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Shi et al. (1999) have presented a nice study on an acoustic approach to measuring the vertical profiles of Suspended Sediment Concentration (SSC) in the Changjiang Estuary. The measured strength of acoustic backscatter waves, tidal current velocities, and salinity profiles of an entire water column at a station were well visualized to facilitate the interpretation of data. We appreciate the authors’ efforts in the collection of this data set.

They also pointed out the unique observation of a suspension jet (Fig. 5, 2300 h) which they attribute to the transport of sediment eroded elsewhere. While their explanation is possible, it is difficult to understand how this jet could survive in strong turbulent mixing environments (see the near bed velocity gradient in Fig. 7, 2300 h). While most of the backscatter wave strength (gray-scale images in Fig. 4) agrees, at least qualitatively, with the vertical profiles of SSC, there are ambiguous portions of data that we would like to point out and discuss.

In examining the data in Fig. 4, 2300 h, we did not observe a dark area at depths between 7 and 8 m, which represents the low SSC region immediately above the bottom mud bed layer as suggested in Fig. 5, 2300 h. We hypothesize that the suspension jet might not exist at all.

The strength of backscattered waves varies with the ratio of the acoustic wave length to the particle size, the number density of particles, and the gradient of the transmitting medium’s acoustic impedance (Kinsler et al. 1982). The acoustic instrument (ASSM) mentioned in the paper has a center frequency of 0.5 MHz, which indicates an acoustic wavelength in water of approximately 3,000 μm (Maa et al. 1997). As mentioned in the paper, the suspended sediment consists predominantly of clay with a primary grain size of 5.5 to 7.4 μm. It is understood that these clay particles were flocculated with floc sizes much larger than the primary particle size. In general, it is common for floc sizes to vary between 10 and 500 μm. Larger floc sizes, while possible, are not common in highly turbulent flows.

The high strength of acoustic backscatter waves indicates that either the clay particles were aggregated as flocs with sizes comparable to or larger than the acoustic wave length or the average spatial separation between the particles/flocs was much smaller than the wave length such that the water-sediment mixture can be treated as a continuum with a sufficiently large gradient in acoustic impedance in the path of acoustic wave propagation. We believe the latter to be the primary explanation for the strong signal received by the ASSM. Regions with low SSC will lack backscattered waves, i.e., the measured strength of backscatter waves would be low. Hence, in gray-scale plots such as those exhibited in Fig. 4, 2300 h, a low SSC region such as that between 7 and 8 m should be represented by a relatively dark shaded area. This is especially true when backscatter waves from the bottom mud can still be observed at 9.5 m. Figure 4, 2300 h, shows that the backscatter wave strength is still quite strong between 7 and 8 m. This high strength implies that the number density (i.e., the SSC) is still high in this layer.

From another point of view, assuming there exists the high SSC jet as proposed by the authors, then there will be three layers of water in the water column: a top layer with low SSC and low salinity, a middle layer with high SSC and high salinity, and a bottom layer with low SSC and high salinity. Two echo waves should arise from the interfaces between layer 1 and layer 2 and between layer 2 and layer 3 because of the different acoustic impedances of the layers. In the gray-scale plots of acoustic images (Fig. 4, 2300 h), however, a bright zone representing a second echo from a depth around 7 m cannot be found.

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Further evidence to support our hypothesis is given in the salinity and velocity profiles (Fig. 7, 2300 h). The velocity profile between water depth = 2.8 to 5.6 m (i.e., H/D = 0.6 to 0.8) was caused by the flood tide and salinity stratification. The velocity profile for the bottom of the water column did not indicate a density stratification, and the SSC should be reasonably uniform below 5.6 m.

Based on the above facts, we believe that the SSC actually continues increasing with depths below 6 m but at a much slower rate, potentially reaching or exceeding 6 g l\(^{-1}\) at 8 m. In other words, there were only two layers in the water column: a top layer from the water surface to 4.5 m with relatively clear water and low salinity, and a bottom layer of sediment plume, which is below 4.5 m, with a high SSC and high salinity.

The SSC profiles shown in Fig. 5, 0200 h, 0500 h, and 0700 h may be also interpreted with the same reasoning. The only exception occurs at 0800 h because of a high bottom velocity (Fig. 7, 0800 h) which may indicate a salinity intrusion wedge at the bottom (Maa and Wang 1987).

**LITERATURE CITED**


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We welcome the opportunity to discuss the estuarine cohesive suspended sediment transport processes underlying the work presented in our paper (Shi et al. 1999) and to respond to several points raised in the discussion note by Maa and Sun. The advent of new acoustic field instrumentation allows the investigation of the dynamics of high concentration cohesive sediments in the estuarine conditions where river runoff, waves, and tidal currents can significantly influence the suspension processes.

Original acoustic images are high quality color ones, but acoustic images presented in our paper are gray-scale ones (Figs. 4 and 6). Although water depth in Fig. 5 should be exactly correlated to that in Fig. 4, they were only qualitatively correlated because of the practical difficulties in defining the estuarine mud bed, i.e., the turbid water-mud bed interface (Shi 1998). The maximum value of concentration measured by our present ASSM is less than 10 g l\(^{-1}\). Although the concentration profiles in Fig. 4 were interpreted from the acoustic images in Fig. 5, there might be a slight shift in the water depth. The sea bottom shown in Fig. 4 might not correspond to the mud bed in Fig. 5. Water depth in Fig. 7 was presented in the relative form. These might have resulted in the different interpretations between our paper and Maa and Sun’s discussion note, e.g., of low SSC region, etc.

Maa and Sun do not believe the mid-water (above the bed) suspended sediment concentration maximum seen in the 12-min averaged data of Fig. 5 could exist in the presence of strong turbulence. To support this contention, they state that Fig. 4 does not show low backscatter (darker shades) deeper than the position of the maximum in the water column. This implies the maximum is an artifact of data processing. In fact, a bright zone representing a second echo from a depth around 7 m in Fig. 4 can be found in the original color acoustic image. Figure 4 for 2300 h also clearly shows sustained intervals or episodes of lower backscatter at 7 to 8 m during the 12-min sampling interval. Modeling by Hamilton (1999) indicates that false maxima can occur in particular circumstances for the compensation method of calibration used for the 0.5 MHz ASSM (see Hamilton et al. 1998), namely if calibrations for sand sizes are applied to other size ranges. This occurred in modeling because sand sizes cause much higher absorption losses than mud sizes. For single backscatter theory calibrations for one mud size could be applied to another mud size with little to no