RECLAMATION

Managing Water in the West

Investigating feasibility of acoustic methods for monitoring suspended sediment

Research and Development Office
Science and Technology Program
(Final Report) ST-2018-1777-01

U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office

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Sedimentation and River Hydraulics, 86-68240

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Investigating feasibility of acoustic methods for monitoring suspended sediment

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Executive Summary

The focus of this scoping project is to address the need for more comprehensive suspended sediment monitoring by exploring the capabilities and limitations of an emerging technique for suspended-sediment surrogate monitoring using hydroacoustic technology. The use of suspended-sediment surrogate methods, such as turbidity, laser-diffraction, and acoustic methods, offer the benefits of continuous temporal monitoring, lower cost, and safer implementation than conventional hand-held methods. The benefit of developing the capability may be widespread within Reclamation; the acquired data could be used to refine computational and theoretical tools, as well as gauge the sediment-related effects of reservoir operations including sedimentation rates and downstream water quality.

The following activities were conducted during the course of the project:

- Participation in the Sediment Acoustics Leadership Team (SALT)
- Acquisition of a LISST-ABS acoustic backscatter sediment monitoring device
- Involvement in the submission of an interagency research proposal and a Reclamation project proposal aimed at monitoring suspended sediment using surrogate methodologies
- Attendance of a USGS-sponsored Sediment Data Collection course

The above independent activities built upon each other in a complimentary fashion, and will help advance Reclamation's ability to address the need for more comprehensive suspended sediment monitoring. Further details on all of the activities supported by this S&T scoping proposal are included as appendices to the report. The activities will lead to new opportunities to better understand complex sediment issues in Reclamation rivers and reservoirs.

Contents

Appendix A – Sediment Acoustics Leadership Team

The PI serves as the USBR representative within the Sediment Acoustics Leadership Team (SALT) and has regularly engaged in teleconference meetings. From the SALT charter:

The Office of Surface Water (OSW) recognizes the need to provide training and to develop standardized techniques and practices, which do not currently exist (March 2012). In order to provide assistance to meet this need, the Sediment Acoustic Leadership Team (SALT) is established by the OSW to develop technical guidance and training for using acoustic metrics to monitor aquatic sediment. The SALT purpose, member composition, tenure, functions, authorities, and duties are described in this document. The SALT is patterned after, and will operate with consultation from the Hydroacoustics Workgroup (HaWG) of the USGS, OSW.

Purpose

The SALT provides assistance and guidance to the OSW regarding all aspects of the development and use of hydroacoustic instrumentation for monitoring characteristics of aquatic sediment, with a focus on fluvial environments. The purposes of the SALT are to:

- Provide a focal point for research and monitoring aquatic sediment using hydroacoustics.
- Assist in the development and application of new methods;
- Provide advice and direction regarding
    - technical issues,
    - instrument development needs,
    - ancillary tool needs,
    - testing, and
    - training;
- Provide advice on work and funding priorities;
- Serve as a developing and reviewing body for draft policies, reports, and similar documents; and
- Facilitate communication between the OSW, USGS, Sediment-Acoustic users, other federal agencies, the research community, and vendors.

Functions

In order for the SALT to accomplish its purpose, SALT members are expected to:

- Participate in conference calls;
- Participate in and address questions on the SALT Forum;
- Identify, review, prioritize, and participate in developing the essential research and methods development needed to provide generalized guidance for methods;
- Report to OSW on progress, issues, and their relative importance;
- Review and recommend specific training on sediment hydroacoustics;

- Plan, prepare, conduct, and evaluate user training as needed and funded;
- Organize and conduct sediment hydroacoustic presentations at conferences and meetings;
- Encourage use of sediment-hydroacoustic technology where appropriate;
- Assist in the preparation and review draft policy memoranda;
- Recommend technology or methods-development investments to OSW;
- Communicate and coordinate with the HaWG and other user groups; and
- Provide an interface between users, HaWG, and OSW;

All members of the SALT are encouraged to communicate with the OSW Chief and/or OSW-supported SALT and HaWG members regarding accomplishments and concerns in the area of sediment hydroacoustics within the USGS.

Appendix B – LISST-ABS

Description

The LISST-ABS is a low-cost acoustic backscatter sensor developed by Sequoia Scientific (Bellevue, WA) specifically for monitoring suspended sediment concentrations. Using a borrowed instrument, the PI and affiliates found good agreement with measured concentrations during a pilot study flow release downstream of Cherry Creek Reservoir (Denver, CO) in May, 2017. For these reasons, the Sedimentation and River Hydraulics Group purchased an instrument in order to build on initial work and position towards opportunity for further study. The LISST-ABS manufacturer brochure with product specifications is included below.

LISST-ABS

Submersible Acoustic Backscatter Sensor

• Sediment Concentration • Superior Response • Fouling Tolerant

Sequoia Scientific, Inc. is pleased to offer the first low-cost acoustic backscatter sensor designed specifically for measuring suspended sediments. The LISST-ABS is a fixed-point sensor. It uses a new and novel technique to internally compensate for sound attenuation, yielding an attenuation-corrected concentration over a wide range.

Why acoustics? Why single-point, and why 8 MHz? Acoustic sensors benefit from their much higher tolerance to fouling than optical sensors, which is an obvious advantage. Single-point use makes them suitable for monitoring wherever optical turbidity type sensors are in use. The choice of 8MHz frequency is made to ensure nearly flat response to particles in the size range 30-400 microns (See figure on back). For example, LISST-ABS maintains calibration over this size range within ~ ±30% from its mean value. In contrast, the sensitivity of optical turbidity sensors changes by ~± 400% over the same size range.

The LISST-ABS also covers a wide concentration range, from 1 mg/L up to 30g/L for 5-10 micron sediments.

Analog voltage, SDI-12, and RS232 outputs are available on the underwater connector. The analog and digital values are available as soon as power is applied. SDI-12 is available on demand.

The LISST-ABS has a maximum operating depth of 100 m. It may be held vertically or pointing into flow for low drag as in towed or river applications. A small wing-shaped towed body is available as an option.

Power source and data storage are external.

LISST-ABS Submersible Acoustic Backscatter Sensor

FEATURES

- Outputs: Concentration in Analog voltage; RS-232 and SDI-12 formats. Some calibration required.
- Sample volume Location: 5.5 cm from sensor face.
- Operating Frequency: 8MHz
- Tolerant to fouling.
- Calibration over 30-400 micron sizes: flat to within ±30%; [compare with ±400% for turbidity sensors]
- Calibration for fine particles below 30 microns: response follows $d^{1.5}$
- Analog, SDI-12 and Digital (RS232) outputs available on the underwater connector
- Simple endcap connector, compatible with many turbidity type sensors.

SPECIFICATIONS (subject to change without notice)

Sensor Type: Point measurement.
Sample volume size: 10 dia x 15 L (mm) approx.
Operating Frequency: 8MHz
Sample volume: approx. 4 cm long, 5.5 cm in front of sensor
Minimum distance from solid boundary: 15cm.
Output: Analog: 0-5V (analog), continuously updated at 1 sec. intervals; RS-232 continuous; SDI-12: polled.
Conversion to physical units: Provided with user calibration.
Working Range: 1mg/L to 30g/L (7-micron silt); or
<20 g/L (200 micron sand)
Calibration: Recommended with sediment samples.
Drift: Internally compensated for temperature, ageing.
Resolution: 0.5% of current value.

Mechanical and electrical

- Sensor Dia.: 2.00 in (5.08 cm)
- Length: 13.25 in (33.65 cm)
- Weight: 1 lb. (0.5 Kg) in air; 0.5 lb. (0.22Kg) buoyant in water.
- Transducer: 10mm dia, ceramic
- External supply : 11-18 Vdc
- Current drain: 100 mA
- Max. Depth: 100 m (Contact Sequoia for deeper rating)
- Material: ABS Plastic
- Connector type: Impulse MCBH-8-MP-SS
- Power on LED: Green, slow blink at idle, double blink while sampling

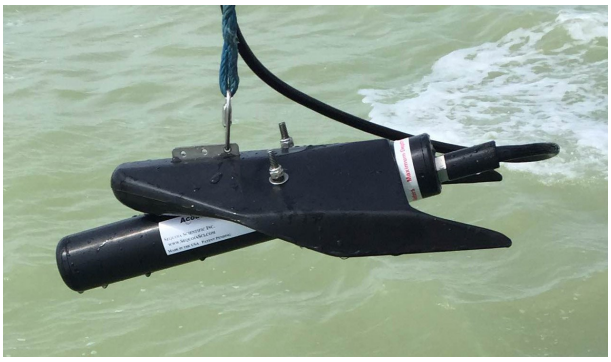
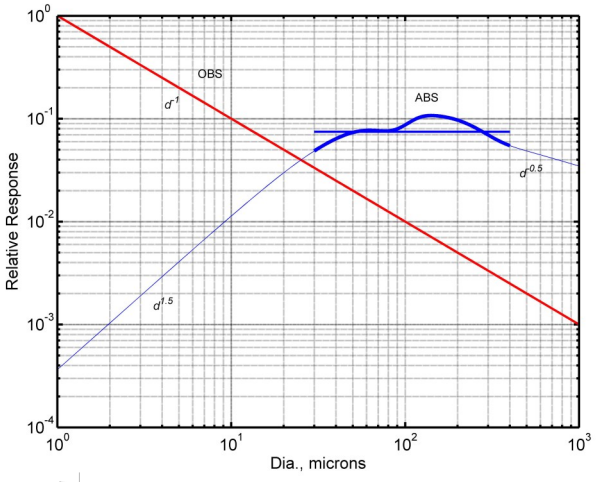


Photo and original concept courtesy of Shawn Hintz, Gravity Consulting, Inc.

Figure on right shows the relative responsivity of optical turbidity meters contrasted with the LISST-ABS acoustic backscatter sensor.

Image on left shows the LISST-ABS mounted to a streamlined depressor wing that allows it to be towed at speeds in excess of 5 knots.



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SEQUOIA

Appendix C – Proposals for Further Study

Two proposals for further study of suspended sediment dynamics using acoustic surrogate methods are in development. One proposal is for interagency applied research submitted to the USGS John Wesley Powel Center for Analysis and Synthesis; the other proposal is concerned with monitoring and analysis of sediment dynamics at Isleta Diversion Dam in New Mexico. In each case, the PI would serve in a supporting role. Both project proposals are pending review.

Powel Center Proposal Project Summary

PI: Molly Wood, USGS; Timothy Straub, USGS; Ricardo Szupiany, Littoral National University, Argentina

Sediment is a leading cause of water body impairment throughout the world, but the availability of temporally- and spatially-rich sediment information has been limited, partially because of high sampling costs, sampler limitations, and safety concerns. Sediment surrogate technologies, such as the use of backscatter measurements from acoustic Doppler meters, have shown promise in estimating suspended-sediment concentrations (SSC) in rivers. These technologies can provide high spatial and temporal resolution observations of SSC and loads or fluxes, which are critical for making informed water resource management decisions. The use of acoustic Doppler current profilers (ADCPs), in particular, to estimate suspended sediment has potential to revolutionize sediment monitoring because of the high spatial resolution they deliver across and along rivers and because existing uses of these instruments for streamflow measurements can be leveraged. However, this potential is not being developed, and much is unknown about what factors influence successful use of the method across a variety of hydraulic, site, and disturbance conditions. We propose to bring together experts in the acoustic and sediment science communities to consolidate, analyze, and disseminate existing, concurrent ADCP and SSC datasets from rivers throughout the world. We would decide on “best” operational practices, reasonable theoretical assumptions, reasonable SSC and grain size thresholds, and minimum required datasets. We would also develop a common software tool for using ADCPs to estimate suspended sediment in rivers.

Isleta Diversion Dam Sediment Monitoring

PI: Drew Baird, USBR

A proposal is being developed in support of the Bureau of Reclamation Lower Colorado Region to monitor suspended sediment in the vicinity of Isleta Diversion Dam. The structure, near Isleta Village Proper in New Mexico, diverts water from the Rio Grande into irrigation canals. Although the Dam has helped reduce the adverse effects of floods and has provided irrigation for agriculture, changes to the natural sediment flux through the system due to the presence of the structure is causing a loss of ecosystem services, including decline of Silvery Minnow populations and increased prevalence of wildfires. Stakeholders are interested in developing better management practices in order to address these concerns; it is believed that a better

understanding of the sediment dynamics (which may be obtained through deployment of acoustic methods) is a necessary step in the process.

Appendix D – Sediment Data Collection Course

Description

The PI attended the USGS-sponsored Sediment Data Collection Course, held in Castle Rock, WA. From the course description:

Sediment Data Collection Techniques is a USGS sponsored training course, held in the Pacific Northwest area near Mount St. Helens. About half of the course is classroom instruction, and the other half is devoted to “hands-on” field experience using a variety of samplers and techniques on bridges and wading in west-central Washington streams including those draining the Mount St. Helens region.

The training course is intended to provide instruction in:

- Basic fluvial-sediment concepts
- Sediment sampler characteristics
- Field techniques (including Safety concepts) for sampling
- Laboratory analyses of sediment samples
- Overview of computation of sediment-discharge records
- Selected methods for estimating sediment properties from surrogate technologies
- Overview of a records computation protocol using continuous turbidity
- Physical bedload samplers, and
- Quality-assurance procedures

The course is designed for:

- Those actively engaged in/or supervising individuals engaged in sediment or water-quality data-collection activities, or who plan to become involved in these activities.
- Those interested in sediment-surrogate technologies for suspended-sediment-, bed-material-, and bedload-data collection.
- Those who are or will be actively involved in the collection of data for Surface-Water Toxic Waste, NAWQA or NASQAN Programs, coal hydrology studies, geomorphic assessments that require fluvial-sediment data, science-supported activities for stream restoration, and other monitoring or research endeavors involving fluvial sediment.