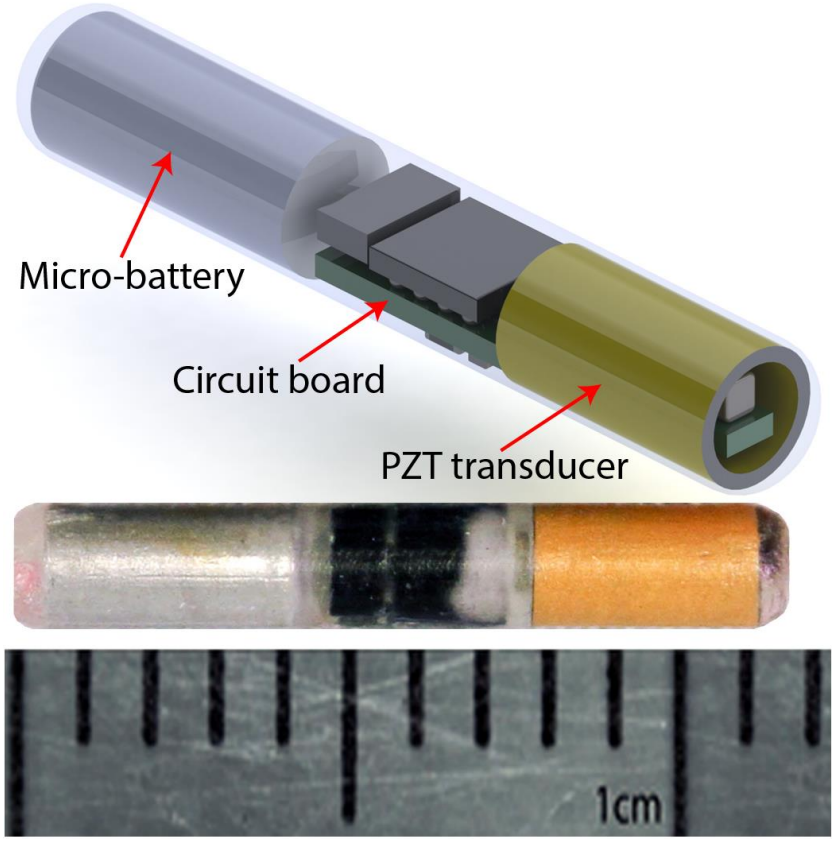

Monitoring Technology Development for Sensitive Species (Juvenile Eel / Lamprey Tag Development)

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Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Title: Monitoring Technology Development for Sensitive Species (Juvenile Eel / Lamprey Tag Development)

Challenge: There are currently technical limitations in the ability to track movement and behavior of key species of concern (American eel and Pacific lamprey), and thus a limitation on the ability to design and implement optimal mitigation solutions at a large number of facilities to improve long-term hydropower sustainability.

Who Benefits: The ability to implant acoustic transmitters to track the movements and habitat use of sensitive species would help operators, developers, design engineers, and biologists better understand behavior and survival to make more informed management decisions regarding new and existing hydropower facilities.

Partners: U.S. Army Corps of Engineers (USACE), Tribal Governments, Dominion Power, regulatory agencies.

Next Generation Hydropower (HydroNEXT)

Optimization

- Optimize technical, environmental, and water-use efficiency of existing fleet
- Collect and disseminate data on new and existing assets
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

Growth

- Lower costs of hydropower components and civil works
- Increase power train efficiency for low-head, variable flow applications
- Facilitate mechanisms for testing and advancing new hydropower systems and components
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

Sustainability

- **Design new hydropower systems that minimize or avoid environmental impacts**
- **Support development of new fish passage technologies and approaches**
- **Develop technologies, tools, and strategies to evaluate and address environmental impacts**
- Increase resilience to climate change

Next Generation Hydropower (HydroNEXT)

Sustainability

- **Design new hydropower systems that minimize or avoid environmental impacts**
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- **Develop technologies, tools, and strategies of evaluate and address environmental impacts**

Impacts

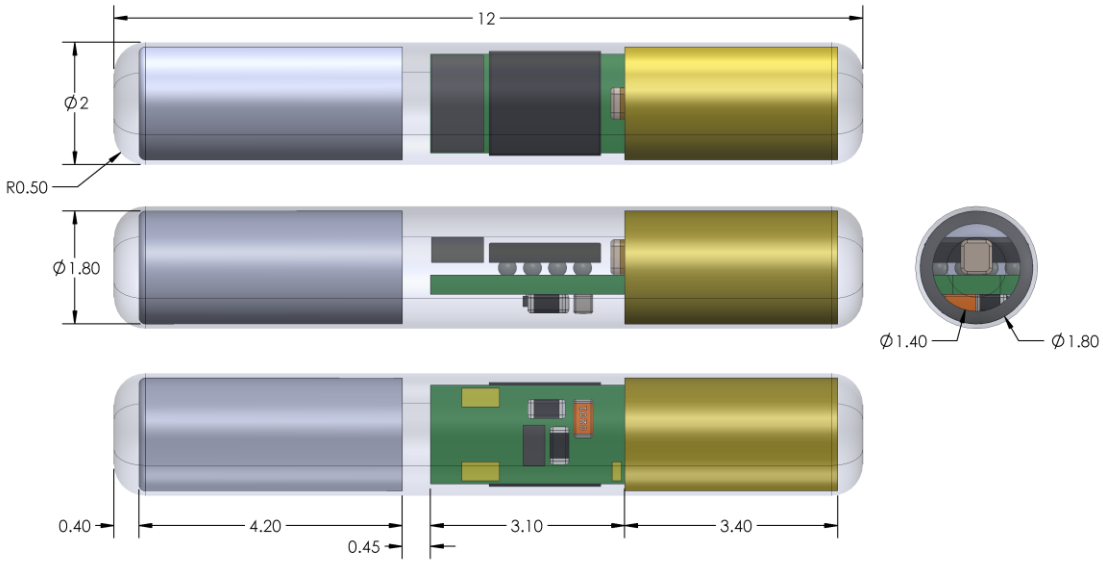
- Reduced impacts to fish as reflected in estimated injury and mortality rates
- End point: routine application of the technology for evaluation and optimization of hydropower systems with fish passage concerns
- Improve fish passage as reflected in number of applications and improved fish passage efficiency
- End point: routine application of the technology for design, evaluation and operations of passage systems for sensitive species
- Transfer of technology as represented by the successful commercialization
- Field-scale evaluations as reflected in number of applications and species
- Final product: A technology for studying migration behavior and survival and habitat use of species and life stages of fish that have not been possible

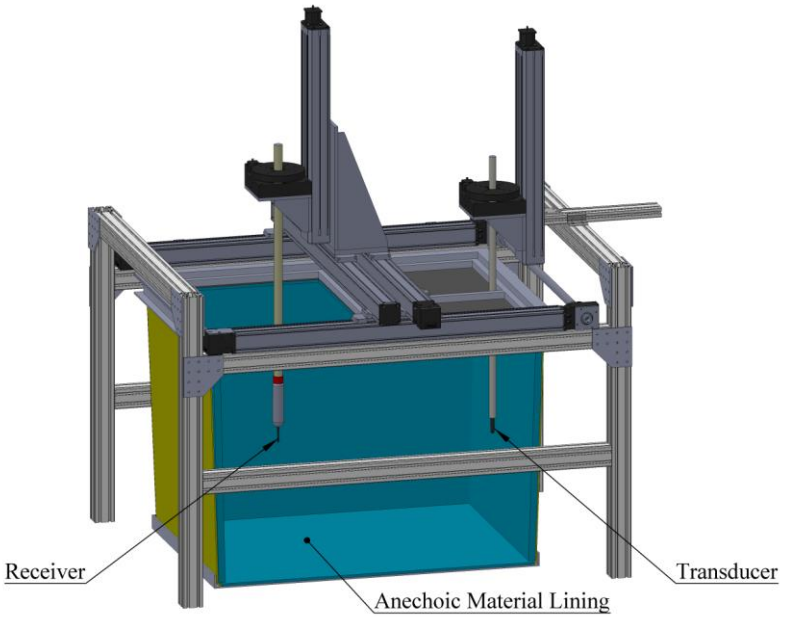
Technical Approach:

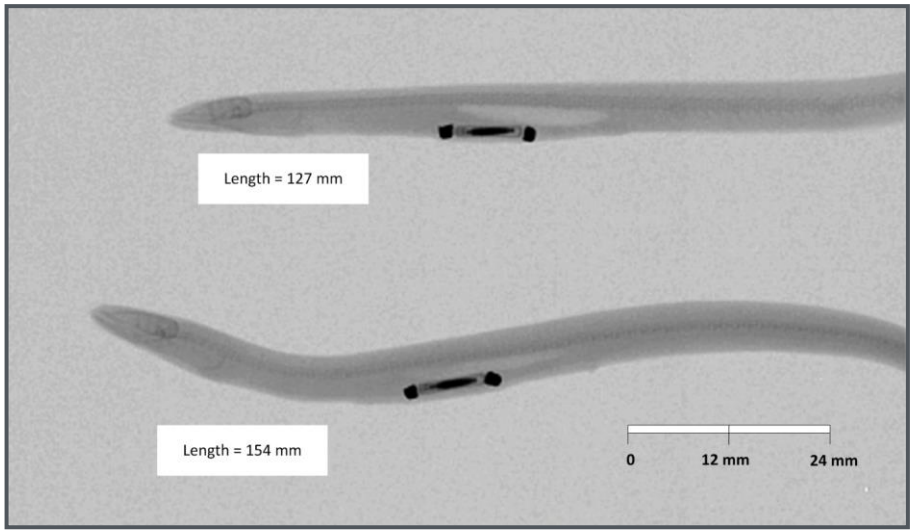
Multi-disciplinary and multi-phase approach

- ❑ Develop the planned range of applications with stakeholders
- ❑ Derive design specifications
- ❑ Design and implementation
  - Develop a primary micro-battery by reducing length and diameter of existing design and using soft packaging materials
  - Integrate the functionality of the tag onto an Integrated Circuit
  - Optimize the transducer design by exploring other resonance modes
  - Design form factors that allows implantation of juvenile eel and lamprey
  - Develop a procedure for implantation that minimizes the time required for implantation and reduces biological effects in juvenile eel and lamprey
  - Assess manufacturability and cost of the parts and whole unit
- ❑ Laboratory evaluation
  - Using benchtop tools and laboratory acoustic water tank
- ❑ Pilot field trial with industry partners
- ❑ Full field trial with industry partners
- ❑ Technology transfer and commercialization

Technical Approach







Accomplishments and Progress

Accomplishment (Selected)	Significance
Developed and prototyped the eel/lamprey acoustic transmitter; Filed a patent	The tag is 2 mm in diameter and 12 mm in length, weighs 0.08 g, and last 20 to 30 days at 5-second ping rate interval. This is the first active tag that can be used to study juvenile lamprey and eel.
Developed tagging protocols for juvenile lamprey and eel (Mueller et al. 2016 in review)	The implantation procedure minimizes handling time and biological effects in juvenile lamprey and eel.
Developed a primary micro-battery	The micro-battery is 1.8 mm in diameter, 4.2 mm in length, weights 0.02 g, and has a capacity of 1 mAhr. It can be used for other small sensors.
Developed a reliable sealing method for micro-batteries (Wang et al. 2016)	The two-layered seal developed extends the shelf life of micro-batteries.
Synthesized key literature for small lithium and lithium ion batteries (Wang et al. 2015)	The invited review by Journal of Power Sources focused on lithium and lithium ion batteries for applications in microelectronic devices. This paper has been cited 45 times.

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Milestones/Deliverables	Start date	Planned end date	Completed date
Define the range of applications	12/31/2014	12/31/2014	12/31/2014
Identify and evaluate components	12/31/2014	3/30/2015	3/30/2015
Identify design alternatives	3/30/2015	6/30/2015	6/30/2015
Submit first design for first round of prototyping	6/30/2015	9/30/2015	9/30/2015
Manufacture the first iteration eel/lamprey tag	9/30/2015	12/31/2015	12/31/2015
Evaluate the performance of the first iteration eel/lamprey tag against engineering assumptions and identify remaining engineering issues	12/31/2015	3/30/2016	3/30/2016
Develop a procedure for implantation of the new transmitter in juvenile eel and lamprey.	3/30/2015	6/30/2016	6/17/2016
Submit final design for final prototyping	3/30/2016	9/30/2016	9/30/2016

Go/No-Go Milestone Description

- Co-funding availability from the USACE — Due: 12/31/2014
- Whether or not a design alternative can be identified — Due: 9/30/2015
- Co-funding availability from the USACE — Due: 03/31/2016

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
N/A	N/A	$500k	$702k	$600k	$708k

- No variances from planned budget
- The cost-share is from USACE
- 90% of project budget has been expended to date

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators:

- USACE, Yakama Nation, Columbia River Inter-Tribal Fish Commission, Bureau of Reclamation, Umatilla Tribe, Nez Perce Tribe, U.S. Geological Survey
- Industry (Dominion Power, Electric Power Research Institute, Grant Public Utilities District (PUD), Chelan PUD, Douglas PUD, Great Lakes Fishery Commission, University of California at Davis)
- Resources and regulatory agencies (U.S. Fish and Wildlife Service, National Marine Fisheries Service)

Communications and Technology Transfer:

- Multi-agency/Stakeholder meetings (3)
- One-on-one webinars (2)
- Presentations at conferences or workshops (6)
- Journal articles (5 published; 5 in review)
- Patent field (1)

Next Steps and Future Research

FY17/Current research:

- Complete laboratory evaluation of the tag's engineering performance by December 2016
- Conduct a pilot field trial for American eel at Roanoke Rapids Dam in North Carolina in collaboration with Dominion Power in 2017
- Conduct a pilot field trial for juvenile Pacific lamprey on the Columbia River in collaboration with USACE and tribal governments in 2017

Proposed future research:

- Explore applications to other key sensitive species such as American shad, delta smelt, river herring
- Full-scale field studies with significant support of industry partners and other agencies
- Commercialization and technology transfer