05/2016
02/05/2016	40	19	47.5	03/05/2016	04/05/2016
06/05/2016	29	24	82.8	07/05/2016	11/05/2016
09/05/2016	40	23	57.5	10/05/2016	21/05/2016
14/05/2016	20	11	55.0	15/05/2016	22/05/2016
17/05/2016	20	11	55.0	18/05/2016	22/05/2016

Table 15 River Tirry mark-recapture trials undertaken in 2016.

Tirry				Date Range of Recaptures	
Release Date	No. Tagged	No. Recaptured	% Recaptured	From	To
05/04/2016	16	6	37.5	06/04/2016	06/04/2016
14/04/2016	18	5	27.8	15/04/2016	15/04/2015
17/04/2016	12	2	16.7	18/04/2016	18/04/2016
29/04/2016	23	0	0	NA	NA
06/05/2016	18	0	0	NA	NA

Utilising the same formula as that employed by the Spey Foundation (Brian Shaw, personal communication) it is possible to derive estimates of the magnitude of the smolt run from the mark-recapture data with associated 95% confidence intervals. In the case of the Fiag the estimate derived is 12,396 smolts ± 1,107. In the case of the Tirry the estimate derived is 1,496 smolts ± 714. The latter should be treated with extreme caution due to the wide confidence limits and the fact that no fish were recaptured from several release groups.

2.3.3 - 2017 Mark-Recapture

On the River Fiag a total of 121 smolts were tagged for mark-recapture, of which 87 smolts were recaptured (71.9%). On the River Tirry a total of 306 smolts were tagged, of which 57 individuals were recaptured (18.6%). Estimates of the size of the run using mark-recaptures gave 3603(+/- 402) for the Fiag and 10845(+/-2572) for the Tirry.

Table 16. River Fiag Mark Recapture Trials undertaken in 2017.

Fiag				Date Range of Recaptures	
Release Date	No Tagged	No Recaptured	% Recaptured	From	To
20/04/2017	40	29	72.5	21/04/2017	23/04/2017
30/04/2017	30	16	55.2	01/05/2017	11/05/2017
02/05/2017	51	41	82	03/05/2017	11/05/2017

Table 17. River Tirry Mark Recapture Trials undertaken in 2017.

Tirry				Date Range of Recaptures	
Release Date	No Tagged	No Recaptured	% Recaptured	From	To
14/04/2017	40	16	40.0	15/04/2017	20/04/2017
15/04/2017	40	9	23.1	16/04/2017	20/04/2017
17/04/2017	40	14	35.9	18/04/2017	21/04/2017
29/04/2017	43	9	21.4	30/04/2017	01/05/2017
30/04/2017	60	3	4.3	30/04/2017	01/05/2017
01/05/2017	17	1	6.3	02/05/2017	02/05/2017
02/05/2017	60	1	3.4	02/05/2017	02/05/2017
11/05/2017	6	0	0	NA	NA

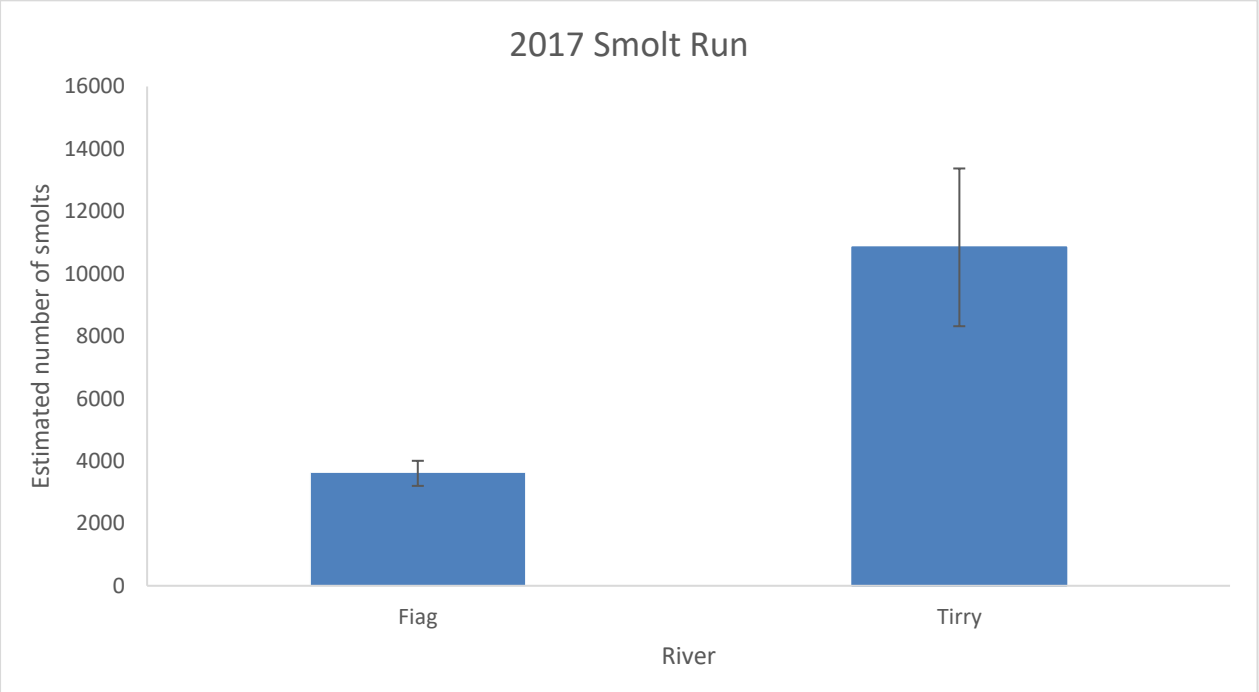


Figure 2. Estimated size of smolt runs on the Fiag and Tirry in 2017.

2.3.4. - 2018 Mark recapture trials

In 2018 Mark recapture trials were again undertaken on the Fiag and Tirry, with the Fiag efficiency being 74.6% overall and the River Tirry being 19.7% efficient overall. Two fish from the River Tirry trials, and one from the River Fiag which were not recaptured were detected at the Shin diversion dam.

Table 18. Mark recapture trials undertaken on the River Fiag in 2018

Fiag			
Release Date	No Tagged	No Recaptured	% Recaptured
19/04/2018	15	15	100
25/04/2018	15	11	73
01/05/2018	15	9	60
07/05/2018	15	12	80
15/05/2018	15	9	6.7

Table 19. Mark recapture trials undertaken on the River Tirry in 2018.

Tirry			
Release Date	No Tagged	No Recaptured	% Recaptured
18/04/2018	26	9	36
22/04/2018	20	5	25
06/05/2018	30	1	3.3

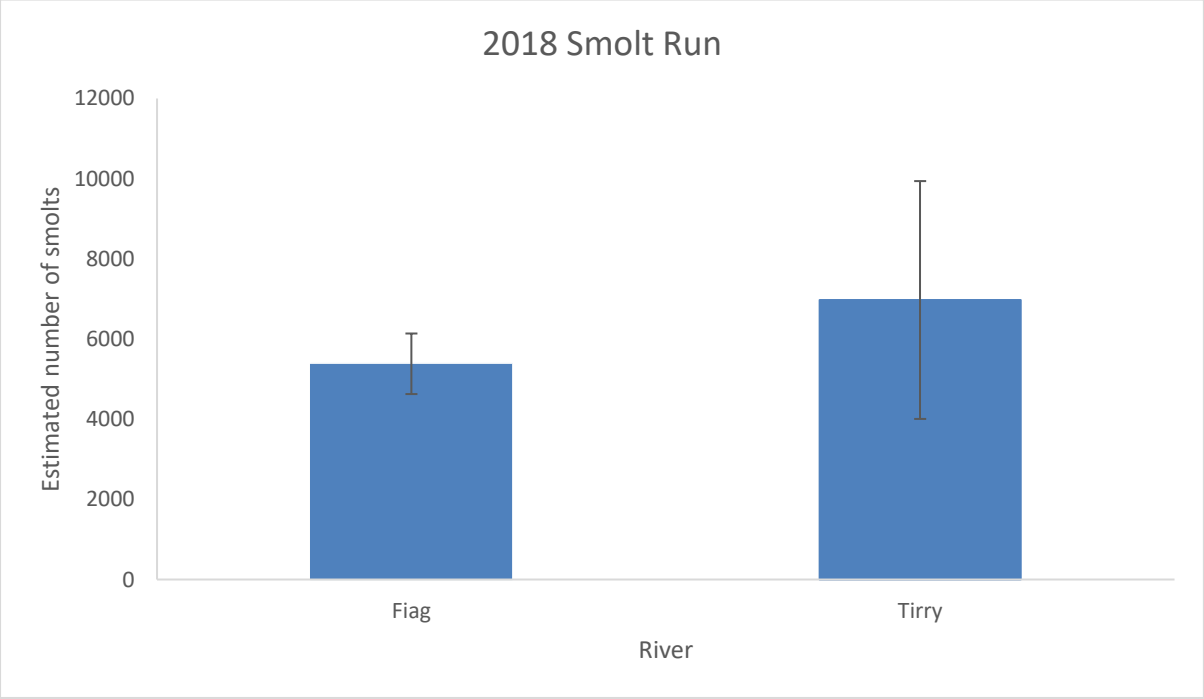


Figure 3. Estimated size of the smolt runs in 2018.

2.3.5 – 2019 Mark recapture trials

Mark Recapture trials on the Fiag and Tirry produced capture efficiencies of 59.05% and 30.47% respectively when averaged across the entire run. A prolonged period of low water was observed, and box traps were again deployed. However, the deployment of the box trap on the Fiag diverted the flow in such a way that the drum of the RST became operational again.

Table 20. Mark recapture trials on the River Tirry.

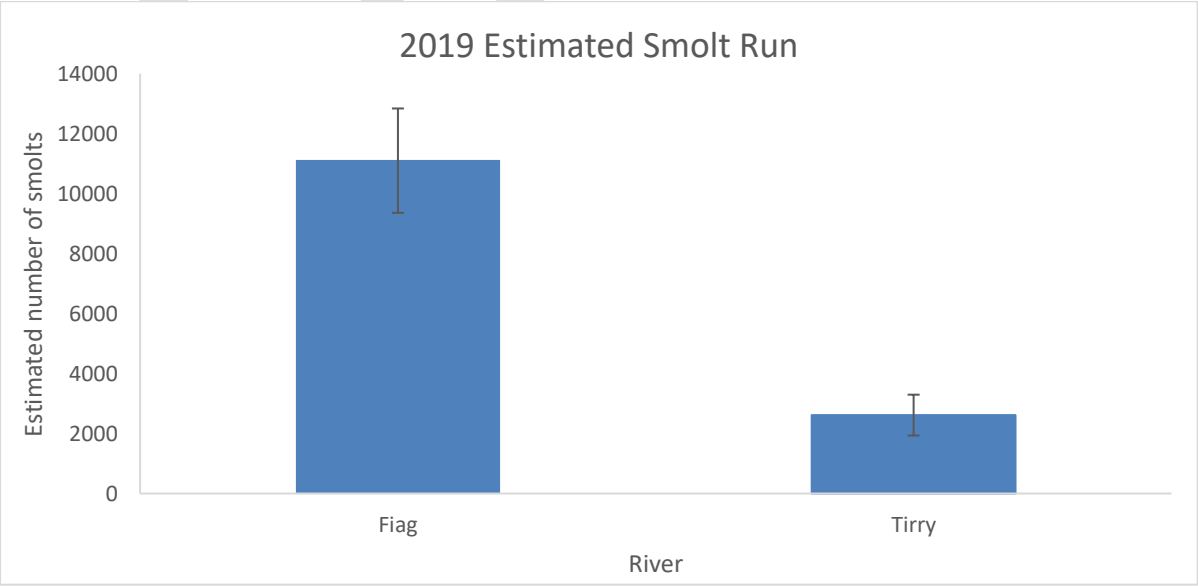
Release Date	Number Released	Number Recaptured	Percentage Recaptured
01/04/2019	21	9	42.86
08/04/2019	33	19	57.58
12/04/2019	30	5*	16.67
21/04/2019	30	5	16.67
25/04/2019	14	1	7.14
Total	128	39	30.47

*on 13/4/19 3 tagged smolts were recaptured, however only 1 tag was read. The two unread smolts have been included in recaptured from the 12th as this is likely to be the release group they are from, however this makes no difference to the total percentage recaptured.

River Fiag trap efficiency

Table 21. Mark recapture trials on the River Fiag.

Release Date	Number Released	Number Recaptured	Percentage Recaptured
09/04/2019	15	5	33.33
12/04/2019	20	6	30.00
25/04/2019	30	21	70.00
29/04/2019	20	15	75.00
30/04/2019	20	15	75.00
Total	105	62	59.05



2.4 Estimation of returning adults from PIT tag returns.

This section details a trial of estimating the number of returning adults from the percentages of returning PIT tagged fish. In the case of the Shin system we are fortunate that there is a resistivity counter at the exact same position as the PIT tag decoder. This allows for estimation of numbers of returning adults from returning percentages of PIT tagged cohorts to be checked by fish counter data, and to see if there is a discrepancy between the two.

Initially this approach will only be completed for the returns in 2017, as we are still awaiting total validated fish counter data from 2018. Returns in 2016 would be complicated by a lack of PIT tagged multi sea winter fish from 2014, as will returns in 2015.

Table 22. Estimated Adult returns in 2017 from 2015 and 2016 cohorts, based on returning PIT tag numbers.

Cohort	Year	Total Smolts	Flow trials	Adjusted smolts	% returns	Estimated adult return
Fiag	2015	2261	748	1513	1.73	26
Tirry	2015	803	390	413	0	0
Fiag	2016	7420	1100	6320	1.87	118

This combine to give an estimated return in 2017 (composed of 2015 and 2016 cohorts) of 144 fish. The total validated counts for 2017 was 184 fish passing upstream. Although there is some discrepancy between these figures, that would be expected. The above method of estimating adult returning fish would assume that every fish has an equal chance of returning. In reality this assumption is likely to be invalid as the PIT tagging process may have an impact on mortality and/or behaviour. In addition, we observe a trend in the mark-recapture trials that trap efficiency tends to decrease as the run goes on, whether this is due to an increase in mortality as the run goes on is unclear. If this was the case, it would be expected to also affect smolts which were released below the dam.

In summary, there are all sorts of uncertainty with factors that affect a fish's survival and likelihood to return which make this approach of estimating returning adults inappropriate. If the uncertainty could be quantified and there was no fish counter, then estimating returning adults with PIT tag information would be a suitable method. However, in the present situation the resistivity counter will be the best method of ascertaining adult numbers.