# Michael Haynes

## Immediate Past Chair, Board of Directors, National Hydropower Association
## and
## Assistant General Manager, Seattle City Light


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***Gary Ivory***
***General Manager,***
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**Gia Schneider**
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***Commercial Director,***
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NATEL ENERGY

## High Performance FishSafe Hydropower Solutions

# How Policy and Legislation Is Making (or Could Make) a Positive Difference in Technology Innovation

WaterPower Week 2024
March 15, 2024

# Who we are

Natel is a technology and engineering company working to support healthy rivers, promote biodiversity, and decarbonize the grid.

**GIA SCHNEIDER**
CEO, co-founder

**ABE SCHNEIDER**
CTO, co-founder

**KIZZIE BROWN**
CFO

**GREGOR CADMAN**
COO, VP Engineering



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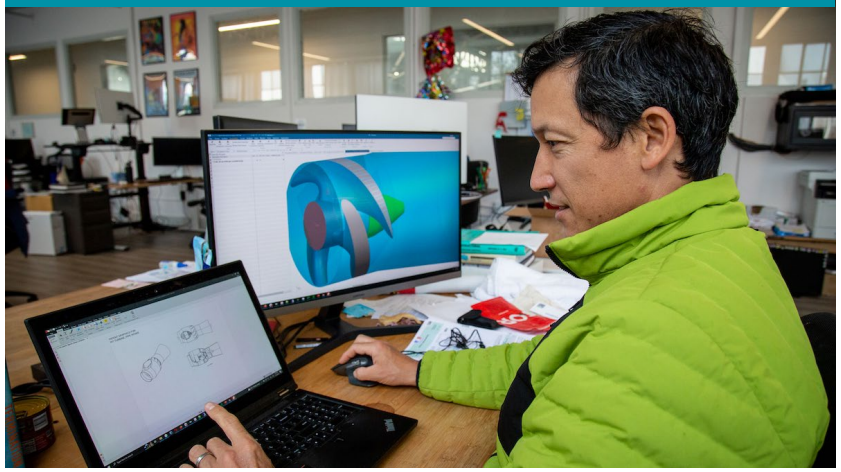
# What we do

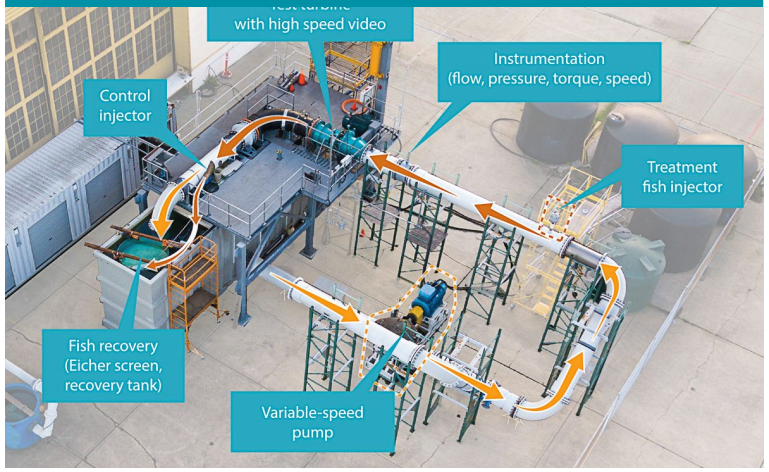
Natel specializes in data-driven hydraulic design of FishSafe™ hydropower turbines.

## FishSafe Turbine Design

## Engineering Services



## Lab Testing: Scale model performance & fish passage




We partner with turbine manufacturing companies to realize our designs. We can work across the value chain to assess feasibility and support implementation of turbines designed for fish safety at hydro projects.



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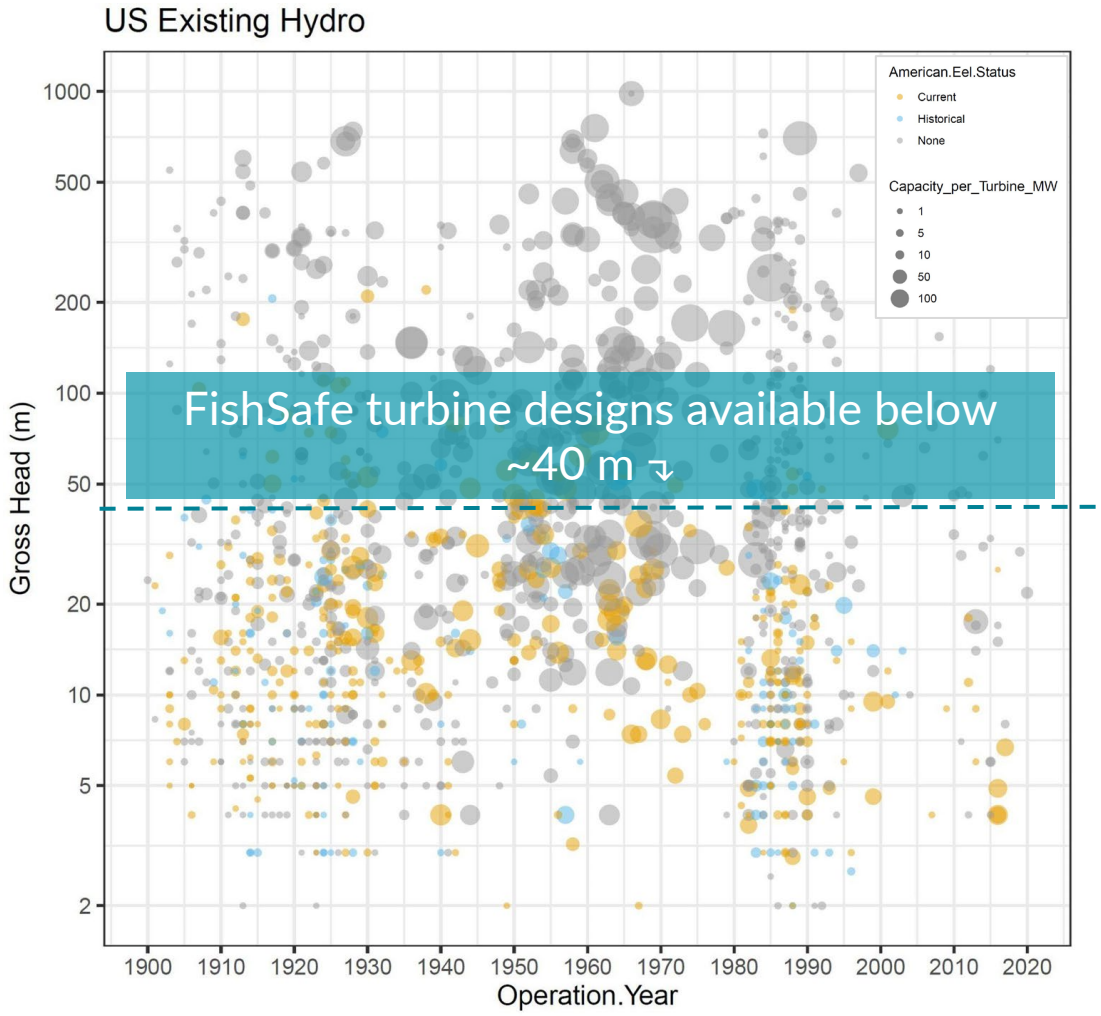
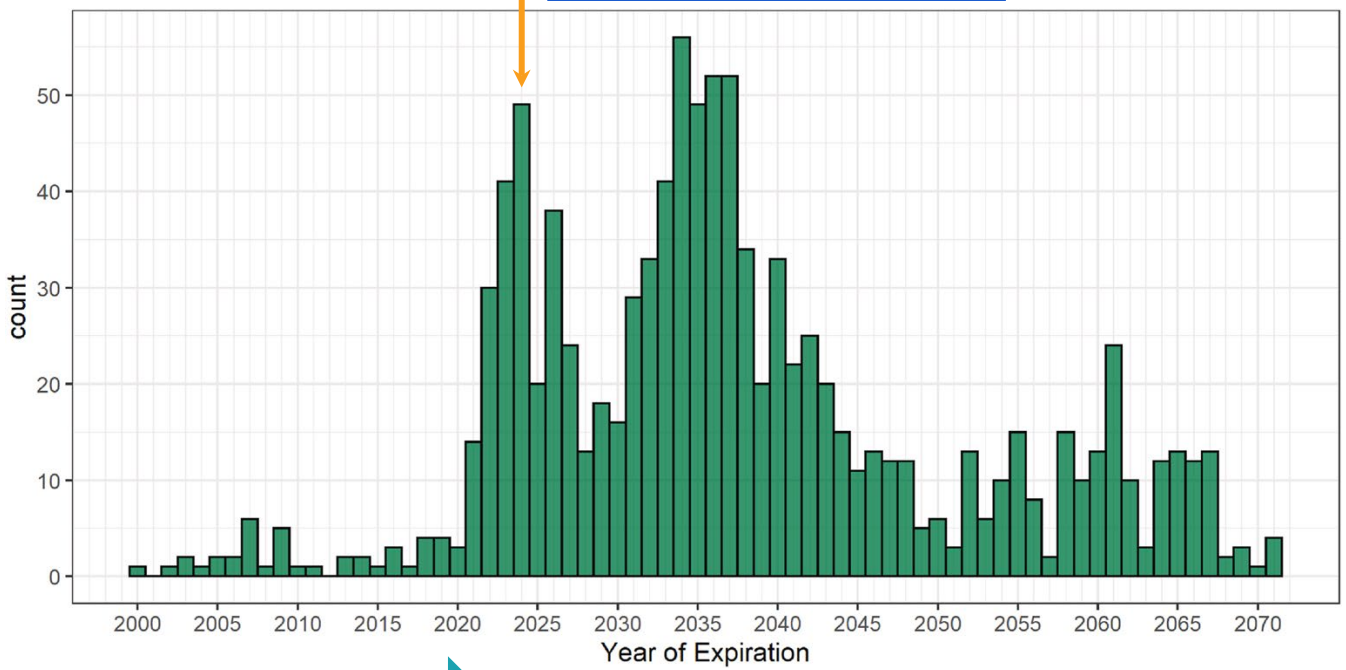
# A once-in-a-generation opportunity




We are here

**Source:** Paul G. Matson, Kevin M. Stewart, Gbadebo A. Oladosu, Emrat Nur Marzan, Scott T. DeNeale, Estimated capital costs of fish exclusion technologies for hydropower facilities, Journal of Environmental Management, Volume 351, 2024, 119800, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2023.119800.




Average age 65 years



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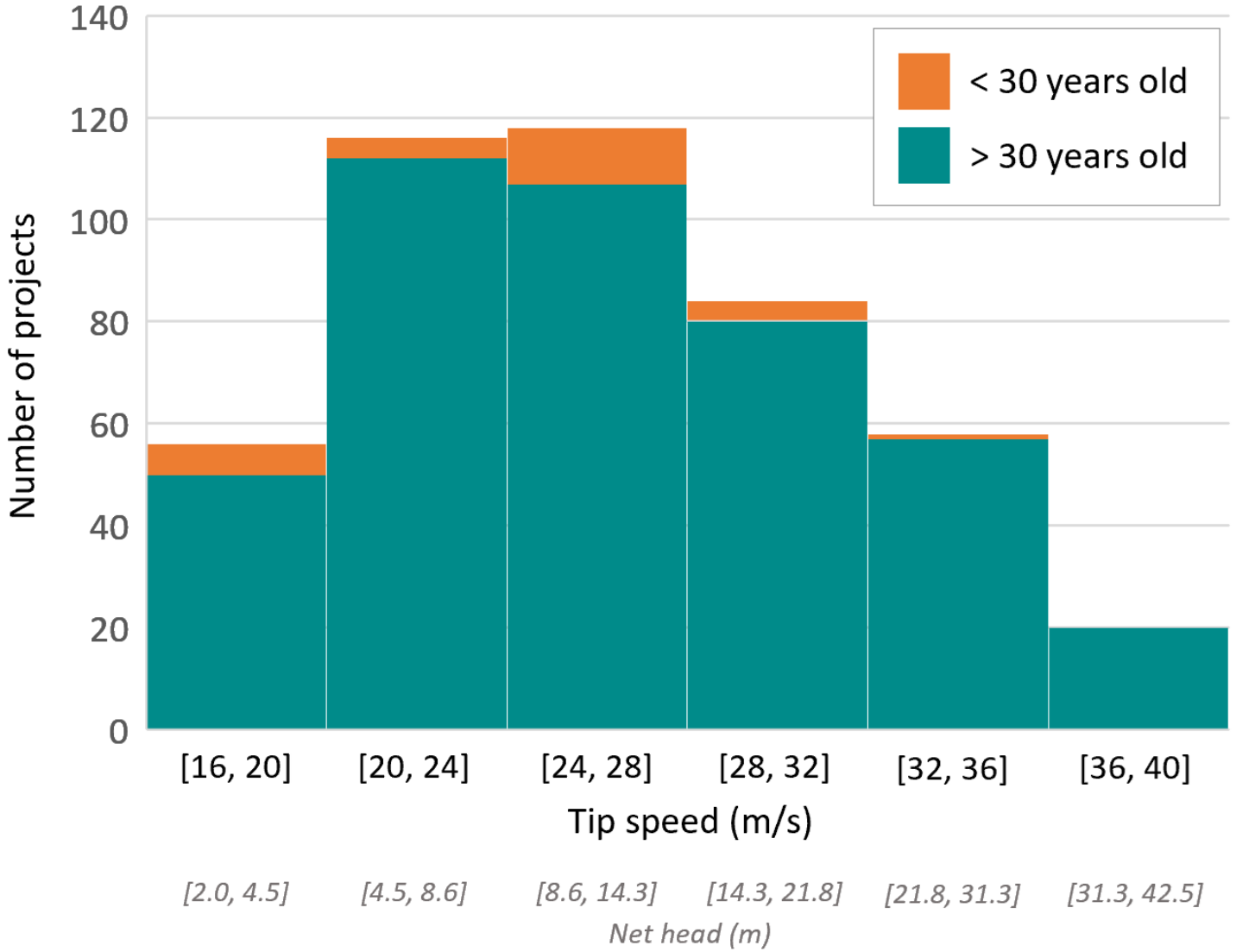
# Most low-head turbines have tip speed between 20-35 m/s




Tip speeds estimated from net head using a correlation derived from hydro projects with known head and tip speed data:

$$U_{tip} = 10.2\ H_{net}^{0.14} + 3.5\ H_{net}^{0.5}$$

*Dataset compiled from US FERC library for sites with available head data, up to 40 m, within current and historical American eel range.*



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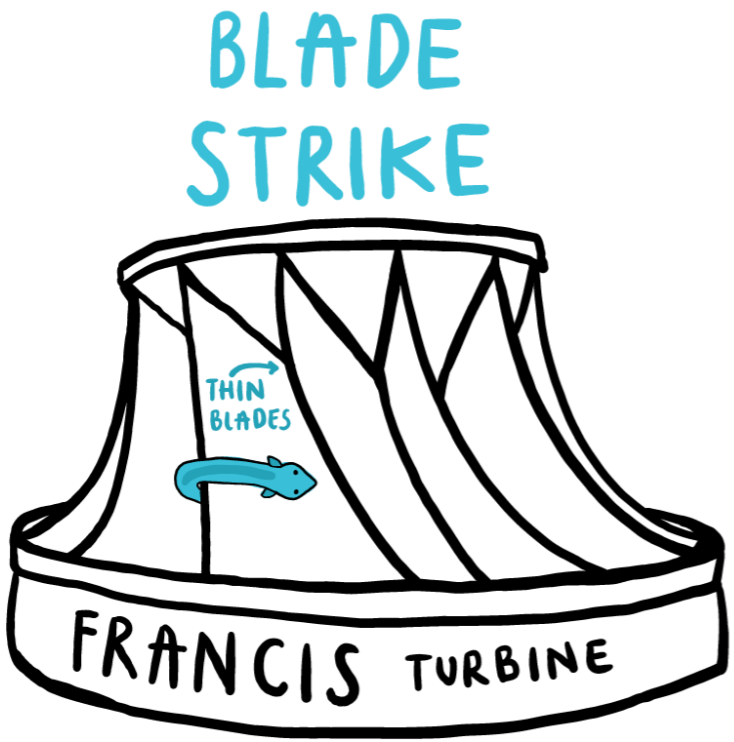
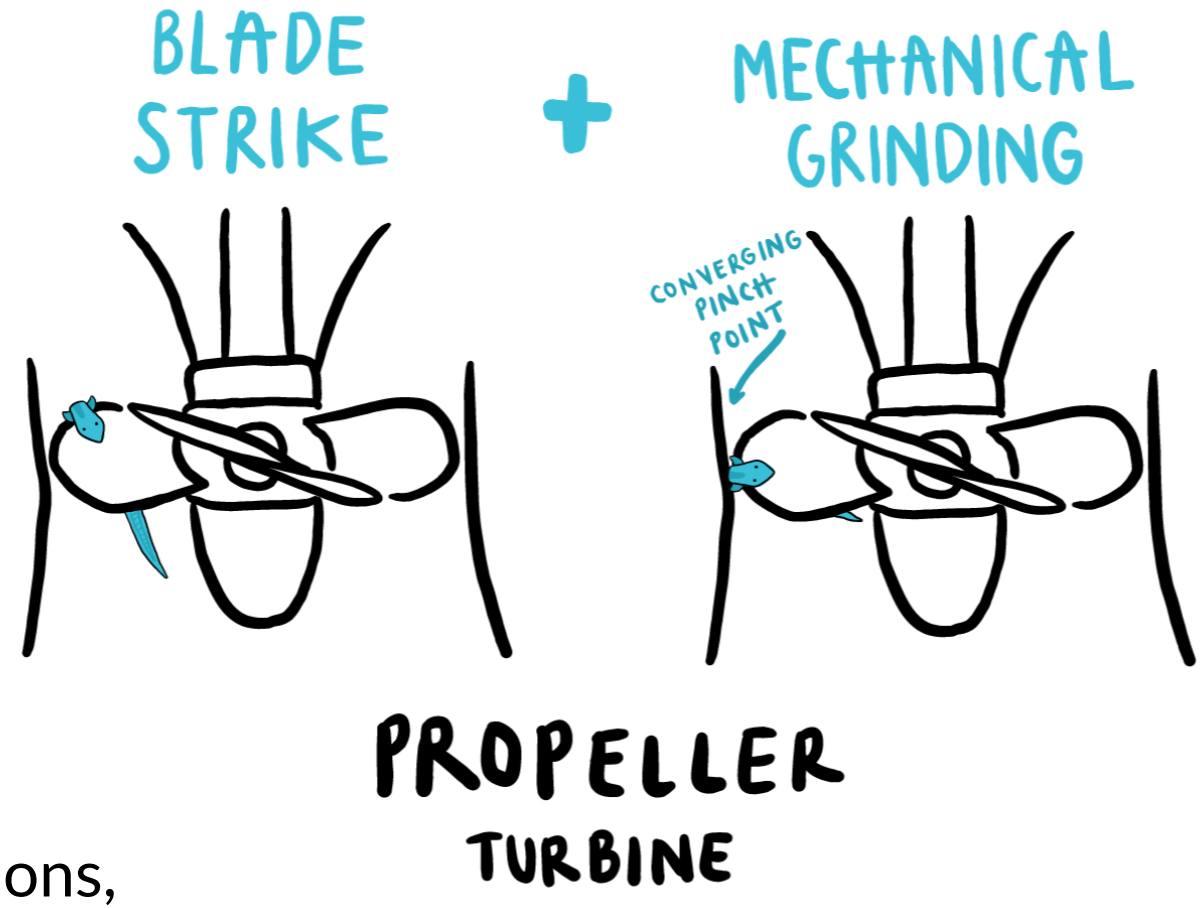
# Injury mechanisms for fish



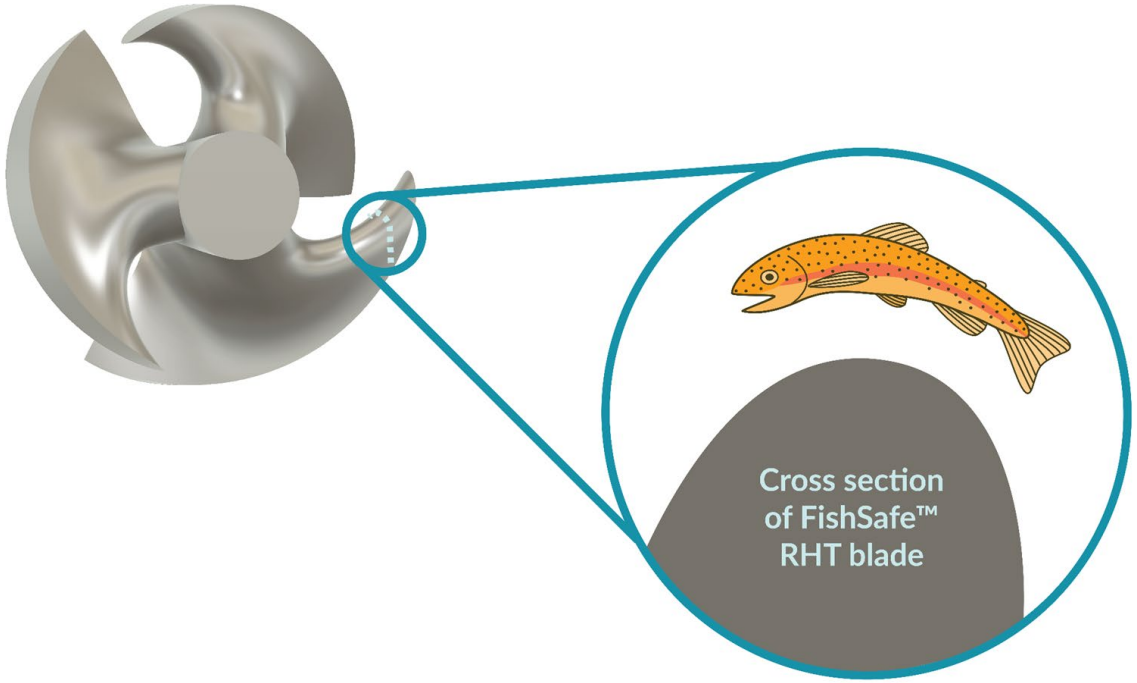




**Blade strike:** spinal fracture, contusions, lacerations,internal organ damage

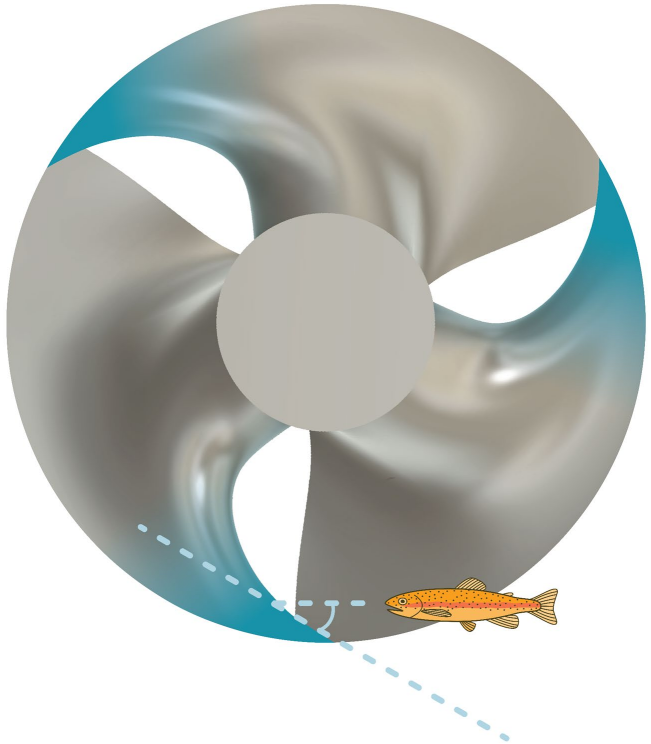
**Mechanical grinding:** severing, laceration

# High performance, FishSafe turbine design

The core of Natel's runner design is a **thick** and **slanted leading edge**. This allows the runner to **rotate at high speeds**—maintaining conventional turbine performance metrics like high power density, high efficiency, compact form factor, and low cavitation—while **passing fish safely** directly through the turbine (eliminating the need for fine screens, bypasses or other compromise solutions).




**Thick Blade** (deflects fish around)



**Tip Slant** (reduces severity of strike)



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# Natel RHT: safe passage of eel

## Natel in-house hydraulic and fish-passage test facility

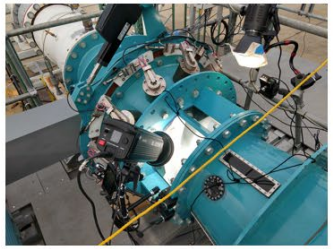
Supported by DOE funding

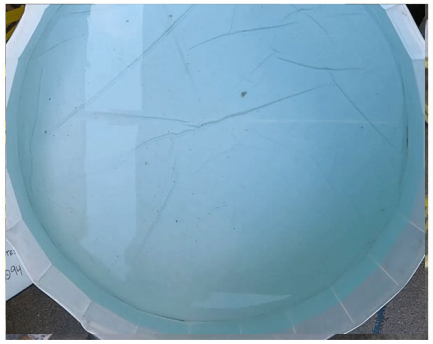
**100% immediate, 72h, and repeat passage survival**

10 m head, 75 kW

Ø55 cm, 667 rpm ($U_{tip}$ 19.2 m/s)

L 35-65 cm (*L/t* 6.4-11.8)





S.M. Watson, A.D. Schneider, L. Santen, K.A. Deters, R. Mueller, B. Pflugrath, J. Stephenson, Z.D. Deng (2022). Safe passage of American Eels through a novel hydropower turbine. *Transactions of the American Fisheries Society*, 151(6), 711-724. https://doi.org/10.1002/tafs.10385



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# Natel RHT: safe passage of salmonids

## Monroe Hydro, Madras Oregon, and Natel in-house lab

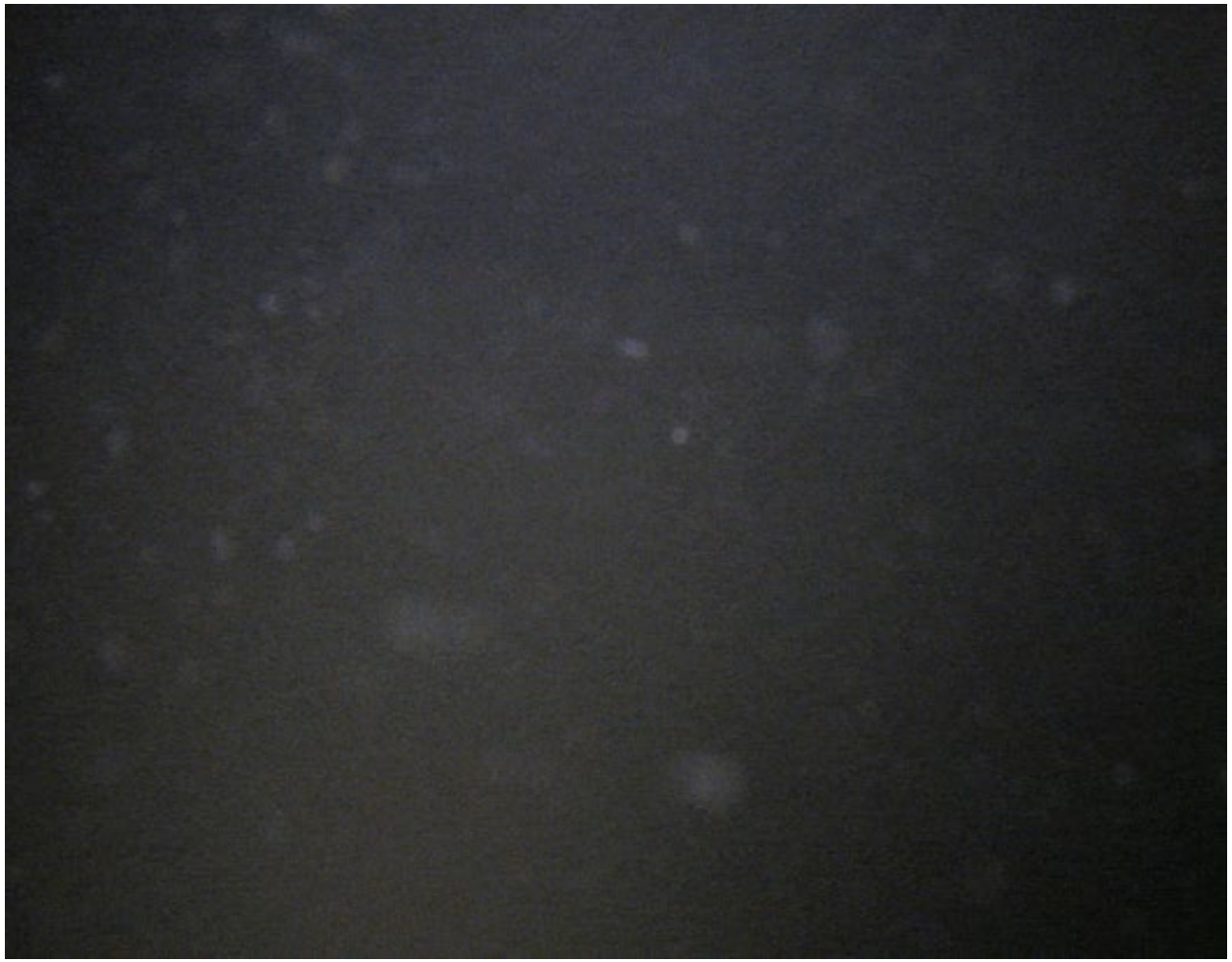
Supported by DOE funding

**100% survival**

Monroe Hydro Plant:
5 m head
Ø190 cm, 130 rpm ($U_{tip}$ 12.9 m/s)
L 20-53 cm (L/t 1-2.7)

In-house test facility:
10 m head
Ø55 cm, 667 rpm ($U_{tip}$ 19.2 m/s)
L 70-153 mm (L/t 1.27-2.8)

https://www.energy.gov/eere/water/articles/pnnl-testing-campaign-verifies-fish-passage-performance-natel-energys





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# Natel RHT: safe passage of alosines

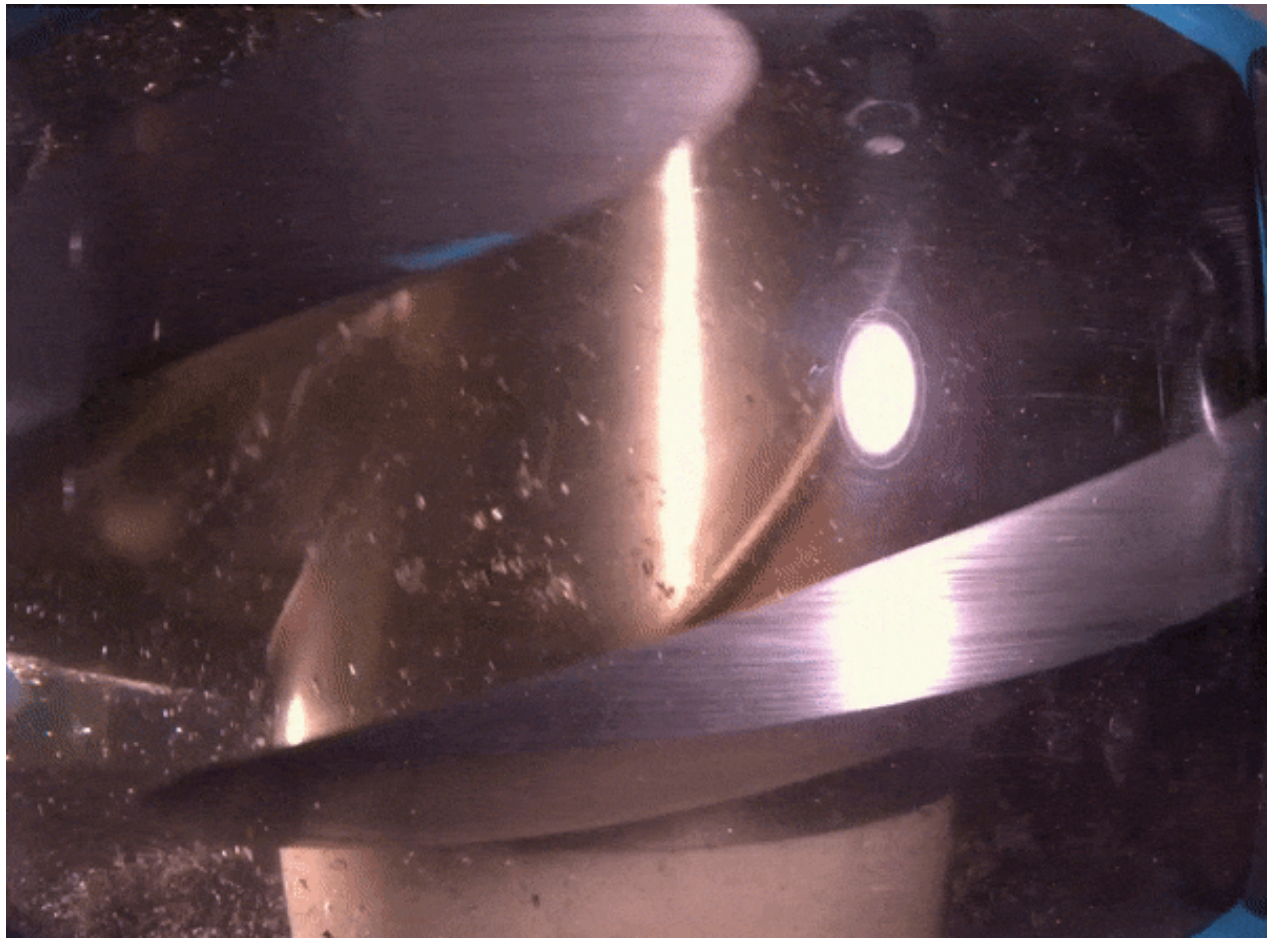
## Freedom Hydro, Freedom, Maine

**98-100% immediate and 48h survival**

7 m head, 30 kW

Ø55 cm, 541 rpm ($U_{tip}$ 15.6 m/s)

L 87-132 mm (L/t 1.6-2.4)



Watson, S., Schneider, A., Gardner, L., Apell, B., Thompson, P., Cadman, G., Gagnon, I., Frese, C., Wechsler, J. (2023). Juvenile Alewife passage through a compact hydropower turbine designed for fish safety. *North American Journal of Fisheries Management*. https://doi.org/10.1002/nafm.10866



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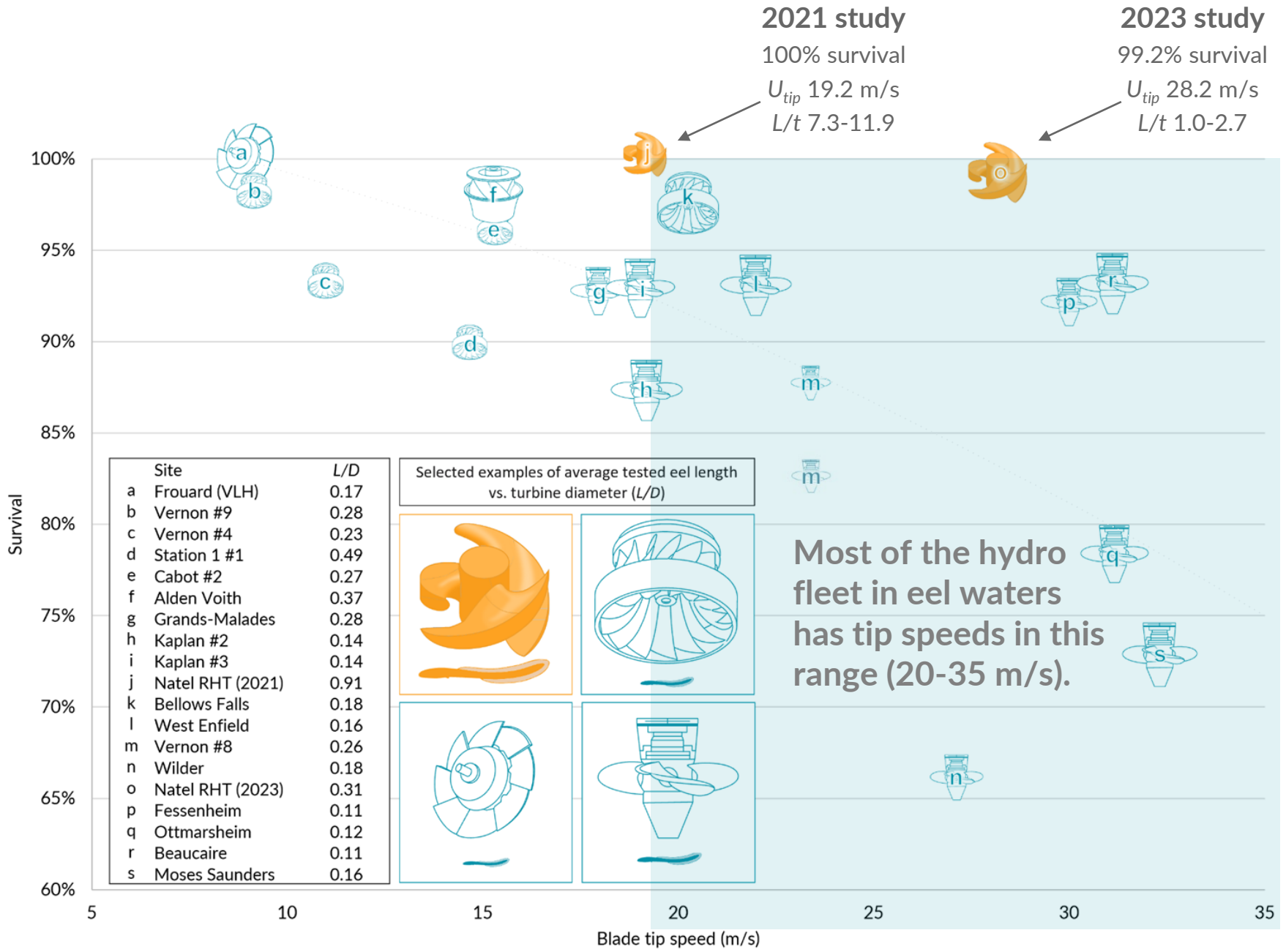
# Maximizing survival at all speeds

## Higher speed than other fish-friendly turbines, higher survival than conventional turbines




### Sources:


Cook T. C., Hecker G. E., Amaral S.V., Stacy P. S., Lin F., Taft E. P. (2003). – Final report – Pilot scale tests Alden/Concepts NREC Turbine. Report DE-AC07-99ID13733 for U.S. Department of Energy.

Heisey, PG, Mathur, D, Phipps, JL, et al. Passage survival of European and American eels at Francis and propeller turbines. *J Fish Biol*. 2019; 95: 1172– 1183.

Lagarrigue, T., Frey, A. (2010). – Test for evaluating the injuries suffered by downstream-migrating eels in their transiting through the new spherical discharge ring VLH turbogenerator unit installed on the Moselle River in Frouard. E.CO.G.E.A. report for MJ2 Technologies.

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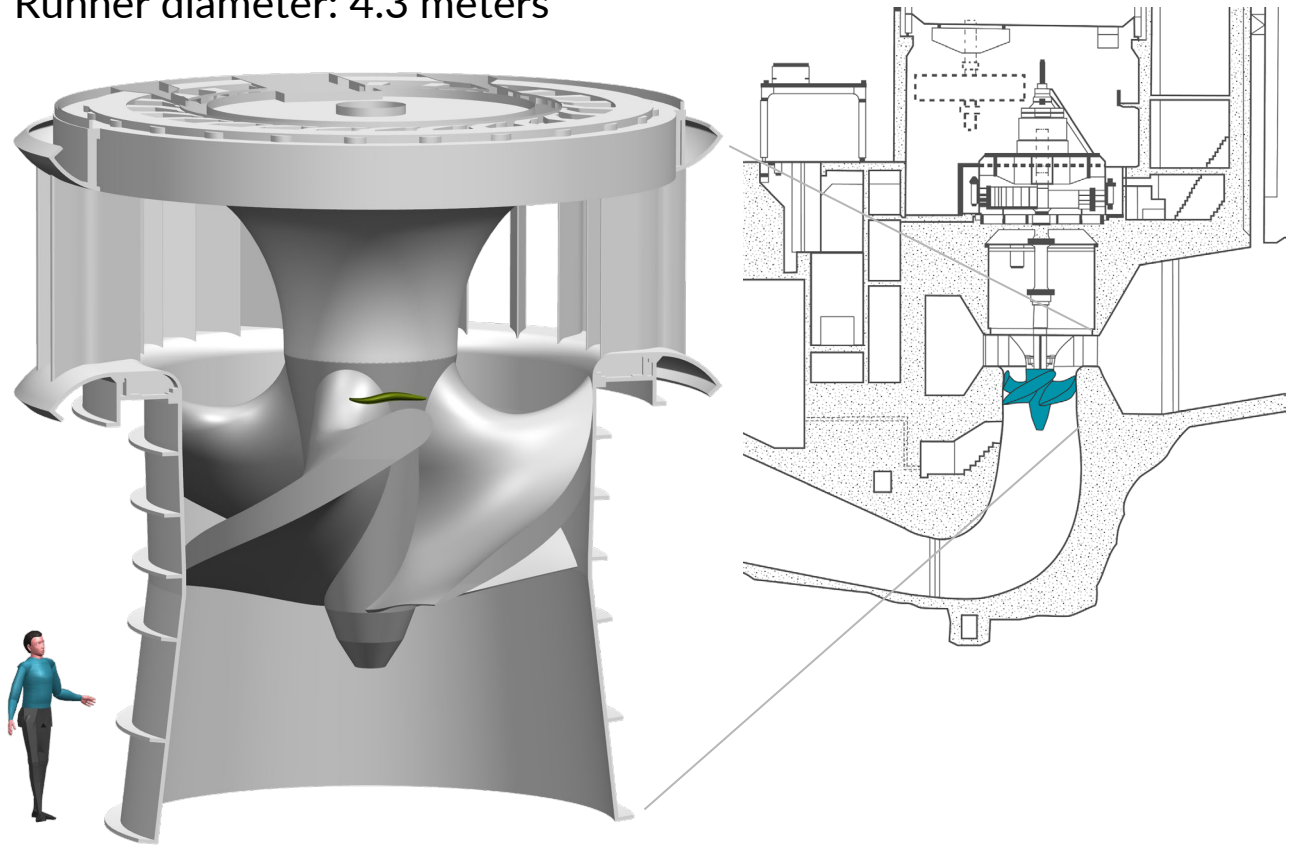
# Projects: design feasibility

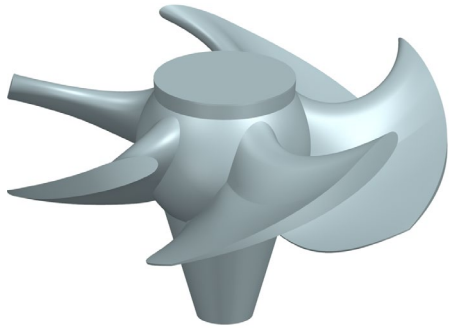
**Runner design to upgrade a 26 MW propeller unit in a multi-unit plant.**

- Same or greater shaft power
- Runner replacement only - no change to existing water passageway or generator
- Fish survival: >98% for eel
- Efficiency: 92.5%
- Runner diameter: 4.3 meters



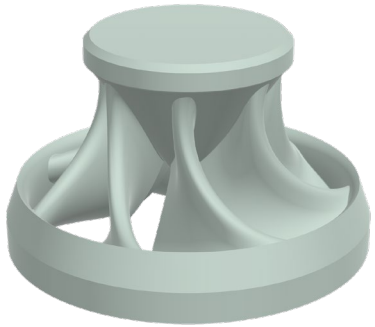
**Runner design to upgrade 7 x 6.3 MW Kaplan units.**

- Fish survival: >96% for up to 40 cm fish (scaly fish); >98% for eel
- Efficiency: 90-92%, excellent part-flow efficiency to 40% flow
- Runner diameter: 3.9 meters



**Runner design to upgrade 4 x 3.1 MW Francis units.**

- Fish survival: 99.6% for eel, >95% for all fish passing thru trash rack
- Efficiency: 92-94%
- Runner diameter: 2.7 meters





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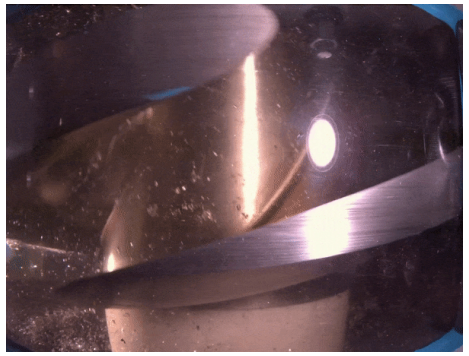
# Safe through-turbine fish passage is possible



"This makes Natel's turbine the **first in the industry** to enable **safe fish passage** for **large and small fish** while meeting **high performance metrics** and **matching standard installation configurations**, and demonstrates significant progress in efforts to preserve biodiversity while advancing renewable energy production."

*—Office of Energy Efficiency & Renewable Energy*

U.S. DEPARTMENT OF ENERGY

Peer-reviewed papers showing benefits of Restoration Hydro Turbine for fish passage: *Journal of Ecohydraulics*, DOI 10.1080/24705357.2020.1768166; *Transactions of the American Fisheries Society*, DOI 10.1002/tafs.10385; *North American Journal of Fisheries Management*, DOI 10.1002/nafm.10866

**Working to create a planet where a reliable, zero-carbon grid is balanced with a thriving natural environment.**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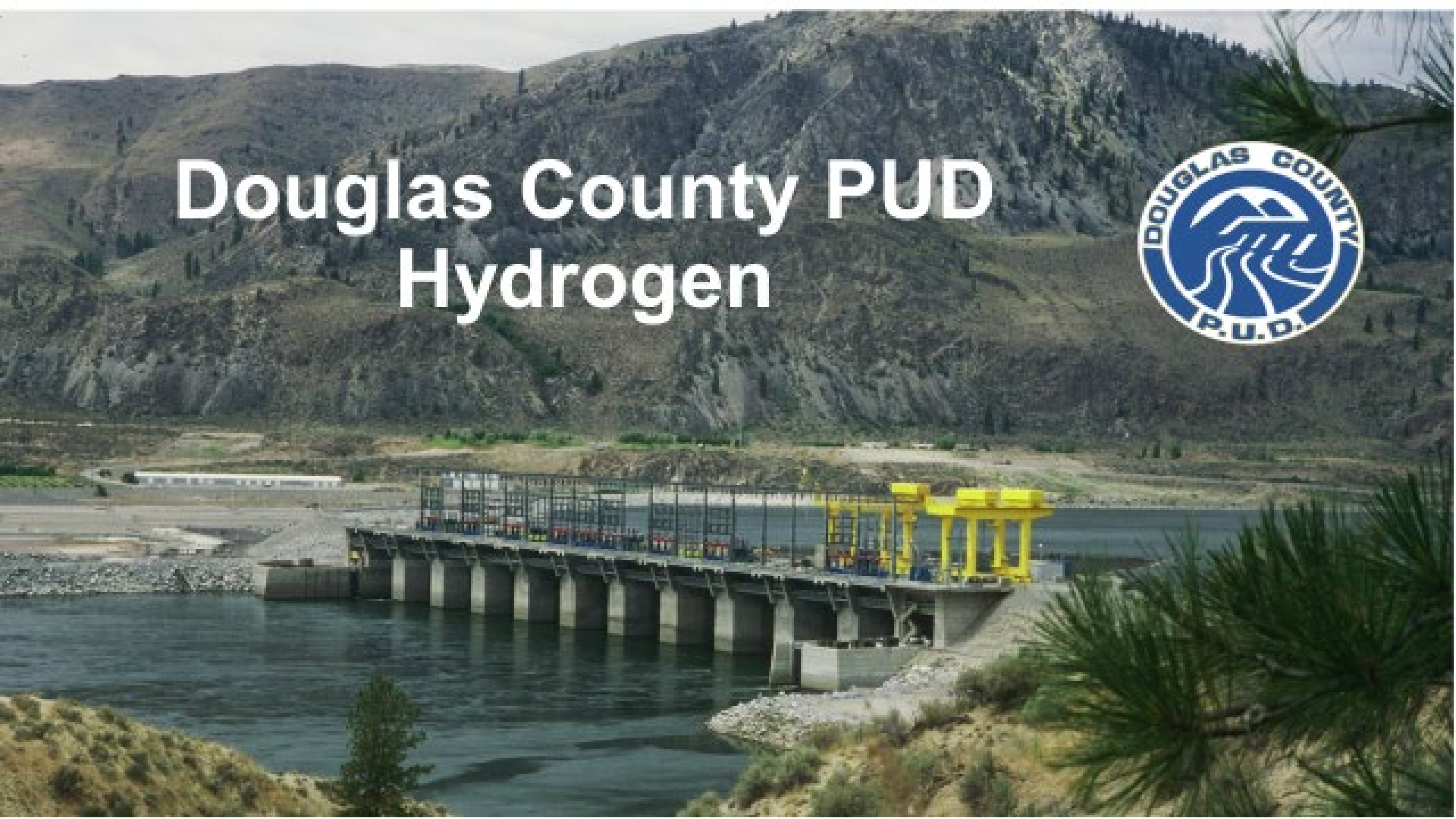
# Douglas County PUD Hydrogen

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