

Investigating the impacts of a small-scale hydropower scheme upon salmonids

PhD student: Robert Brackley[†]
Supervisors: Colin Bean[‡], Rhian Thomas[†]

[†] The University of Glasgow, [‡] Scottish Natural Heritage

Thursday, 27th March 2014
University of Stirling



European Union

European Regional
Development Fund
Investing in your future



Ireland's EU Structural Funds
Programmes 2007 - 2013

Co-funded by the Irish Government
and the European Union



Special EU Programmes Body
Foras Um Chláir Speisialta An AE
Boord O Owre Ocht UE Projects



**Northern Ireland
Executive**

www.northernireland.gov.uk

A project supported by the European Union's INTERREG IVA Programme managed by the Special EU Programmes Body

Outline

- Background to UK small hydropower development: growth, drivers, conflicts and impacts
- Archimedean screw turbines – a hot topic
- Research objectives
- Current work, challenges and some results
- Future plans



Background to UK hydropower development

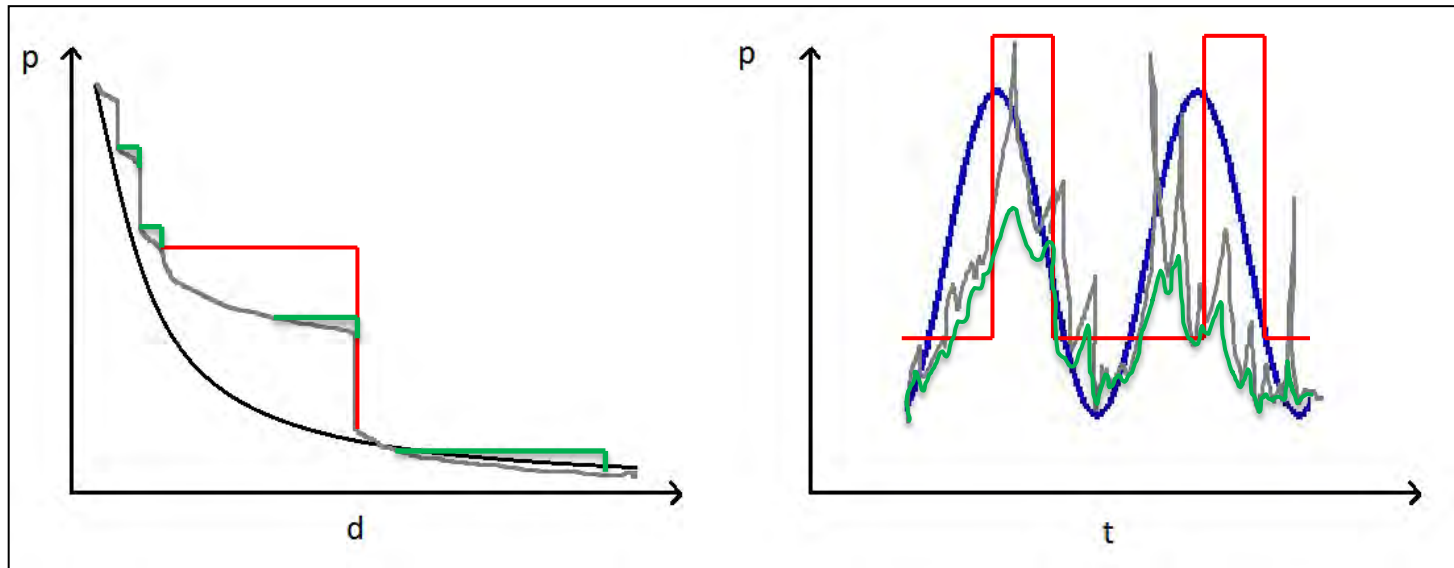
- In the UK most hydropower development occurred in the 1930s to 1970s
- Large –scale schemes using large impoundments, high heads and long diversions to generate many megawatts of power
- The resulting alterations to catchment hydrology and introduction of impounding barriers have been catastrophic for some migratory fish populations



This has led to the recent interest in small-scale hydropower schemes as a potentially more benign alternative



Hydropower impacts



- Effects on migratory fish species – loss of longitudinal connectivity to spawning and feeding grounds
- Physical barriers
- Behavioural barriers: false attraction flows and changes to hydrology
- Mechanical damage, damage from rapid acceleration/deceleration, shear stress, gas embolism, cavitation



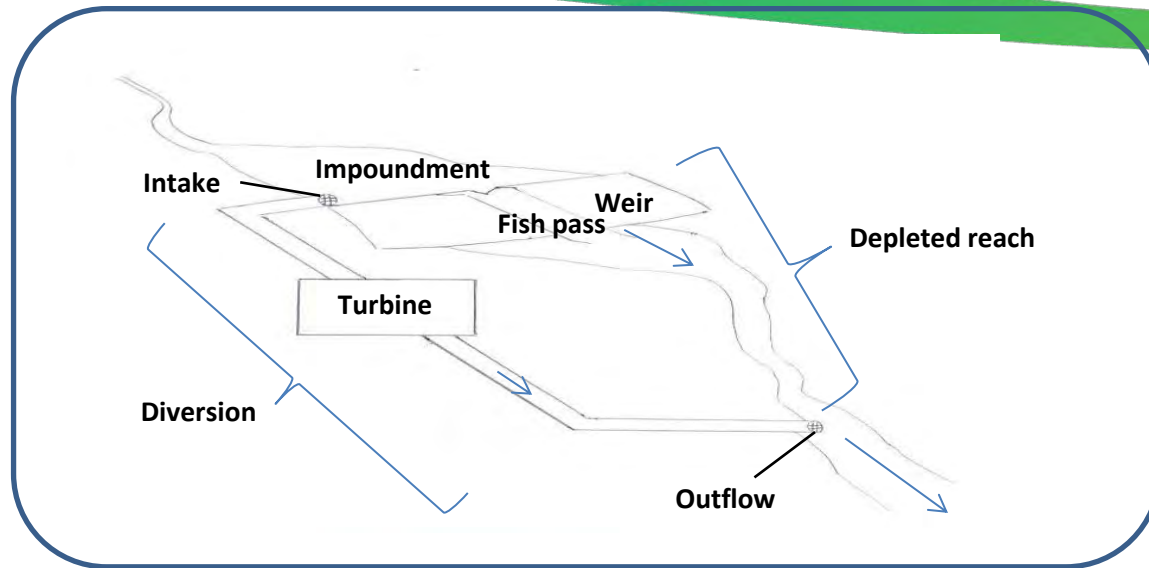
Small hydropower growth in the UK

- Driven by global concerns over fossil-fuel dependency and climate change: legislated in Europe as the EU Renewables directive
- Government incentives: feed-in tariffs a major driver for small-scale renewables development, esp. <100kW
- Environment Agency identified 25935 existing obstructions as potential candidates for development in England and Wales*.

• Environment Agency (2010). Mapping hydropower opportunities and sensitivities in England and Wales



Potential impacts at small scale schemes



Impact	Mitigation
Barrier... <ul style="list-style-type: none"> to fish movements - physical as well as behavioural constraint associated increase in predation risk Fish attraction to outflow 	Fish passes Environmental flows Reduce attraction flow Physical/behavioural barriers at outflow
Mechanical damage <ul style="list-style-type: none"> to fish and others by entrainment through turbines 	'Fish friendly' turbines, physical/behavioural barriers at intake Seasonal operation
Change of in-stream habitats <ul style="list-style-type: none"> Altered flow regime and variability Loss of depth and wetted area for aquatic biota Change in sediment deposition — implications for spawning fish 	Environmental flows
Effects beyond directly altered reach <ul style="list-style-type: none"> Material and energy fluxes 	
Cumulative effects <ul style="list-style-type: none"> of multiple schemes in series 	Catchment-scale planning Environmental flows



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
- Rotational speeds of 20 to 65rpm

Environment Agency good practice guidelines:

Neither fish screen nor bypass required if...

*

No of blades	Fixed speed		Variable speed	
	Minimum Dia. m	Maximum rpm	Minimum Dia. m	Maximum rpm
5	3.0	24	2.3	29
4	2.2	30	1.6	36
3	1.4	40	1.1	48



Research objectives

Principal research aims for migratory fish

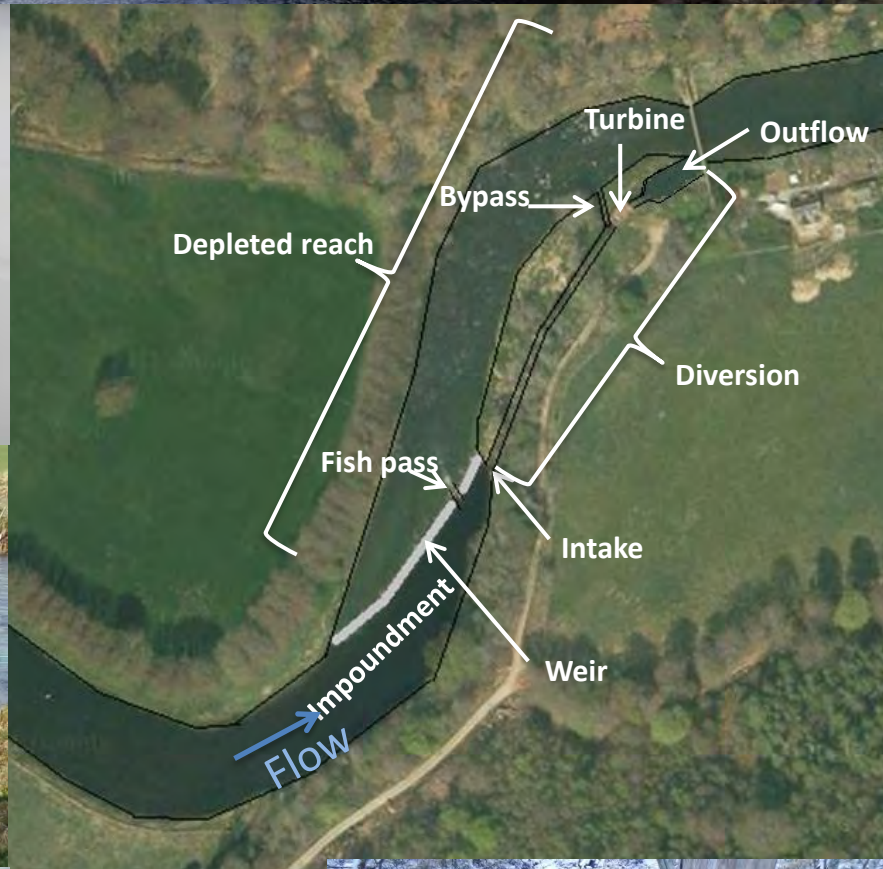
- Upstream migrants:
 - Is there a problem of attraction and delay at the hydro outflow?
 - At what conditions do fish ascend past such schemes?
- Downstream migrants:
 - What proportion of fish are exposed to turbine passage?
 - Are fish damaged from passage through Archimedean screw turbines?
 - Is there a problem of delay to migration in the hydro intake channel?
 - How are the above related to site design, operational conditions and environmental conditions?

Approaches

- Telemetry: Radio and PIT tracking to assess behaviour of upstream and downstream migrating salmonids in the vicinity of the scheme
- Relate behaviour to hydrodynamics, turbine operation, scheme layout, environmental conditions...
- Turbine passage trials to test for damage to downstream moving fish

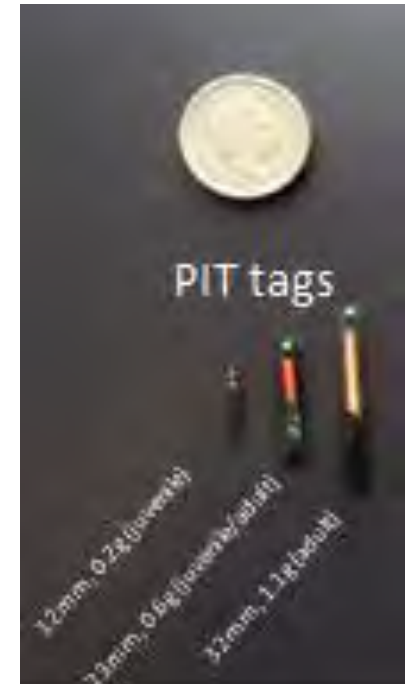


Fish monitoring at Craigpot hydro



PIT telemetry

- Passive integrated transponder
- An unpowered tag which responds by induction to an electromagnetic field generated by current passed through a loop antenna
- Emits its own unique code which is detected and stored by a logger, along with time of detection
- Fish are tagged surgically under anaesthesia and released so that approaches $<1\text{m}$ to the PIT antenna may be recorded





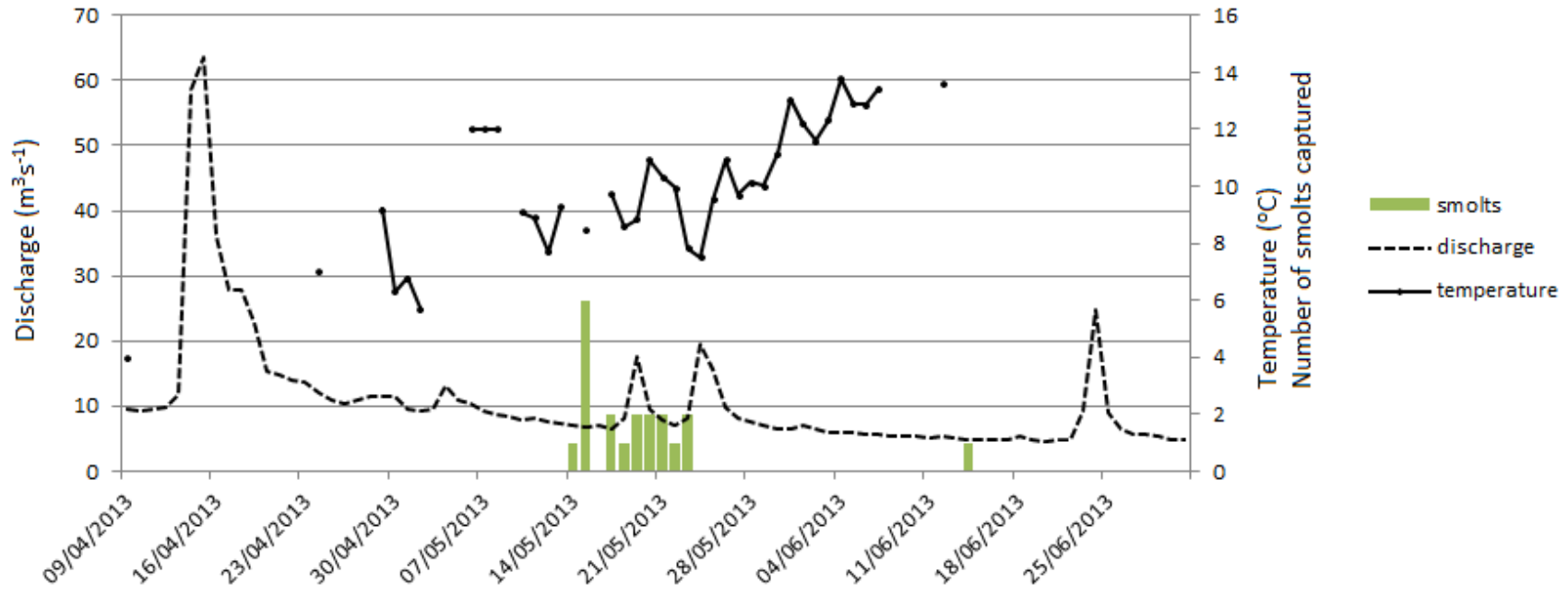








Smolt PIT tagging 2013

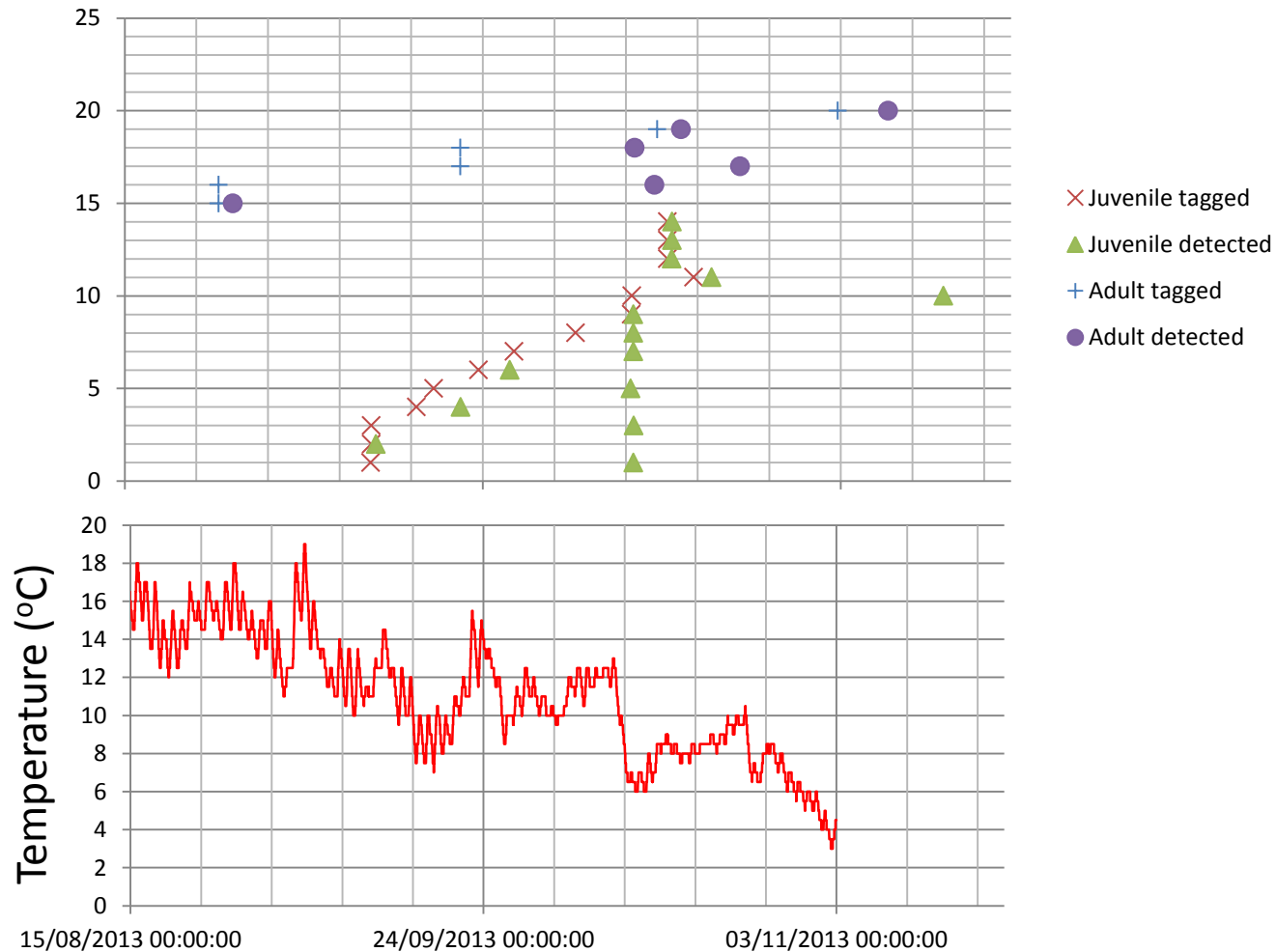


- 18 salmon and 6 brown trout smolts were PIT tagged during 2 months continuous rotary screw trapping
- 2 salmon smolts and one brown trout were re-detected in the turbine channel
- Smolt speed of 0.61m/s between intake and outflow antennas (c.f. $U_{\max} = 1.2\text{m/s}$)



Autumn parr PIT tagging

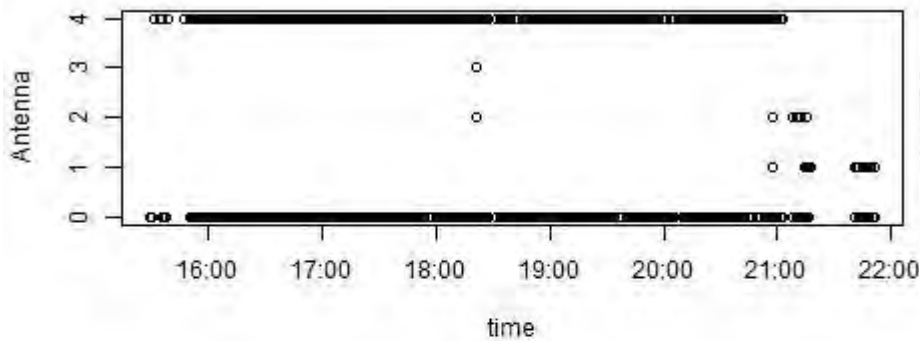
- 156 salmon and 20 trout parr PIT tagged during Oct and Nov



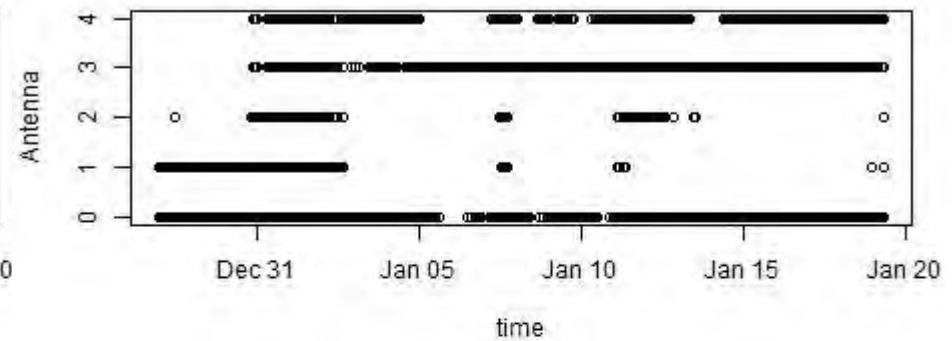
Adult radio tracking data summary

- 8 of 22 radio tagged fish visited/ascended Craigpot hydro
- Four descended as kelts

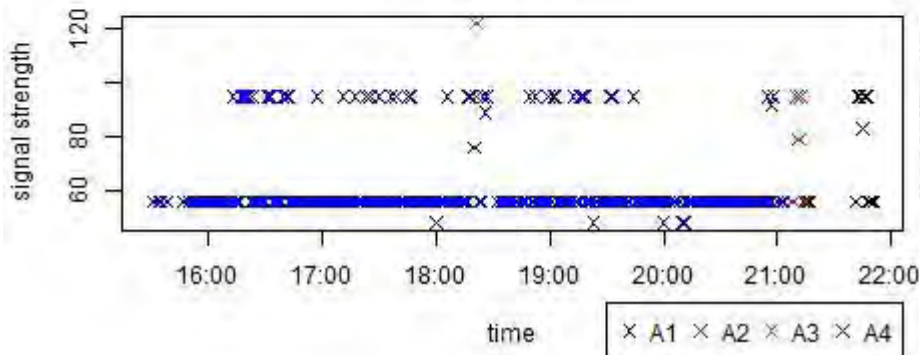
Fish 12 Upstream



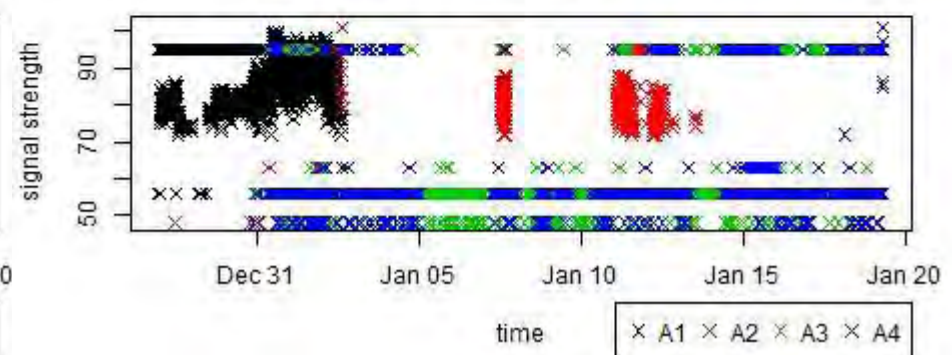
Fish 18 downstream



Fish 12 Upstream



Fish 18 downstream



Future work

- Salmon smolt turbine trials
 - Characterise and quantify potential damage
 - External signs
 - Scale loss
 - Blood biochemistry correlates for tissue damage
- Repeat of wild smolt tracking work
- Extension of adult salmon tracking study to another AST hydro scheme in the upper Don, and to a new installation near Selkirk



Acknowledgements

Colin Adams

Mick Bestwick (Highland Eco-Design)

Jennifer Dodd

Don Rivers Tust: Jamie Urquhart, Ian Morrison

Don District Salmon Fishery Board: Jim Kerr, Martyn Webster, Stephen Murphy, John Davison

Alistair Duguid

David Fettes

Darren Green

IBIS students

IBIS staff: Lindsay Wilson and Hannah Taylor

Kemnay Angling Club: Gordon Macdonald, Robbie Menzie, Marc Coull

Xavier Lambin

Loch Lomond Fisheries Trust

Martyn Lucas

Alisdair Macdonald

Dave Mann (Mannpower Consulting)

Jessica Monhart

Sam Martin

Kate O'Connor

Gary Sutherland

Brian Shaw

Jimmy Turnbull

Jamie Wallace (Highland Eco-Design)

Stuart Wilson

John Webb

And many more....



Any Questions?

IBIS



European Union

European Regional
Development Fund
Investing in your future



Special EU Programmes Body
Foras Um Chláir Speisialta An AE
Boord O Owre Ocht UE Projects



Northern Ireland
Executive

www.northernireland.gov.uk



Queen's University
Belfast



University
of Glasgow



Ireland's EU Structural Funds
Programmes 2007 - 2013

Co-funded by the Irish Government
and the European Union

A project supported by the European Union's INTERREG IVA Programme managed by the Special EU Programmes Body