SEA TROUT SMOLT EMIGRATION IN A RIVER WITH LOW-HEAD BARRIERS

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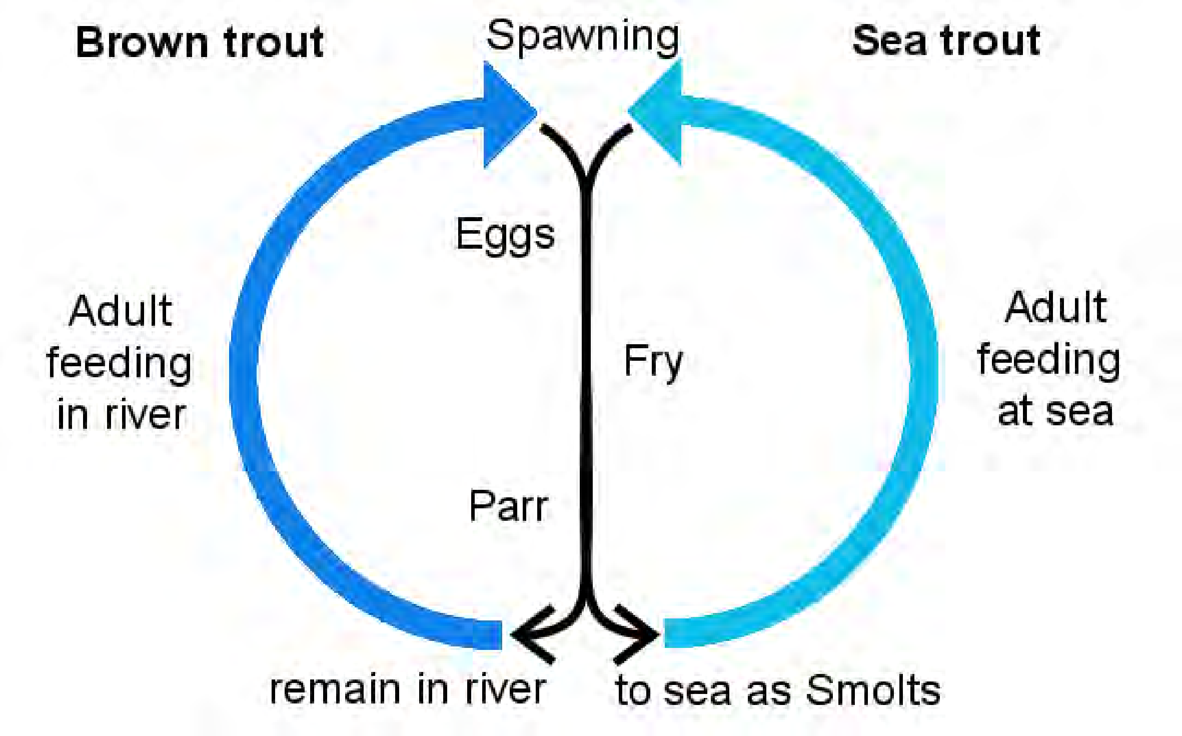
In-stream barriers and their impacts

- In-stream barriers are estimated to be in half of the worlds rivers and play a role in fragmenting fluvial ecosystems [1]
- Barriers also cause the alteration of the downstream flux of water and sediment, restrict nutrient movement and alter water temperatures within rivers [2]
- Further to this they also restrict or completely obstruct fish movement to habitats required for essential life history stages [3]
- Until recently low-head barriers were only considered an impediment to upstream migrants or benthically oriented downstream migrants

[1](Dynesius and Nilsson, 1994; Nilsson et al., 2005); [2](Poff and Hart, 2002); [3](Lucas and Baras 2001)

Sea trout lifecycle

- Sea trout are the anadromous life history variant of brown trout (*Salmo trutta*)
- Brown trout remain in the river
- Sea trout migrate to sea after 2-3 years within the river
- However, generally considered one whole population within the Tweed



Smolts and their importance

- Smoltification in juvenile salmonids is a change between freshwater residency to a saltwater capable migratory form
- Smoltification involves a great deal of morphological and physiological adaptation
- Smolts represent the final product of the freshwater stage in the sea trout lifecycle
- High smolt mortality can therefore have a large impact on sea trout populations

Smolt predators - River

Estuary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Previous research findings

- Prior to current work only one paper investigated how low head weirs affect smolts
- Aarestrup and Koed (2003) found that low head weirs situated at fish farms delayed fish 7 days on average and mortalities of 38% were recorded
- However, weirs in question were water in-takes for fish farms which diverted ~40% of stream flow, not overflowing weirs.

Aims

- To better understand the behaviour and success of migrating sea trout smolts in the river Tweed.
  - Investigate environmental impacts on smolt migration.
  - To understand the role of in-stream barriers on migratory behaviour.

Tagging

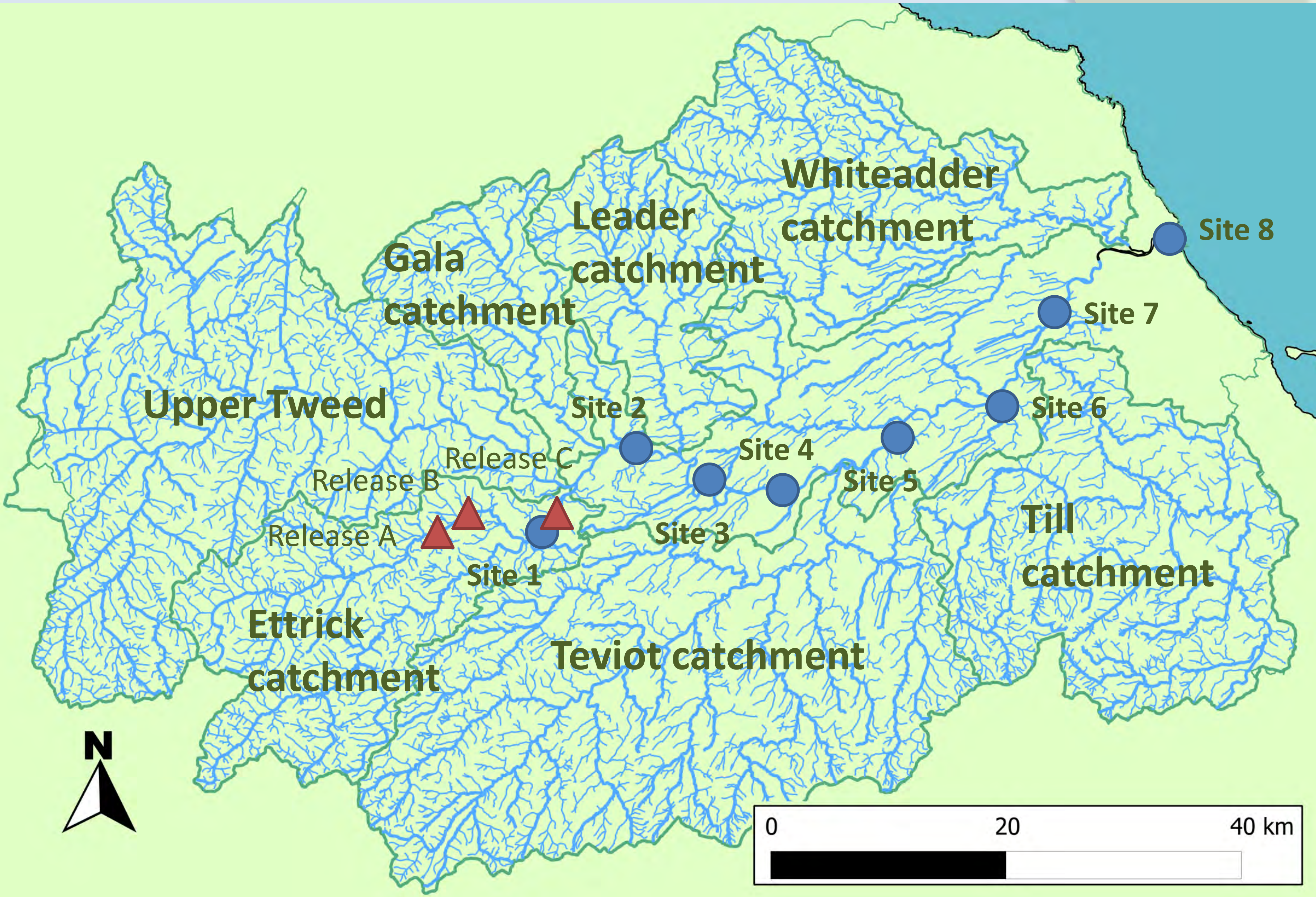
- Fish were tracked using acoustic telemetry
- 7.3 mm acoustic tags were used for sea trout smolts
- All tags inserted via incision into the peritoneal cavity
- Incision closed with sutures
- All surgery completed under UK Home Office licence

Release sites

- Fish released 100 m from capture point in 2010 (n=43)
- Fish released in two further release points in 2011, 1 km downstream from original release point and 100 m downstream from a major in-river obstruction

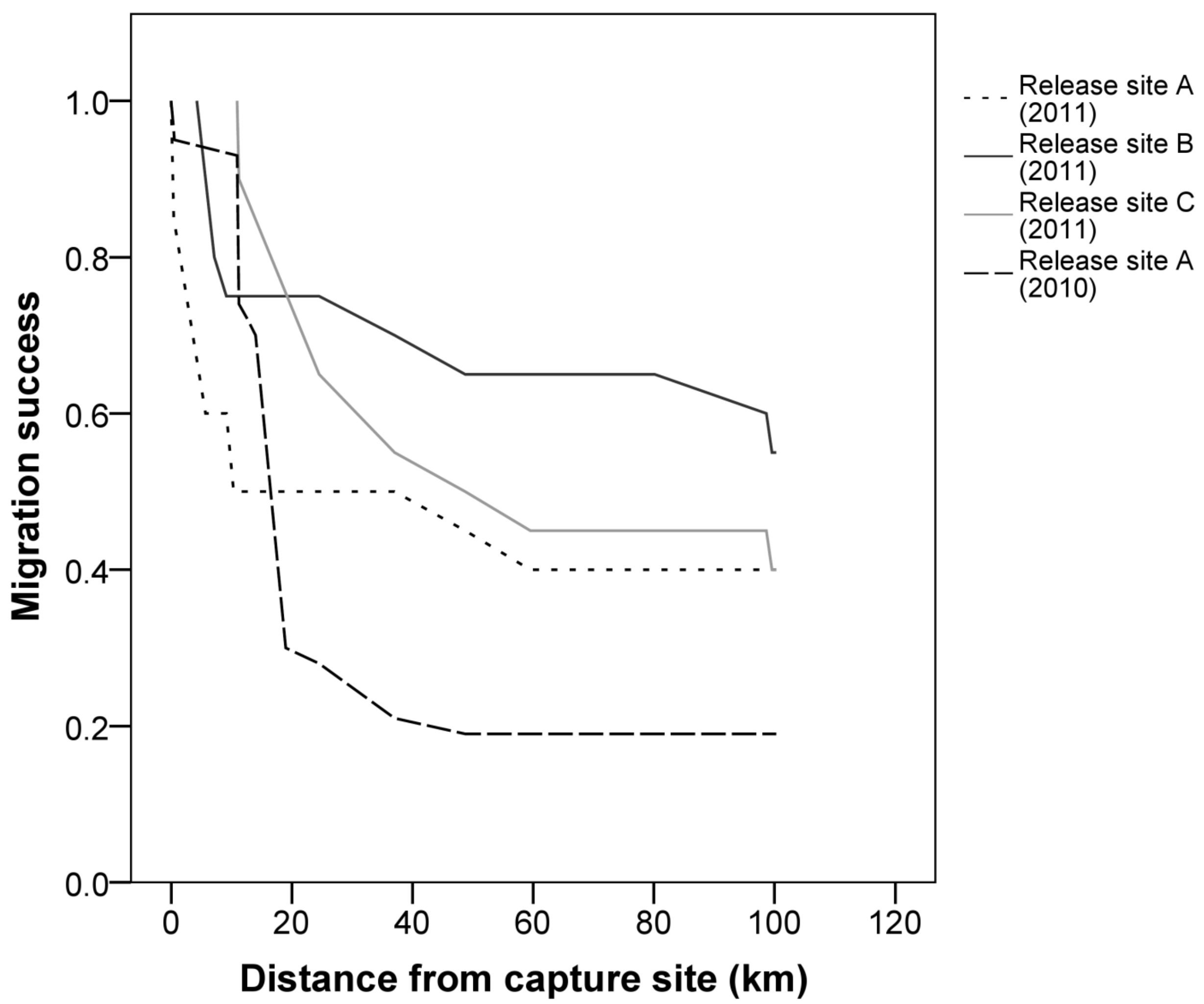
Tracking

- Fish were tracked using a combination of automatic listening stations (ALS) and manual tracking.
- ALS network spread throughout the migration route (every 10 km approx)
- Manual tracking completed between ALS stations to search for missing fish


Whiteadder catchment
Leader catchment
Gala catchment
Upper Tweed
Ettrick catchment
Teviot catchment
Till catchment
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
Site 8
Release A
Release B
Release C
N
0
20
40 km

Results

Migratory success



2010: n=36, R^2= 0.495, F= 12.064, p= 0.005

2011: n=53, R^2=0.84, F=84.731, p<0.001

Gauld *et al*. 2013

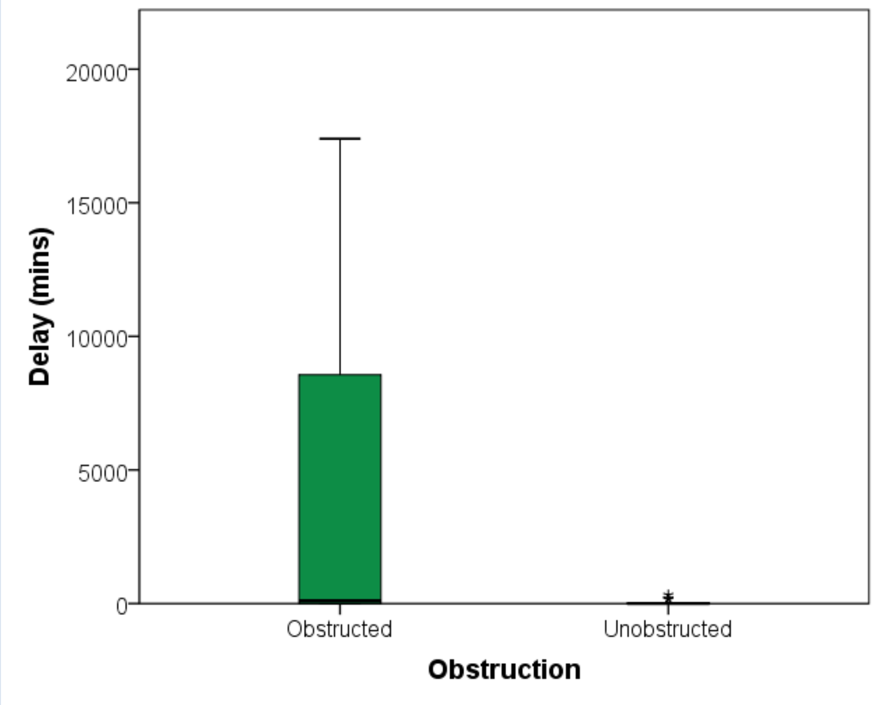
Migratory delay

ALS Station	Upstream of in-river structure	In-river structure characteristics	2010 Delay (median(Q_1- Q_3), minutes)	2011 Delay (median(Q_1- Q_3), minutes)
1	Yes	Intact	4497.3 (109.9-25029.4)	5.8 (2.7-26.4)
2	Yes	Ruinous	7.1 (1.8-18.8)	2.1 (0.9-4.6)
3	Yes	Cut	1.11 (0.2- 2.7)	0.1 (0.1-0.5)
4	No	-	2.5 (1.3-81.6)	0.6 (0.1-0.8)
6	No	-	5 (3.1-18.9)	0.9 (0.1-1.1)
7	No	-	4.7 (2.7-11.7)	1.7 (0.9-2.7)
8	No	-	460 (61.8-1244.8)	314.3 (4.6-1719.9)

Gauld *et al*. 2013

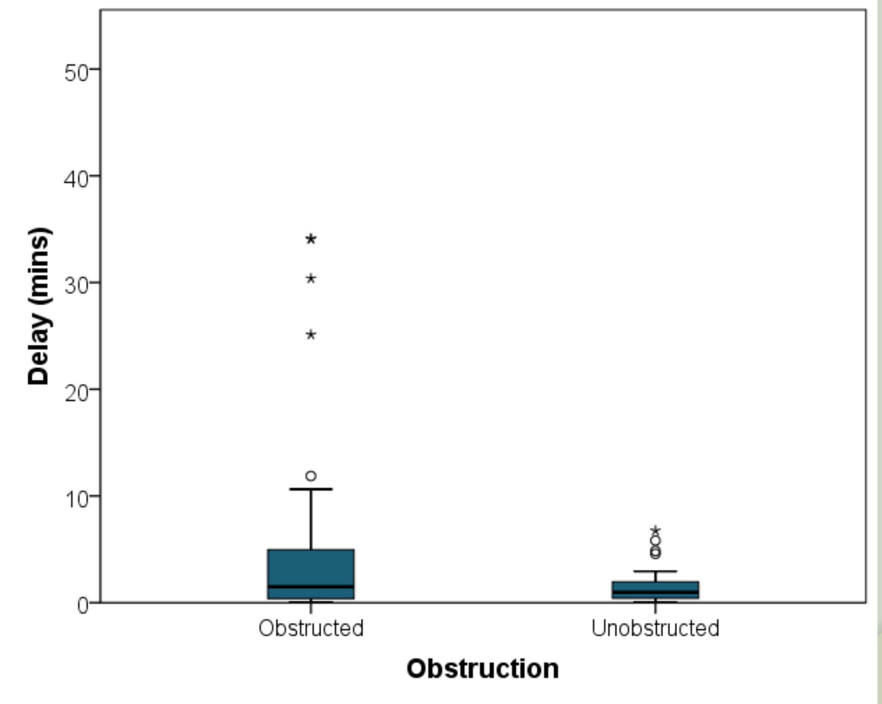
Smolt delay in river sections with weirs

2010



n=80, Z=-2.865, p=0.004

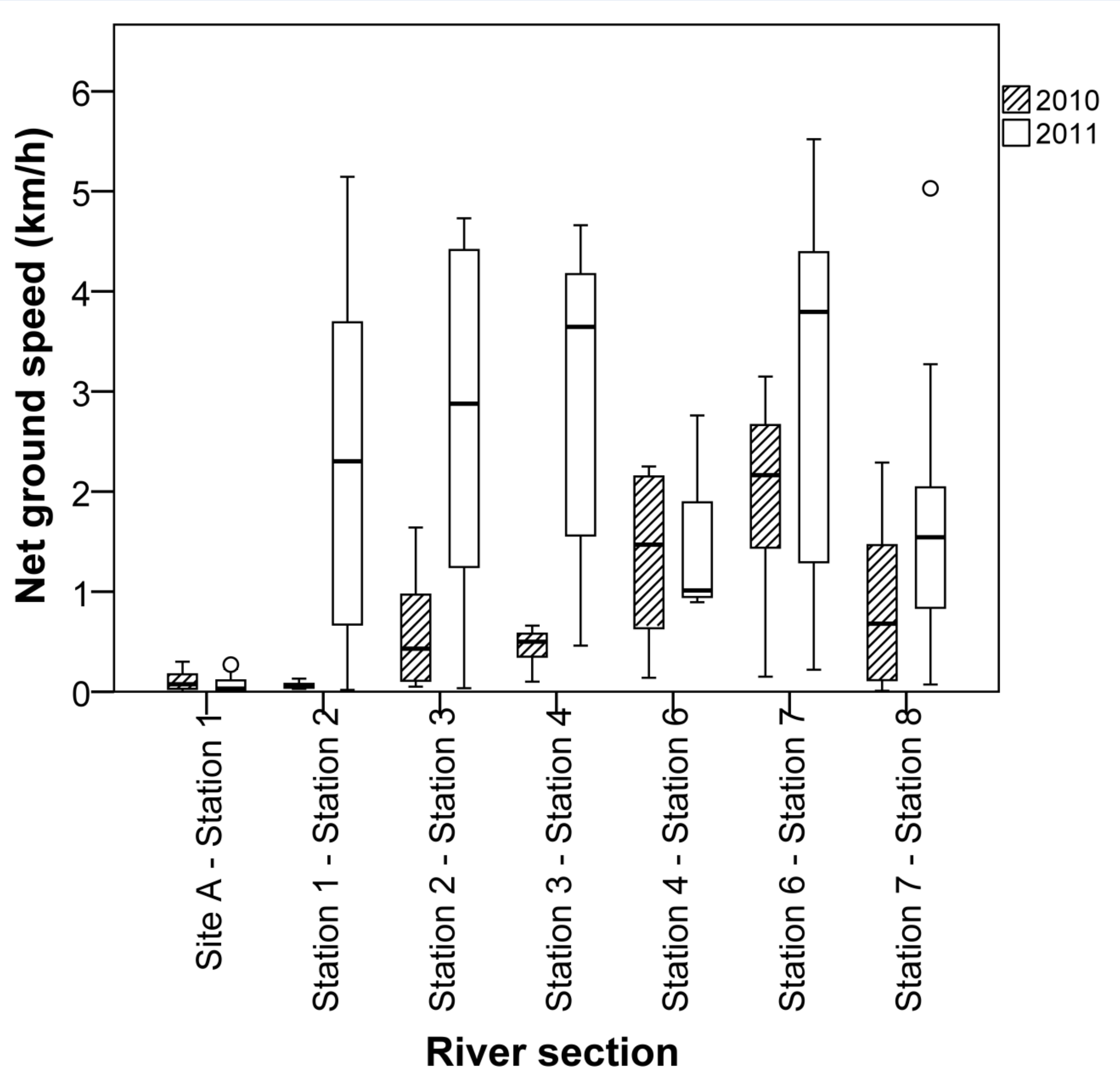
2011



n=129, Z=-1.767, p=0.077

Gauld *et al*. 2013

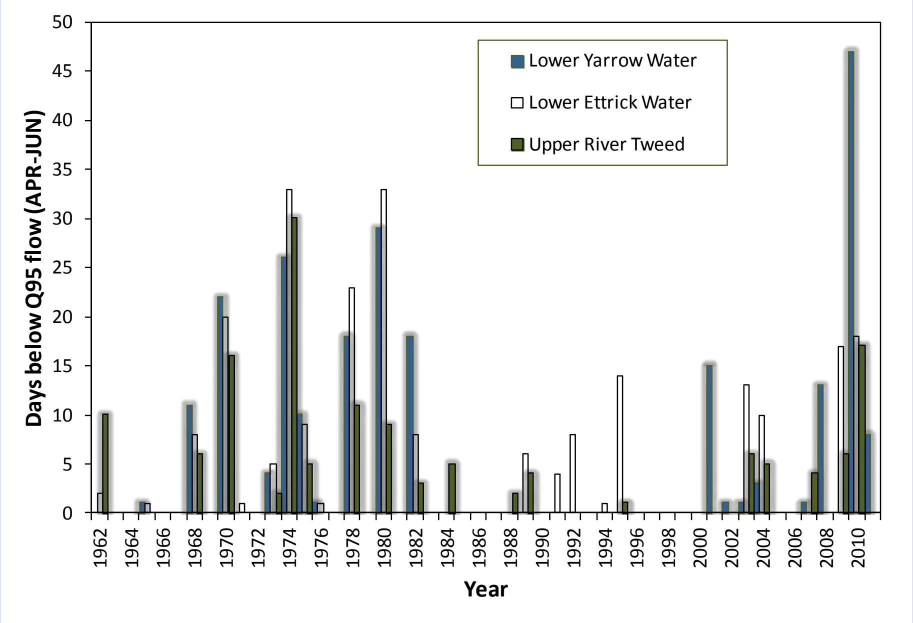
Net speeds

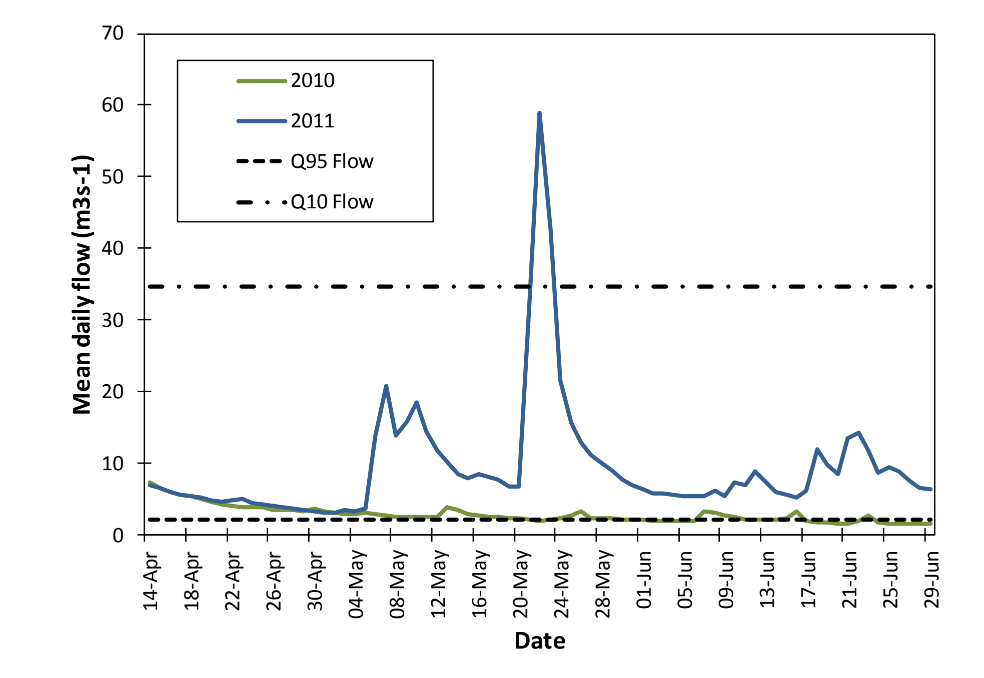


$n = 205$, $F = 5.673$, $p < 0.001$

Gauld *et al*. 2013

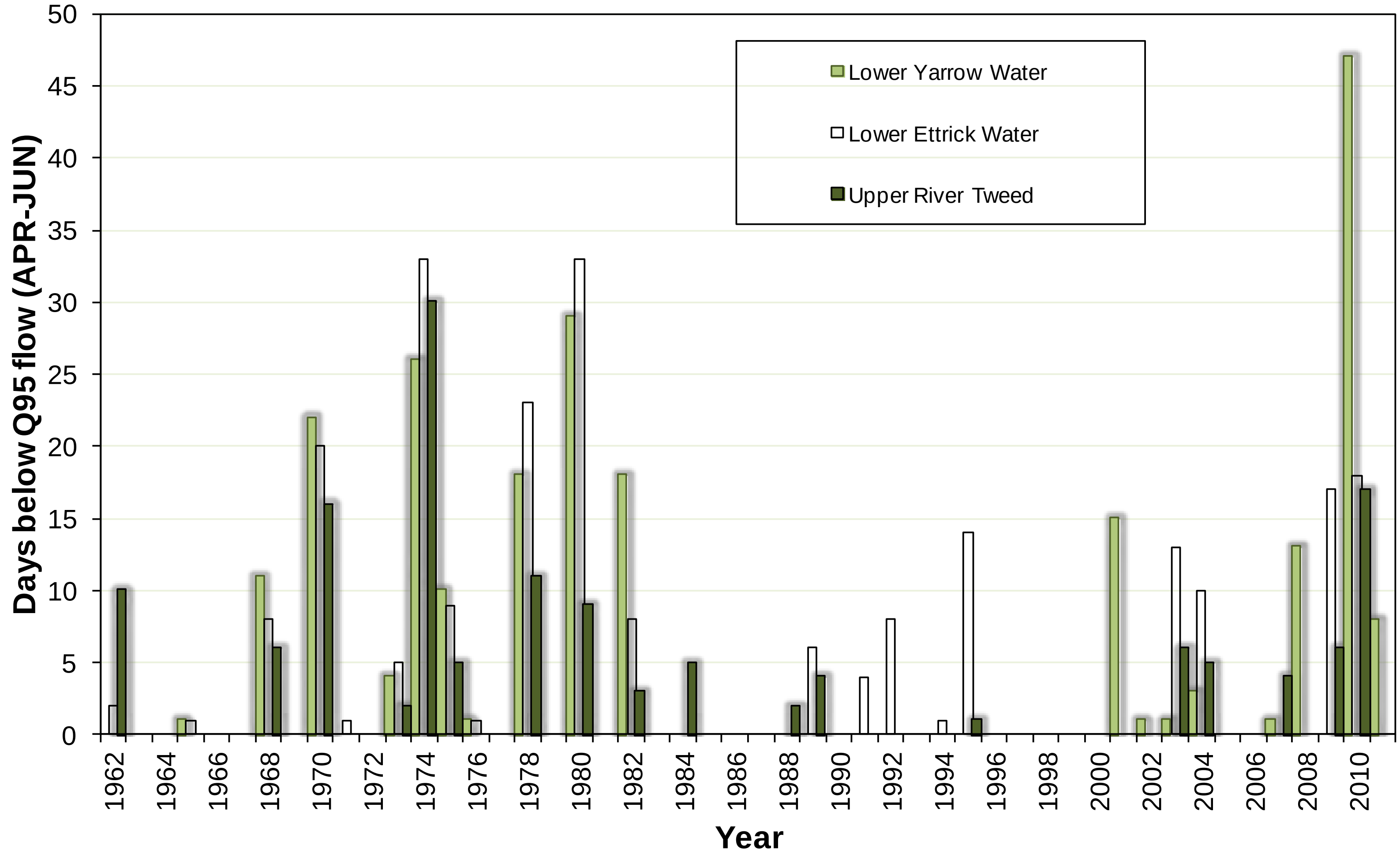
Flow conditions during smolt migration





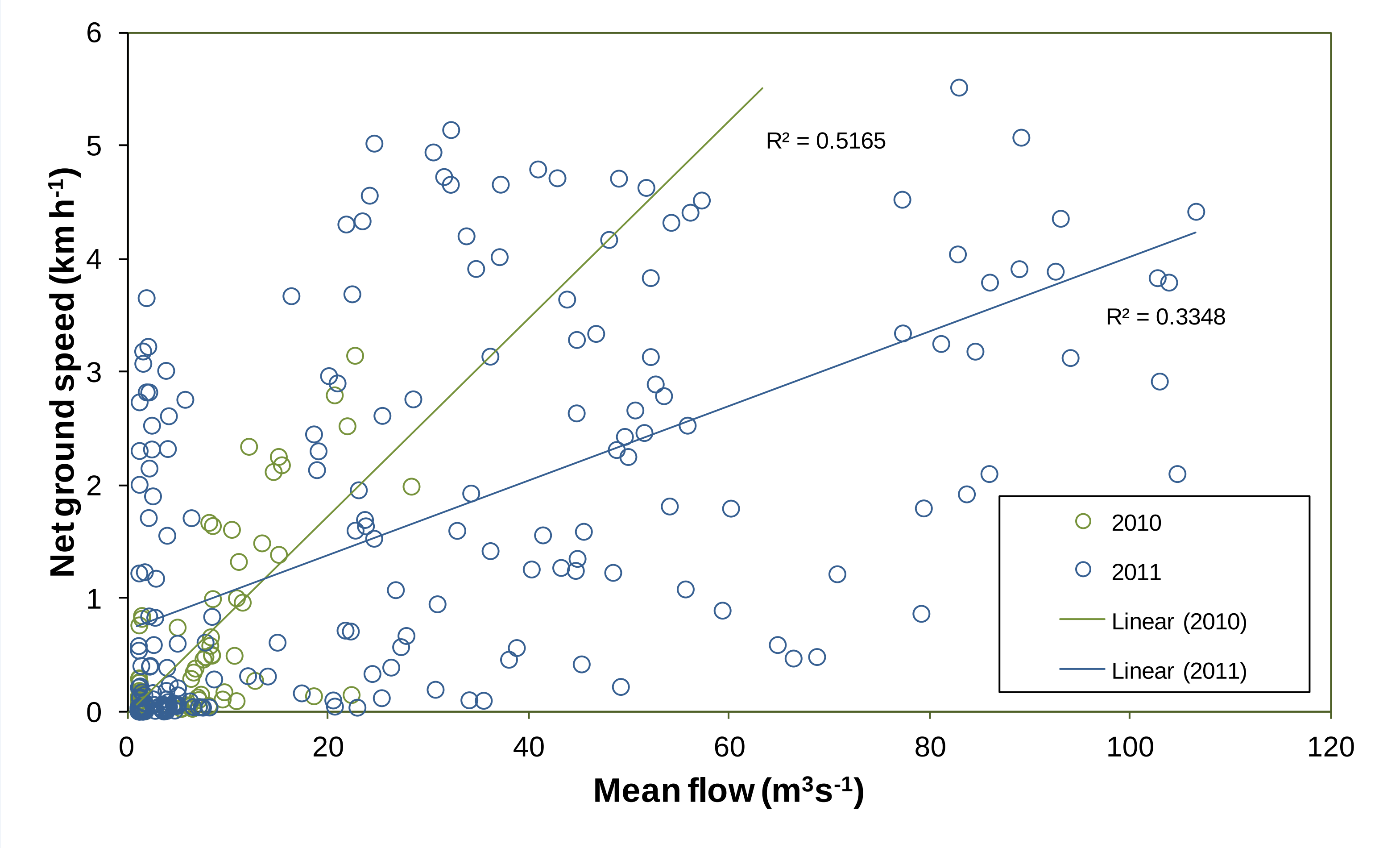
Gauld *et al*. 2013

Historical perspective



Gauld *et al.* 2013

Smolt speed vs river flow



2010: (*n*=88, *R*=0.719, *p*<0.001); 2011: (*n*=218, *R*=0.579, *p*<0.001);
ANCOVA: (*n*=306, *F*=147.73, *p*<0.001)

Gauld *et al*. 2013

Conclusions

- Migratory success declines with distance travelled from release site
  - Largest declines experienced near river obstructions
  - Smolt losses appear to be lower in unobstructed river sections
- Flow conditions have a large impact on behaviour
  - Smolt migration speeds increase with elevated flows
  - Behavioural responses to flow varied between years
- Obstructions in rivers delay fish significantly during periods of low flow

Future research and management implications

- Smolt passage at low head weirs needs more research
- Possible combination of acoustic and radio telemetry, ability to attribute smolt losses to terrestrial predators and place monitoring stations where acoustic is unsuitable.
- Management needs to consider weirs as a threat to smolts
- Passage provision for smolts should be incorporated into future fish passage fascilites
- Removal of weirs should also be considered in the right scenarios [4,5]

[4] (Garcia de Leaniz 2008); [5] (Kemp and O'Hanley 2010)

Thanks

- Dr Martyn Lucas & Dr Ronald Campbell
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- River Tweed Commission Bailiffs
- River Tweed Boatmen
- River Tweed landowners
- Members of lab 16 at Durham

Living North Sea

THE Tweed FOUNDATION

The Interreg IVB North Sea Region Programme

Investing in the future by working together for a sustainable and competitive region