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In Situ Measurement of Geoacoustic Sediment Properties: An Example From the ONR Mine Burial Program, Martha's Vineyard Coastal Observatory

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Abstract

In support of the Office of Naval Research's Mine Burial Program (MBP), in-situ acoustic and resistivity measurements were obtained using ISSAP (In situ Sound Speed and Attenuation Probe) [1], a device developed and built by the Center for Coastal and Ocean Mapping. One of the field areas selected for the MBP experiments is the Wood's Hole Oceanographic Institute (WHOI) coastal observatory based off Martha's Vineyard. This area is an active natural laboratory that will provide an ideal environment for testing and observing mine migration and burial patterns due to temporal seabed processes. Seawater and surficial sediment measurements of compressional wave sound speed, attenuation, and resistivity were obtained at 87 station locations. The ISSAP instrument used four transducer probes that were arranged in a square pattern giving approximate acoustic path lengths of 30 cm and 20 cm and a maximum insertion depth of 15 cm. The transducers operated at a frequency of 65 kHz. Five acoustic paths were used; two long paths and three short paths. A 15.4 µs pulse was generated at a repetition rate of 30 Hz. The received signal was combined with the transmitter gate pulse to generate a composite signal that was sampled at a frequency of 5 MHz with a National Instruments PCI-6110E data acquisition board. Two resistivity probes were mounted on the ISSAP platform and positioned in locations selected to limit interference with the acoustic signals. Also mounted on the platform were a color video camera and light, and a Jasco Research UWINSTRU, which measured platform pitch and roll angles, heading, depth, and temperature. At each of the 87 stations, the ISSAP probe was lowered into the seawater to a location approximately 6m above the seafloor. A measurement cycle was completed by transmitting 10 pulses on each of the five paths and repeating three times for a total of 150 measurements. Resistivity measurements were obtained from both probes following completion of the acoustic measurements. The ISSAP platform was then lowered into the seafloor where two acoustic and resistivity measurement cycles were completed in the sediment. Probe insertion was aided by the video signal which provided imagery of the seafloor. The instrument was removed from the sediment and a second seawater measurement cycle completed. Typically, a sequence of measurements (300 acoustic and 40 resistivity measurements in seawater and similarly in sediment) was completed in 4 minutes. Recorded waveforms were processed for sound speed using two methods, cross-correlation and envelope detection [2]. In conjunction with the MBP experiments, several surveys (sidescan, interferometric bathymetry, and multibeam) have been completed.

Figure 1. Arrangement of transducer probes on ISSAP and method of mounting. Also shown are the 1.) color video camera, 2.) light, 3.) altimeter transducers and 4.) 65 kHz compressional wave probes (4) with path separations of 20 and 30 cm.

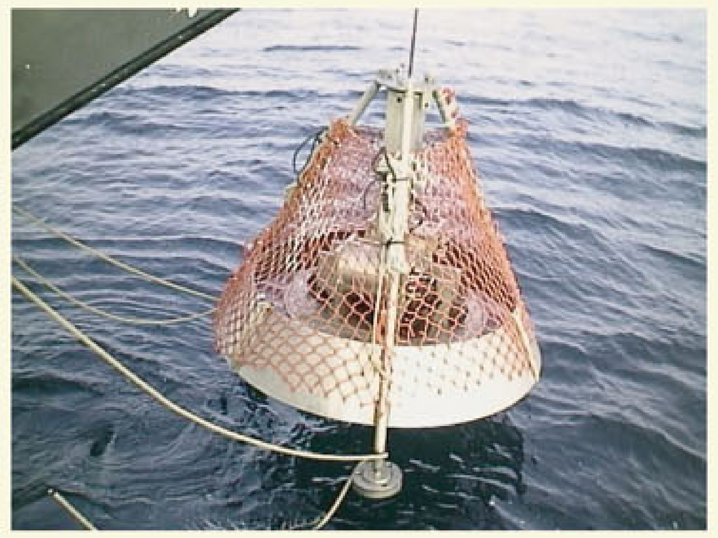


Figure 2. Deployment of ISSAP probe. The ISSAP instrument weighs approximately 275 kg, has a height of 1.5 m, and a 9.4 m square footprint. The outer frame consists of a protective tripod reinforced with a tapered skirt. Articulated tripod feet allowed for vertical probe insertion on slopes up to 20 degrees.

References

1. Mayer, L. A., Kraft, B. J., Simpkin, P., Lavoie, P., Jabs, E., and Lynskey, E., In-situ determination of the variability of seafloor acoustic properties: an example from the ONR GEOCLUTTER area. In Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance, ed. by N. G. Pace and F. B. Jensen, Kluwer Academic Publishers, The Netherlands, pp. 115-122 (2002)

2. Kraft, B. J., Mayer, L. A., Simpkin, P., Lavoie, P., Jabs, E., Lynskey, E. and Goff, J. A., Calculation of in-situ acoustic wave properties in marine sediments, In Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance, ed. by N. G. Pace and F. B. Jensen, Kluwer Academic Publishers, The Netherlands, pp. 123-130 (2002)

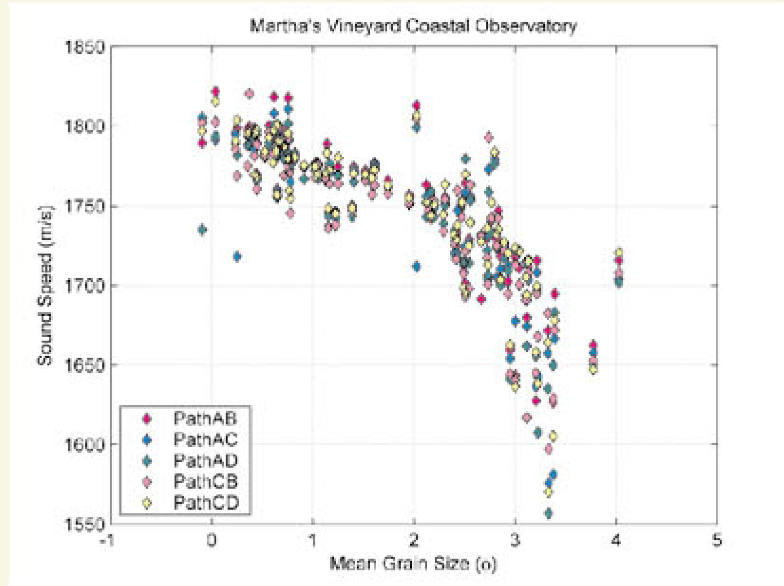


Figure 3. Relationship showing measured sound speed and mean grain size.

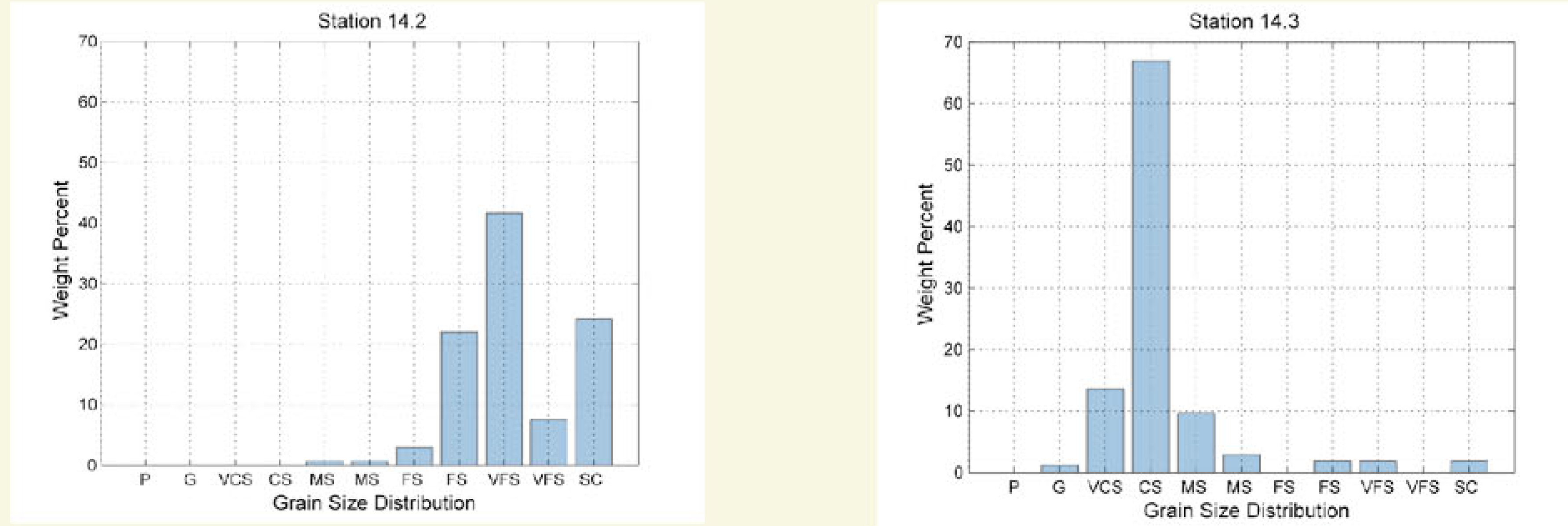
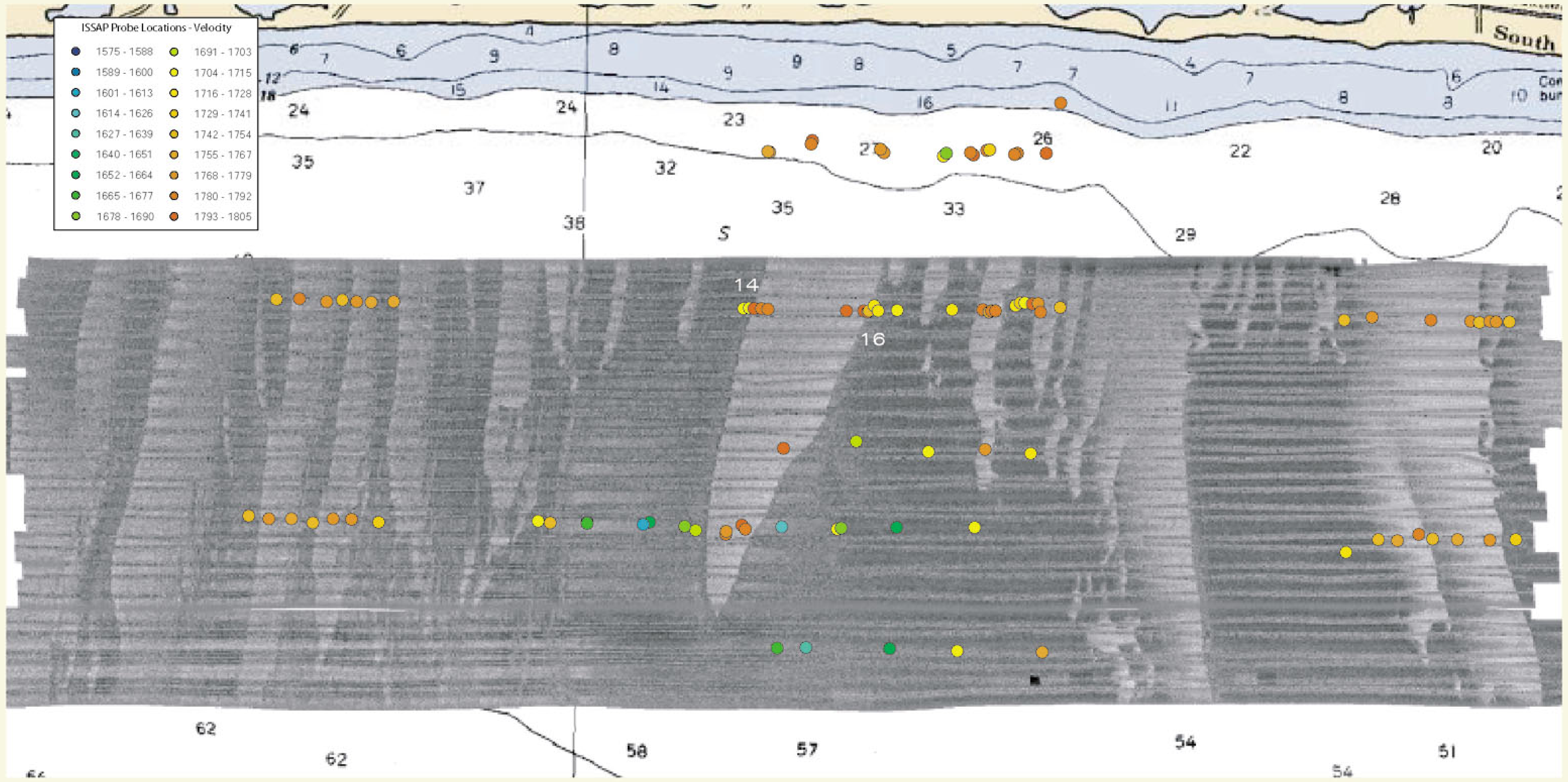


Figure 4. Grain size distibutions for stations 14.2 and 14.3. Across the fine to coarse transition boundary the sediment changed from a clayey fine sand to a medium to coarse sand.



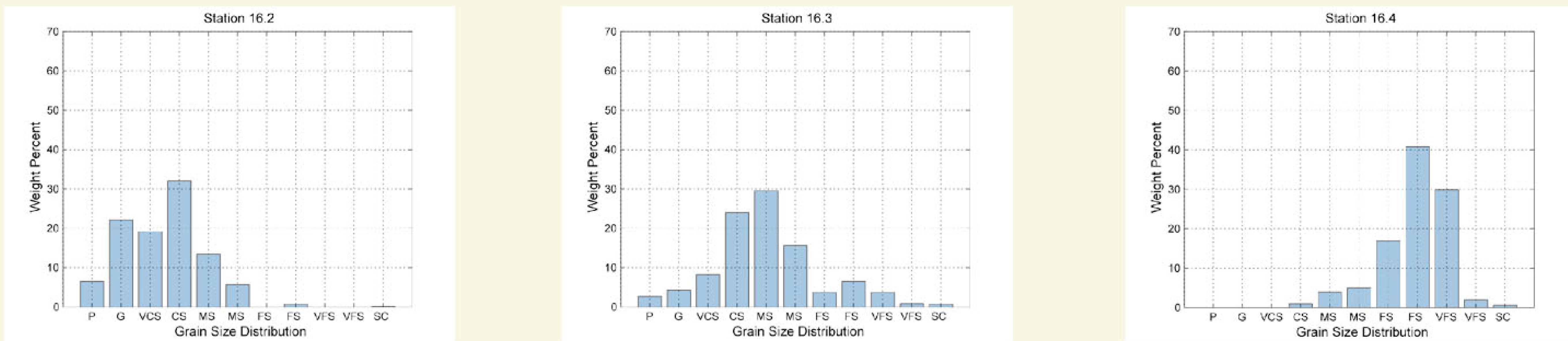


Figure 5. Grain size distributions for stations 16.2, 16.3, and 16.4. Across the coarse to fine transition boundary the sediment changed from a slightly pebbly coarse sand to a fine sand without any pebbles.