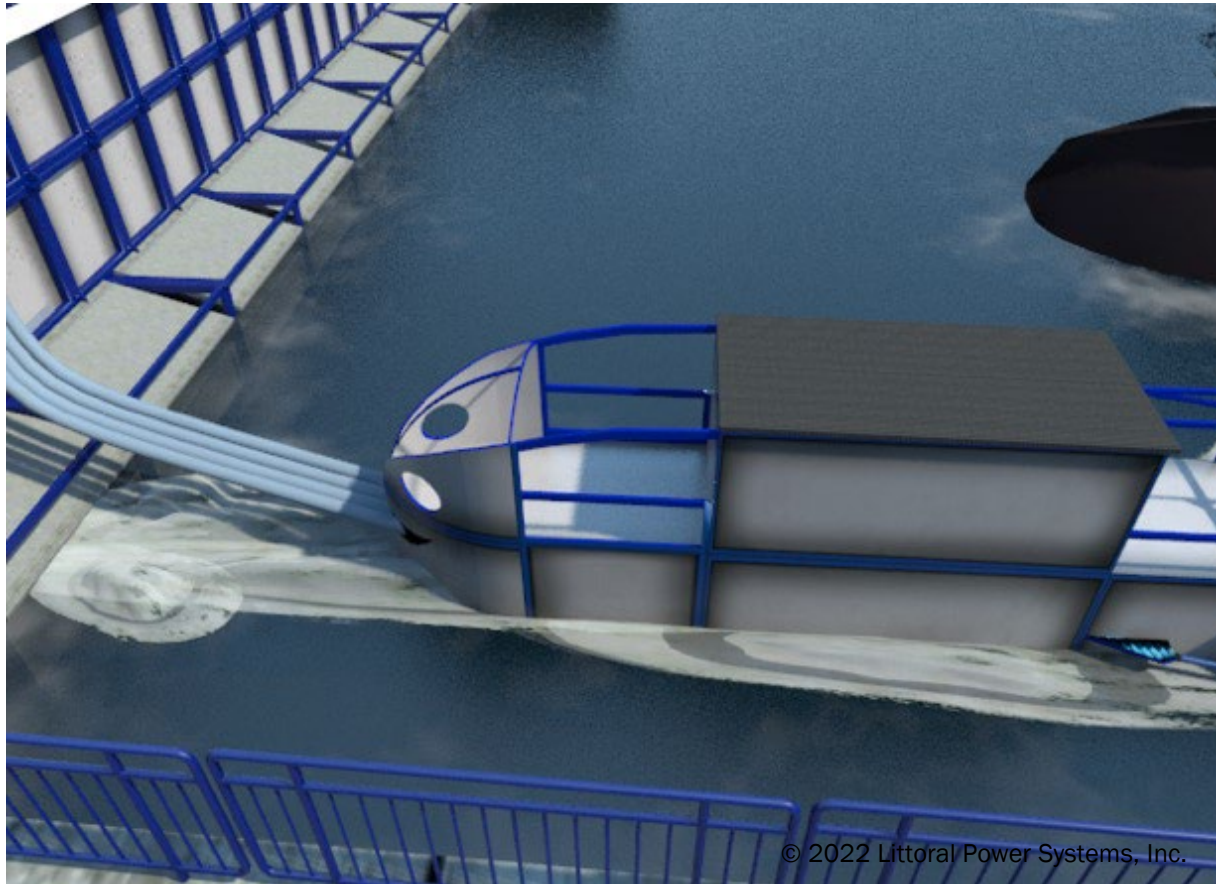


DE-EE0008969 – Prefabricated zero ascend omnisppecies (ZAO) modular fish passage attraction modules



Katherine (Kathie) Leighton
Littoral Power Systems, Inc. (LPS)

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July 27, 2022

Project Overview

Project Summary

- Numerous hydropower facilities, whether at greenfield, non-powered dam, or relicensing sites, require cost effective fish passage technology. The challenges are: 1) cost, 2) attracting and passing both weak and strong swimmers, 3) placing the entry in the path of the fish, and 4) attracting fish especially in competition with turbine outflow. The zero ascend omnispecies fish passage attraction module, ZAO-Attractor™, address all of these challenges by integrating the successful Whooshh fish passage system into a unique floating body shape with an adjustable entry that takes advantage of the turbine out flows for attraction rather than competing with them.

Intended Outcomes

- A successful ZAO-Attractor makes volitional, upstream attraction and passage of weak (e.g., river herring) to strong (e.g., Atlantic salmon) fish available at a small fraction of the cost of traditional approaches, making it affordable to low impact and small hydro projects.
- It is a prefabricated system that can be assembled and set up in a matter of days.
- Each module has the capacity to pass 43,200 fish a day. Multiple modules can be deployed at a site for increased capacity. Modules can be moved to find the best place for fish entry. The modules can be removed and/or relocated providing resilience against climate change.
- ZAO-Attractor requires no water from the headpond, leaving as much water as possible for energy generation.

Project Information

Principal Investigator(s)

- David Duquette (LPS)
- Janine Bryan, Ph.D. (Whooshh)

Project Partners/Subs

- Whooshh Innovations
- Electric Power Research Institute
- Oak Ridge National Lab
- Santee-Cooper
- Alden Research Laboratory
- Kelson Marine
- GZA GeoEnvironmental

Project Status

Ongoing

Project Duration

Aug. 1, 2020 – June 30, 2023

Total Costed (FY19–FY21)

\$476,771

Project Objectives: Relevance

Relevance to Program Goals: ZAO-Attractor supports the following WPTO goals

Innovations for low-impact
hydropower growth
2021 – 2025

- testing of new cost-competitive technologies
- test prototype at full scale
- actively pursue/apply advanced manufacturing opportunities
- upgrades at existing hydropower plants

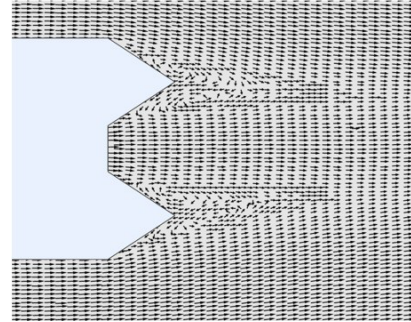
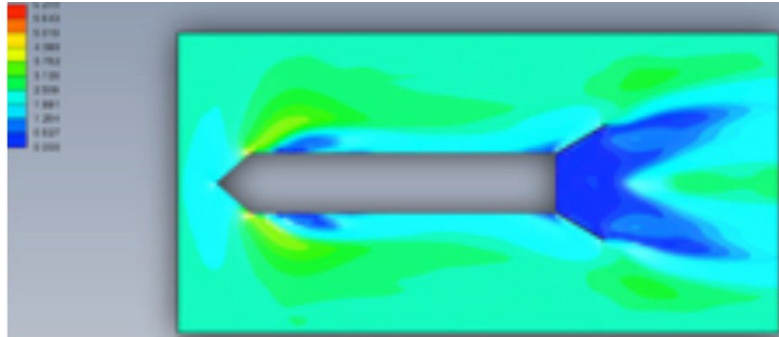
Innovations for low-impact
hydropower growth
2026 – 2030

- revolutionary improvement via standardization and modularity
- powering currently non-powered dams
- development of new stream-reaches

Environmental science
2021 – 2025
2026 – 2030

- field validation of innovative fish passage technologies benchmarked for cost and performance
- quantifiable improvements in fish passage performance linked to fish population and restoration goals

Project Objectives: Approach



Passage

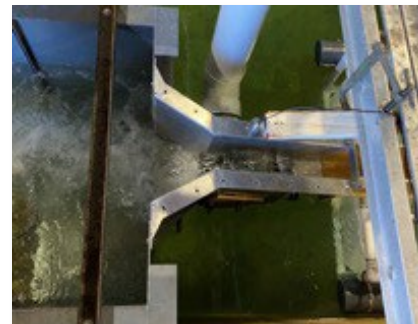
- Via Whooshh Passage Portal™:
- Whooshh FishL Recognition scanner – images fish for rapid sorting decision
- Whooshh GateKeeper™ sorting component – removes unwanted fish, sorts others into proper sized Whooshh Migrator™ tube
- BurstBuster™ accelerator automatically activates and gently glides the fish up and over the dam

Attraction

- No flow from the headpond
- Body shape and location modulates turbine outflows to create attraction flow
- Floating system can be moved to where the fish congregate

Entry

- Side and bottom tail fins adjust for fish preferred entry characteristics
- Final entry through Whooshh Fish Faucet, which has a false weir 1”-2” above the surface of the tailwater and 1-2 cfs flow



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Validation of attraction and entry of American shad via field test of critical full scale elements.
- Field study report correlating quantified flow field and entry geometry with entry data.
- Product specifications for ZAO-Attractor with integrated passage components, and advanced materials or manufacturing.
- Techno-economic dataset.

Outcomes:

- Existing hydropower plants get relicensed and new hydropower plants get built because:
 - high cost, poorly located permanent fishways are replaced with a low cost, flexible, relocatable alternative.
- Hydropower plants can provide temporary fish passage during new construction and upgrades that may block existing fishways.

Project Timeline

FY 2019

Project Start 8/20
Preliminary design package
Design review for advance manufacturing opportunities

FY 2020

Industry survey
Modeling inputs
Preliminary CFD
Lab test report: river herring entry into false weir
ORNL CRADA

ORNL CRD leading to hydrodynamic design
Preliminary ZAO design: structural, buoyancy, stability, mooring, anchoring, advanced manufacturing and materials considerations
Whooshh component integration
Cost breakdown and LCOE framework
Go/No-go review in process

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
\$1,000 K	\$250 K	\$1,250 K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
\$0K	\$0K	\$478 K	\$478 K

- This project has been a tremendous opportunity to partner with the Electric Power Research Institute (EPRI) and its hydropower members. After being selected for award LPS and EPRI discovered that there was important synergy between the two projects, and agreed to have much of the EPRI project subsumed into this project. The extent of the stakeholder engagement described on the next pages is a result of this partnership. EPRI has committed to provide the full required cost share amount, and to date (6/15/22) has provided \$223,203 in cost share.
- This project was significantly supported by ORNL directly funded by DOE for an unknown amount that is not included above.

End-User Engagement and Dissemination

- ZAO-Attractor will be sold, fabricated and installed for:
 - Hydropower projects coming up for relicensing and new hydropower at non-powered dams, particularly eastern facilities with weaker or less aggressive migrating fish like river herring and American shad. Smaller projects where costs are a larger percentage of revenue critically need a low cost fish passage solution.
- End-user engagement during the project:
 - LPS and EPRI identified 260 existing hydropower sites coming up for relicensing between 2023 and 2033 that are located in states bordering the Atlantic Ocean.
 - Interviewed the operators of 16 that responded as interested. They are located in SC, NC, PA, NY, CT, ME and Canada.
 - Results on tailwater and turbine outflow characteristics inform the ZAO-Attractor requirements and commercialization strategy.
- Diversity, equity and inclusion (DEI): LPS is mindful of company DEI goals across all projects. LPS employees are 38% women, 13% LGBTQ+, and 13% persons of color.

The screenshot shows a survey form with various sections: 'Date of Interview', 'Version', 'INSTRUCTIONS', 'Survey User', 'Project Information', 'Survey Points of Contact', 'Fish Species', 'Fish Passage & Passage Capabilities', 'Fish Species', 'Tailwater & Turbine Outflow Characteristics', and 'Diversity, Equity and Inclusion (DEI)'. The form includes a table for 'Tailwater & Turbine Outflow Characteristics' with columns for Turbine 1 through Turbine 7 and rows for various parameters like 'Tailwater bottom elevation at draft tube outlet', 'Draft tube bottom elevation', etc.



End-User Engagement and Dissemination

- Describe how the project results or information have been/are planned to be disseminated and any technology transfer and/or commercialization plans.
 - Budget Period 2 plans include a field test in collaboration with Santee Cooper, South Carolina utility provider, who are actively looking for a fish passage solution at that site - potential to be the first sale of ZAO-Attractor.
 - With a successful conclusion of this project, LPS and Whooshh intend to partner to offer ZAO-Attractor for sale.
 - Product data related to selling ZAO-Attractor will be made available on LPS's website, through direct contact with potential customers, and through trade shows and conferences.
 - Invention information will be published in patent applications.
 - The final report will include a public section for immediate dissemination through osti.gov , and a detailed section that will be uploaded to osti.gov for dissemination after the protected data stage.



Letter of Intent

July 1, 2020
Page 2

web site.

[Redacted text]

This letter does not constitute a binding agreement between the parties but merely expresses their intent with respect to the transactions contemplated hereby. No such binding agreement will be in effect, and neither party shall be deemed to have incurred any obligation with respect to the transactions contemplated hereby, unless and until a definitive agreement is executed by each of the parties.

If this letter accurately sets forth our understanding with respect to the subject matter hereof, kindly execute this letter where indicated below and return such executed copy to me. We will work with you in the utmost good faith to give rise to a successful commercialization of the ZAO system.

Very truly yours,

Handwritten signature of David J. Duquette in black ink.

David J. Duquette, CEO

Agreed and accepted:

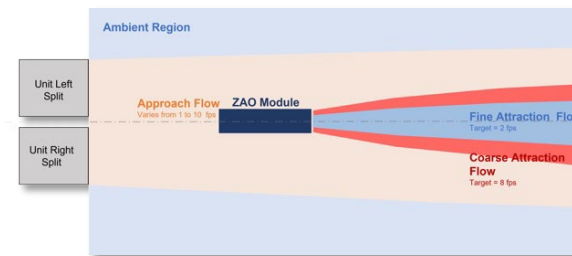
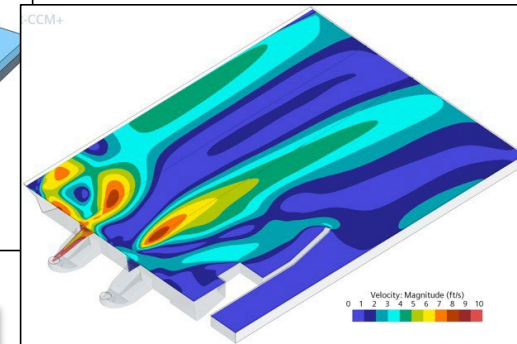
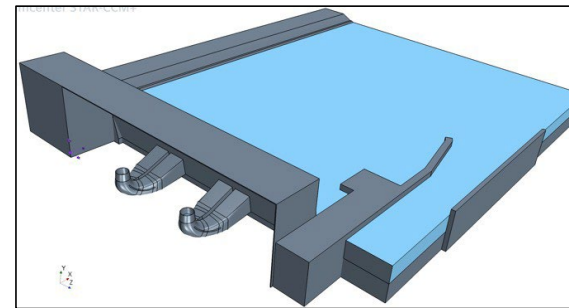
Whooshh Innovations Inc

By: [Signature]
Name: Vince Bryan III, CEO

Littoral Power Systems, Inc. | 15 Dover Street, Suite 103 | New Bedford, MA 02740

Performance: Accomplishments and Progress

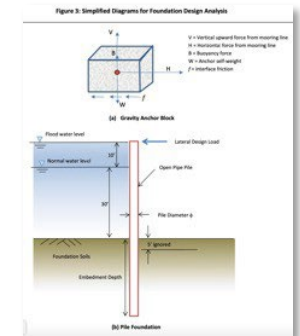
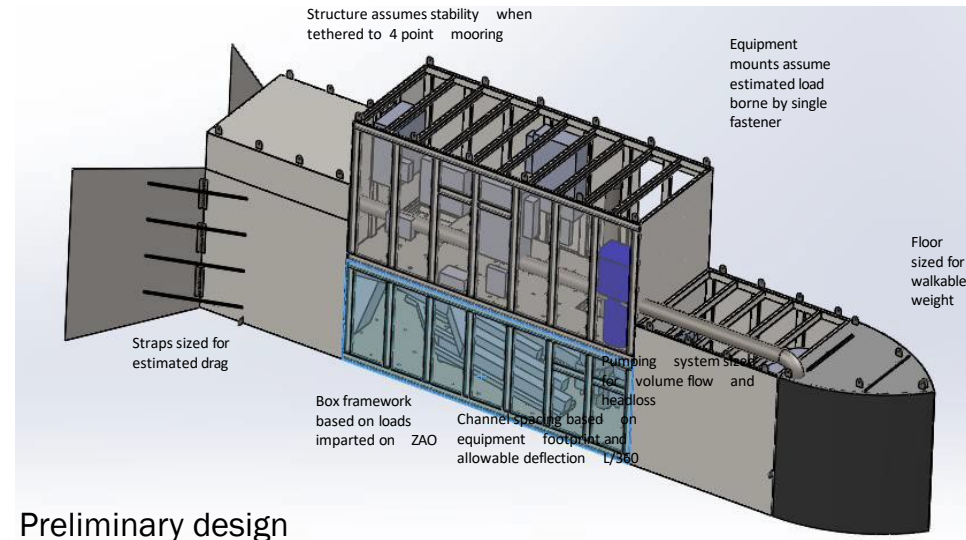
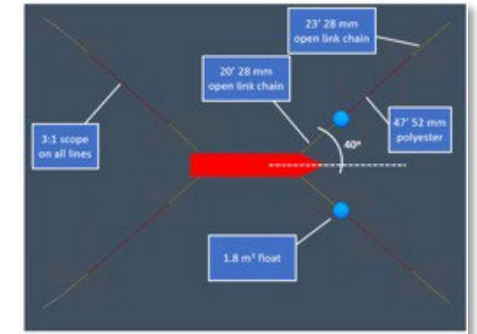
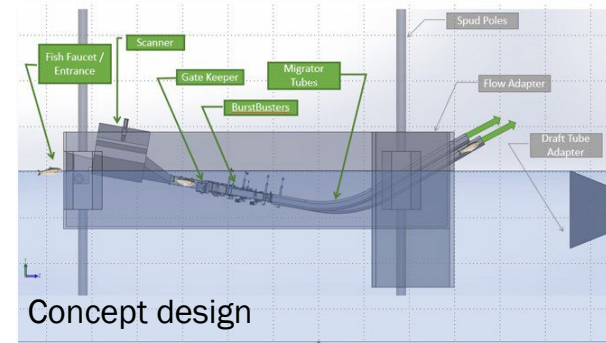
- Target species are the fearful American shad and weak swimming river herring
- Lab tests with American shad identify possible adverse flow pattern and need for field testing with the false weir entry
- Developed SolidWorks model of tail race from data supplied by Santee Cooper
- Voith provided computational fluid dynamics model of the turbines
- Using the above inputs, ORNL developed models and used their supercomputers to performed hydrodynamic simulations of turbine outflow around various ZAO shapes and at various tailwater positions, which defined ZAO's hydrodynamic surface contour



Will the resulting downstream flows attract Am. shad and river herring? Fish and environmental experts consulted agree it is promising but the only way to know...is field testing with live fish!

Performance: Accomplishments and Progress

- Developed and analyzed preliminary design
 - Partially submerged, floating vessel with hydrodynamic shape
 - Adjustable tail fin – angle and size
 - In floor ballast to achieve required buoyancy and stability when combined with anchorage
 - Structural design
 - Mooring, anchoring, geotechnical – gravity anchors or piles
 - Advanced materials/manufacturing considerations for the fins
 - Auxiliary attraction flow pump system
 - Integrated Whooshh scanning, sorting, bypass, and passage components



Performance: Accomplishments and Progress (cont.)

- Identify any patents, awards, or other important recognition that have resulted from this project.
 - LPS has applied for a non-provisional patent
 - Recognition of value led Santee Cooper to commit to contribute their support in field testing at their Santee River Spillway



Jane H. Campbell, P.E.

Sr. Director

Environmental and

Water System Management

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June 22, 2022

Ms. Katherine Leighton, Program Manager
Littoral Power Systems, Inc.
5 Dover Street
New Bedford MA 02740

Reference: LPS proposal to Santee Cooper, "Letter proposal for field testing ZAO-Attractor™ at the Santee Spillway" dated May 24, 2022

Subject: Letter of Commitment: Collaboration with Littoral Power Systems (LPS) to conduct field studies on ZAO-Attractor

Dear Ms. Leighton,

Future Work

- Field testing at Santee Cooper Spillway on the east side of Lake Marion near Pineville SC. 600 cfs turbine. Testing being planned for March 2023.
- Whooshh's Passage Portal was tested there in March 2022, which provides a baseline for comparison.
- Initial concept for the field prototype is being circulated for comment to the testing team including Santee Cooper biologists, engineers, and site crew.



Power house

Place ZAO downstream of power house similar to where the Whooshh Passage Portal was located.



Q&A