

Development of an injectable micro-acoustic transmitter for fish passage evaluation

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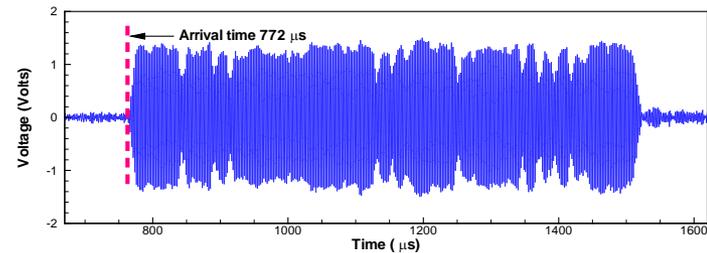
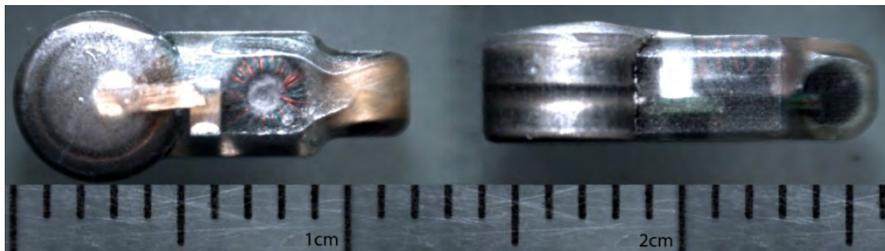
2012 Anadromous Fish Evaluation Program Review, Nov. 28, 2012



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Juvenile Salmon Acoustic Telemetry System (JSATS) components

- ▶ The JSATS consists of acoustic microtransmitters, receivers, and data management and processing software.



Current USACE Procurement specifications

- ▶ Dimension: 12 mm long x 5 mm wide x 4 mm high
- ▶ Dry Weight: 430 mg
- ▶ Volume: 160 mm³
- ▶ Source Level: 153 dB re: 1μPa @ 1 meter
- ▶ Coding: 65,536 unique 31-bit codes
- ▶ Frequency: 416.7 kHz ± 0.5%
- ▶ Pulse rate interval (PRI): Configurable
- ▶ Tag life: minimum 20 days at 3-s pulse rate interval



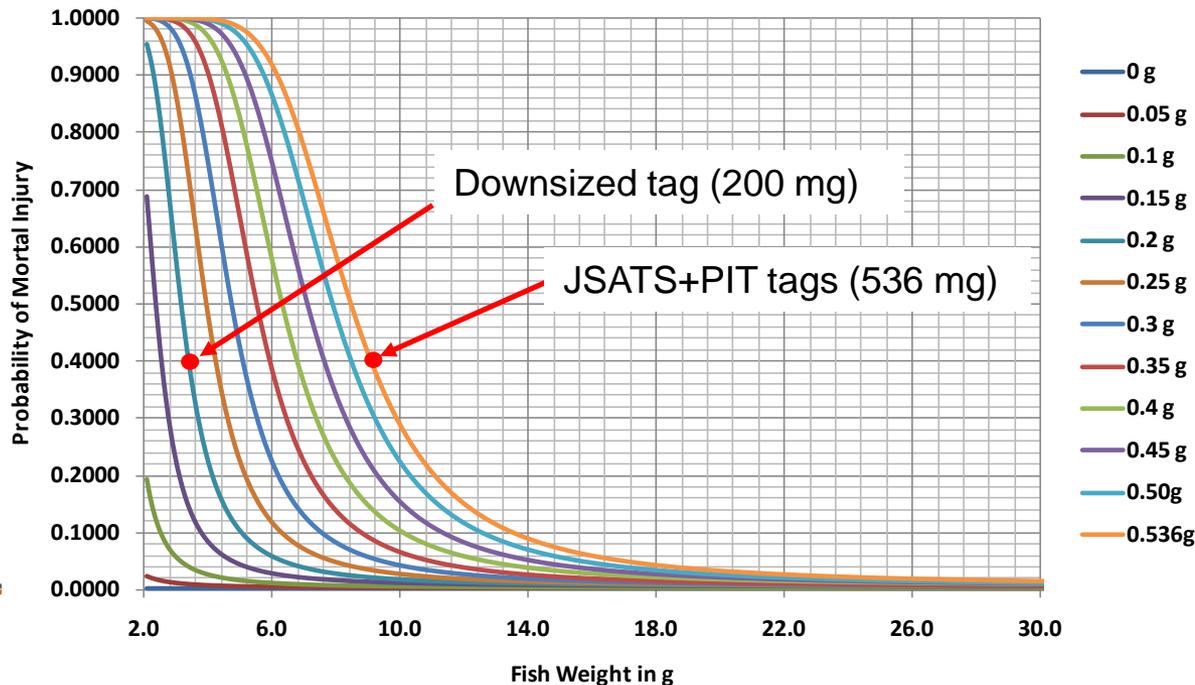
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Potential biological benefits for transmitter weight reductions

- ▶ The equation is an indicator to assess the relative biological effect of tag burden (Skalski and Seaburg 2010).
- ▶ Both JSATS and PIT tags (536 mg) are currently implanted in juvenile Chinook salmon greater than 95 mm in length (9 g in weight) .
- ▶ 200 mg tag could be implanted in juvenile Chinook salmon 3.5 g in weight (70 mm in length).

$$p_{\text{Mort}} (\text{hatchery fish}) = \frac{e^{-5.886+4.108*LRP+0.929*\text{Tag Burden}}}{1 + e^{-5.886+4.108*LRP+0.929*\text{Tag Burden}}}$$

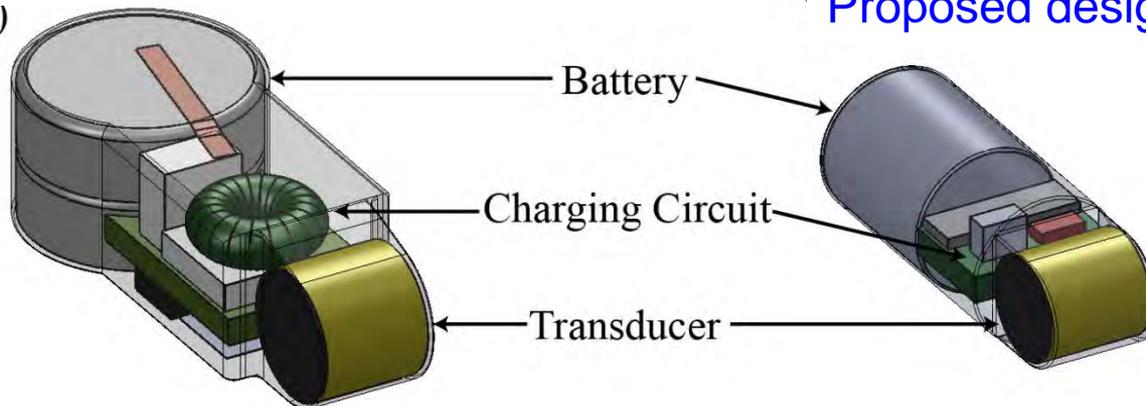


Proposed specifications

- ▶ Implantation by injection using gauge 8 (3.427-mm ID) or 9 (2.997-mm ID) veterinary-grade needles
- ▶ Meet performance requirements of existing transmitters

Current JSATS transmitter design

a)



Proposed design



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Approach

- ▶ Multidisciplinary approach with team from diverse backgrounds.
- ▶ Develop the planned range of applications in collaboration with stakeholders.
- ▶ Integrate the functionality of the transmitter onto an Application-Specific Integrated Circuit (ASIC).
- ▶ Develop a primary micro-battery based on lithium/carbon monofluoride (Li/CF_x) chemistry.
- ▶ Determine the most efficient piezoelectric material for this application and optimize the transducer design for converting electrical energy into acoustic signals.
- ▶ Design form factors that permit transmitter shapes amenable to applications and implantation by injection.
- ▶ Develop a procedure for implantation that minimizes the time required for implantation and bio-effects in test fish.
- ▶ Assess manufacturability of the parts and whole unit in qualities required for dam passage survival studies using JSATS.



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Functionality of Downsized Tag

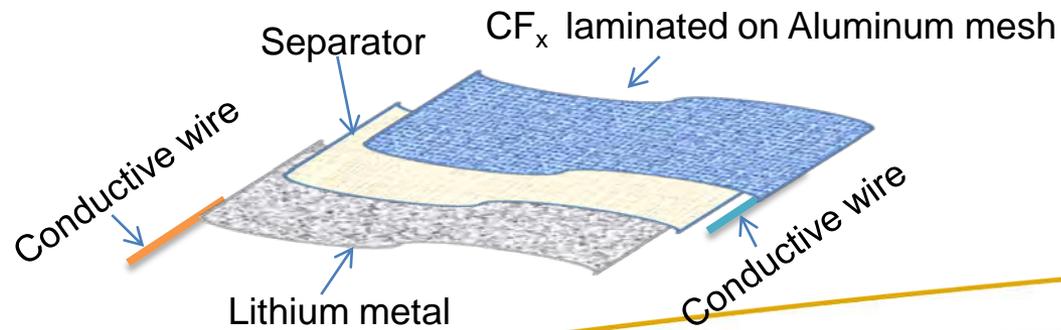
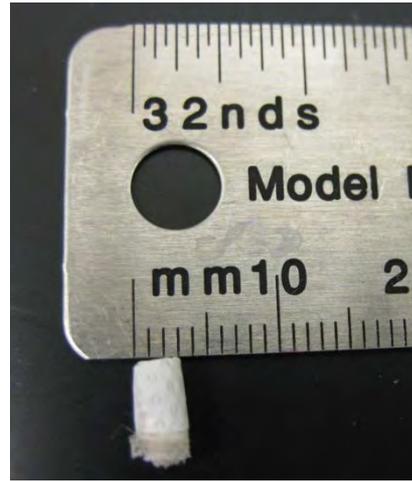
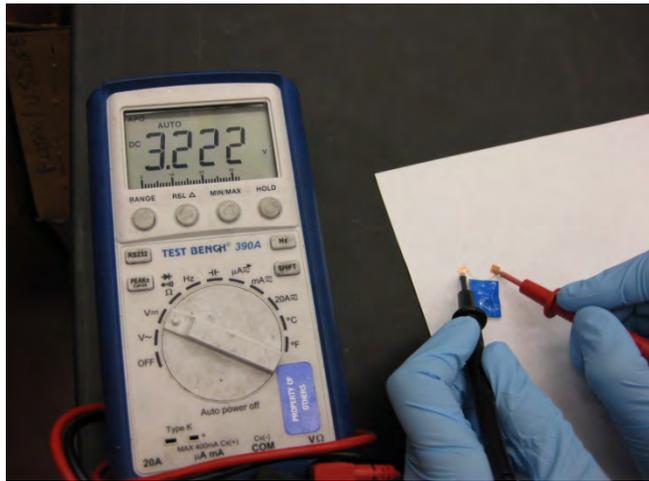
- ▶ Programmable transmit length (up to 64-bit)
- ▶ Programmable source level
- ▶ Programmable pulse rate
- ▶ Temperature sensor
- ▶ Hibernate until fixed time has elapsed
- ▶ Close-range RF for programming and On/Off switch.



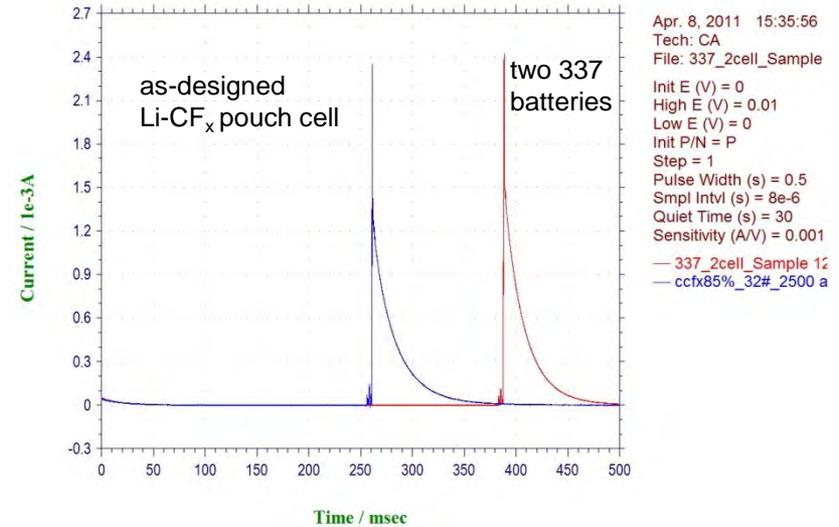
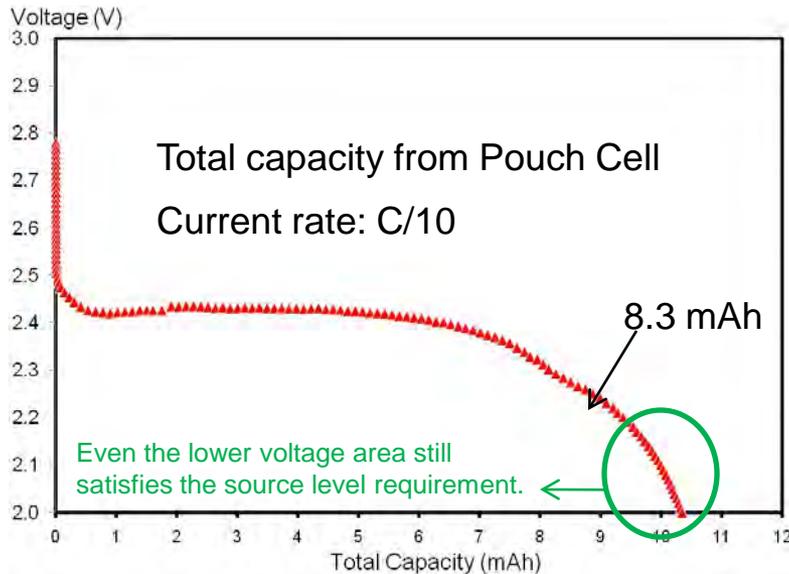
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Li-CF_x Micro Pouch Cell

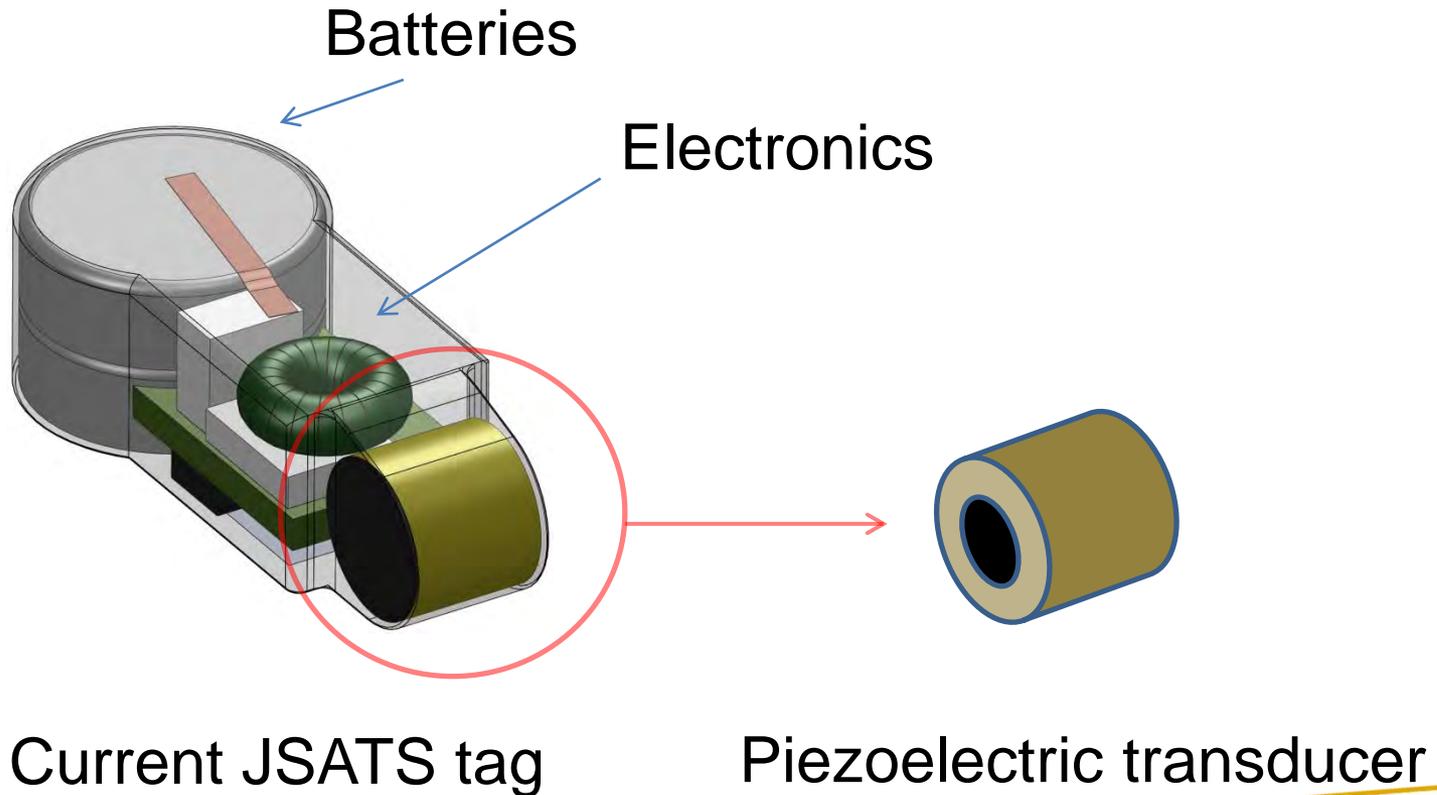


Li-CF_x Micro Batteries Satisfy the Requirement for JSATS

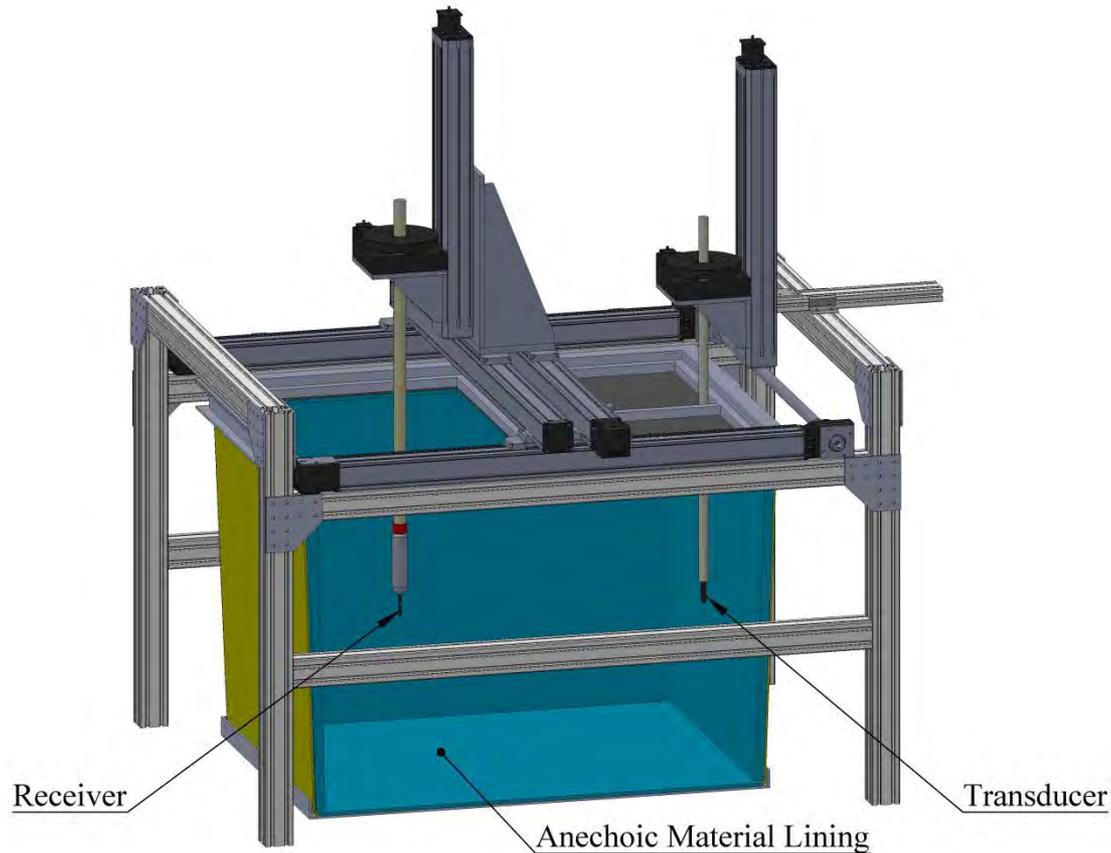


- Operation voltage is flat at ~ 2.4 V compatible with the circuit board design.
- Capacity from as-designed pouch cell exceeds the practical requirement.
- Pulse current from single Li-CF_x cell is equal to that from two 337 batteries.
- Significantly reduced weight.

Piezoelectric transducer in JSATS tag



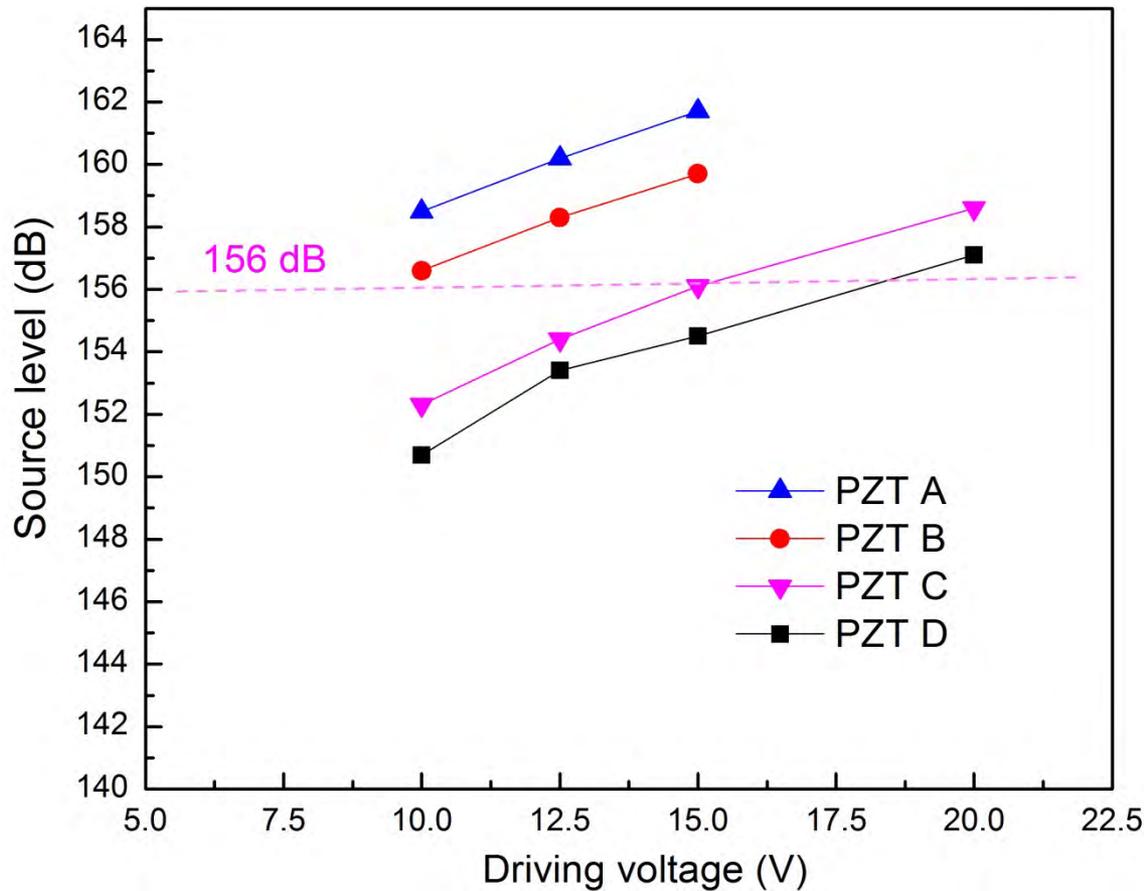
The source level and beam pattern evaluations in PNNL Bioacoustic and Flow Lab, accredited by A2LA



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Voltage response of different PZT tubes using hot glue as backing material



Bio-evaluation results

- ▶ Implantation using gauge 8 needles
- ▶ 100% survival rate
- ▶ 100% tag retention
- ▶ Reduced implantation time
- ▶ Reduced bioeffects compared to existing tags



Summary

- ▶ On schedule for completion and competitive procurement early 2013.
- ▶ Significant reductions in costs of use by using injection instead of surgical implantation
- ▶ Ability to study fish species and sizes that are too small for the current transmitter, and provide information for the development of fish-friendly hydro systems internationally
- ▶ Gathering knowledge to build further downsized and flexible transmitters for species with thin and flexible bodies such as juvenile lamprey.



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Questions?

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