Development of a system for *in situ* measurements of geoacoustic properties during sediment coring

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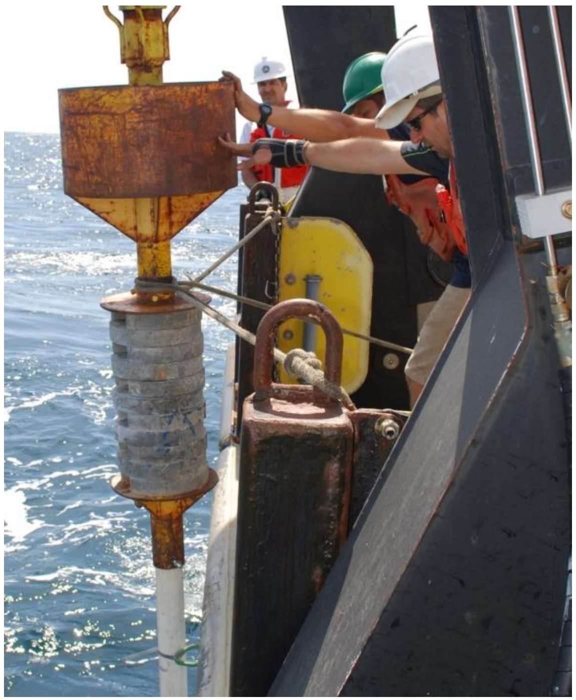
Background and Motivation

Sediment cores provide valuable insight on the physical properties of the seabed, and laboratory measurements of sediment wave speed from cores are often considered "ground truth."



Gravity core recovery during the Mud Patch survey, August 2015.

Sectioning and capping the core for later analysis.

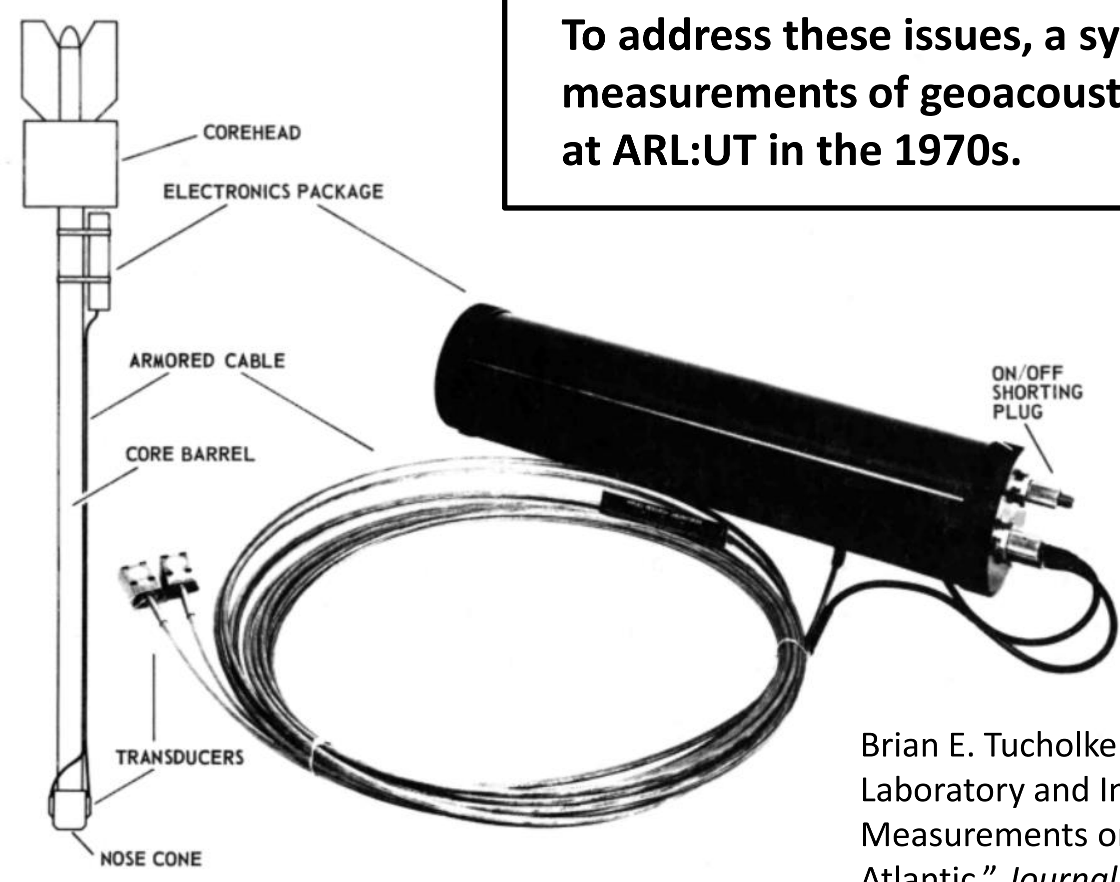
Image obtained from http://www.geotek.co.uk/products/mscl-s

Core logger for shipboard and laboratory measurements.

Background and Motivation

Sound-speed estimates obtained from cores can be inaccurate due to changes in pressure, temperature, and mechanical properties of the sediment caused by removal of the core from the seabed and its subsequent transport to the laboratory.

To address these issues, a system for obtaining *in situ* measurements of geoacoustic properties was developed at ARL:UT in the 1970s.



Compressional wave speed was estimated from travel time between a single source-receiver pair mounted inside the nose cone of the corer.

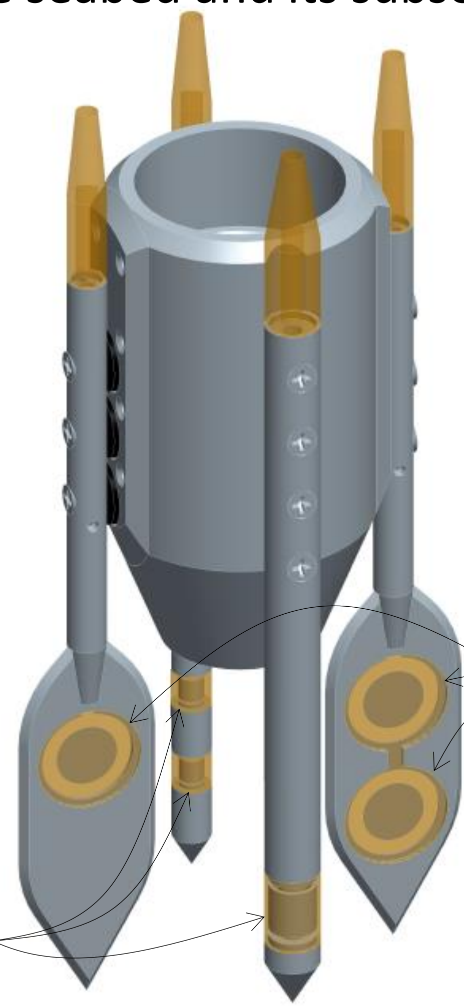
Brian E. Tucholke and Donald J. Shirley, "Comparison of Laboratory and In Situ Compressional-Wave Velocity Measurements on Sediment Cores From the Western North Atlantic," *Journal of Geophysical Research*, 84(2), 1979.

Background and Motivation

Sound-speed estimates obtained from cores can be inaccurate due to changes in pressure, temperature, and mechanical properties of the sediment caused by removal of the core from the seabed and its subsequent transport to the laboratory.

The transducers are mounted outside the nose cone to minimize the effect of sediment disturbance caused by penetration of the corer.

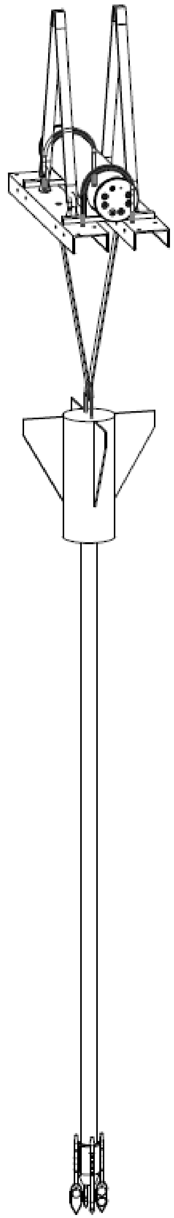
Compressional and shear wave speed and attenuation are estimated from differential measurements made with two receivers.

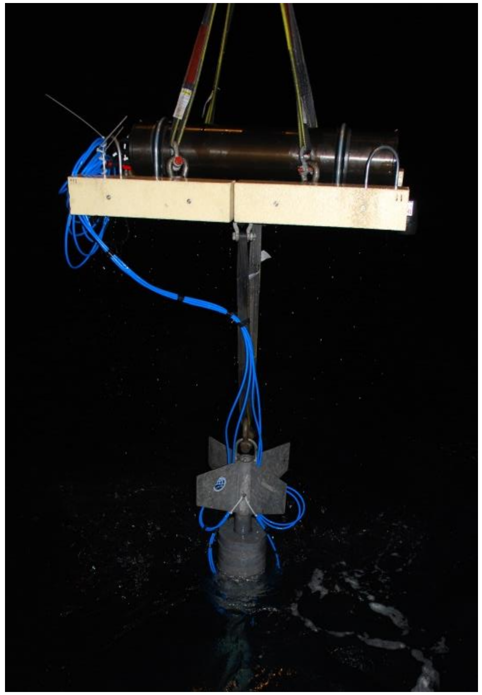


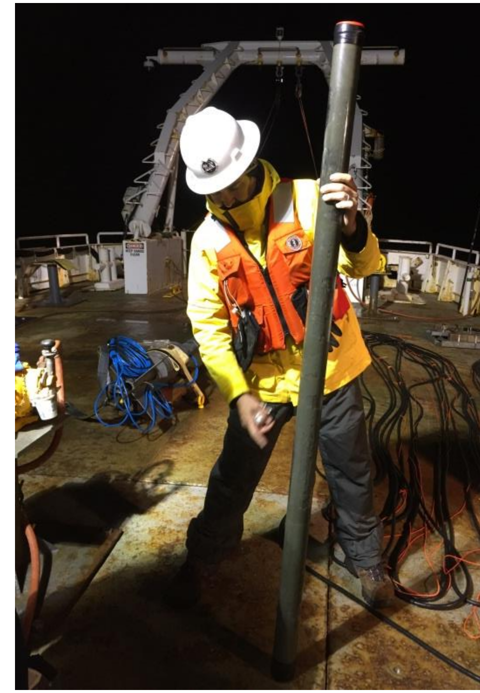
Outline

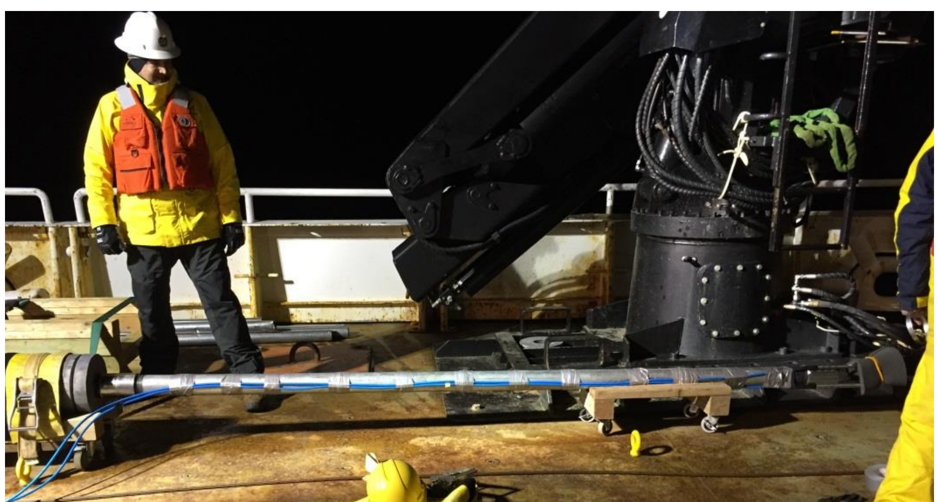
- System description
  - System Components
  - Compressional wave transducers
  - Shear wave transducers
- 2016 Engineering Test
  - Experiment description
  - Preliminary results
  - Comparison to Core Logger data

System Components

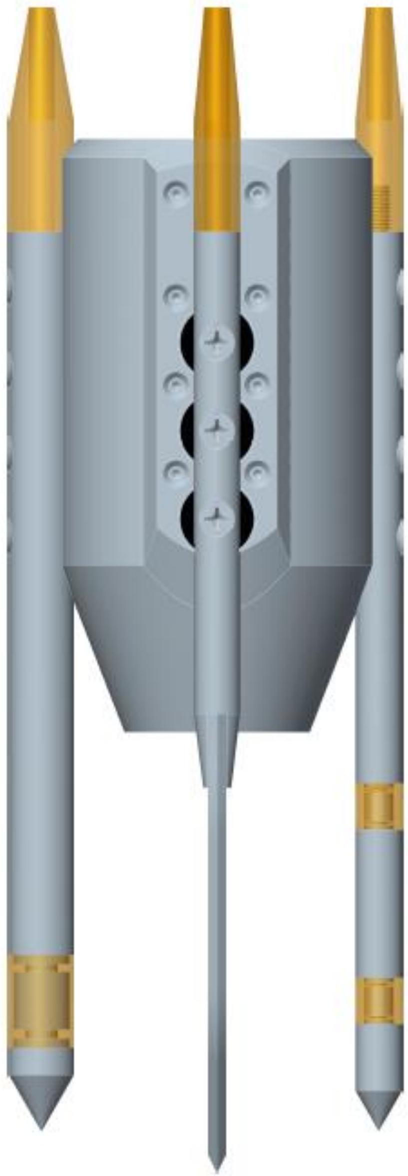








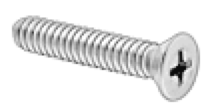
Compressional Wave Measurements



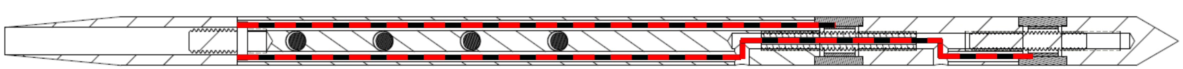
P-Wave Measurements with Cylindrical PZT Elements

	OD (mm)	ID (mm)	Length(mm)
Source	19.0	16.0	20.0
Receiver	10.0	8.0	10.0

Input signal: 20 cycles of sinusoid at 50 kHz



Transducer probe assemblies are attached to the nose cone with screws so a single probe can be replaced if one is damaged.



Sound Speed Uncertainty

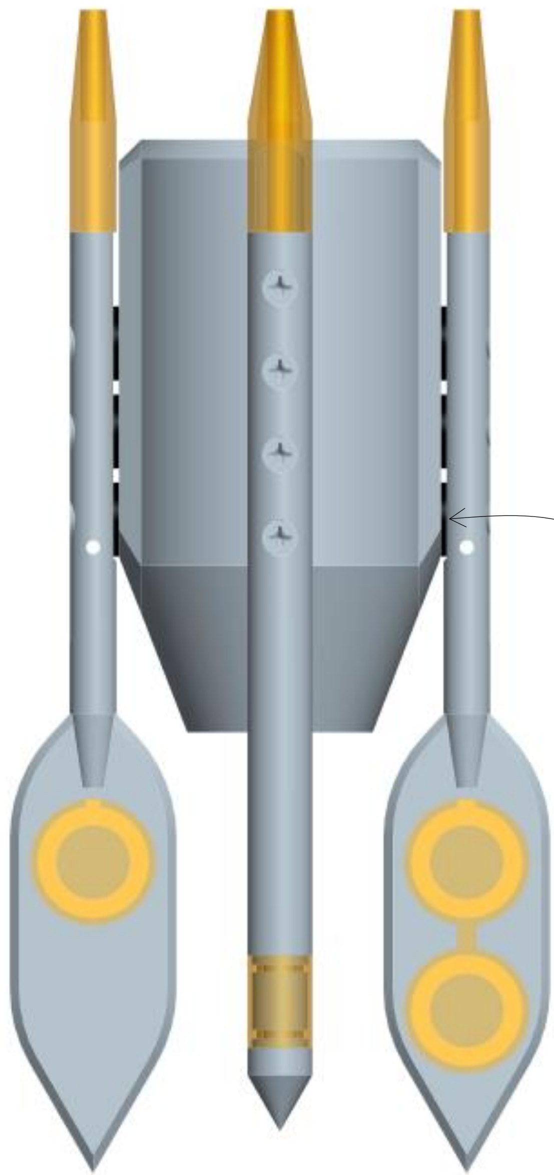
$$\sigma_v = \sqrt{\left(\frac{\partial f}{\partial t}\right)^2 \sigma_t^2 + \left(\frac{\partial f}{\partial x}\right)^2 \sigma_x^2}$$

$\sigma_t = 1 \times 10^{-6}$ sec

$\sigma_x = 1 \times 10^{-3}$ m

$\sigma_v = 20$ m/s

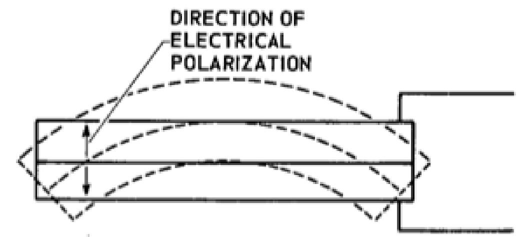
Shear Wave Measurements



S-Wave Measurements with Bender Elements

Both source and receiver elements are the same size: diameter 26.0 mm, thickness 0.36 mm.

Source is in parallel configuration
Receiver is in series configuration
(schematic illustrates series)



Input signal: 8 cycles of sinusoid at 1 kHz

Rubber vibration isolators were used to attach the shear wave probe assemblies to the nose cone to minimize waves traveling through the structure.

Sound Speed Uncertainty

$$\sigma_v = \sqrt{\left(\frac{\partial f}{\partial t}\right)^2 \sigma_t^2 + \left(\frac{\partial f}{\partial x}\right)^2 \sigma_x^2}$$

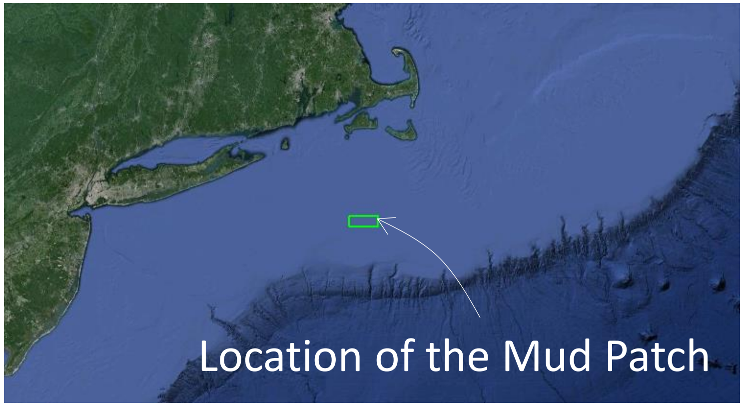
$\sigma_t = 2 \times 10^{-5}$ sec

$\sigma_x = 1 \times 10^{-3}$ m

$\sigma_v = 3$ m/s

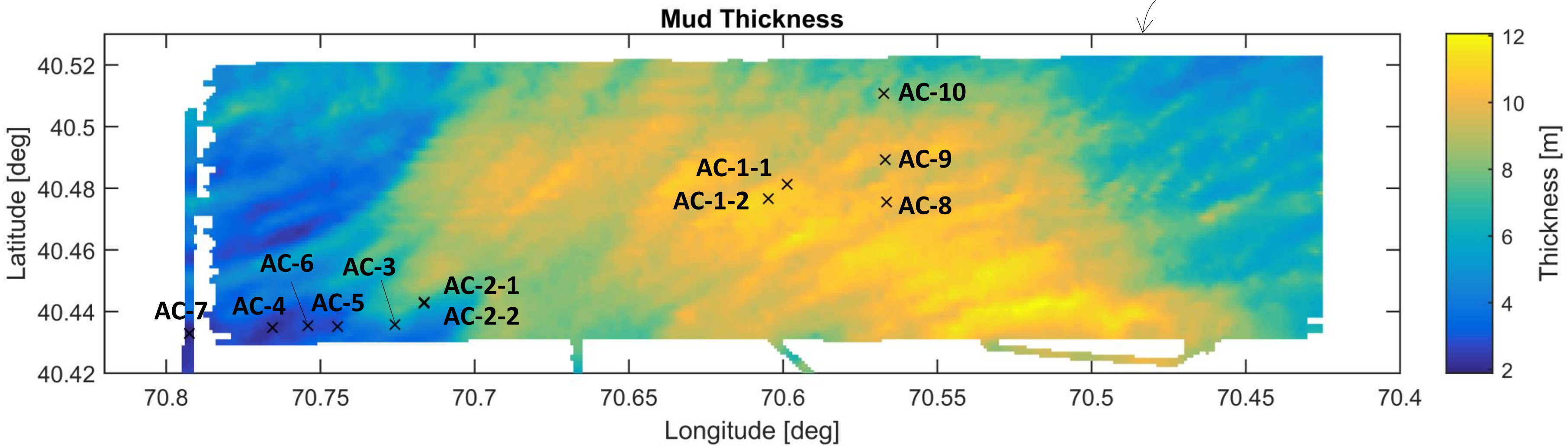
2016 Field Test

An engineering test was conducted in the Mud Patch in the North Atlantic as part of the environmental survey for the ONR Seabed Characterization Experiment.

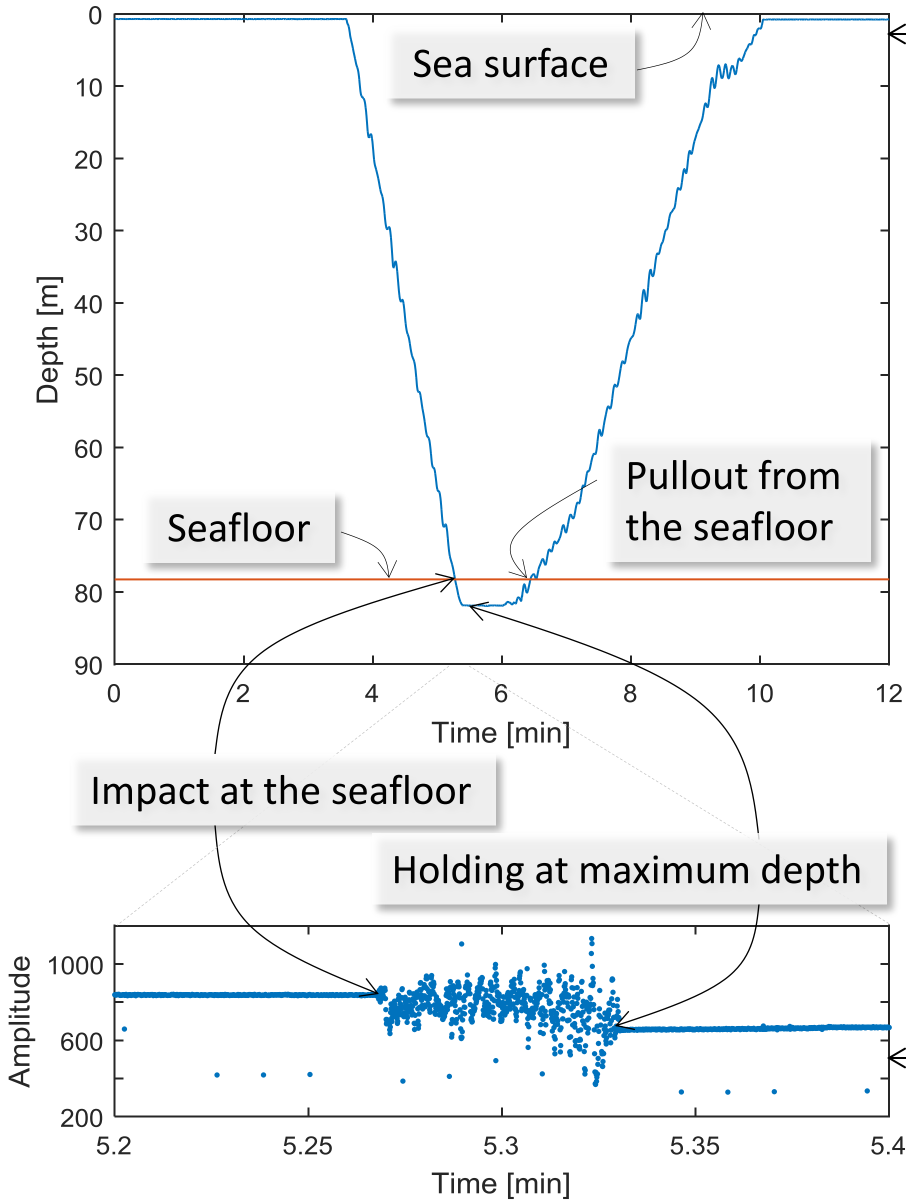


Twelve gravity cores were collected in ten locations with the in situ system attached.

Thickness of the mud layer estimated from CHIRP seismic data (courtesy John Goff), assuming a sound speed of 1480 m/s.



Mud Patch Results



Depth measured by pressure sensor on the PV for AC-4-1.

The penetration depth of the acoustic probes was estimated from acoustic signature of impact with the seafloor and penetration into the seabed.

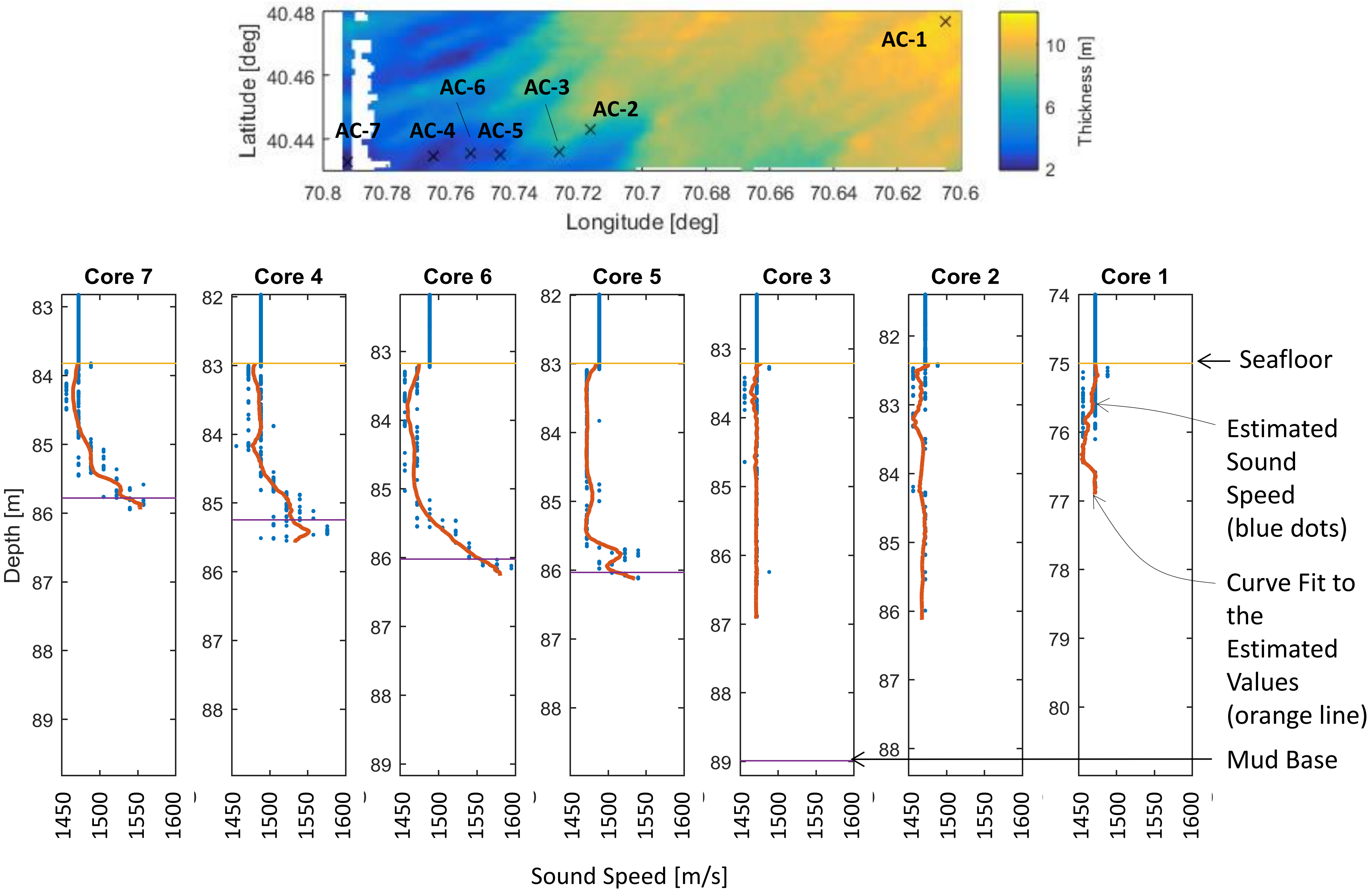
On average the acoustic record extends to depths 50% deeper than the length of the recovered core.

Reasons for the difference are (1) loss of material during recovery (2) plugging of the core during penetration into the seabed (3) compaction of the sediment.

For AC-4-1, measured length of the recovered core was 1.5 m, the depth of the acoustic record extended 2.7 m into the seabed.

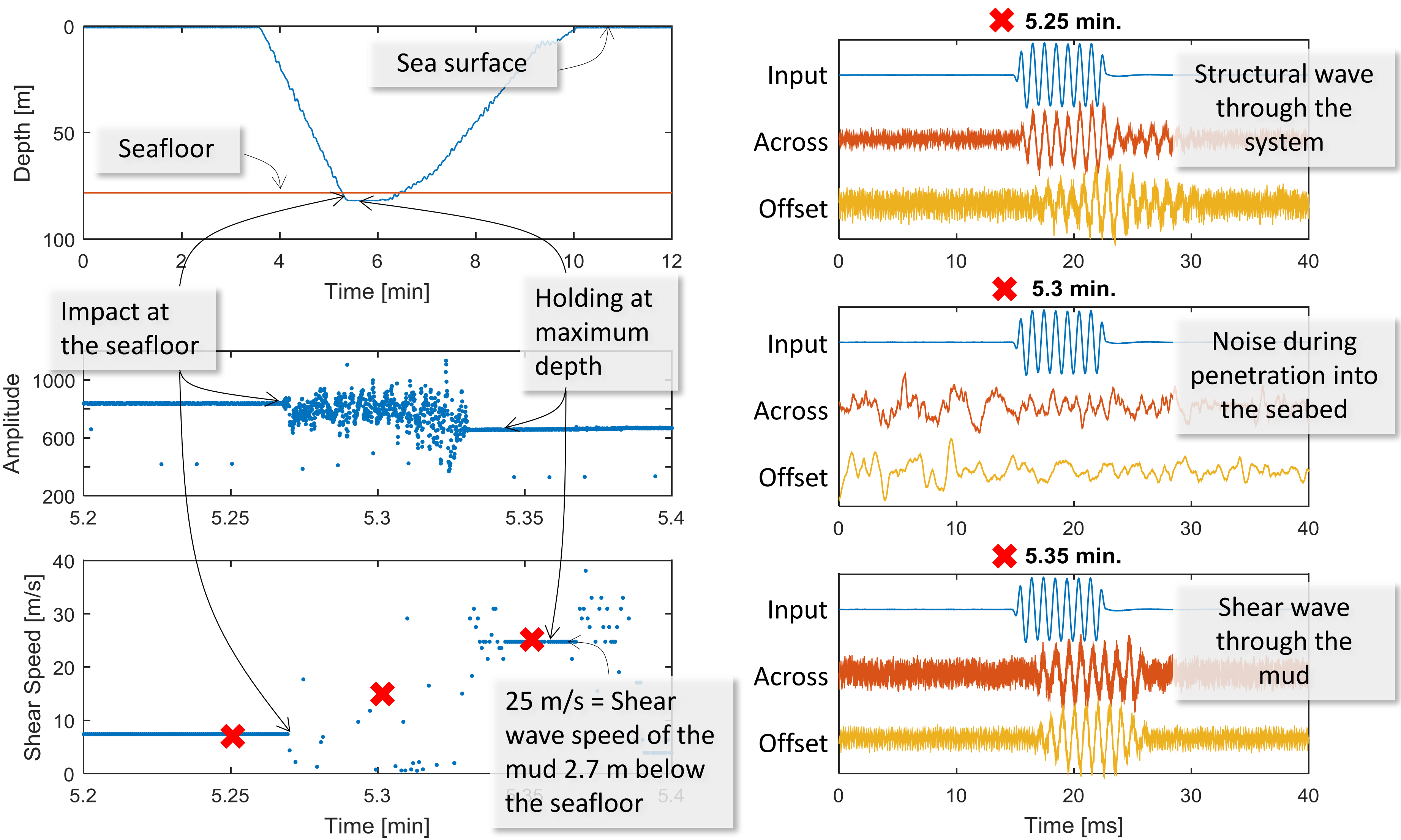
Amplitude of the compressional wave receiver mounted in the tip of the probe assembly for AC-4-1.

Mud Patch Results



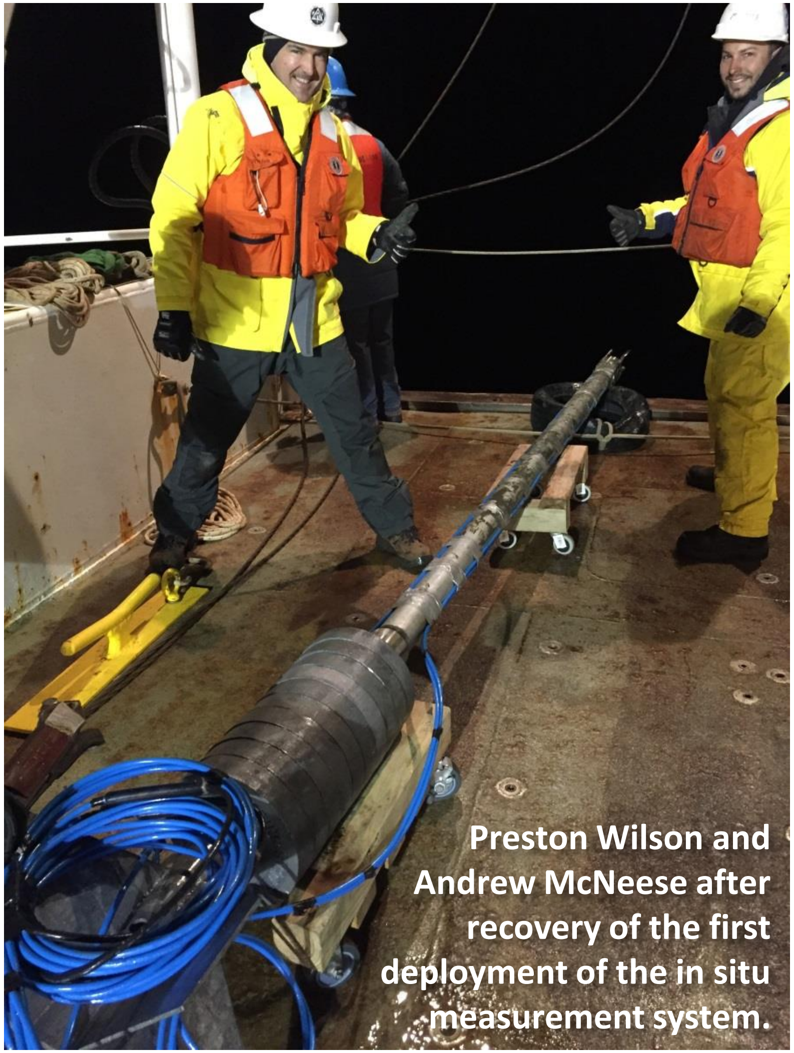
Mud Patch Results

Shear Wave Speed

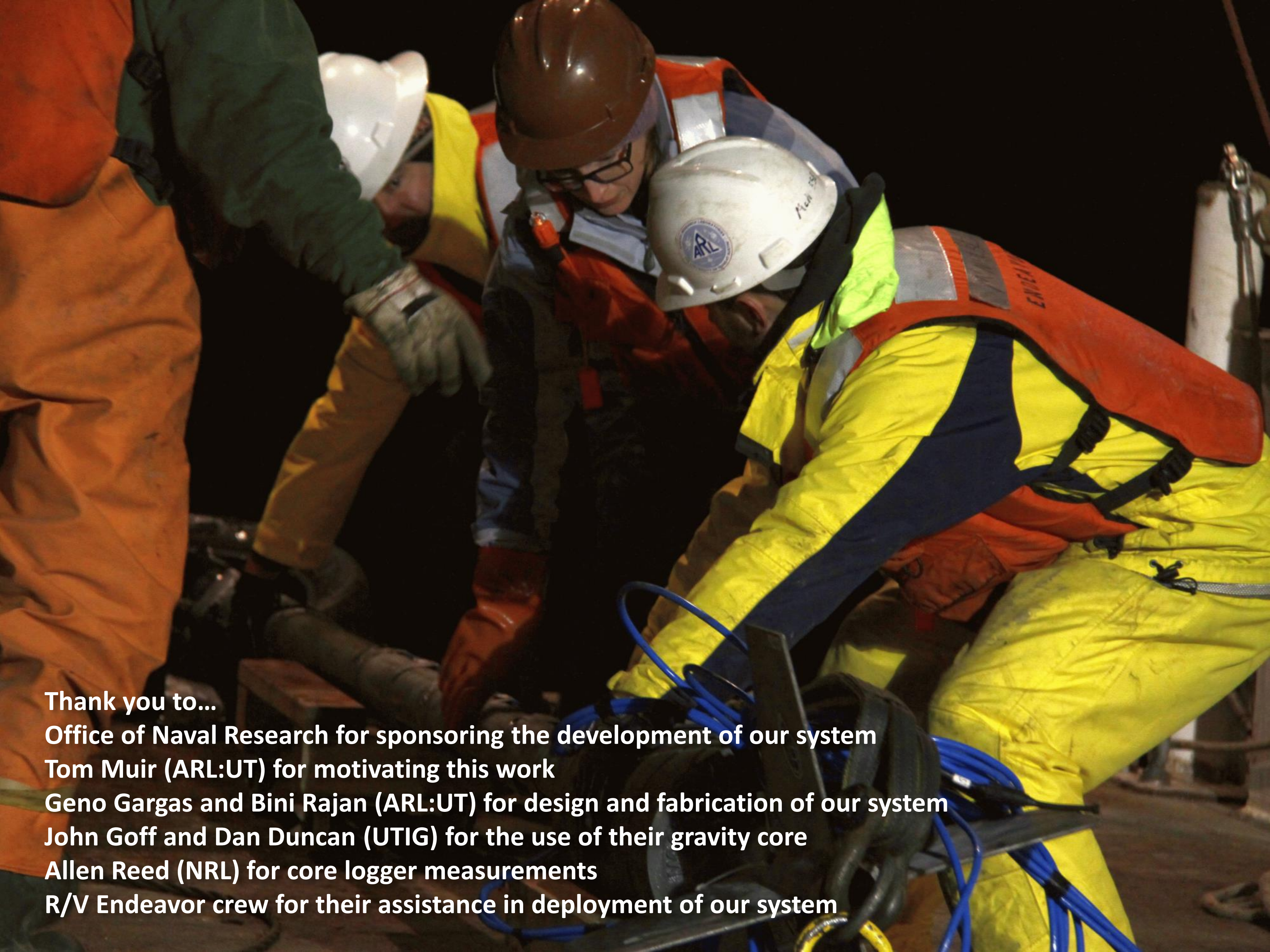


Summary and Conclusions

- Developed a system for in situ measurements of compressional and shear wave speed and attenuation while coring
- Completed an engineering test of the system in April/May 2016
- The system survived testing with the gravity core, although one compressional wave probe was bent
- The depth of the in situ record was on average 50% longer the length of sediment retrieved in the cores
- Compressional wave speed measurements were consistent with the environmental description from the CHIRP survey
- Estimates of shear wave properties and compressional wave attenuation are more challenging



Preston Wilson and Andrew McNeese after recovery of the first deployment of the in situ measurement system.



Thank you to…
Office of Naval Research for sponsoring the development of our system
Tom Muir (ARL:UT) for motivating this work
Geno Gargas and Bini Rajan (ARL:UT) for design and fabrication of our system
John Goff and Dan Duncan (UTIG) for the use of their gravity core
Allen Reed (NRL) for core logger measurements
R/V Endeavor crew for their assistance in deployment of our system