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Fishway design in the temperate S. Hemisphere

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Presenter Information

Martin Wilkes, Evelyn Habit, Oscar Link, Lee Baumgartner, Craig Boys, Justin O'Connor, Matthew Jones, and Ivor Stuart

Fishway design in the temperate S. Hemisphere

Fish Passage 2017, Corvallis, Oregon

Martin Wilkes (Coventry U.)
Evelyn Habit & Oscar Link (U. Concepción); Luiz Silva (UFSJ)
Angus Webb (U. Melbourne); Lee Baumgartner (Charles Sturt U.)
Craig Boys (NSW Dept. Primary Industries/Charles Sturt U.);
Justin O'Connor, Matthew Jones & Ivor Stuart (Arthur Rylah Institute)



DTU Aqua
National Institute of Aquatic Resources



Knowledge Exchange for Efficient Passage of Fish in the Southern Hemisphere (KEEPFISH)

Martin Wilkes (Coventry U.); Kim Aarestrup & Niels Jepsen (DTU-Aqua); Bernd Ettmer (HSM); Paul Franklin & Cindy Baker (NIWA); Evelyn Habit & Oscar Link (U. Concepción); Paul Kemp (U. Southampton); Paulo Pompeu (UFLA); Luiz Silva (UFSJ); Angus Webb (U. Melbourne)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 690857.

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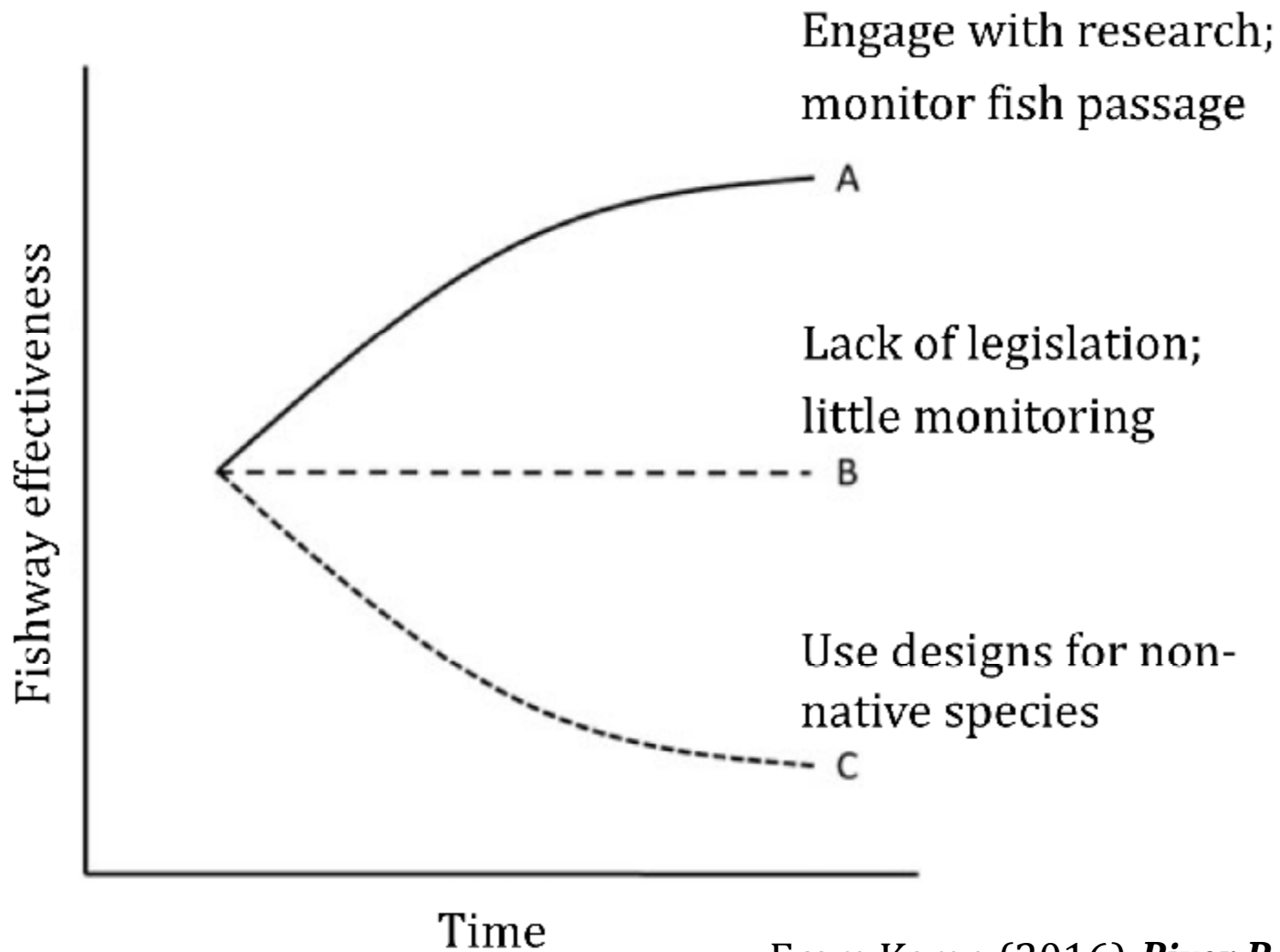
Fish passage in the Southern Hemisphere Network (FISH-Net)

Outline

- Global trends in fishway effectiveness
- The (neglected) temperate Southern Hemisphere
- A new approach to fishway design criteria:
 - Upstream fishway design for “migratory” species
 - Mortality during downstream passage
- Applications to hydropower planning, design and monitoring

Global trends in fishway effectiveness

Global trends in fishway effectiveness



From Kemp (2016) *River Res. Appl.*

Global trends in fishway effectiveness

RIVER RESEARCH AND APPLICATIONS

River Res. Applic. (2016)

Published online in Wiley Online Library



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The development of fish passage research in a historical context

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ARTICLE INFO

ABSTRACT

Grupo de Pesquisa em Tecnologia de Pesca e Conservação de Recursos Aquáticos e Ambientais (GPAZ/UEM)

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FA

Title: structures assisting the migrations of non-salmonid fish: Latin America...

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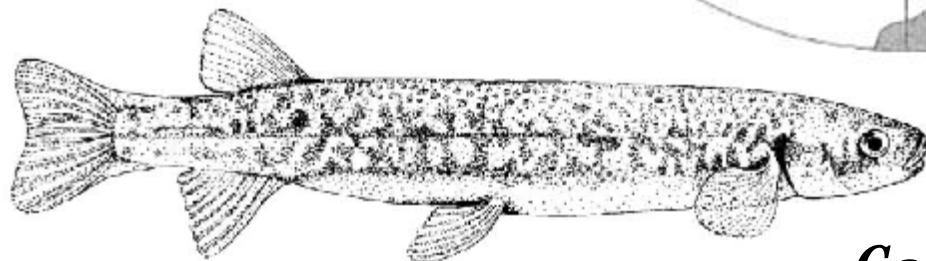
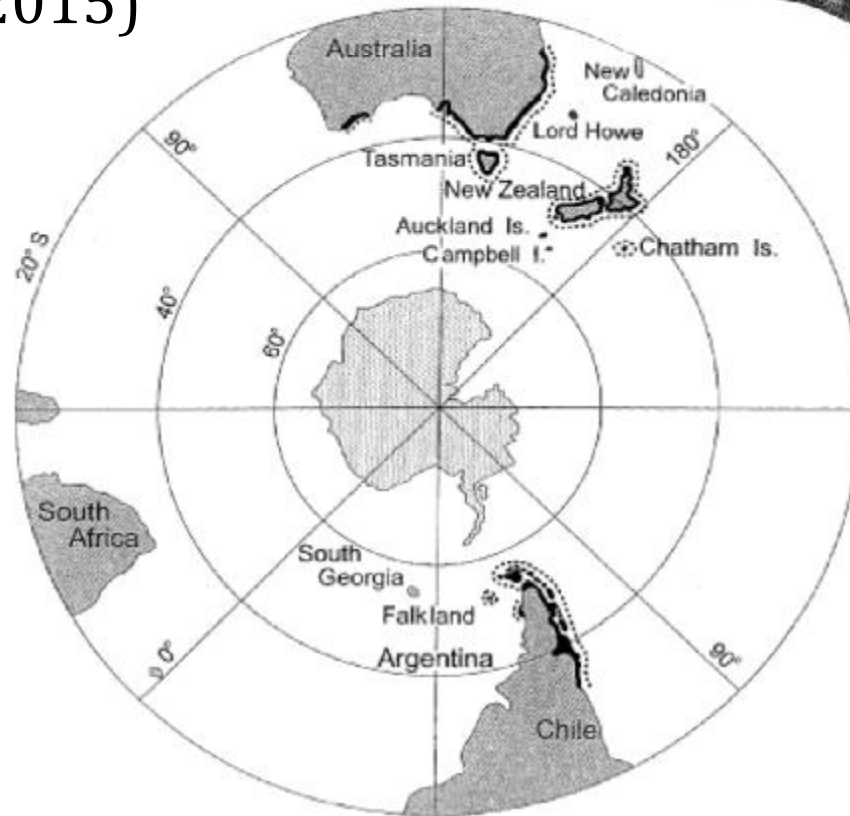
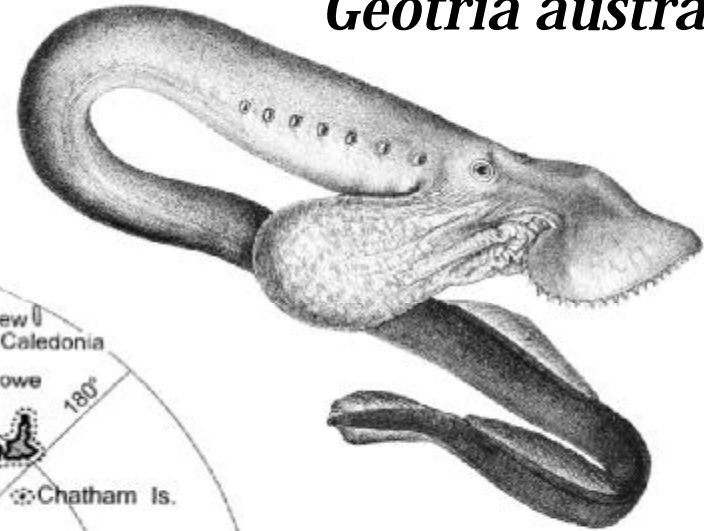
SS

The temperate Southern Hemisphere

Fish fauna

“Non-sport” fish <150 mm
(Link & Habit, 2015)

Geotria australis



Galaxias maculatus

Chilean freshwater species

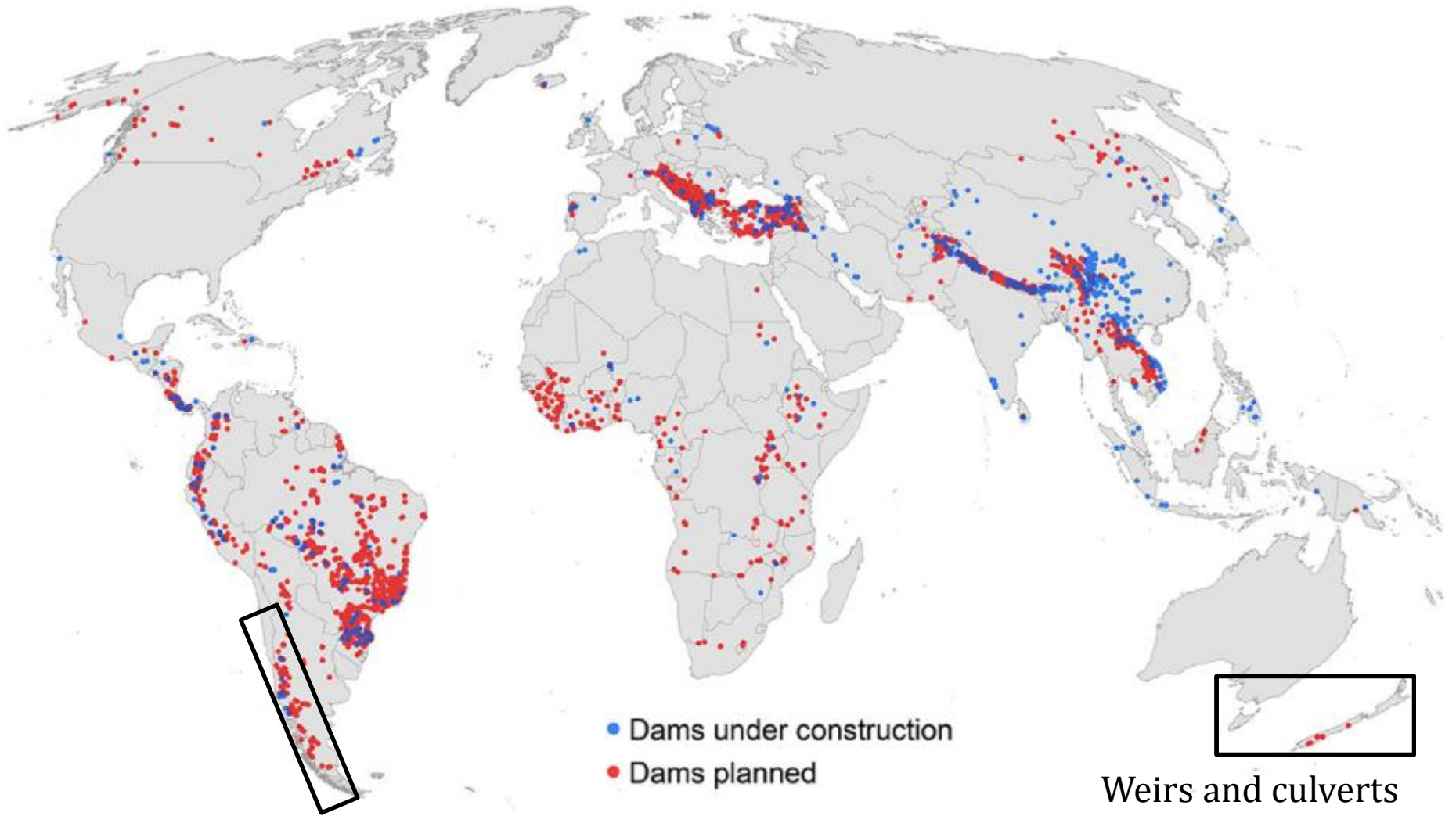
Wilkes et al. (in prep.)

Order	Family	Species	Conservation status	Life-history	
Petromyzontiforms	Geotridae	<i>Geotria australis</i>	Vulnerable	Anadromous	
	Mordaciidae	<i>Mordacia lapicida</i>	Endangered	Anadromous	
Characiforms	Characidae	<i>Cheirodon pisciculus</i>	Vulnerable	Resident	
		<i>Cheirodon galusdae</i>	Vulnerable	Resident	
		<i>Cheirodon kiliani</i>	Endangered	Resident	
		<i>Cheirodon australe</i>	Vulnerable	Resident	
Siluriforms	Nematogenyidae	<i>Nematogenys inermis</i>	Endangered	Resident	
	Trichomycteridae	<i>Bullockia maldonadoi</i>	Endangered	Resident	
		<i>Trichomycterus areolatus</i>	Vulnerable	Resident	
		<i>Trichomycterus chiltoni</i>	Endangered	Resident	
		Diplomystidae	<i>Diplomystes chilensis</i>	Endangered	Resident
			<i>Diplomystes nahuelbutaensis</i>	Endangered	Resident
			<i>Diplomystes camposensis</i>	Endangered	Resident
			<i>Diplomystes incognitus</i>	Not classified	Resident
Galaxiforms	Galaxiidae	<i>Galaxias maculatus</i>	Vulnerable	Catadromous*	
		<i>Galaxias globiceps</i>	Endangered	Resident	
		<i>Galaxias platei</i>	Least concern	Resident	
		<i>Brachygalaxias bullocki</i>	Vulnerable	Resident	
		<i>Aplochiton zebra</i>	Endangered	Resident	
		<i>Aplochiton marinus</i>	Endangered	Marine-estuarine	
		<i>Aplochiton taeniatus</i>	Endangered	Catadromous**	
Artheriniforms	Artherinopsidae	<i>Basilichthys microlepidotus</i>	Vulnerable	Resident	
		<i>Odontesthes mauleanum</i>	Vulnerable	Resident	
		<i>Odontesthes brevianalis</i>	Vulnerable	Resident - Estuarine	
Perciforms	Percichthyidae	<i>Percichthys trucha</i>	Near threatened	Resident	
	Perciliidae	<i>Percichthys melanops</i>	Vulnerable	Resident	
		<i>Percilia irwini</i>	Endangered	Resident	
		<i>Percilia gillissi</i>	Endangered	Resident	
Mugiliforms	Mugilidae	<i>Mugil cephalus</i>	Least concern	Catadromous	

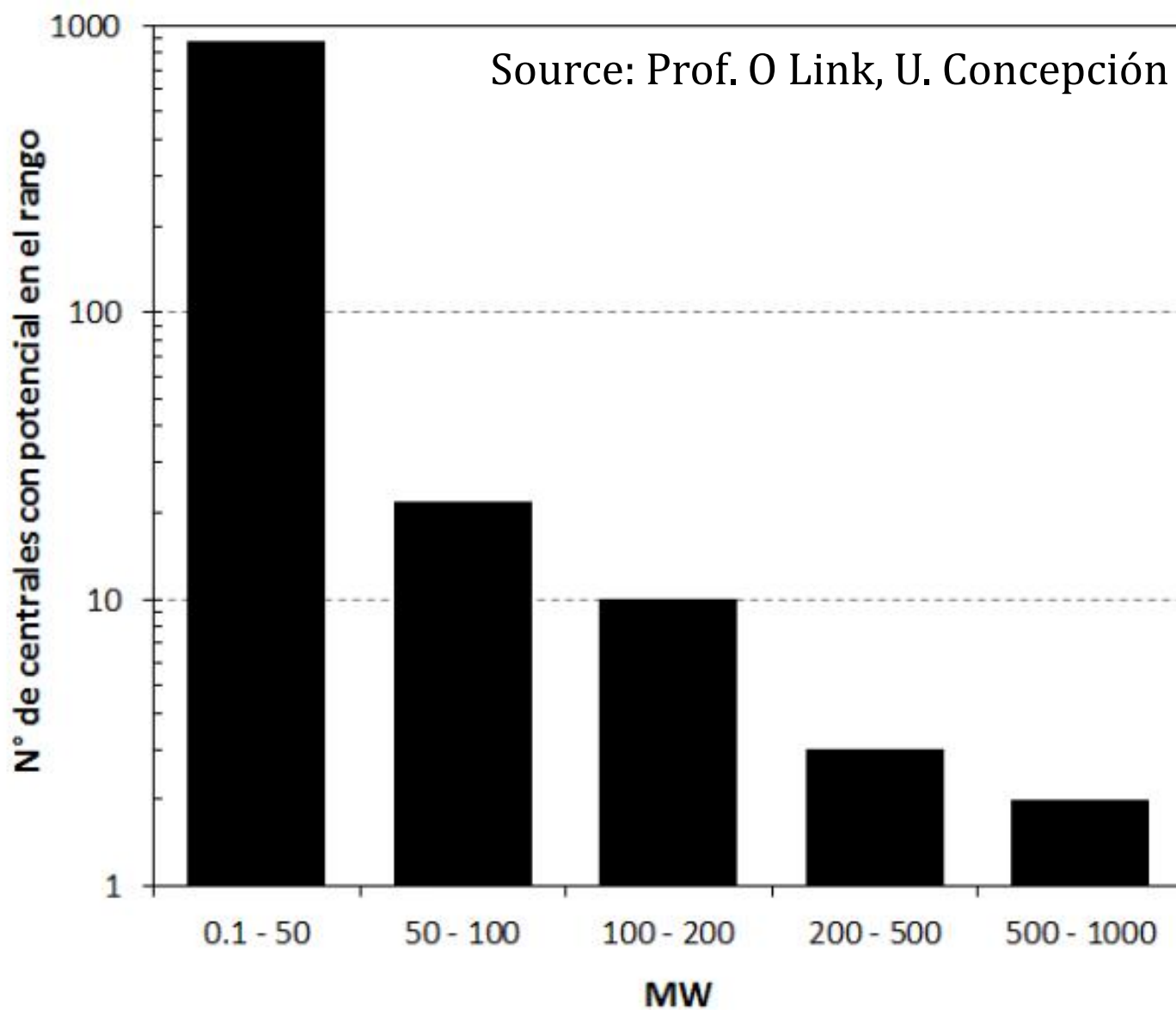
Adapted from Link & Habit (2015) *Rev. Environ. Sci. Biotechnol.* 14 (1) 9-21.

Hydropower pressure

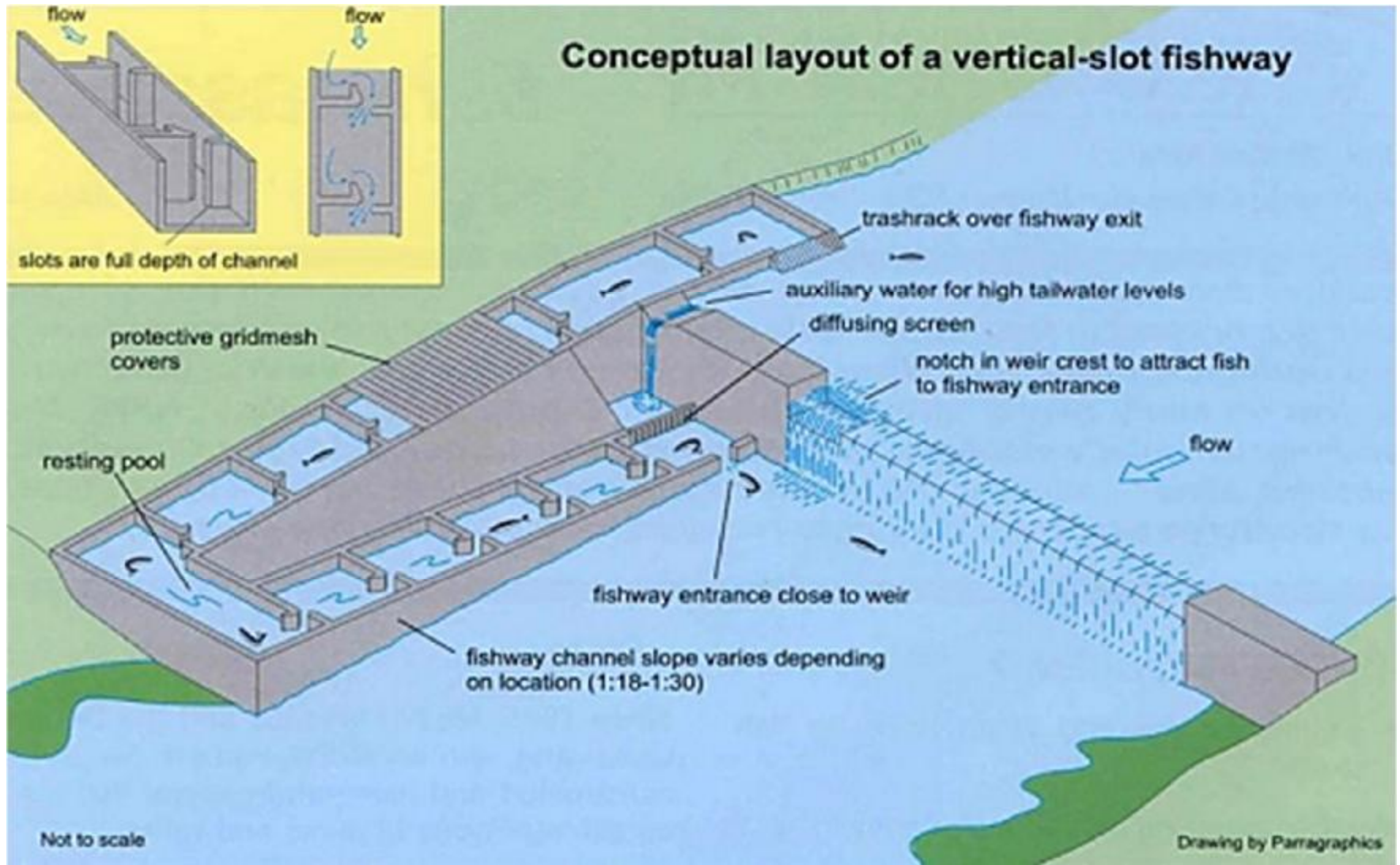
Zarfl et al. (2015) *Aquat. Sci.* 77 (1) 161-170.



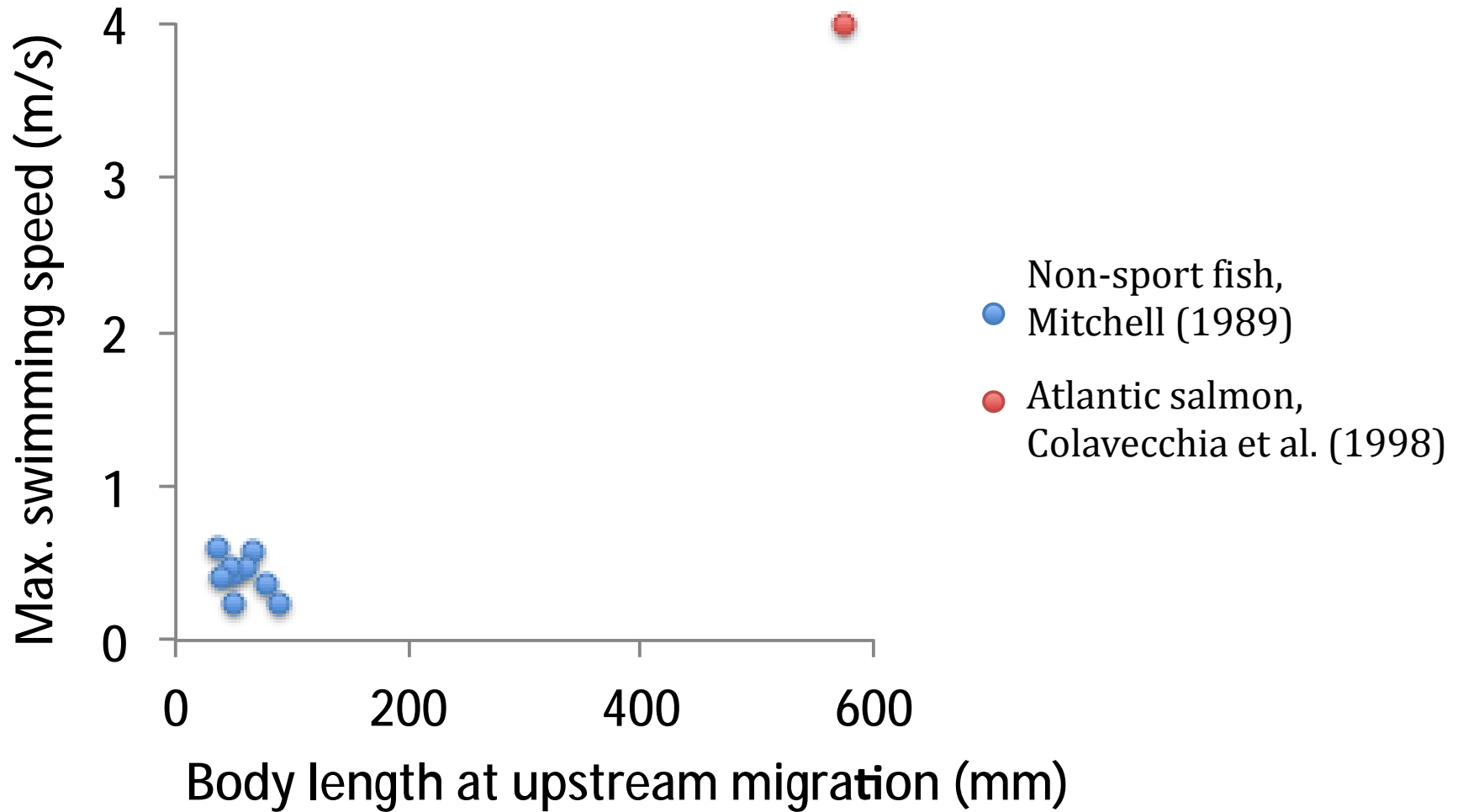
Rapid hydropower development in Chile



Fishways as mitigation



"Non-sport" fish



A new approach to fishway design criteria

Design criteria

- Approach:
 - Systematic evidence review (Eco Evidence)



Design criteria



- Approach:
 - Systematic evidence review (Eco Evidence)
 - Expert elicitation workshops

The image shows two overlapping presentation slides. The top slide is titled 'Expert Elicitation Workshop' and features a collage of images including a blue fish, a hand holding a small object, and a stream. The bottom slide is titled 'Scenario guide' and features a similar collage of images. At the bottom of the bottom slide, the text reads: 'Fishway design criteria for non-sport species' and '26 September 2016, University of Melbourne'.

Design criteria

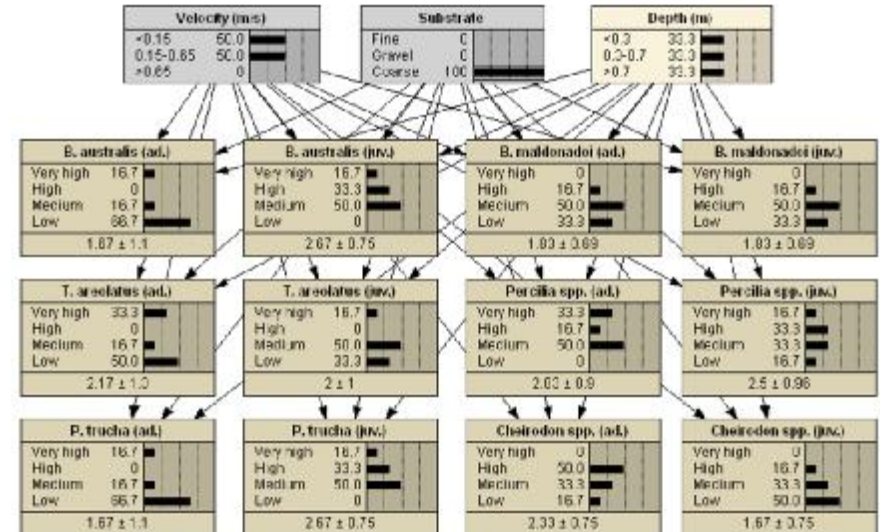


- Approach:
 - Systematic evidence review (Eco Evidence)
 - Expert elicitation workshops
 - Bayesian Networks

Expert Elicitation Workshop

Scenario guide

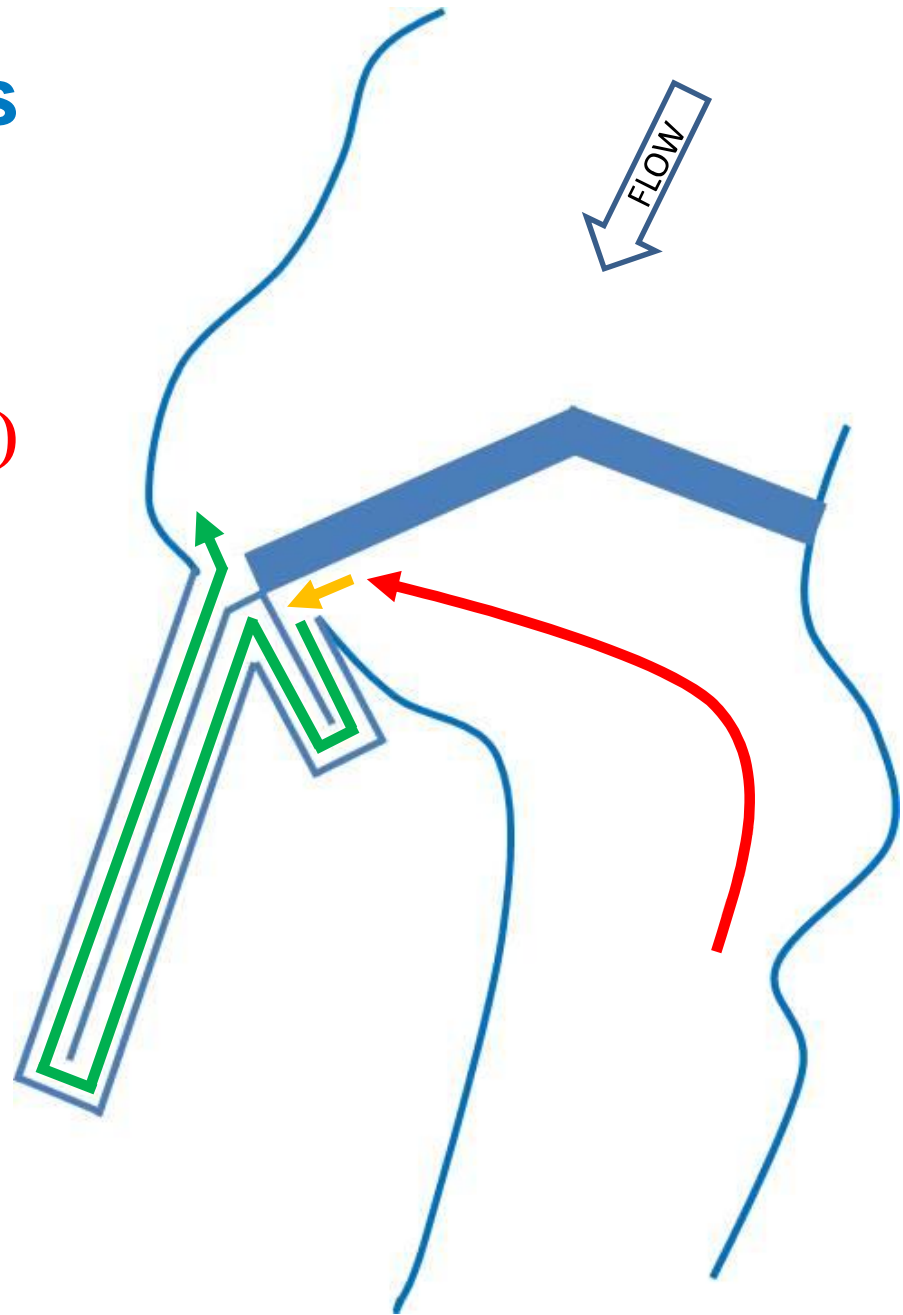
Fishway design criteria for non-sport species
26 September 2016, University of Melbourne



Fishway effectiveness

Definitions

- **Attraction efficiency (%)**
- **Entrance efficiency (%)**
- **Passage efficiency (%)**

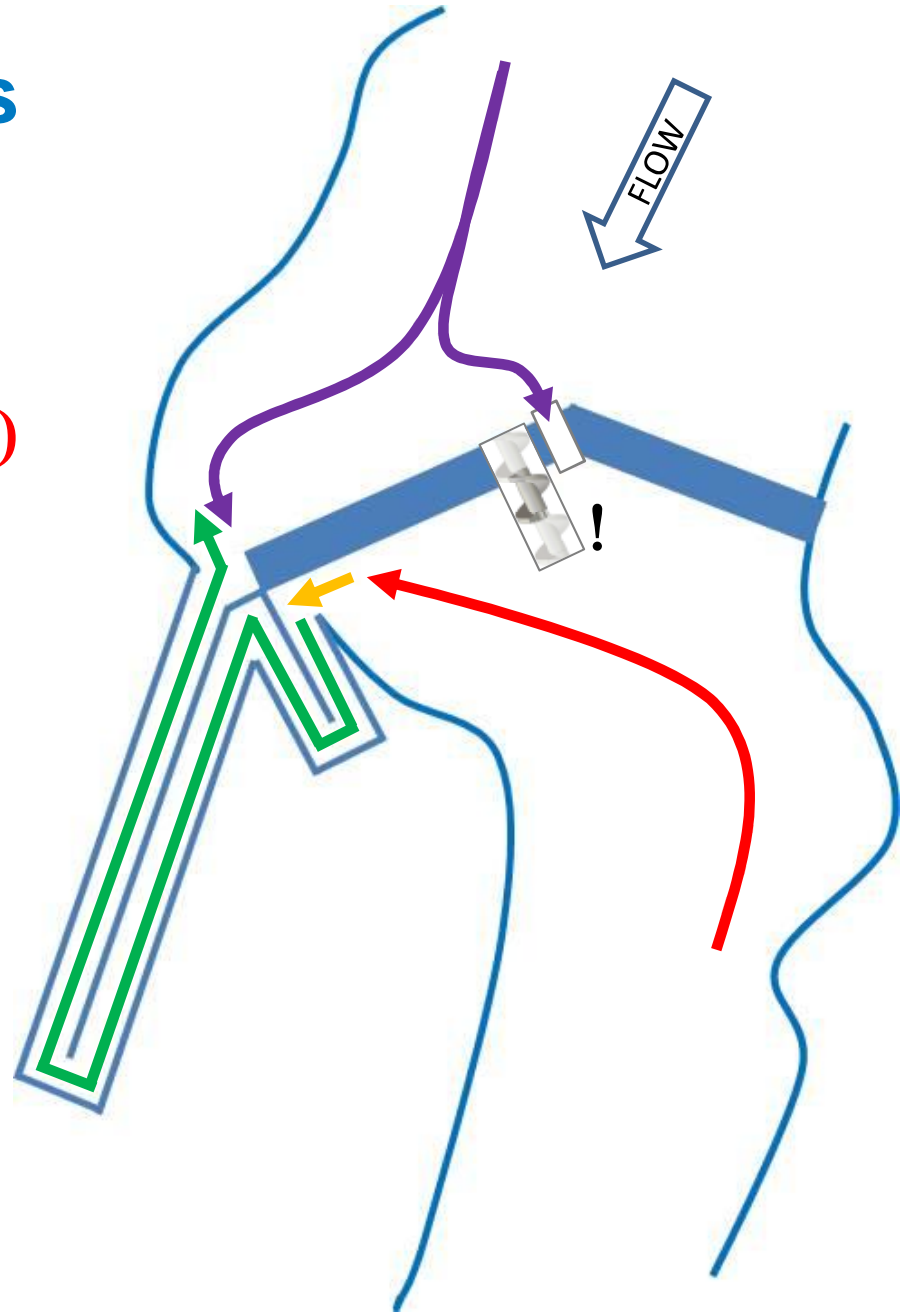


Kemp & O'Hanley (2010)

Fishway effectiveness

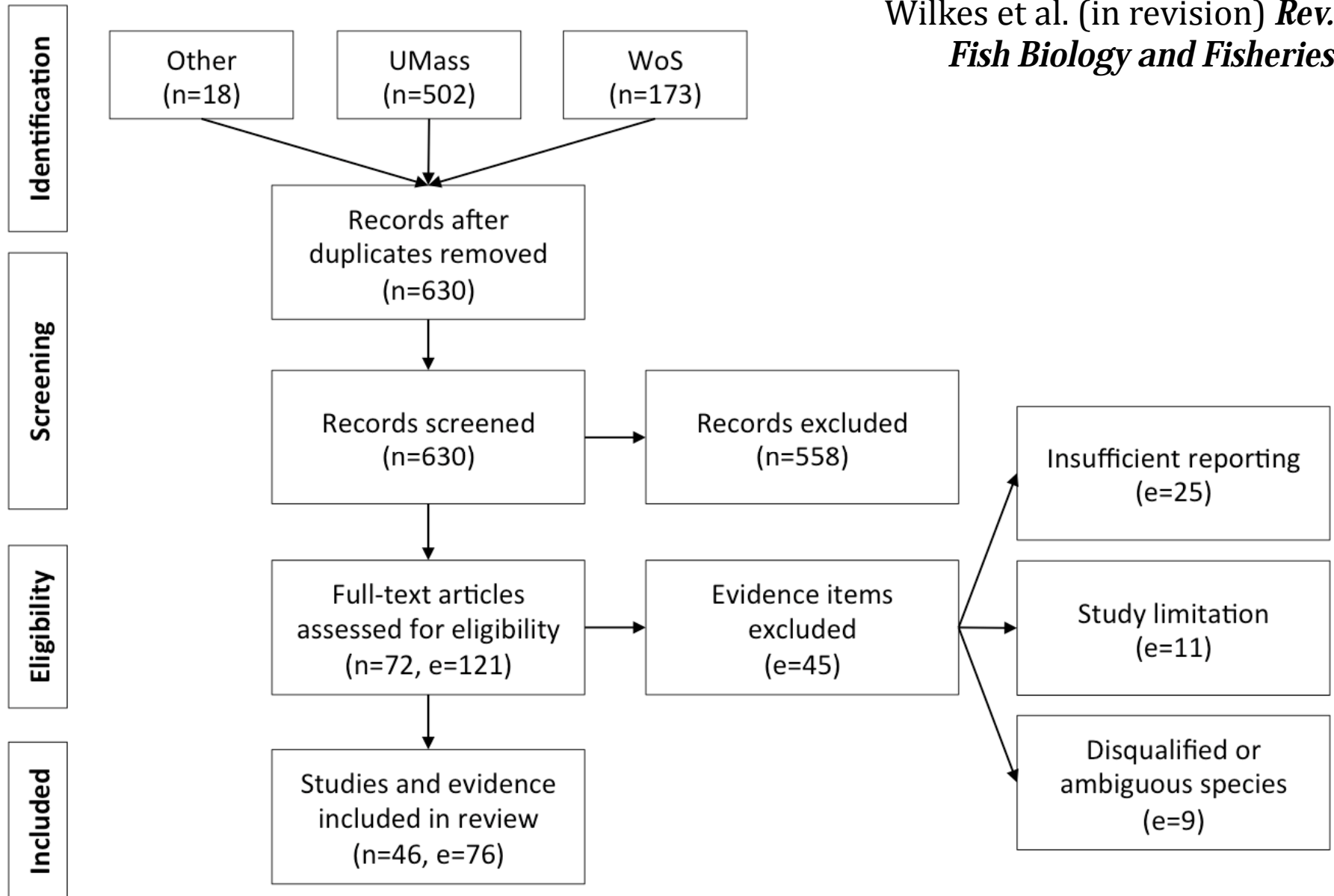
Definitions

- **Attraction efficiency (%)**
- **Entrance efficiency (%)**
- **Passage efficiency (%)**
- **Guidance efficiency (%)**
- **Turbine entrainment (% mortality)**
 - Pressure
 - Fluid shear
 - Blade strike



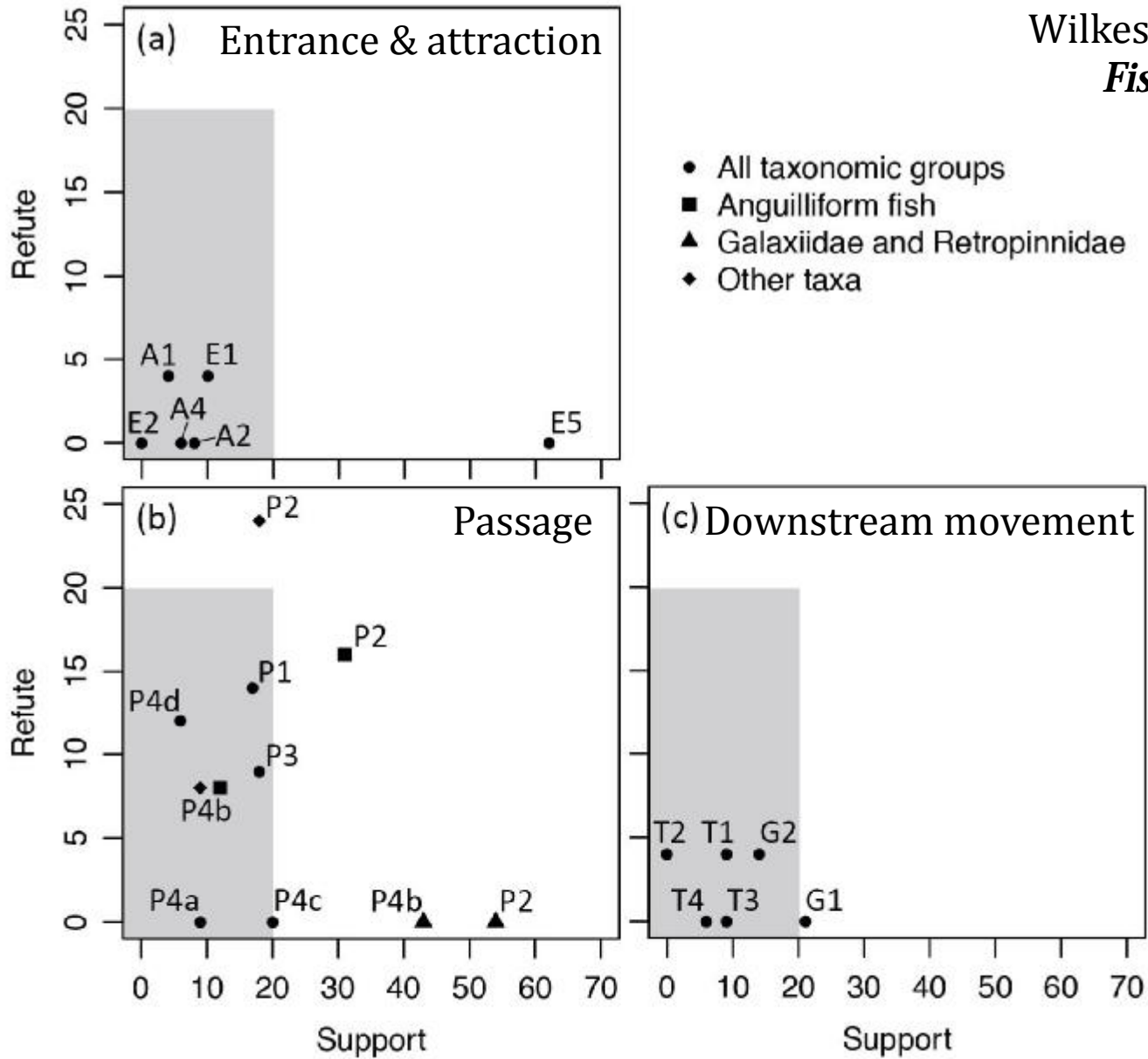
Systematic evidence review

Wilkes et al. (in revision) *Rev. Fish Biology and Fisheries*



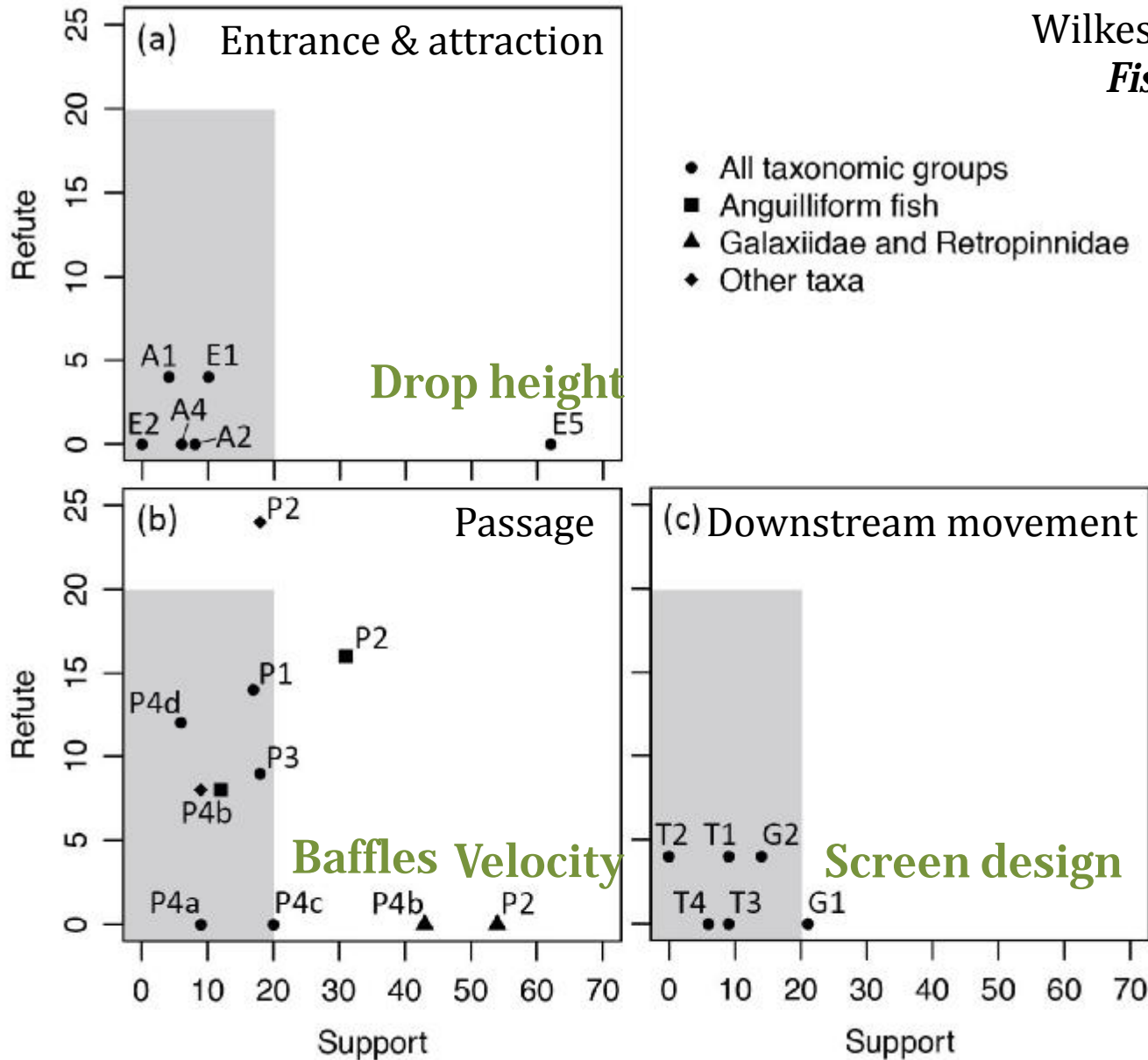
Systematic evidence review

Wilkes et al. (in revision) *Rev. Fish Biology and Fisheries*



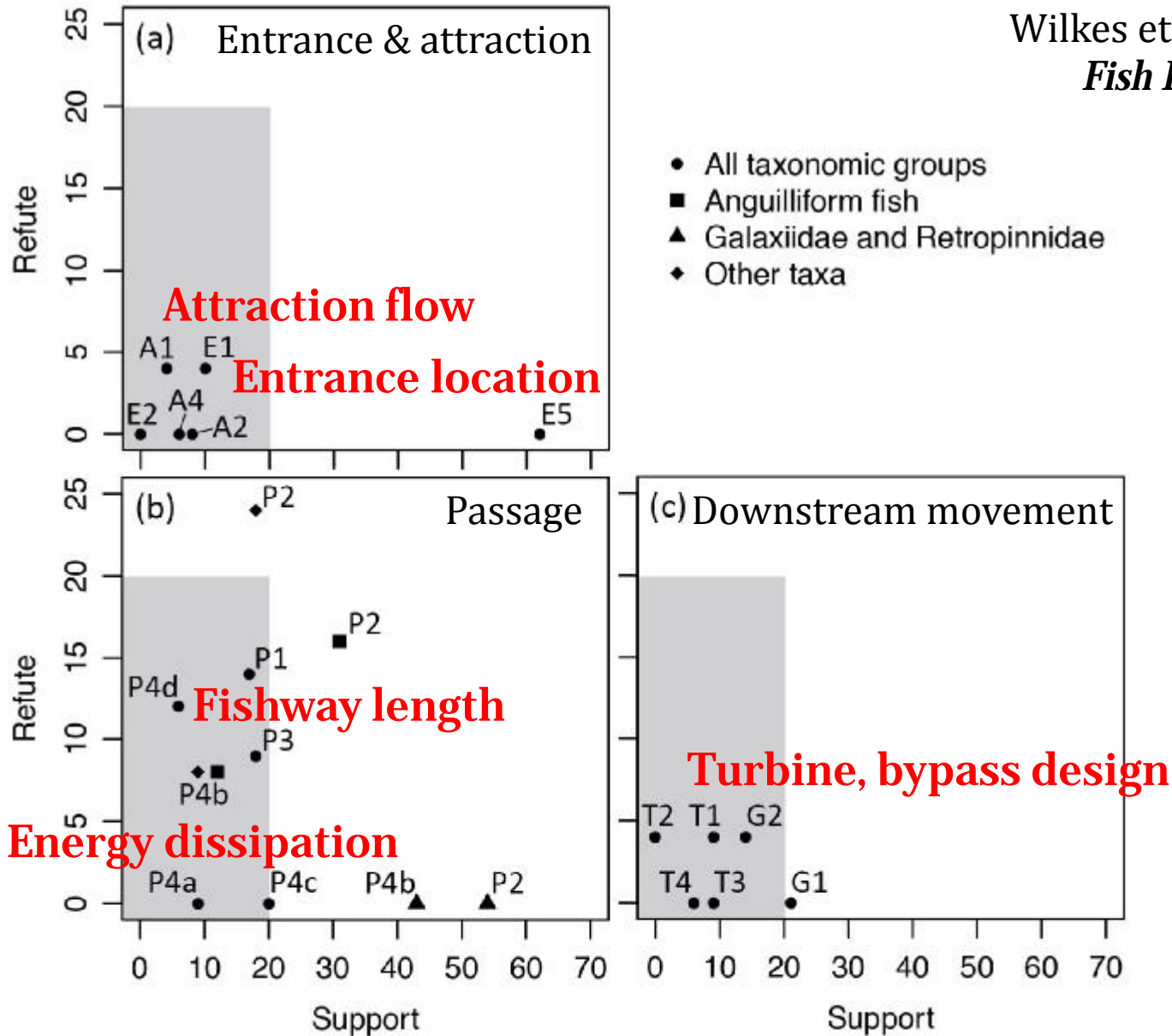
Systematic evidence review

Wilkes et al. (in revision) *Rev. Fish Biology and Fisheries*



Systematic evidence review

Wilkes et al. (in revision) *Rev. Fish Biology and Fisheries*



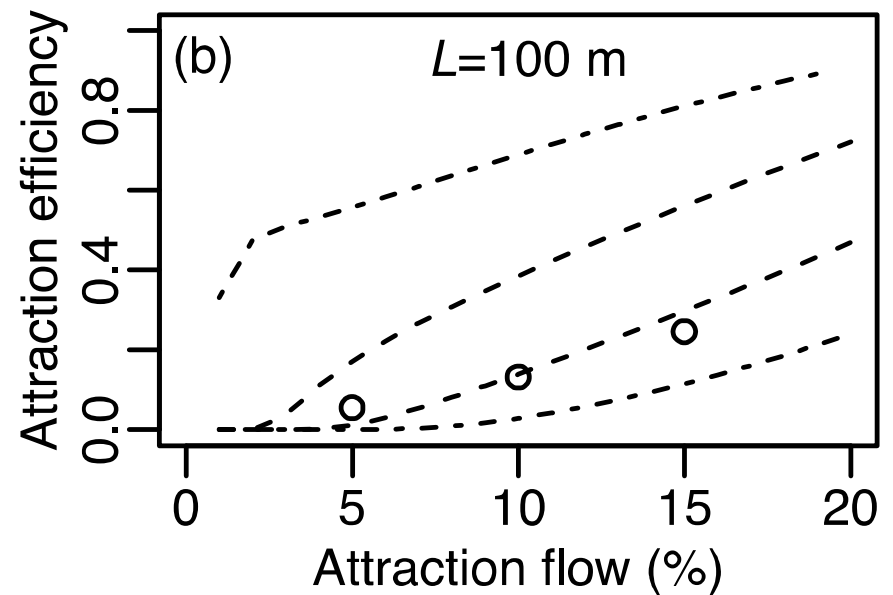
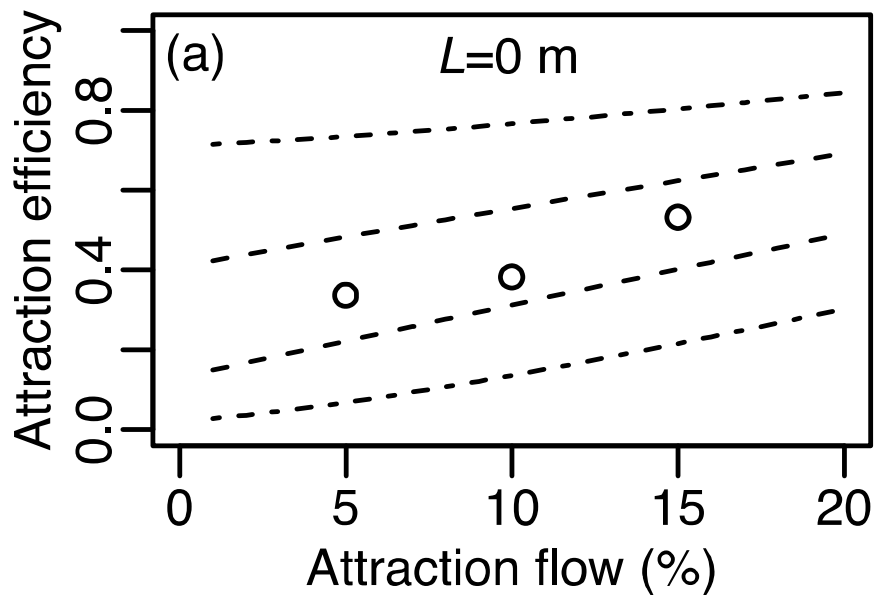
Systematic evidence review

- Key findings:
 - Not enough empirical evidence
 - Attraction of fish and downstream movement neglected
 - Incomplete monitoring data and insufficient reporting
 - Need to combine little evidence with expert knowledge and numerical modelling

Bayesian networks: Upstream passage

L=Distance of entrance from Barrier

- Best estimate
- - - 50% intervals
- - - - 95% intervals



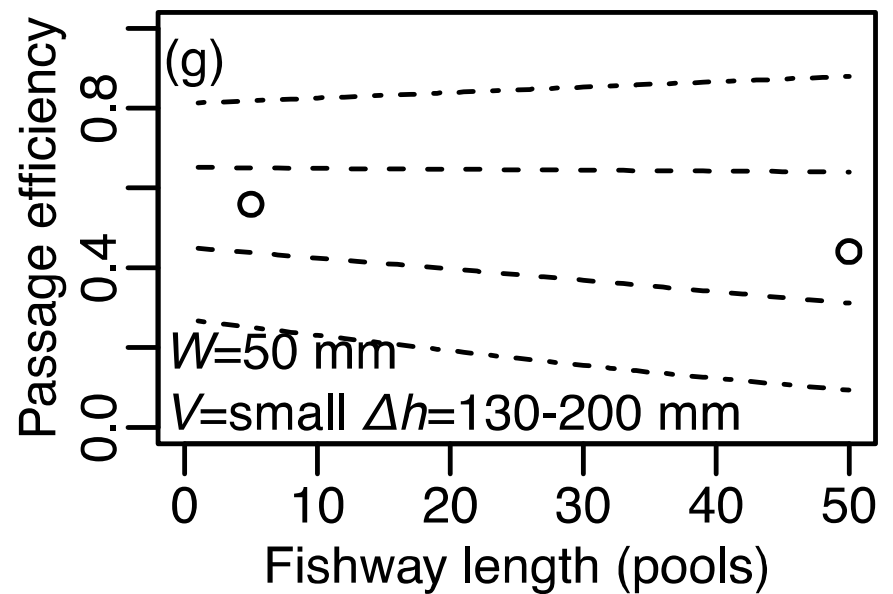
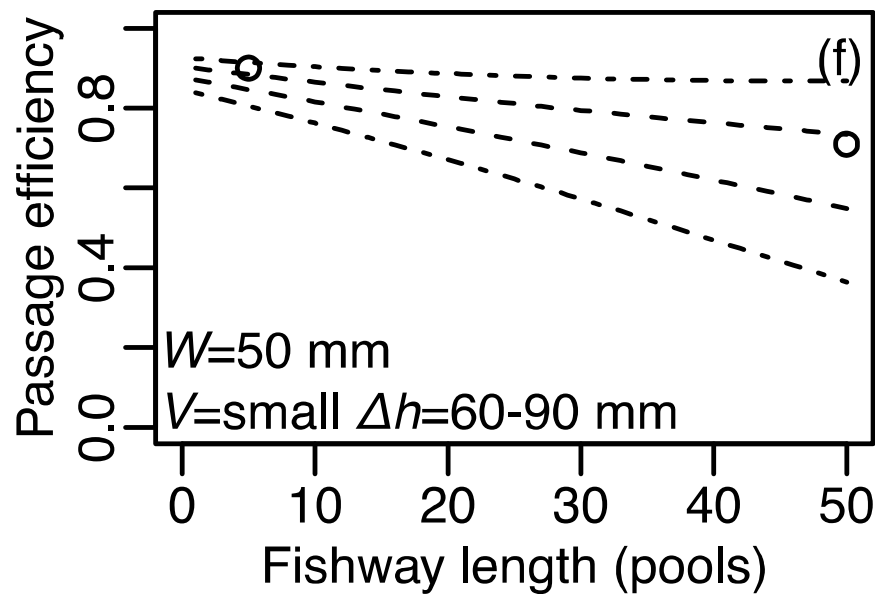
Bayesian networks: Upstream passage

W =slot width

V =pool volume

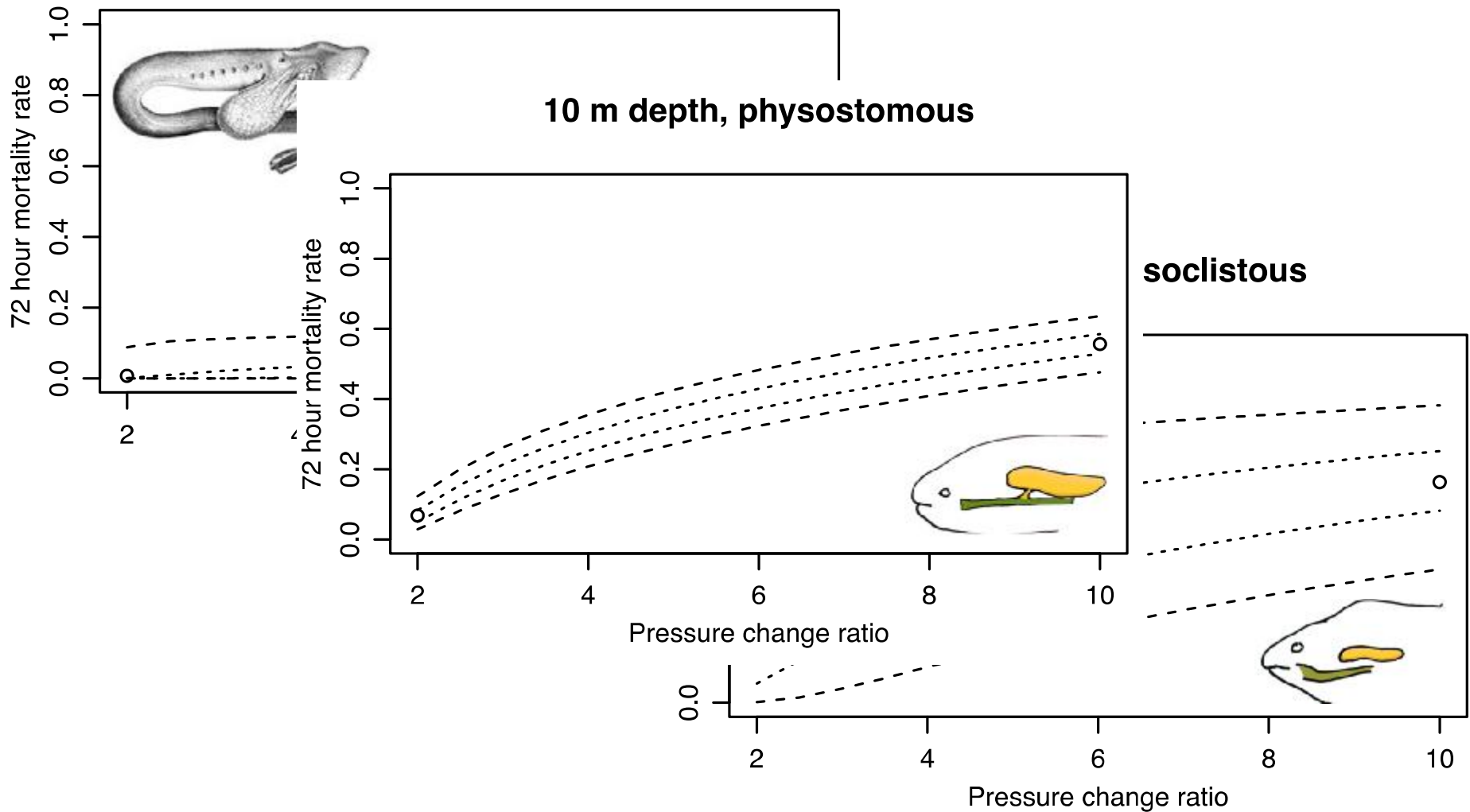
Δh =head loss

- Best estimate
- - - 50% intervals
- - - - 95% intervals



Bayesian networks: Downstream passage Pressure

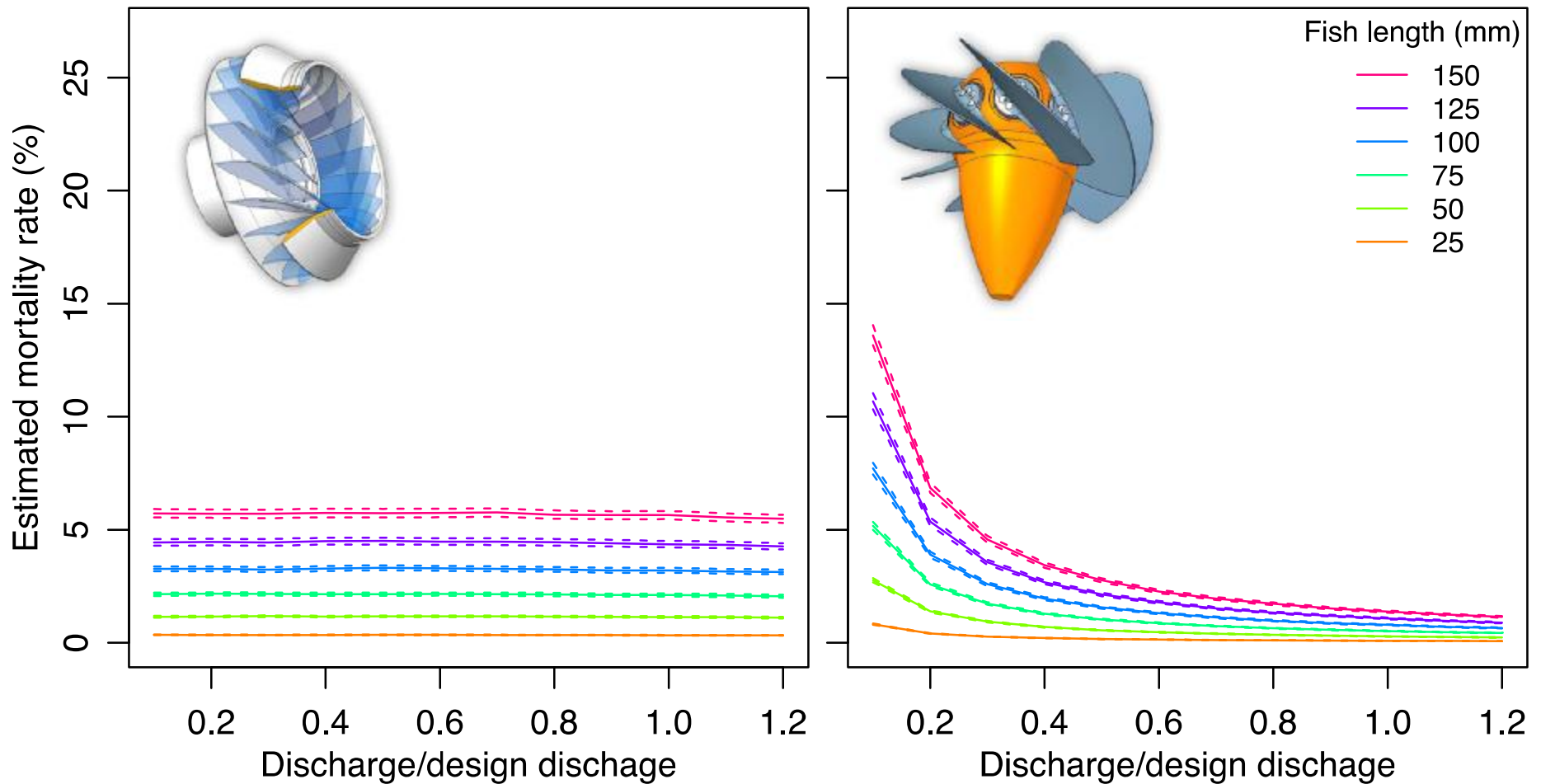
1 m depth, no swim bladder



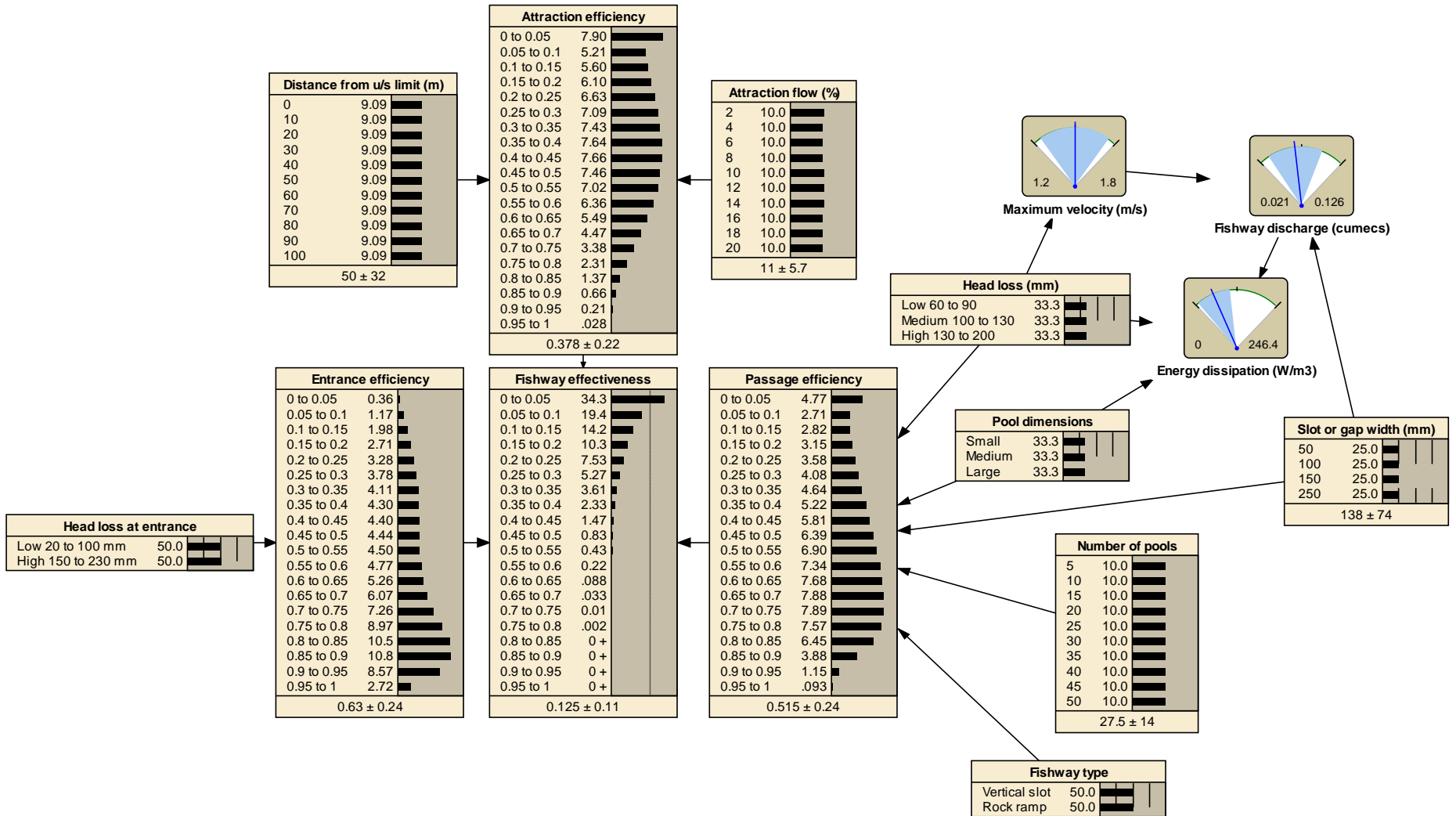
Bayesian networks: Downstream passage

Blade strike

Francis turbine (Ferguson et al., 2008) Kaplan turbine (Deng et al., 2007)

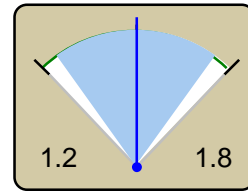


Upstream fishway design

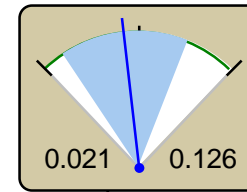


Upstream fishway design

Attraction flow (%)		
2	10.0	█
4	10.0	█
6	10.0	█
8	10.0	█
10	10.0	█
12	10.0	█
14	10.0	█
16	10.0	█
18	10.0	█
20	10.0	█
11 ± 5.7		

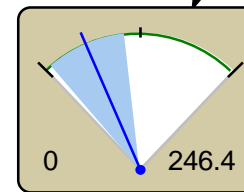


Maximum velocity (m/s)



Fishway discharge (cumecs)

Head loss (mm)		
Low 60 to 90	33.3	█
Medium 100 to 130	33.3	█
High 130 to 200	33.3	█



Energy dissipation (W/m³)

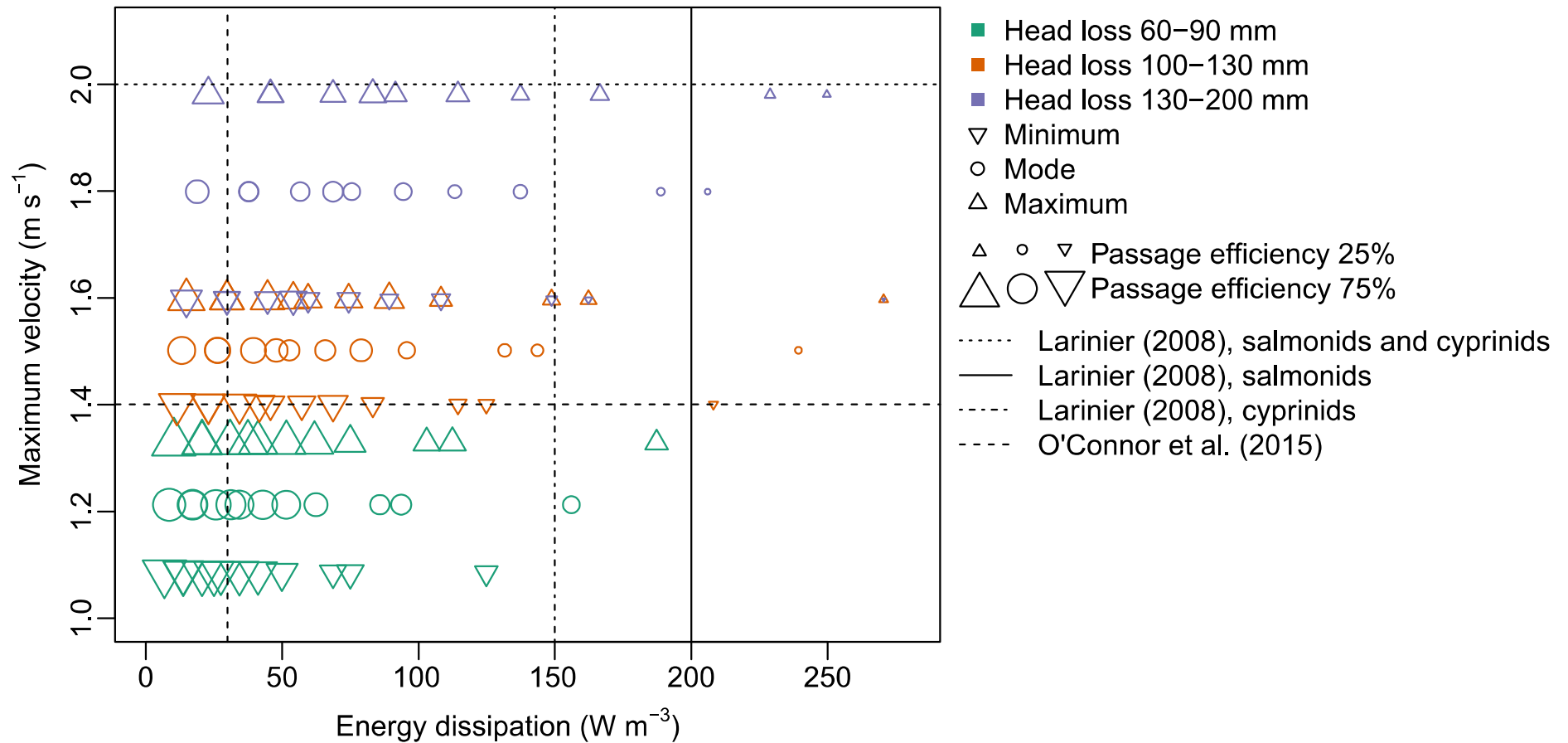
Pool dimensions		
Small	33.3	█
Medium	33.3	█
Large	33.3	█

Slot or gap width (mm)		
50	25.0	█
100	25.0	█
150	25.0	█
250	25.0	█
138 ± 74		

Passage efficiency		
0 to 0.05	4.77	█
0.05 to 0.1	2.71	█
0.1 to 0.15	2.82	█
0.15 to 0.2	3.15	█
0.2 to 0.25	3.58	█
0.25 to 0.3	4.08	█
0.3 to 0.35	4.64	█
0.35 to 0.4	5.22	█
0.4 to 0.45	5.81	█
0.45 to 0.5	6.39	█
0.5 to 0.55	6.90	█
0.55 to 0.6	7.34	█
0.6 to 0.65	7.68	█
0.65 to 0.7	7.88	█

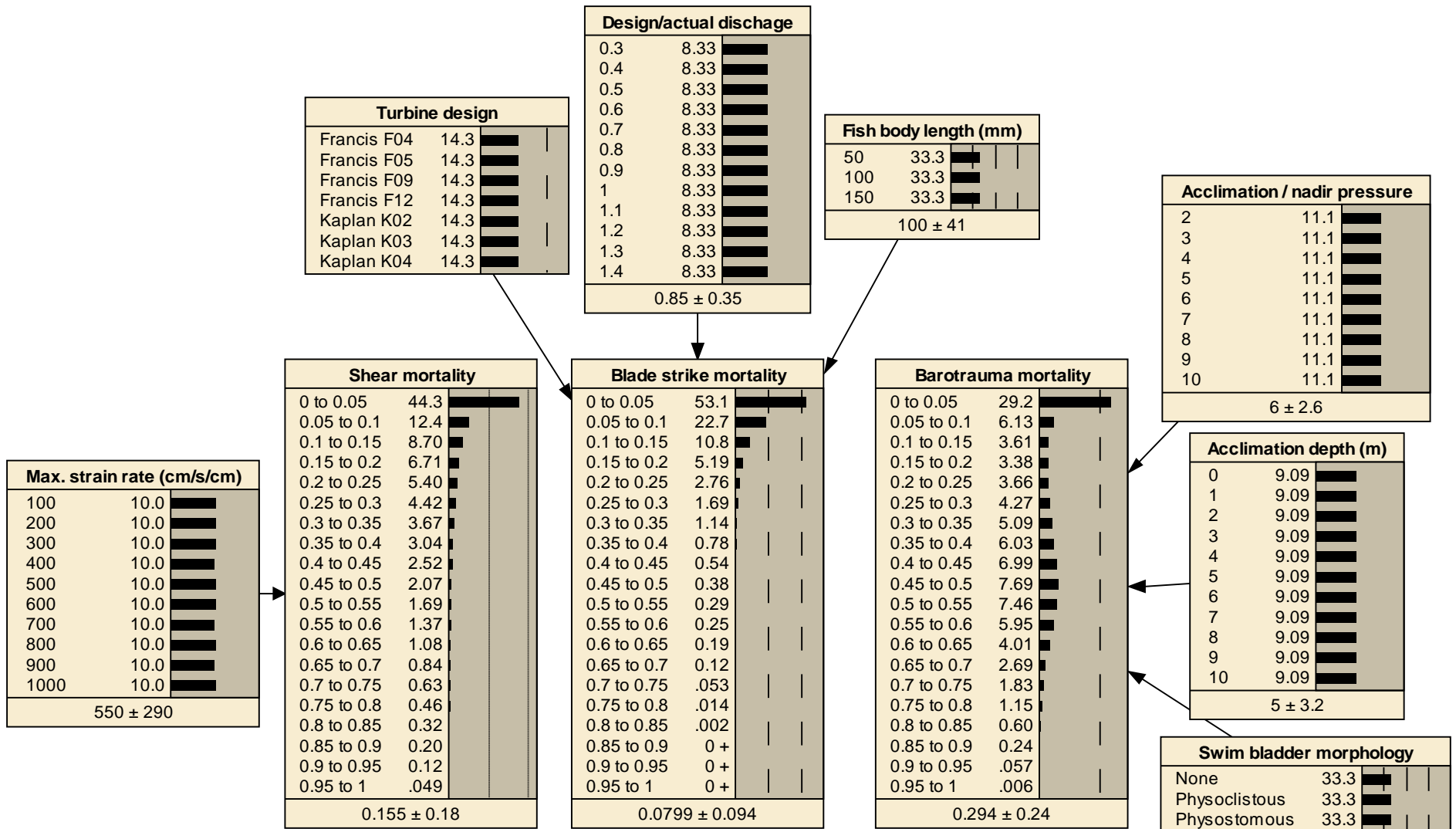
Number of pools		
5	10.0	█
10	10.0	█
15	10.0	█

Upstream fishway design criteria

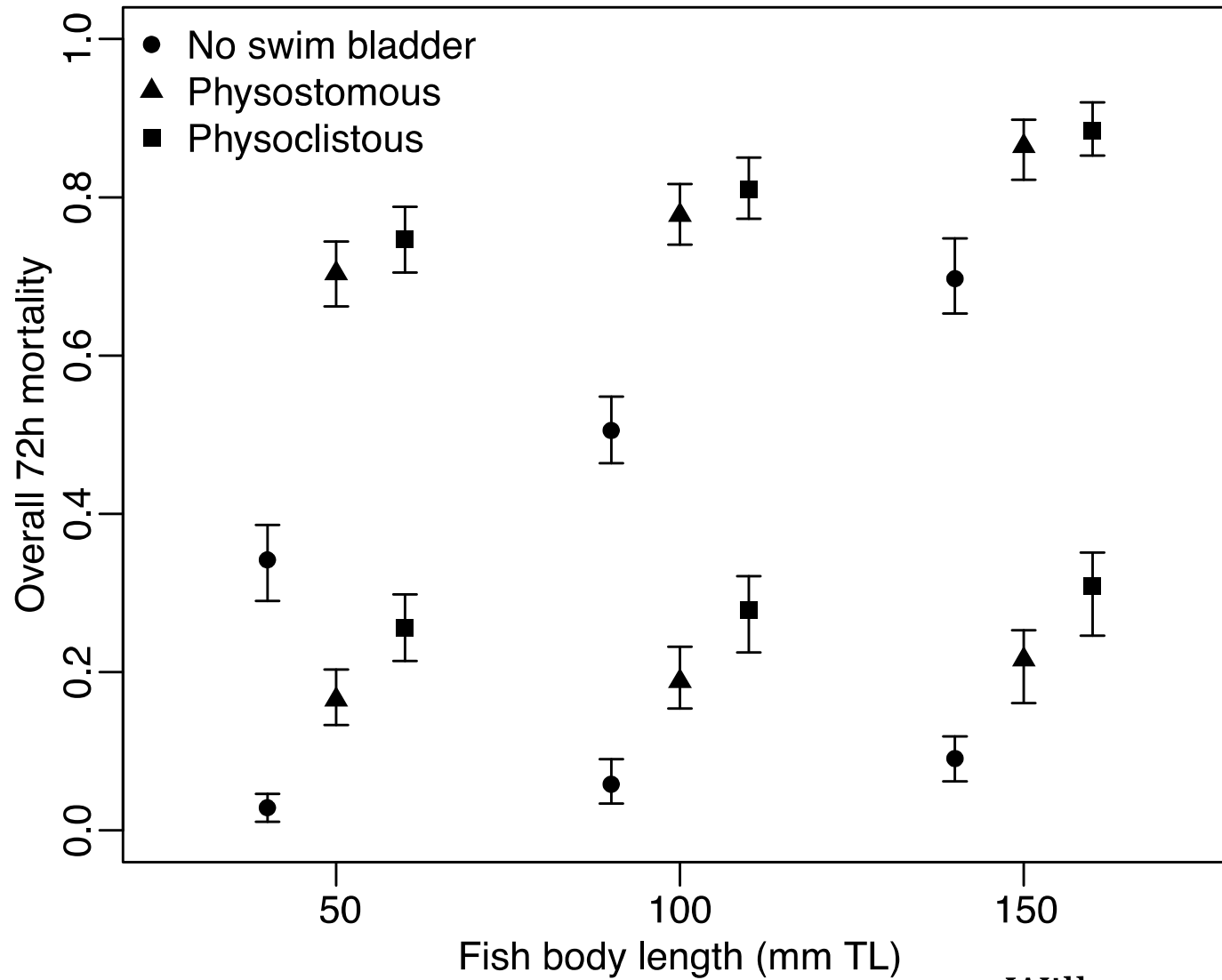


Wilkes et al. (in prep.)

Mortality during downstream passage



Mortality during downstream passage



Wilkes et al. (in prep.)

Bayesian networks

- Key findings:
 - N. Hemisphere criteria an order of magnitude too high
 - Attraction flow, turbine design and pressure most sensitive design parameters
 - Solutions could be near 0% or near 100% effective, depending on design
 - Local extinction, decline in fisheries and ecosystem services expected without sensitive planning and design

Applications to hydropower planning, design and monitoring

Applications

- Predict impact of barrier for planning and EIA
- Design fishways for any target species or group
- Set targets for fish screens and bypasses
- Trade-offs between cost, hydraulic & biological performance
- Prior probabilities for basic fish passage research

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