

Dec 12th, 3:40 PM - 5:20 PM

# Machine learning for automated sonar monitoring of outmigrating American eel behavior

Paul T. Jacobson PhD  
*EPRI*

Follow this and additional works at: [https://scholarworks.umass.edu/fishpassage\\_conference](https://scholarworks.umass.edu/fishpassage_conference)

---

Jacobson, Paul T. PhD, "Machine learning for automated sonar monitoring of outmigrating American eel behavior" (2018).  
*International Conference on Engineering and Ecohydrology for Fish Passage*. 32.  
[https://scholarworks.umass.edu/fishpassage\\_conference/2018/December12/32](https://scholarworks.umass.edu/fishpassage_conference/2018/December12/32)

This Event is brought to you for free and open access by the Fish Passage Community at UMass Amherst at ScholarWorks@UMass Amherst. It has been accepted for inclusion in International Conference on Engineering and Ecohydrology for Fish Passage by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact [scholarworks@library.umass.edu](mailto:scholarworks@library.umass.edu).



# Eel Passage Research Center

## Upper St. Lawrence River and Selected Hydropower Project Facilities



**A Virtual Center**

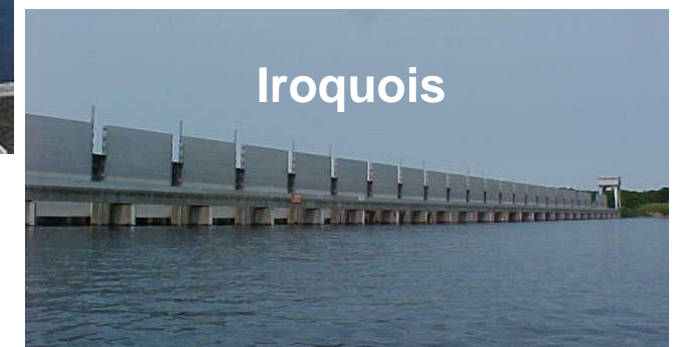
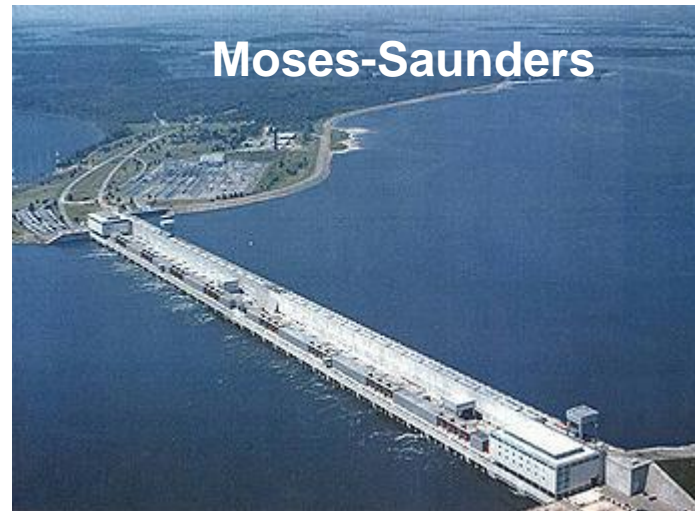
**Initial term 2013-2018**

**Currently preparing for  
the second term  
(2019-2023)**

# Eel Passage Research Centre

**Goal:** Maximize survival rate of eels that would otherwise pass through turbines at Moses-Saunders and Beauharnois without significantly reducing power production.

- Screening infeasible
- Behavioral guidance (e.g. light, electricity) to collection points
  - Above M-S (Iroquois)
  - Above Beauharnois
- Capture and Transport Below Beauharnois

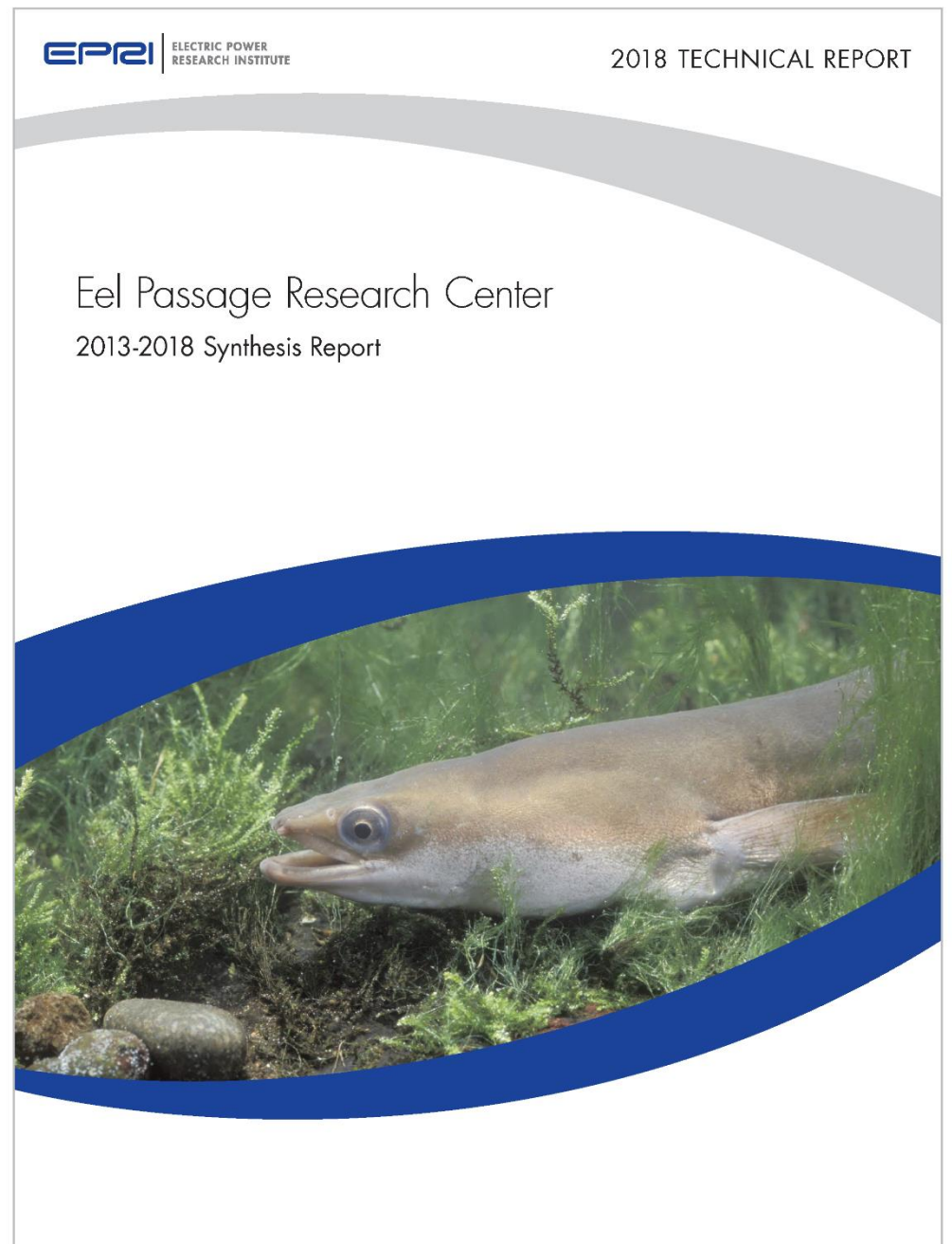


# Eel Passage Research Center: *2013-2018 Synthesis Report*

Report available for free download at:

**[www.epri.com](http://www.epri.com)**

**Report ID: 3002014733**





# Hydroacoustics Technologies for Monitoring Eel in the St. Lawrence River

**Relative  
Abundance**

**Movements**

**Behavior**

# EPRC study

## ■ Test 3 Sonars

- Simrad EK60 Split-beam Echosounder (120 kHz)
- Mesotech M3 Multi-mode Multibeam Sonar (500 kHz)
- Sound Metrics ARIS Explorer Multibeam Sonar (1100/1800 kHz)



Kongsberg Mesotech Ltd.

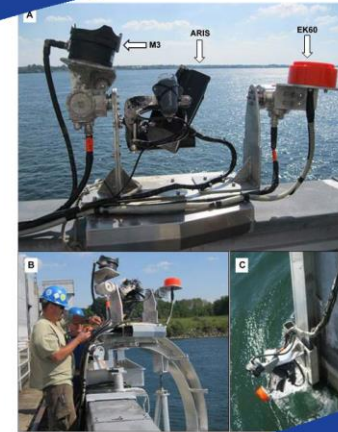


Report available for free download at:

**[www.epri.com](http://www.epri.com)**

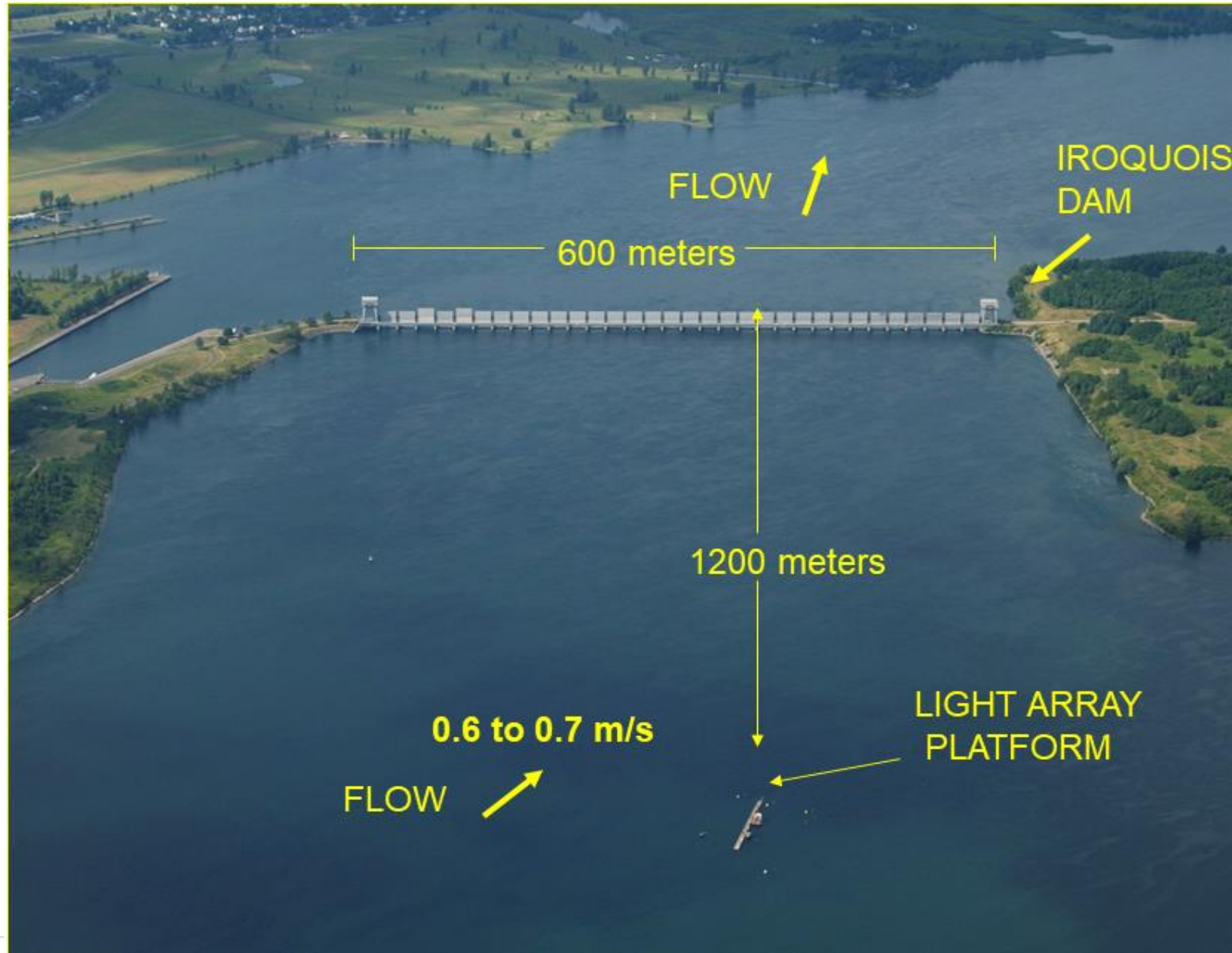
**Report ID: 3002009406**

Assessment of Technologies to Study  
Downstream Migrating American Eel Approach  
and Behavior at Iroquois Dam and Beauharnois  
Power Canal

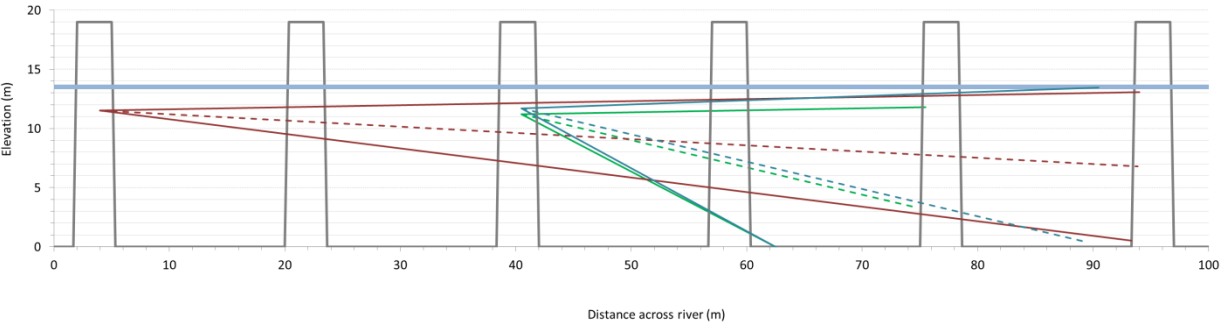
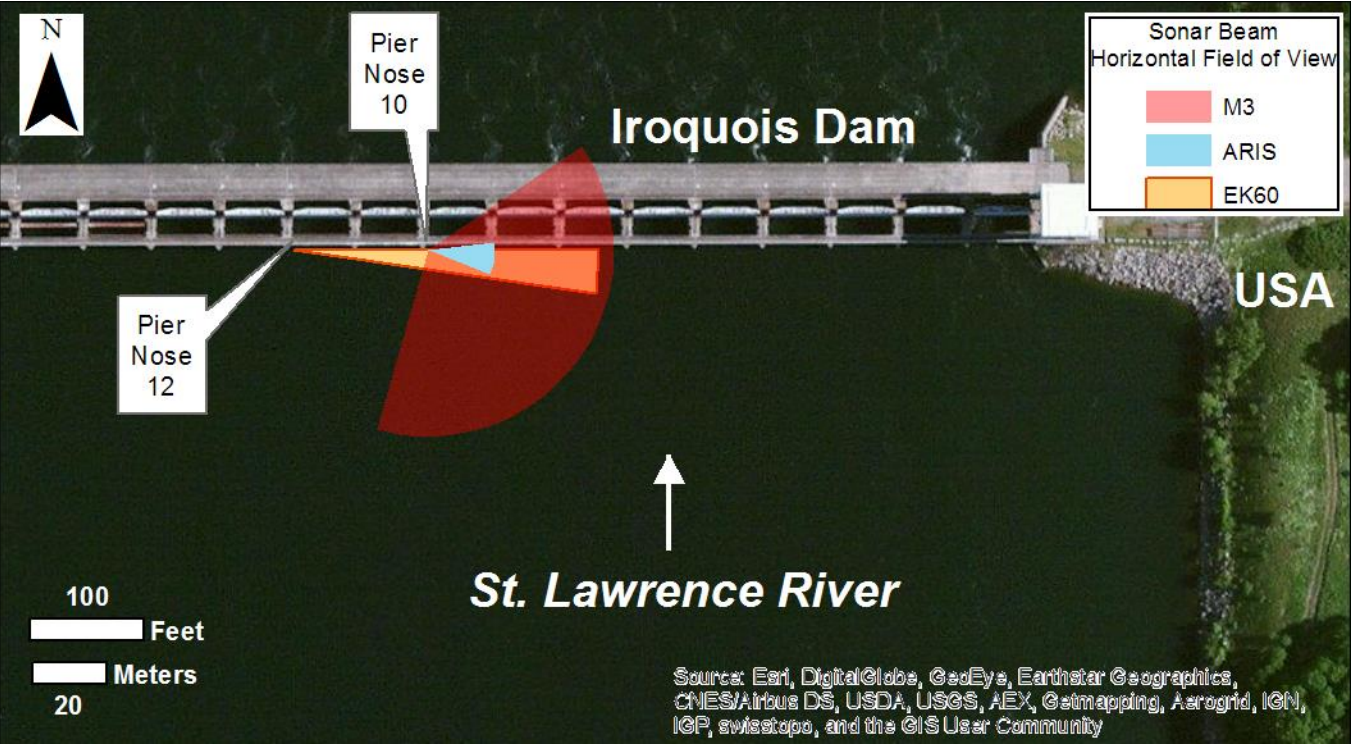




# Iroquois Water Control Dam, Saint Lawrence River

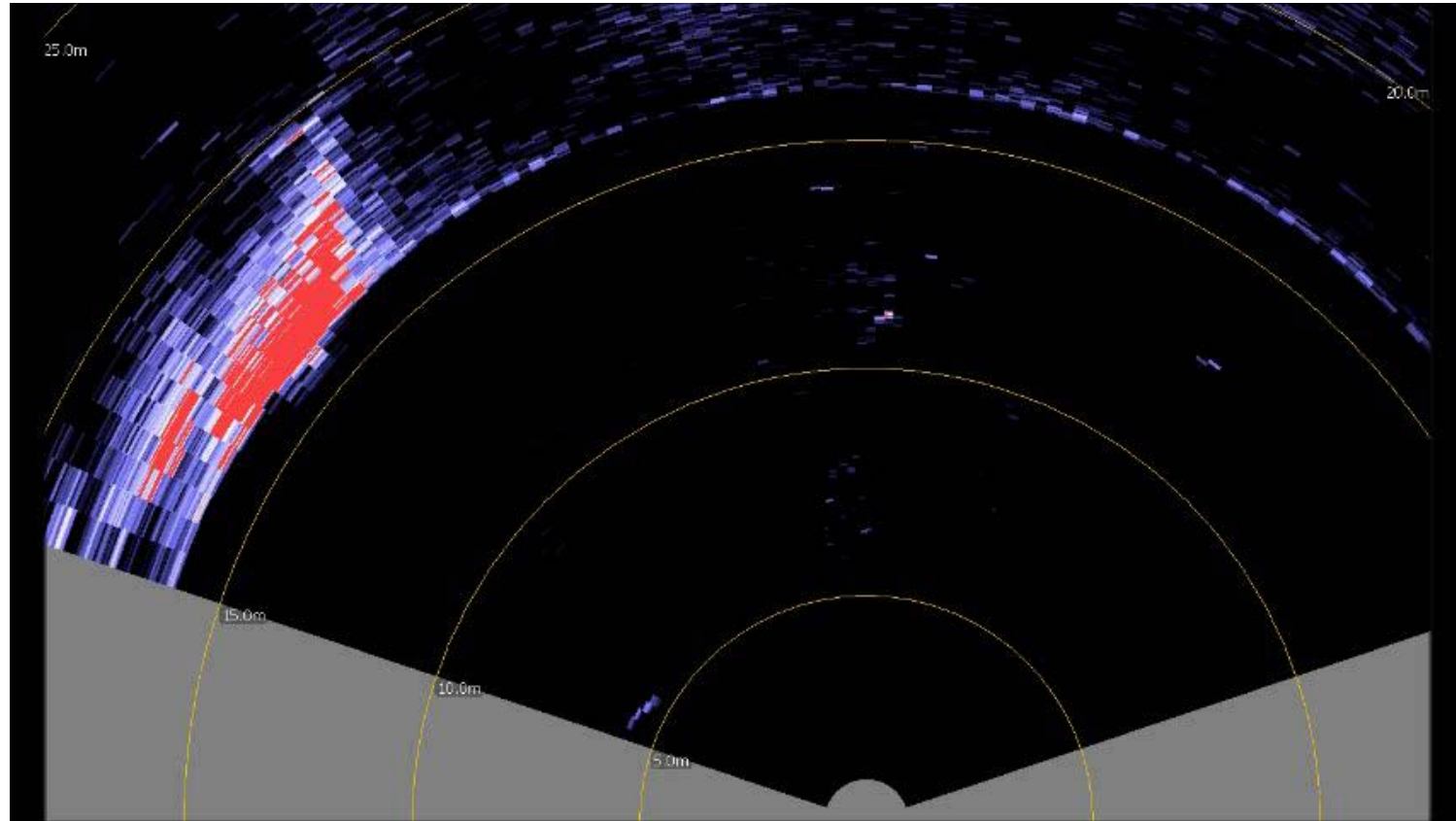


# Study Area & Beam Coverage: Horizontal & Vertical Sampling Extent

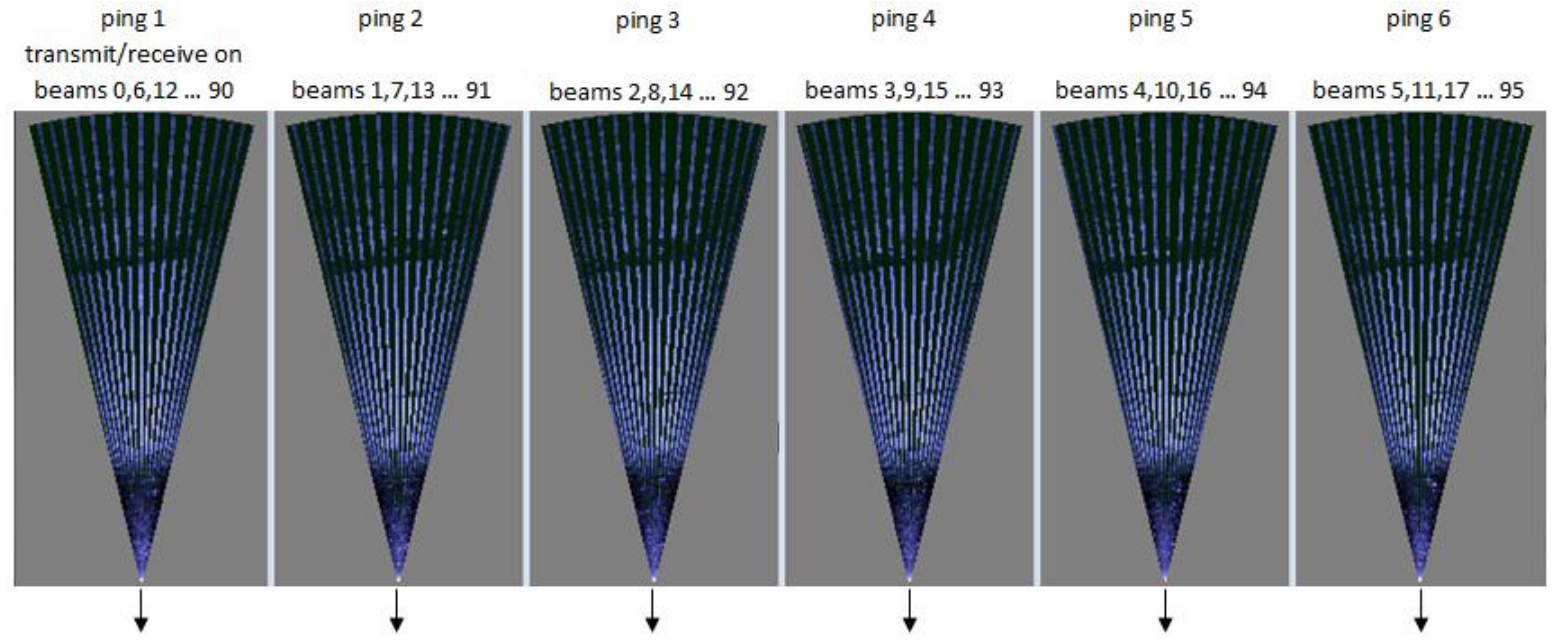


# M3 Example of an Eel

83-cm Eel (ID 931) at 9 m on 18 Sep 2015 (~12:13)

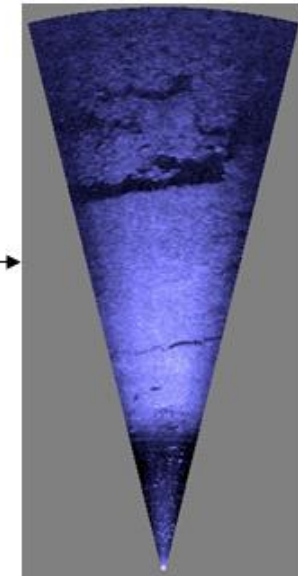


# ARIS Image Frame



**Composite of 6 successive transmissions (pings) of 16 beams (96 beams total)**

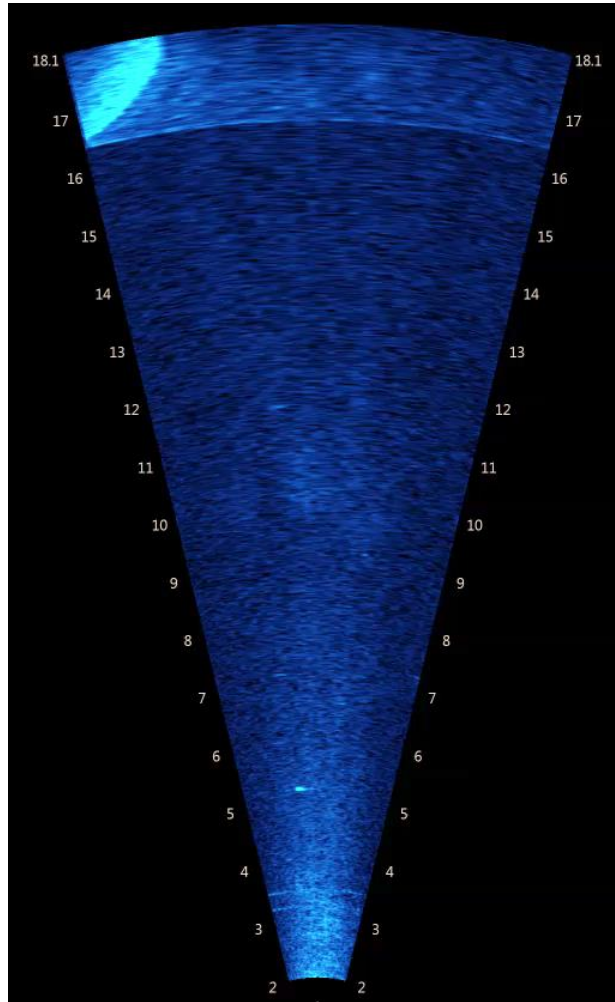
6 pings combined to form  
96-beam image of 1 frame



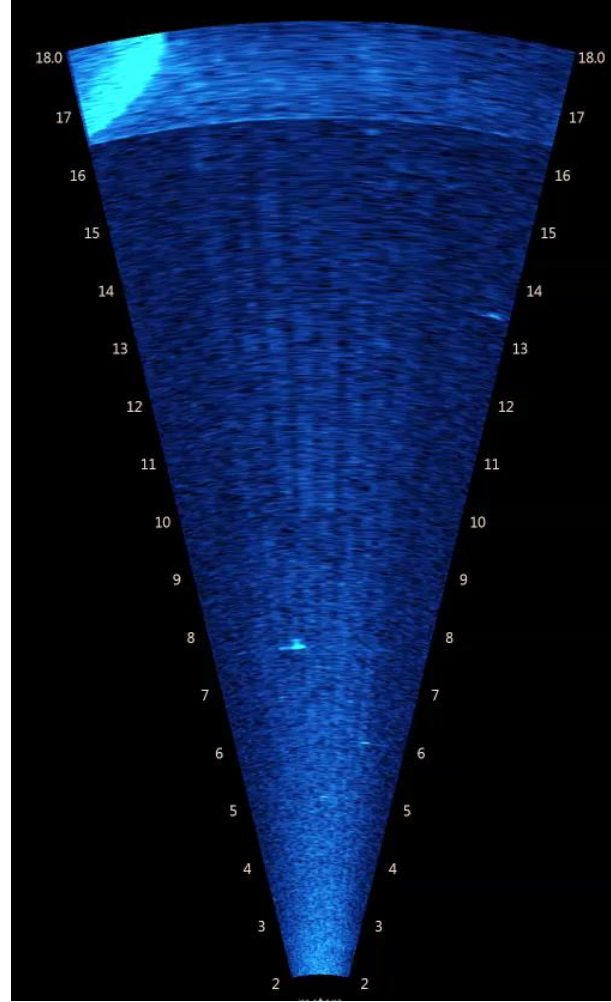
example:  
maximum range: 35 m  
cycle period: 0.048 s  
maximum temporal separation within  
frame: 5 x cycle period = 0.24 s

# ARIS Sonar

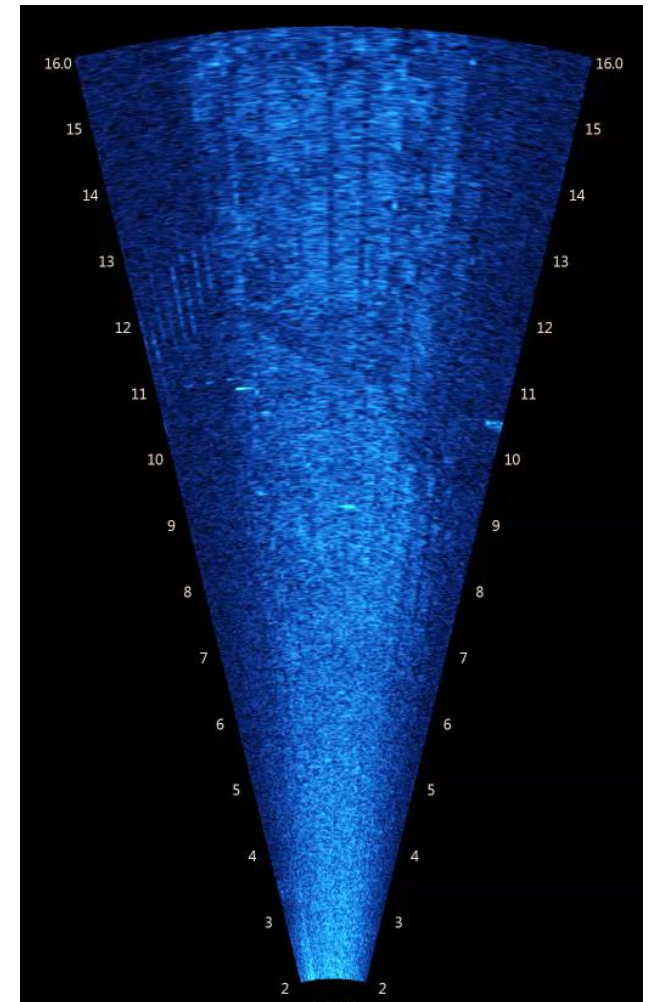
76cm live eel released at 6m



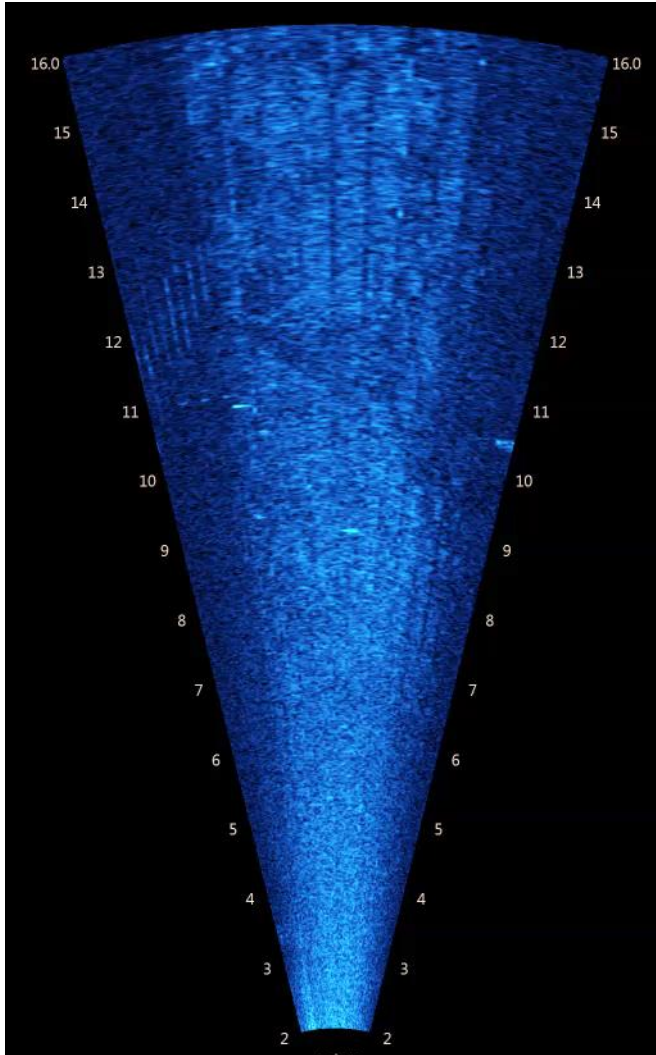
91cm live eel released at 12m



130cm stick released at 10m



# Motion Artifact – Example of a 130-cm stick in ARIS movie



- Motion artifacts distorts image to resemble anguilliform “squiggle” that makes interpretation difficult
  - Alters echo shape over time
- A long, fast moving, rigid object mimics the changing shape of an eel in typical anguilliform swimming motion
  - Leads to false positives
- Factors:
  - Target speed within a single frame
  - Target orientation relative to the trajectory
  - Maximum range (affects cycle period, i.e. ping rate within a frame)

# Machine Learning and Data Analytics for Automated Detection, Identification, Enumeration, and Tracking of Migrating Adult Eels from Sonar Data



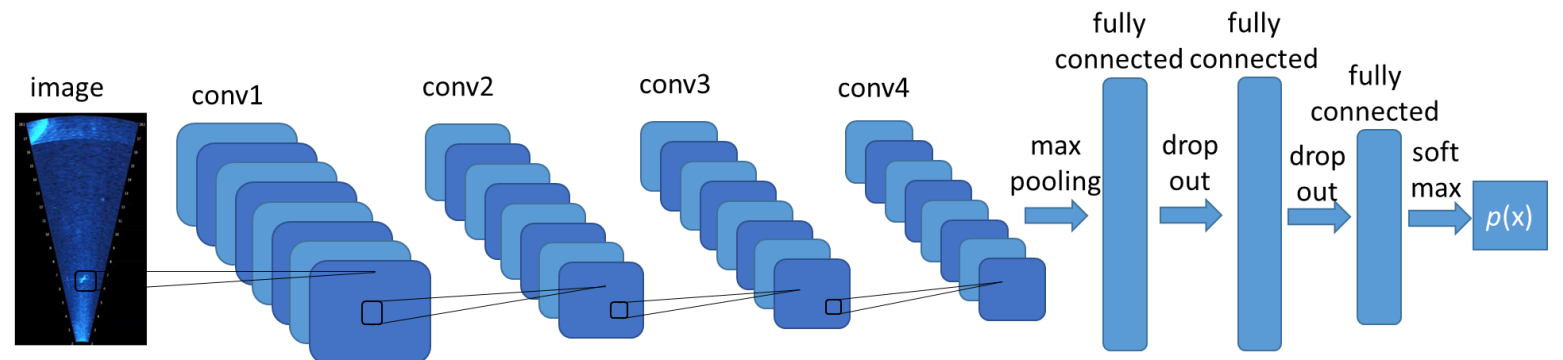
## Principal Investigators:

Paul Jacobson, Electric Power Research Institute  
Daniel Deng, Pacific Northwest National Laboratory

## Project Objective:

Develop and demonstrate software tools to automate detection of adult American eel from multi-beam imaging sonar data

**DOE Funding: September 1 Start  
12-month Period of Performance**



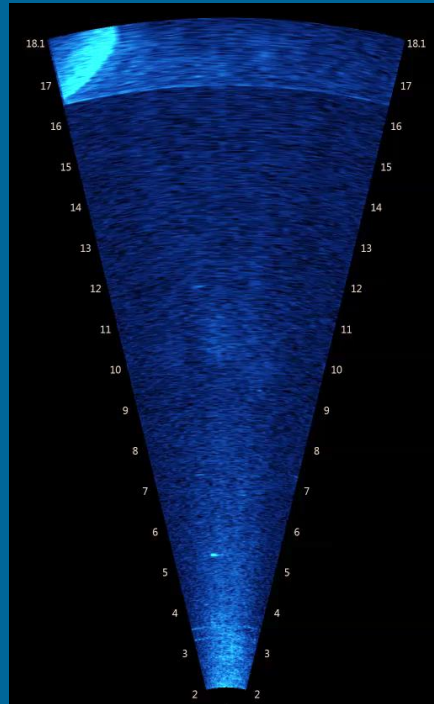
## Eel Behavior Poorly Understood

- Species of concern, relatively rare
- Migration episodic and variable over many months each year
- Eel behavior critical to design and operation of protection technologies



## Imaging Sonar One of Best Tools

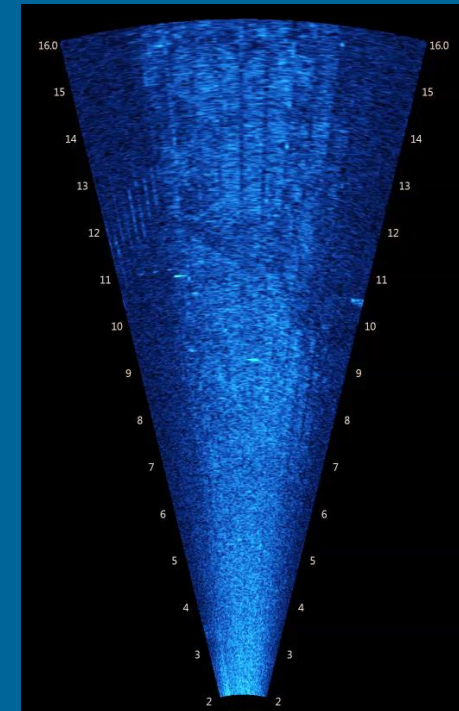
- ID of free-swimming eels
- Observe abundance & behavior
- Test/monitor response to protection technologies



Live Eel

## Analysis Complex & Costly

- Large data volume
- Time consuming to analyze
- Subject to classification errors, many false targets



Stick



# Analysis of Imaging Sonar Data Will Be:

## Faster

- Near real time results

## Cheaper

- Reduced data storage requirements
- Reduced requirements for highly skilled labor

## Better

- Results objective and consistent
- Reduced classification error
- Results actionable in immediate-, near-term

# Machine Learning (AI) Tools for Sonar Image Classification

## Task 1: Analysis of Existing Field Data & Supplemental Lab Data Collection

- Compilation of existing field data (including known eel targets) and collection of additional in-lab data
- **Application space discovery and specification**
- Wavelet filtering to reduce noise and convolutional neural network analysis for image classification (eel, non-eel target, no target)
- Exploration and quantification of performance space and classification accuracy

## Task 2: Software Tool Development and Dissemination

- Encapsulation of analytical methods in R programming language software tools
- Posting of software tools to public domain R users' site (*Comprehensive R Archive Network*)
- **Technology transfer (via webcast) to sonar equipment manufacturers, technical service providers, and other end users**

**End Point: Rapid, computerized data analytics replace slow, costly human labor**



**Paul T. Jacobson**  
**pjacobson@epri.com**  
**410-489-3675**



# Together...Shaping the Future of Electricity