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Dec 11th, 11:40 AM - 12:40 PM

# Fish passage hydrodynamics New Zealand context

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**Presenter Information**

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Monday, 18 February 2019

# Fish passage hydrodynamics

Insights into overcoming migration challenges for small-bodied fish

**Morten Knapp**, John Montgomery, Colin Whitaker,  
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ENGINEERING



# Overview

- Culverts as migration barriers
- What are small-bodied fish and why should we care?
- How can we reconcile culvert remediation with migration of small-bodied fish?

# Culverts at road crossings



What we have



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What we want to have

# Best practices: Expectation versus reality

- Fast economic expansion → construction of less ,ideal` culverts
- Guidelines too unspecific, not relevant to the local fish-fauna or not properly enforced
- Guidelines tend to be focused on averaged criteria for flow and fish performance which oversimplifies fish behaviour and increases cost when accomodating weak swimmers

# What are small-bodied fish and why should we care about them?

- Fish up to ~15 cm (including juveniles)  
→ tend to be weak swimmers
- Limited commercial and recreational relevance  
→ under-represented in research
- Diadromous species tie into both marine and riverine/ lacustrine ecosystems as predators and prey

# 'Whitebait'

- Juveniles of various migratory fish species
- Members of the family Galaxiidae in the southern hemisphere
- 5 species of Galaxiids in New Zealand, 4 of them in decline



# So why whitebait?

- Some commercial and recreational value
- Diadromous → vulnerable to migration barriers
- Some species are widespread



common  
galaxias/  
īnanga



climbing  
galaxias/  
kōaro

# Designs for remediation



Tautened mussel spat ropes



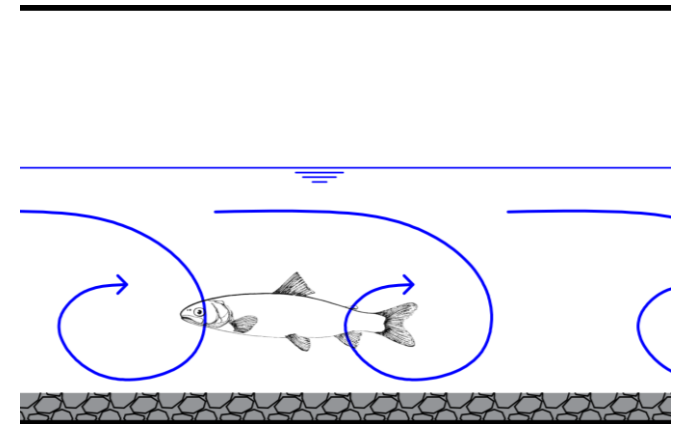
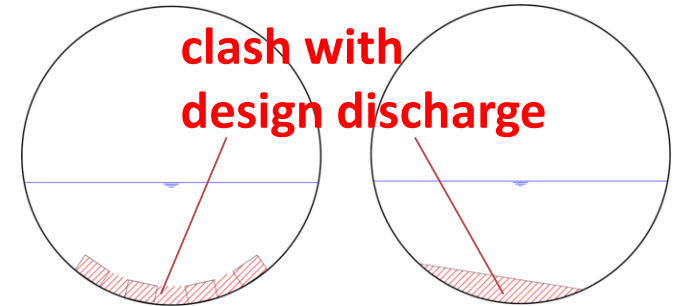
Spoiler baffle inlay

# Remediation conflicts inside the culvert

High profile baffles: reduce usable cross section and introduce turbulence

Invert roughening: less intrusive, will still introduce turbulence

However: small-bodied fish do not require much space to swim

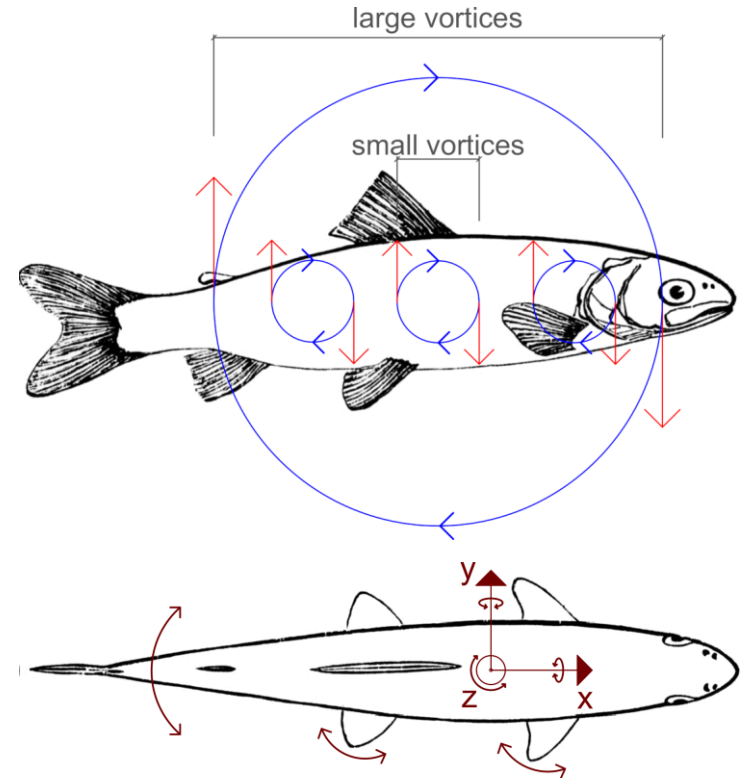


# Ethohydraulics

- Ethology + hydraulics:  
Study of the interrelation of locomotion of aquatic organisms and flow characteristics
- Spatially and temporally resolved flow features and fish kinematics
- Kinetics of flow interaction (forces acting on fish body) as well as behavioural analysis
- Ideally in 3 dimensions for complex flows

# Observing fish swimming

- Conditions for loss of stability (turbulence)
- State of energy preservation vs. upstream ascend
- Coping mechanisms
- Preferred swimming environment



# Flow velocimetry

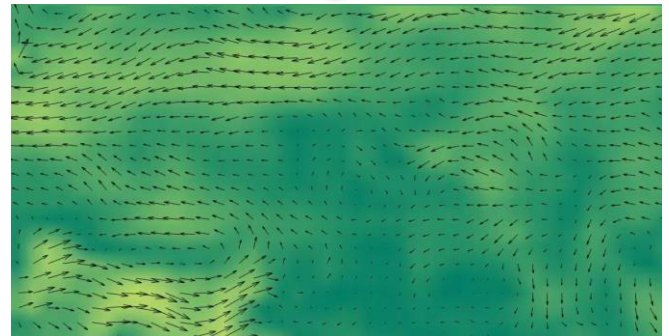
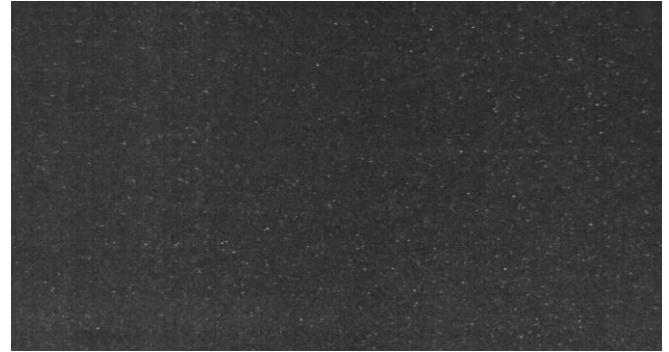
ADV (acoustic Doppler velocimeter):

- Simple set-up, usable in the field under most conditions (non-visual)
- Difficult to capture flow field or turbulence

PIV/PTV

(Particle tracking/ imaging velocimetry):

- Difficult set-up, nearly impossible to use in the field
- Very detailed 2D (or 3D) flow field



# Fish tracking

## Tagging

(e.g. passive integrated transponder/ PIT):

- Difficult set-up, with lower accuracy but usable in the field under most conditions
- Invasive, especially for very small fish

## Videometry:

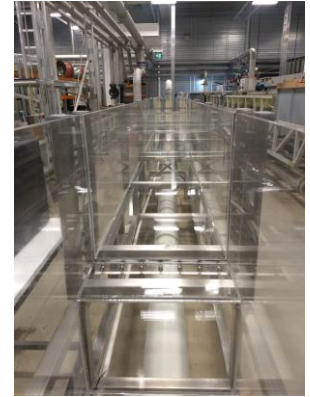
- Simpler set-up, with high accuracy but difficult to use in the field
- Usable on any species



PIT for surgical implantation

# Test set up for ethohydraulic studies

- 600 mm wide 18 m long recirculating flume to simulate culverts
- LED PIV/PTV and fish tracking based on videometry → striving for 3D videometry
- Live trials with īnanga (adult and juvenile) applying novel designs to improve upstream passage
- Goal: help inform fish passage guidelines for small-bodied individuals





# Conclusion

- Small-bodied fish are often overlooked but very susceptible to migration barriers e.g. culverts
- Remediation of culverts for small-bodied fish is challenging with current approaches
- Study of correlation between fish behaviour and hydrodynamics (=Ethohydraulics) can help tackle the remediation challenge
- Laboratory based research at UoA allows detailed observation under finely controlled boundary conditions



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Thank you!

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