



“Sound Science”: Sediment Monitoring Using Acoustic Surrogates in the U.S. Geological Survey

**Continuous Monitoring: Innovations in Applications and Instrumentation
9th National Monitoring Conference
ACWI, NWQMC
April 29, 2014**

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**OSW, Federal Interagency Sedimentation Project
water.usgs.gov/fisp**

**U.S. Department of the Interior
U.S. Geological Survey**

Relevance of Sediment Monitoring

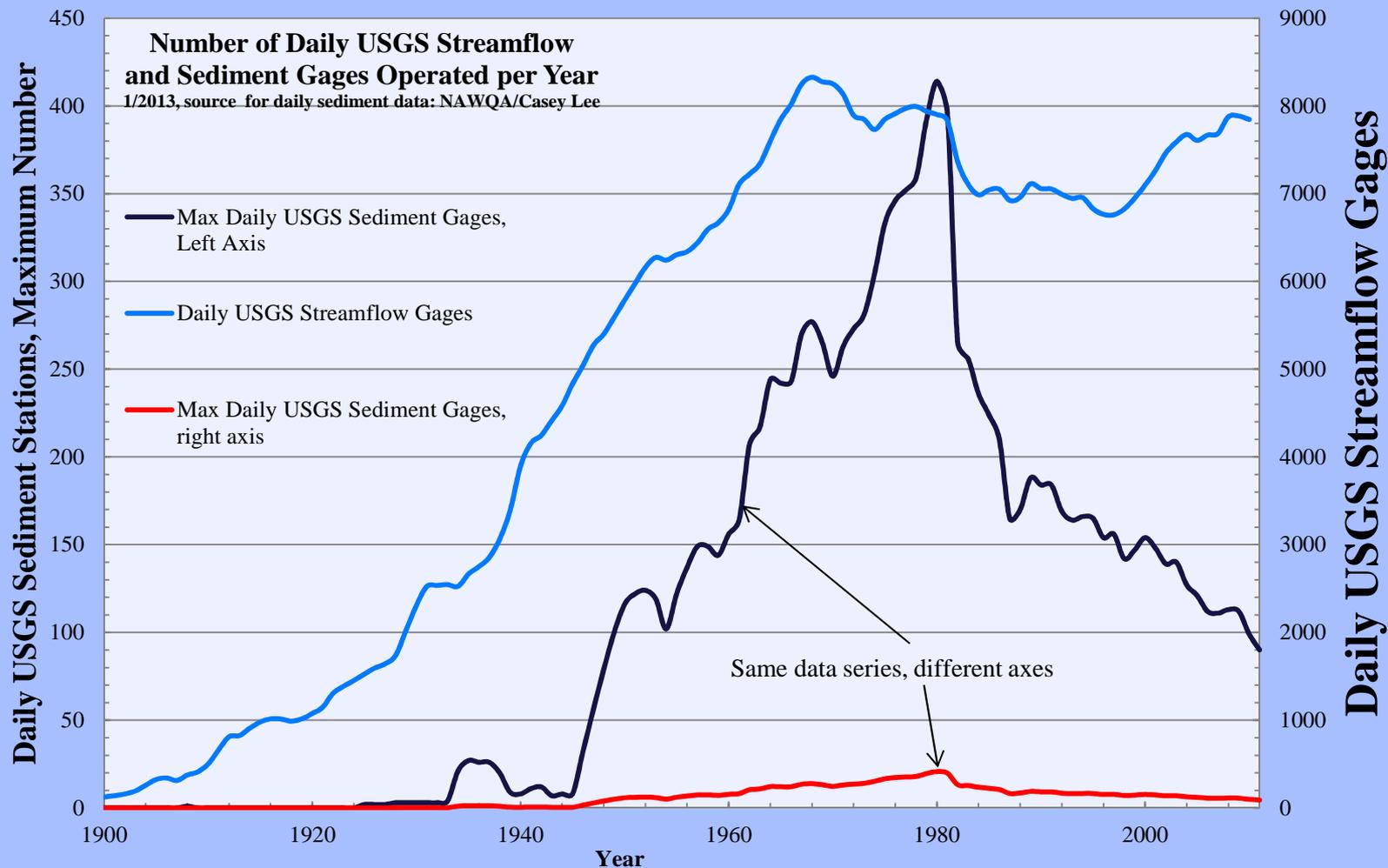
Causes of Impairment for 303(d) Listed Waters

[Description of this table](#)

NOTE: Click on a cause of impairment (e.g. pathogens) to see the specific state-reported causes that are grouped to make up this category. Click on "Causes of Impairment Reported" to see a list of waters with that cause of impairment.

Cause of Impairment Group Name	Number of Causes of Impairment
Pathogens	10,722
Metals (other than Mercury)	7,621
Nutrients	6,893
Organic Enrichment/Oxygen Depletion	6,367
Sediment	6,142
Polychlorinated Biphenyls (PCBs)	5,457
Mercury	4,747
pH/Acidity/Caustic Conditions	4,096
Cause Unknown - Impaired Biota	3,366
Turbidity	3,129
Temperature	3,013
Salinity/Total Dissolved Solids/Chlorides/Sulfates	1,897
Pesticides	1,872

Overview of USGS Streamflow and Sediment Monitoring



U.S. Department of the Interior
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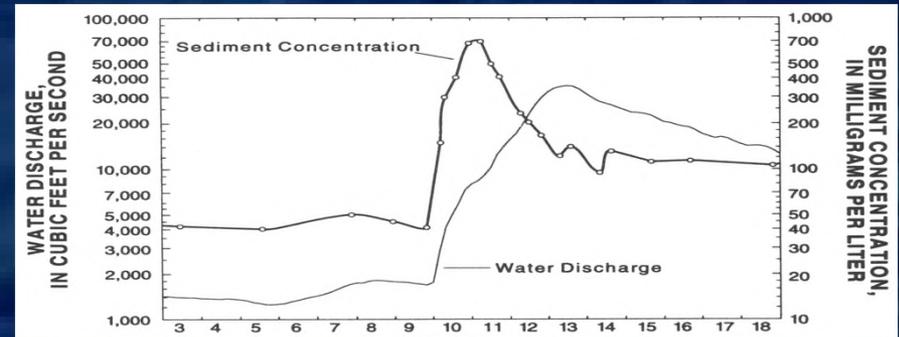
Traditional Suspended-Sediment Monitoring

Physical Samples and Gravimetric Analyses

- Difficult
- Expensive
- Labor intensive
- Essential

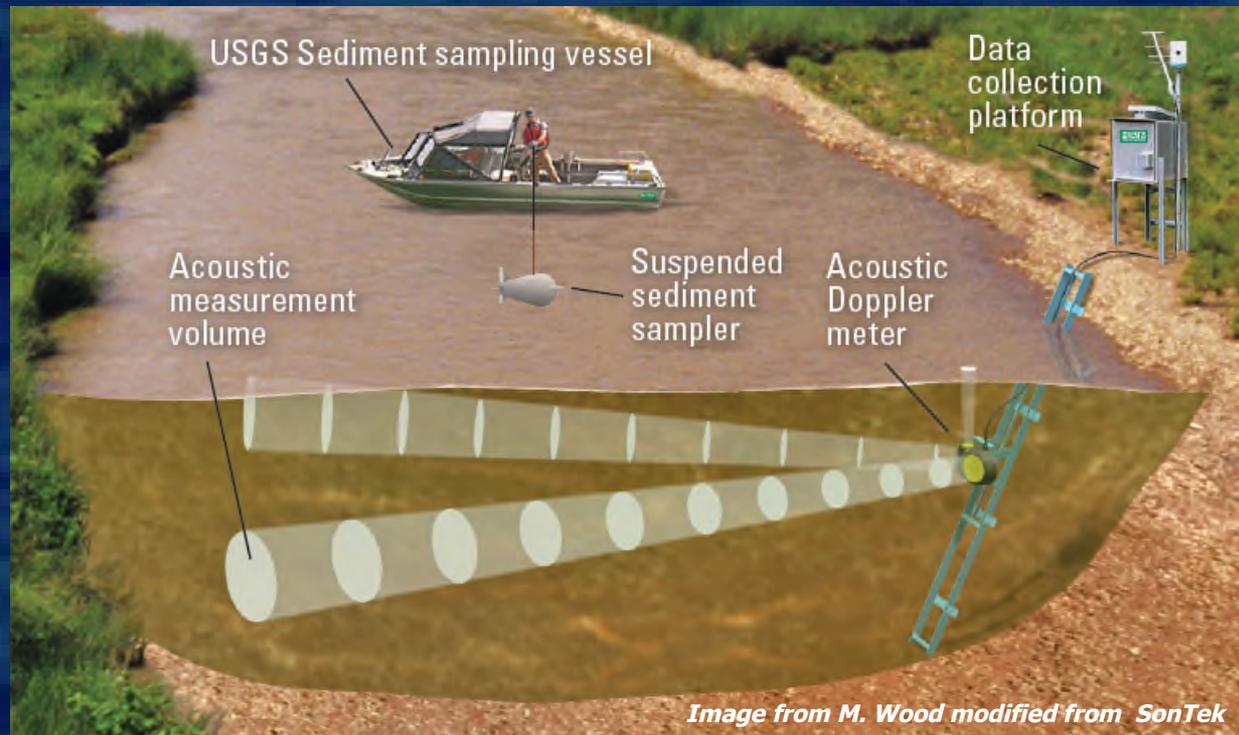


Limited samples often provide inadequate resolution of variability and require large interpolations



Continuous Sediment Acoustic Method

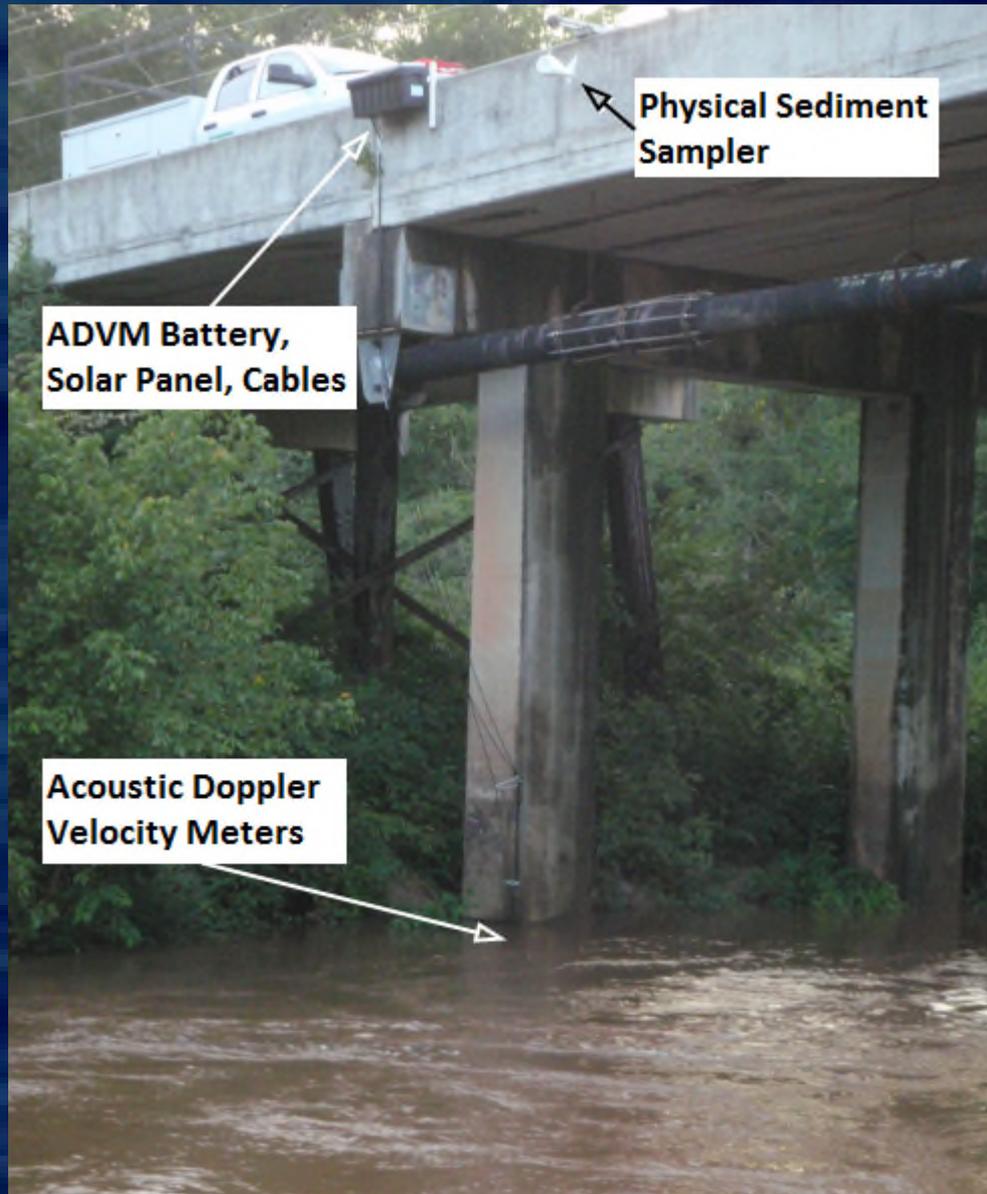
USGS operates over 500 index velocity gages for continuous flow records. Each one could likely be used as a continuous sediment surrogate site.



Methods and Tools are developed and being documented

Question: Can we leverage these data and installations for sediment acoustics?

Yellow River at Gees Mill Road near Metro Atlanta, GA, 02207335



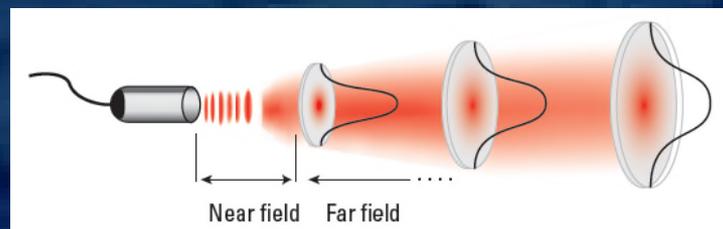
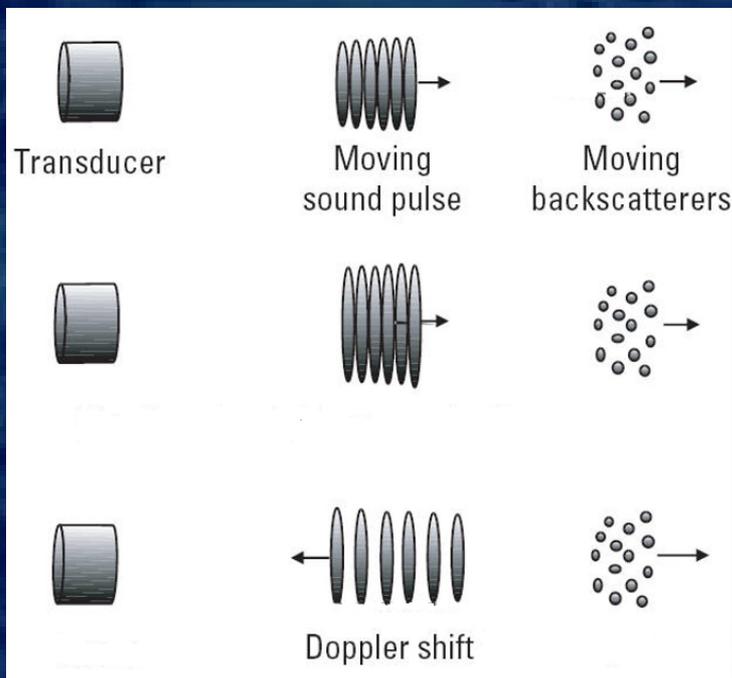
Acoustic Doppler Current Profilers (A) 1.2MHz (B) 1.5MHz (C) 3.0MHz



Acoustic Surrogates of SSC -- principles

$$SSC = 10^{(b_0 + b_1 \overline{SCB} + b_2 SAC)} \times BCF$$

$$SCB = MB + 20(\log_{10}(\psi R)) + 2R\alpha_w + 2R(SAC)$$



Surrogate Analysis and Index Developer (SAID) Tool

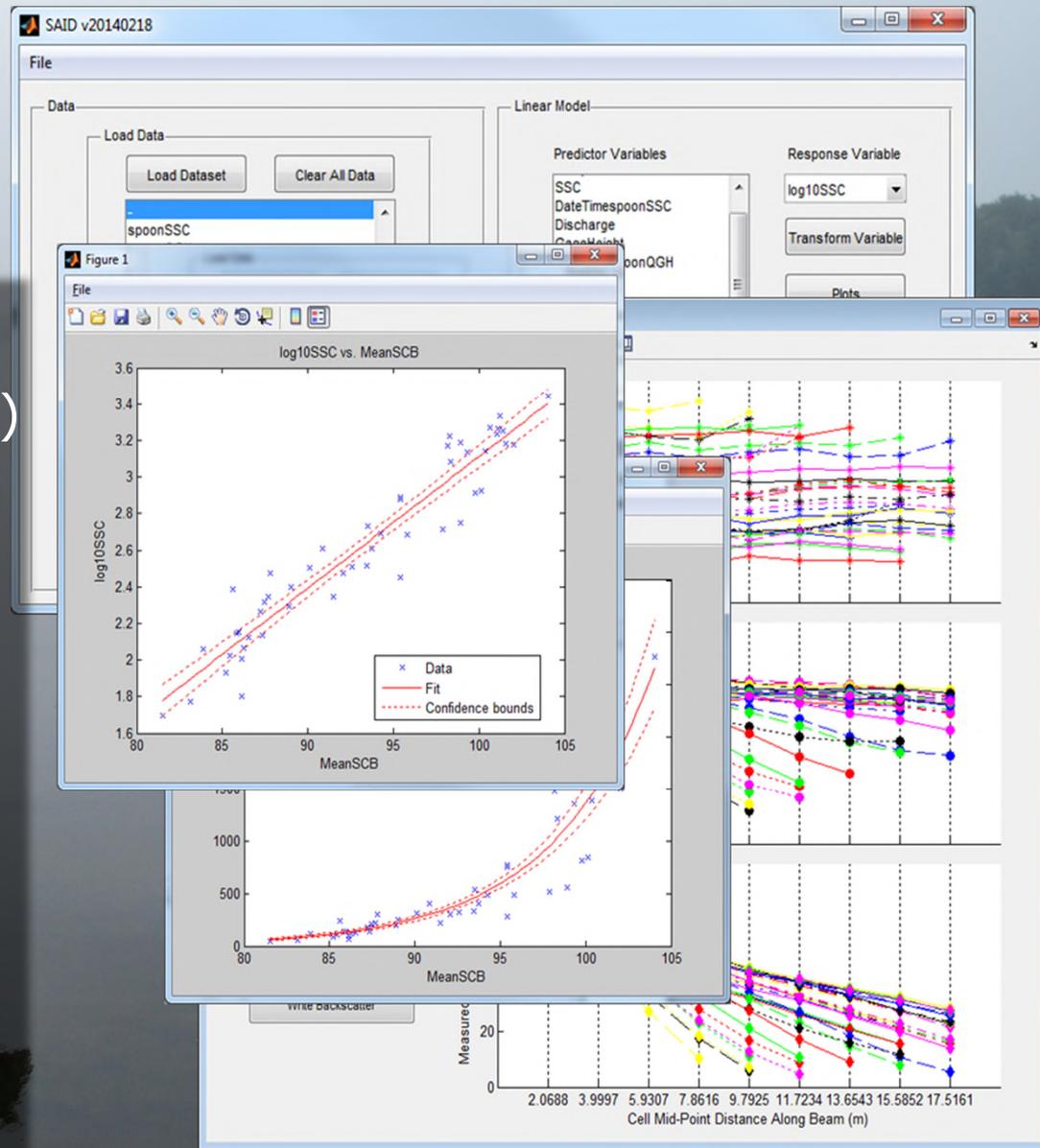
Assists in the creation of **regression models** that relate response and predictor (surrogate) variables

Processes **acoustic parameters** to be used as predictor variables for **suspended sediment concentrations**.

Supports **guidelines**

Multi-agency sediment acoustic methods work

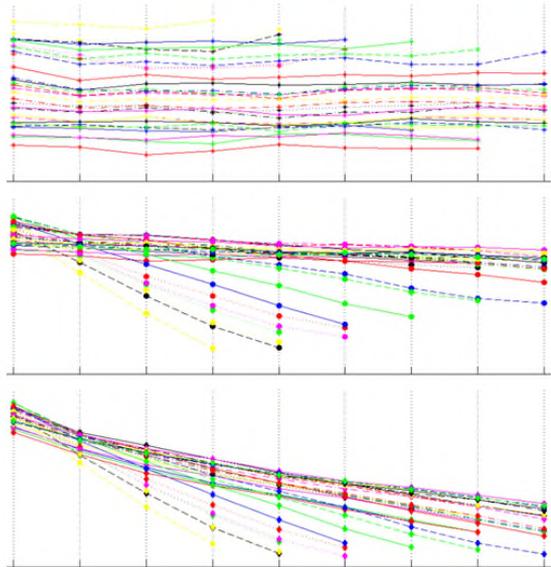
USGS Techniques & Methods 3-C4 for turbidity and SSC



SAID Resources

Surrogate Analysis and Index Developer
(SAID) Tool

User Manual



Manual Version

20140416

Software Version

20140416

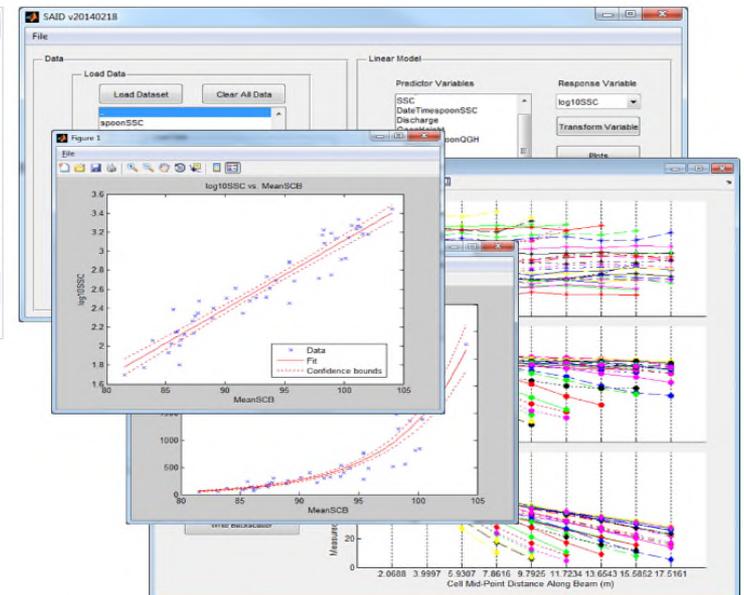
Website



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The Surrogate Analysis and Index Developer (SAID) Tool

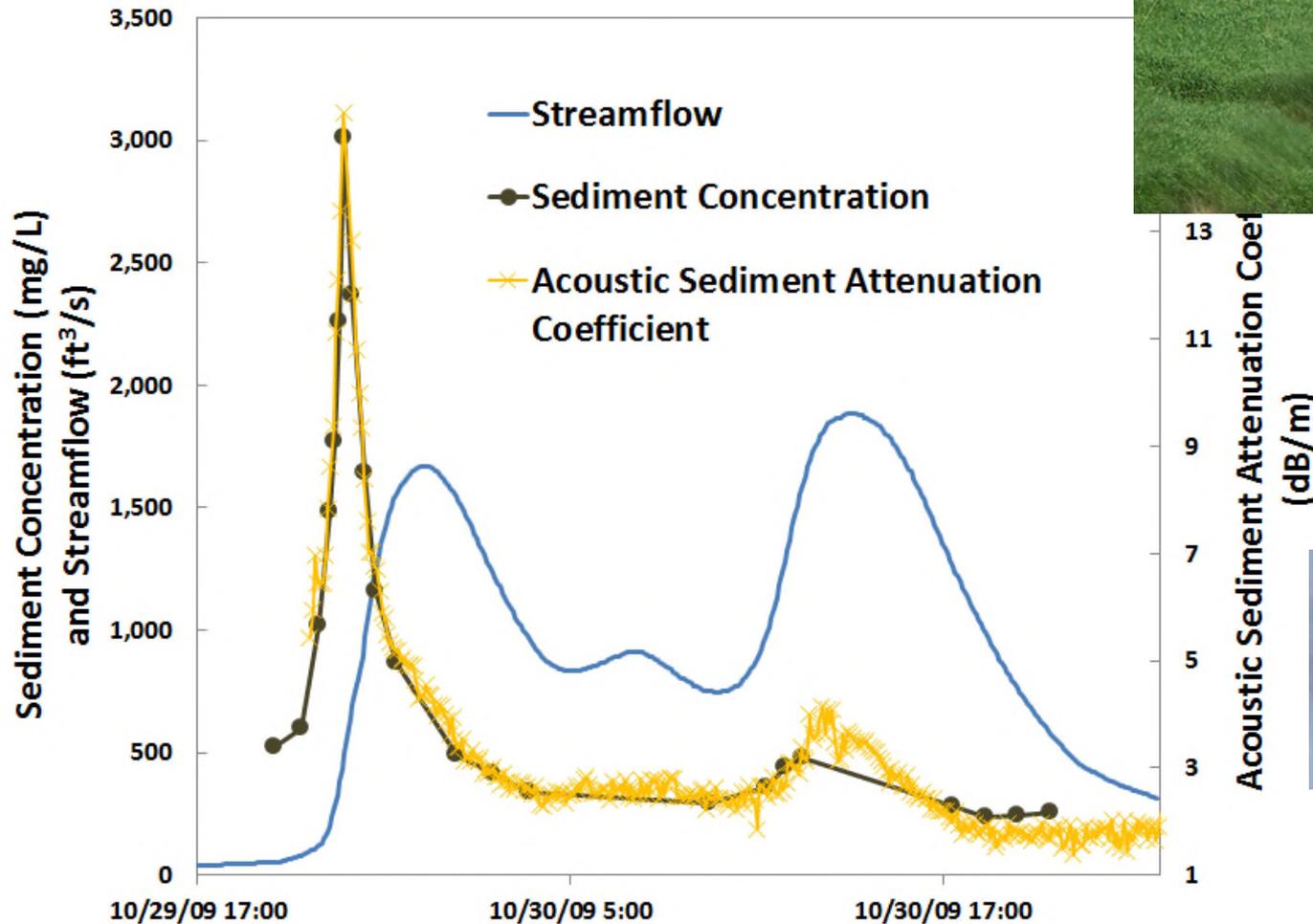
- SAID Menu
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- Features
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- Bug Reports or Suggestions
- User Group
- Collaborators
- SALT Home



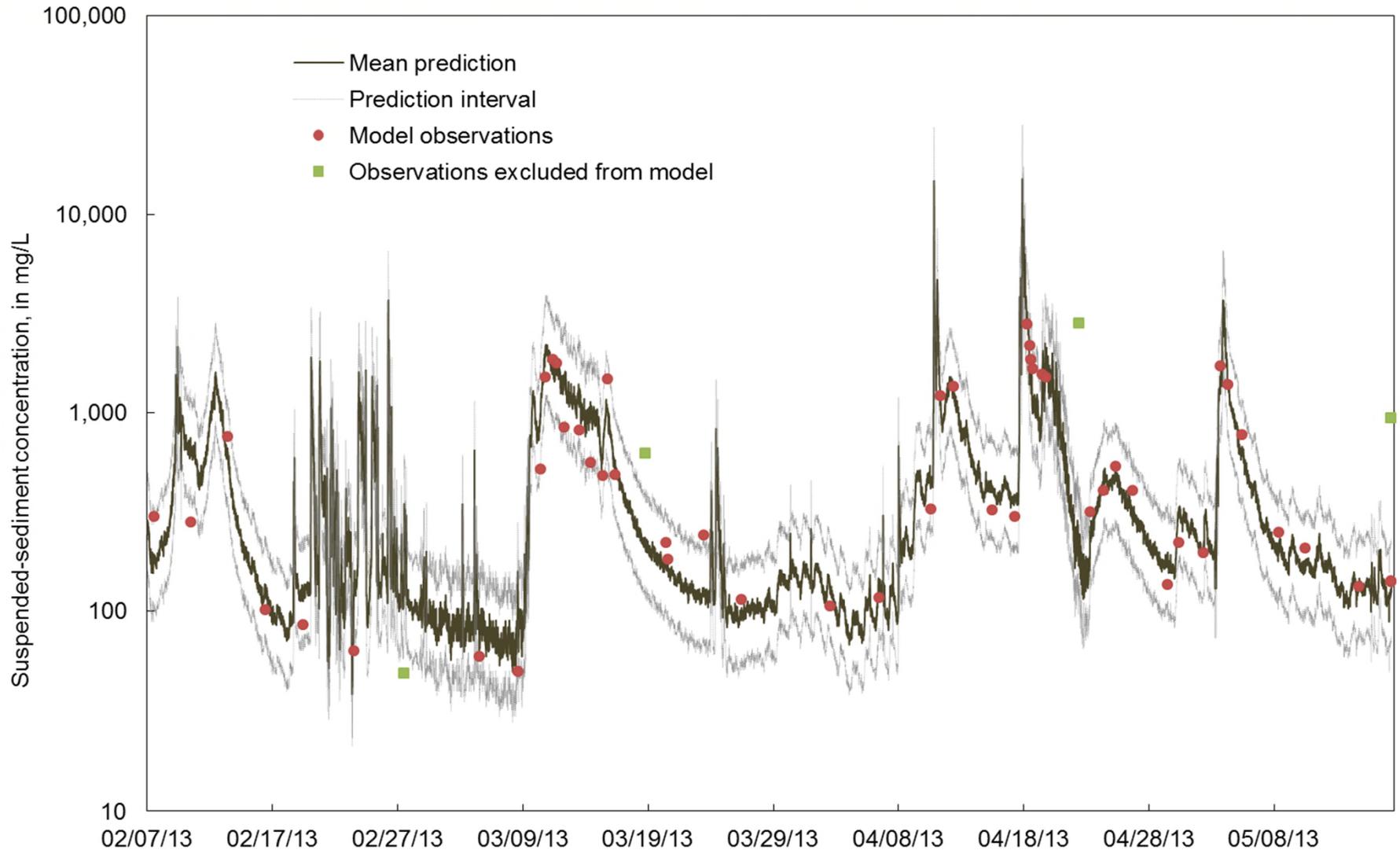
The Surrogate Analysis and Index Developer (SAID) tool is a stand-alone tool to assist in the creation of ordinary least squares (OLS) regression models by providing visual and quantitative diagnostics to the user. The tool also processes acoustic parameters to be used as predictor variables using a constant spatial suspended sediment concentration method. The method utilizes acoustic backscatter data from fixed-mount stationary acoustic Doppler velocity meters (ADVM).
Within the program, you can:

<http://water.usgs.gov/osw/SALT/SAID/>

Kickapoo Creek near Bloomington, IL



Elwha River at Diversion Structure near Port Angeles, WA



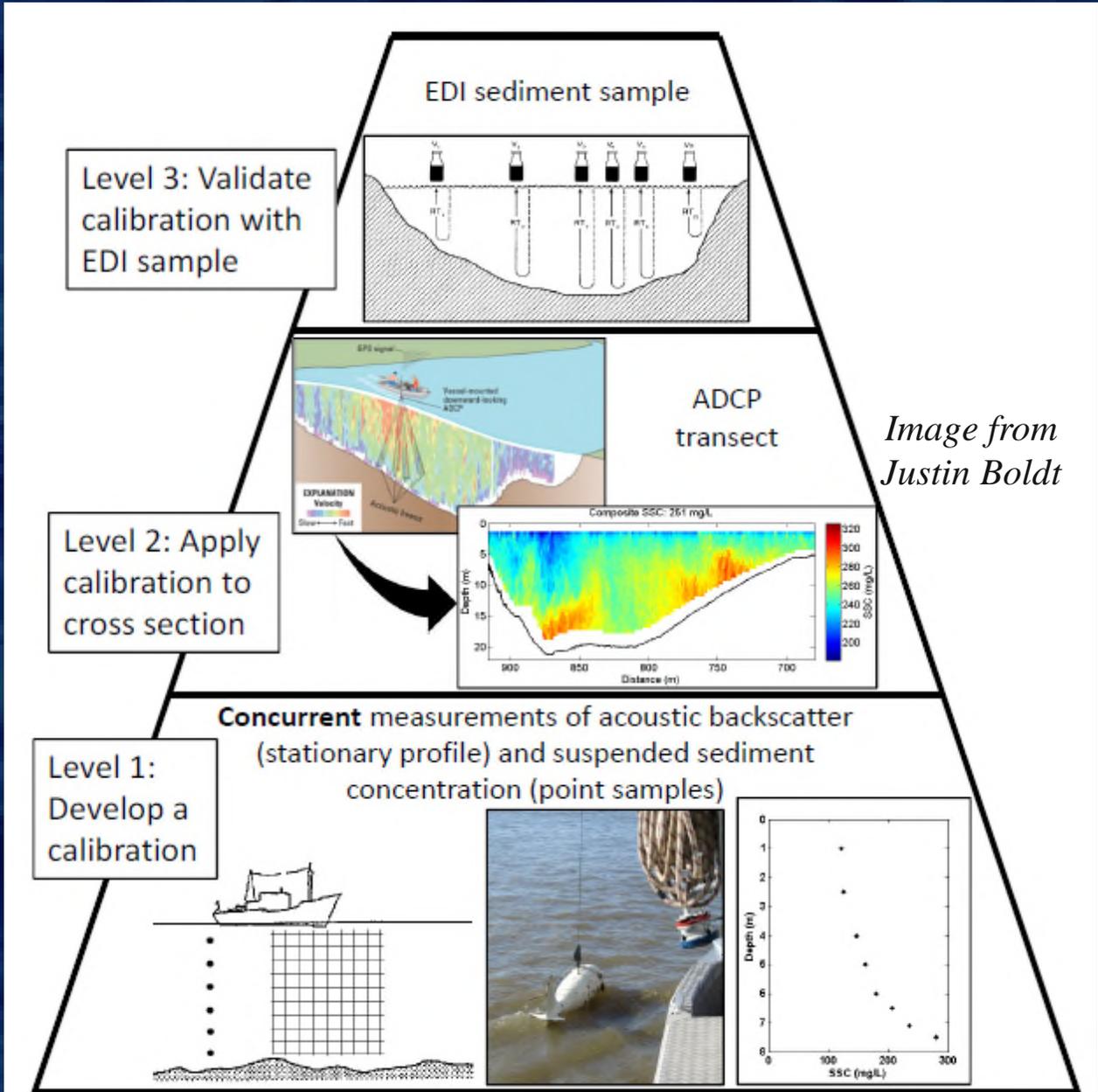
Utility of Real-Time Sediment

- Early warning for municipal water supply and hydropower facilities
- Track sediment loads after wildfire, construction activities, levee failures, etc.
- Monitor river response to remediation activities and changing land uses

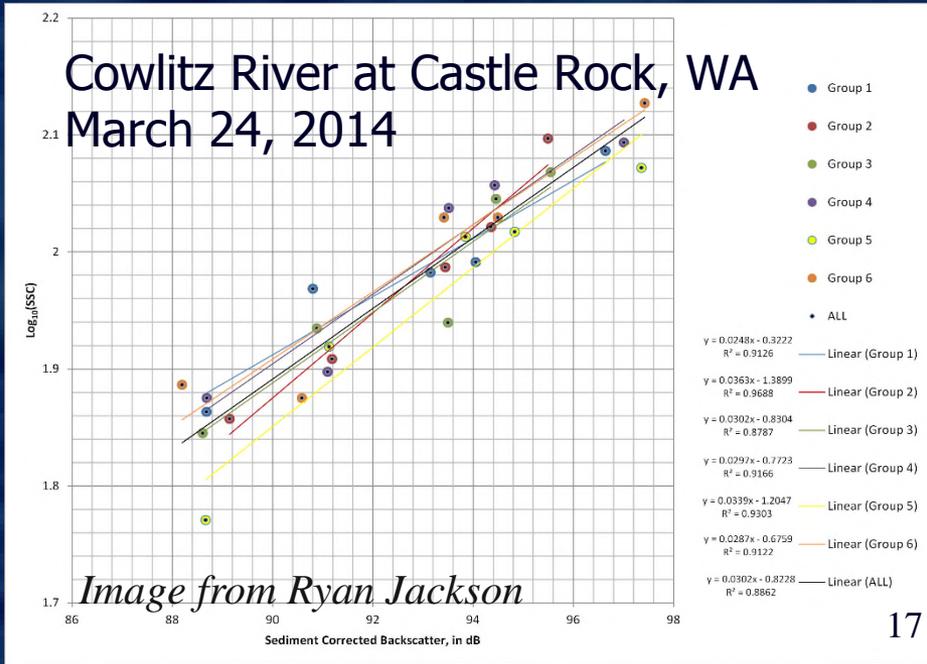
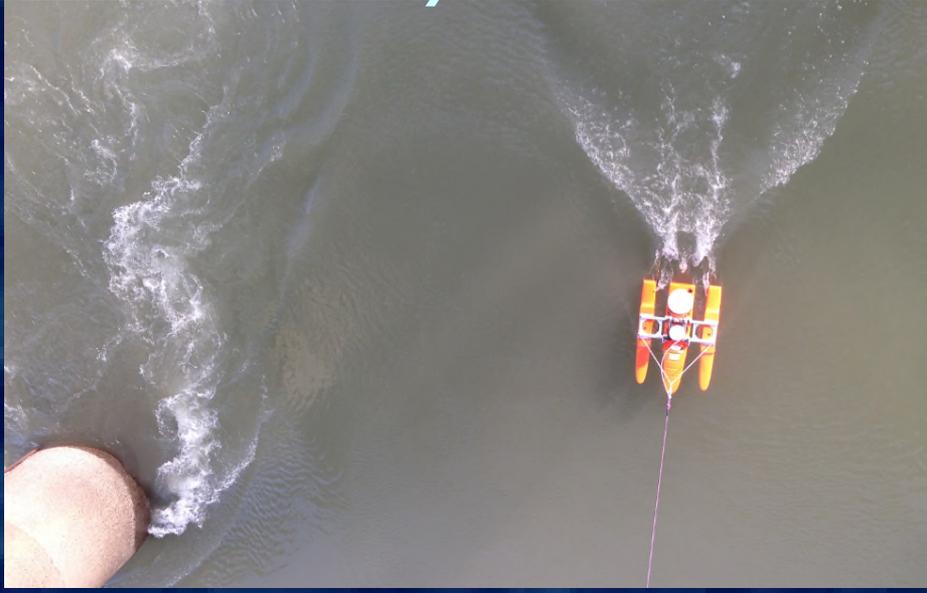
nwis.usgs.gov

nrtwq.usgs.gov

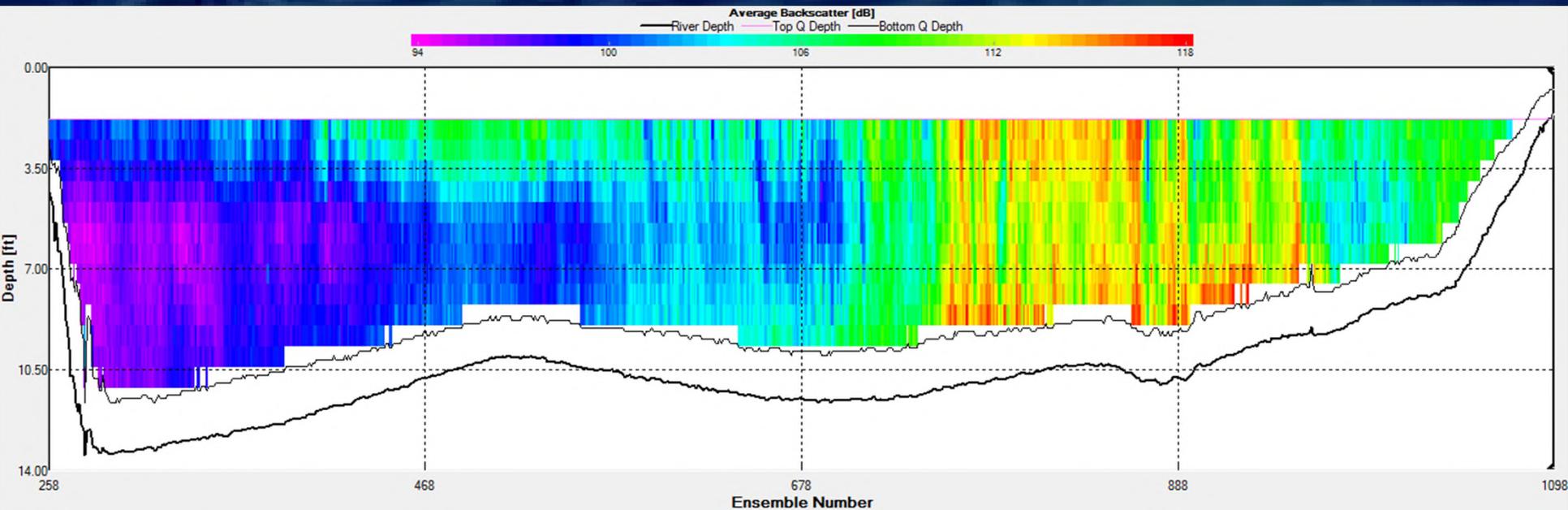
Discrete Measurements of SSC by Acoustics



Discrete Measurements of SSC by Acoustics

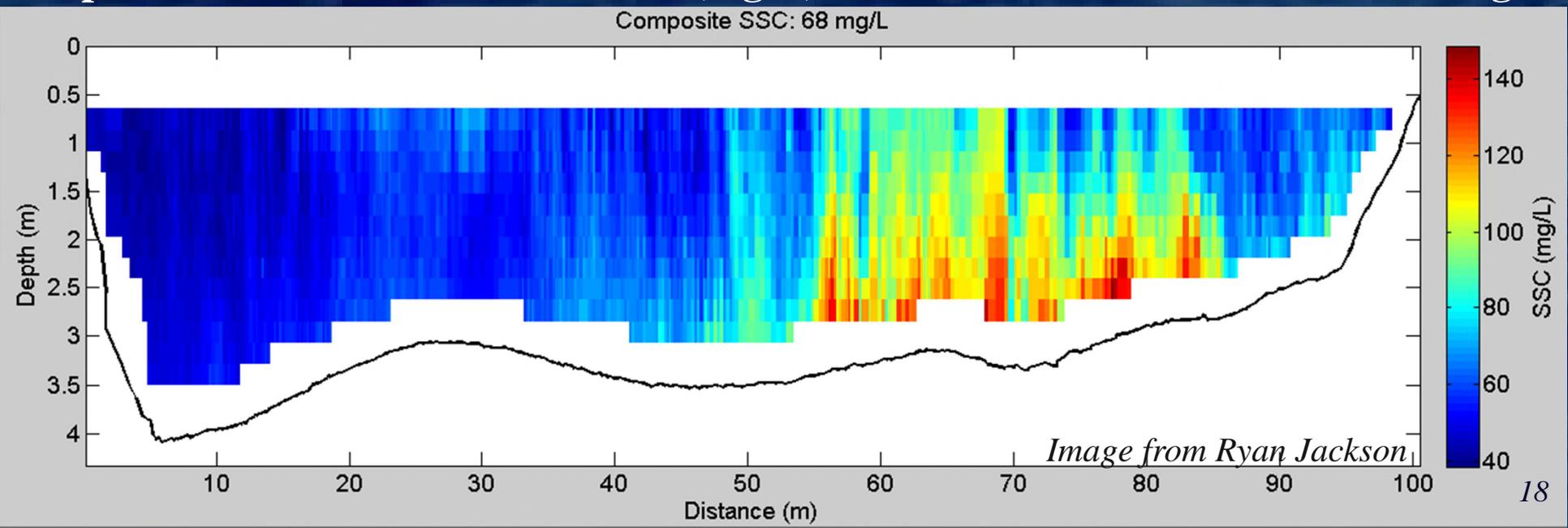


Measured Backscatter (dB)



Suspended Sediment Concentration (mg/L)

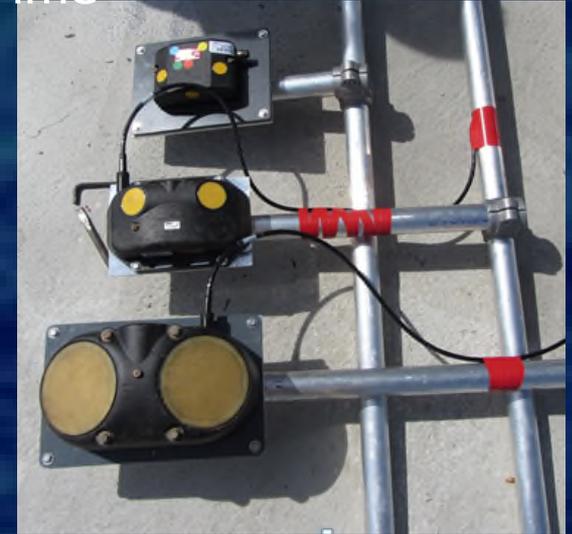
EDI = 71.4 mg/L



Acoustic Surrogates of Sediment

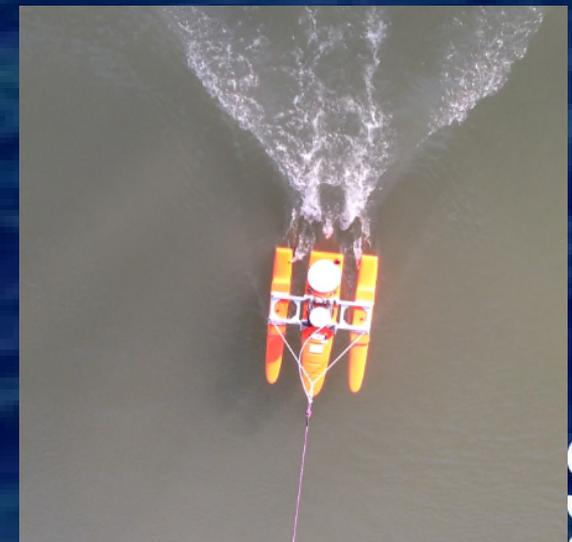
Advantages

- Continuous, High Temporal Resolution & Real Time
- Discrete, High Spatial Resolution
- Greater Accuracy
- Greater Understanding
- Concurrent Velocity
- Highly Robust
- Ubiquitous in Streamflow Monitoring
- Reduced Cost
- Large Sample Volume
- Multi-frequency indicates Sediment Size



Disadvantages

- Complexity of Signal Processing
- $SSC \sim Acoustics$ Varies with Instrument & Site
- Resolution and Low Concentration Limit



SEDIMENT ACOUSTIC LEADERSHIP TEAM (SALT)

- **Research:** Promote and conduct to address next issues
- **Methods:** Training and Guidance on Best Practices
- **Tools:** Surrogate Analysis & Index Developer Tool (SAID); Real Time processing tools (for NWIS & NRTWQ); Stationary Time-Series Analysis
- **Demonstration Sites:** Continuous real-time acoustic-SSC.
- **Representatives:** OSW, WSCs [IL, ID, TX, CO, CA], OFAs

Sediment Acoustics

water.usgs.gov/osw/SALT/

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Continuous Time-Series Methods

Discrete Measurement Methods

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Training

Mailing Lists and Forums

Demonstration Sites

SALT and Contacts

