

Fish Swimming Performance: effect of flume length and fatigue definitions

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Importance of Fish Swimming Performance



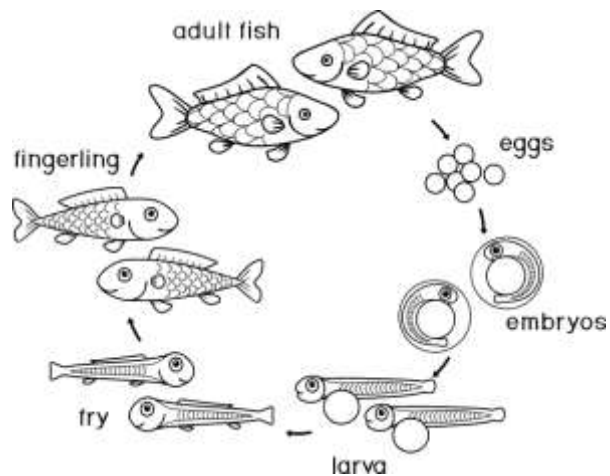
Fish passage



Fish migration*



Predator-prey interaction



Fish reproduction/survival



Habitat selection

* Photo retrieved from: <https://www.wanderfisch.info/en/migration>

What is Fish Swimming Performance?

- Time a fish can swim, under imposed flow conditions, **until fatigued**

Time to fatigue

$T_f \leq 20$ sec (Burst)







$20 \text{ sec} \leq T_f \leq 200$ minutes (Prolonged)

$T_f \geq 200$ minutes (Sustained)



Fish fatigued while being impinged/resting on the rear grid

What is Fatigue?

Reference	Fatigue definitions used
 <p>Romão et al. 2012</p>	<p>unable to remove itself from the grid despite 2 sec consecutive electric stimulation in a maximum 10 s period</p>
 <p>Tudorache et al. 2010</p>	<p>Impinged against the downstream grid and did not move for 3 sec</p>
 <p>Peake and Farrell, 2006</p>	<p>fell against the downstream retaining screen of the respirometer for 5 sec, and could not be stimulated (by gentle prodding) to resume swimming</p>
 <p>Karlsson-Drangsholt et al. 2018</p>	<p>stop swimming, despite encouraging the fish to move away from the grid by pinching the tail gently for 10 sec</p>
 <p>Veza et al. 2020</p>	<p>impinged on the downstream screen and ceased moving for more than 15 sec</p>
 <p>Heuer et al. 2021</p>	<p>stopped at the end of the test area, lightly patted the downstream wall for 20 s and still could not swim</p>

2 different fatigue definitions

Tapped fatigue

→ The time to fatigue defined as the **fish refusing to swimming despite tapping it for 3 times** as it stayed attached on the rear grid for ≥ 3 seconds.

Untapped Fatigue

→ The time to fatigue defined as the **fish refusing to swimming while being attached to the rear grid for the first time for 5 seconds** until the first tap.

Effect of flume length on swimming performance

Burst and coast:

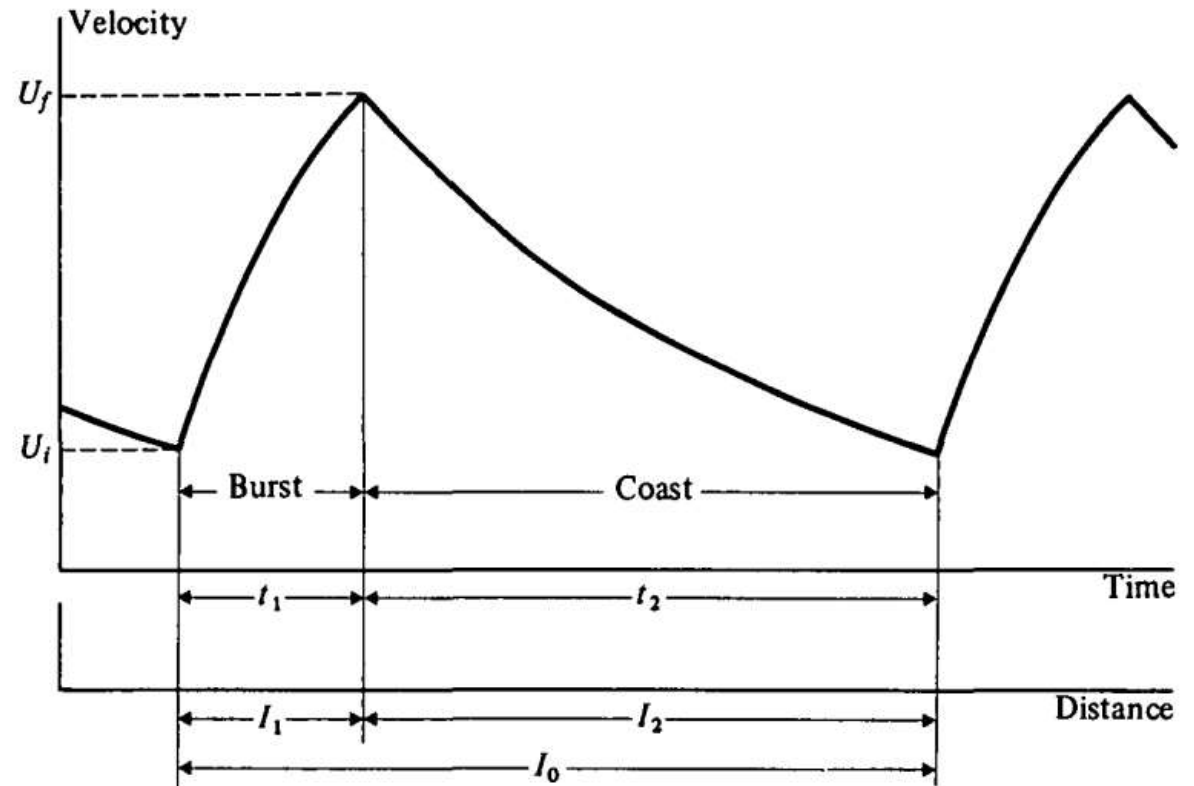
An energy saving swimming technique to increase performance

Burst movements involve higher tail beat frequencies and amplitude

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Flume length hinders:

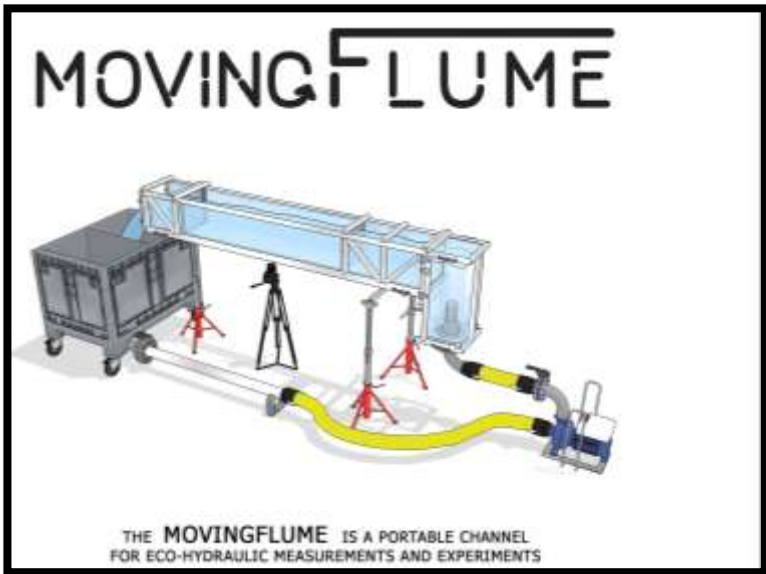
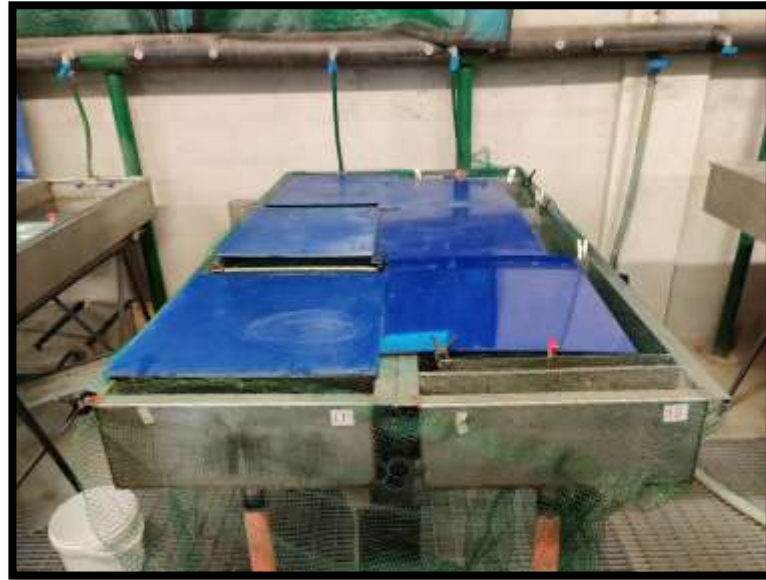
- Burst-and-coast behavior



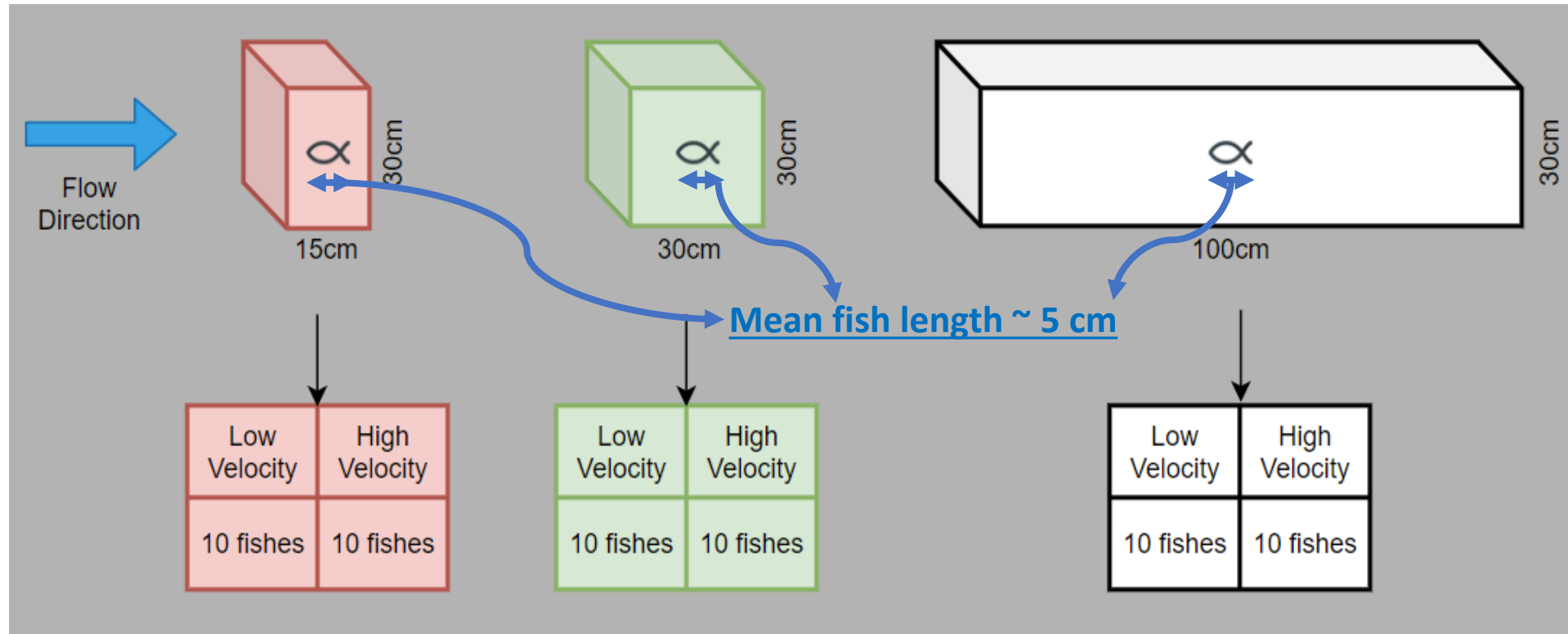
From: Videler and Weihs, 1981

Question of interest

- **Does flume length affect the fish swimming performance?**
- **Does the definition of fatigue influence fish swimming performance?**



Experimental configurations



Mean low flow velocity ~ 35 cm/s

Mean high flow velocity ~ 45 cm/s

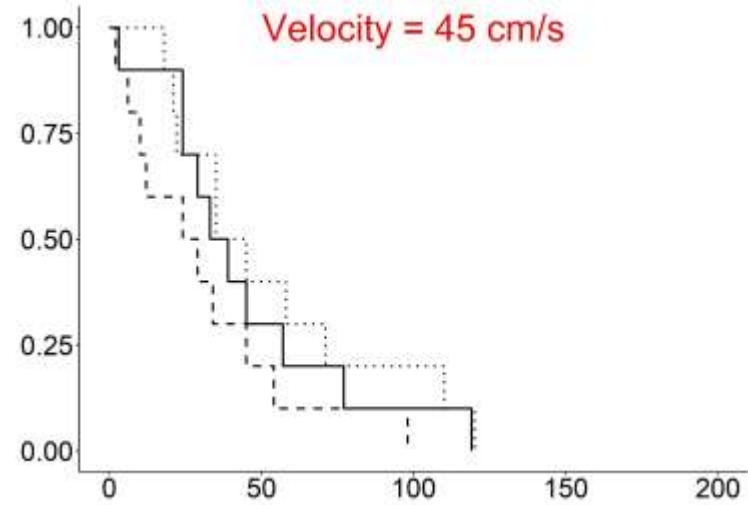
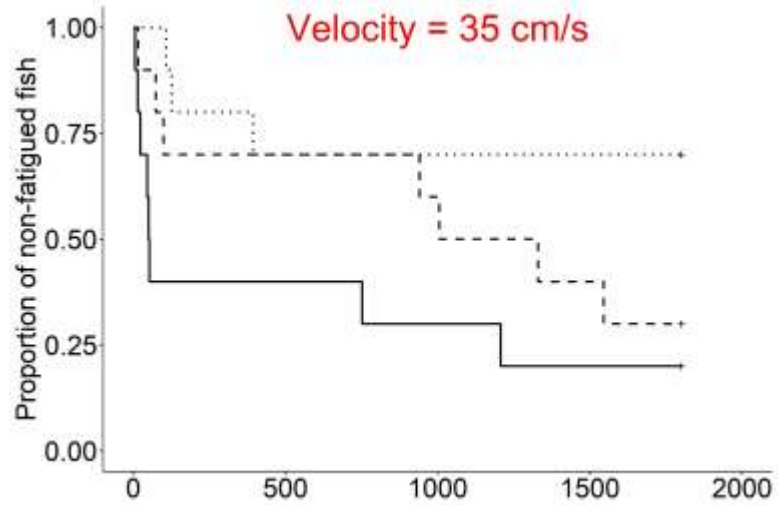
6 treatments with 10 fish each ~ A total of 60 fishes.

Survival Analysis

- Studying the **time passed** before some **event** occurs **to one or more covariates** that may be associated with that quantity of time
- **Cox Proportional-Hazards Regression Model**
- **Kaplan-Meier fatigue curves**

Results

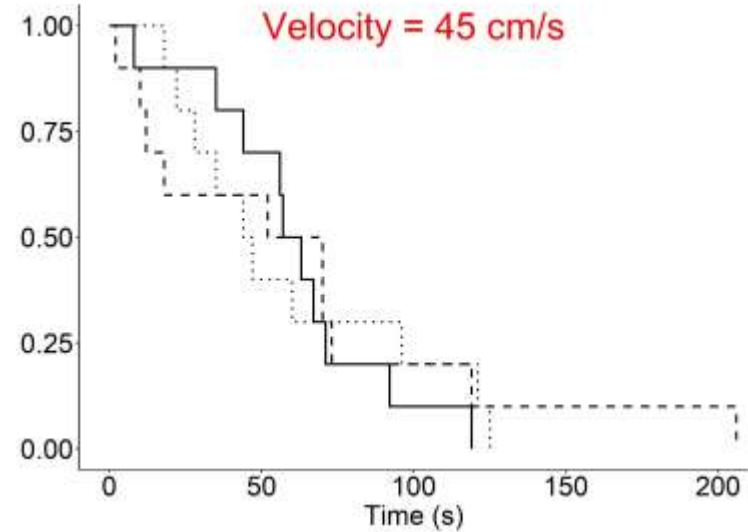
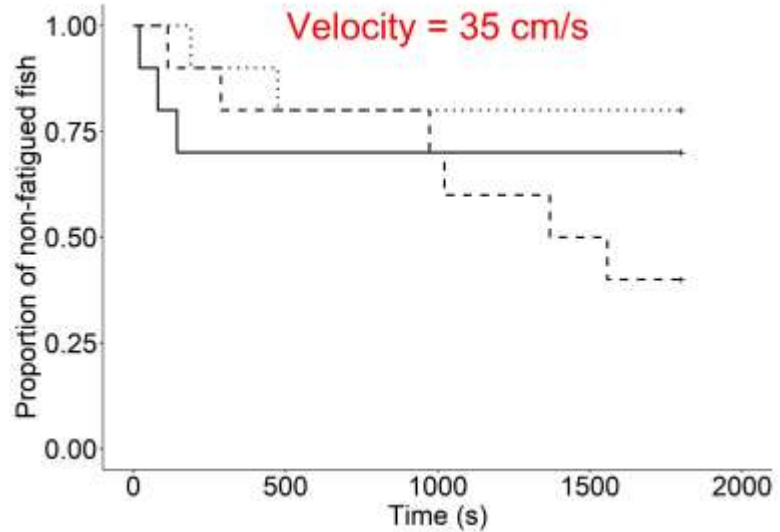
Untapped fatigue



Flume length

- 15 cm
- - - 30 cm
- 100 cm

Tapped fatigue



3 key takeaways

1. **Fish Behavior – Very Important**
2. **Fatigue is sensitive to its definition**
3. **Flume length influence swimming behavior and performance**

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Thank you



Any questions/comments?