Session E9: Migration of Atlantic Salmon (Salmo Salar) at Low-Head Archimedean Screw Hydropower Schemes

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Migration of Atlantic salmon at low-head Archimedean screw hydropower schemes

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Small hydropower growth in Scotland

Schemes licensed over time

Year

Number of schemes

Scheme size

- >2MW
- >0.5 - 2 MW
- >100 - 500 kW
- >15 - 100 kW
- ≤ 15 kW

2007  2008  2009  2010  2011  2012  2013  2014

0  20  40  60  80  100  120  140

Courtesy of Richard Gosling and Ellie Willmott, SEPA Hydrology team
Small hydropower growth in Scotland

2010

- < 15 kW
- 15 - 100 kW
- 100 - 500 kW
- 500 - 2000 kW
- > 2000 kW

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Small hydropower growth in Scotland

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Archimedean screw turbines

- Low head (>1m), high flow (0.6 - 6 cumecs)
- Diameters from 0.8 to 5m
- 2 to 5 blades
- Intake velocities: ~1m/s
- Maximum rotational speeds of ~ 30rpm

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Neither fish screen nor bypass required if...

*E.A. Guidance for run of river hydropower  2013   ** SEPA Guidance for developers of Run of River Hydro (2014)
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Neither fish screen nor bypass required if...

* Appropriate protection of the leading edge
* No screen on tailrace
* Sufficient room for the safe transit of the fish species present

<table>
<thead>
<tr>
<th>Number of blades</th>
<th>Minimum diameter of turbine (m)</th>
<th>Maximum rotational speed of turbine (rpm)</th>
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<tr>
<td>5</td>
<td>3.0</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>2.2</td>
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<tr>
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Investigating the risks to migrating salmonids

Smolt migration

Adult spawning migration

Atlantic salmon life cycle

Smolt

Parr

Fry

Eggs

Eyed eggs

Alevin

Adult
Investigating the risks to migrating salmonids

Smolt migration
- Risk of increased mortality from passage through ASTs

Adult spawning migration

Atlantic salmon life cycle
- Eggs
- Eyed eggs
- Alevin
- Fry
- Parr
- Adult
- Smolt
Investigating the risks to migrating salmonids

**Smolt migration**
- Risk of increased mortality from passage through ASTs
  Timing of smolt sea entry may be critical due to availability of post-smolt prey, subsequent growth and predator avoidance.
- Risk of delay to migration at hydropower schemes

**Adult spawning migration**
Investigating the risks to migrating salmonids

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Adult spawning migration
- Delay/disruption by hydropower an important risk
Investigating the risks to migrating salmonids

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**Adult spawning migration**
- Delay/disruption by hydropower an important risk
  Repeat spawners can contribute to stability of population
- Risk of increased mortality of post-spawned fish from hydropower passage
Methods used for monitoring fish movements near to hydro schemes
Study sites

- Craigpot
- Philiphaugh
- Strathdon
Smolt tracking study 2013 + 2014
Smolt tracking results

- 27% of radio tagged salmon smolts passed through the turbine

Migration lag between release and first detection

Diel timing of first detection

Time spent in turbine channel
Salmon smolt turbine trials
Estimates for probability of scale-loss

Enolase activity in blood serum*

*Braceland et al. (2014). Serum enolase: a non-destructive biomarker of white skeletal myopathy during pancreas disease (PD) in Atlantic salmon Salmo salar L. Journal of Fish Diseases
Monitoring adult passage at 3 distinctive hydro sites

- Craigpot
- Philiphaugh
- Strathdon
Monitoring layout

Craigmolais
- Open intake channel
- Turbine
- Fish pass
- Weir
- Outflow channel

Strathdon
- Intake pipe
- Open outflow channel
- Turbine
- Depleted reach
- Weir
- Fish pass

Philiphaugh
- Turbine
- Fish pass
- Weir
- Outflow channel

Scale: 100m
Adult passage success*

- Craigpot: 90%
- Strathdon: 68.4%
- Philiphaugh: 50%

*Does not imply a hydro scheme-effect on non-ascending fish
Adult passage results
(-preliminary)

- Number of visits
- Mean visit time (hours)
- Time from first to last detection (days)

Box plots comparing 'No pass' and 'Pass' for different stations:
- Craigpot
- Strathdon
- Philiphaugh
Outflow attraction

Proportion of fish which visited the turbine outflow

Craipot

Strathdon

Philiphaugh
Conclusions and ongoing work

- **Smolt passage at Craigpot**
  - The proportion of naturally migrating tagged smolts which were exposed to turbine passage was 27%.
  - Naturally migrating tagged smolts did not appear to be delayed at Craigpot under the observed conditions.
  - Ongoing analysis to relate smolt passage route and behaviour to the abstraction rate and environmental variables.
  - There was no apparent change in visible condition of turbine passed smolts relative to non-turbine passed smolts.
  - Initial blood chemistry results indicate no bulk effect on turbine passed fish relative to non-turbine passed fish, though there may yet be a low prevalence of invisible damage.
  - Further work will use additional analytes to explore potential impacts.

- **Adult upstream passage at 3 distinctive low-head hydro schemes**
  - Passage success, complexity of movements and time at scheme is very variable and likely to be influenced by site location within catchment, site layout and hydrodynamics.
  - Ongoing analysis to relate fine-scale behaviour to turbine operation and environmental variables.
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