Riverine obstacles to fish movement: a rapid assessment tool

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The issue:

What is a obstacle to fish migration?

Anything that can alter behaviour or that results in delay or stopping of movement

What types of obstacles are there for fish?

Physical: e.g. leap , velocity, depth

Chemical: e.g. Temperature, DO

Behavioural e.g. light, orifice size

Low flows e.g. upstream abstraction

The issue:
River obstacle passage and fish

- Traditionally – if fish species of interest (i.e. salmon) seen to pass then considered passable / porous
- Complex temporal and spatial aspects relating to river network and fish management

- Directional / species bias in terms of passage information available
- Species assemblage? Priority species?
- Migrations at different life stages / sizes
- Migrations at different times / river flows

The fish: swimming performance

Species	Body Length (m)	Burst speed (ms^{-1})	Sustained speed (ms^{-1})	Reference
Atlantic salmon	0.10m (parr)	0.596 (maintained for 20s)	0.596 (maintained for 10 mins	Bourne et al (2011)
Atlantic salmon	0.50m (grilse)	2.666 (maintained for 20s)	2.666 (maintained for 10 mins	Bourne et al (2011)
Atlantic salmon	0.71m (MSW salmon)	3.256 (maintained for 20s)	3.256 (maintained for 10 mins	Bourne et al (2011)
Atlantic salmon	0.55-0.60m	4.06 (maintained for 20s)		USFS (2003)
Atlantic salmon	0.55-0.60m		2.16 @ 18°C (maintained for 10 mins	USFS (2003)
Atlantic salmon	0.55-0.60m		1.76 @ 12°C (maintained for 10 mins	USFS (2003)
Brown trout	0.01m		0.77 @ 12.5°C	Peake et al (1997)
Brown trout	0.25m		1.5 @ 12.5°C	Peake et al (1997)
Brown trout	0.50m		2.69 @ 12.5°C	Peake et al (1997)
Brown trout	0.01	0.40 (maintained for 20s @ 12.5°C)		Using equation from Hunter & Mayor (1986)
Brown trout	0.25	0.76 (maintained for 20s @ 12.5°C)		Using equation from Hunter & Mayor (1986)
Brown trout	0.50	1.21 (maintained for 20s @ 12.5°C)		Using equation from Hunter & Mayor (1986)
River lamprey		1.1-1.3		Laine et al, 1999
River lamprey		1.5		Kemp et al (2010)
Sea lamprey	0.50m	0.91 (maintained for 20s) at 12°C		Using equation from Hunter & Mayor (1986)
Sea lamprey	0.50m	1.08 (maintained for 20s) at 15°C		Using equation from Hunter & Mayor (1986)

Bourne, C. M., Kehler, D. G., Wiersma, Y. F. & D. Cote (2011) Barriers to fish passage and barriers to fish passage assessments: the impact of assessment methods and assumptions on barrier identification and quantification of watershed connectivity. *Aquatic Ecology* 45, 389-403

Hunter, L A. and Mayor, L (1986)., "Analysis of fish swimming performance data: Volume I" *Reports.* Paper 144. Report prepared by North-South Consultants for the Department of Fisheries and Oceans and Alberta Department of Transportation http://scholarworks.umass.edu/fishpassage_reports/144

Kemp, P. S., Russon, I. J., Vowles, A. S. & M. C. Lucas (2010) The influence of discharge and temperature on the ability of upstream migrant adult river lamprey (Lampetra fluviatilis) to pass experimental overshot and undershot weirs. River Research and Applications 27 (4), 488-498

Laine A., Kamula, R. & J. Hooli (1998) Fish and lamprey passage in a combined Denil and vertical slot fishway. Fisheries Management and Ecology 5, 31-44

Peake, S. McKinley, R. S. & D. A. Scruton, (1997) Swimming performance of various freshwater Newfoundland salmoninds relative to habitat selection and fishway design. *J. Fish Biol.* 51, 710-723

USFS (US Forest Service) (2003) FishXing 3.0, available at www.stream.fs.fed.us/fishxing/

Behavioural stimuli also need to be considered

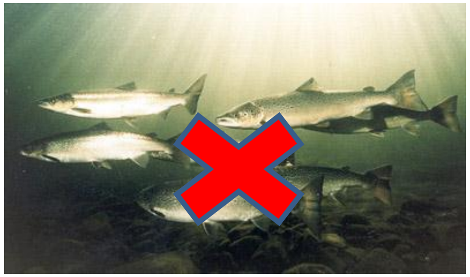
The issue:
Obstacles creating variable selection pressures on fish communities

Complete barrier to fish passage?

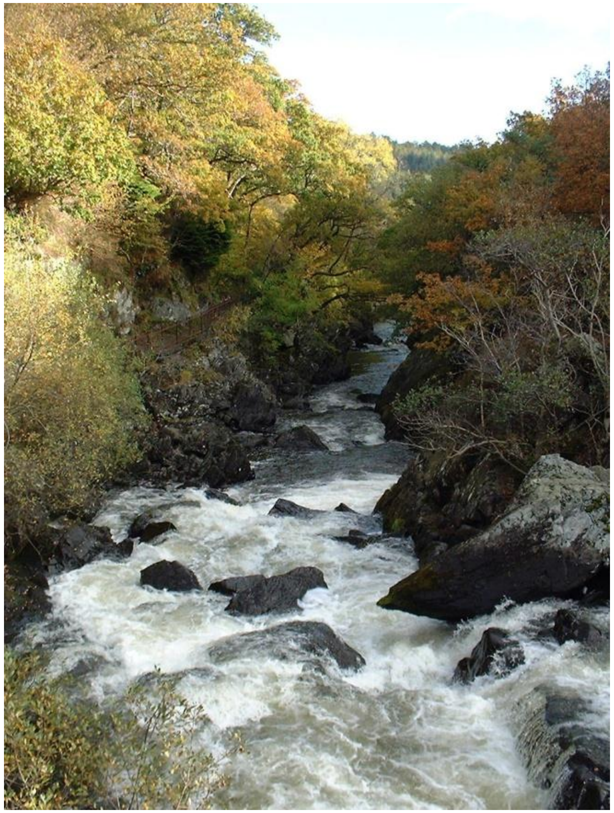
Eel passage ?

Upstream stocking?

Downstream survival?



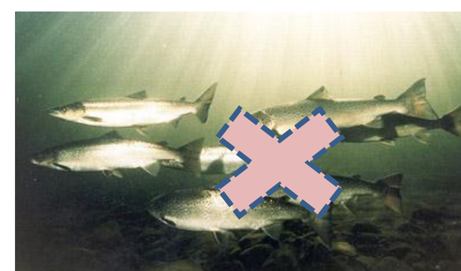
Selection pressure seasonal/ intermittent?



Partial / species specific barrier

Thermal barrier

Suitable flow conditions during migration periods?

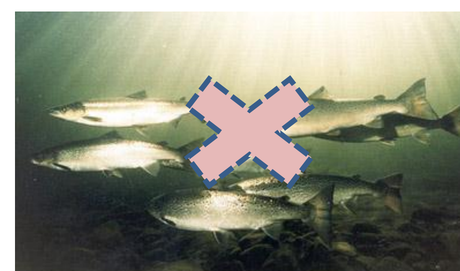


Selection pressure temporary?

Natural temporary barrier

Flow conditions during migration period

Ecological benefits ?



The issue:

- Complex array of natural and man-made features on river networks providing spatial and temporal obstacles to fish movement.
- Requirement to not only identify locations, but assess and compare their impact on fish passage in terms of numerous local, national and international management objectives / priorities.

The structures:

- Culverts
- Weirs (gauging & non-gauging)
- Fords / Bridge or Aquaduct footings
- Abstraction off-takes
- Dams
- Sluices
- Natural obstacles

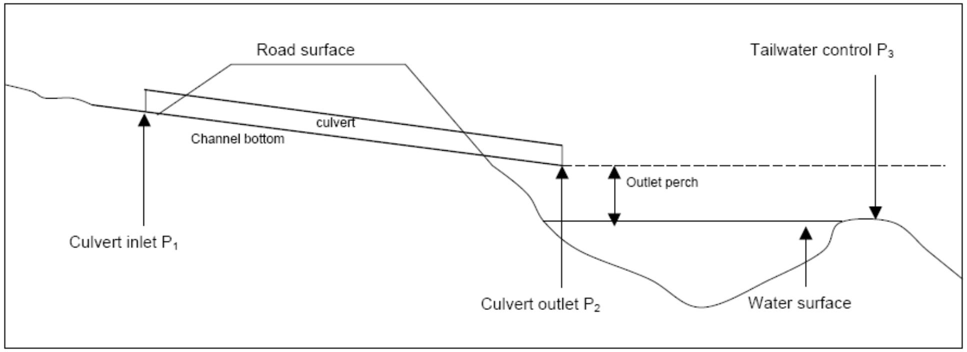
All share a number of key considerations in terms of facilitating fish passage:

Jump (vertical drop with water depth requirement)
Swim (water velocity, length required, water depth)
Combination

Culverts

Important features to consider:

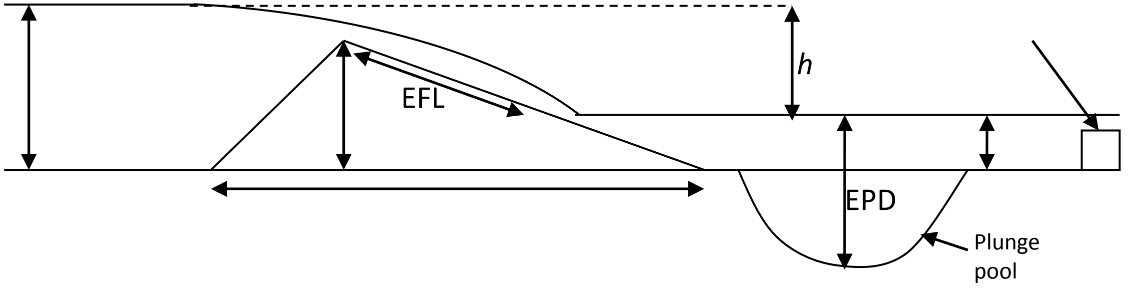
- Length
- Water velocity
- Gradient
- Outlet drop present at height
- Depth of water in plunge pool
- Water depth in culvert
- Material



Weirs

Important features to consider:

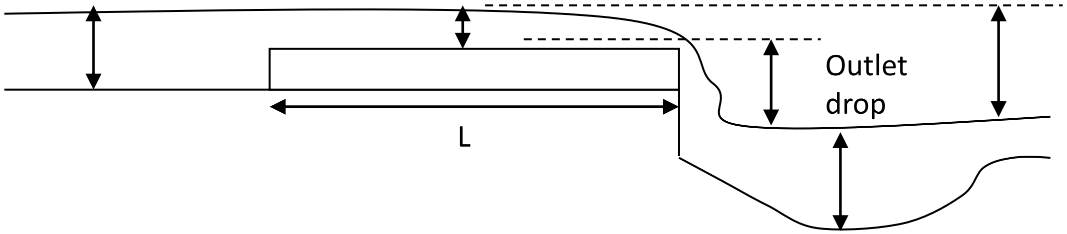
- Length
- Water velocity
- Gradient
- Depth of water in plunge pool
- Water depth over face
- Material



Fords and bridge footings

<u>Important considerations</u>

- Velocities & depths
- Hydraulic Head difference
- Associated outlet drop characteristics



Natural obstacles

- Type of obstacle: jump/swim/combination?
- Hydraulic head
- Multiple channels and ascent routes
- Permanence?
- Mechanical damage to downstream migrants
- Passable under varied flow conditions?

The application:

- SNIFFER (2012) WFD111 (2a) Coarse resolution rapid-assessment methodology to assess barriers to fish migration
- Jump, Swim or Combination obstacles
- Water velocities, distances, and water depths are measured at appropriate locations to describe variation and include potential fish passage routes
- Combinations of measurements compared to species –specific assessment tables to ascertain a conservative "score"

Scores:

0.0 = completely impassable

0.3 = partial obstacle but high impact

0.6 = partial obstacle but low impact

1.0 = no obstacle

Provides "snapshot" at low flows but information collected to inform passage assessment at higher flows

http://www.sniffer.org.uk/files/7113/4183/8010/WFD111_Phase_2a_Fish_obstacles_manual.pdf

The application: assessing potential routes for fish passage across river structures

Surveyors assess the separate “fish passage channels” present at a structure and include in the final assessment

Provides final assessment for species / lifestage and direction

The benefits of a standard approach

- Simple and relatively quick to collect measurements
- Common terminology and methodology to allow multiple partner discussion of issues
- Assessment at low flows enables “worst case scenario”
- Standard assessment measurements provide comparable baseline for prioritising further actions across multiple locations
- Combination of data and images can be used to inform if further engineering / fish or camera survey required

Limitations of approach

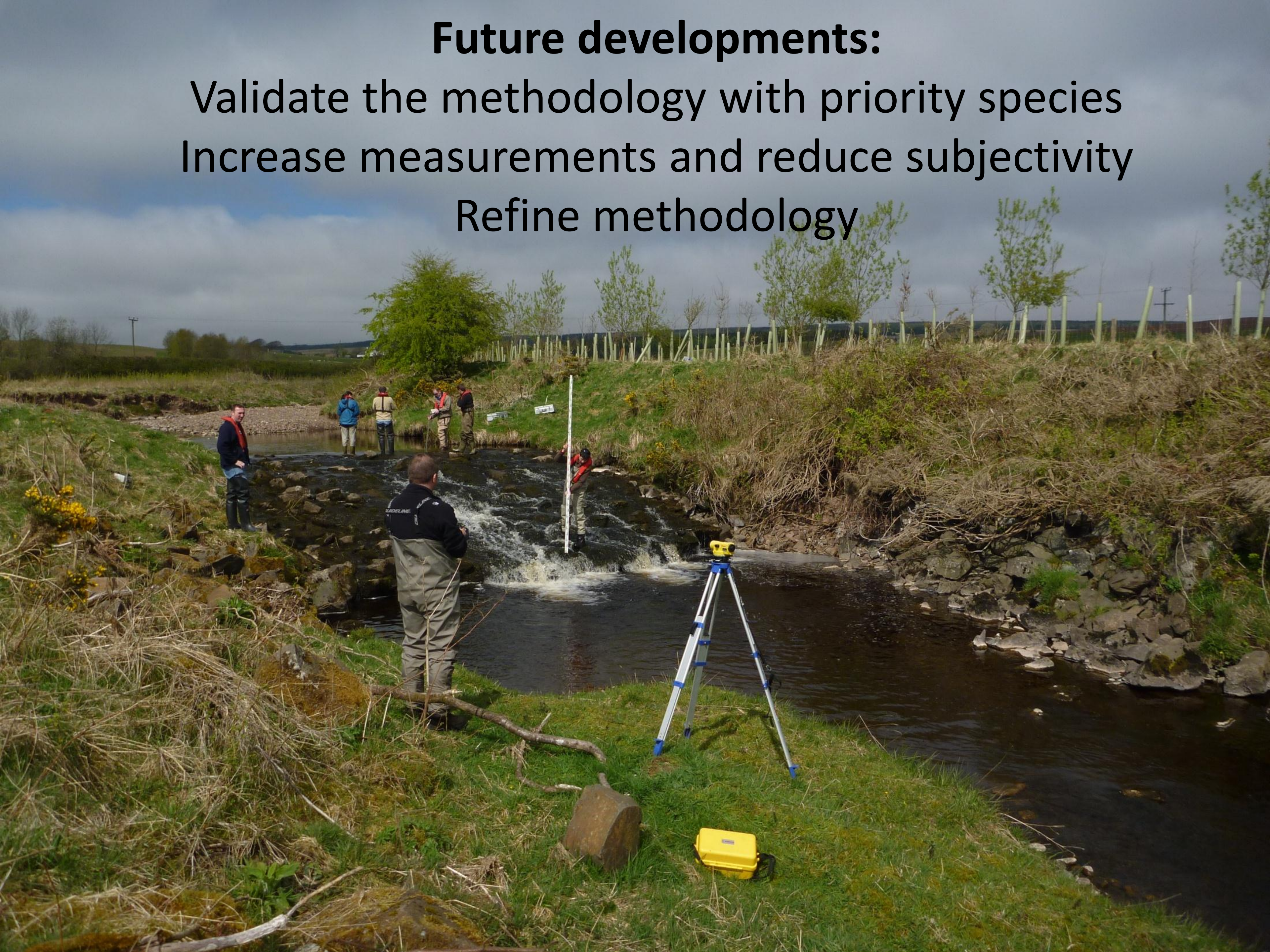
- Rapid "first look" assessment technique with limited outputs
- Still relies on including the subjective assessment of the severity of certain features
- Low flow conditions to collect data but severely restricted under elevated flow conditions
- Has to be used in conjunction with local fish ecology information
- Flow, physical habitat and water quality information all need to be considered in order to provide full picture of passability.

Future developments:

Validate the methodology with priority species

Increase measurements and reduce subjectivity

Refine methodology



For further information :

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Scottish Natural Heritage
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http://www.sniffer.org.uk/files/7113/4183/8010/WFD111_Phase_2a_Fish_obstacles_manual.pdf