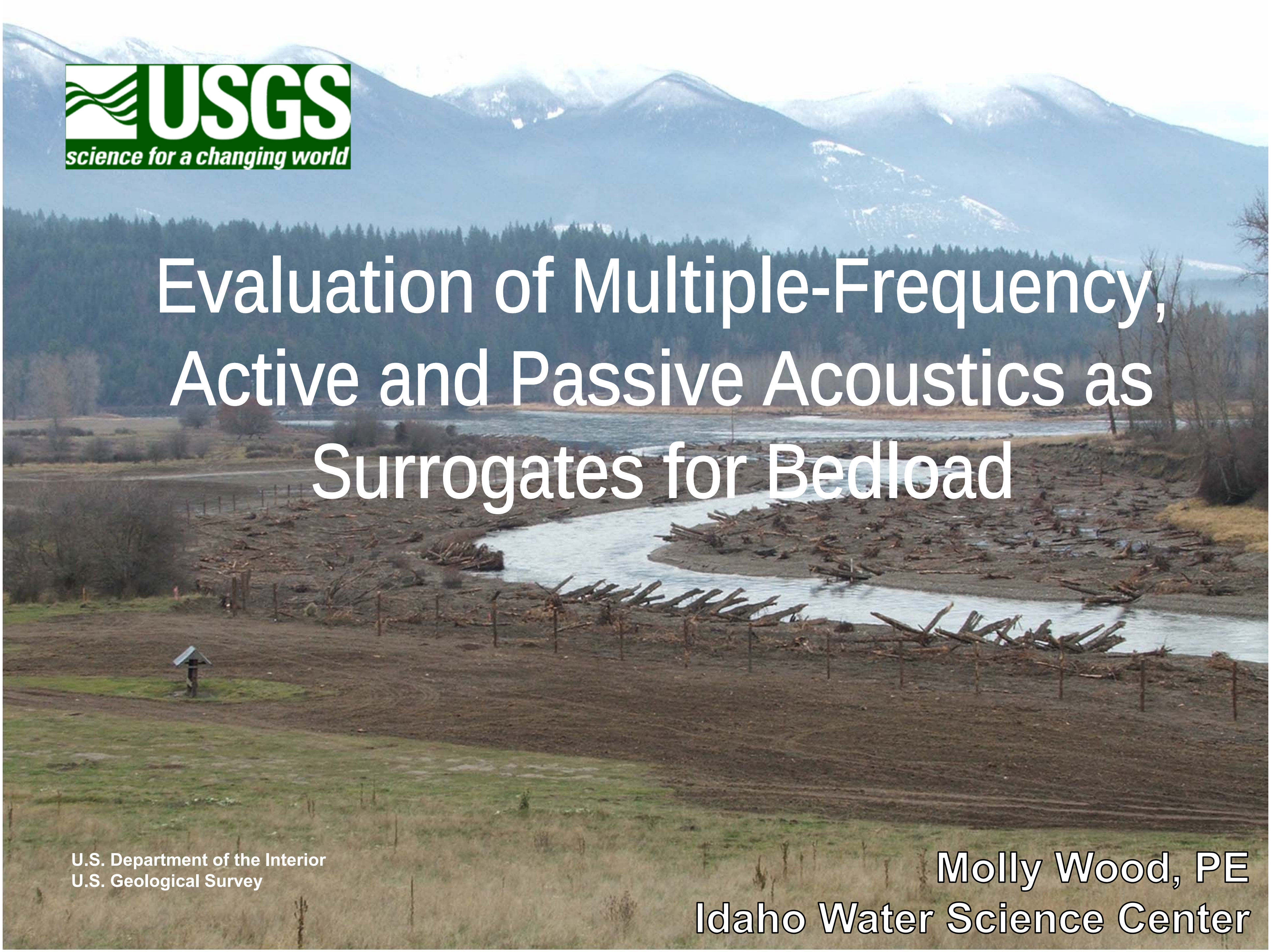


Evaluation of Multiple-Frequency, Active and Passive Acoustics as Surrogates for Bedload

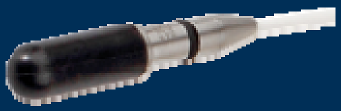
U.S. Department of the Interior
U.S. Geological Survey

Molly Wood, PE
Idaho Water Science Center

Questions

- “Active” Acoustics: Can we use ADCPs of multiple frequencies to “see” bedload transport in different grain size categories?

- “Passive” Acoustics: Do hydrophones verify information from ADCPs, or can we use them to get additional information?



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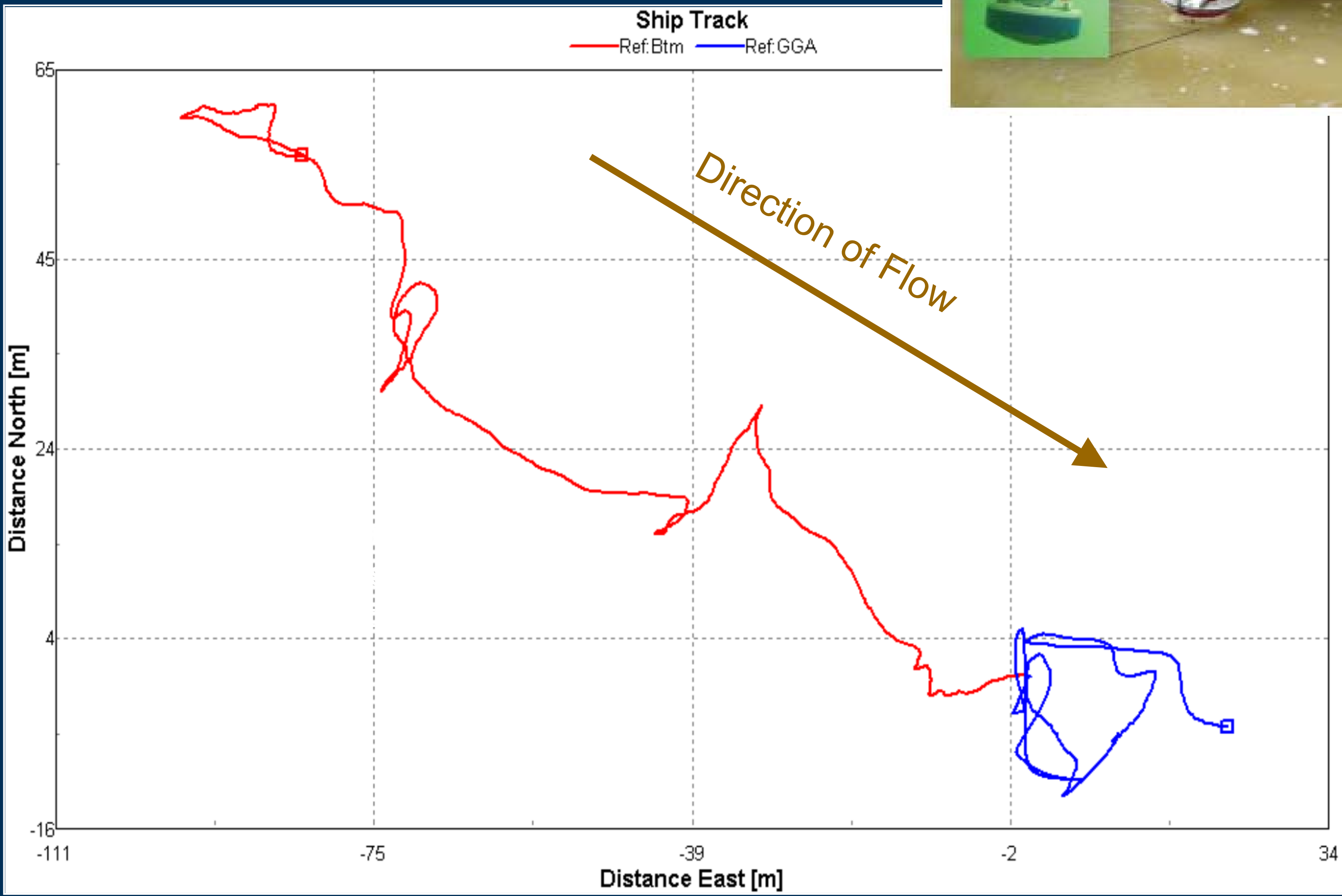
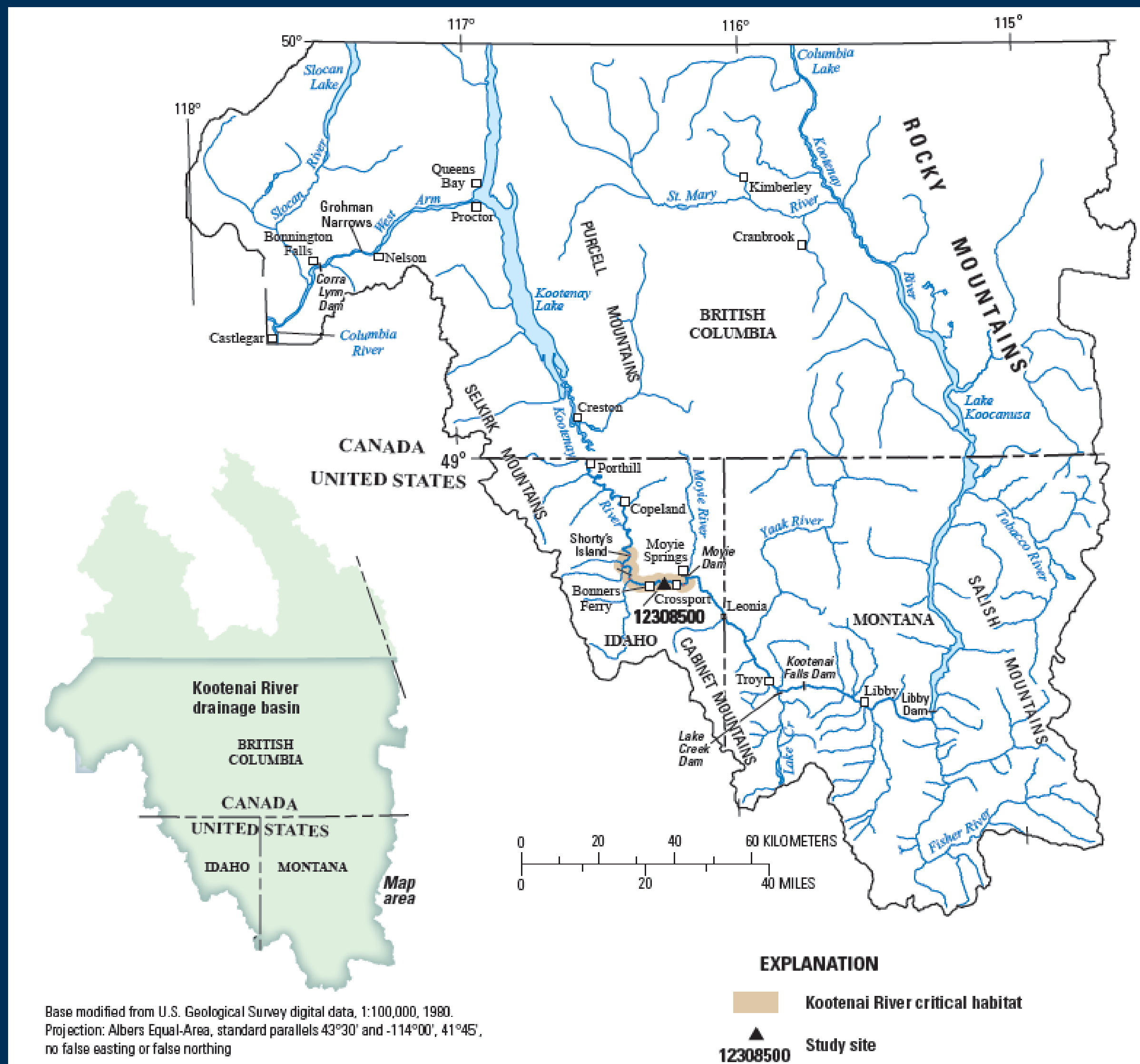
Apparent Moving Bed



Bedload Surrogate Pilot Study

- Kootenai River at Crossport, Idaho
- May 17-18, 2012
- Mostly funded by FISP
- Scientists from USGS and University of Montana

Study Site: Kootenai River, Idaho



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Bedload Surrogate Pilot Study

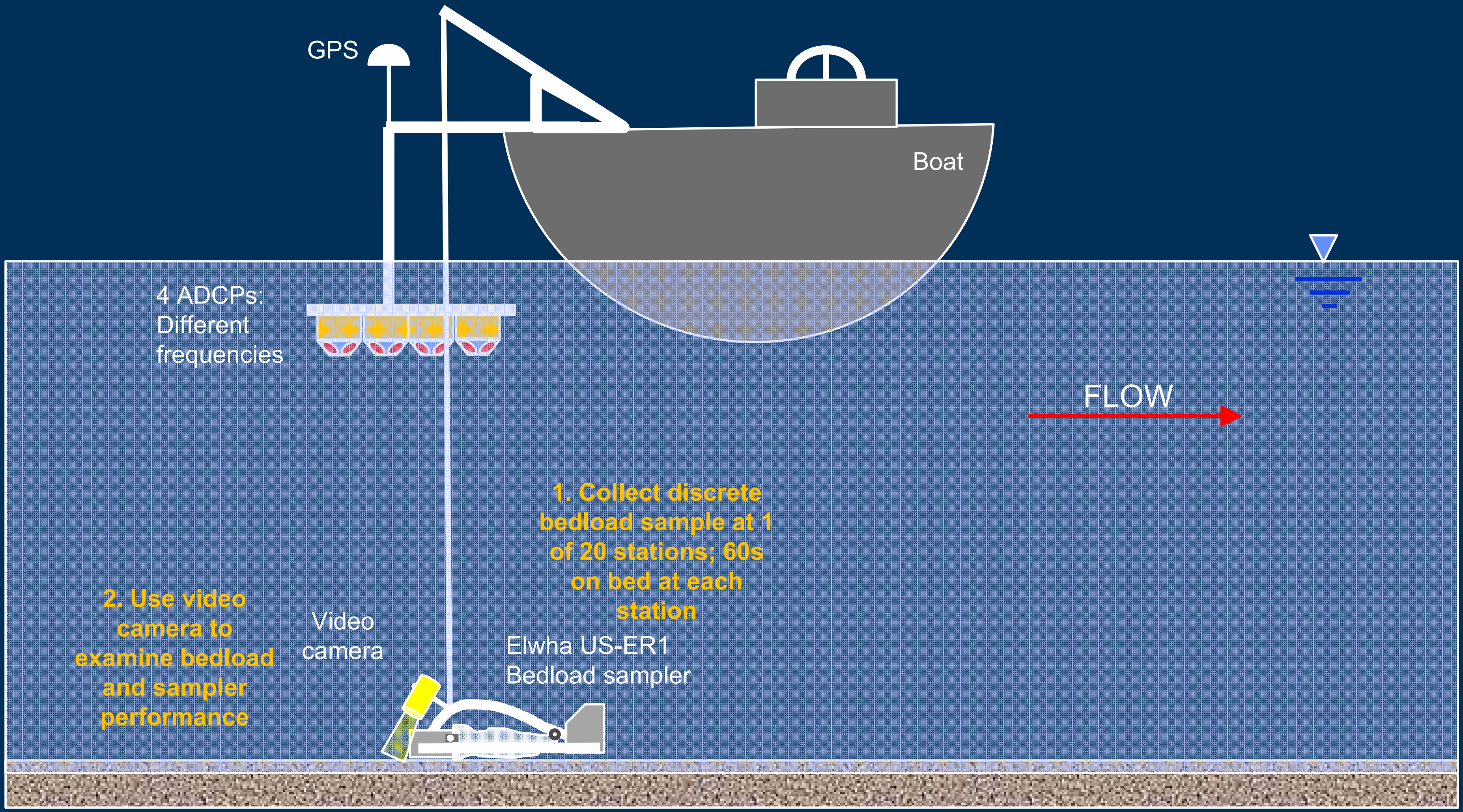
- Four elements:
  - Active acoustics: multiple frequency ADCPs
  - Physical bedload sample collection
  - Video camera on bedload sampler
  - Passive acoustics: hydrophone
- Steady flow ~38,000 cfs

Active Acoustics

- 4 ADCPs:
  - 0.6MHz TRDI Rio Grande
  - 1.0MHz SonTek M9
  - 1.2MHz TRDI Rio Grande
  - 2.0MHz TRDI StreamPro
- Differential GPS

USGS

Bedload Samples and Camera



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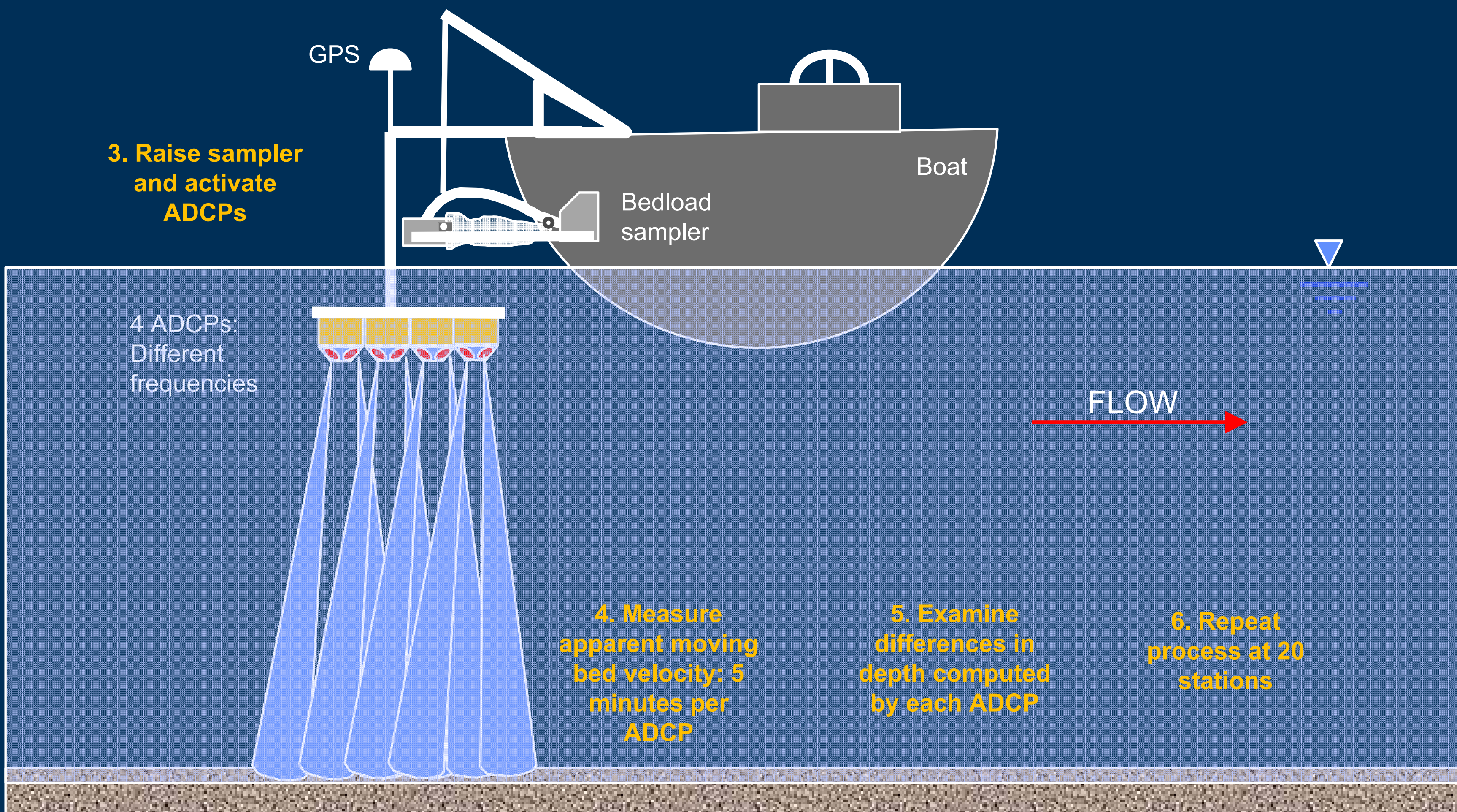
Active Acoustics



USGS

Active Acoustic Relations

- Regress ADCP apparent moving bed velocity with bedload
- Apparent moving bed velocity:
  - $V_{mb} = \frac{DU_{BT} - DU_{DGPS}}{T}$
  - DGPS GGA string used
- Bedload:
  - $Q_b = K(\frac{W_t}{T_t})M_t$
  - From Edwards and Glysson (1999)
- 22 samples used for analysis

USGS

Passive Acoustics

- Pair of Brüel and Kjaer 8103 hydrophones
- 10 octave bands, 0.03 – 16 kHz
- Mounted 1’ below water on separate boat
- Longitudinal transects along reach

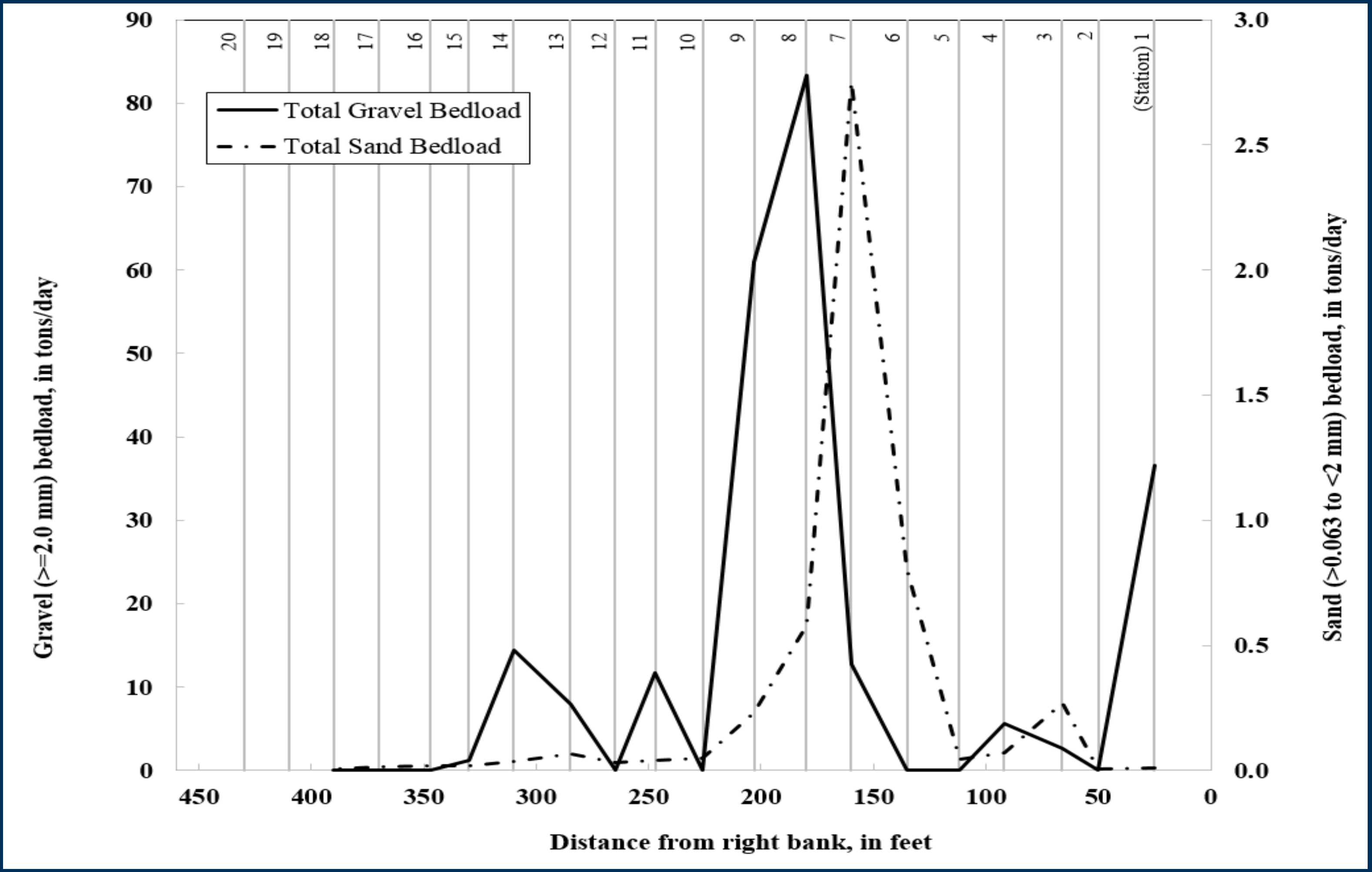
USGS

UNIVERSITY OF MONTANA

Flathead Lake Biological Station


RESULTS

Bedload Distribution



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Sampler Performance

- Sampler often turned sideways or backwards when deployed with camera
- Tried multiple configurations
- Aborted video and continued sampling

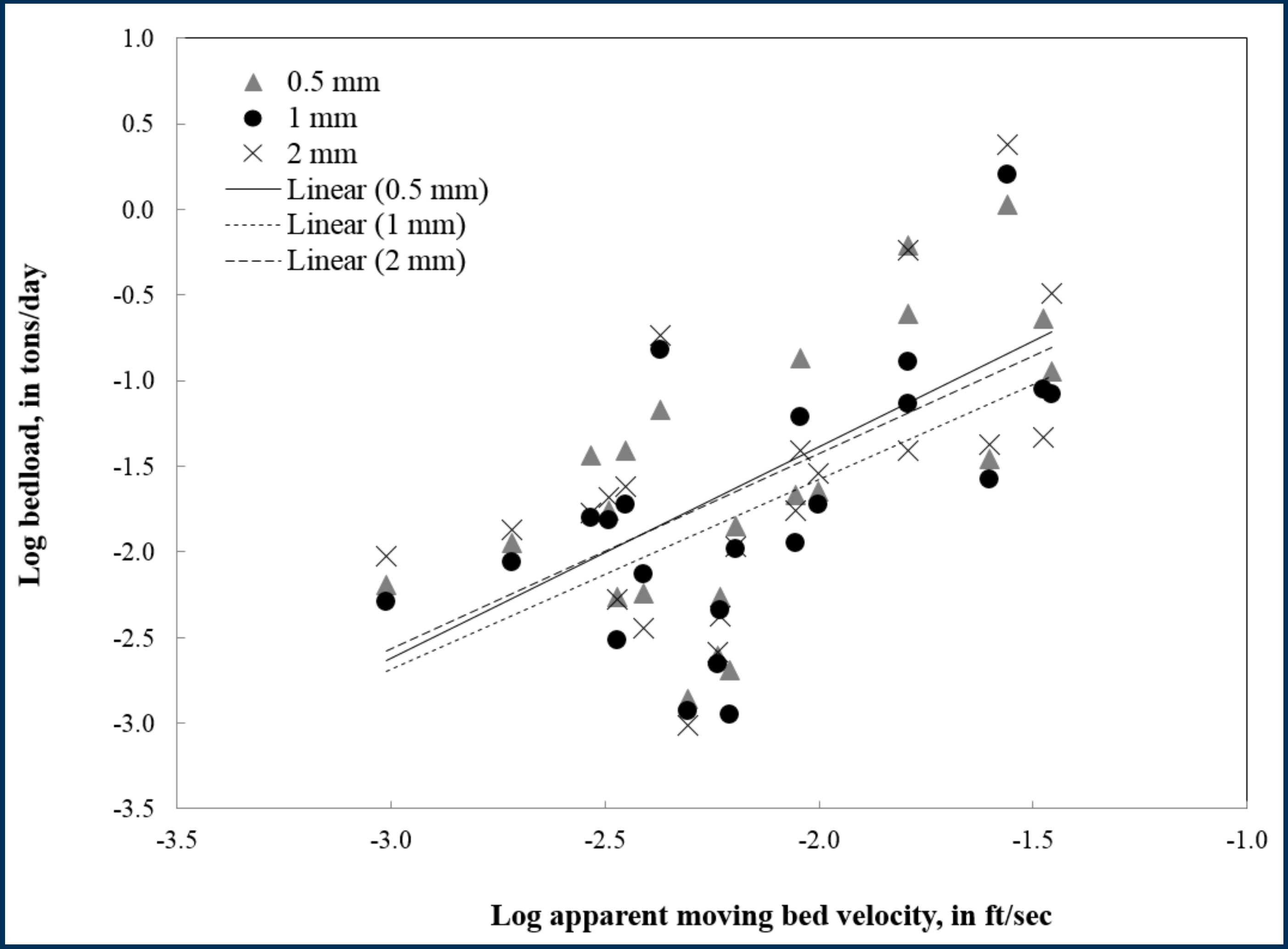
USGS

Active Acoustic Relations

- Low overall transport during event, particularly sands
- Low apparent moving bed velocities (0.001 – 0.064 ft/sec)
- 1.0 and 1.2MHz ADCPs: stat. sig. relations with 0.5-1.0 mm sand and 2.0 mm gravels
- 2.0MHz ADCP: stat. sig. relations with 0.5-1.0 mm sand only
- 0.6MHz ADCP: related better to 8.0-31.5 mm gravels than other ADCPs, but not stat. sig.

USGS

1.2MHz ADCP



0.5 mm
1 mm
2 mm
Linear (0.5 mm)
Linear (1 mm)
Linear (2 mm)
Log bedload, in tons/day
Log apparent moving bed velocity, in ft/sec
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0

Active Acoustic Relations

- Use of a range of frequencies did not improve ability to define relations for individual size categories
- High uncertainty in relations
- 1.2MHz ADCP: best relations overall
- Results from 1.0 – 1.2MHz ADCPs show promise

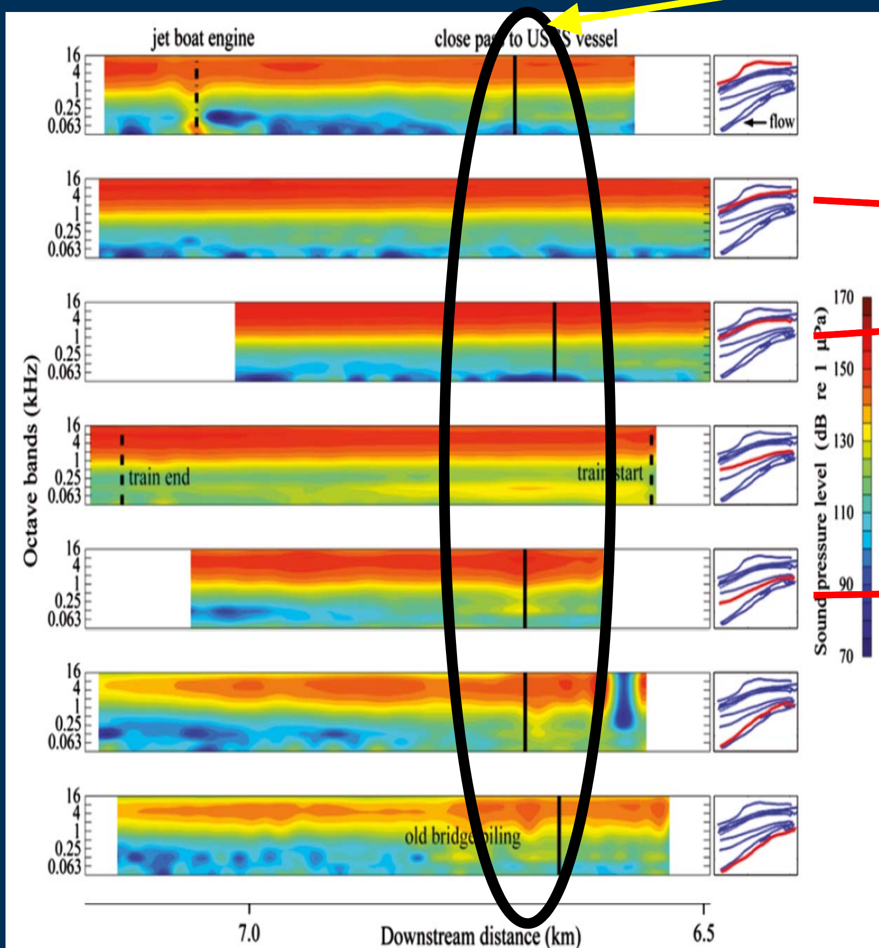
USGS

ADCP Depth Differences

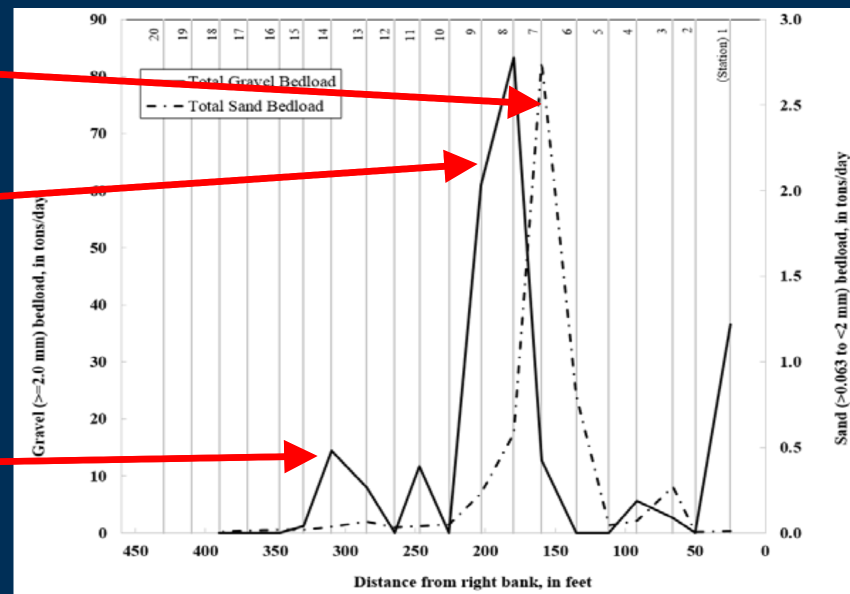
- Unable to safely anchor boat
- Differences in ensonified area and boat movement – high uncertainty
- Greatest depths measured by 0.6MHz
- Otherwise no clear patterns; 0.6% COV among ADCP depths

Passive Acoustics

Black oval: rough location of USGS boat (ADCPs and samples)



From Lorang and Tonolla (2014); courtesy www.schweizerbart.de



- Corroborated ADCP and sample results
- Gravel response (2-8 kHz)
- Sand response (8-16 kHz)
- Could possibly use passive acoustics to measure spatial variability and aid in targeting sample collection?

Ideas for Future Work

- Use passive and active acoustics together to "see" sand and gravel
  - ADCPs: best for sands/very fine gravels
  - Select site and event with higher transport
  - Try again to anchor
- More video assessment of sampler performance

USGS

QUESTIONS?

Thanks to:

- FISP
- Ryan Fosness and Greg Pachman (USGS)
- Mark Lorang and Diego Tonolla (UM)