Jun 22nd, 9:30 AM - 10:10 AM

Plenary Speaker: Universal Lessons from Fish Passage Research, Design and Application in Australia

Martin Mallen Cooper
Fishway Consulting Services

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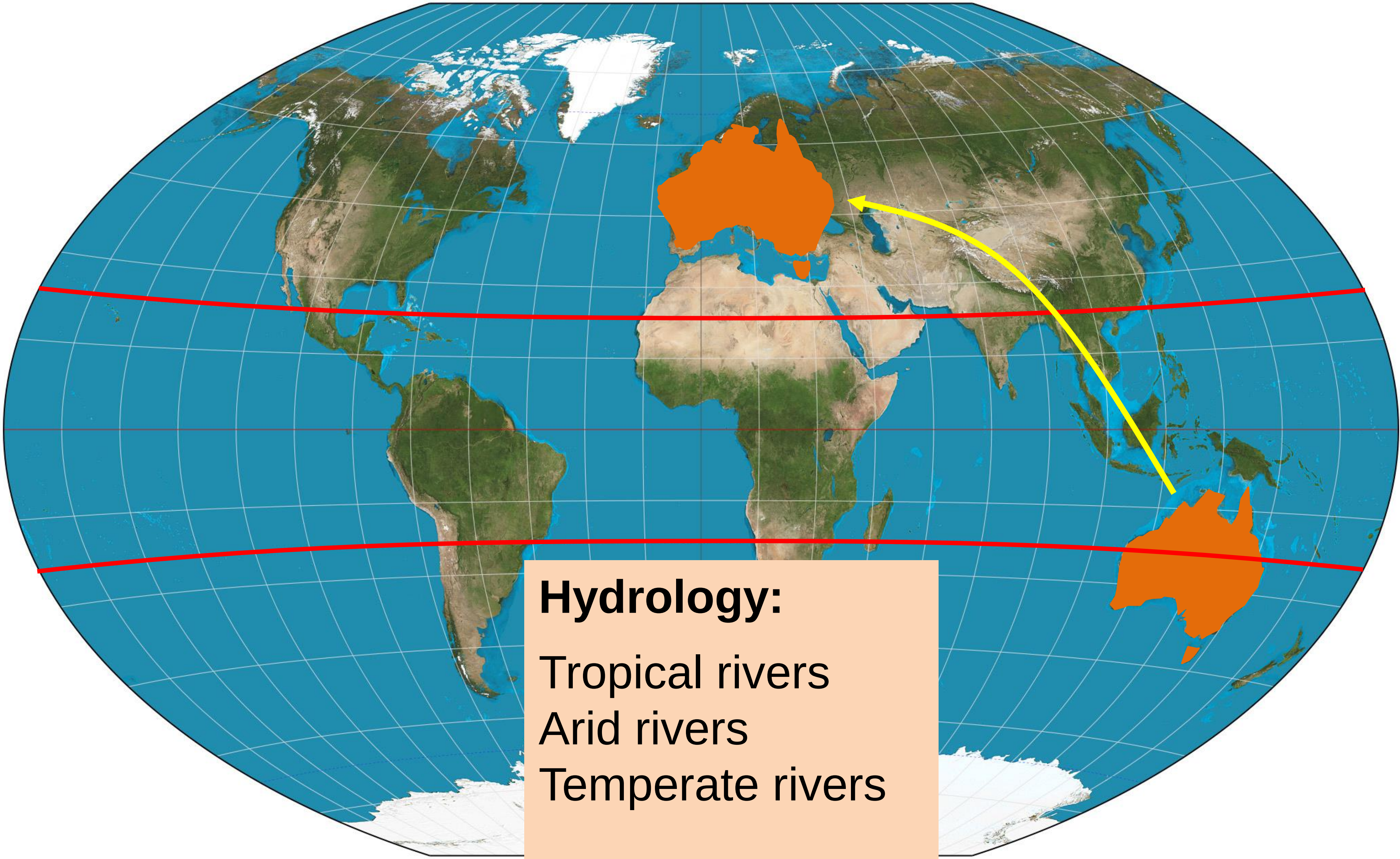
https://scholarworks.umass.edu/fishpassage_conference/2015/June22/101

Fish passage in Australia: universal lessons

Martin Mallen-Cooper
Fishway Consulting Services

- Background
- Hydraulics
- Migration ecology
- Fishway design - trends
- Challenges

Background - Geography



Hydrology:

Tropical rivers
Arid rivers
Temperate rivers

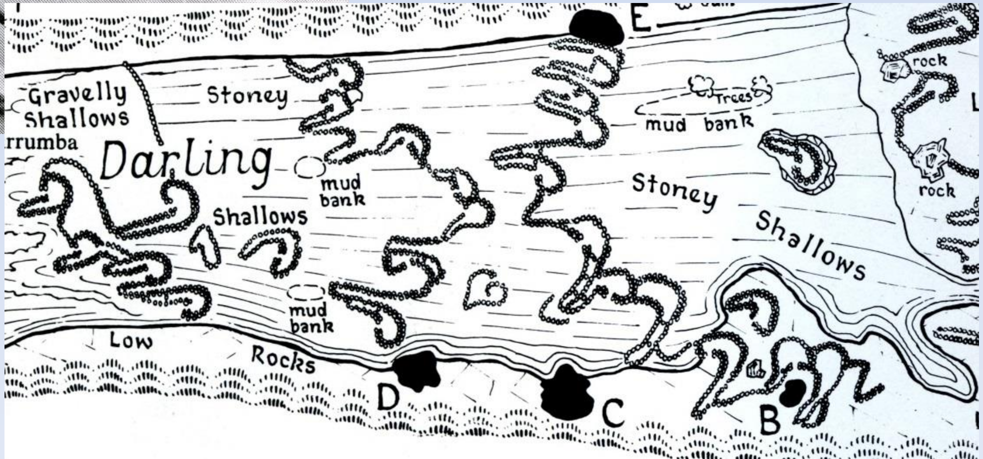
Tropics - freshwater sawfish

Arid – desert rainbowfish

Temperate – Murray cod

Background - Fish Biology

40,000 years



Background - Fish Biology

- 200+ species of freshwater fish
- Most are endemic
- No native salmonids
- Anadromous fish are rare

  (migrate from the sea to freshwater to spawn)

Background - Fish Biology

Common Migration Strategies - coastal rivers

Australian bass - catadromous

Migrate downstream to spawn in estuary/sea

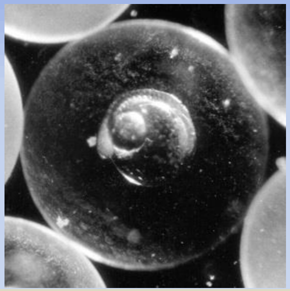
Juveniles migrate upstream

Background - Fish Biology

Common Migration Strategies – large rivers

Golden perch - potamodromous

Migrate upstream to spawn



Eggs, larvae drift downstream

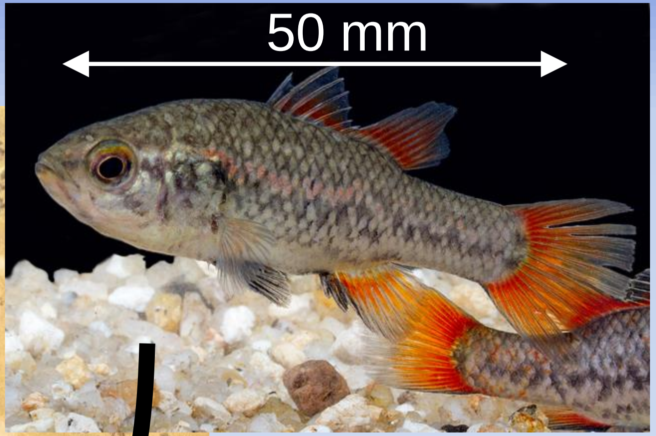
Juveniles migrate upstream

But . . . diversity of migration!

Background - Fish Biology

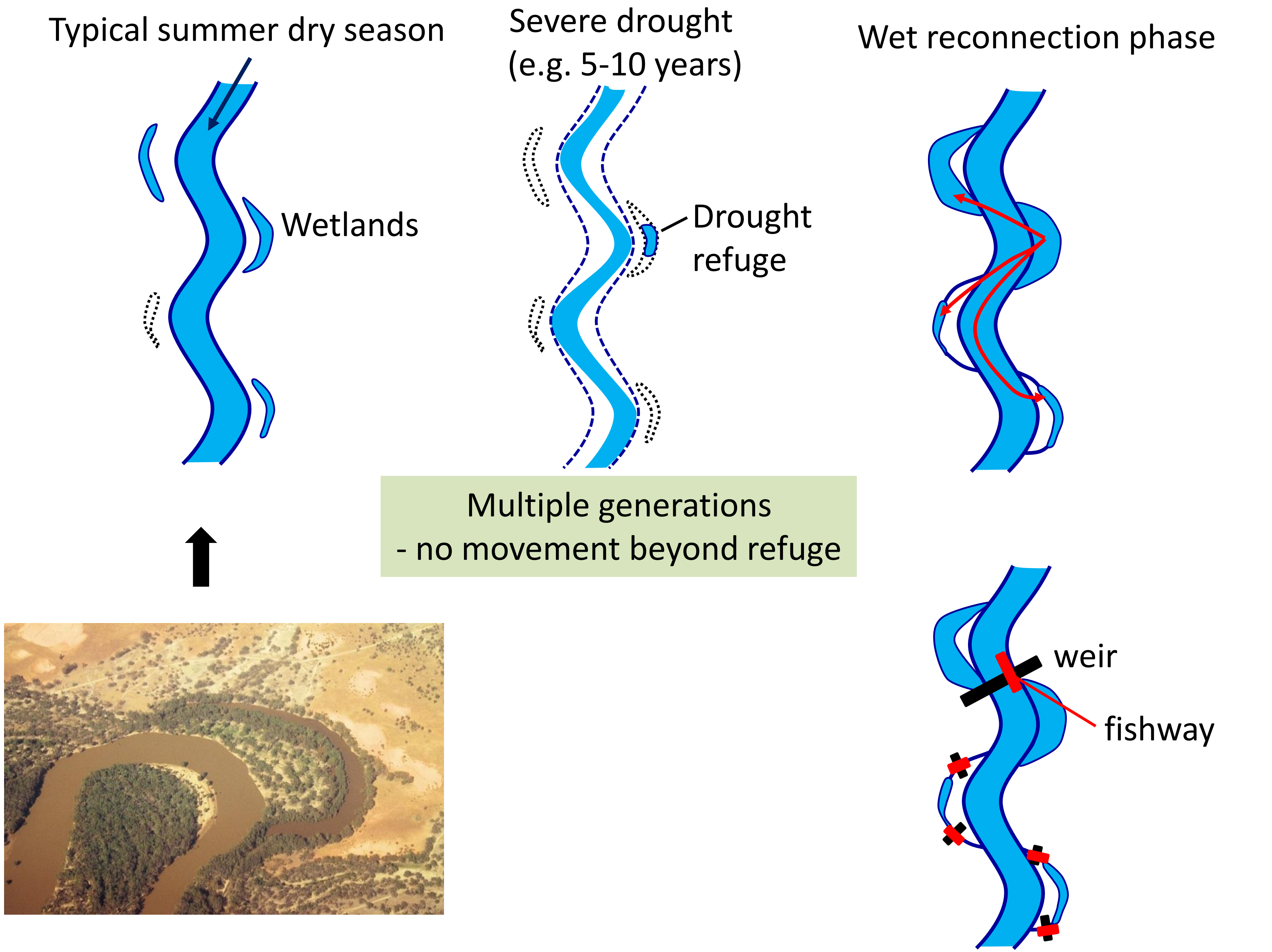
Less Common (but no less important) Migration Strategies

“Non-migratory”, “resident” species?!



Pygmy perch

- endangered
- wetlands



Typical summer dry season
Wetlands
Severe drought
(e.g. 5-10 years)
Drought
refuge
Wet reconnection phase
Multiple generations
- no movement beyond refuge
weir
fishway

Background - Fish Biology

Summary for Fish Passage:

- 20-1400mm fish migrating upstream
- larvae drifting downstream
- Complex intergenerational movements
  - ➢ longitudinal and lateral

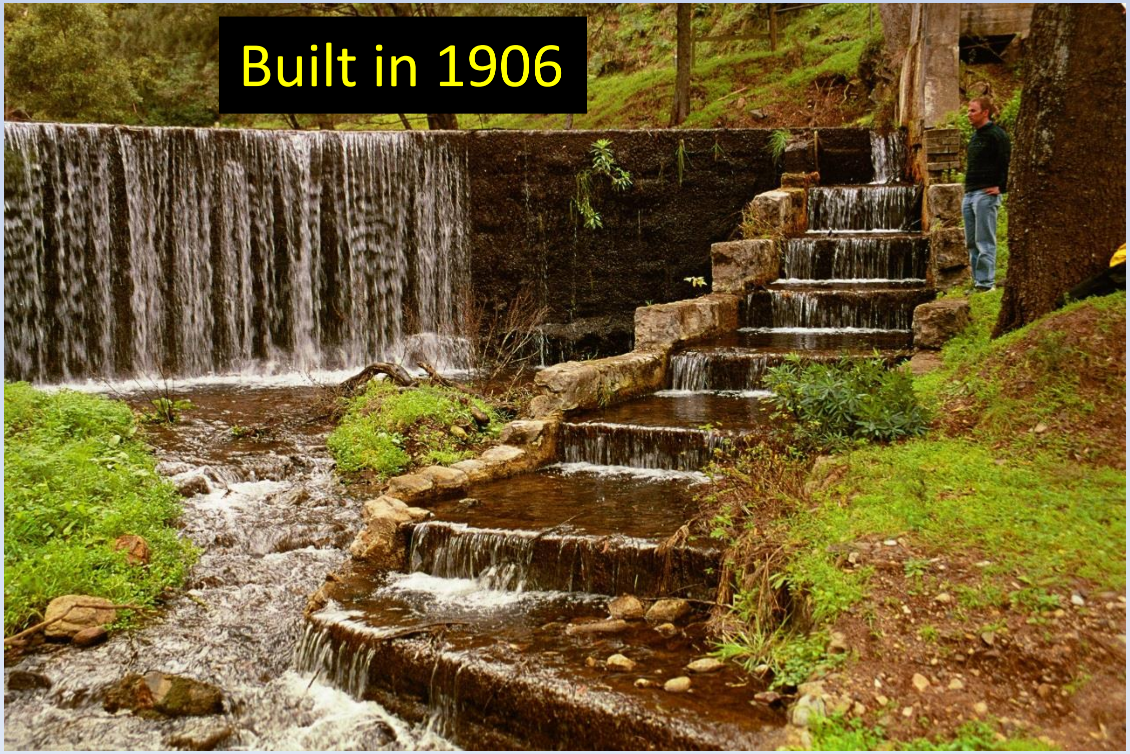
History of Fishways in Australia

Europeans – 227 years

Irrigation - 125 years

Fishways - 110 years

Fishways – for 80 years, based on salmonid designs



Note: little monitoring

History of Fishways

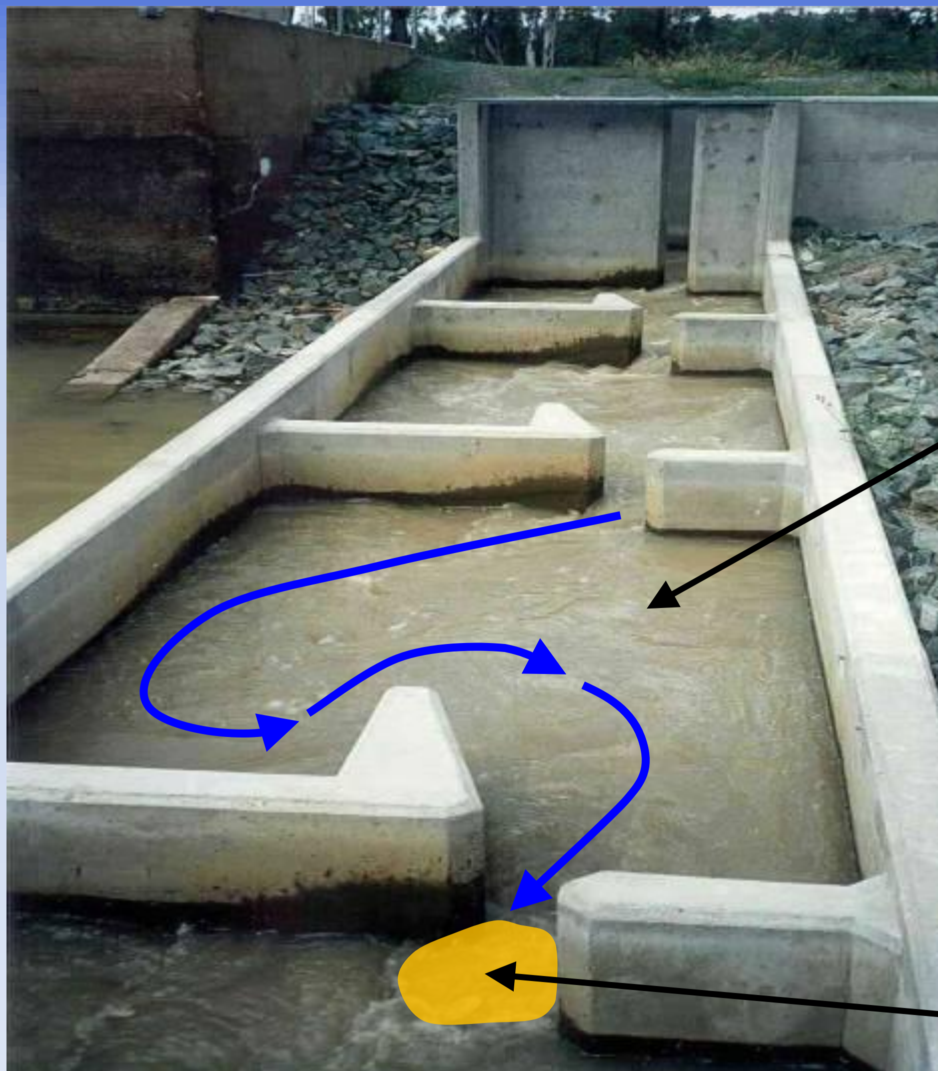
Head loss or step height between pools:

300 mm is a salmonid standard
165 mm for larger native fish
50-100 mm for small native fish

Outline

- Background
- Hydraulics
  - Vertical-slot design & turbulence
  - Denil fishways – limits for small fish
- Migration ecology
- Fishway design - trends
- Challenges

Vertical-slot design & turbulence



Turbulence =

$$\frac{\text{Energy entering the pool}}{\text{Pool volume}}$$

High velocity

Vertical-slot design & turbulence

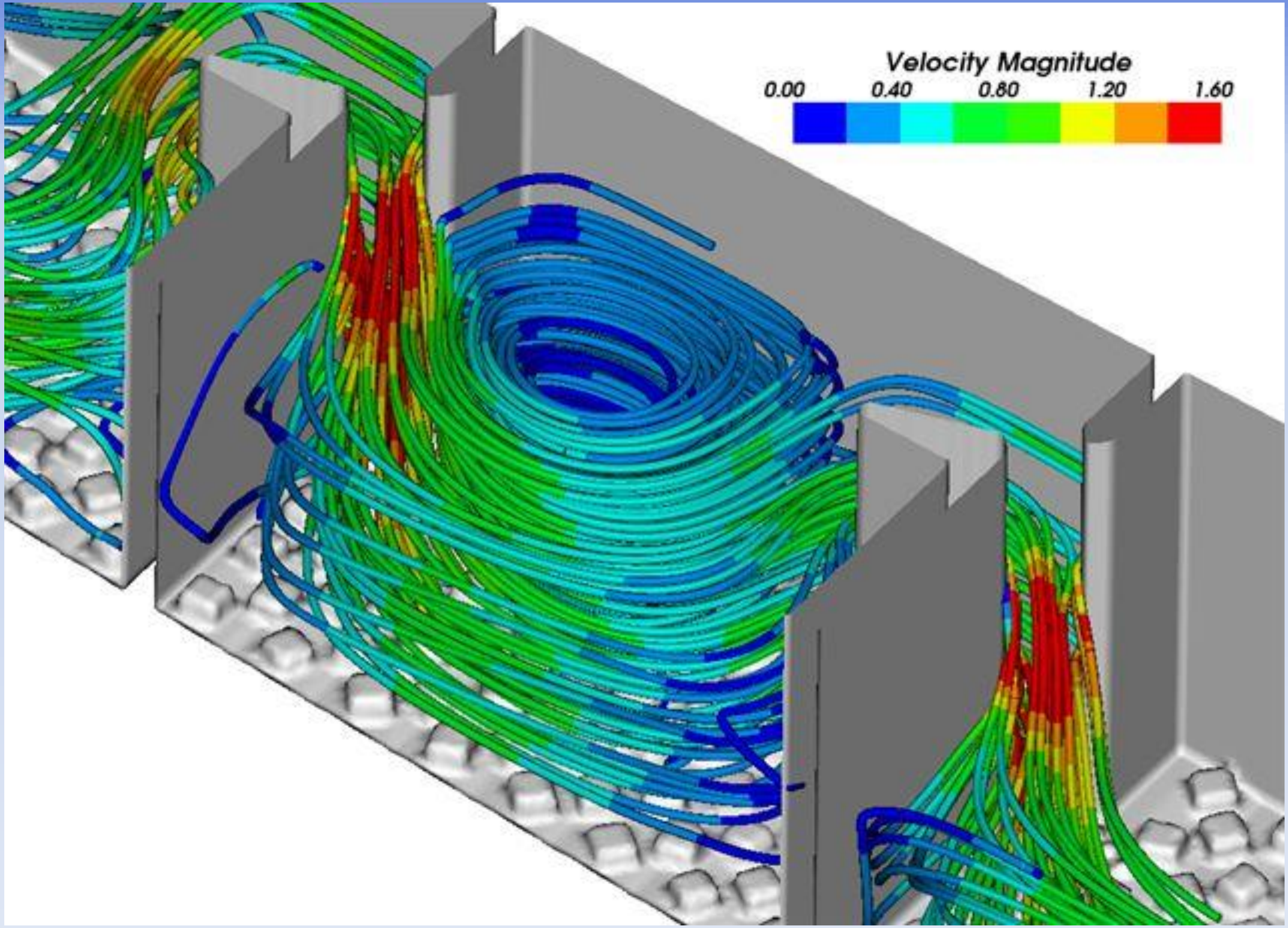
- increased roughness in the slot

Experiment, replicated, controls

No improvement in fish passage!

Vertical-slot design & turbulence

Modelling with Computational Fluid Dynamics (CFD)



Vertical-slot design & turbulence

Standard design

Vertical-slot design & turbulence

Vertical-slot design & turbulence

Vertical-slot design & turbulence

Results:

- Wall roughness - slight improvement for 1 of 3 species
- Reducing discharge (same velocity) – 10X increase in fish numbers

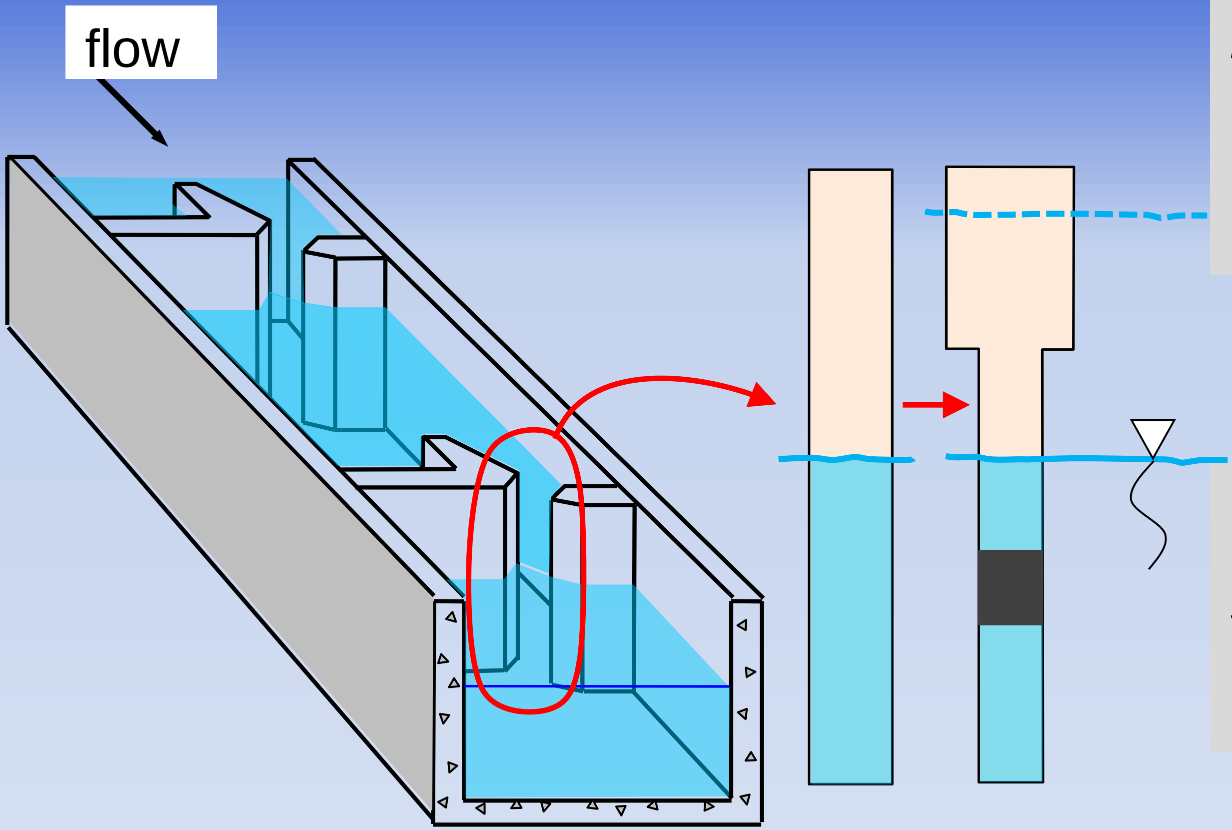
↓ Design

Manipulate baffle profile

⇒ 1:20 gradient with 1:30 performance

Modelling a powerful tool; but test with fish!

Vertical-slot design & turbulence



High flow

Large fish migrating

High turbulence (75 Watts/m^3)

More discharge & attraction

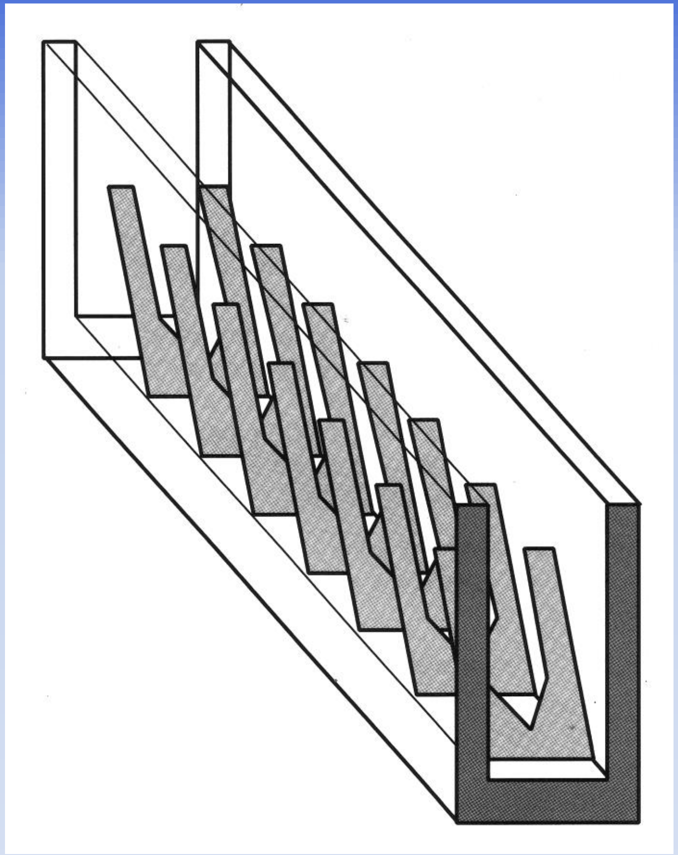
Low flow

Small fish migrating

Low turbulence (35 Watts/m^3)

⇨ Dual function fishway

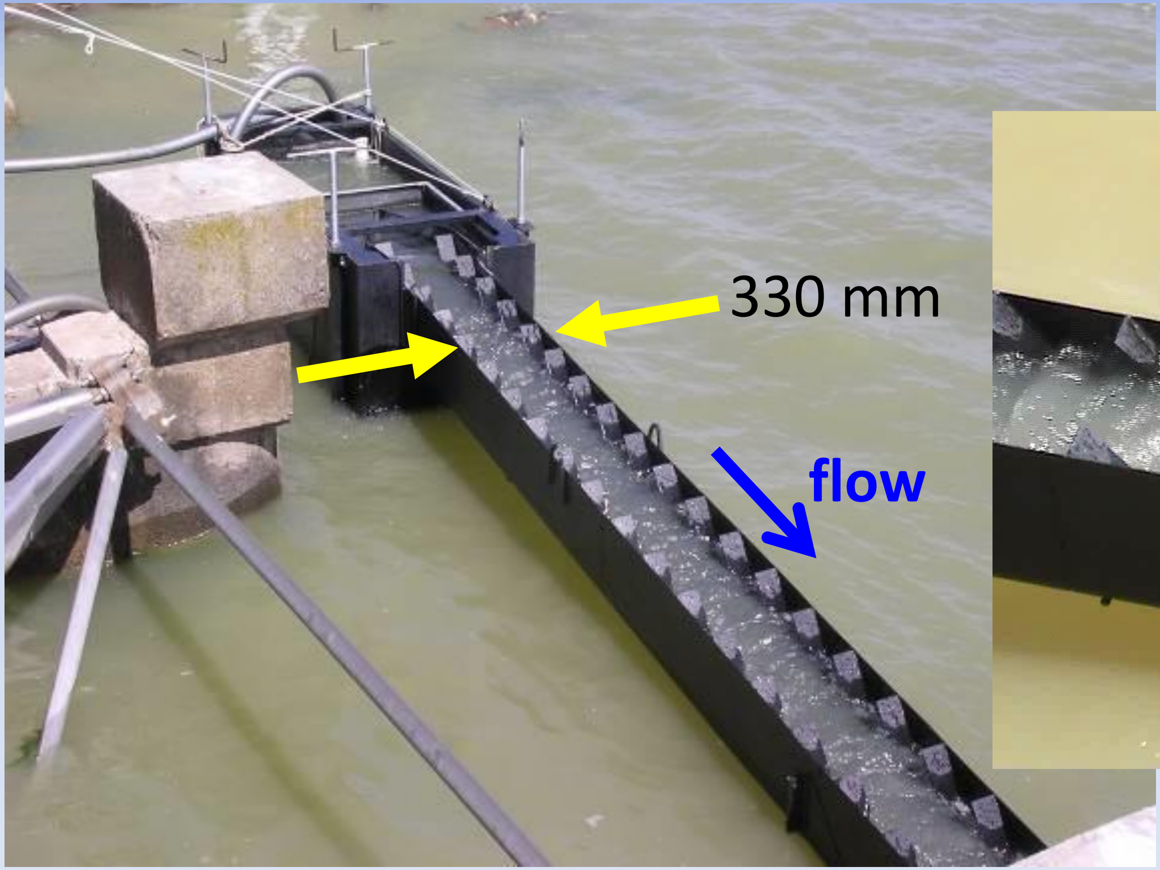
Denil fishways – limits for small fish



Experience in Australia

- 180 mm fish 1:6 gradient
- 60 mm fish 1:12 gradient
- 20-60 mm???

Denil fishways – limits for small fish



Denil fishways – limits for small fish

Results:

Gradients

- 1:9
- 1:15
- 1:25

Small fish (25-60 mm)

2 species effective passage at 1:25

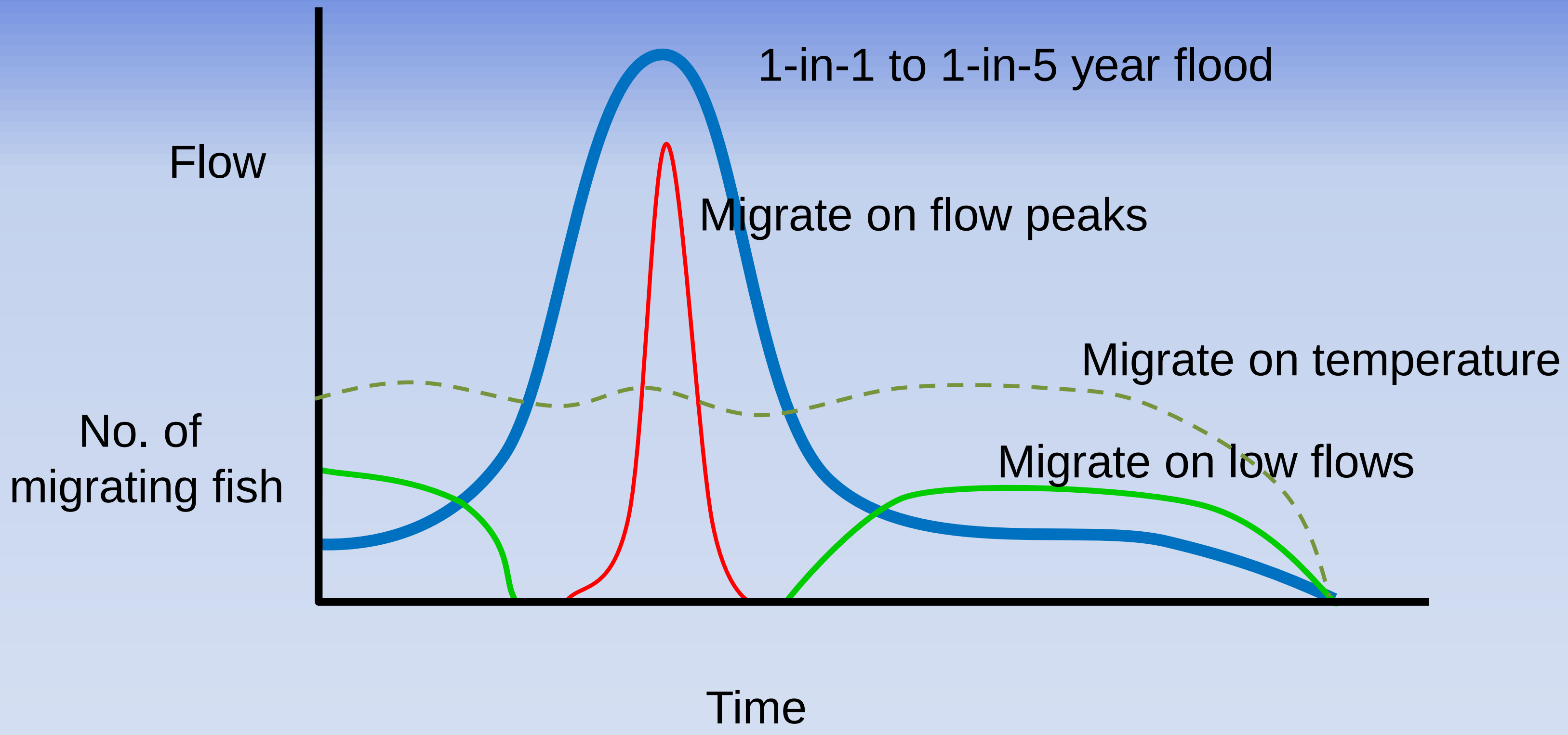
2 species very poor – all gradients

Conclusion:

- Denils remain useful for larger fish
- Very poor for small fish <60 mm

Migration Ecology

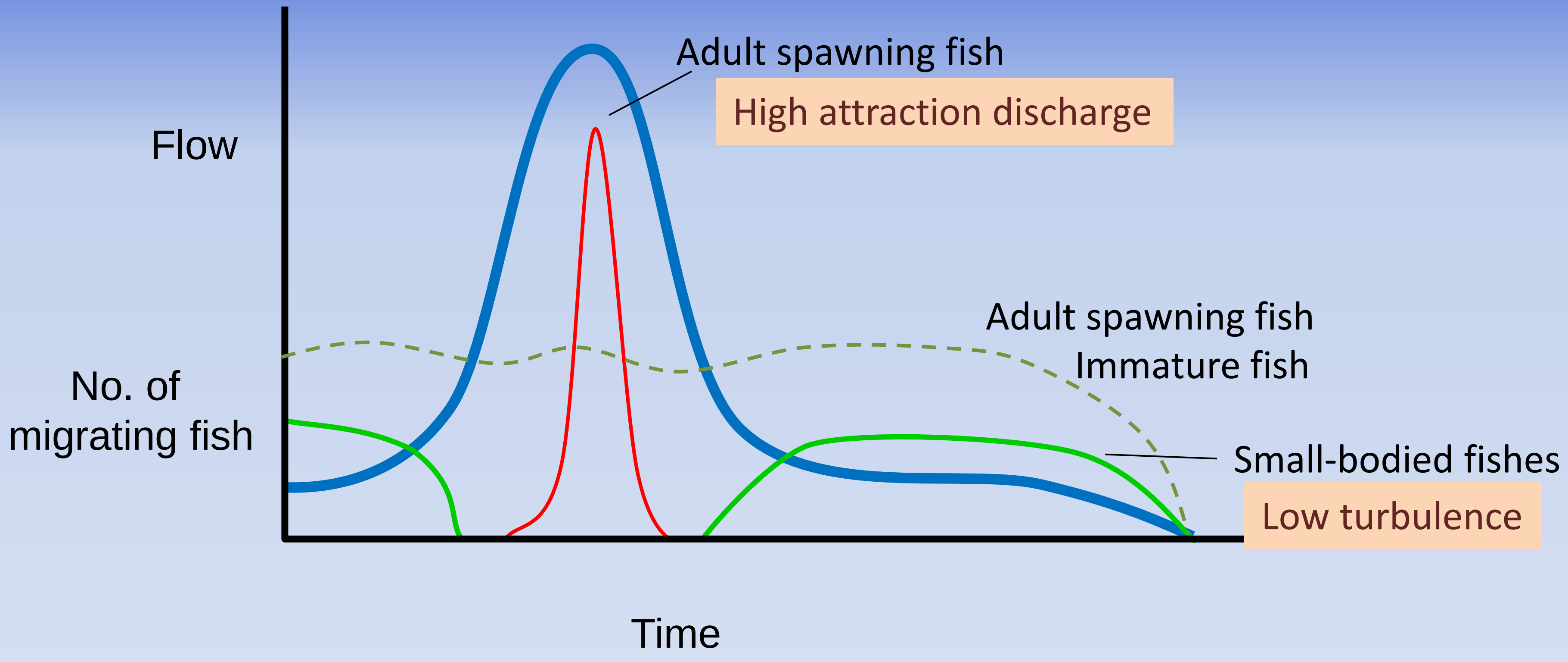
Biology ⟷ Hydrology



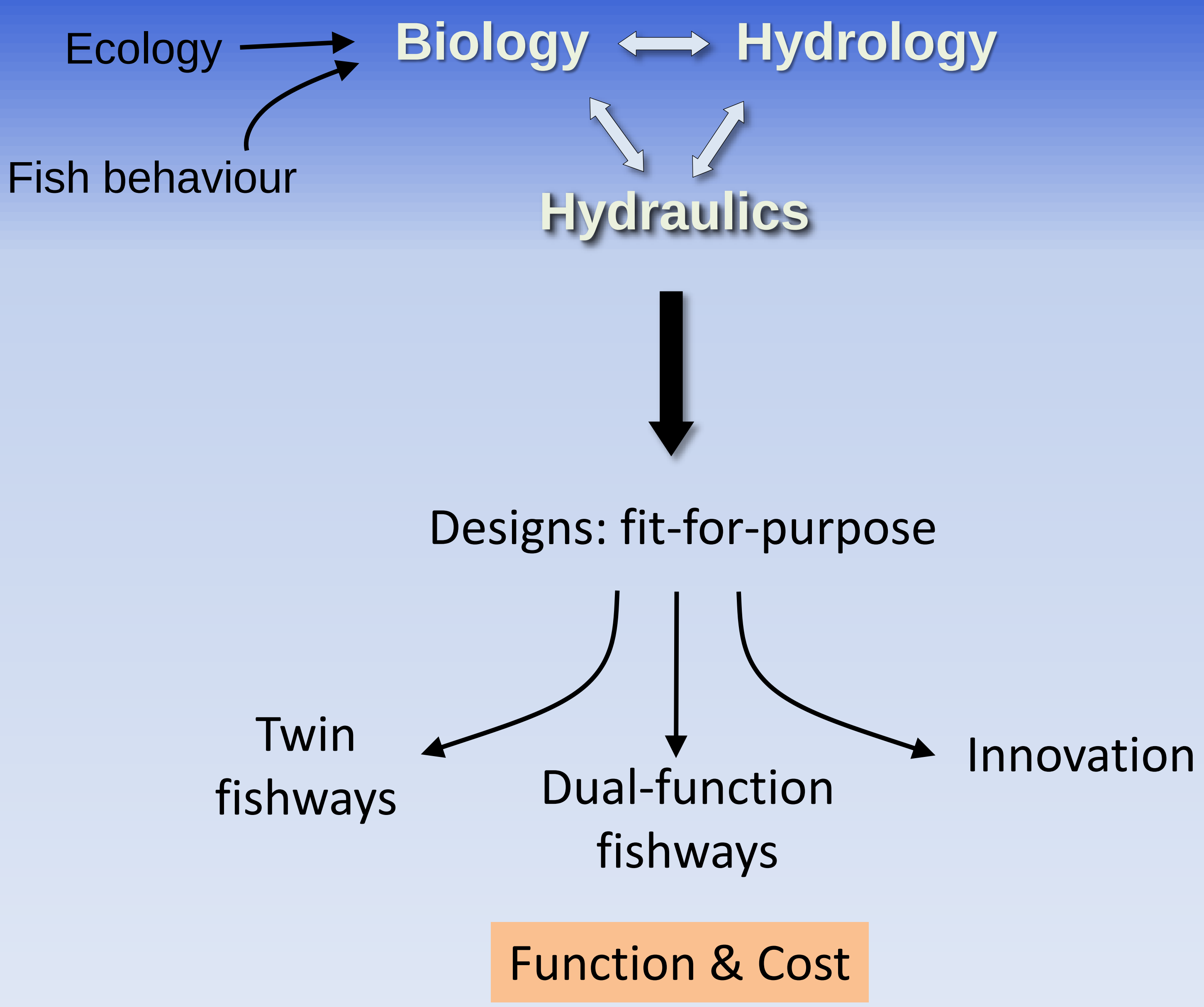
- Species
- Life stage

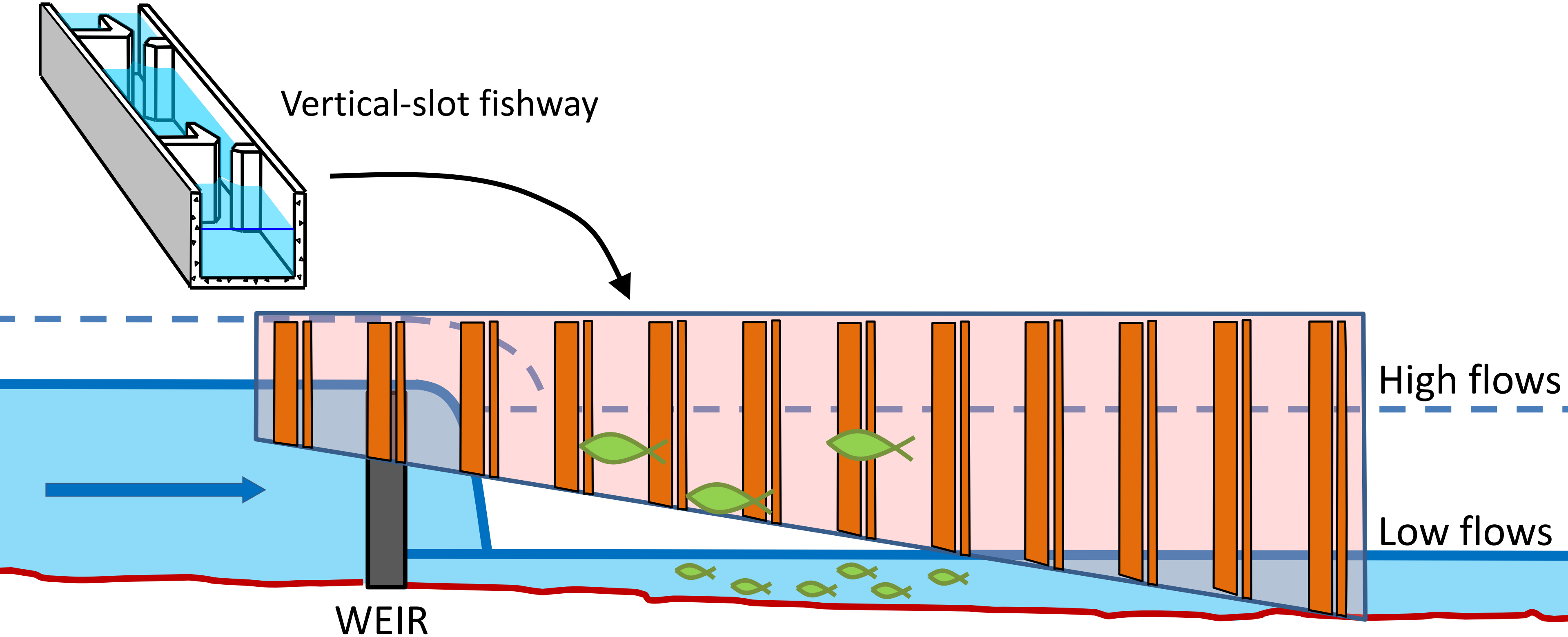
Migration Ecology

Biology ⟷ Hydrology

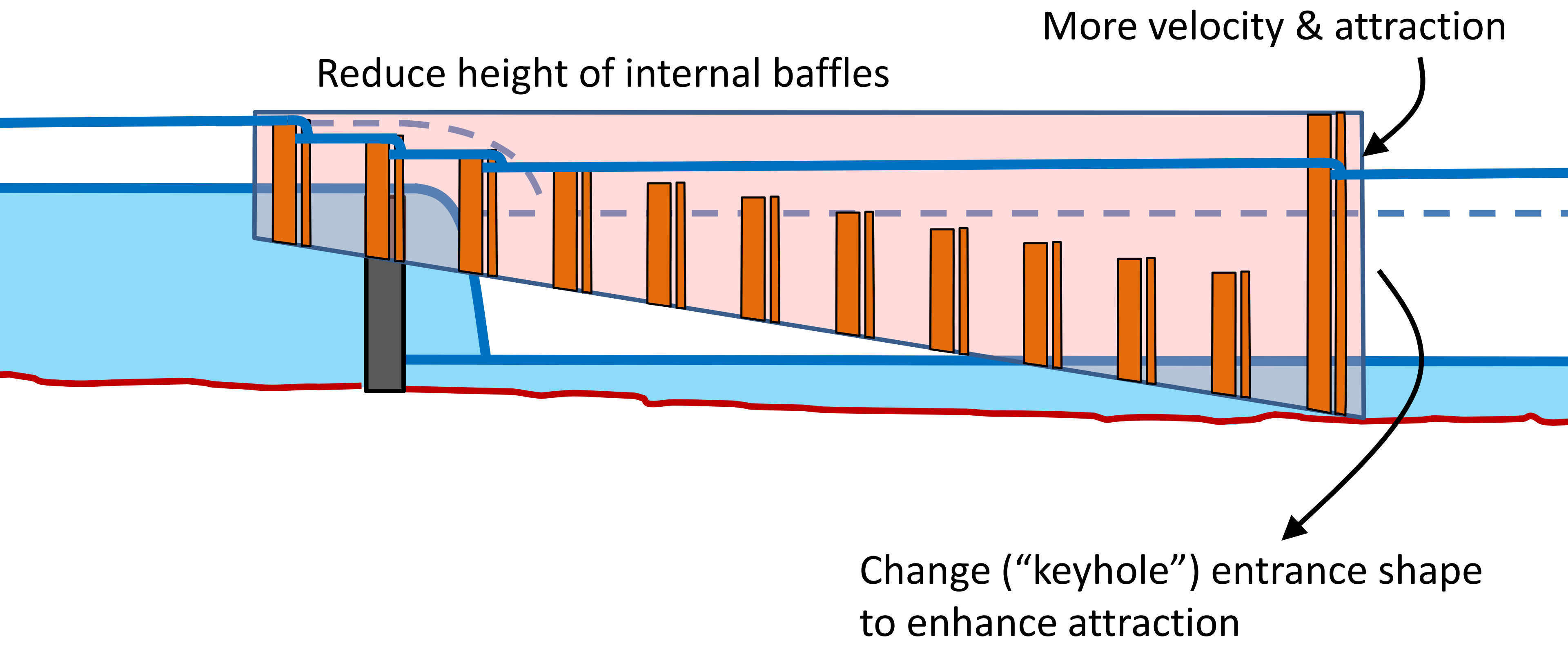


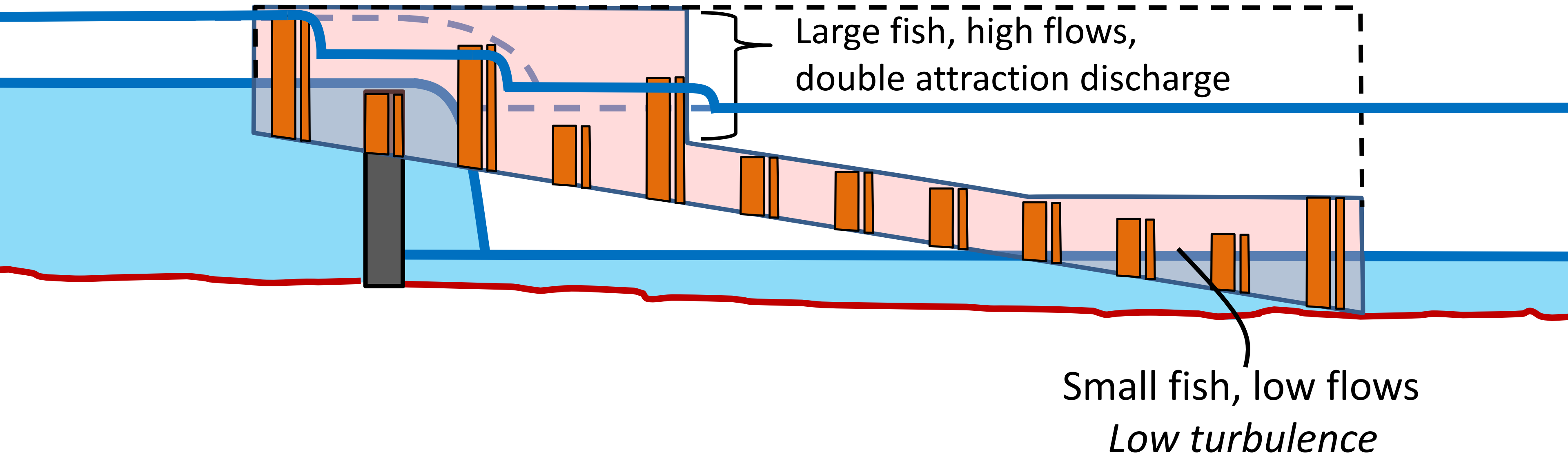
Migration Ecology



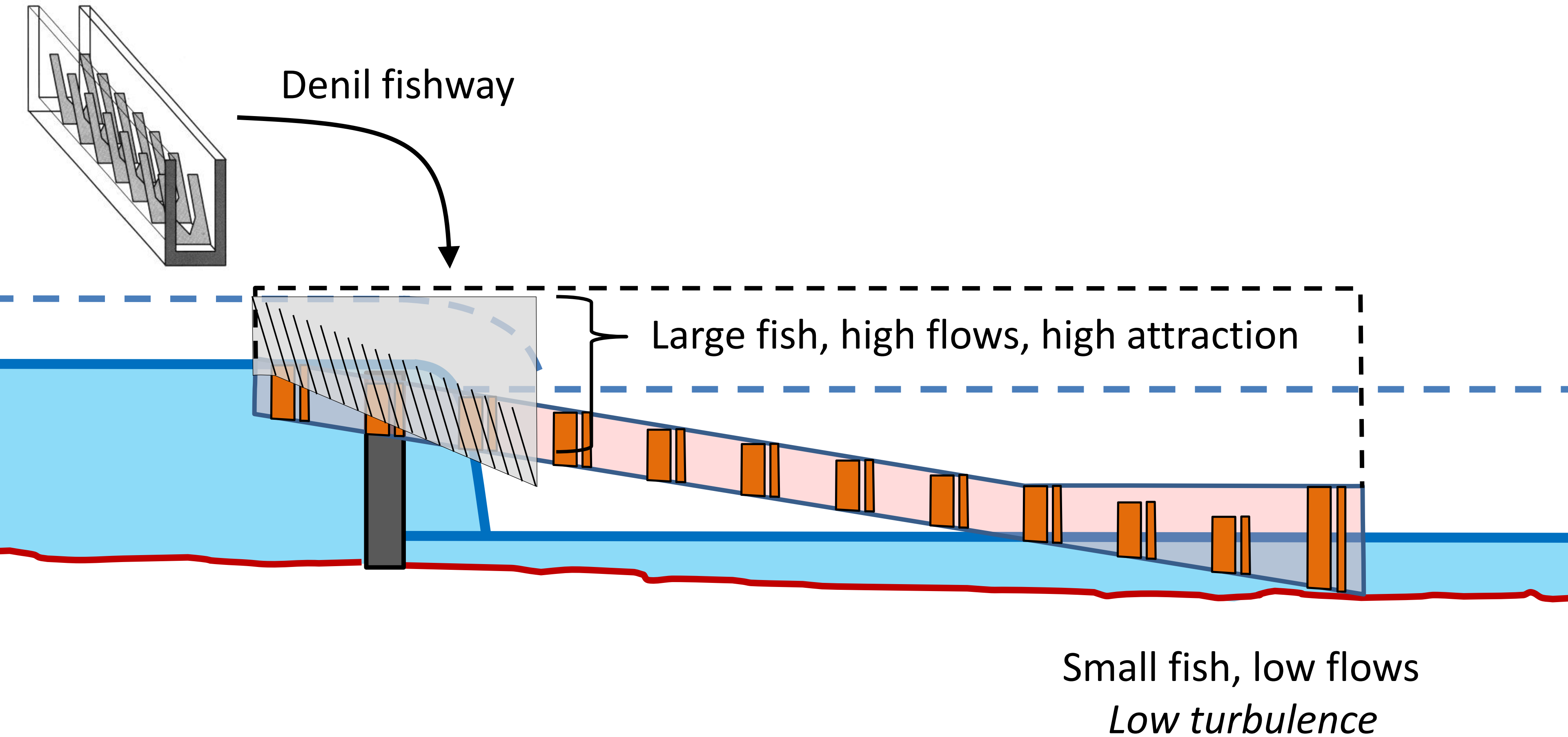


Vertical-slot fishway
High flows
Low flows
WEIR

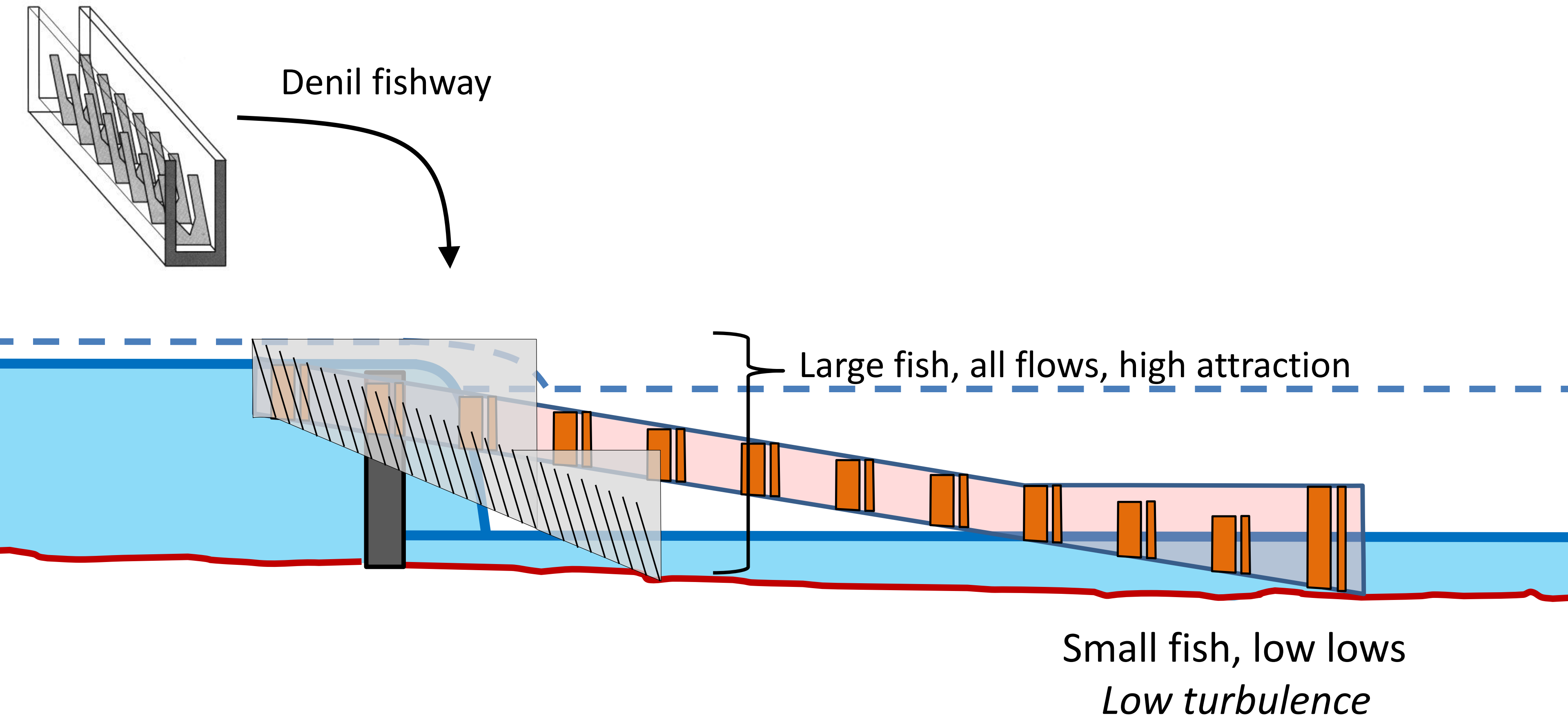

More velocity & attraction
Reduce height of internal baffles
Change (“keyhole”) entrance shape
to enhance attraction



⇨ Dual function fishway



- Twin fishways
- 2 cheaper than 1
- Biology and hydrology basis of design



- Also, fish lock for small fish & vertical-slot for large fish
- Separating ecological & hydrological function

Fishway Design – other developments

Trapezoidal Weirs

- Small fish
- Attraction flow
- Gauging
- Pass debris

- Function determines design
- Scientists/engineers partnership

Fishway Design – other developments

Fishway Design – other developments

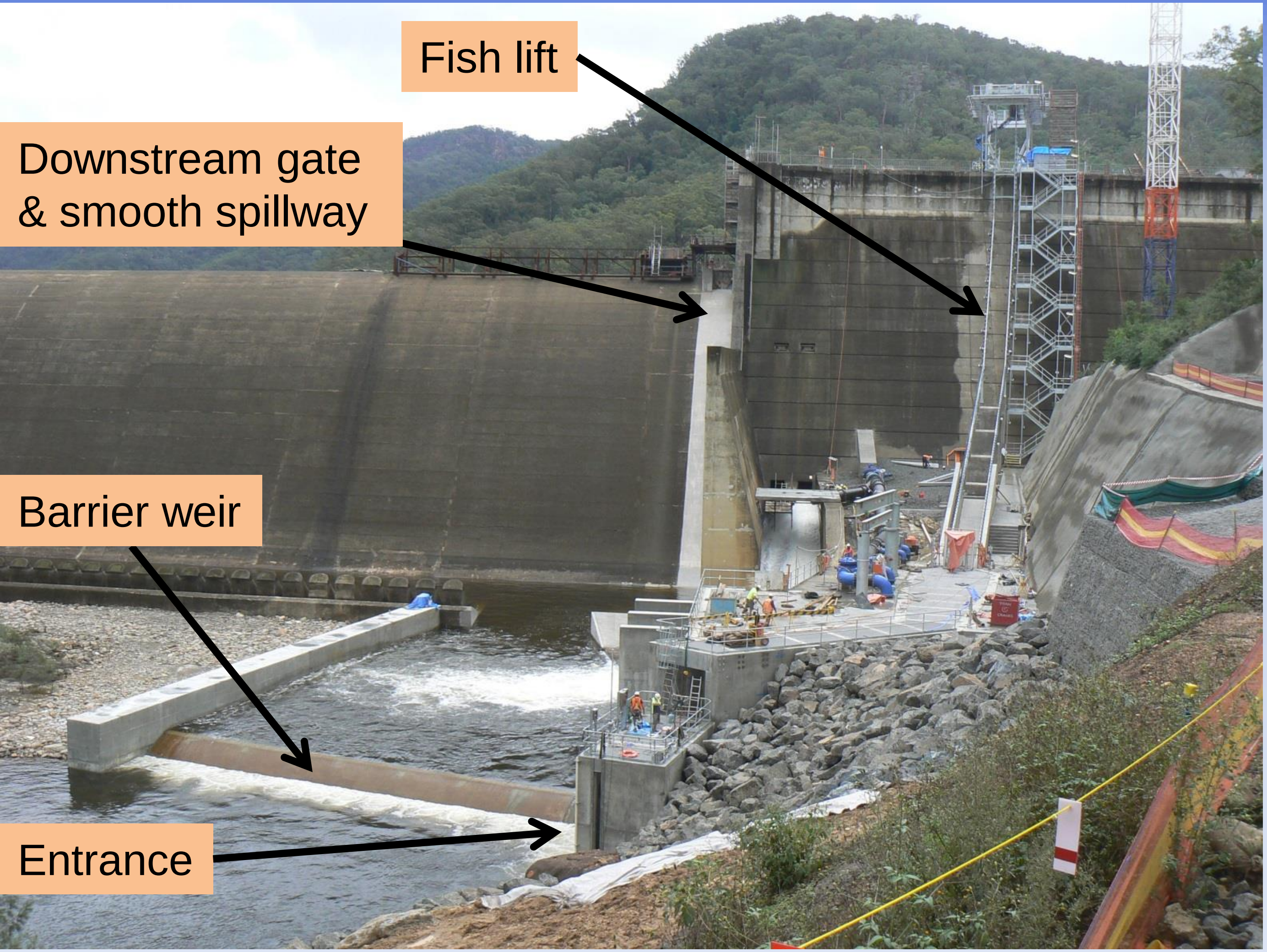
Fishway Design – other developments

Nature-like hybrids

Pool-type fishways
"cone fishway"

Fishway Design – other developments

High Fish Passage



Tallowa Dam

20-700 mm fish

Physical modelling

3 other dams, incl.

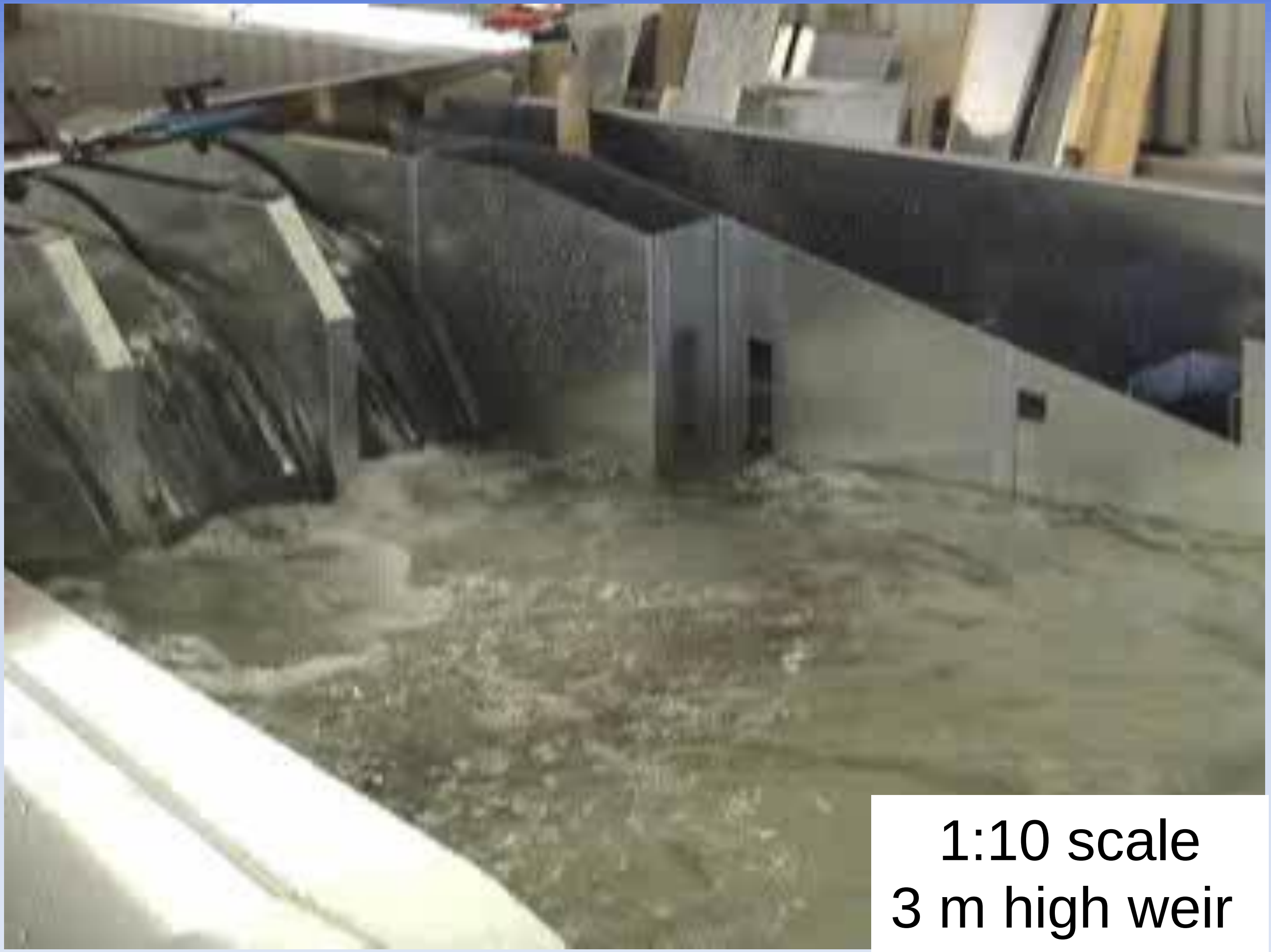
- trap & transport
- D/S fish lock
- D/S fish lift
- screened intakes

Fishway Design - trends

- Entrance
  - integrated from the beginning
- Low maintenance
- Simplicity

Fishway Design - trends

Physical modelling

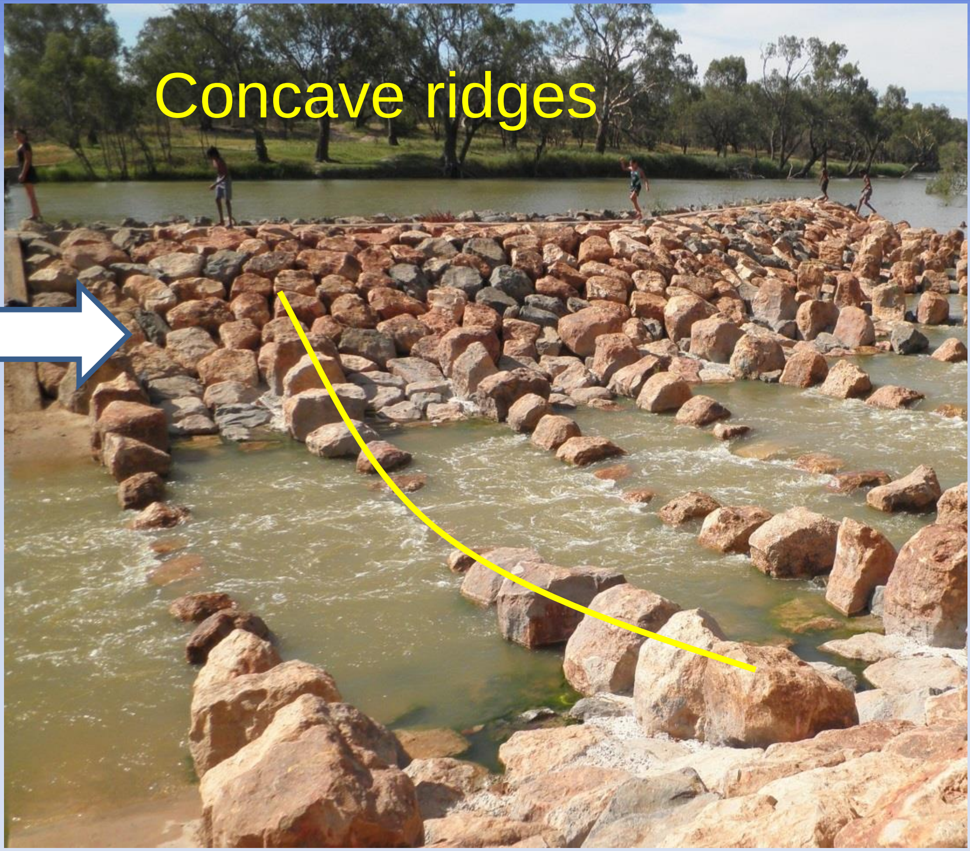


design of abutments, spillways, gates, weir orientation . . .

Fishway Design - trends

- Entrance
- Low maintenance
  - Fishway design choice, application
  - Designed to ensure continuous operation
- Simplicity

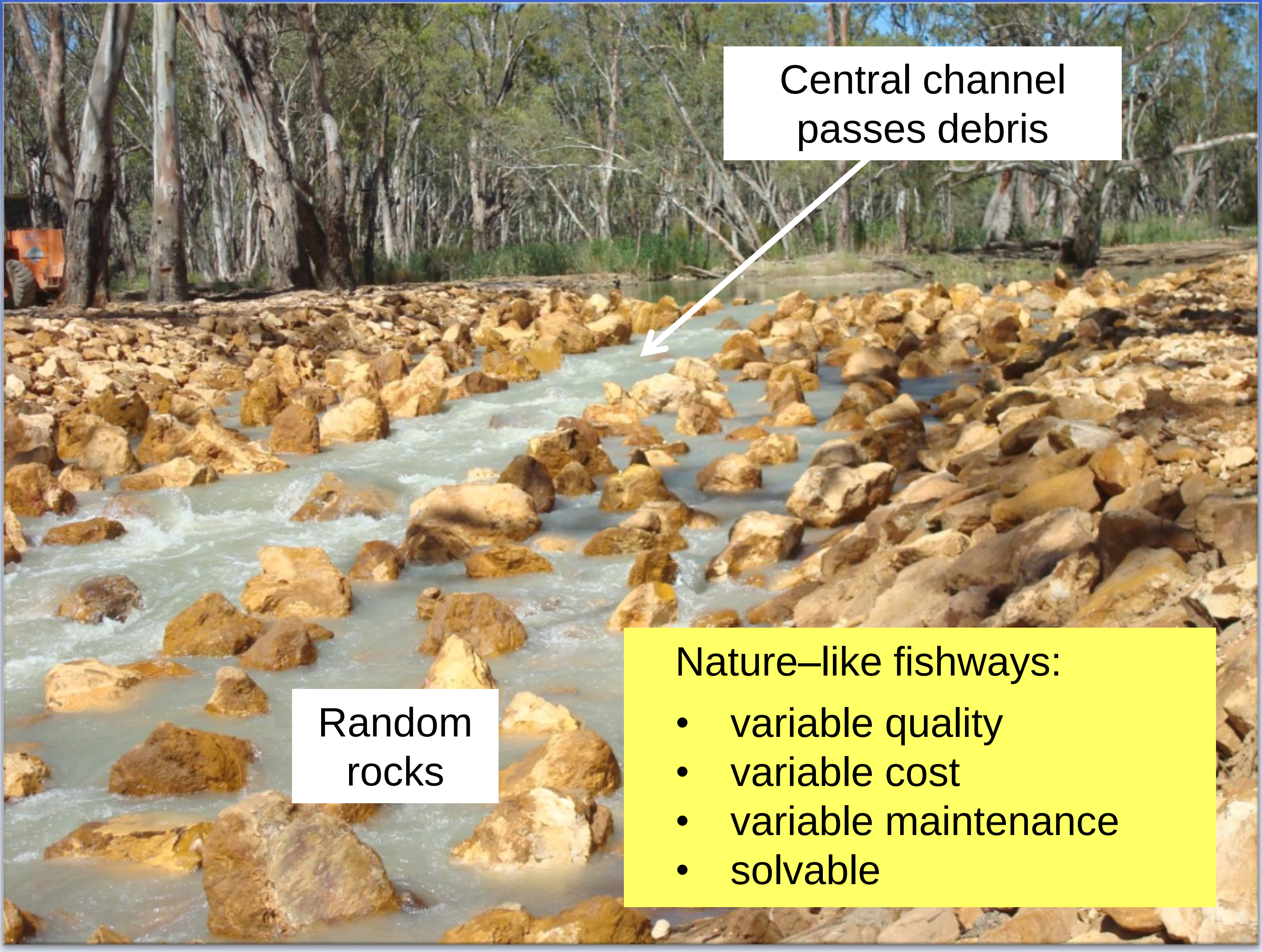
Fishway Design - trends



- Hydraulically sensitive
- Collects debris

- Hydraulically robust
- Debris passes

Fishway Design - trends



Fishway Design - trends

- Entrance
- Low maintenance
- Simplicity
  - minimising flow-control gates & manual controls
  - selecting non-mechanical fishways where possible
  - ensure continuous operation

Challenges

1. Research and monitoring

2. Performance indicators
    - common vs rare species
    - long-lived vs short-lived species

3. Reservoirs as fish barriers (larval drift)

4.

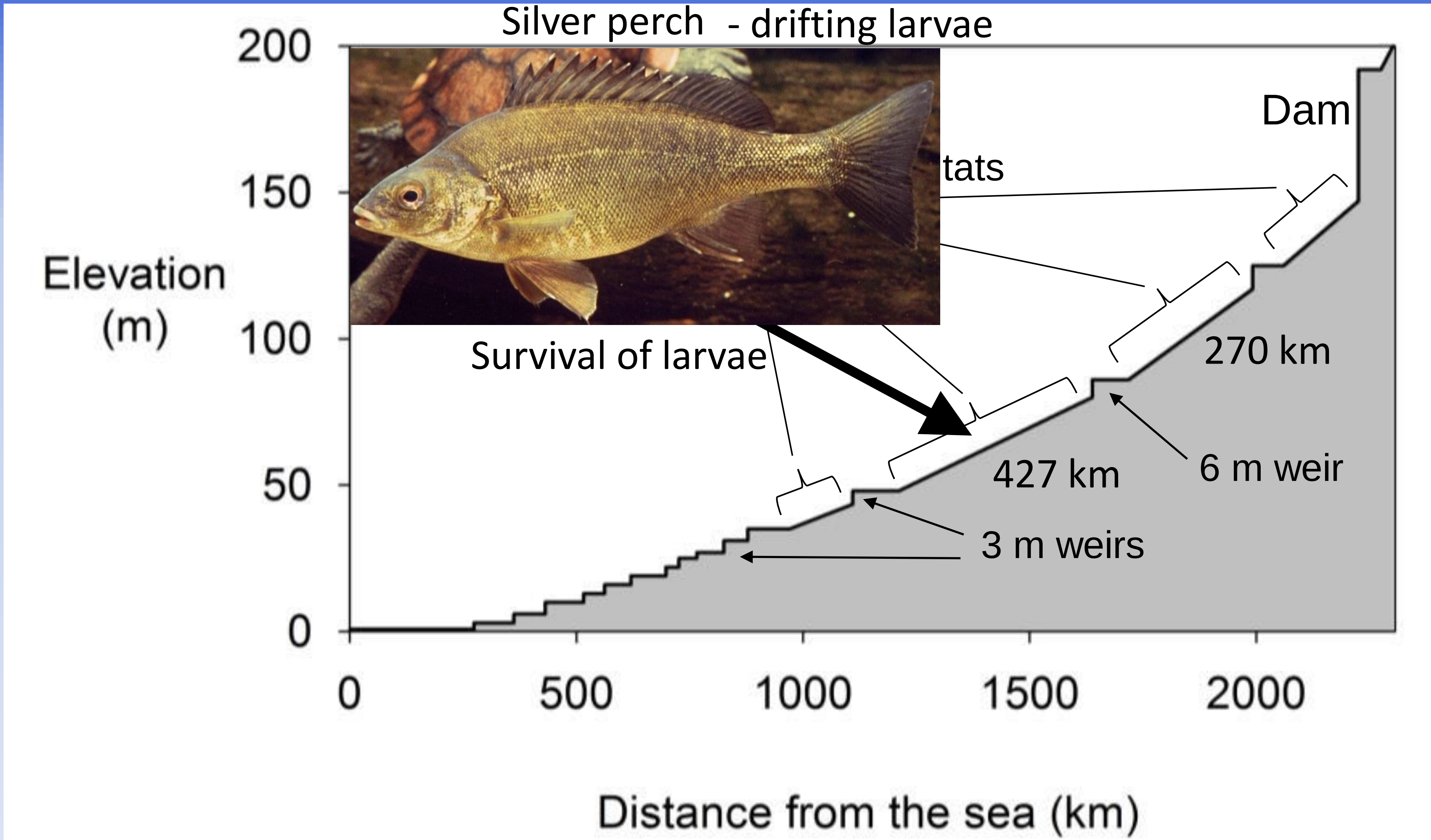
Ease of funding:

1. Fishways
2. Monitoring
3. Research

Challenges

Reservoirs as fish barriers

Murray River Profile

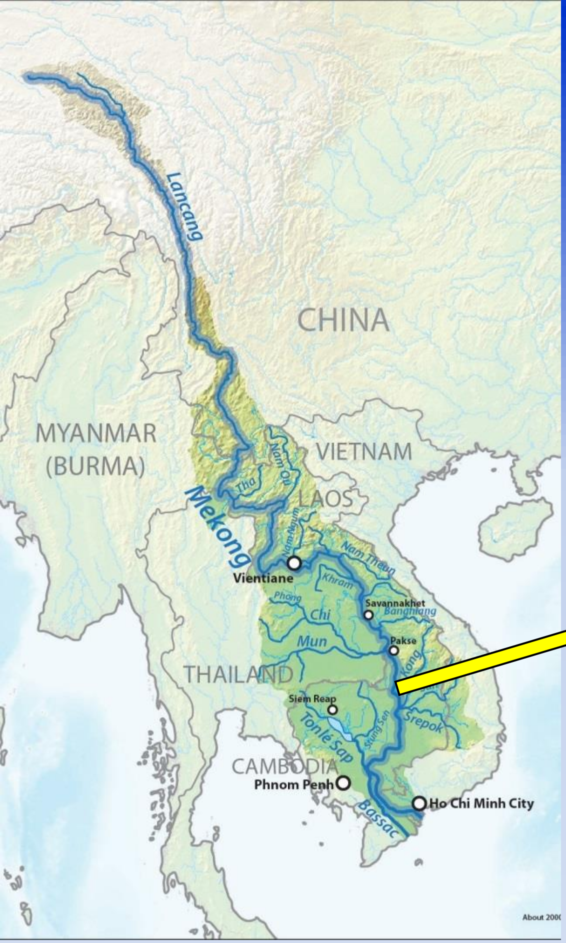


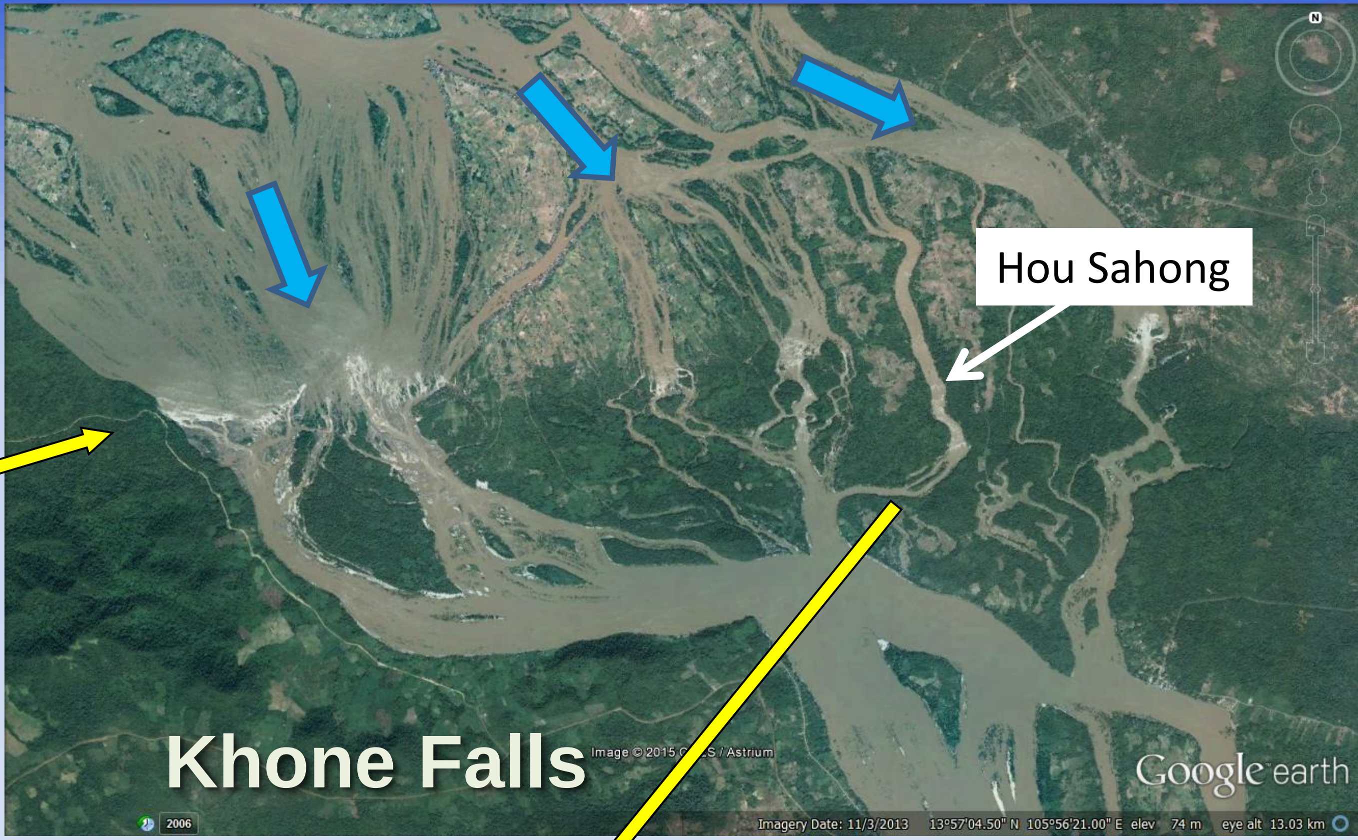
Minimum spatial scale of flowing water habitat required

Challenges

1. Research and monitoring
2. Performance indicators
3. Reservoirs as fish barriers (larval drift)
4. Tropical Fish Passage
   - Low weirs solvable, with research
   - Large dams: larval drift
     turbine passage and tropical species
     high biomass, high flows, diversity of behaviour
     attraction flow

Mekong River





Gradient 1:100 to 1:250

90% time > 70 m^3/s

River = 20,000 m^3/s; channel = 2,000 m^3/s

Conclusions

1. Design Process

Biology, hydrology, hydraulics
⬇
Function
⬇
Design options
⬇
Cost effectiveness

2. Site focus; catchment vision
   - conserve flowing water (lotic) habitats

3. Transparency – risk, knowledge gaps

4. Collaborate