ESTIMATING SSC USING DOWNLOOKING ADCPS: MISSOURI RIVER EXAMPLE

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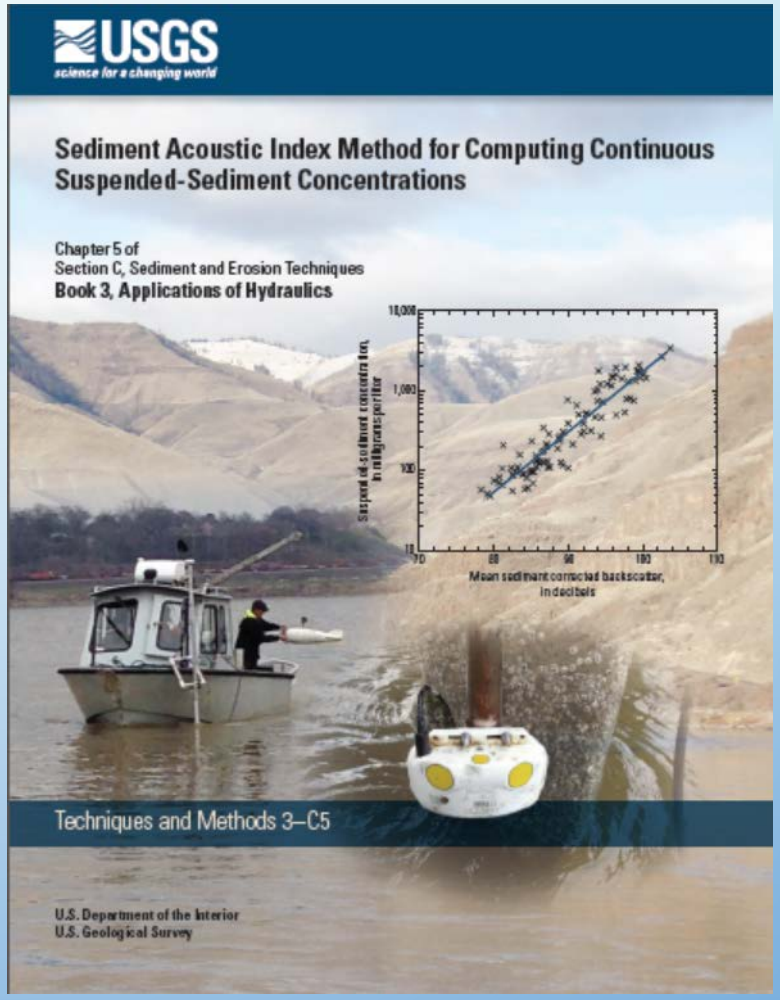
REGIONAL WATER DATA CONFERENCE 2017

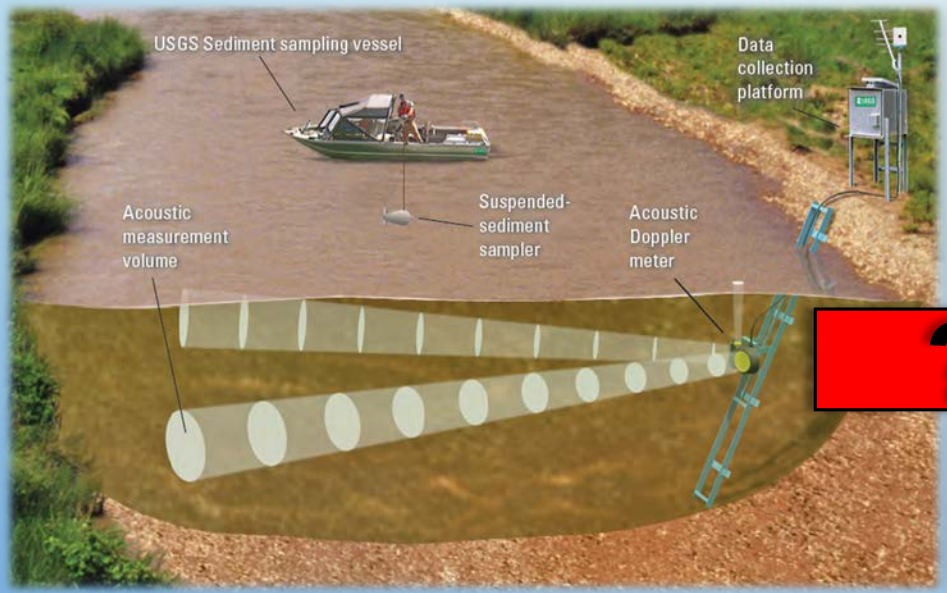
BACKGROUND

- WE NOW HAVE THIS (TM3-C5):



BACKGROUND

- CAN WE USE THE SAME METHOD FOR DOWNLOOKING ADCPS?



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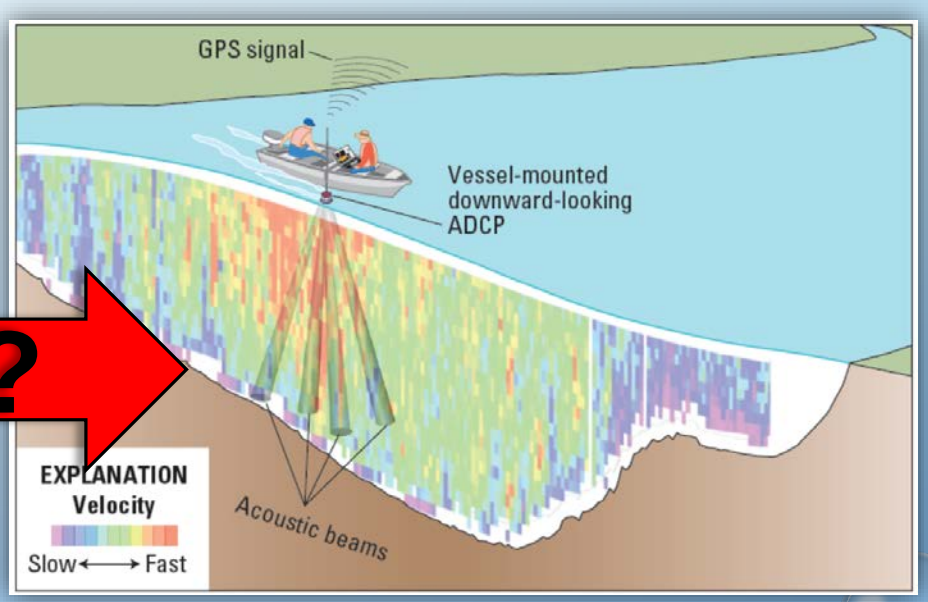
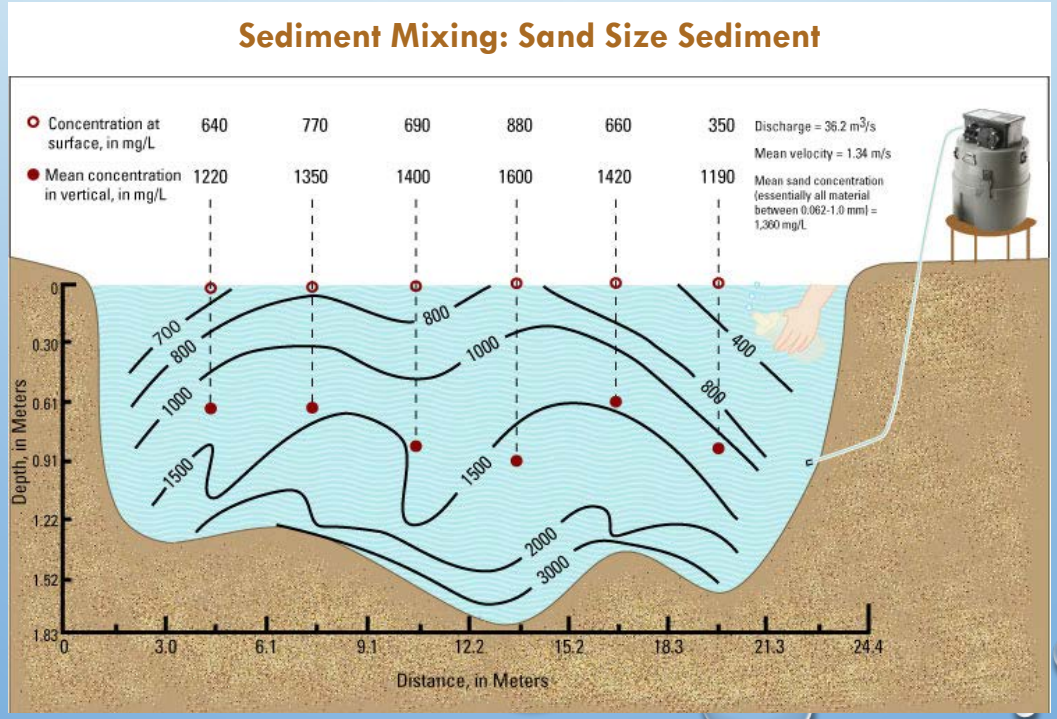


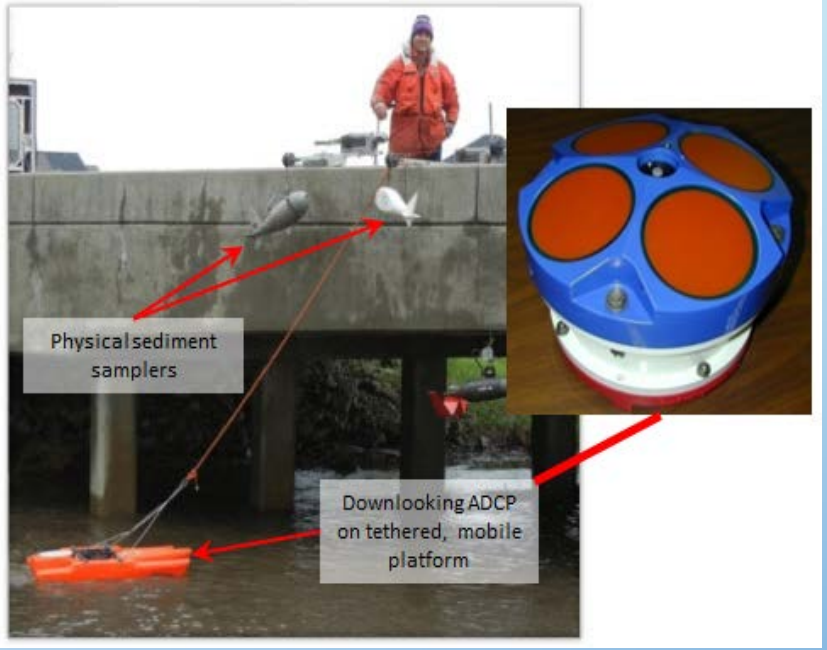
BACKGROUND

- NOT EXACTLY! WHY?
  - A MAJOR ASSUMPTION OF THE SIDELOOKING METHOD IS SEDIMENT HOMOGENEITY WITH THE ACOUSTIC MEASUREMENT VOLUME (CONSTANT SEDIMENT ATTENUATION AT A TIME STEP)
  - THIS ASSUMPTION ALMOST NEVER VALID VERTICALLY IN SAND-BEDDED RIVERS



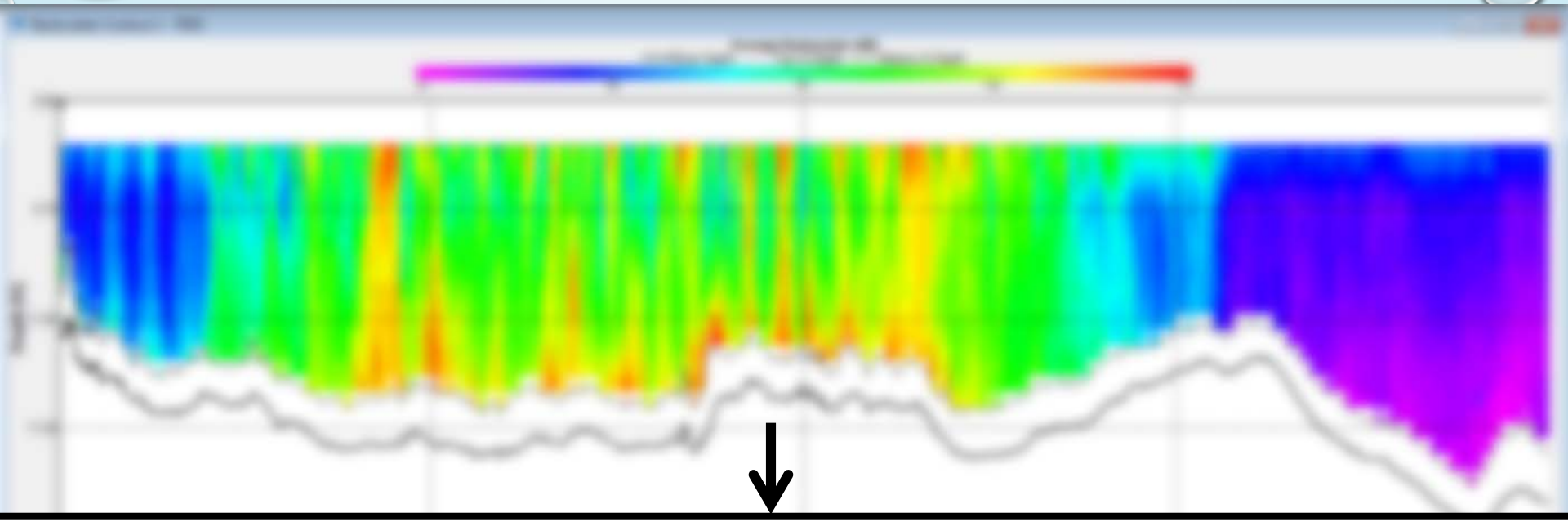
MOTIVATION

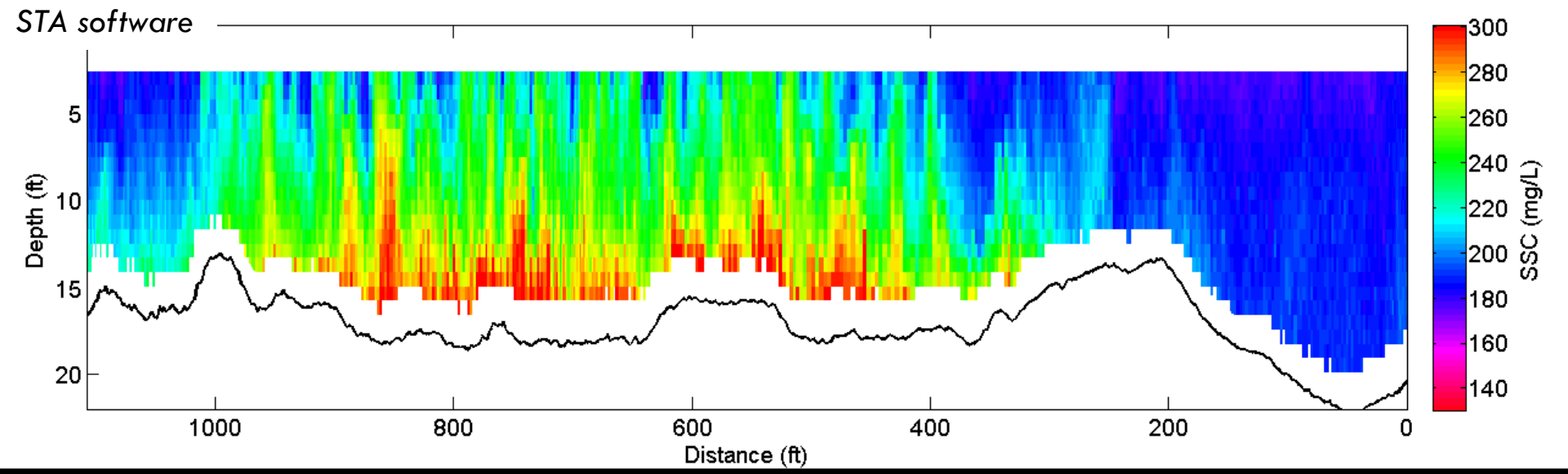
- OTHER RESEARCHERS HAVE INVESTIGATED USE OF DOWNLOOKING ADCPS FOR SEDIMENT TO ANSWER SPECIFIC QUESTIONS….
- WE USE ADCPS FOR STREAMFLOW MEASUREMENTS AT THOUSANDS OF GAGES ACROSS U.S……
- NEED FOR OPERATIONAL METHOD, LEVERAGING ADCP USE, THAT COULD BE USED AT MANY LOCATIONS
- COULD REVOLUTIONIZE SEDIMENT MONITORING



MOTIVATION

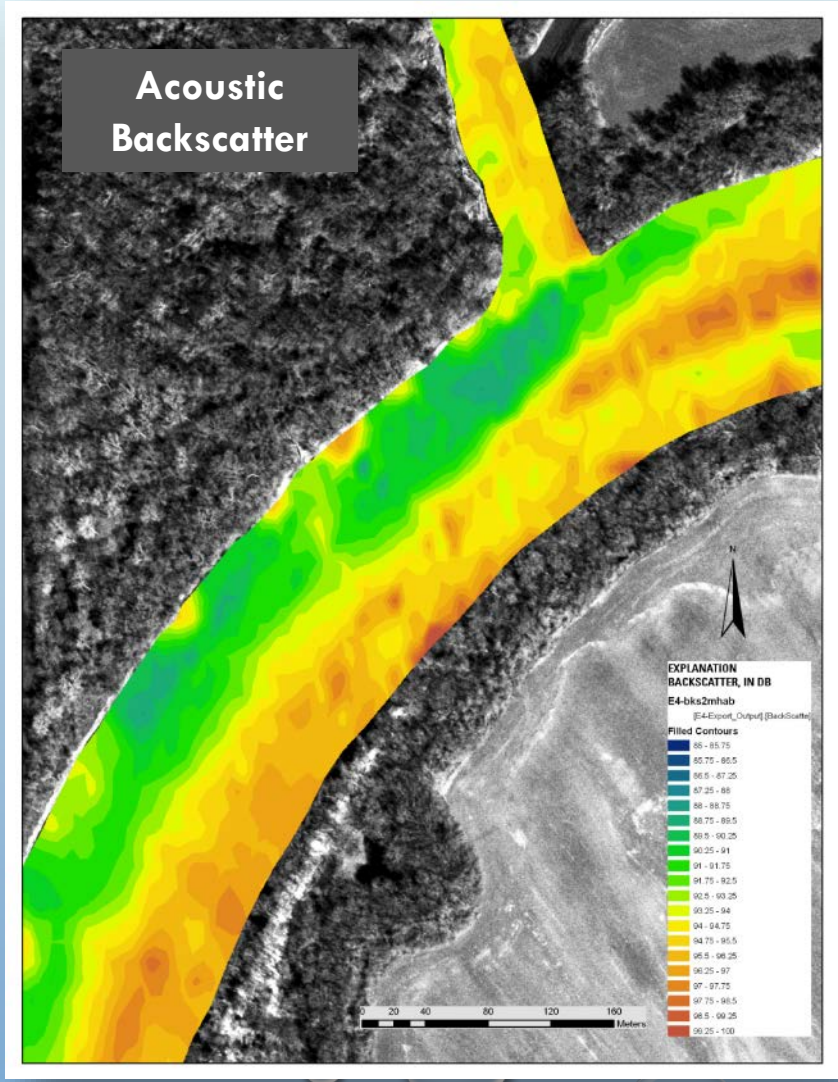
Source: Justin Boldt, USGS





MOTIVATION

Future: Reach-Scale, Rapid Sediment Mapping

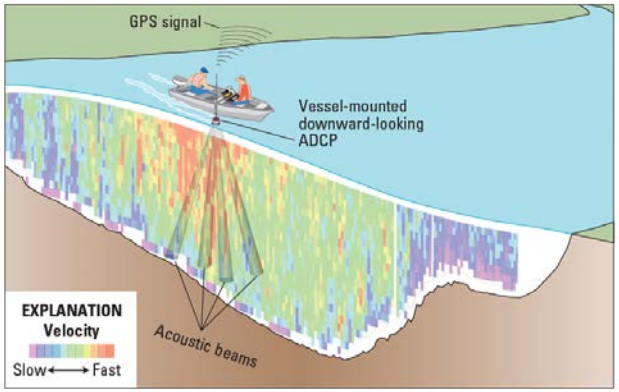


Source: Ryan Jackson, USGS

OVERVIEW

- DATA REQUIREMENTS
- CALIBRATION METHOD (STA SOFTWARE)
- DATA DISPLAY
- EFFORTS TO DATE FOR DEVELOPING OPERATIONAL METHOD – MISSOURI RIVER FOCUS

DATA REQUIREMENTS



INPUTS

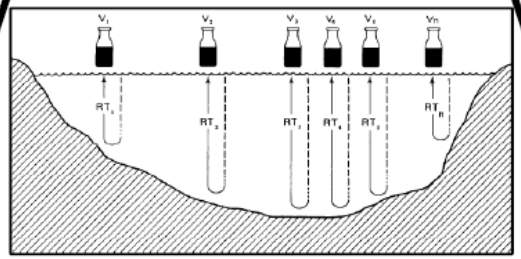
- **Stationary ADCP**
- **Sediment point samples**
- **ADCP cross section(s)**

→ **MATLAB-based tool (called STA)**

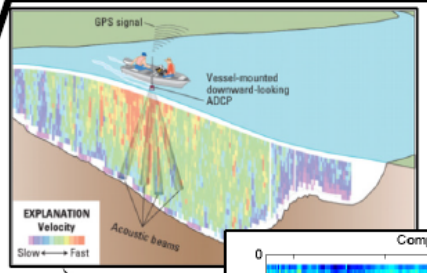
Source: Justin Boldt, USGS

Source: Justin Boldt, USGS

EDI sediment sample

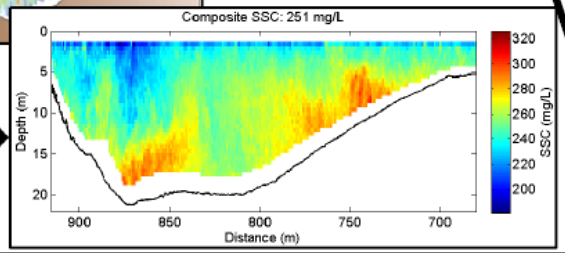


Level 3: Validate calibration with EDI sample



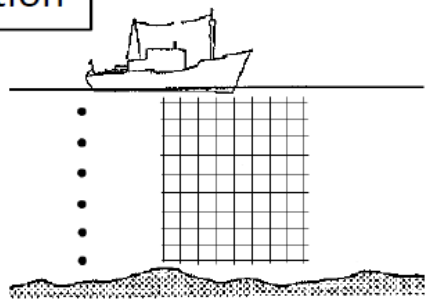
ADCP transect

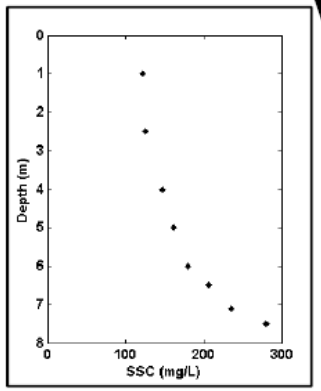
Level 2: Apply calibration to cross section



Concurrent measurements of acoustic backscatter (stationary profile) and suspended sediment concentration (point samples)

Level 1: Develop a calibration





CALIBRATION METHOD

$$SCB = K_c * RB + 20 * \log_{10}(\psi R) + 2\alpha_w R + 2\alpha_s R$$

K_c = instrument echo intensity scale factor

Ψ = near-field correction (Downing et al., 1995)

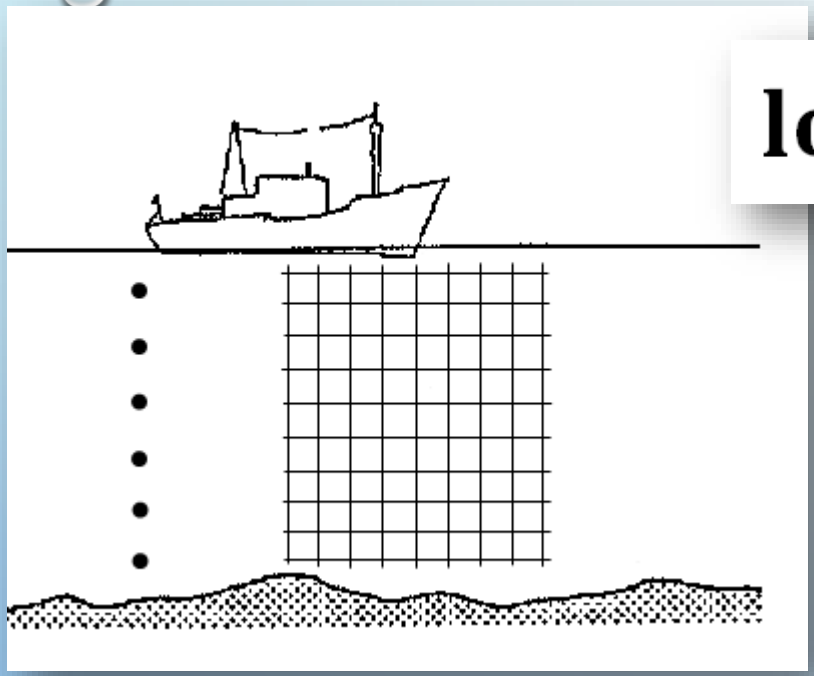
R = range along beam

α_w = sound absorption coefficient (Schulkin and March, 1962)

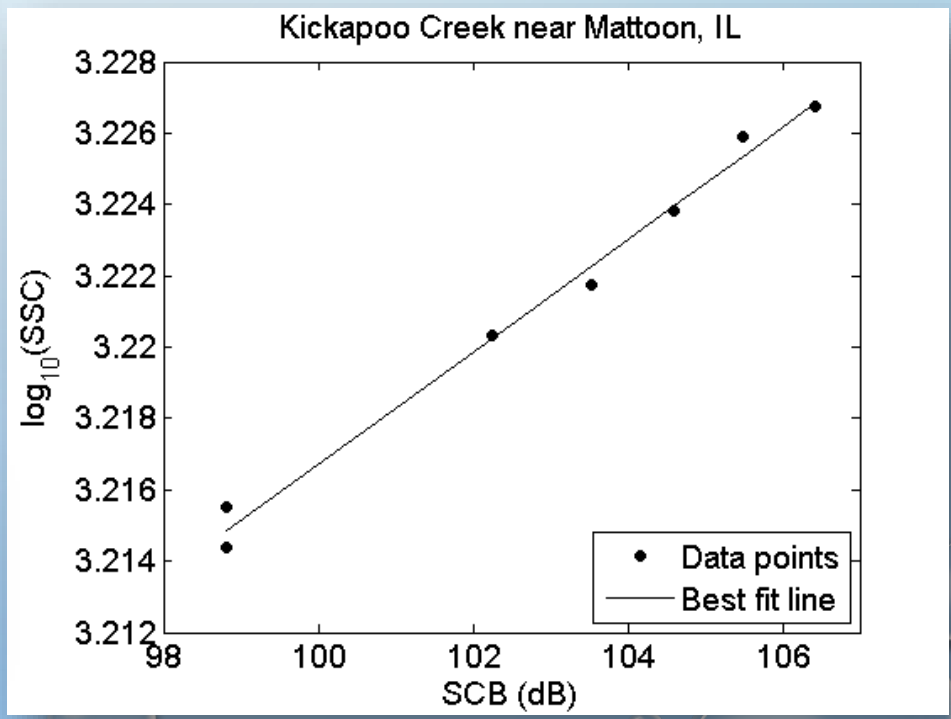
α_s = sediment attenuation coefficient (Wright et al., 2010 & Landers, 2010)

Source: Justin Boldt, USGS

CALIBRATION METHOD

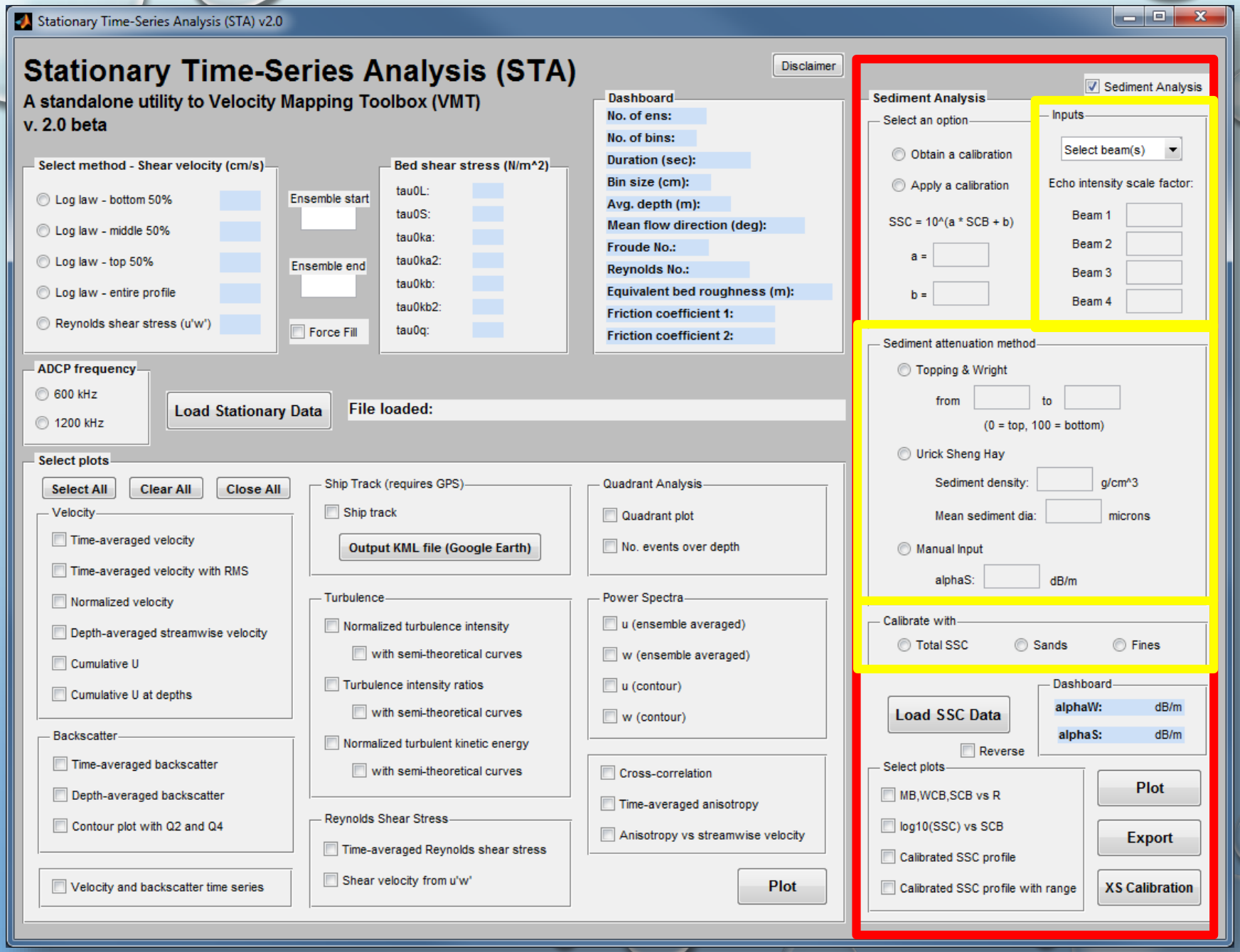


$$\log_{10} SSC = a * SCB + b$$



$$SSC = 10^{(a*SCB+b)}$$

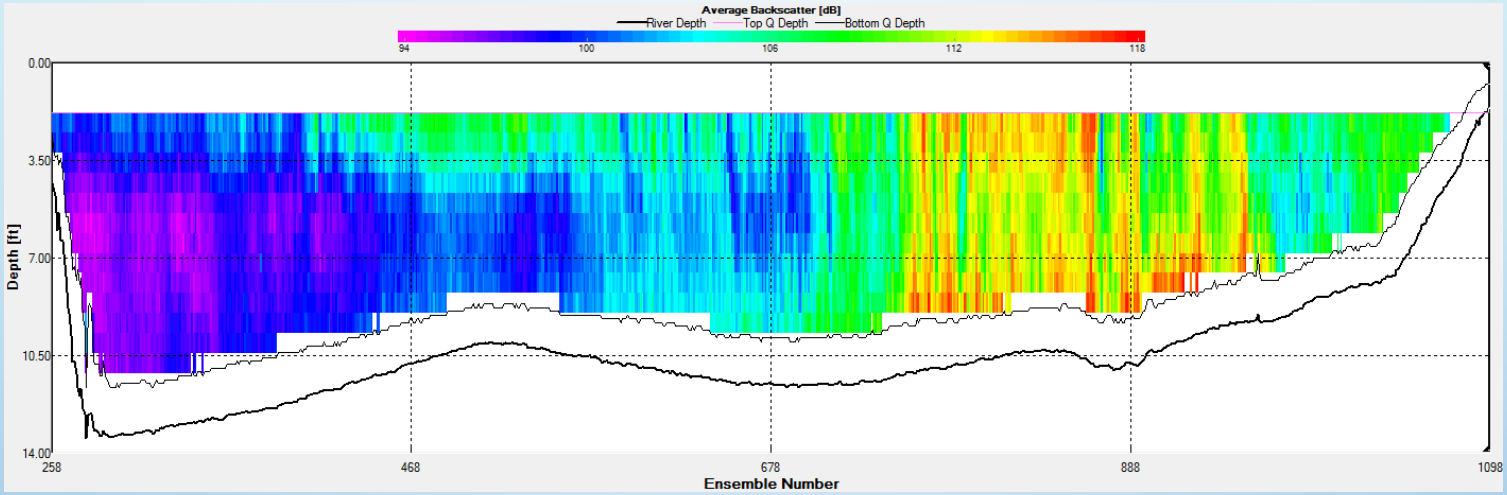
Source: Justin Boldt, USGS



Source: Justin Boldt, USGS

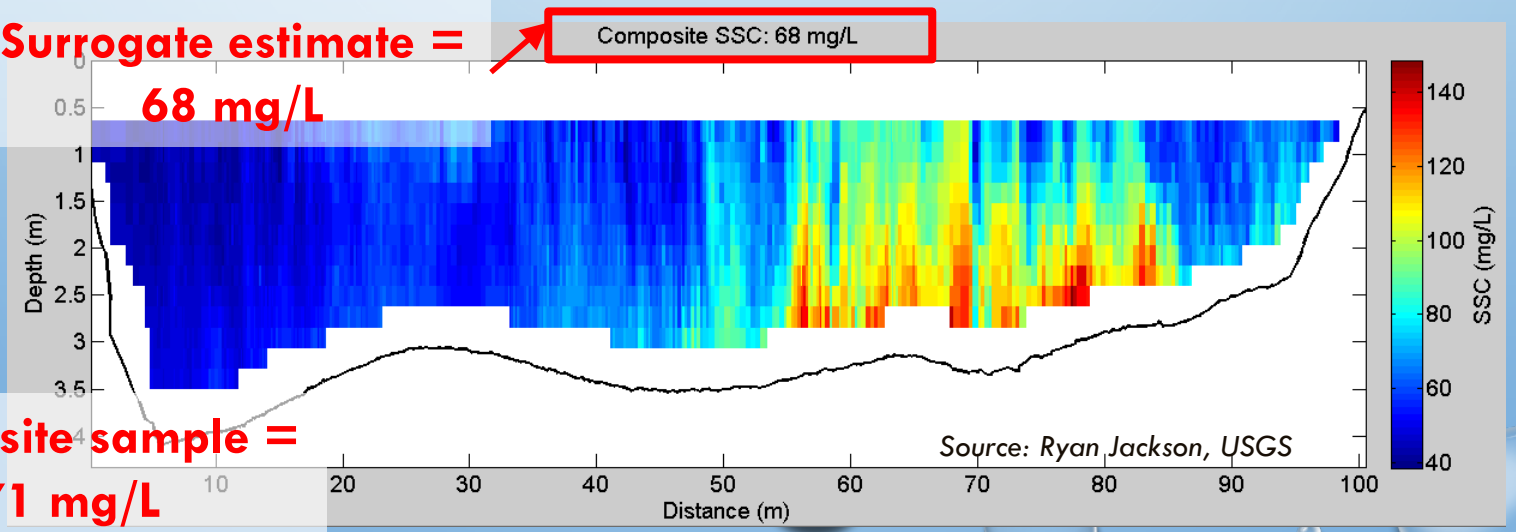
DATA DISPLAY

Measured Acoustic Backscatter (dB)



Suspended Sediment Concentration (mg/L)

Surrogate estimate = 68 mg/L



Composite sample = 71 mg/L

2016 ADCP~SSC "SUMMIT"

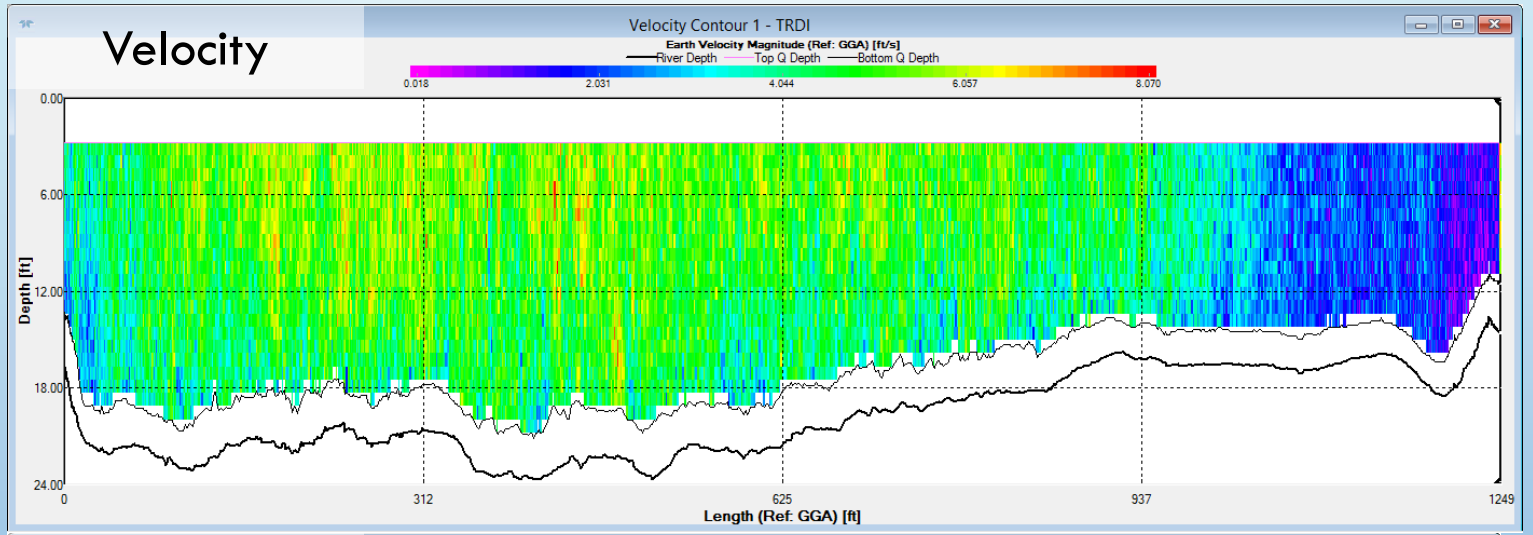
- JULY 18-22, 2016 IN URBANA, IL AND ST. LOUIS, MO
- DISCUSSED STEPS TO ADVANCE USE OF DOWN-LOOKING ADCPS FOR SUSPENDED SEDIMENT
- FIELD EFFORT
- PARTICIPANTS: USGS - JUSTIN BOLDT, MARK LANDERS, AMANDA MANASTER, KEVIN OBERG, TIM STRAUB, MOLLY WOOD, RYAN BEAULIN, GARY JOHNSON, BEN RIVERS. UNIVERSIDAD NACIONAL DE LITORAL (ARGENTINA) - RICARDO SZUPIANY

MISSOURI RIVER FIELD EFFORT

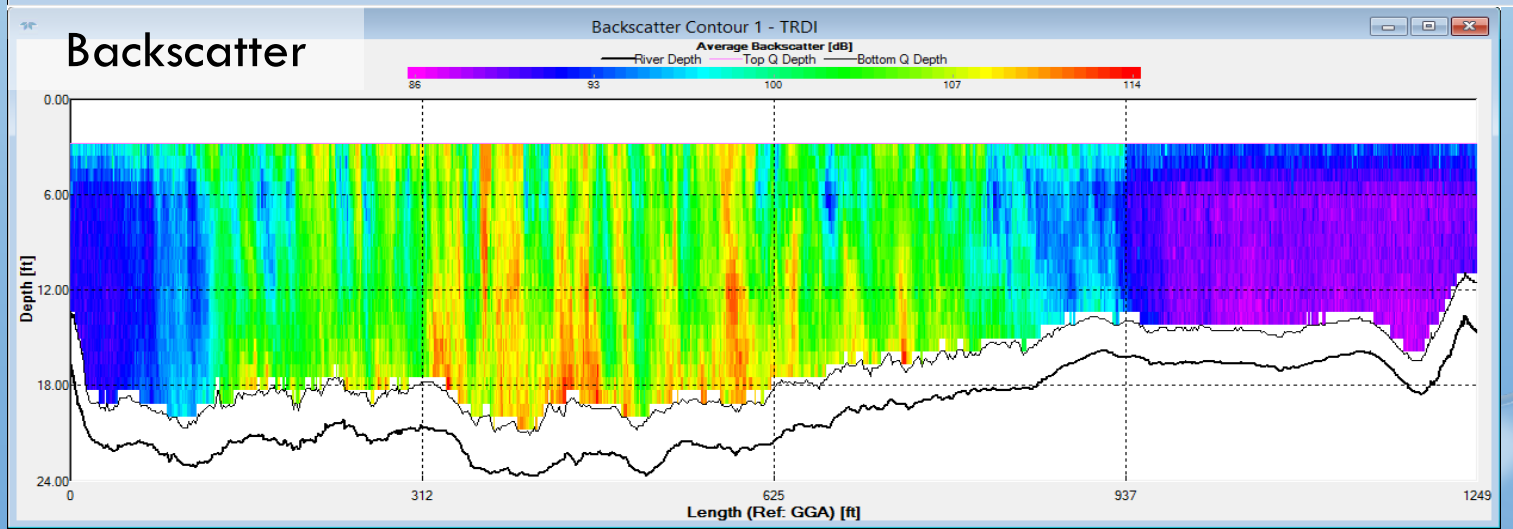
- INSTRUMENTS USED:
  - 600 AND 1200KHZ TRDI RIO GRANDE
  - 1200KHZ TRDI RIVERPRO
  - MULTIFREQUENCY SONTEK M9
  - SEQUOIA LISST-ABS
  - YSI 6920 SONDE W/ TURBIDITY PROBE
  - P-6 POINT SEDIMENT SAMPLER
  - BM-54 BED MATERIAL SAMPLER

EXAMPLE CONTOURS FROM 1200KHZ RIO GRANDE

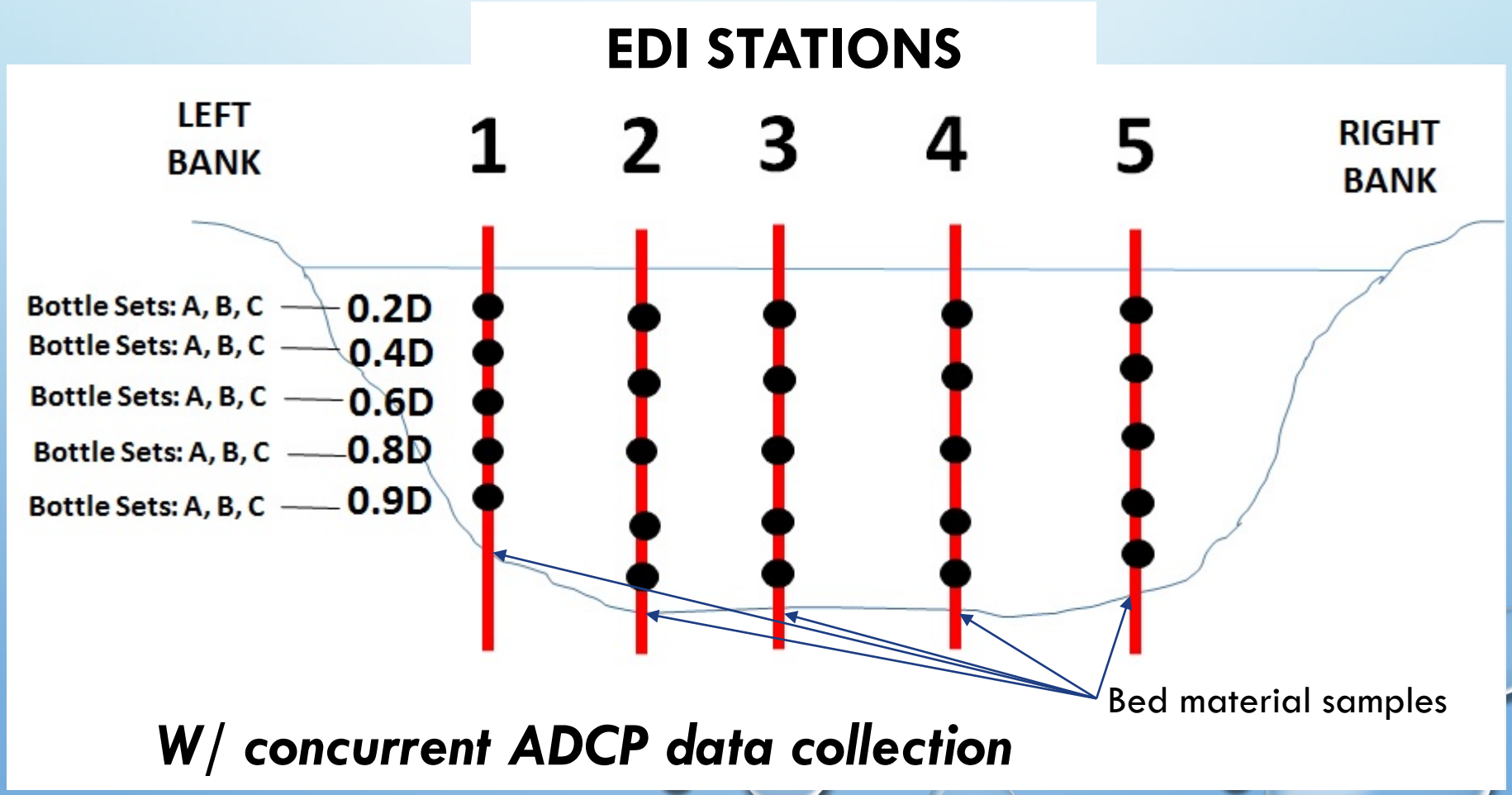
Velocity



Backscatter



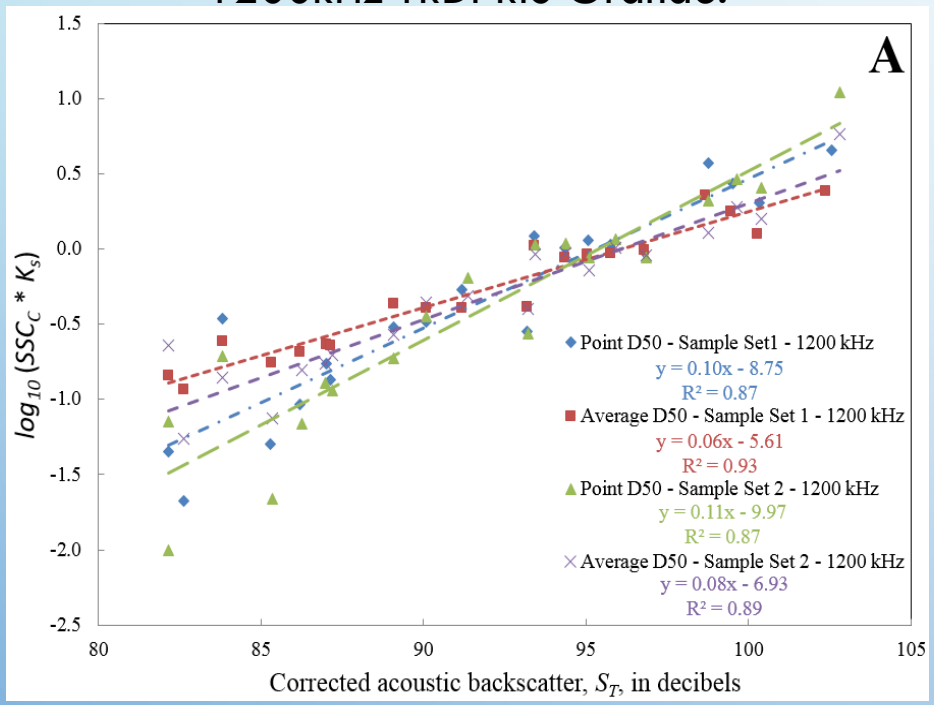
SAMPLING SCHEME



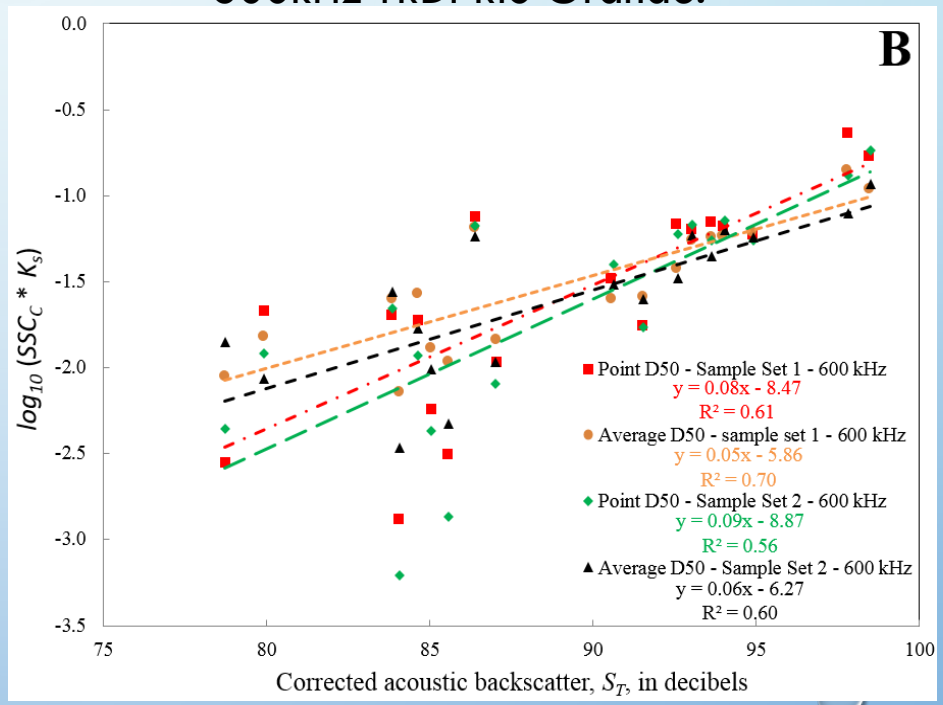
W/ concurrent ADCP data collection

CALIBRATIONS FOR SAND CONCENTRATIONS

1200kHz TRDI Rio Grande:

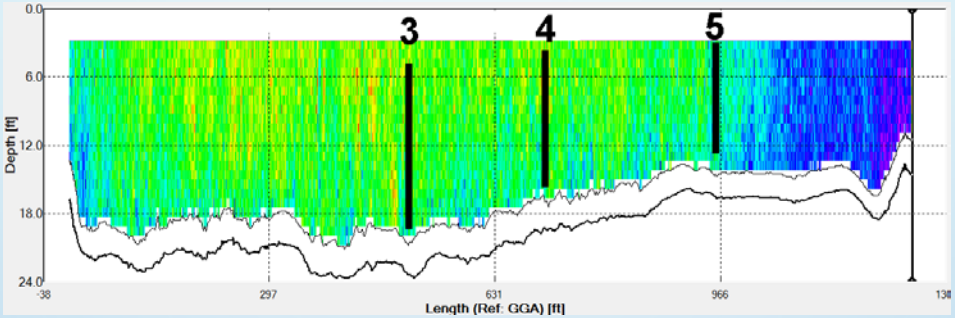


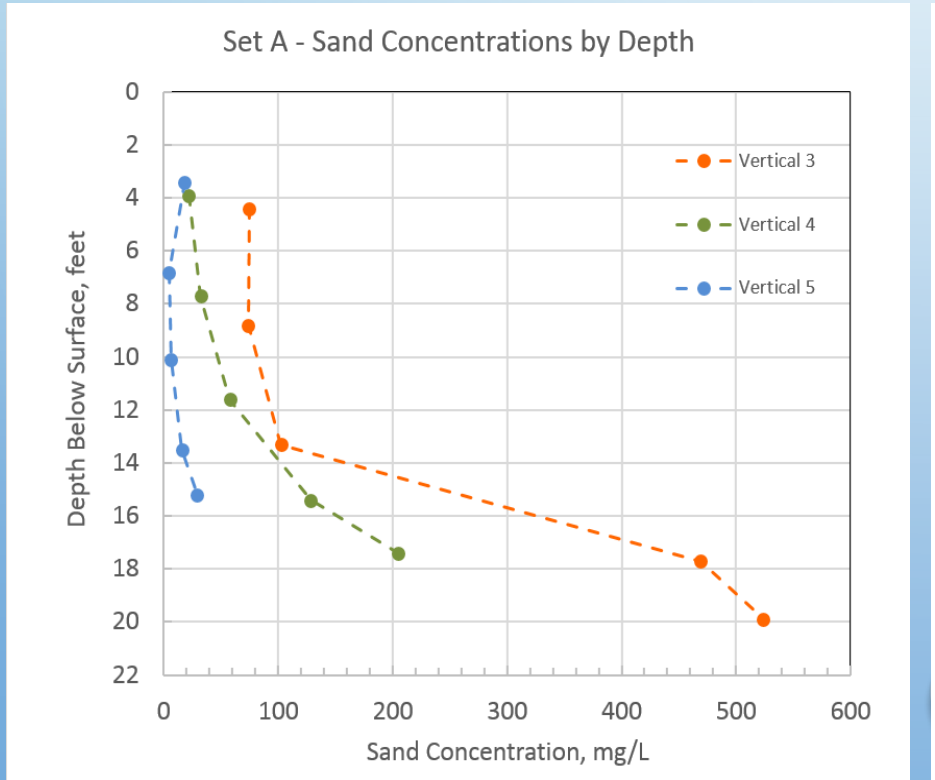
600kHz TRDI Rio Grande:

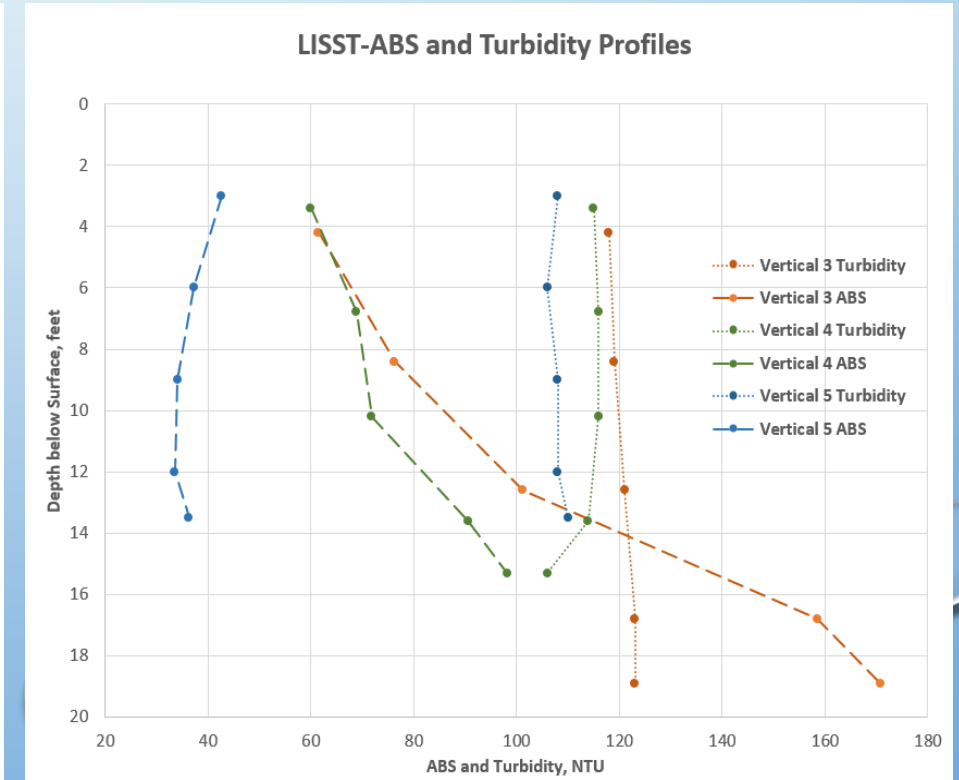


- HIGHER SCATTER NEAR SURFACE
- POORER CALIBRATION WITH 600KHZ
- SOURCES OF NOISE?

SAND, TURBIDITY, AND LISST-ABS PROFILES







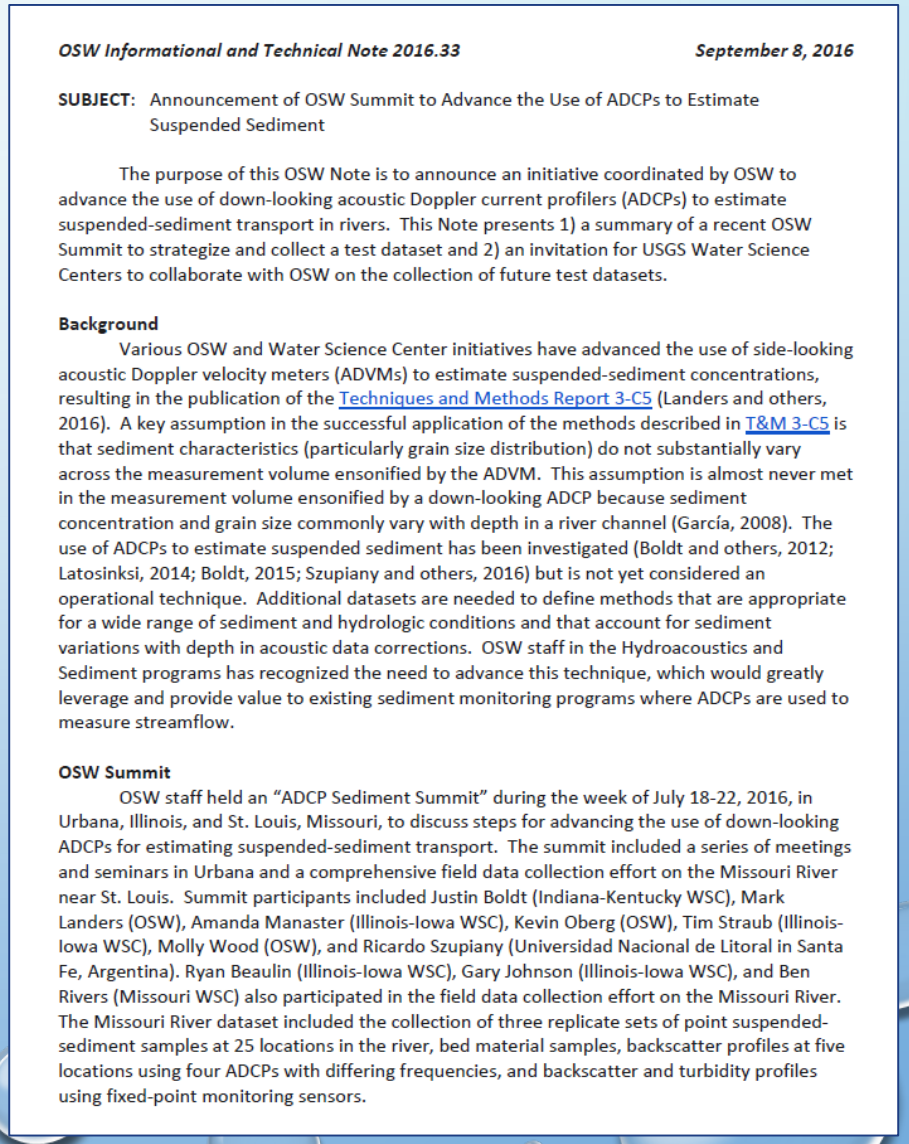
NEXT STEPS – MISSOURI RIVER DATASET

- PROCESS REMAINDER OF ADCP DATASETS
- DEVELOP CALIBRATIONS IN STA AND APPLY TO CROSS-SECTION BACKSCATTER
- INVESTIGATE SOURCES OF SURFACE SCATTER AND NOISE
- LOOK FOR COMMONALITIES WITH OTHER DATASETS

More Information:
Conference paper by Wood and others (2017): http://www.rioacoustics.org/

OSW NOTE 2016.33

- DESCRIBED 2016 ADCP~SSC SUMMIT AND MISSOURI RIVER WORK
- SOLICITED HELP FROM WSCS FOR COLLECTION OF TEST DATASETS



OSW Informational and Technical Note 2016.33 *September 8, 2016*

SUBJECT: Announcement of OSW Summit to Advance the Use of ADCPs to Estimate Suspended Sediment

The purpose of this OSW Note is to announce an initiative coordinated by OSW to advance the use of down-looking acoustic Doppler current profilers (ADCPs) to estimate suspended-sediment transport in rivers. This Note presents 1) a summary of a recent OSW Summit to strategize and collect a test dataset and 2) an invitation for USGS Water Science Centers to collaborate with OSW on the collection of future test datasets.

Background

Various OSW and Water Science Center initiatives have advanced the use of side-looking acoustic Doppler velocity meters (ADVMs) to estimate suspended-sediment concentrations, resulting in the publication of the Techniques and Methods Report 3-C5 (Landers and others, 2016). A key assumption in the successful application of the methods described in T&M 3-C5 is that sediment characteristics (particularly grain size distribution) do not substantially vary across the measurement volume ensonified by the ADVM. This assumption is almost never met in the measurement volume ensonified by a down-looking ADCP because sediment concentration and grain size commonly vary with depth in a river channel (García, 2008). The use of ADCPs to estimate suspended sediment has been investigated (Boldt and others, 2012; Latosinksi, 2014; Boldt, 2015; Szupiany and others, 2016) but is not yet considered an operational technique. Additional datasets are needed to define methods that are appropriate for a wide range of sediment and hydrologic conditions and that account for sediment variations with depth in acoustic data corrections. OSW staff in the Hydroacoustics and Sediment programs has recognized the need to advance this technique, which would greatly leverage and provide value to existing sediment monitoring programs where ADCPs are used to measure streamflow.

OSW Summit

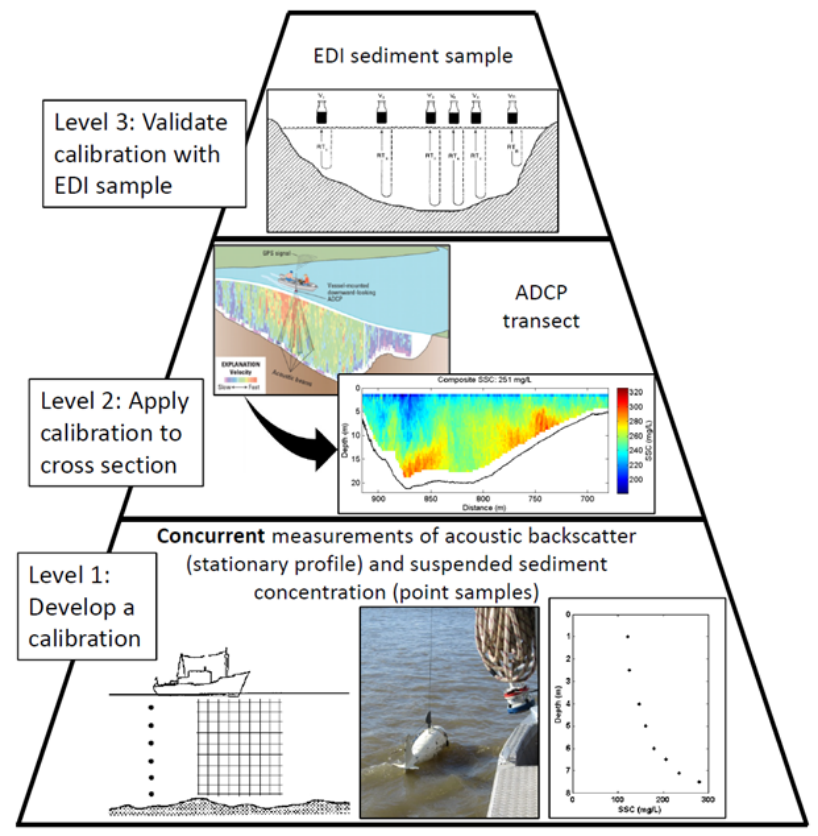
OSW staff held an "ADCP Sediment Summit" during the week of July 18-22, 2016, in Urbana, Illinois, and St. Louis, Missouri, to discuss steps for advancing the use of down-looking ADCPs for estimating suspended-sediment transport. The summit included a series of meetings and seminars in Urbana and a comprehensive field data collection effort on the Missouri River near St. Louis. Summit participants included Justin Boldt (Indiana-Kentucky WSC), Mark Landers (OSW), Amanda Manaster (Illinois-Iowa WSC), Kevin Oberg (OSW), Tim Straub (Illinois-Iowa WSC), Molly Wood (OSW), and Ricardo Szupiany (Universidad Nacional de Litoral in Santa Fe, Argentina). Ryan Beaulin (Illinois-Iowa WSC), Gary Johnson (Illinois-Iowa WSC), and Ben Rivers (Missouri WSC) also participated in the field data collection effort on the Missouri River. The Missouri River dataset included the collection of three replicate sets of point suspended-sediment samples at 25 locations in the river, bed material samples, backscatter profiles at five locations using four ADCPs with differing frequencies, and backscatter and turbidity profiles using fixed-point monitoring sensors.

ADCP~SSC TEST DATASETS COLLECTED 2016-17

- MISSOURI RIVER AT ST. CHARLES, MO
- SACRAMENTO RIVER AT FREEPORT, CA
- ILLINOIS RIVER AT FLORENCE, IL
- MISSOURI RIVER AT NEBRASKA CITY, NE

YOU CAN HELP US!

- FUNDS MAY BE AVAILABLE IN FY18 TO AUGMENT EXISTING MONITORING
- POINT, ISOKINETIC SAMPLES
  - INDIVIDUAL ANALYSIS
  - SOME LEVEL OF FULL PARTICLE SIZE INFORMATION NEEDED
- CONCURRENT ADCP PROFILES AT EACH VERTICAL
- MOVING-BOAT ADCP MEASUREMENTS
- DEPTH-INTEGRATED EDI SAMPLES



QUESTIONS?

YOUR FRIENDLY NEIGHBORHOOD OSW/OSD SEDIMENT TEAM….
MARK AND MOLLY