European Offshore Wind Deployment Centre

Environmental Research & Monitoring Programme

North East Scotland Salmon and Sea Trout Tracking Array

River Dee Trust (RDT), Marine Scotland Science (MSS)

Interim Report January 2019

VATTENFALL

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Overview

This document forms the 2018 interim report for the North Ease Scotland Salmon and Sea Trout Tracking Array and is provided to give an overview of the project so far and the data gathered. This project is funded by Vattenfall under the Environmental Research and Monitoring Programme for the European Offshore Wind Deployment Centre.

Migration routes of salmon and sea trout ("salmonids") from the Rivers Dee, Don and Ythan will be investigated over three years (2018-2020) through tagging and tracking of migrating juvenile salmonid smolts. The data derived from the tracked individuals will be combined with local sea current information, to estimate actual swimming vectors of smolts. The use of the hydrodynamic Scottish Shelf Model (SSM), developed by Marine Scotland Science, will therefore provide a view of smolt dispersion around NE Scotland. The predictive capacity of the proposed work would be transferable to other windfarm and major construction projects.

Salmon smolt tracking

2018 tracking overview

Objectives of 2018

- Capture and tag
  - 100 Salmon smolts
  - 50 Sea trout
- Deploy receivers in river, harbour, and at arrays located at 4km and 10km from the harbour
- Deploy Acoustic Doppler Current Profiler (ADCP) for duration of smolt run
- Recover receivers and download data
- Interim report

Progress against objectives

a) Capture and tag 100 salmon smolts

We caught and captured all required salmon smolts (Sheeoch 61, Beltie 32 and Dinnet 7). The conditions were fairly dry with several small rises in water. With the 3rd of May accounting for 39 fish after a small rise in water levels. The last fish was tagged on the 23rd May 2018. 30 of these smolts were tagged with the larger temperature and depth sensing tags and 70 were tagged with ID tags.
At the same time, we captured and tagged 53 seatrout smolts (Scheeoch 20, Beltie 25, Dinnet 8) with the last being tagged on the 20th May 2018. Of these smolts 19 were tagged with larger temperature and depth sensing tags and 34 were tagged with ID tags.

b) Deploy receivers in river, harbour, and at arrays located at 4km and 10km from the harbour.

Between March and April 2018 157 receivers were deployed to monitor movements of the tagged smolts: 12 were place in the River Dee, 4 were place in the harbour (in two 'gates'). The remaining 141 were placed in 3 arrays: 42 receivers in the first arc at 4km, 8 receivers in a second small array at approximately 8km and finally 90 receivers in an arc at 10km (Figure 1). The marine receivers were deployed by RV Alba na Mara over 3 days in March, the River Dee Trust (RDT) deployed the in-river receivers at the start of March and Aberdeen Harbour kindly provided time on board their boat the Sea Herald to deploy the Harbour moorings

c) Deploy Acoustic Doppler Current Profiler (ADCP) for duration of smolt run.
The ADCP was deployed by RV Alba na Mara during the same cruise as the receiver deployments in March and is marked in Figure 1.

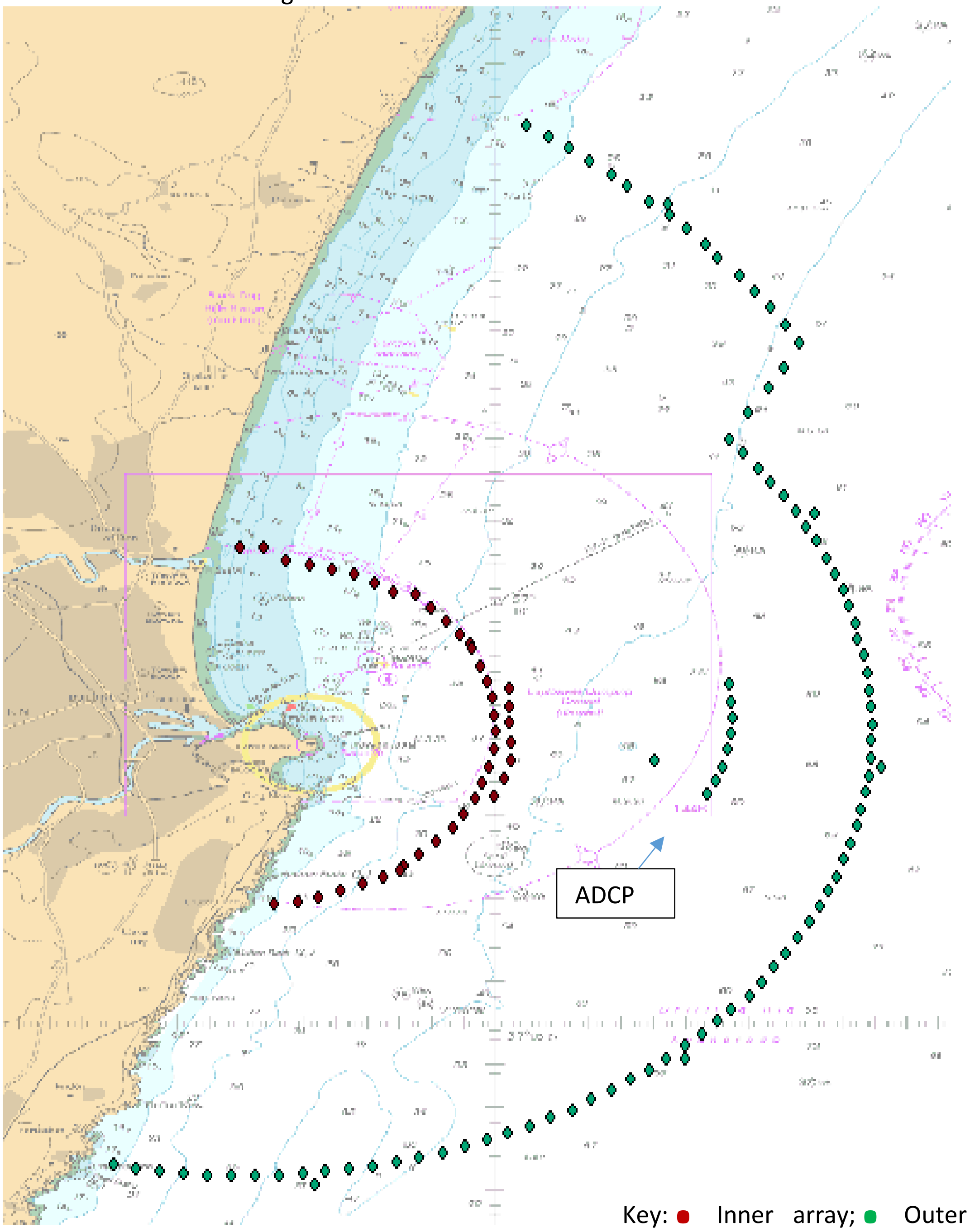

Figure 1: Aberdeen Bay Smolt Tracking Array

d) Recover receivers and download data.
Receiver recovery proved more challenging than expected with strong currents causing difficult conditions for the ROV and some of the pop-up canisters seizing due to excessive marine growth. We set aside £20k for the manual recovery of ROV moorings. This was to cover 10 days with a vessel, which should have been sufficient (we expected it to take 8 days, plus 2 days contingency). This allowance of time for recovery of ROV moorings was underestimated in the initial costing. To date we have taken 19 days recovering the moorings and several receivers have yet to be recovered (2 VR2AR and 7 VR2Tx) - these will be collected in the next month. The RV Alba na Mara managed to recover 33 pop-up moorings in a single day, removing the fears of failure in the canister system. However, two pop-ups were handed in by Fishermen, one by Vattenfall staff when it was found floating in the windfarm area and another collected from Balmedie Beach. The project team met with Vattenfall to discuss the mooring recovery situation at the end of 2018.

Main points of meeting:

- Four recovery trips made so far
- Six days 26 moorings
- Eight days 51 moorings
- One day 33 pop-ups Alba na Mara
- Four days 20 ROV Alba na Mara (very poor weather)
- Two pop-ups confirmed lost.

Lessons learned and actions for next year to aid recoveries:

- ROV moorings to be fitted with 'master links' (large yellow metal ring)
- ROV recovery should be avoided below 60m-65m
- Pop-us to be relocated do deeper locations (i.e., over 60m-65m)

Two benefits:

- Pop-ups less likely to get fouled up in deeper water
- ROV better and faster in shallower water and the 'master link' should increase the speed and efficiency of hooking on to mooring for recovery

These lessons learned should reduce the time spent recovering moorings next year and thus the cost.

e) Interim report.

All data from recovered receivers has been downloaded and is currently being processed, as such please note the presented data is draft only.

Durations of residency at receivers

Salmon Smolts

Salmon smolts migrating down the river spend differing amounts of time at each receiver station. These differences are evident from the data both within and between years and are likely to be influenced by on environmental conditions like river discharge (river flow rate). The main factor controlling the migration of smolts is thought to be flood events. These events can be a minor rise in river levels, or big spate events where the river levels rise dramatically. It is thought that rises in river levels encourage fish to move and that the later in the season the flood event occurs the smaller the rise in river levels needs to be to trigger a migration response in salmon smolts. Residence events at stations were calculated using the software program R and the VTrack package. A smolt was assumed to be resident at a receiver if there were more than two detections within an hour (Figure 2). The expected range of a receiver is roughly a 100m diameter circle in the river, depending on ambient noise levels and river conditions. This means that if a fish is recorded more than two times within the space of an hour, it is not moving at any great speed and thus reflects low swimming speeds. Such events are called residency events within the scientific literature, and here the standard definition was applied (i.e., two records within an hour).

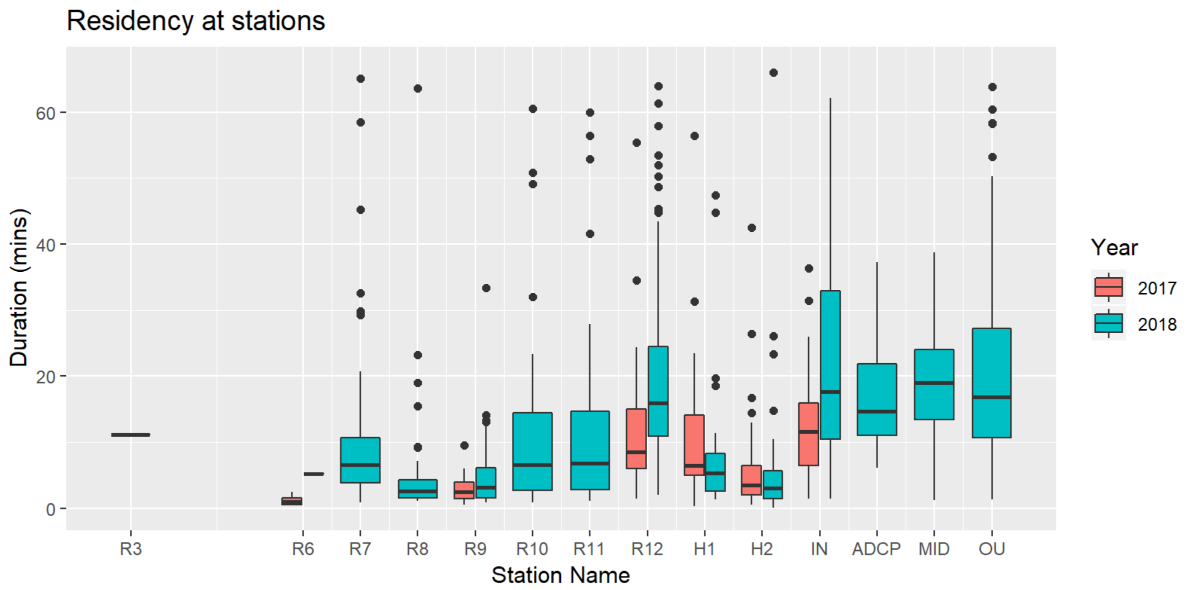

Figure 2. Salmon residencies at receiver locations for both 2017 and 2018. Boxes represent the 25th, 50th (median), and 75th percentile values; whiskers (vertical black lines) represent the range of 95% of the data; black dots represent data points that fall outwith the 95% limits. Stations are ordered from left to right upstream to downstream.

Salmon smolts appear to migrate rapidly in the river with average residencies under 10 minutes, with the exception of R12 in 2018, until they reach the sea arrays where the duration increased to over 12 minutes. The IN array shows a difference between the two years but this may be due to the extra seven receivers doubling the array in the middle. This effectively doubles the detection range of IN at that location. There may be several reasons salmon smolts spend different amounts of time at locations R12 and H1 between 2017 and 2018, these include: tagging timing within the migration window, noise in the harbour and other disturbances like suspended sediments, or river levels. The data needs further examination to identify any correlation to environmental factors.

Sea trout smolts

Sea trout residencies were calculated using the same Vtrack package and parameters. They show a slightly different pattern with the average residency time in the river being much lower than those in the tidal and salt water arrays. R12 is below the head of the tide and is brackish if not salt most of the time.

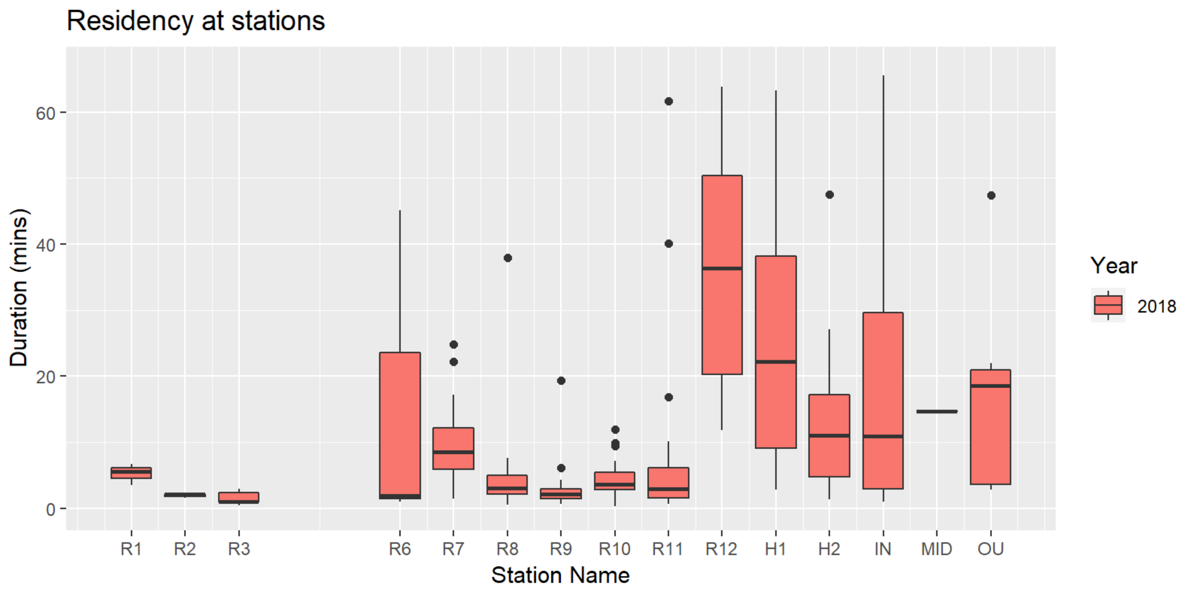

Figure 3. Seatrout residencies at receiver locations for 2018. Boxes represent the 25th, 50th (median), and 75th percentile values; whiskers (vertical black lines) represent the range of 95% of the data; black dots represent data points that fall outwith the 95% limits.

Fish Progression

Salmon and sea trout were tracked down through 12 receiver stations in the river, four in the harbour and out to sea. Figure 4 illustrates the progression and detections of salmon smolts down the river and out to sea. Individual tracks plotted vary in complexity and need individual scrutiny. Note that dots are the receiver locations and that the detection and travel route of a smolt from one receiver to the next is shown with a line. The tracks of smolts are stacked, hence the colour of a dot or line shows the last fish that travelled past a receiver and/or between a given set of receivers, so if multiple smolts were detected at the same receiver station and followed the same path only the last smolt is visible. If a smolt was not detected at all receivers along the route, the lines that are drawn between two receivers can appear to go over land. This shows that misdetections are relatively common in the river environment and highlights the fact that receivers are not as efficient compared to the marine environment.

From Figure 4 it seems that a majority of smolts leave the harbour in varying directions but then move in a South-Easterly direction (indicated by the higher density of lines). It is also evident from Figure 4 that salmon smolts don't use the near-shore environment after leaving the river (indicated by the grey coloured dots in Figure 4 which means no smolts were detected at those locations). Figures 5 and 6 shows a typical salmon smolt track from this year's tracking there seems to be a pattern of South East movement followed by a return to North East at the outer array.

The number of unique tag IDs detected at each station is summarised in Table 1. 91 (91%) of salmon smolts (100 total) were detected in 2018, with 85 being detected at R12 (93% of detected IDs). This is in contrast to 2017 when 38 of 60 tags were detected and 30 were detected at R12 (78.9%). Again, this needs further scrutiny as some IDs may pass a receiver without being detected.

When the current data from the ADCP is processed and combined with this movement data the actual swimming speed and directions will be calculated.

Station	Seatrout 2018	Salmon 2018	Salmon 2117
R1	3	2	
R2	4	1	
R3	5	5	
R4	2	3	8
R5	1	2	
R6	5	8	33
R7	33	87	
R8	31	86	
R9	27	64	25
R10	28	78	
R11	28	69	
R12	29	85	30
H1	19	45	30
H2	21	74	32
IN	9	72	26
ADCP	0	6	
MID	1	9	
OU	8	66	

Table 1. Numbers of unique tag IDs detected at each receiver station over both 2017 and 2018. In 2017 only 7 receiver stations were present.

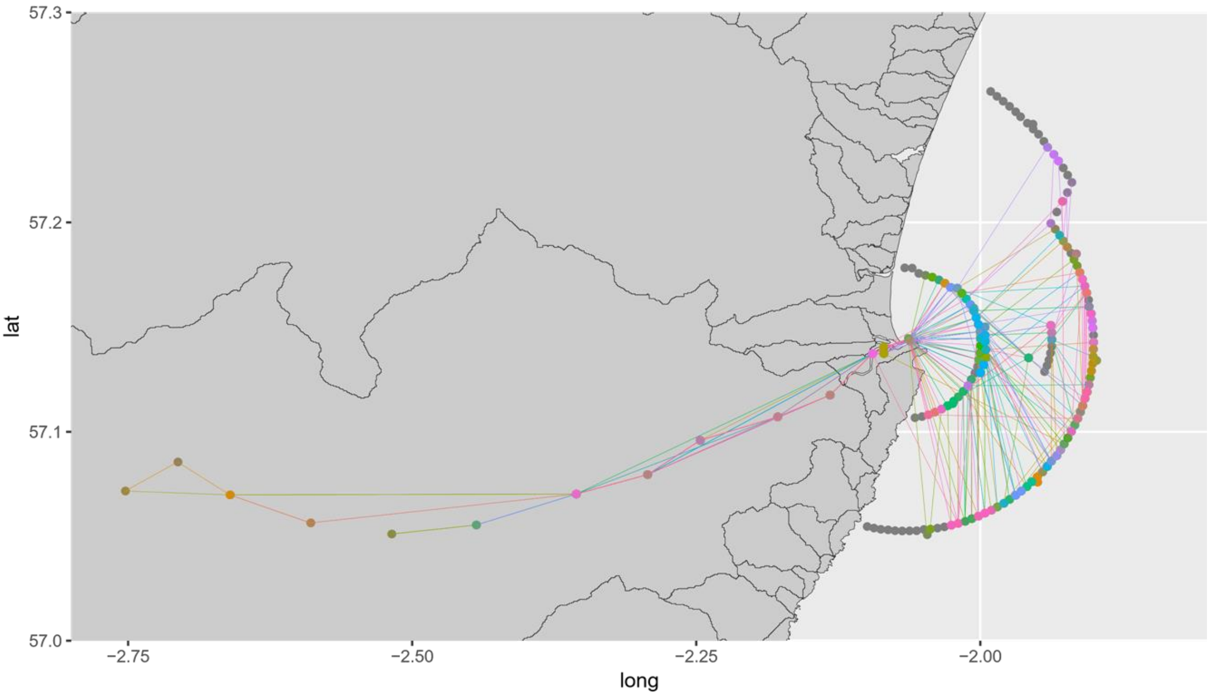

Figure 4. Tracks of all salmon smolts tagged. Each colour represents an individual smolt, with the receiver stations and lines coloured by the last smolt detected passing (or grey if no smolts were detected). The black lines represent river catchment boundaries.

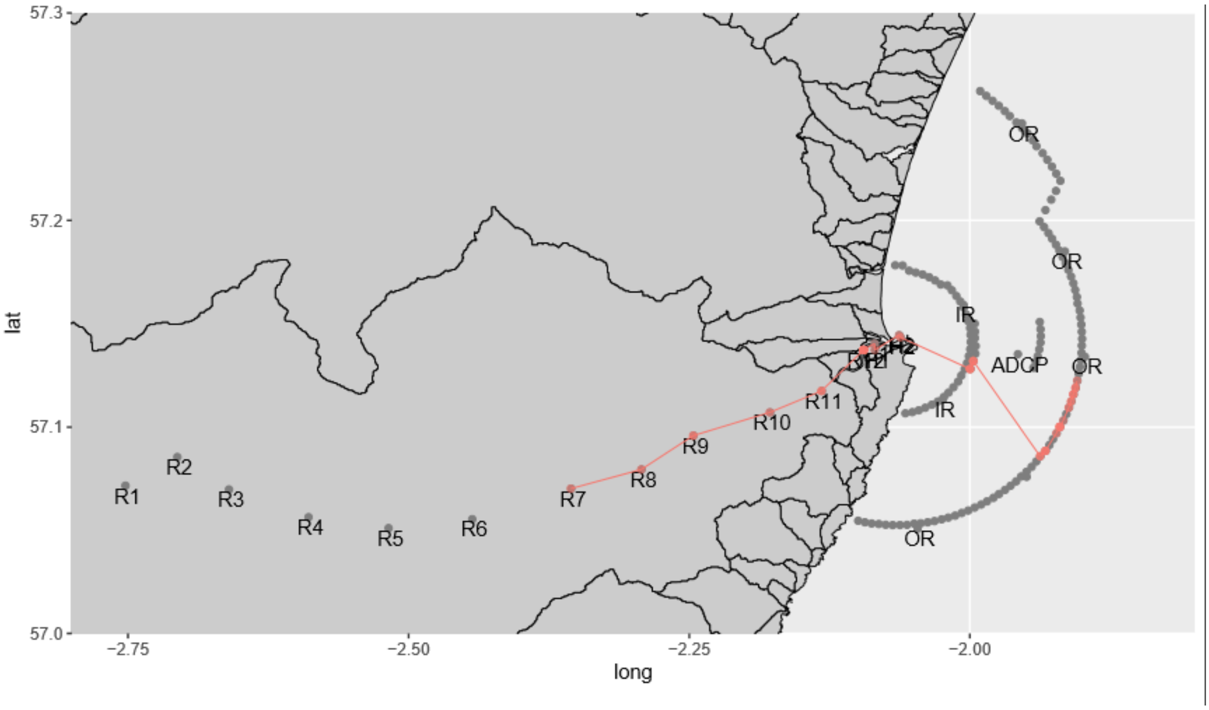

Figure 5. Tracks of a salmon smolt number 93. Showing initial movement to the South East and then North East.

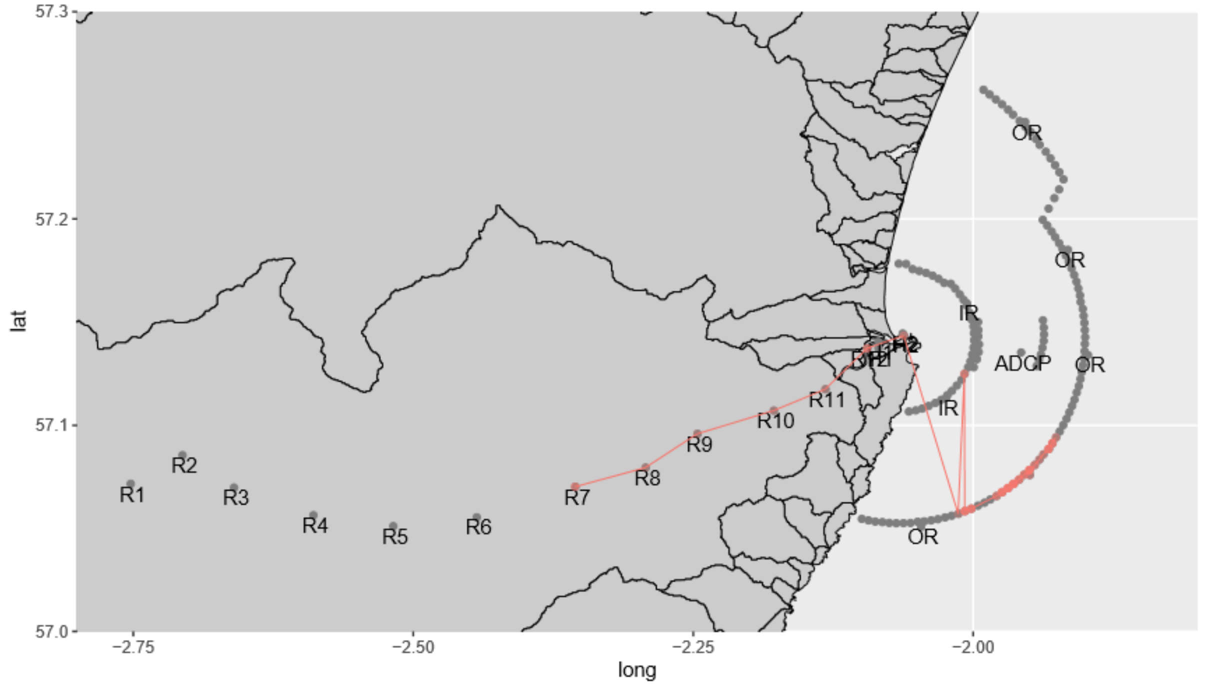

Figure 6. Tracks of a salmon smolt number 46. Again, showing initial movement to the South East and then North East.

Sea trout

Sea trout display a different behaviour to salmon with fewer leaving the river and more appear to use the areas closer to the coast. Figure 7 shows the pattern of all the sea trout movements. They have longer average residence times at R12 and H1 than salmon smolts and are detected much less frequently on the outer array.

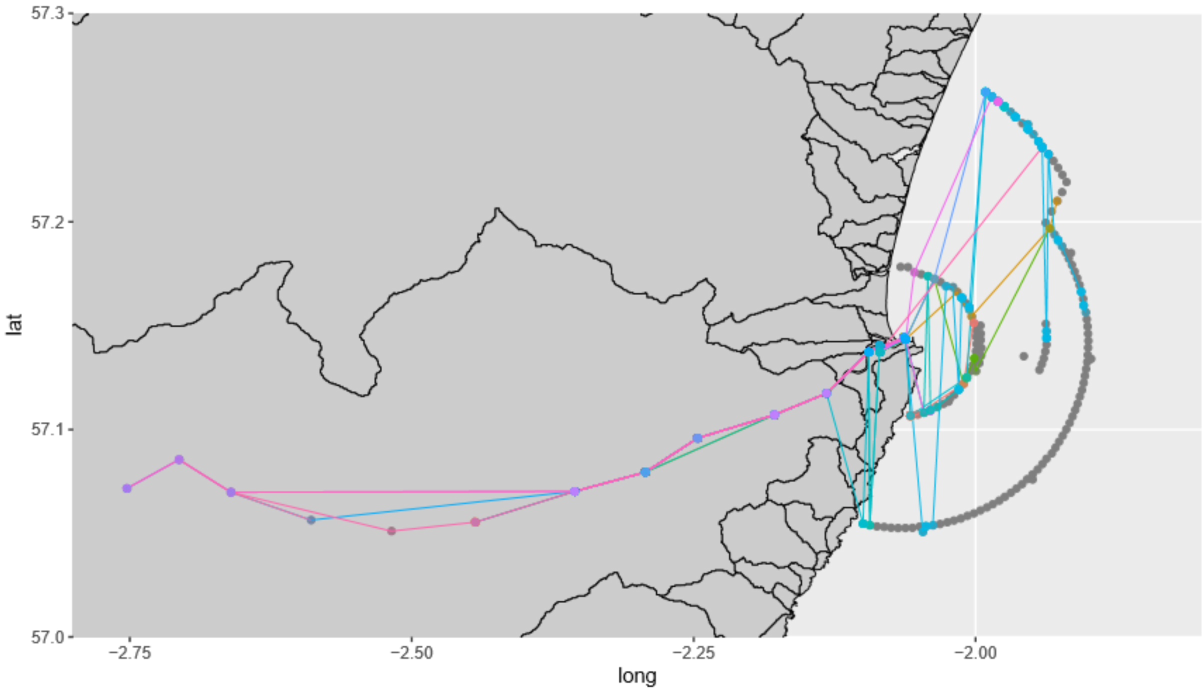

Figure 7. Tracks of all seatrout smolts tagged. Each colour represents an individual smolt, with the receiver stations coloured by the last smolt detected passing (or grey if no smolts were detected).

Time and duration of smolt run

In 2018 the salmon smolts began to appear in the harbour from the 22nd of April and their presence peaked between the 30th of April and the 10th May. This is very similar to the 2017 pattern when fish peaked between the 26th April and the 8th of May. The small numbers of smolts present in the harbour early and late represent fish tagged early or late in the tagging programme and taking advantage of separate rises in river level to migrate down river and out to sea. A comparison of this is shown in Figure 8. It shows the presence of smolts in the harbour as a density function of the data, rather than an actual number, which allows for interpolation of the data to give insight into the trends. Therefore, there are no values on the vertical axis, the densities are relative and have no units of measurement. A peak in the curve represents a higher presence of smolts.

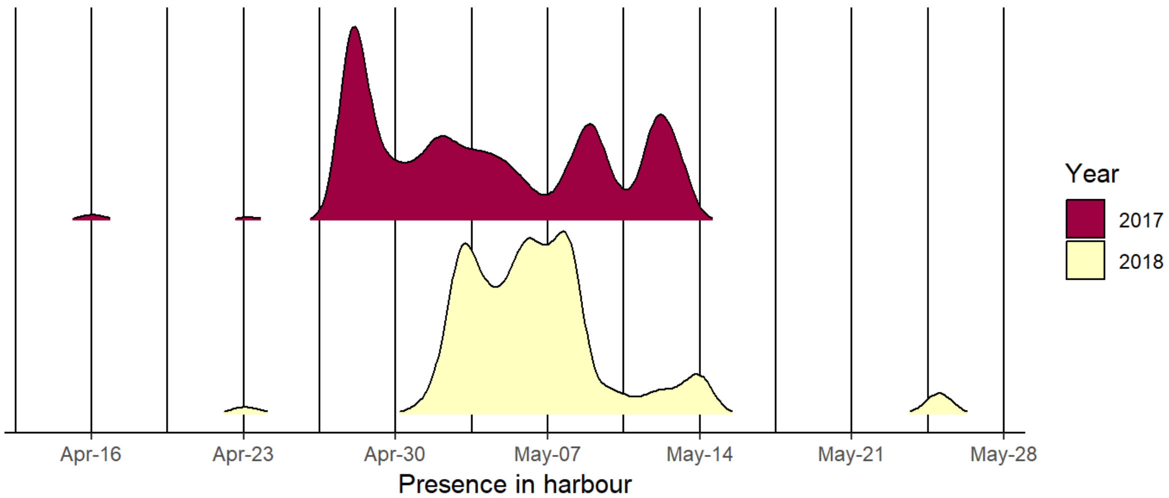

Figure 8. Salmon smolt presence in the harbour in 2017 and 2018. The coloured areas represent the years 2017 (red) and 2018 (yellow).

Depth and temperature tags in salmon smolts

Temperature

Of the 40 salmon smolts tagged with temperature and depth tags only one temperature tag and one depth tag have shown unusual readings (figure 9). Tag serial number 20 has shown a spike in temperature in the outer harbour (station H2) at 35°C and then two detections at 37.6°C. This is indicative of predation by either a mammal or bird with the tag still present in the predator when passing a receiver.

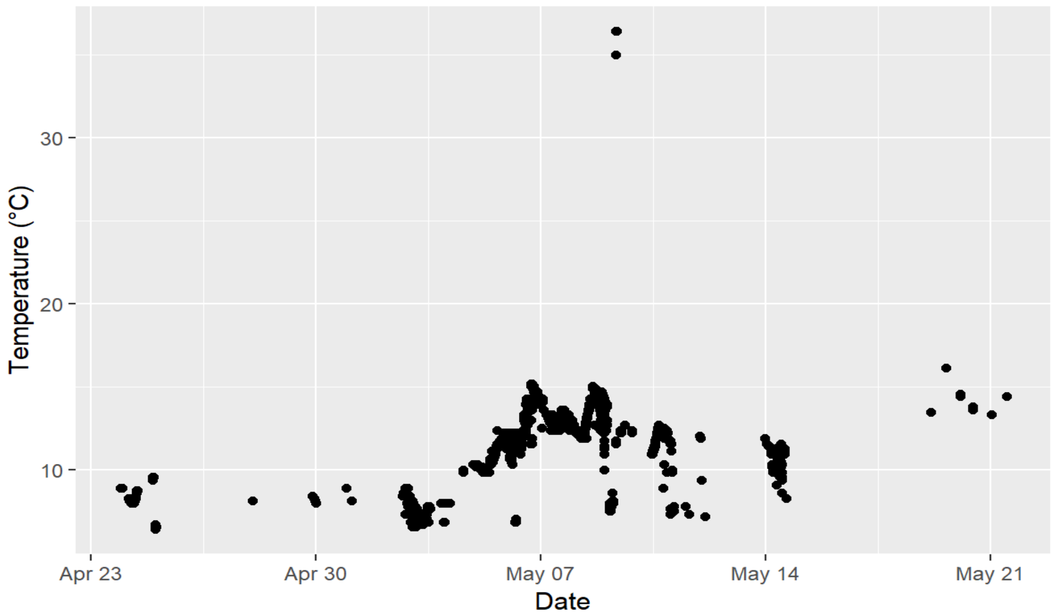

Figure 9. Temperature readings from salmon smolt tags.

Depth

Of the salmon smolts detected with depth data associated only one shows unexpected results (Figure 10). The salmon smolt with serial number 23 unexpectedly drops to 10.2m in the outer harbour (H2). This comes after showing normal migration behaviour of between 1-2m depth. Just prior to the descent to 10m there is a period where the salmon smolt is on or close to the surface (Figure 11). This may be a predation event by a fish or other predator as the first detections of this event are at R12 (Boating Club) and within 2h the tag is detected at the mouth of the harbour (H2).

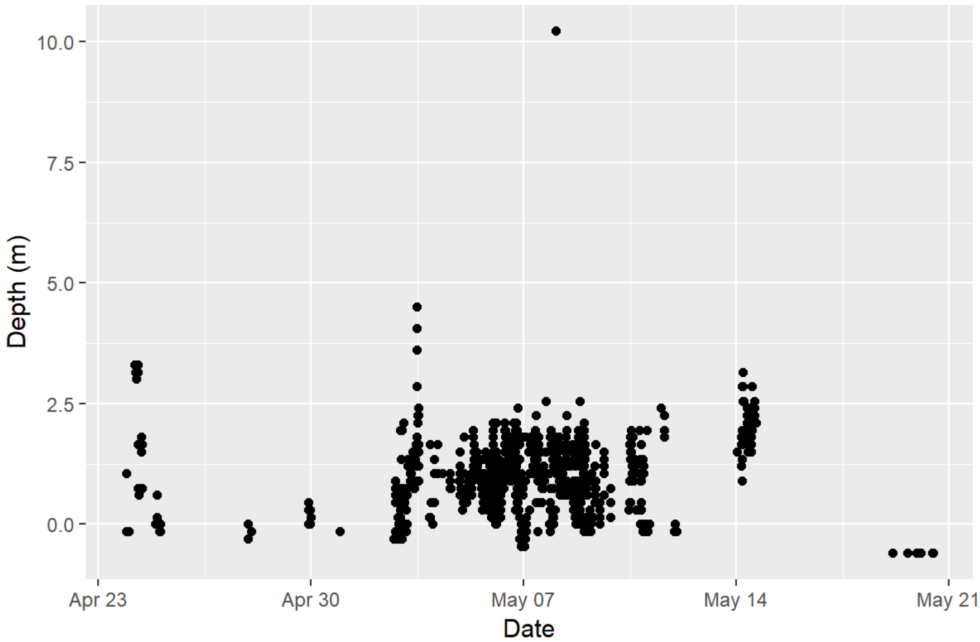

Figure 10. Depth readings from salmon smolt tags.

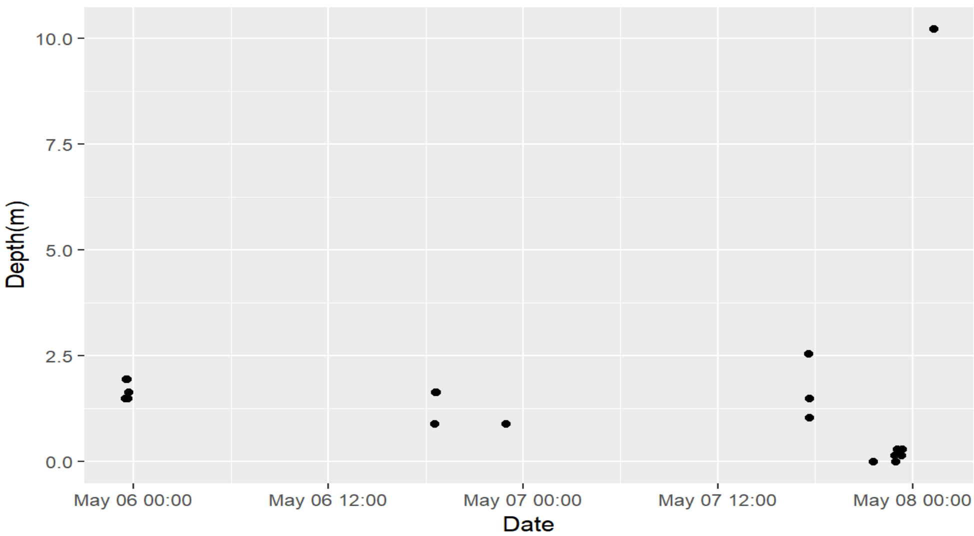

Figure 11. Depth readings for salmon smolt serial number 23.

2018 river tracking

In the 2018 RDT tracking study, which runs separately alongside the Vattenfall project and aims at a better understanding of migration behaviour and identify areas of potential risk to smolt migration success, 100 smolts were tagged at the Baddoch Burn by MSS staff. Again, the smaller V5 tags were used, which resulted in relatively low tag burdens (up to 3% of body weight). The better performance of the receivers for the V5 tags in the river allowed for an assessment of tag losses and loss rates, adding valuable context to the V7 tagged smolts and their migratory patterns in the marine environment.

In contrast to 2017, in-river tag loss in 2018 was more in line with studies in other rivers, with 0.20% per kilometre of river travelled. However, in 2018 there was a stark contrast with tag losses in the harbour: loss rate over the final 2.3 km was 12.17% per km. At the smolt stage compensatory survival no longer plays a role, hence it is thought that any losses that occur in the river could lead to a reduction in the number of returning adults. As such, the high loss rate in the Aberdeen Harbour is considered problematic and further investigations are carried by the RDT staff to determine possible causes.

Statistical modelling indicated that swimming speed of smolts was positively related to discharge (river flow rate) and day of the year. This reflects the strong response to increases in discharge 'triggering' migration which could be used as a proxy for determining when smolts are likely to be active, which has implication for activities carried in the river and harbour environment. Moreover, the positive relationship with day of the year suggests the need for smolts to reach the sea at a time that coincides with favourable ocean conditions that maximise survival chances. Additionally, migration speed during the night was found to be significantly higher than during the day. Coincidentally, most movement (i.e., the number of first detections at receiver stations) was recorded during the night.

Owing to different tagging times, the smolts tagged at the Baddoch were present in the harbour before the smolts tagged described above. Namely, they were present between the 17th of April 2018 and the 15th of May 2018. This indicates that despite the difference in tag timing, and a different arrival date, both groups of smolts exited the river around the same time (i.e., around 15th May 2018).

Plans for 2019

During 2019 the plan is to maintain the inner array in the same location for consistency and push further offshore with several smaller arrays as seen in Figure 9. These arrays will be approximately 25-30km offshore. In addition to these arrays a small array will be added to monitor fish leaving the Don. This is a challenging location to monitor with an anchorage and the Vattenfall wind farm in close proximity. This Don array will make tracking of the nearshore movements of the Don smolts possible with the outer array capturing the offshore migrations of a proportion of them.

The receiver locations in the River Dee and Aberdeen Harbour will be co-located with the RDT and also place up to four receivers in the Don and Don estuary giving us good covarage in both rivers and saltwater transition points.

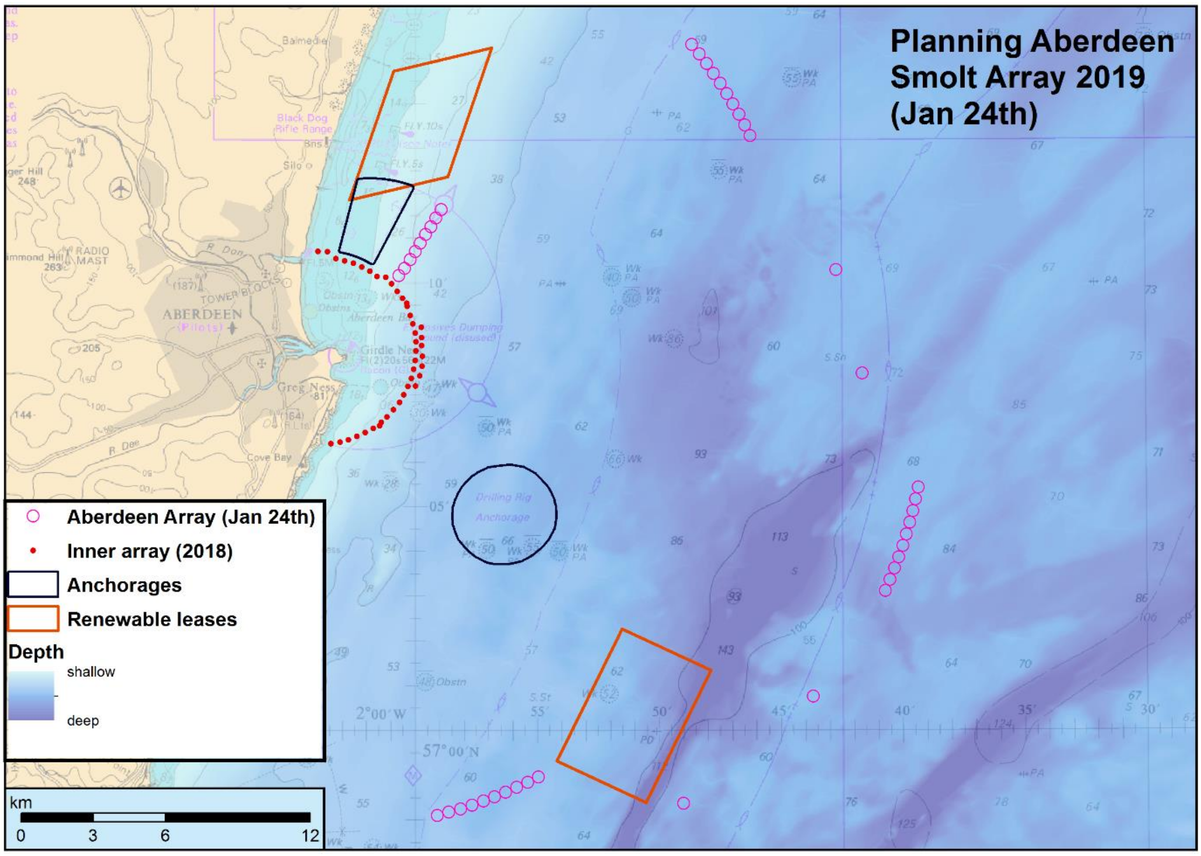

Figure 12. Proposed marine layout for 2019. Map created on January 24th 2019.

The planned receivers and tags for 2019 have been listed below. The final location of the 35-42 pop-ups are still to be finalised.

Tagging

River Dee:

- 100 Salmon Smolts
- 50 ID
- 50 Predator tags (these are new to the market and will give a time lapsed since exposure to stomach acid)

River Don:

- 50 Salmon Smolts all with ID tags

Receivers

River Dee:

- Up to 12 in River
- Four in Harbour

River Don

- Three in River
- One in estuary

Sea Arrays:

- 42 innner array
- Eight in small Don Array
- 35-42 pop-ups in three or 4 arrays at 25-30km offshore.