RECLAMATION *Managing Water in the West*

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The Knowledge Stream

Research Update

Acoustic Hydrophones to Measure Sediment Transport

Measuring underwater sounds of moving sediment can help quantify sediment in rivers

Bottom Line

Passive acoustic hydrophones can track sediment movement on a riverbed.

Better, Faster, Cheaper

Existing passive hydroacoustic technology holds promise to consistently provide reliable bedload measurements at a lower cost to better manage gravel-bed rivers.

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Collaborators

- **National Center for Physical Acoustics (NCPA) at the University of Mississippi**
- **Agricultural Research Service (ARS) in Oxford, Mississippi**
- **Trinity River Restoration Program (TRRP)**

Problem

Quantifying sediment transport in rivers and streams is important for understanding and managing regulated rivers. Sediment accumulations and deficits can adversely affect infrastructure such as levees, bridges, and wastewater treatment plants, as well as riparian and aquatic habitats. Sediment can also accumulate in reservoirs, reducing capacity. Thus, understanding how sediment moves within a river (both sediments suspended in the flow and bedload sediment, larger material that rolls along the bed of a river) is vital to managing river channel morphology, habitats, and infrastructure.

Bedload sediment (larger sand and gravel not suspended in the water) moves along the river bottom during high flows or floods and is difficult to track. Conventional methods samples isokinetically (collecting sediment when the velocity in front of the collected is the same as the adjacent velocity in the river) to collect a sample of moving bedload. Humans must operate the sampler for each test from a bridge or boat. However, these conventional sampling methods provide samples only one time and in one place. These discrete, infrequent measurements make it difficult to quantify sediment transport loads and understand how coarse sediment moves through a river system. During high flows, samplers can be difficult or even unsafe to operate, making it problematic to obtain data during floods (when most of the sediment is transported). Moreover, conventional methods have high costs for labor and lab analysis.

Solution

Underwater gravel collisions make noise, which hydrophones (microphones for underwater recordings) can measure as acoustic energy. Prior research has indicated that passive hydroacoustic technology shows great promise to obtain quantifiable measurements of coarse bedload in rivers (Barton 2006, Barton et al. 2010). Additionally, Mason et al. (2007) showed that it may also be possible to obtain information regarding sediment size from the frequency distribution of sounds. Thus, recording the sounds that gravel makes when moving along the riverbed might be used to measure the total sediment transport for different size classes of gravel. Hydrophones also may detect when bedload transport initiates. Understanding when the gravel bedload starts to move is important for calibrating sediment transport equations and for managing riverflows, particularly where causing or avoiding movement of gravel is an important goal of river restoration projects.

This Science and Technology Program research project is determining whether placing acoustic hydrophones in a river channel can provide quantitative, accurate, and continuous bedload measurements. The hydrophones use materials that produce electricity when subjected to water pressure changes (sound in water) and are widely used for military, geophysical, and marine biology applications. Hydrophones can be securely placed so that they can safely record data even during high flows. Thus, hydrophones can be programmed to provide continuous data about the bedload movement or be programmed to sample periodically. This research is in the first year of a 3-year effort with planned laboratory and field experiments.

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Application

The first field deployments of hydrophones took place on the Trinity River near Weaverville, California, in early May 2012. The Trinity River Restoration Program (TRRP) is a partnership of Federal, State, Tribal, and local government agencies, collaborating with river stakeholders to rehabilitate the managed river to the dynamic state needed to restore the world class salmon and steelhead fishery.

We are using concurrent measurements to correlate the acoustic energy from hydrophones with the measured bedload transport. During this study, the TRRP has collected bedload data using conventional methods (a TR-2 bedload sampler deployed from a cataraft collecting physical samples of moving bed material). Our hydroacoustic sampling used six hydrophones and pre-amplifiers connected to laptop PCs running LabVIEW software. The photograph below shows both methods of measuring bedload sediment at Lewiston, California, with the cataraft in the background and hydrophones (shown in circles) in the foreground, deployed at 5 and 10 meters apart.

Lab tests are also taking place at the National Sediment Lab (USDA-ARS, Oxford, Mississippi) in a 30-x 1.2-meter flume capable of transporting and recirculating gravel up to 80 millimeters. Ongoing tests explore ways to mount the hydrophone in a manner that will minimize flow noise, which could obscure the collection of sounds from gravel impacts on the channel bed. An anechoic (no echo) underwater chamber has been developed to examine the sound of individual gravel strikes with varying momentum.

Future Plans

Future field deployments of the hydrophones to obtain more calibration data are planned on the Trinity River and Elwha River in Washington State. The Elwha River study will provide information on bedload movement in a different environment and will focus on sediment changes resulting from the current dam removal projects.

Future lab tests in a model flume will measure sounds that different sized gravels make over a range of flow velocities in a controlled environment. To minimize ambient flow noise during flume experiments, gravel particles will be tethered to a variable-speed carriage to be towed over a gravel bed. Water will not be in motion during these tests.

"The Trinity has variable flows throughout the year that create dynamic geomorphic change; support fish, wildlife, and riparian vegetation; and attract rafters, guides, birders, and other outdoor enthusiasts.

Collaborative efforts such as this hydroacoustic study that help develop methods for real-time river monitoring make the Trinity River a destination for scientists and science-based adaptive management, too."

Robin Schrock,
TRRP Executive Director