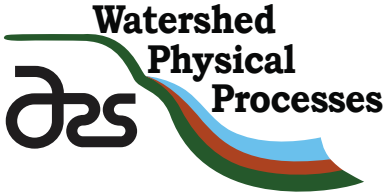
Estimating measurement area for passive acoustic monitoring of Sediment-Generated Noise (SGN)

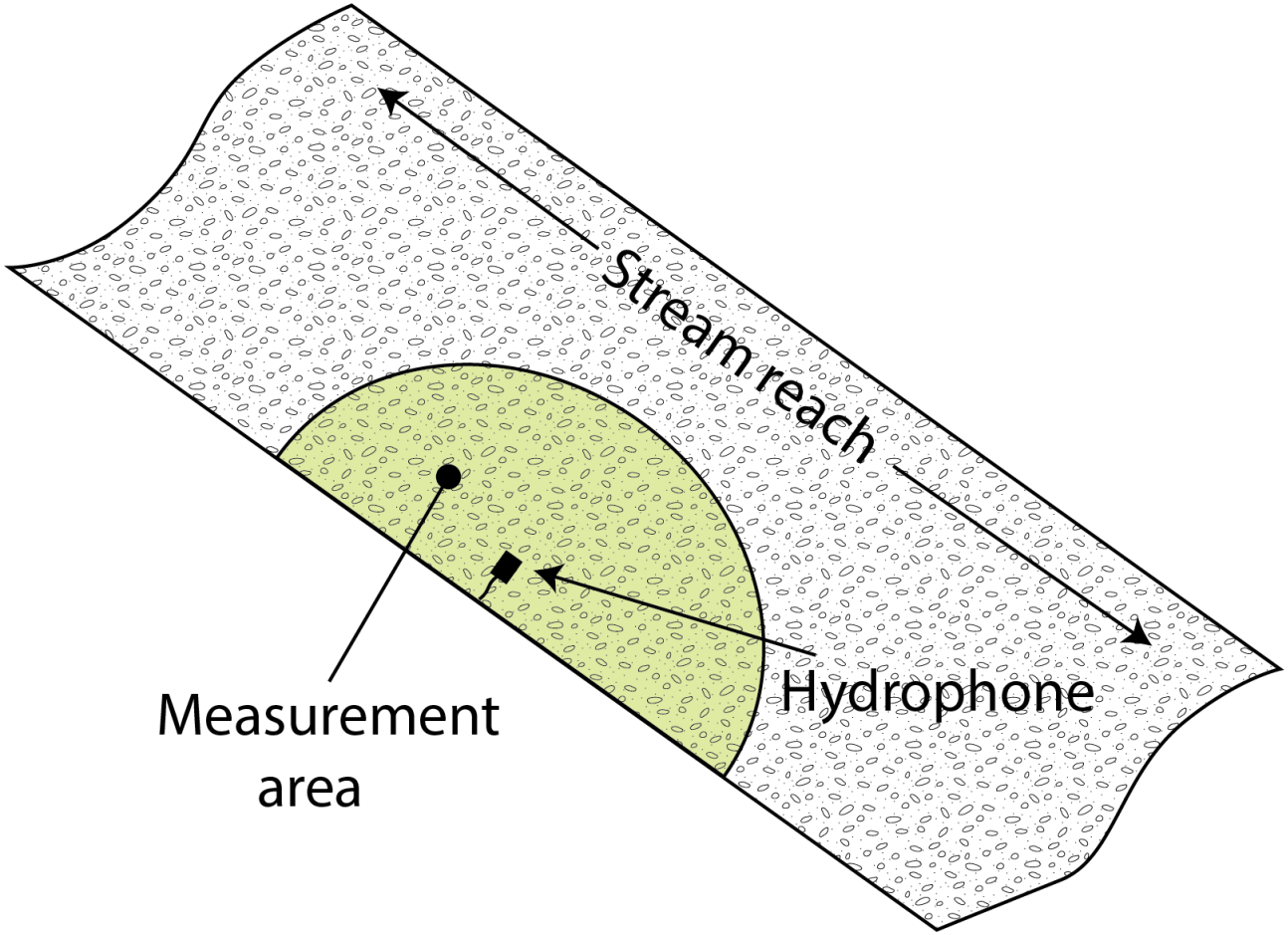
Daniel G. Wren, J.R. Rigby, Roger A. Kuhnle, James Chambers, Bradley Goodwiller, and Brian Carpenter



Timeline:

September 26, 2014:	Received authority to use funds
October-December:	Collection of field data
January-August:	Data analysis and report preparation
August 25, 2015:	Project ends

Goal: define the measurement area of a typical hydrophone for measuring SGN in a stream



Justification:

- Step towards development of a general approach to converting SGN data into bedload flux
- To determine how much of stream is being monitored
- For planning number of instruments to place in channel
- For quantification of uncertainty and data quality

Factors affecting size of sampling volume

- **SGN properties**
  - Amplitude
  - Frequency
- **Physical location**
  - Bed material size distribution
  - Water depth
  - Bed roughness
  - Position of hydrophone in stream channel (i.e., side vs. middle)
- **Hydrophone parameters**
  - Frequency response (also affected by recording system)
  - Directivity
  - Noise floor
- **Recording system**
  - Noise floor (also affected by hydrophone)
- **Multi-source**(constructive and destructive interference)

Factors affecting size of sampling volume

- **SGN properties**
  - Amplitude
  - **Frequency**
- **Physical location**
  - Bed material size distribution
  - **Water depth**
  - **Bed roughness**
  - Position of hydrophone in stream channel (i.e., side vs. middle)
- **Hydrophone parameters**
  - Frequency response (also affected by recording system)
  - Directivity
  - Noise floor
- **Recording system**
  - Noise floor (also affected by hydrophone)
- **Multi-source**(constructive and destructive interference)

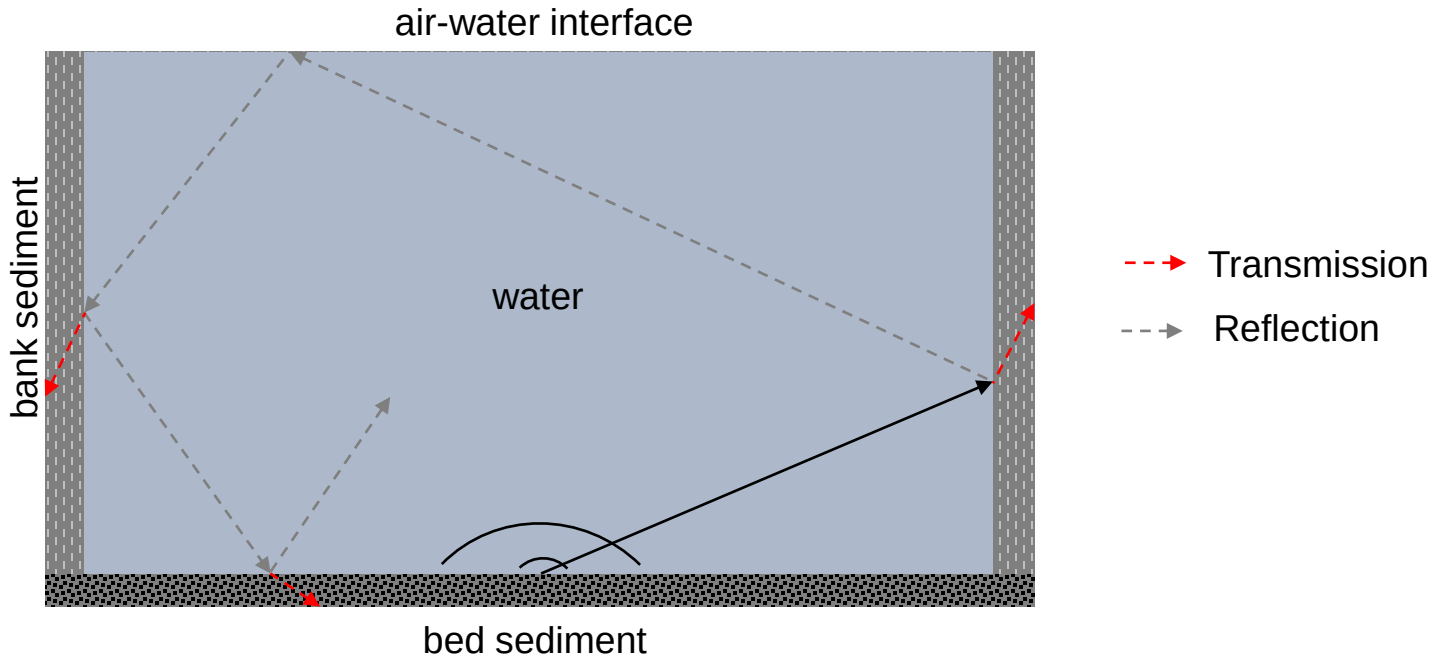
Research efforts will be focused on these factors:
low frequency cutoff
waveguide propagation
effects on cutoff frequency and prop.

Factors affecting size of sampling volume

- **SGN properties**
  - Amplitude
  - **Frequency**
- **Physical location**
  - Bed material size distribution
  - **Water depth**
  - **Bed roughness**
  - Position of hydrophone in stream channel (i.e., side vs. middle)
- **Hydrophone parameters**
  - Frequency response (also affected by recording system)
  - Directivity
  - Noise floor
- **Recording system**
  - Noise floor (also affected by hydrophone)
- **Multi-source**(constructive and destructive interference)

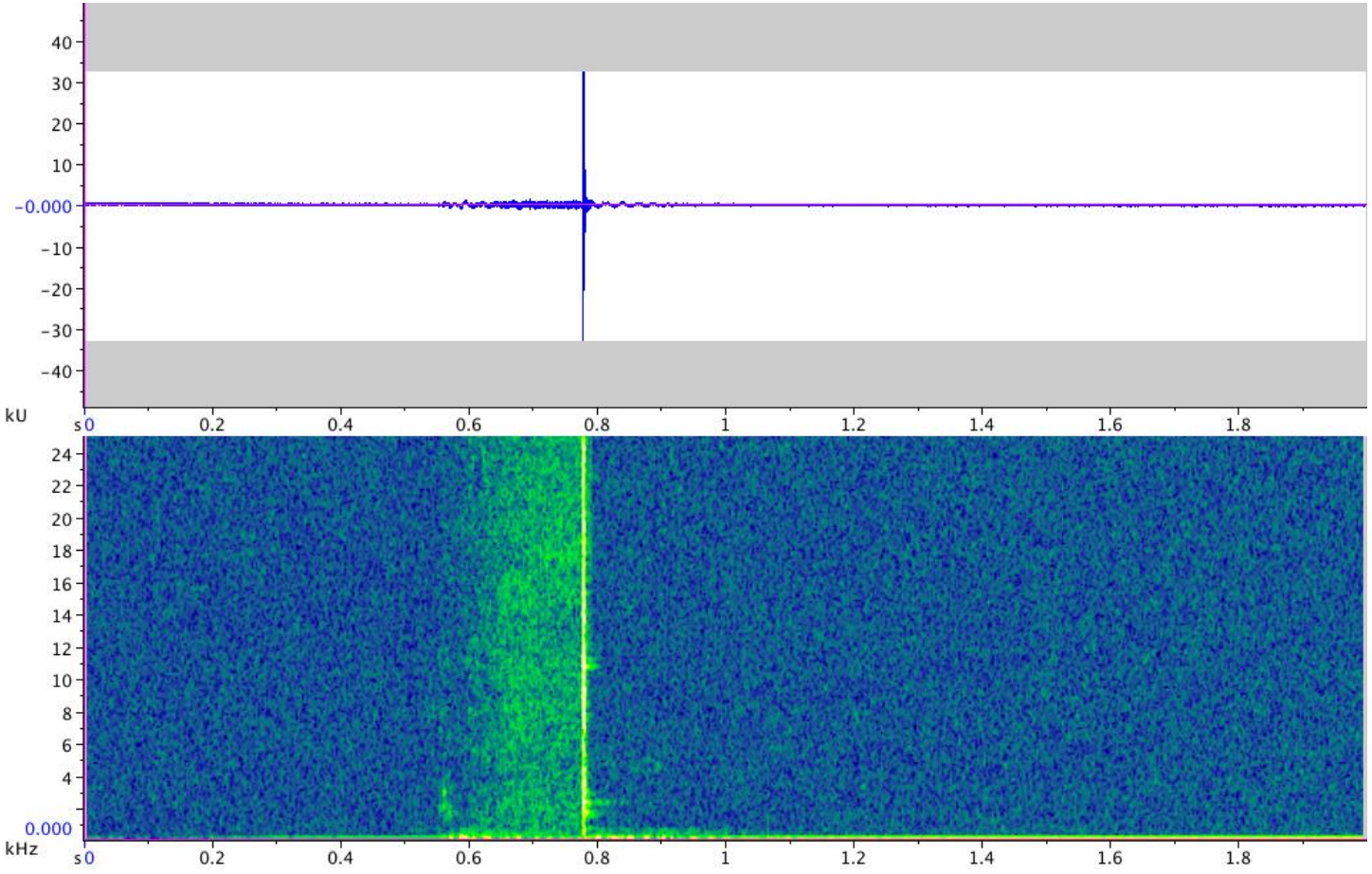
effects on signal propagation

Boundary Acoustic Properties



Mechanical sound source

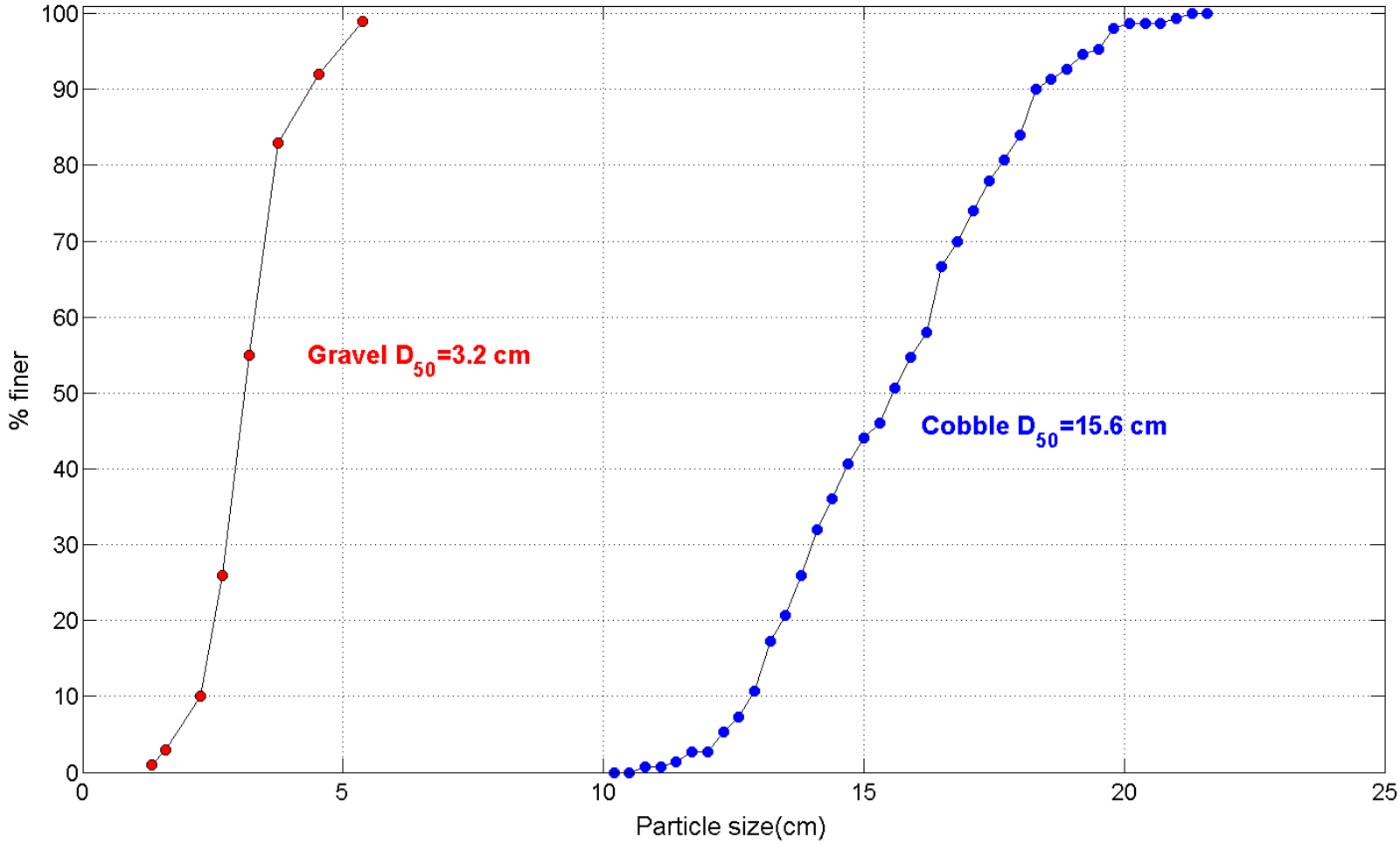
Sound from impactor



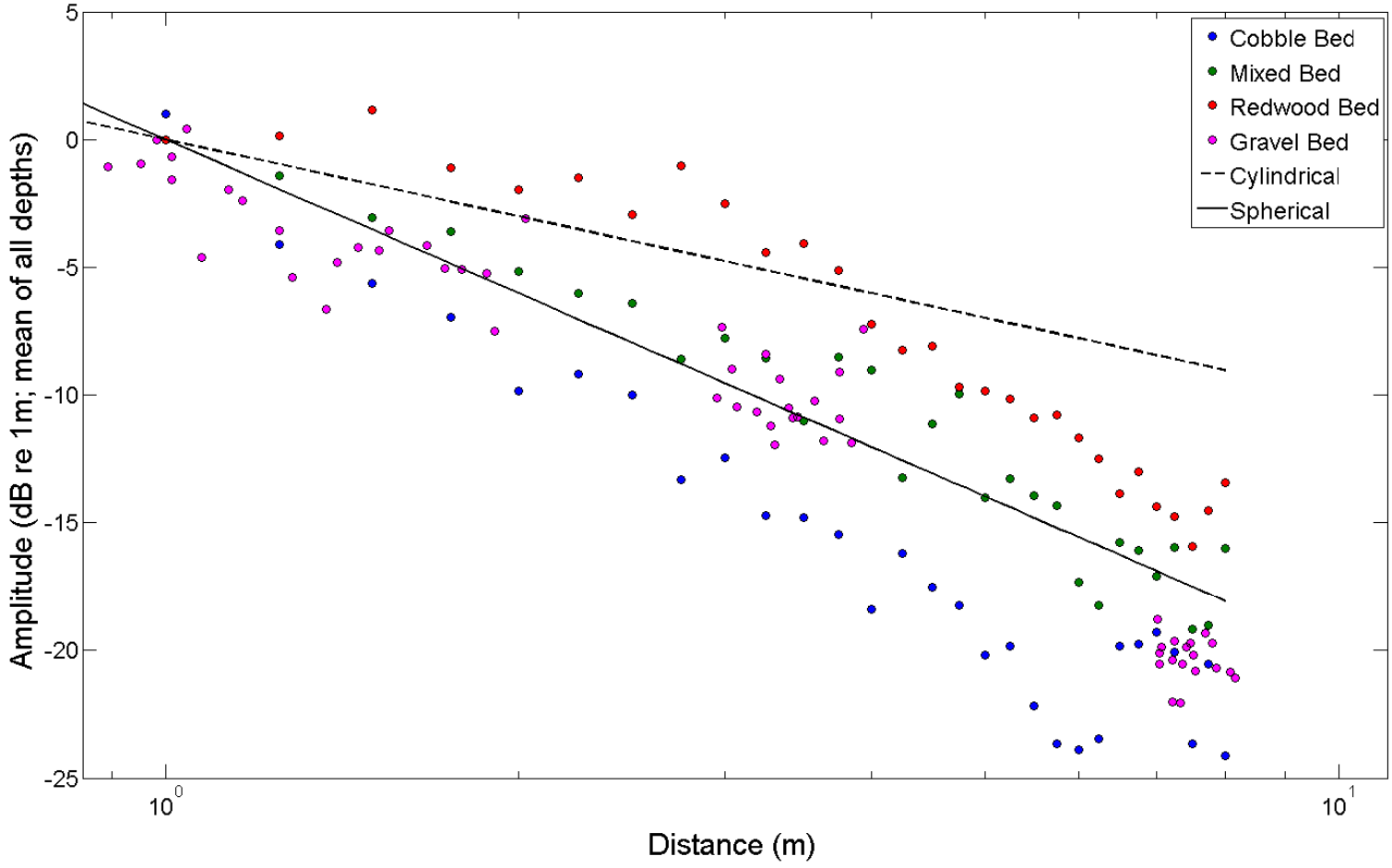
Cobble bed measurements

Mixed cobbles and gravel

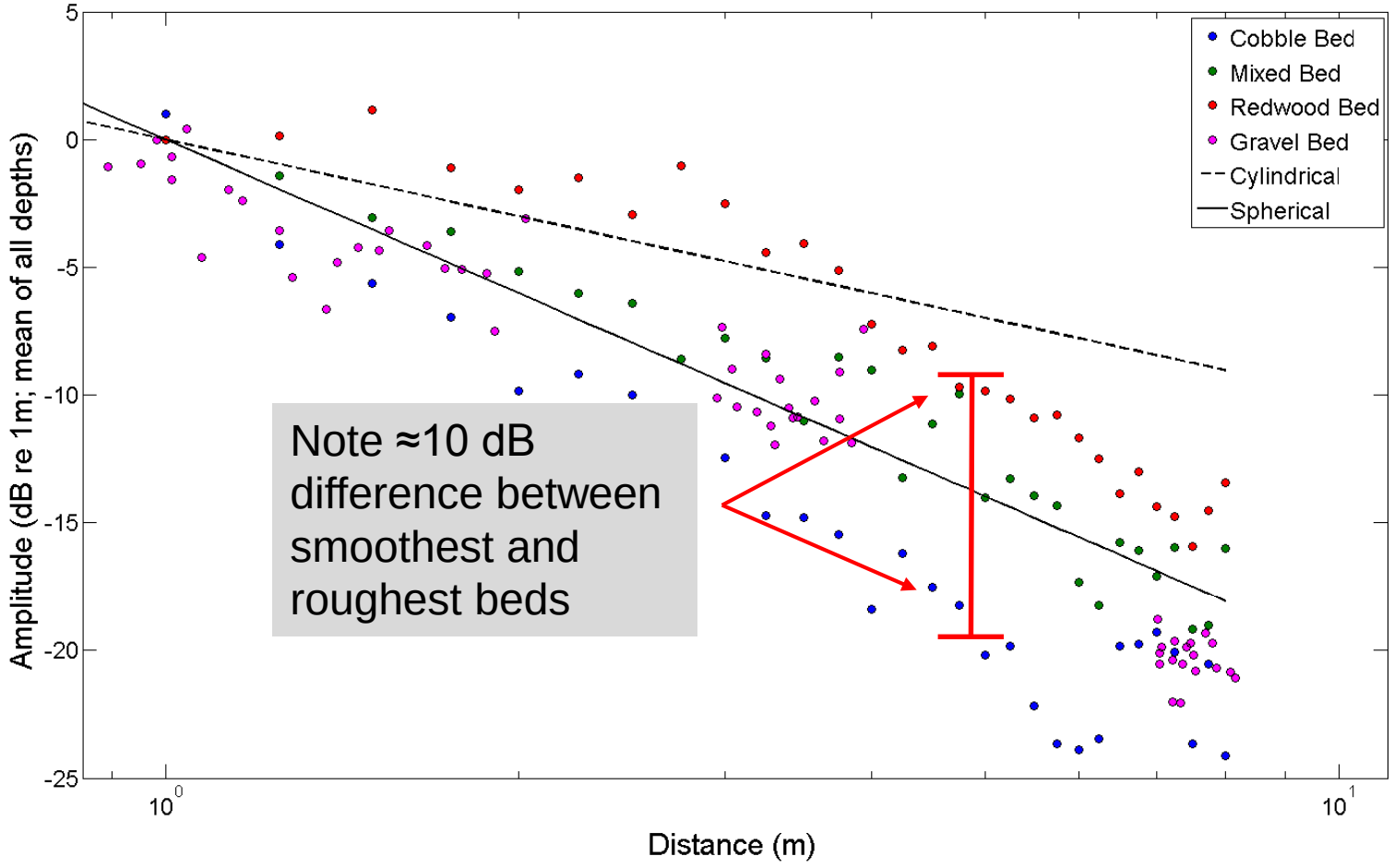
Particle size distributions



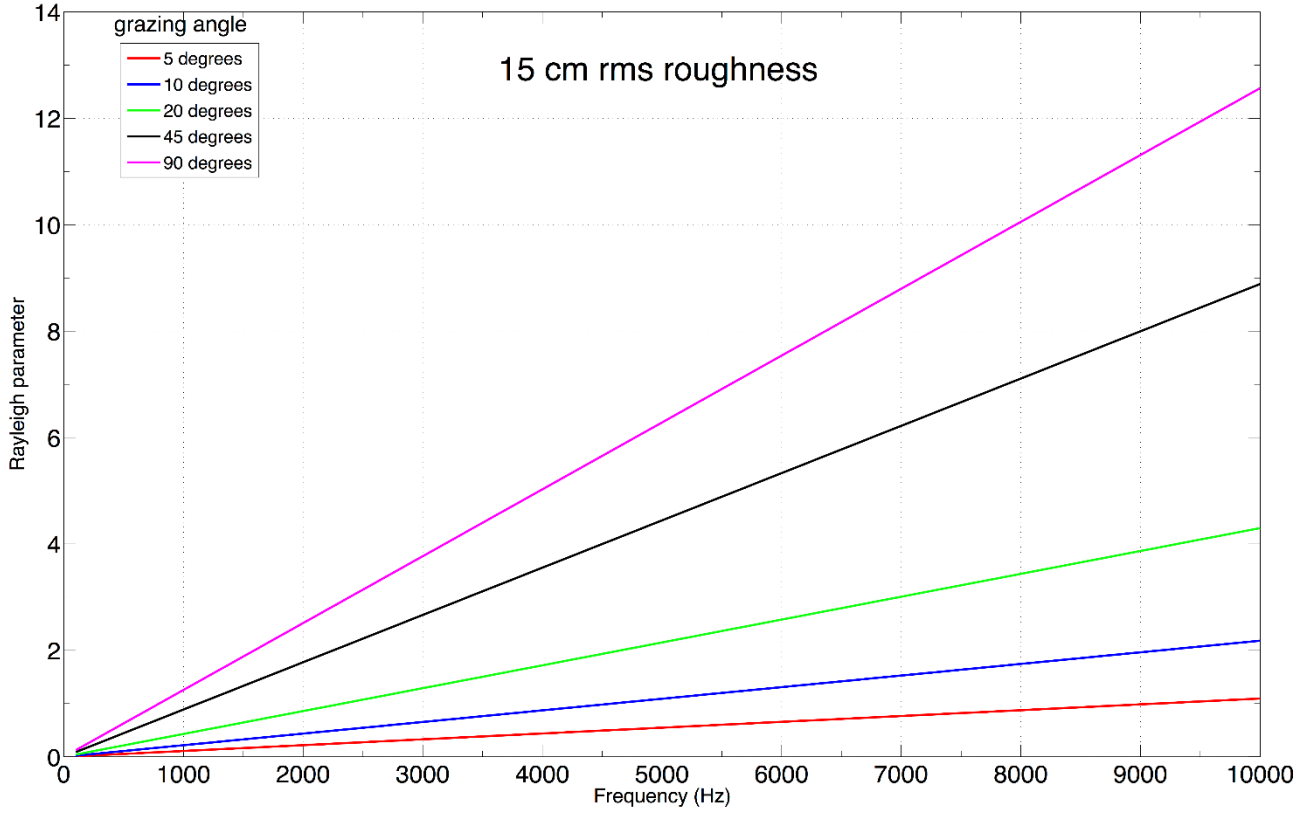
Results from propagation experiments



Results from propagation experiments



Rayleigh parameter

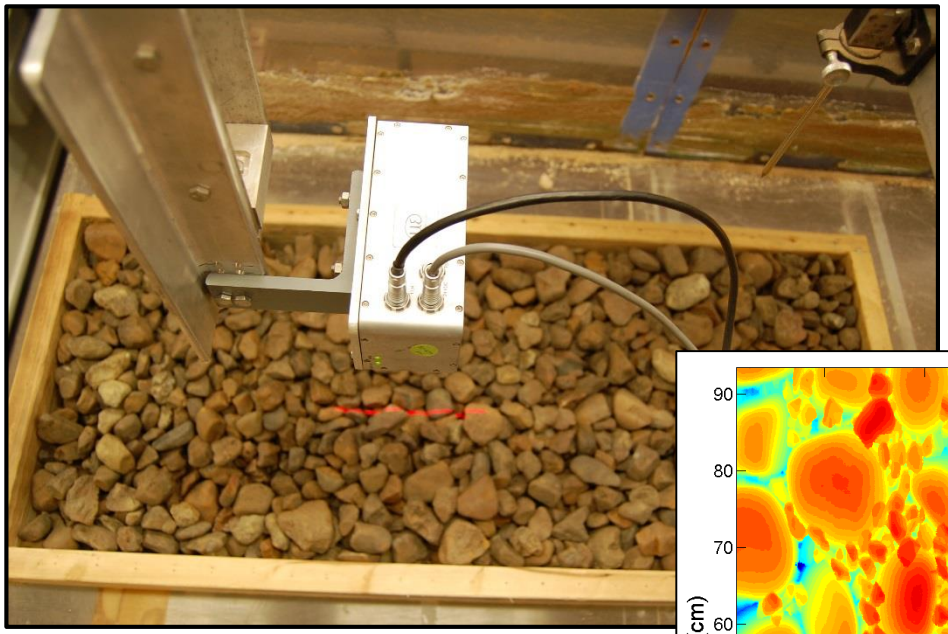


$R = kh \sin\theta$,

where:
k=wave number,
h=rms roughness height
θ =grazing angle.
R>>1: scattering
R<<1: reflecting

Quantifying roughness

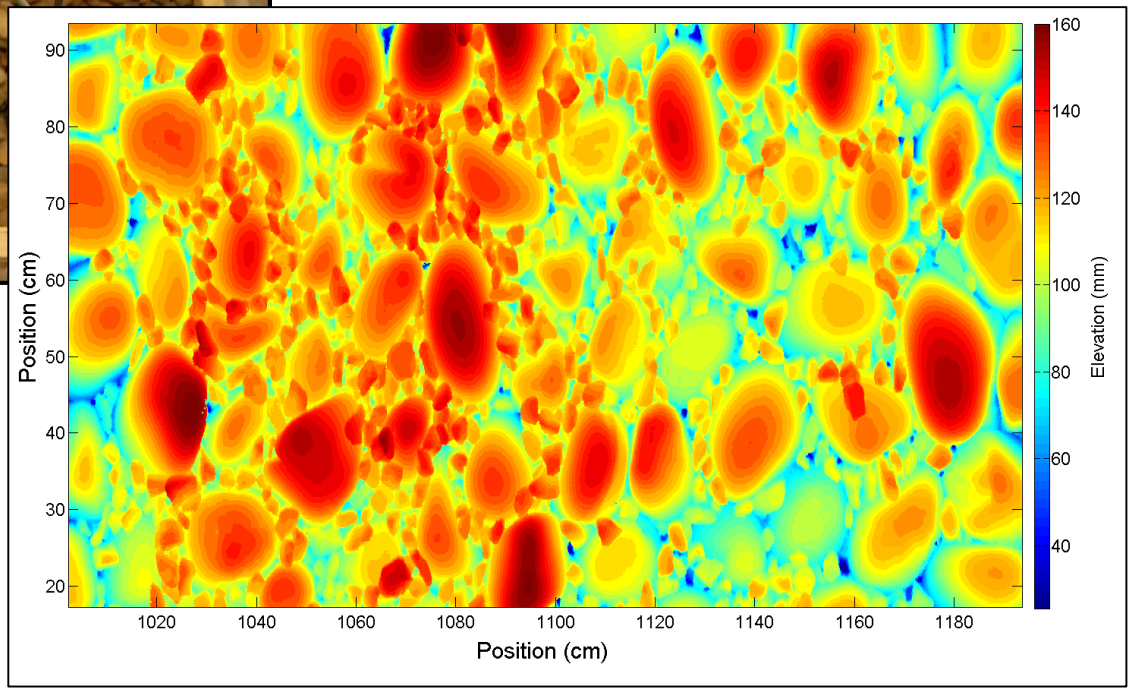
Laser scanning gravel sample



RMS roughness:

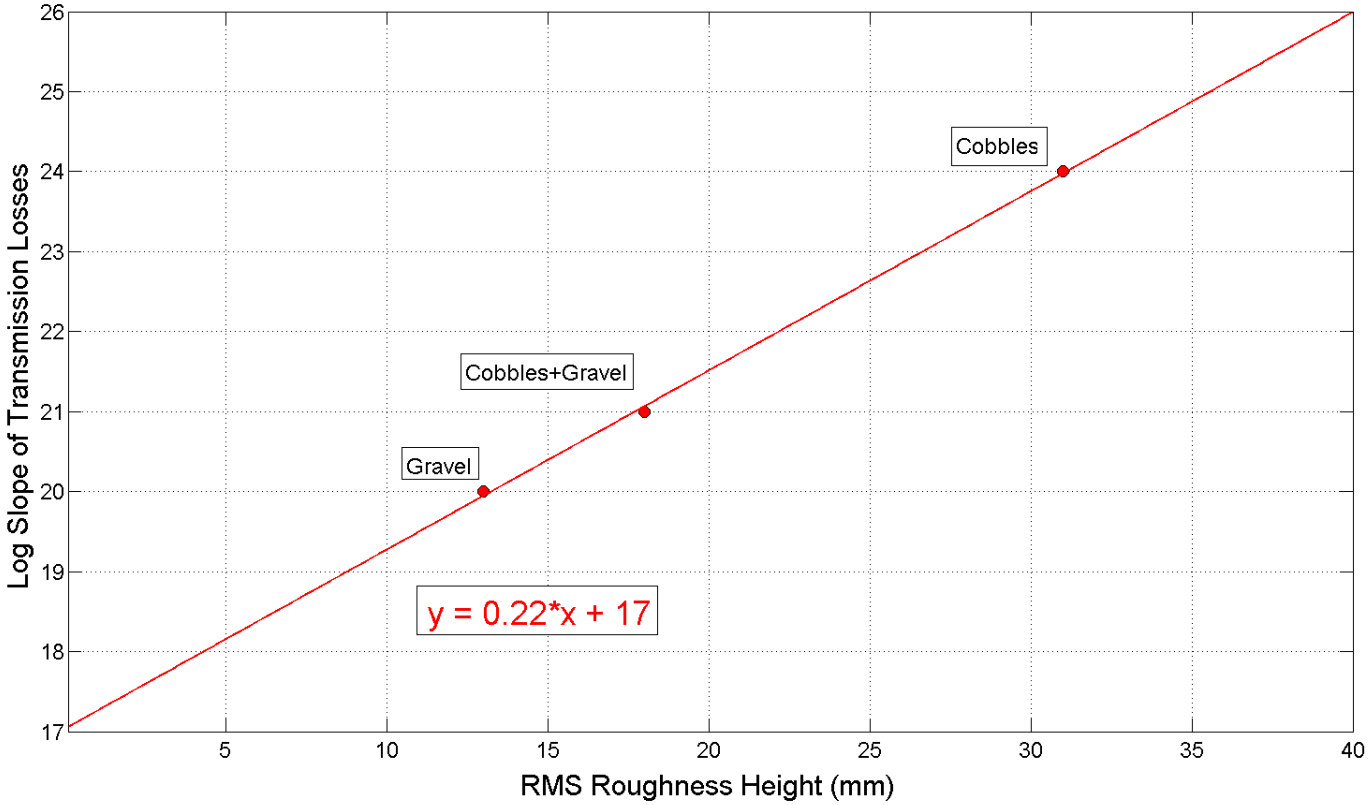
Gravel ≈ 13 mm
Cobbles ≈ 31 mm
Cobbles+gravel ≈ 18 mm
Redwood lattice ≈ 8 mm

Laser scan of cobble+gravel sample



Summary of transmission loss results

Transmission Loss (TL) can be expressed as:
TL=X*log(R)
where: X=loss multiplier and R=Range
For example: for cobbles, loss is: TL=24*log(R)



Conclusions

- Sound propagation experiments at the National Sedimentation Laboratory have been completed for several types of bed roughness
- Geometric spreading was found to be less important to propagation than bed roughness and the nature of the sound field (i.e. coherent, reverberant, type of waveguide, etc.)
- A basic predictive relationship for amplitude attenuation over rough beds was established

Next steps:

- Consulted with Physical Acoustician, Dr. Richard Raspet
- Measurements in stream channels will be collected in order to characterize the nature of the sound field: reverberant vs. coherent
  - The shape of the channel, especially a wedge or lack of one at the banks, will be an important parameter
  - Bottom composition and depth will also affect the measurements, but we are beginning to gain a better understanding of these from our laboratory work
- Based on results, laboratory experiments may also be carried out
- Continue to work on propagation model and best way to summarize and present it