DESIGN AND IMPLEMENTATION OF A FIELD DEPLOYABLE PASSIVE ACOUSTIC BEDLOAD-MONITORING SURROGATE

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ABSTRACT

Various methods of employing passive acoustics to monitor bedload transport have been explored in both the lab and field. Expanding upon this research, a hydrophone-based passive acoustic bedload-monitoring system was designed, tested and deployed by researchers at the University of Mississippi and the National Sedimentation Laboratory in Oxford, MS. Several field studies have been conducted at various sites: the Elwha River in Port Angeles, WA; the Trinity River in Weaverville, CA; Bear Creek in Denver, CO; and the Walnut Gulch Watershed in Tombstone, AZ. At each field study, acoustic data was collected alongside physical measurements of bedload transport. Preliminary results correlating sediment transport with the measured sediment generated noise will be presented. In addition, the design and fabrication of an improved prototype system is underway. The new system is designed to be more easily deployed and operable by non-experts. This will greatly expand the range of available testing environments. Results from this effort will be presented alongside any available calibration data taken with the new system.

EXTENDED ABSTRACT

The prospect of using passive acoustic methods to monitor bedload transport has been investigated in various facets. The acoustic properties of impacting gravel particles were investigated (Thorne 1985) in a laboratory setting. Preliminary work was done on the Trinity River (Barton et al. 2010) which showed that using hydrophones to detect gravel movement showed promise. To continue this research, a passive acoustic system comprising of equipment already owned by researchers at the National Center for Physical Acoustics was assembled and tested. The system was tested at four different field sites shown in Figure 1: the Trinity River in Weaverville, Ca; the Elwha River in Port Angeles, CA; the Walnut Gulch Watershed near Tombstone, AZ at the Lucky Hills sub-watershed; and Bear Creek in Denver, CO.

Figure 1 Top Left: Photograph of the first iteration of the passive acoustic bed load monitoring system, deployed at Douglas City on the Trinity River, CA. Top Right: Installation of three hydrophones at the Elwha River, WA. Bottom Left: Installation of two hydrophones at the Lucky Hills subwatershed near Tombstone, AZ. Bottom Right: Installation at the Bear Creek, near Denver, CO

Figure 2 shows positive correlation between acoustic root-mean-square (rms) and bedload discharge at the Trinity River. The discharge was determined from concurrent physical samples taken by Graham Matthews and Associates. Although there were physical samples taken at the Elwha River, they were designed to calibrate the impact plates also being tested at the time. The physical samples were repeated at individual locations, and were thus unusable as a 'total discharge' measurement. Therefore, an attempt was made to correlate the acoustic data with the data collected from the impact plates spanning the river. Figure 3 shows that the overall trends between acoustic rms and bedload discharge are positively correlated. The data from Walnut Gulch in still in analysis as of this writing. All of these tests indicate the usefulness of acoustic surrogates. For this reason, the researchers at the NCPA began a project to redesign the system to make it much more portable, robust and user-friendly.

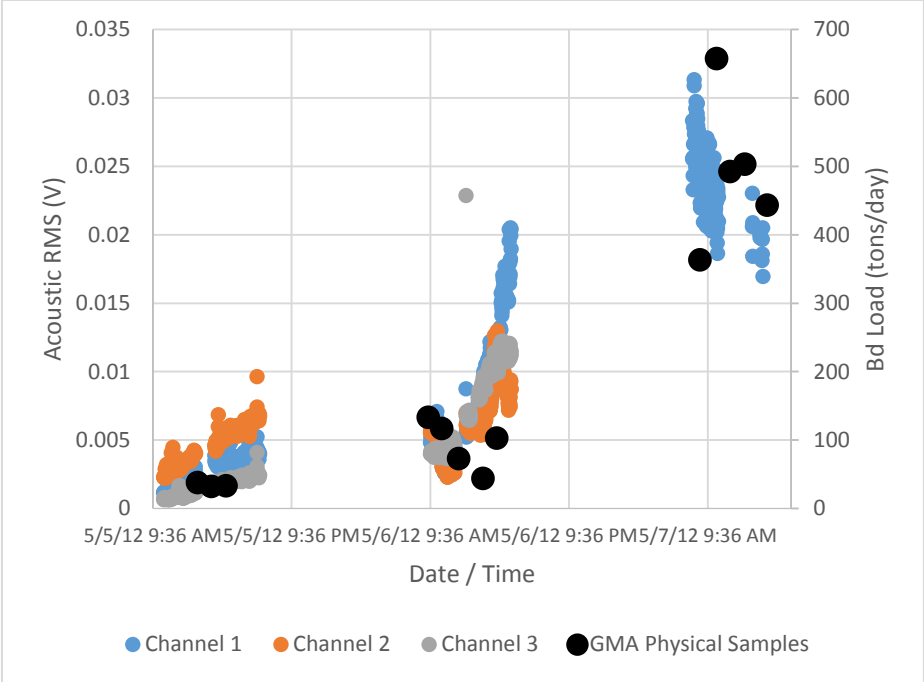

Figure 2 Acoustic data shown with physical measurements of bed load at the Douglas City site on the Trinity River, CA. Graham Matthews and Associates collected the physical bed load measurements

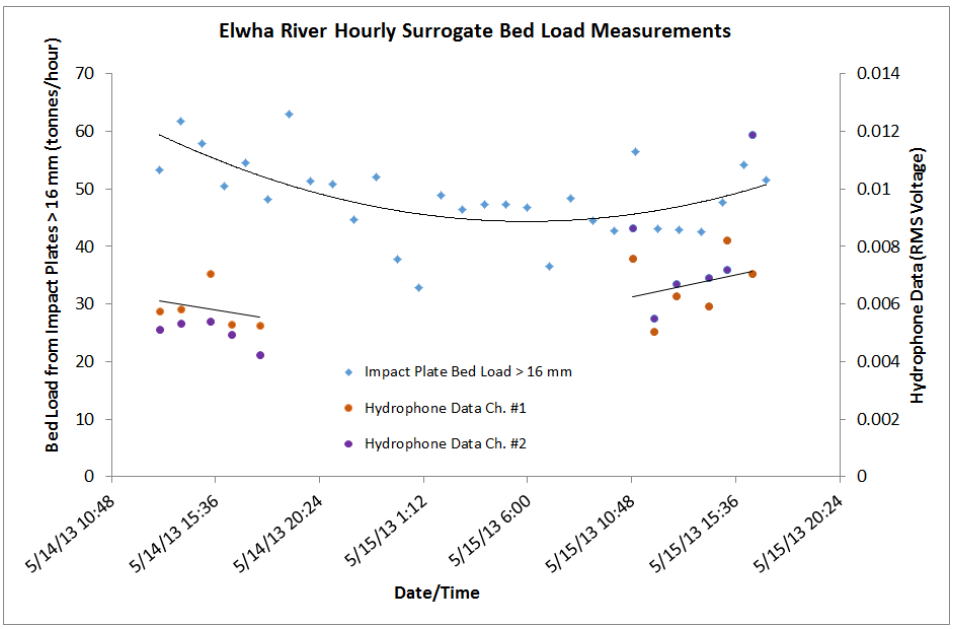

Figure 3 Comparison of bed load transport measured with the Elwha bed load impact plate system using a preliminary calibration and data from two hydrophones deployed approximately 70 meters upstream. Data shown are hourly averages of both systems

The system as it was deployed in the aforementioned field studies was comprised entirely of laboratory-grade equipment. As such, many of the components were delicate and unwieldy. Every aspect of the data collection process was investigated for improvements. The improvement process began with researching and testing alternate hydrophone options. The RESON TC-4013 hydrophones used in the field studies are delicate and far more sensitive than is necessary for the project. After testing three alternatives, the HTI 96-MIN Exportable hydrophone was chosen. This hydrophone is suitably sensitive at the audio range, and has a built-in amplifier. This eliminates the need for the external amplifiers required by the RESON hydrophones. In addition, the HTI hydrophones are sturdy and robust. A casing and mounting system for this hydrophone are currently in design. The casing will be designed to reduce flow noise around the hydrophone as much as possible, and it will also provide protection from debris. Other areas of the system including data recording, power requirements, and duration of operation are still under investigation as of this writing.

REFERENCES

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