

The ecological benefits of barrier removal: evidence and debate

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Adaptive Management of Barriers in European Rivers

Breakages of longitudinal and lateral connectivity restrict or alter movements of water, nutrients, sediment, biota - and dramatically alter habitat



Estuarine barrage



Large valley dam

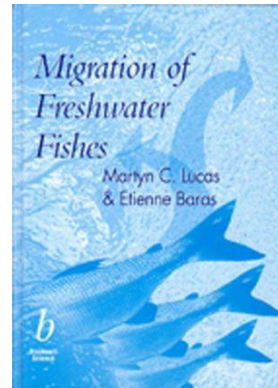
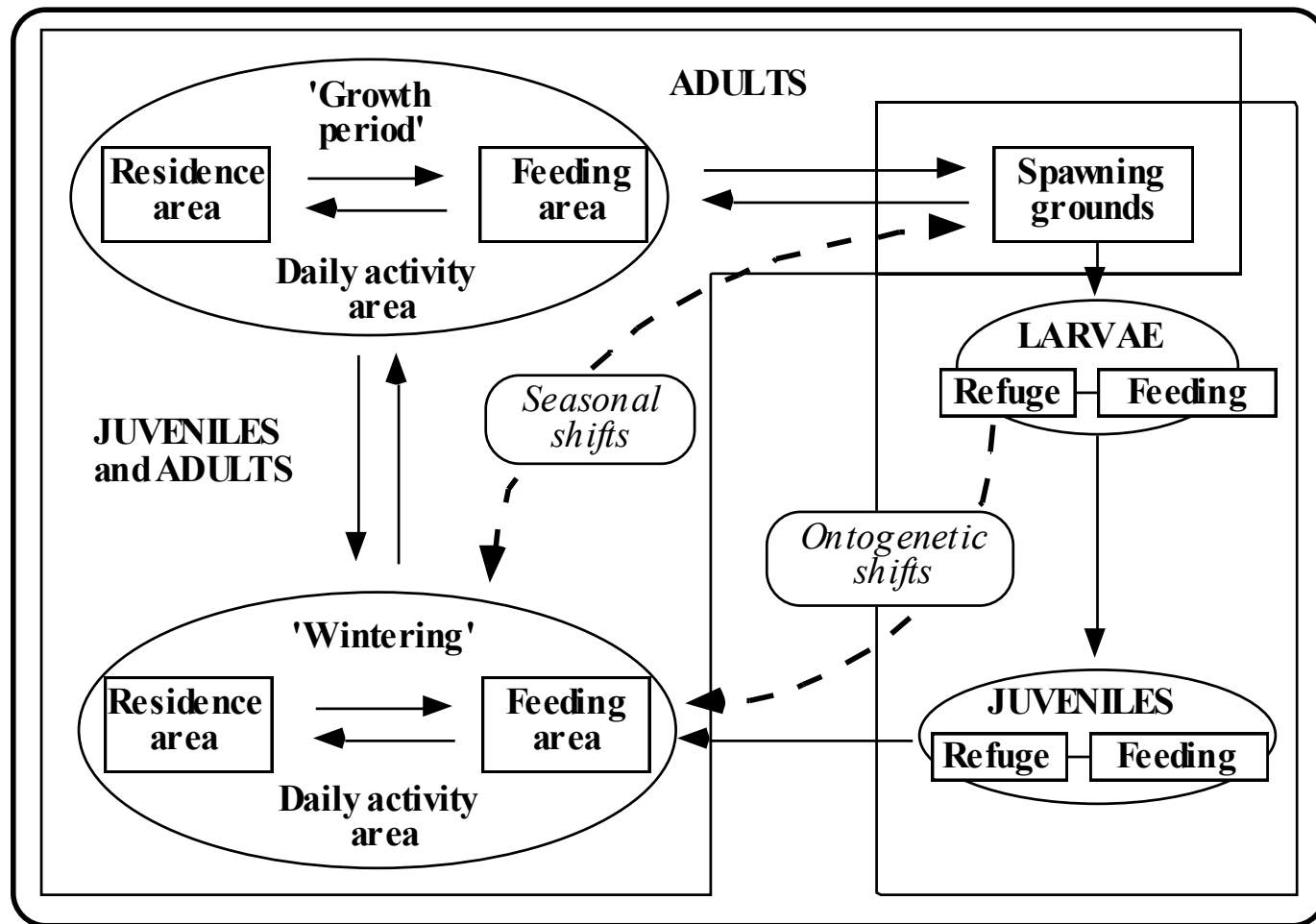


Low-head barrier



Levees

Functional Life Units of fishes



Lucas &
Baras
(2001)

Diverse and natural habitat conditions → diverse community



The Holy Grail !

Barrier being made 'transparent' to whole fish-community passage



Embrey Dam, Rappahannock River, Virginia

New opportunities for restoring river connectivity

Advances in science of dam removal

Articles

What Goes Up, May Come Down

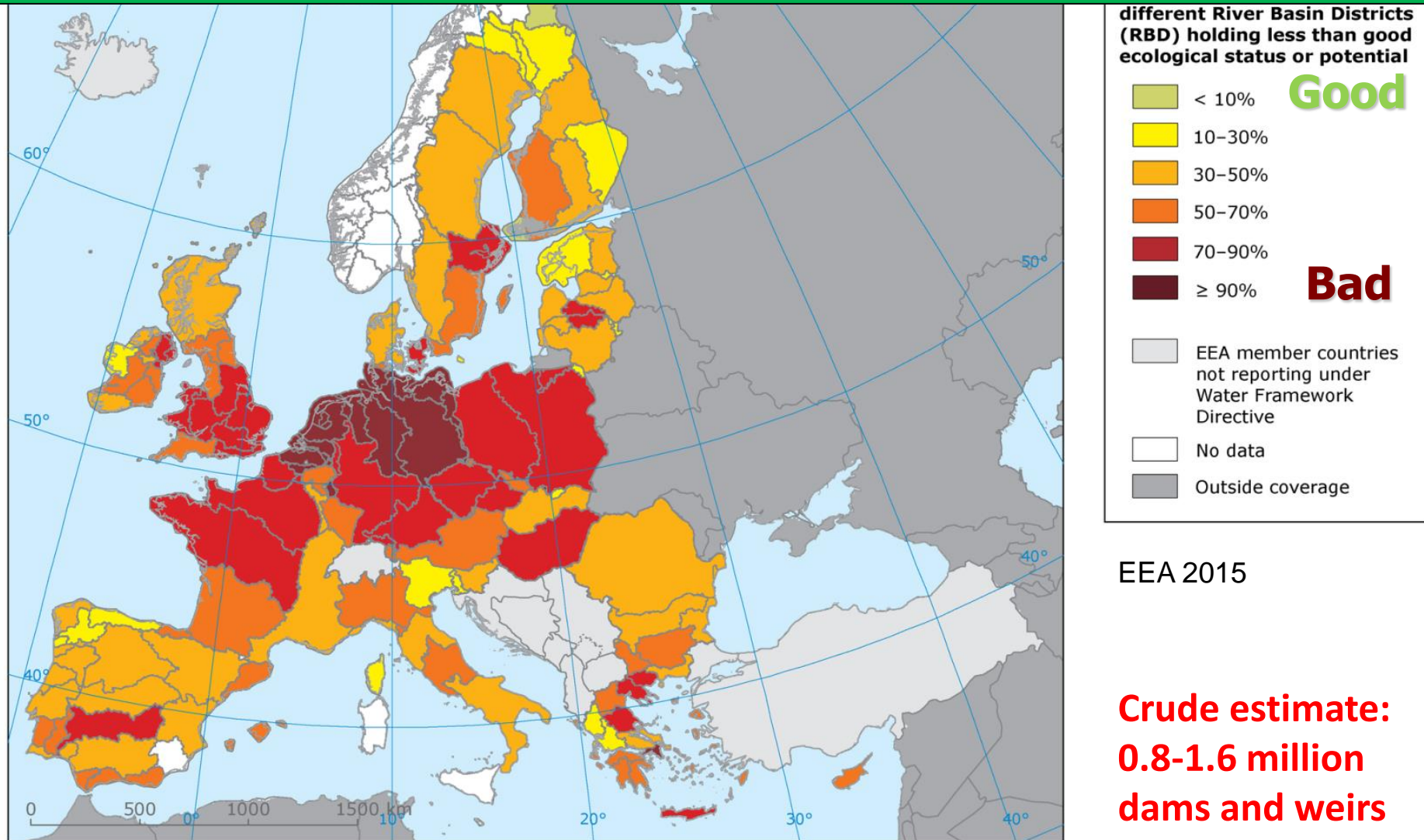
"The lack of studies cries out for new research and peer-reviewed papers by experts in social, economic, and ecological fields." Babbitt, 2002

Bioscience special issue on dam removal, 2002



WFD: Ecological Status of European Lakes & Rivers

Many failures due to fragmentation & habitat loss

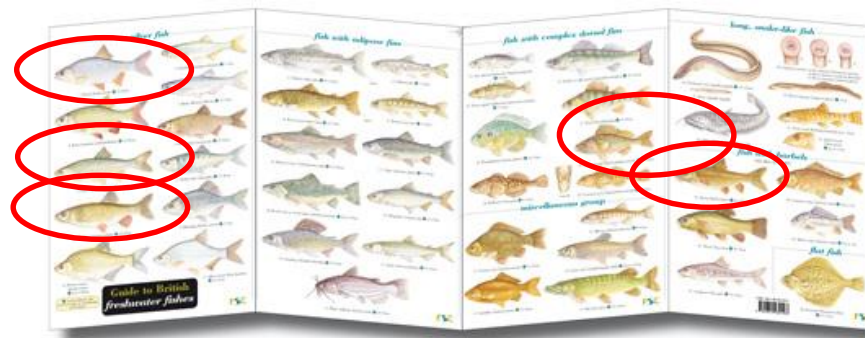


EEA 2015

**Crude estimate:
0.8-1.6 million
dams and weirs
(AMBER)**

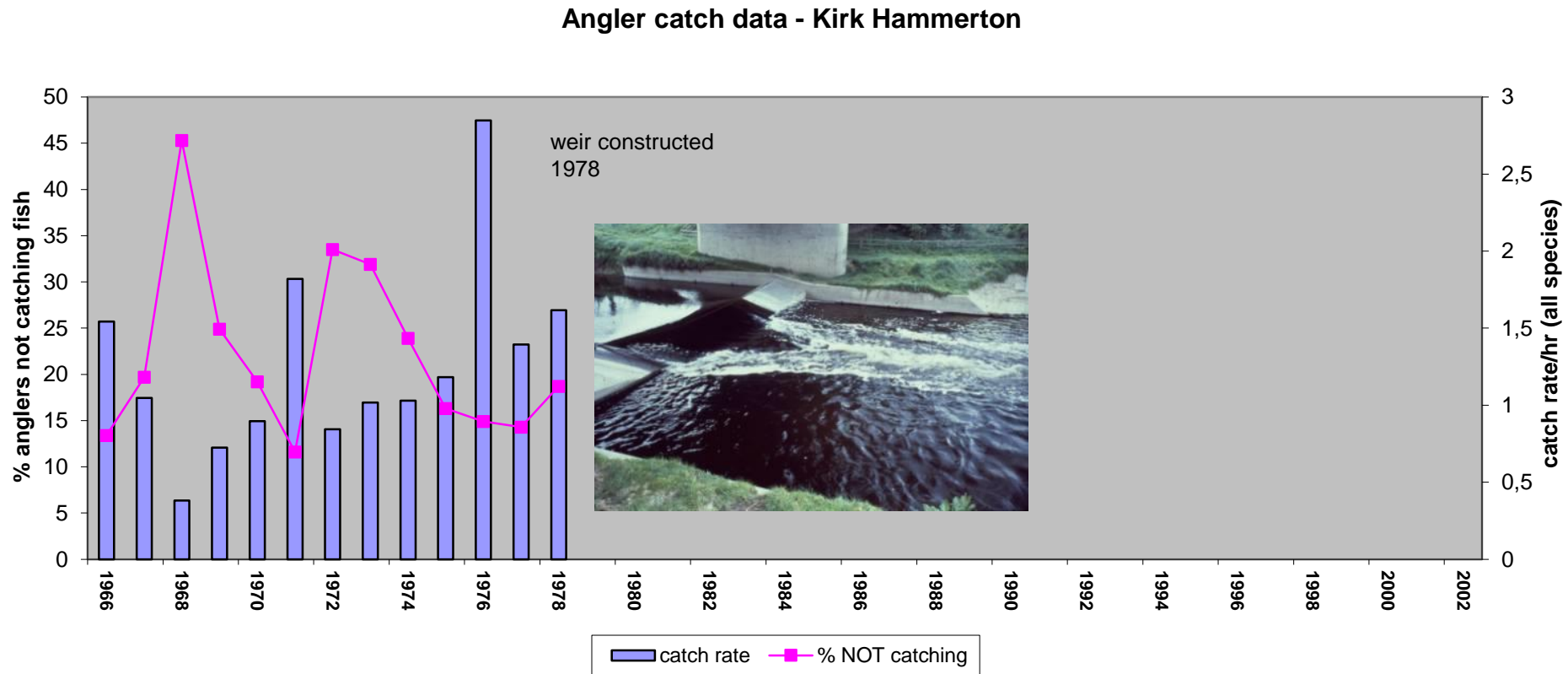
Story of a weir removal for ecological reasons

- Flat-V flow-gauging weir, built 1978
- River Nidd, tributary of Yorkshire Ouse (Humber basin)
- First obstacle upstream of Ouse confluence
- Dominated by rheophilic cyprinid community (*Leuciscus*, *Rutilus*, *Barbus* etc)



The utility of baseline data and evidence.....

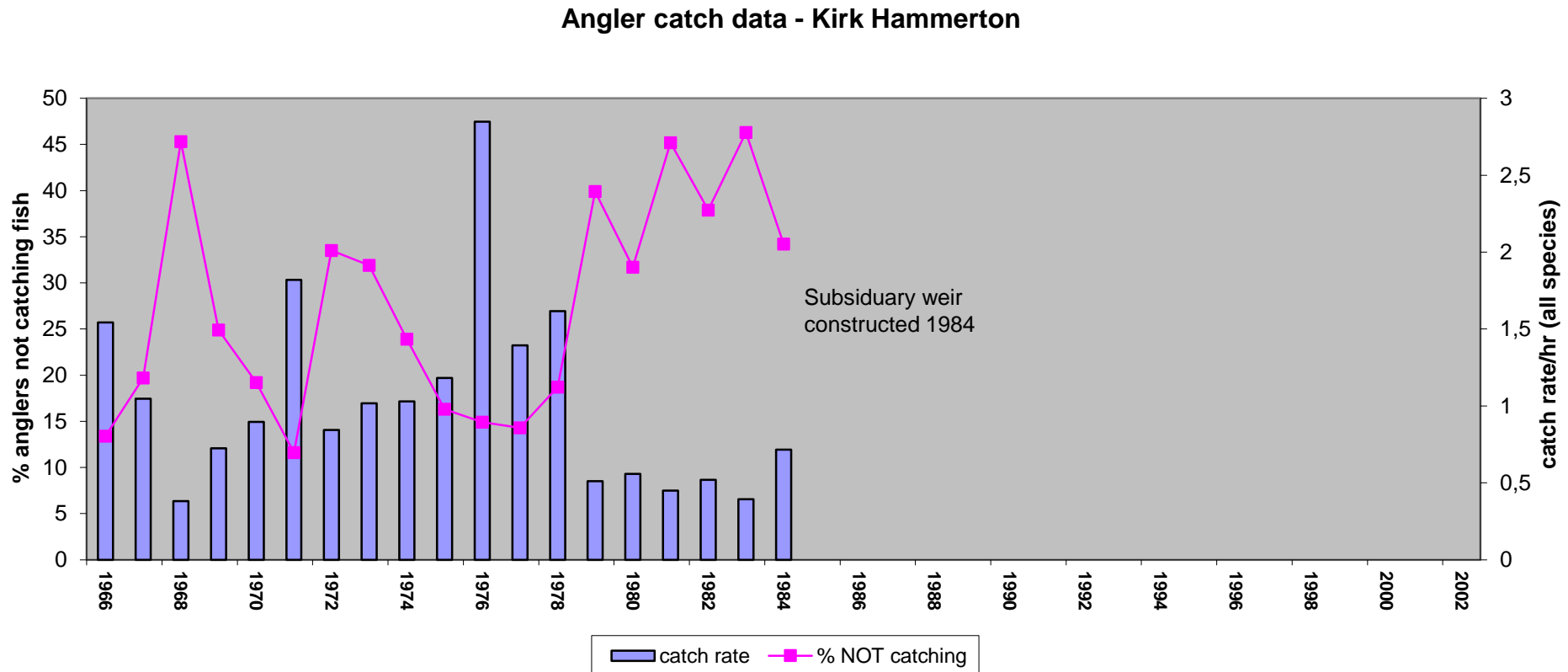
Series of timed angling competitions held historically, upstream of the planned site of weir – data recorded



Hats off to Steve Axford and Paul Frear! (Yorkshire Water Authority / National Rivers Authority / Environment Agency)
[though we can debate whether angler catches reflect fish stocks objectively]

The utility of baseline data and evidence.....

BACI – Before, After, Control, Intervention



Anglers not happy – believe weir is cause of reduced catches, due to restricted upstream movement rather than changes in habitat

- They wanted the “Tommy Cooper Method”

The Tommy Cooper Method of Dam/Weir removal –

“Just Like That!”



Radio-tracking of barbel (*Barbus barbus*) on the Nidd

- Showed seasonal migrations – downstream to deeper, slower areas in autumn-winter, upstream to riffles in spring

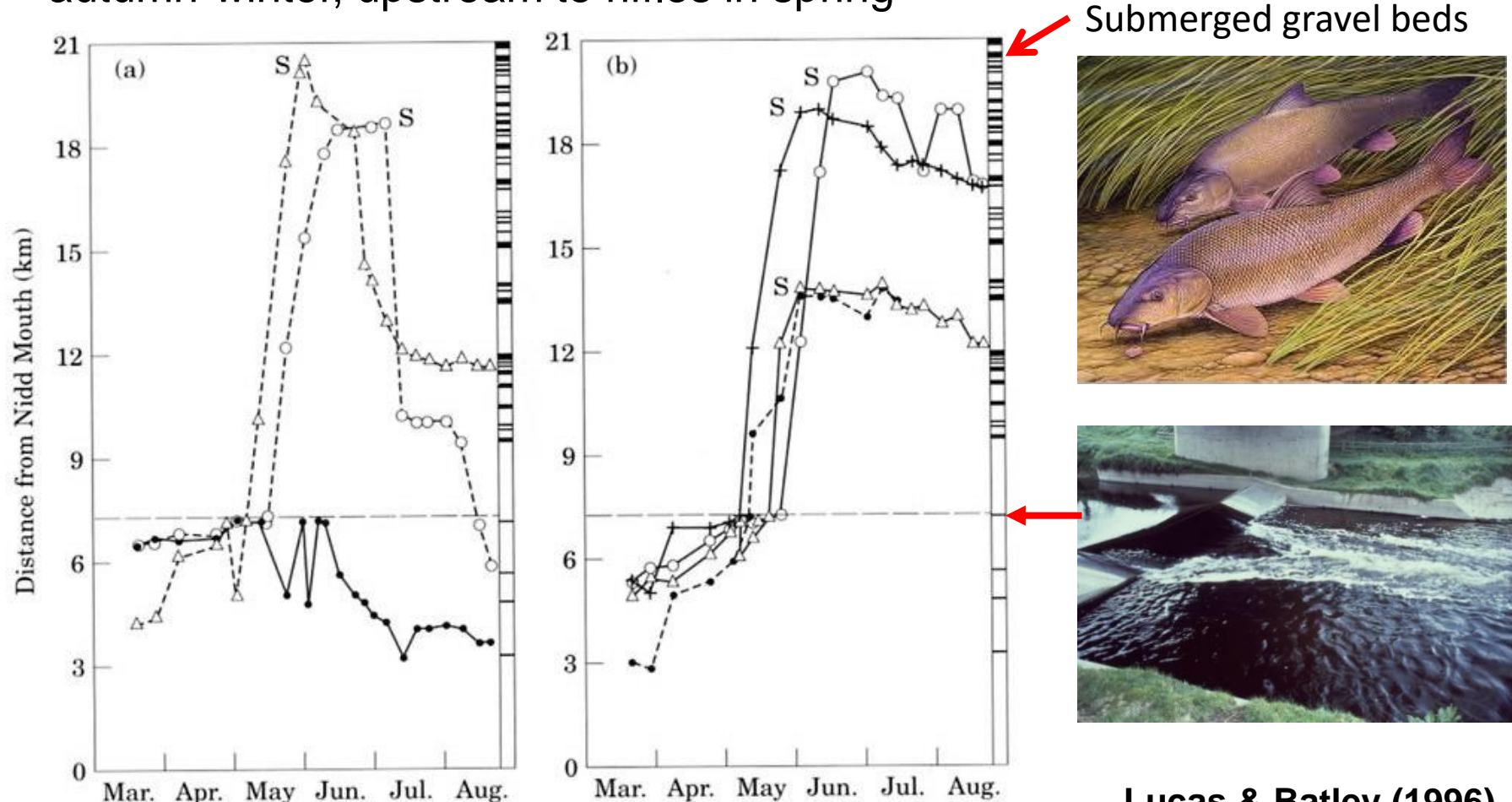


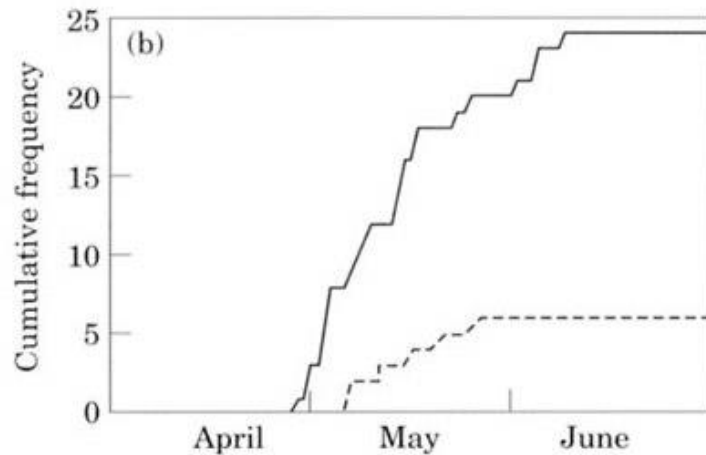
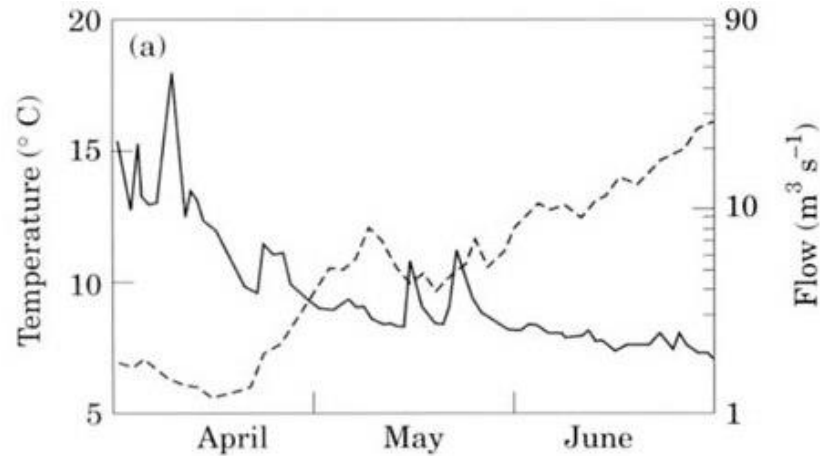
FIG. 4. (a) Example tracks for barbel released below Skip Bridge which were ultimately successful (Δ , \circ) and unsuccessful (\bullet) in passing upstream over Skip Bridge gauging weir. (b) Tracks of other barbel which negotiated the gauging weir. The horizontal dashed line indicates the position of the gauging weir. The bars in the right-hand column of each graph display the distribution of spawning habitat along the stretch of river, while S denotes location of the tagged fish in the presence of spawning/courting conspecifics.

Lucas & Batley (1996)
J. Applied Ecology

Lucas & Frear (1997) *J. Fish Biology*

Longitudinal movements – potamodromous fishes

Many lowland river fishes are spring migrants, temperature increases often coincide with flow declines, making passage harder



(a) Water temperature (---) and flow (—) during the main period of study, April–June 1994.
(b) Cumulative number of barbel, moving upstream past point A, below the weir (—) and point B, immediately above weir (---). Fifteen fish attempted to pass the weir, several times in some cases, hence the final cumulative total exceeds the total number of fish tracked.



“Thin” flow,
~ 2 m/s
over weir
face

Lucas & Batley (1996) *J. Appl. Ecol.*
Lucas & Frear (1997) *J. Fish Biol.*

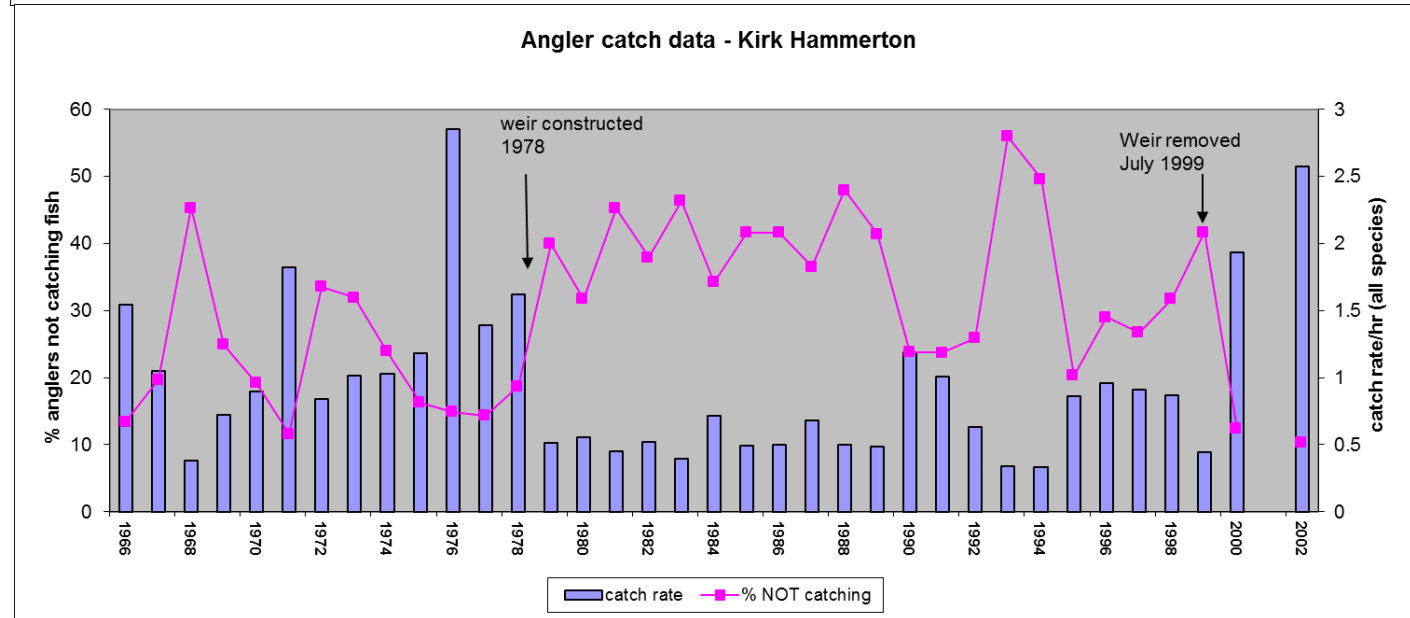
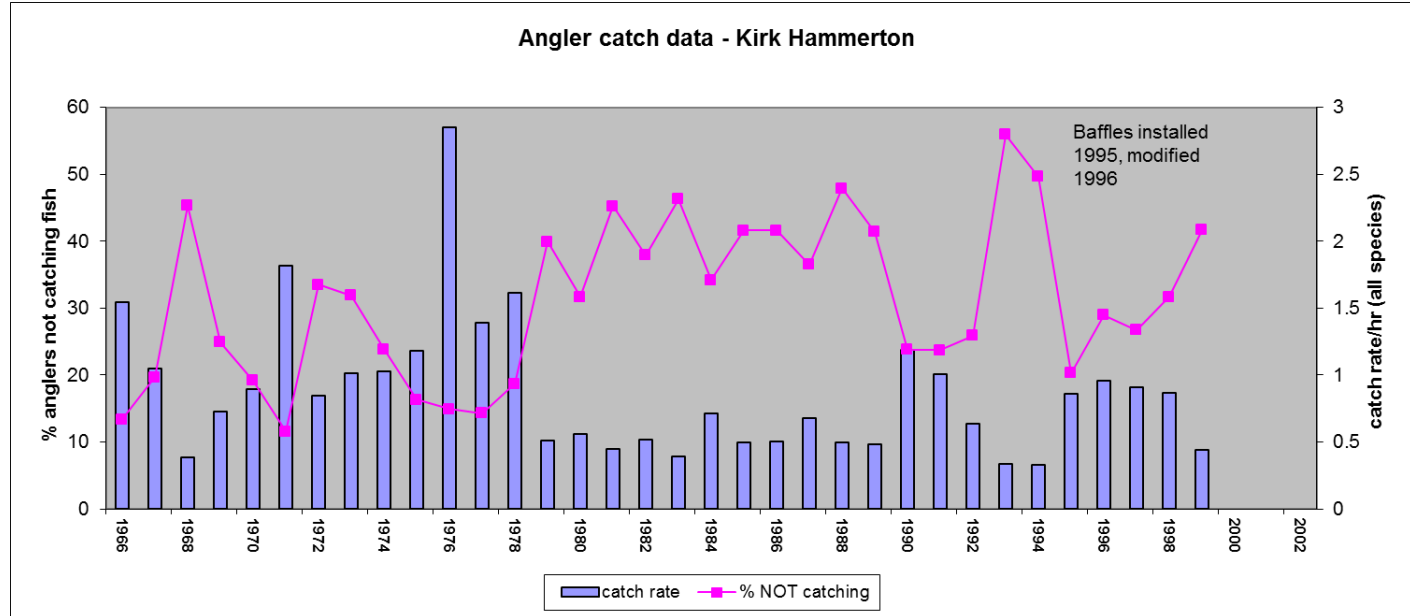
The utility of standardised time series data...

(from S. Axford & P. Frear)

Attachment of
baffles (1995)
actually
decreased fish
(video +
radiotrack)

Weir removed 1999

Sampling angling
catches stopped
2002 – an error,
financial necessity
or convenience??



Anadromous river lamprey migration and barriers

EU Habitats and Species Directive – EU-wide part protection, threatened species

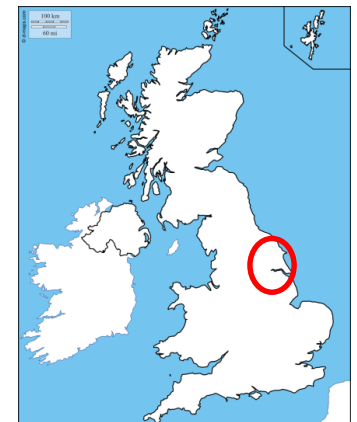


Iain Russon

- Sea lamprey
- European river lamprey
- European brook lamprey

Adult (sexually immature) river lamprey (*Lampetra fluviatilis*) migrating upstream in a river in northern England in winter (at night).

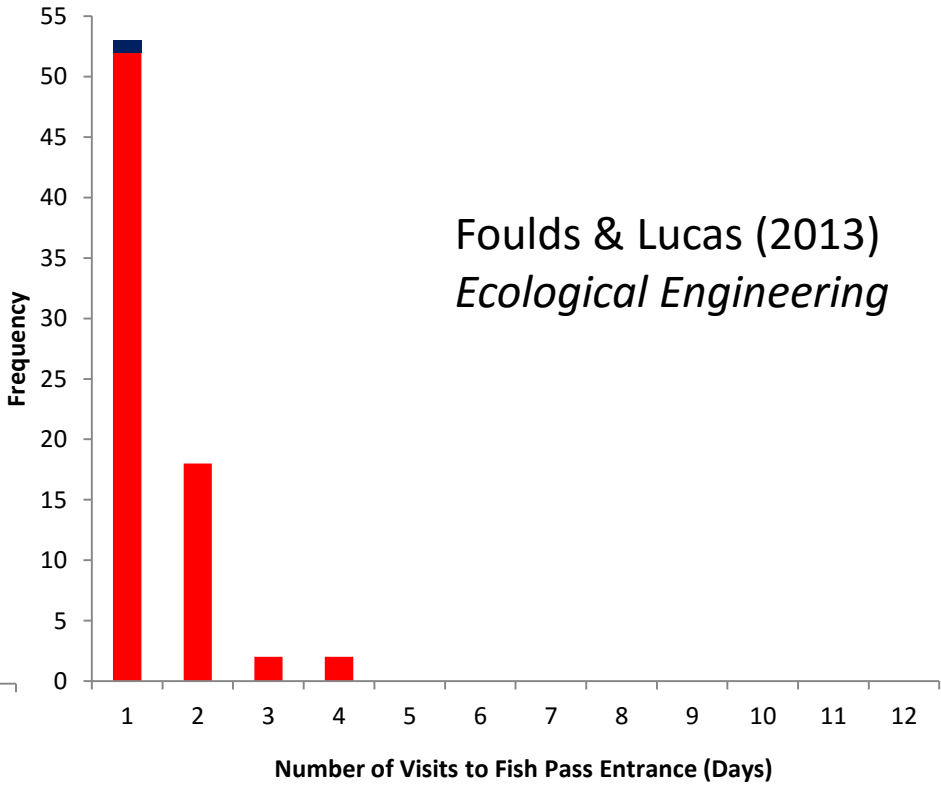
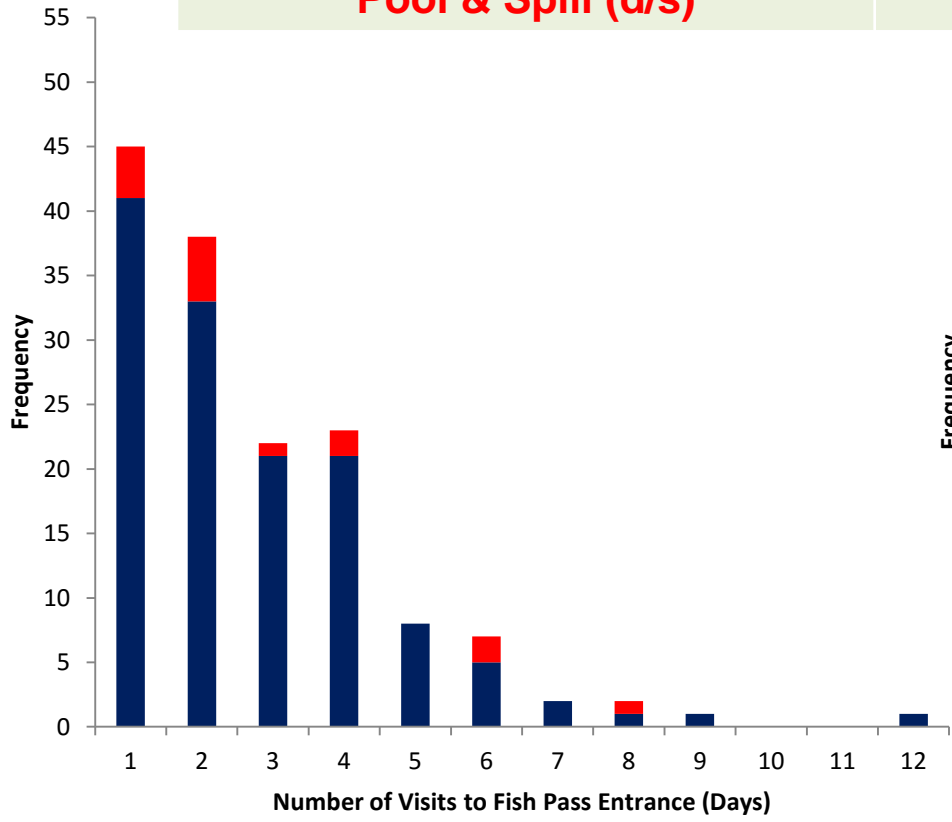
NB – Unlike Pacific lamprey, European river lamprey and sea lamprey do not exhibit suck-and-climb ascent behaviour at steep smooth inclines



Passage efficiency for river lamprey at two technical fish passes

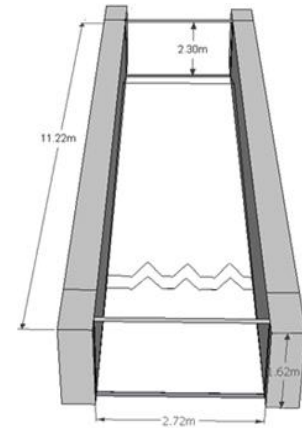
- 300 river lamprey captured, PIT-tagged, released below fish passes and studied over one full migration season (autumn to spring, ca. 6 months)
- No spawning habitat d/s of Pool & Spill fishway, but spawning habitat at Denil

Fish Pass Design	Attraction Efficiency	Passage Efficiency
Denil baffle (u/s)	87%	0%
Pool & Spill (d/s)	47%	5.4%



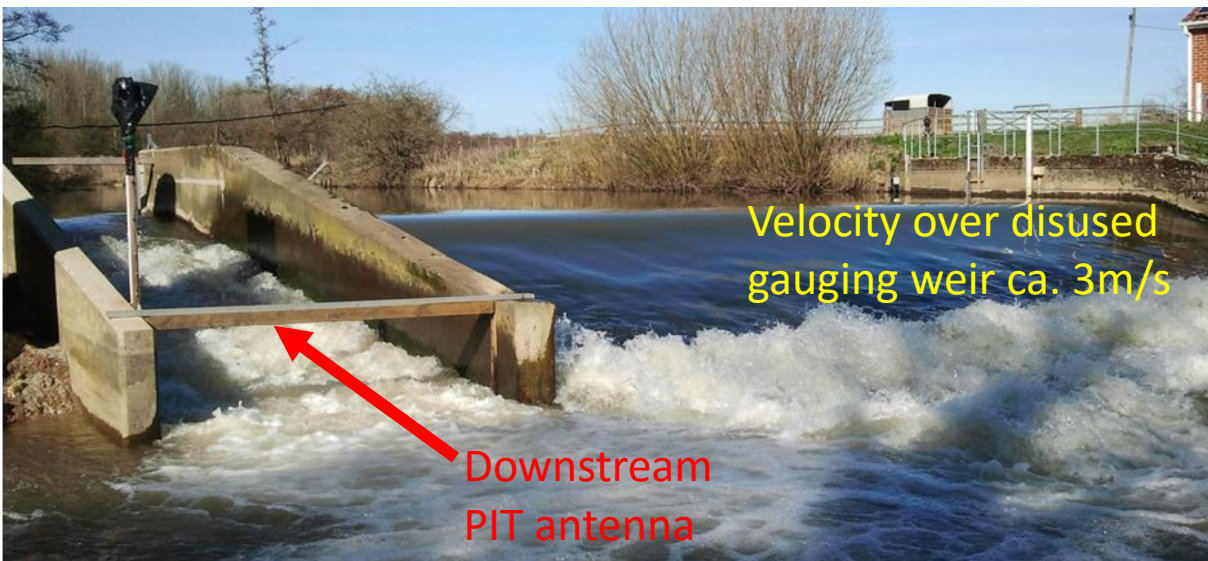
Foulds & Lucas (2013)
Ecological Engineering

**Buttercrambe flow-gauging weir, built 1975 – Yorkshire Derwent
Special Area of Conservation (lamprey = a primary reason)**
Change to ultrasonic gauging – weir redundant – remove?? (best for
lamprey and ecology)
XX – flood risk concern, facilitate commercial HEP on site



Intead, installed Larinier superactive baffle fishway

- Environment Agency's recent preferred choice of technical pass at low-head sites for upstream passage of wide range of sizes and species.
- Lamprey passage efficiency determined by telemetry



**Fishway attraction efficiency:
90.7%**

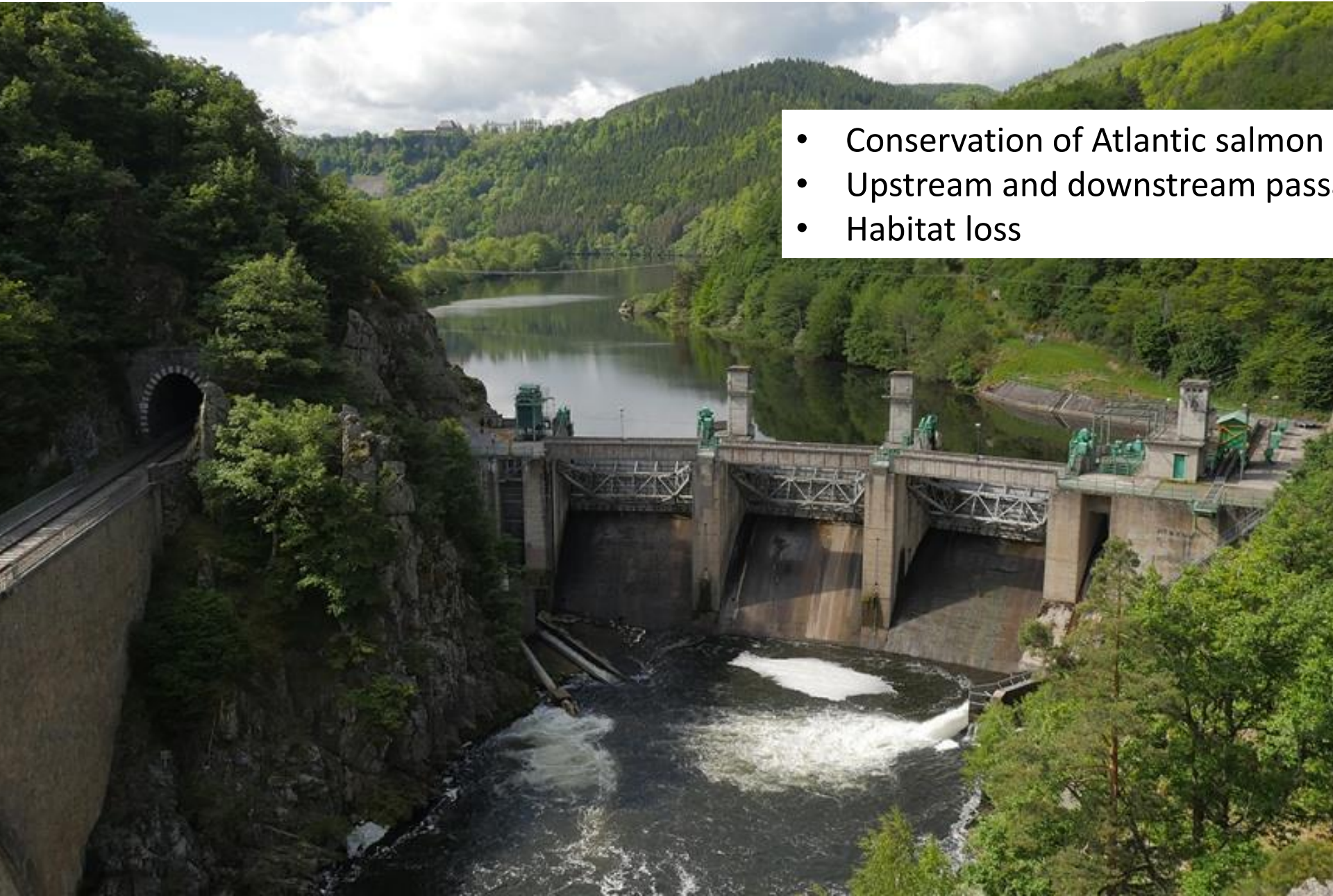
**Fishway passage efficiency:
0.3%!!!**

**Passage over weir directly
13.8%**

Tummers et al (2016)
Ecological Engineering

Poutès Dam – River Allier, France

- Conservation of Atlantic salmon
- Upstream and downstream pass
- Habitat loss

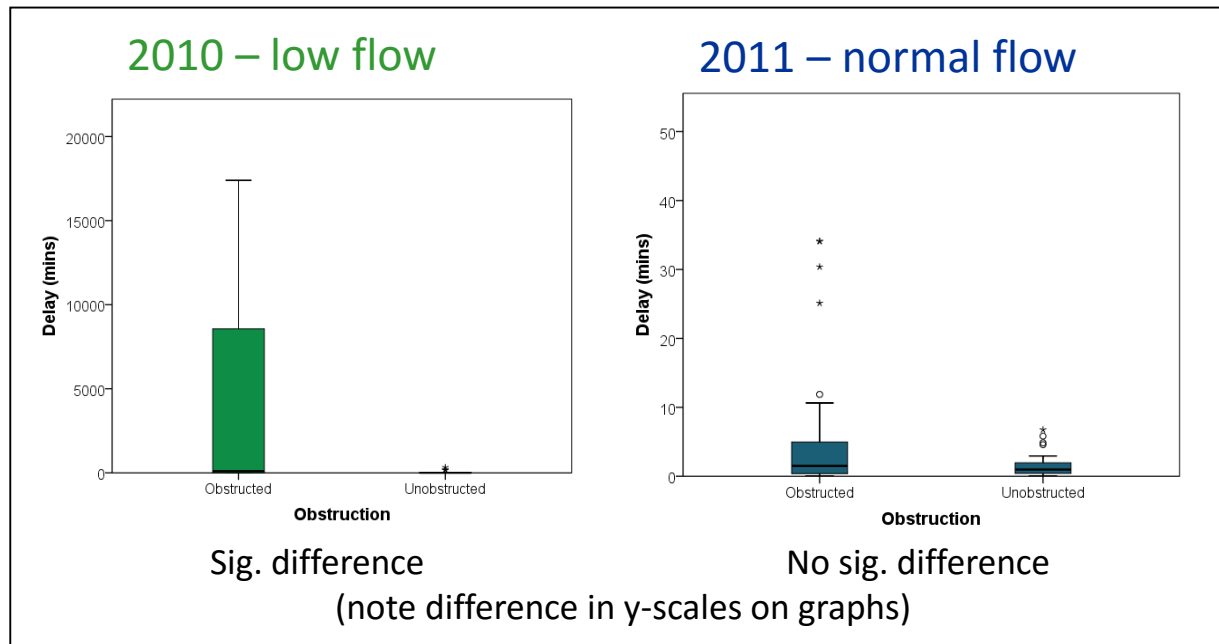


Difficulties in downstream migration at low-head barriers

- Downstream movement not expected to be a problem at open, 'simple' low-head barriers, especially for 'midwater' fishes like salmonid smolts
- Little investment for assisting downstream migration – in UK it is assumed that small barriers will not markedly affect downstream migration
- Effects of low flows – at barriers and open reaches
- Telemetry of downstream migration of sea trout smolts



Philphaugh weir, Tweed system, Scotland



**In cold lowland streams with salmonid populations,
barriers can have major effects on populations**

Natural gradient and variation = healthy populations



Jan Nielsen, DTU, Denmark



Research article

30 years of data reveal dramatic increase in abundance of brown trout following the removal of a small hydrodam



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ABSTRACT

Humans and freshwater ecosystems have a long history of cohabitation. Today, nearly all major rivers of the world have an in-stream structure which changes water flow, substrate composition, vegetation, and fish assemblage composition. The realization of these effects and their subsequent impacts on population sustainability and conservation has led to a collective effort aimed to find ways to mitigate these impacts. Barrier removal has recently received greater interest as a potential solution to restore river connectivity, and reestablish high quality habitats, suitable for feeding, refuge and spawning of fish. In the present study, we present thirty years of data from electrofishing surveys obtained at two sites, both prior to and following the removal of a small-scale hydropower dam in Central Jutland, Denmark. We demonstrate that the dam removal has led to a dramatic increase in trout density, especially in young of the year. Surprisingly, we found that this increase was not just upstream of the barrier, where the ponded zone previously was, but also downstream of the barrier, despite little changes in habitat in that area. These findings suggest that barrier removal may be the soundest conservation option to reinstate fish population productivity.

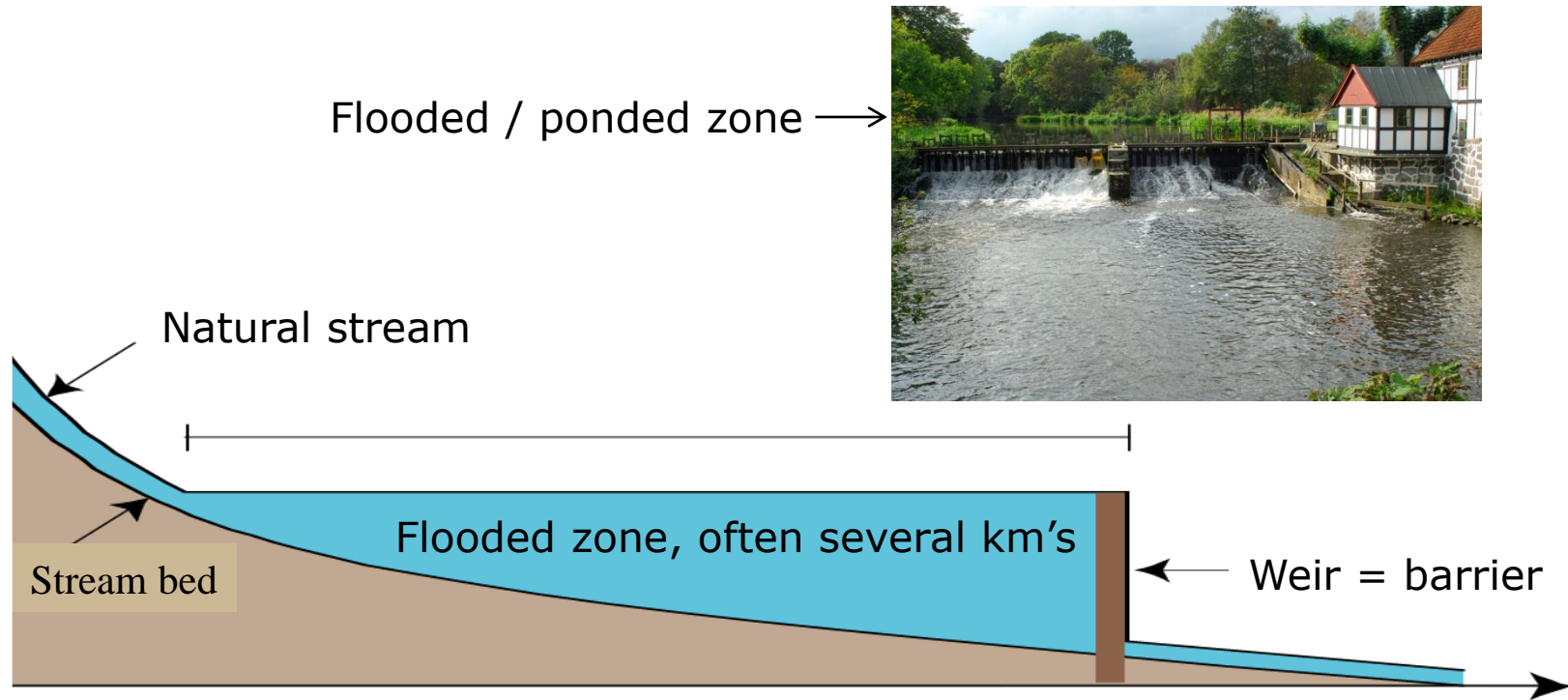
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See also:

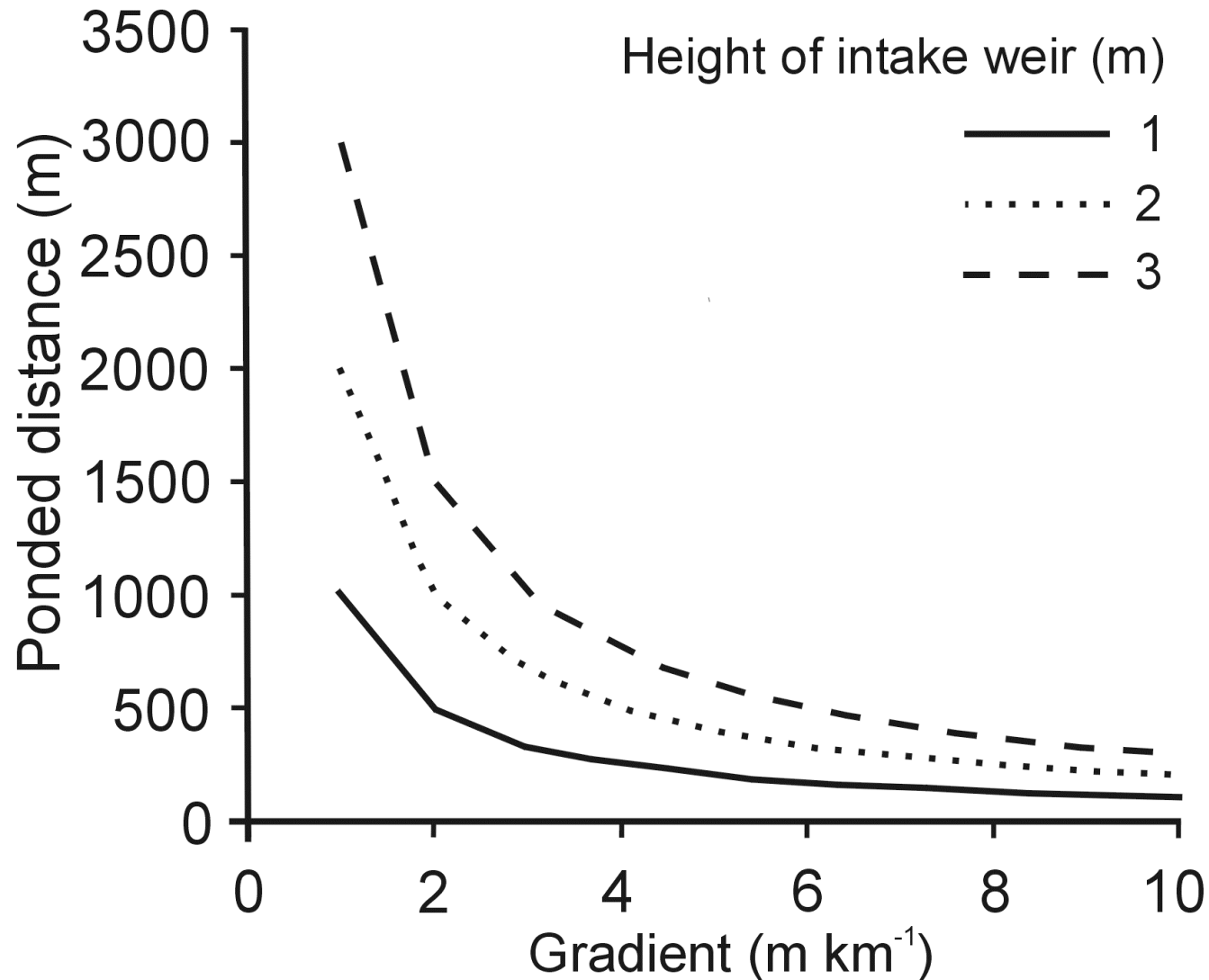
Birnie-Gauvin, K. *et al* (2017) Shining a light on the loss of rheophilic fish habitat in lowland rivers as a forgotten consequence of barriers, and its implications for management.

Aquatic Conservation: Marine and Freshwater Ecosystems DOI: 10.1002/aqc.2795

In lowland rivers weirs can have a great negative impact on rheophilic habitat



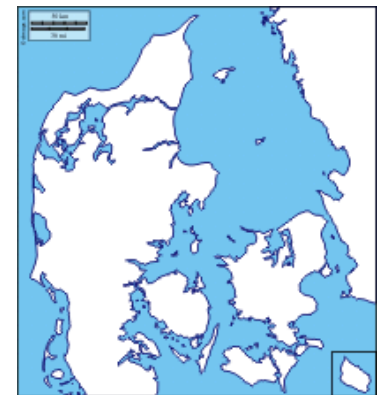
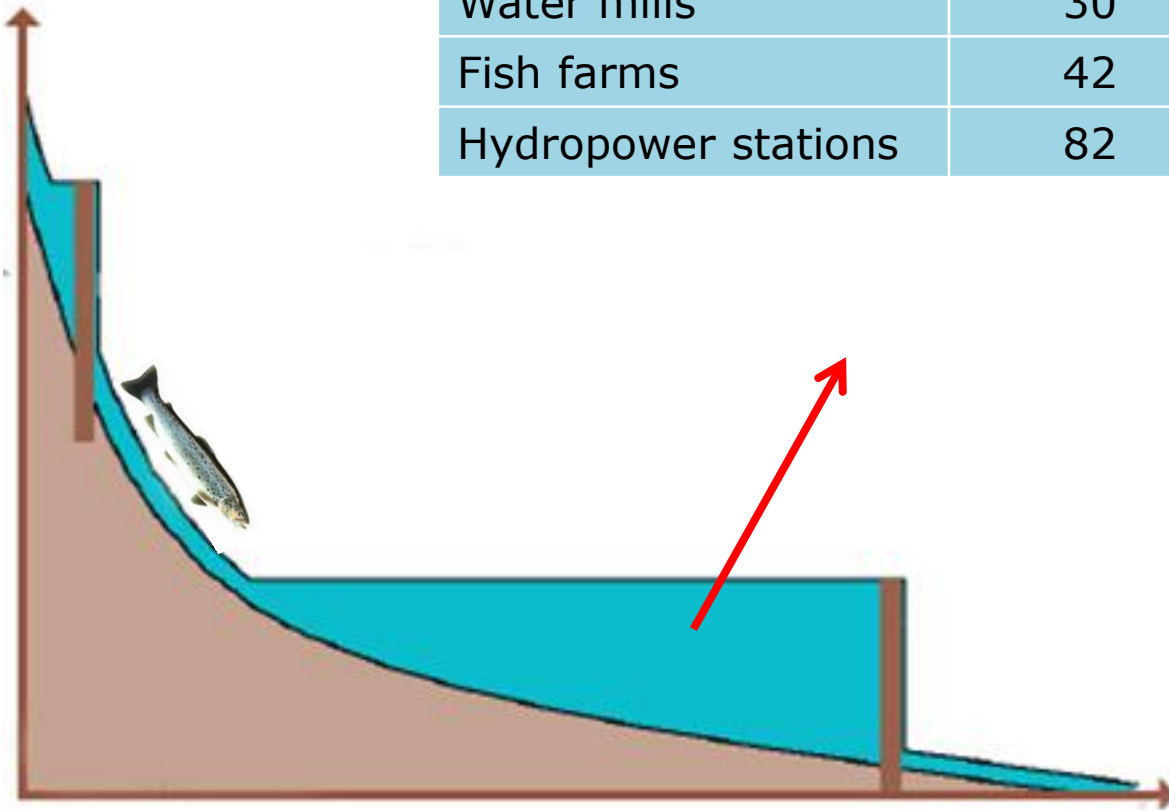
Dam/weir height and stream gradient have a major effect on ponded distance and loss of rheophilic fish habitat



Barriers at weirs for downstream migrating fish

(an overlooked problem ?)

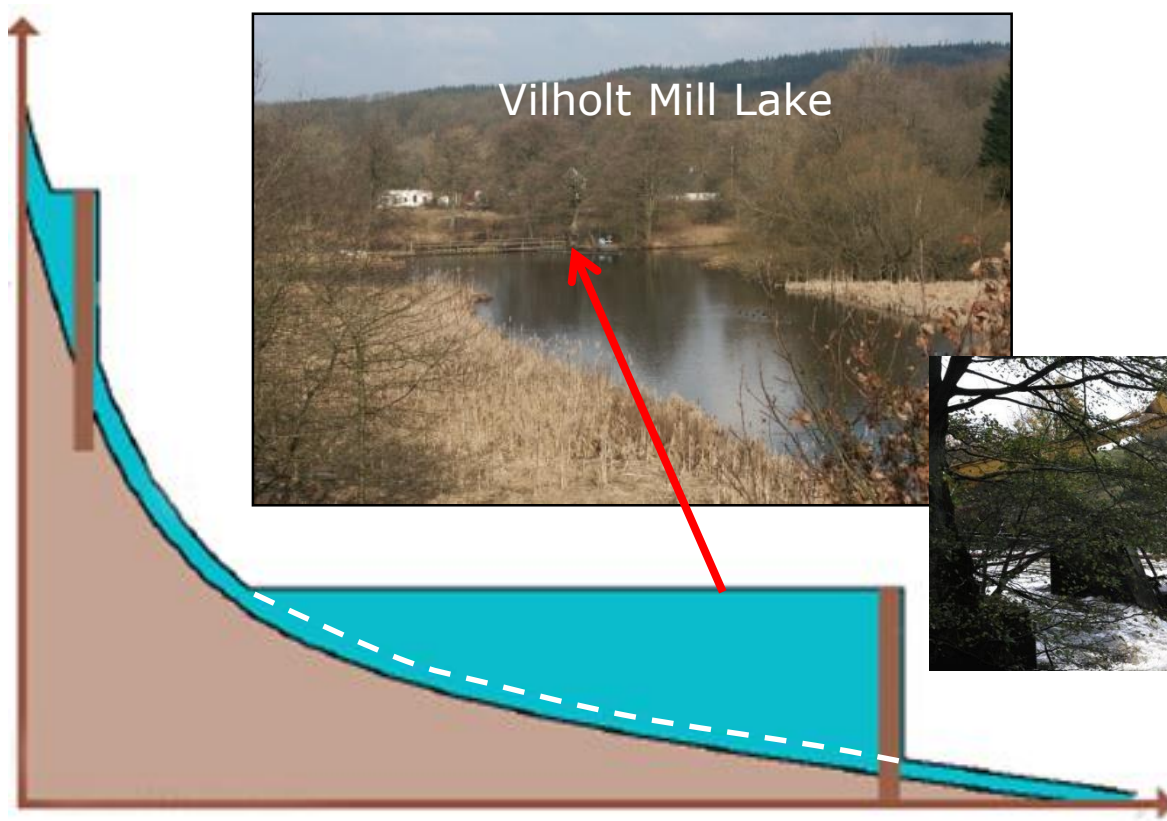
Weir at	Mean % smolt loss
Water mills	30
Fish farms	42
Hydropower stations	82



Jan Nielsen, summarising multiple Danish studies

Re-establishment of natural spawning and nursery areas

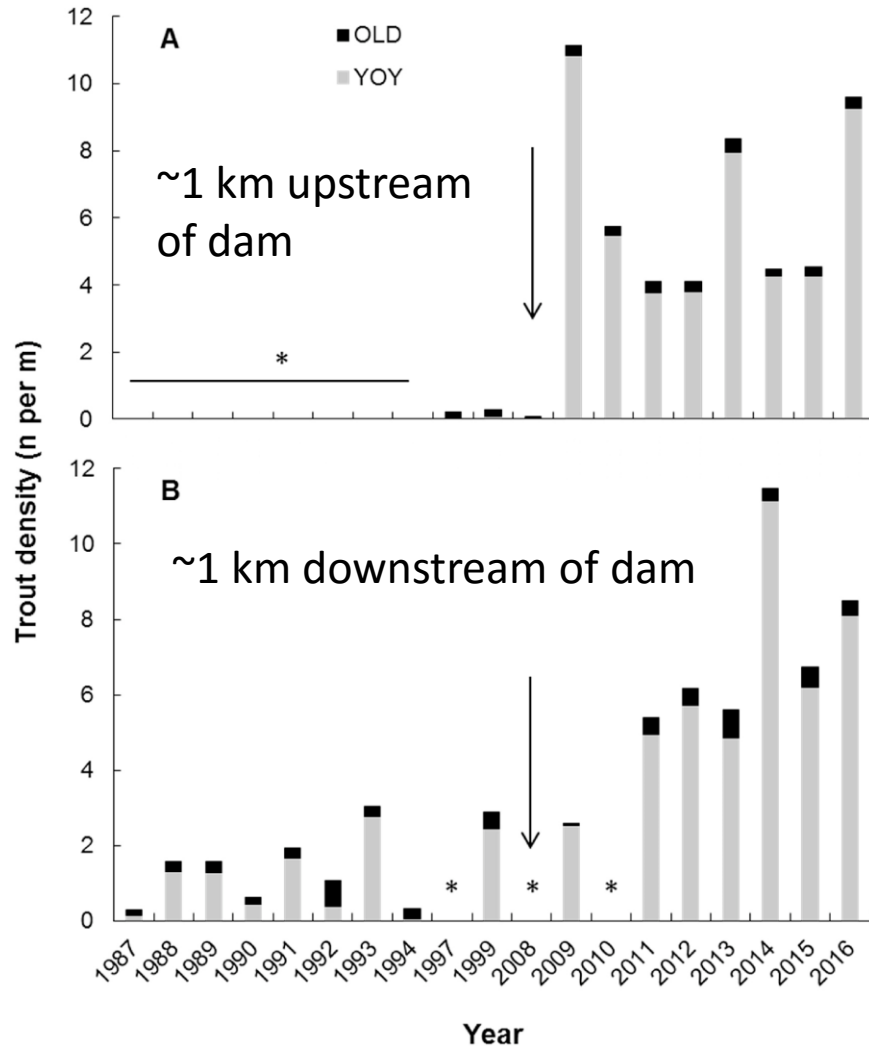
in the flooded zone of the River Gudenaå - just by removal of the weir in 2008



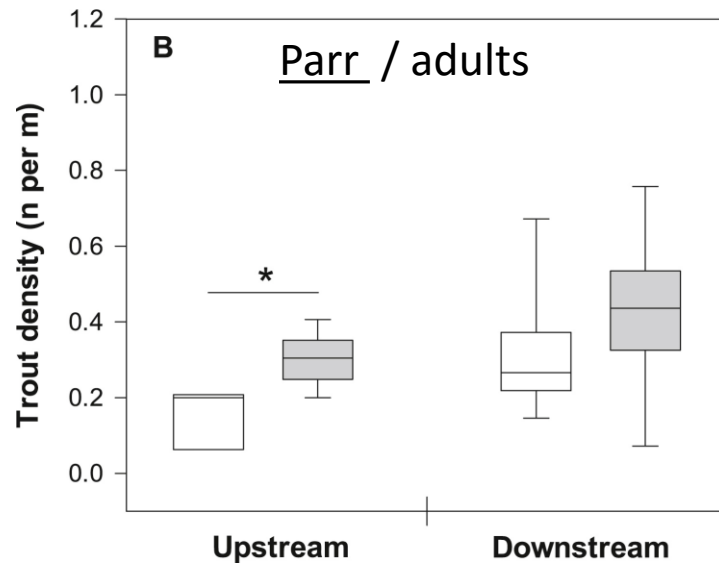
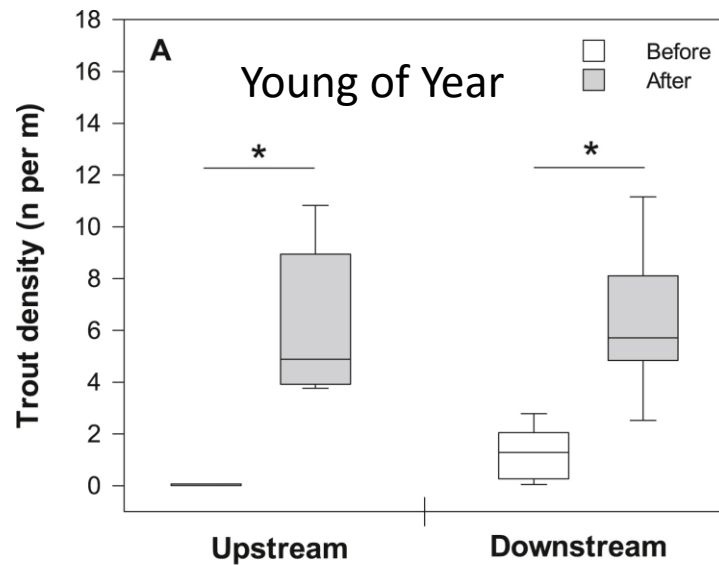
Jan Nielsen, DTU, Denmark

The brown trout and natural spawning areas upstream of the dam responded well

after 146 years of inactivity in the flooded zone



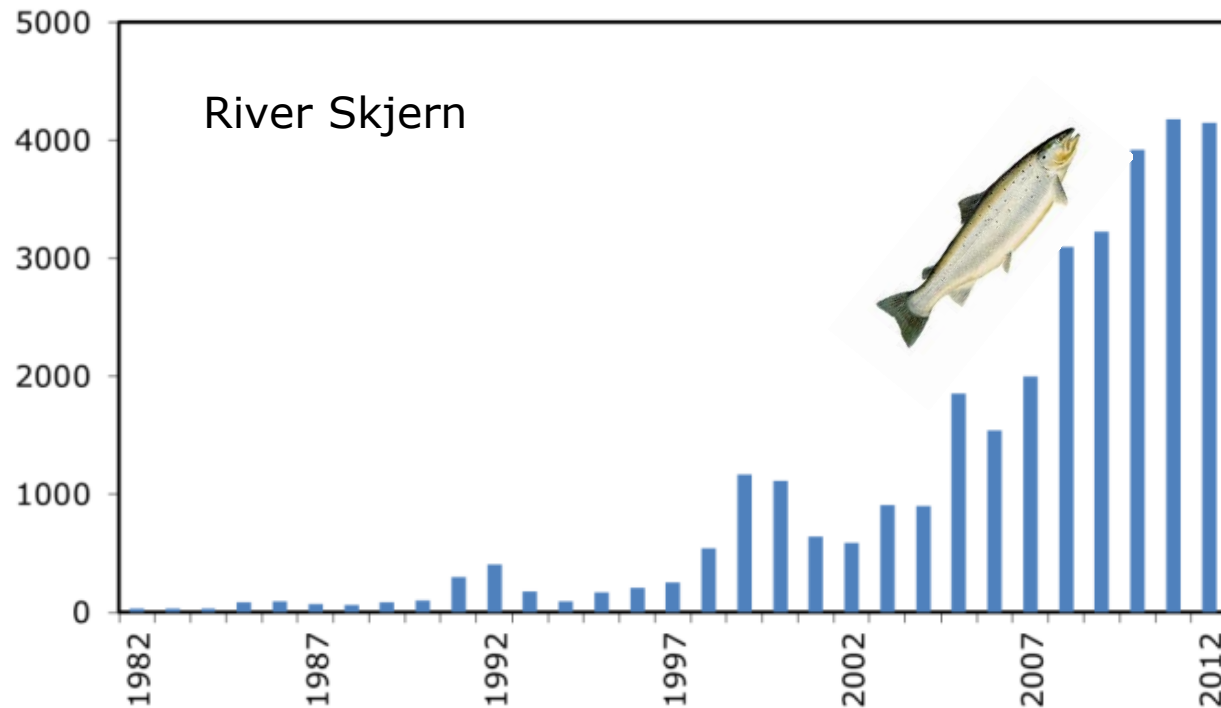
From Jan Nielsel, DTU Denmark, and from Birnie-Gauvin et al (2017) *JEM*



Boxplots of densities of trout before and after removal of the dam

From Jan Nielsen DTU, Denmark
& Birnie-Gauvin et al. (2017) JEM

Dam removal is a key part of the Danish strategy for Increasing the spawning run of salmon in Danish rivers



Jan Nielsen, DTU, Denmark

There can be good ecological reasons for not removing obstacles – or even for building new ones

e.g. slowing spread of Aquatic Invasive Species

Articles

Ecological Benefits of Reduced Hydrologic Connectivity in Intensively Developed Landscapes

C. RHETT JACKSON AND CATHERINE M. PRINGLE

Bioscience (2010) 60, 37-46

A broad perspective on hydrologic connectivity is necessary when managing stream ecosystems and establishing conservation priorities. Hydrologic connectivity refers to the water-mediated transport of matter, energy, or organisms within or between elements of the hydrologic cycle. The potential negative consequences of enhancing hydrologic connectivity warrant careful consideration in human-modified landscapes that are increasingly characterized by hydrologic alteration, exotic species, high levels of nutrients and toxins, and disturbed sediment regimes. While connectivity is integral to the structure and function of aquatic ecosystems, it can also promote the distribution of undesirable components. Here we provide examples illustrating how reduced hydrologic connectivity can provide greater ecological benefits than enhanced connectivity does in highly developed, human-modified ecosystems; for example, in urban landscapes, "restoration" efforts can sometimes create population sinks for endangered biota. We conclude by emphasizing the importance of adaptive management and balancing trade-offs associated with further alterations of hydrologic connectivity in human-modified landscapes.

Keywords: hydrologic connectivity, restoration, ecosystem management, hydrology, aquatic ecosystems

Articles

Intentional Fragmentation as a Management Strategy in Aquatic Systems

FRANK J. RAHEL

Bioscience (2013) 63, 362-372

Maintaining or restoring connectivity in aquatic systems can enhance migratory fish populations; maintain genetic diversity in small, isolated populations; allow organisms to access complementary habitats to meet life-history needs; and facilitate recolonization after local extirpations. However, intentional fragmentation may be beneficial when it prevents the spread of nonnative species or exotic diseases, eliminates hybridization between hatchery and wild stocks, or stops individuals from becoming entrapped in sink environments. Strategies for fragmenting aquatic systems include maintaining existing natural barriers, taking advantage of existing anthropogenic features that impede movement, severing artificial connectivity created by human actions, and intentionally creating new barriers. Future challenges for managing fragmentation include maintaining hydrologic connectivity while blocking biological connectivity in water development projects; identifying approaches for maintaining incompatible taxa, such as sport fishes and small nongame species; and developing selective barriers that prevent the passage of unwanted species while allowing normal life-history movements of other species.

Keywords: fragmented ecosystems, invasive species, dams, migration, connectivity

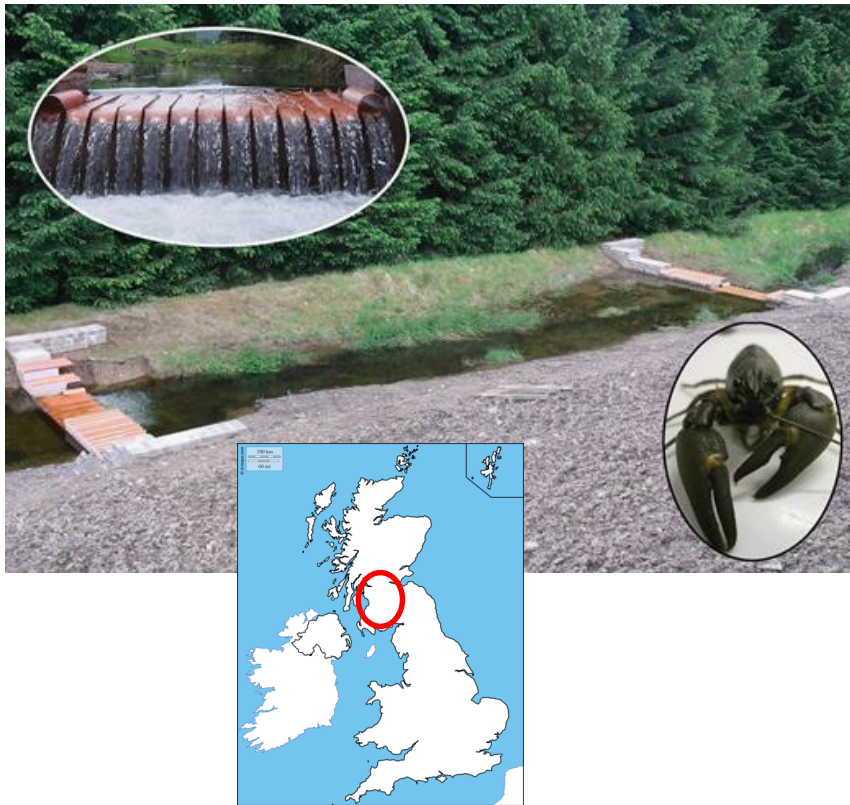


Signal crayfish upstream dispersal barriers – can they work?

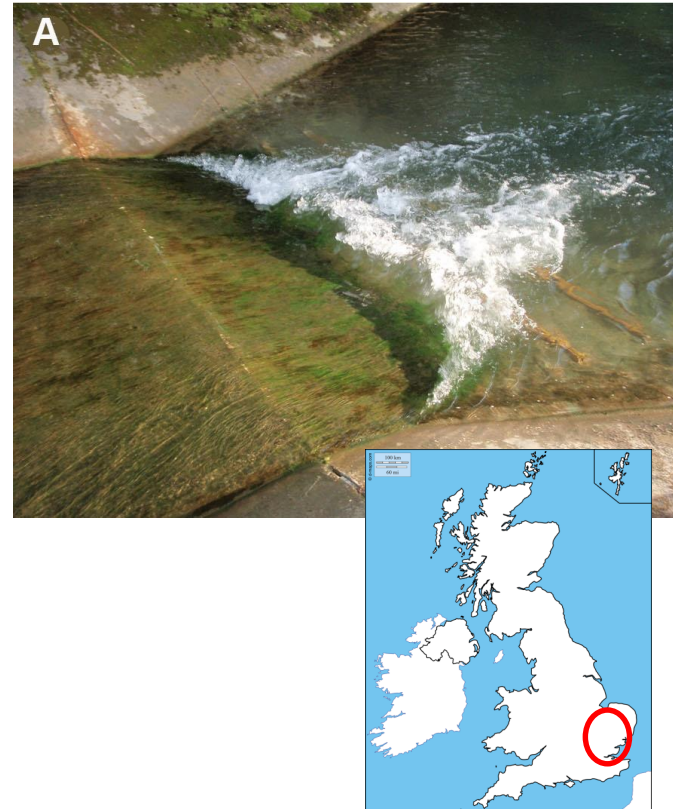
No field tests of intentional barriers published.....

Upper Clyde (Annan boundary)

Installed but no data / tests (C. Bean)

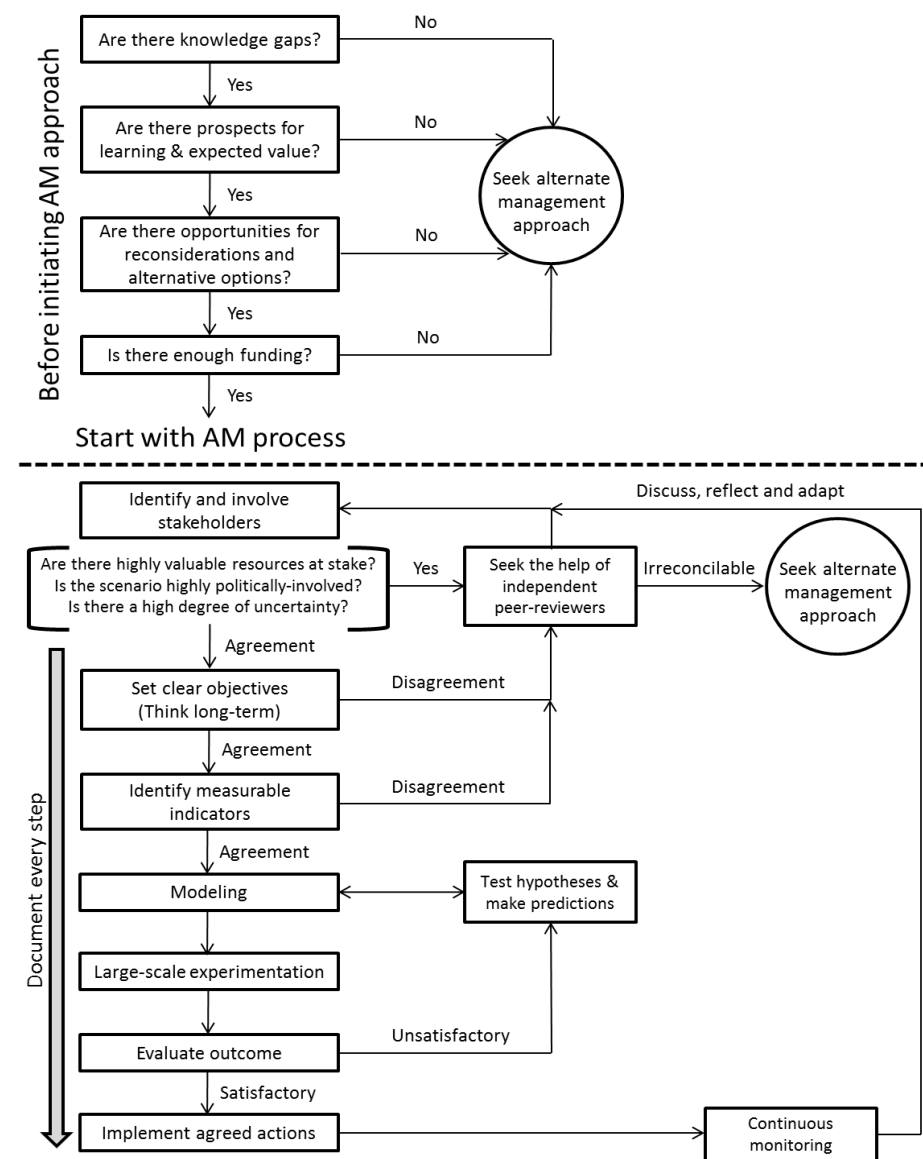


Rosewarne *et al.* (2013) - River Glem, upstream movements at existing sloping weir reduced by 45% cf control section - but NOT designed to limit crayfish



2017: Kerr (Northumberland Rivers Trust) & Lucas – attempted installation and testing (fish vs signal crayfish movement) of full-width, sub-surface, vertical, lipped weirs in R. Pont – but gave up due to lack of buy-in from Environment Agency and perceived flood risk / ecological ‘damage’

Restoring connectivity in rivers benefits from an adaptive management approach, for which barrier removal is only one option – and often less likely in urban environments



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Discussion

Adaptive management in the context of barriers in European freshwater ecosystems

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- Conservation

ABSTRACT

Many natural habitats have been modified to accommodate for the presence of humans and their needs. Infrastructures – such as hydroelectric dams, weirs, culverts and bridges – are now a common occurrence in streams and rivers across the world. As a result, freshwater ecosystems have been altered extensively, affecting both biological and geomorphological components of the habitats. Many fish species rely on these freshwater ecosystems to complete their lifecycles, and the presence of barriers has been shown to reduce their ability to migrate and sustain healthy populations. In the long run, barriers may have severe repercussions on population densities and dynamics of aquatic animal species. There is currently an urgent need to address these issues with adequate conservation approaches. Adaptive management provides a relevant approach to managing barriers in freshwater ecosystems as it addresses the uncertainties of dealing with natural systems, and accommodates for future unexpected events, though this approach may not be suitable in all instances. A literature search on this subject yielded virtually no output. Hence, we propose a step-by-step guide for implementing adaptive management, which could be used to manage freshwater barriers.

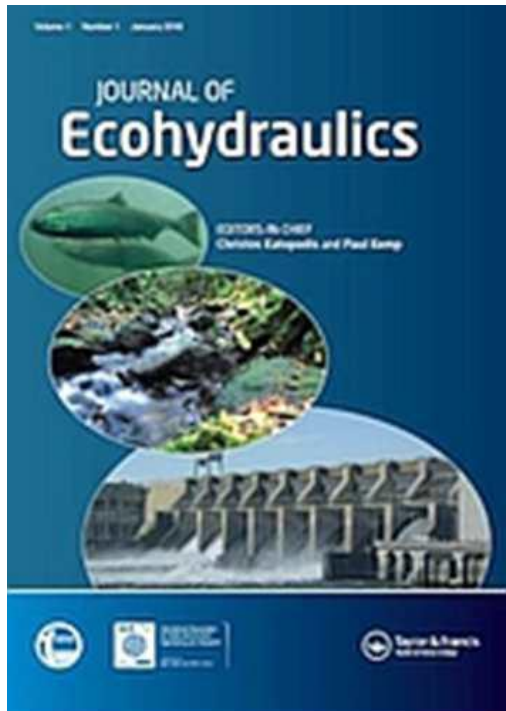
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Birnie-Gauvin et al. (2017)

Thanks for listening!

And a shameless plug for

[Journal of Ecohydraulics](#) (Editors: Chris Katopodis & Paul Kemp)



- All aspects of interaction between river flows and biota / ecological processes
- Ecological aspects of dam/weir removal are ideal for this journal
- Double peer review



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