

Cooperating Parties Group

**LOWER PASSAIC RIVER RI/FS
NEWARK, NEW JERSEY**

APPENDIX M - ATTACHMENT A

**FALL AND SPRING PWCM ABS-SSC
AND OBS-SSC REGRESSIONS**

Prepared by:



A.1 Introduction

The 2009 Fall and 2010 Spring PWCM deployments in the LPR consisted of moored ADCP, CTD, and OBS sensors with continuous *in situ* measurements (every 12 minutes) of various physical parameters at RMs 1.4, 4.2, 6.7, 10.2, and 13.5 within the LPRSA. Figure 1 shows the locations of the moorings. The Fall 2009 deployment lasted from October 10, 2009 to December 16, 2009, and the Spring 2010 deployment from March 22, 2010 to July 23, 2010.



Figure 1. Location map of PWCM mooring deployments.

The ADCPs were deployed in the bottom-mounted, upward-facing configuration and measured the depth-profile of velocity and echo intensity. The CTD and OBS sensors were deployed 3' above the bed and 3' below the water surface for measurements of surface and bottom salinity, temperature and turbidity along with water depth. In addition, a surface OBS sensor was deployed within the impoundment of Dundee Dam (RM 17.5) to measure the turbidity associated with the water flowing into the LPR. The data recorded by the moored instruments were periodically recovered, and the instruments serviced and redeployed. In addition to the moored deployments, vessel-mounted downward-facing ADCPs were periodically used to measure the cross-sectional velocities across transects at each of the mooring locations. Salinity and turbidity casts were performed at three locations along cross-river transects at each of the mooring locations. In addition, water samples were collected periodically at the mooring locations and measured for suspended sediment concentrations (SSC). These SS concentration measurements were used to relate the measured turbidity and acoustic back-scatter (ABS; calculated from echo intensity following the methods of Deines, 1999 and Wall et al., 2004). The resulting OBS-SSC and ABS-SSC relationships are applied to the continuous time-series measurements of OBS and ABS to estimate time-series of SSC at each of the mooring locations. The following sections present the OBS-SSC and ABS-SSC relations, and a comparison of the OBS-derived and ABS-derived SSC which acts as a check on the estimated SSC time-series.

A.2 OBS-SSC Relationships

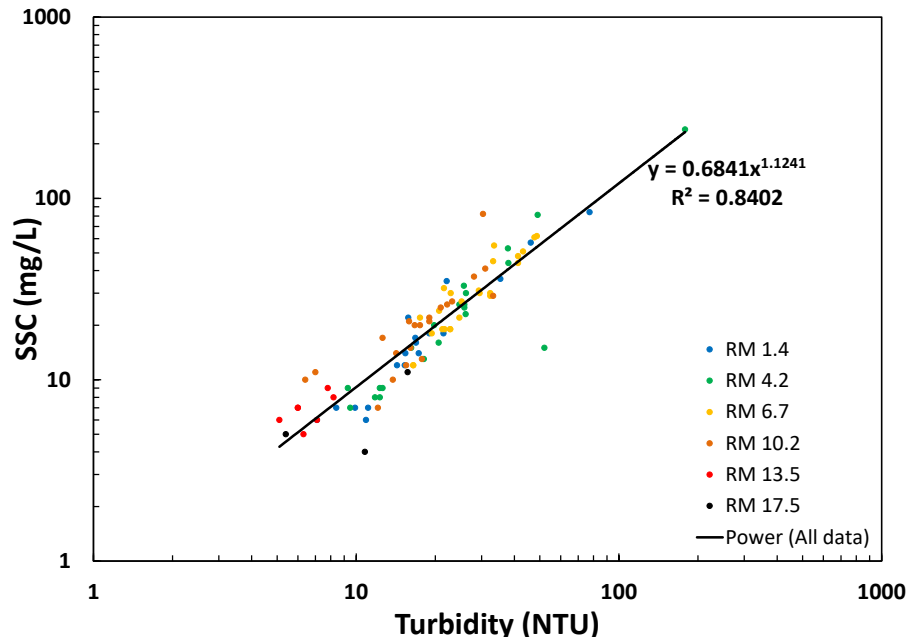


Figure 2. OBS-SSC relationship using the Fall 2009 PWCM data.

Figure 2 and Figure 3 show the OBS-SSC relationships derived using the water samples and mooring turbidity measurements from the 2009 Fall and 2010 Spring PWCM deployments, respectively.

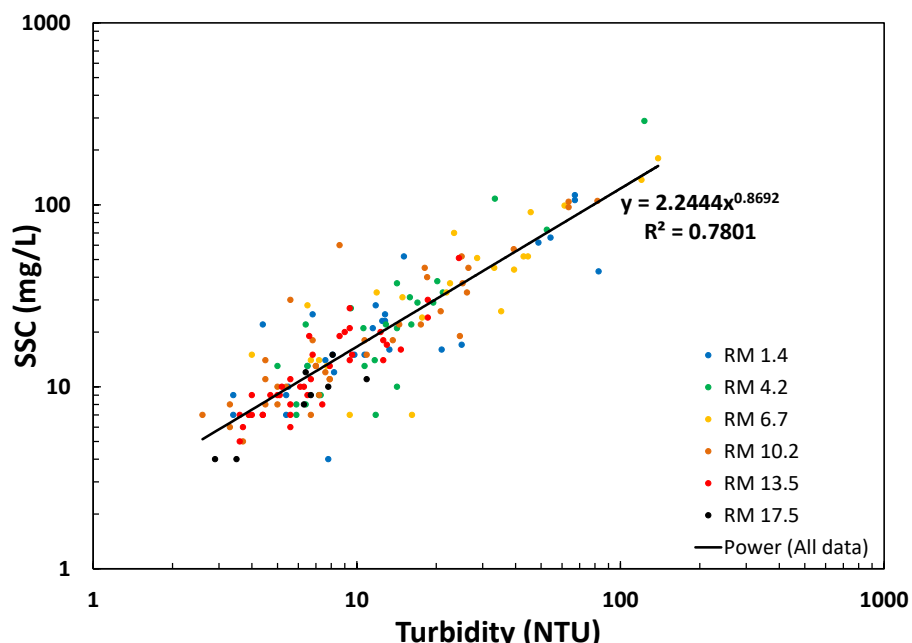


Figure 3. OBS-SSC relationship using the Spring 2010 PWCM data.

The overall relationship of OBS-SSC is similar for both datasets. However, the Spring 2010 data shows somewhat more variability than the Fall 2009 data. The Spring 2010 deployment started about 1 week following a relatively extreme discharge event (16,000 cfs on March 16, 2010, a 1 in 25 year event). During the deployment, discharge ranged from a peak of about 10,000 cfs in late March to about 200 cfs at the end of the deployment. It is possible that some of the variability in the OBS-SSC relationship may be related to potential differences in the size and density of the particles in suspension under these different discharges.

A.3 ABS-SSC Relationships

Figure 4 shows the location-specific ABS-SSC relationships derived using the water samples and mooring ABS measurements from the 2009 Fall deployment. The ABS-SSC pairs show relatively consistent trends at all the locations, with the exception of RM 10.2 where two separate ADCPs were used during the deployment. As described in Wall et al, 2004, ADCPs are not factory calibrated to produce identical values of echo intensity for a given water sample. Therefore, two separate relationships were derived at RM 10.2 using the data collected prior to and after the servicing event mid-way through the deployment when the ADCP at this location was replaced. The correlation R^2 at the various locations ranges from a low of 0.65 to 0.87, indicating that the regressions capture most of the variance in the data.

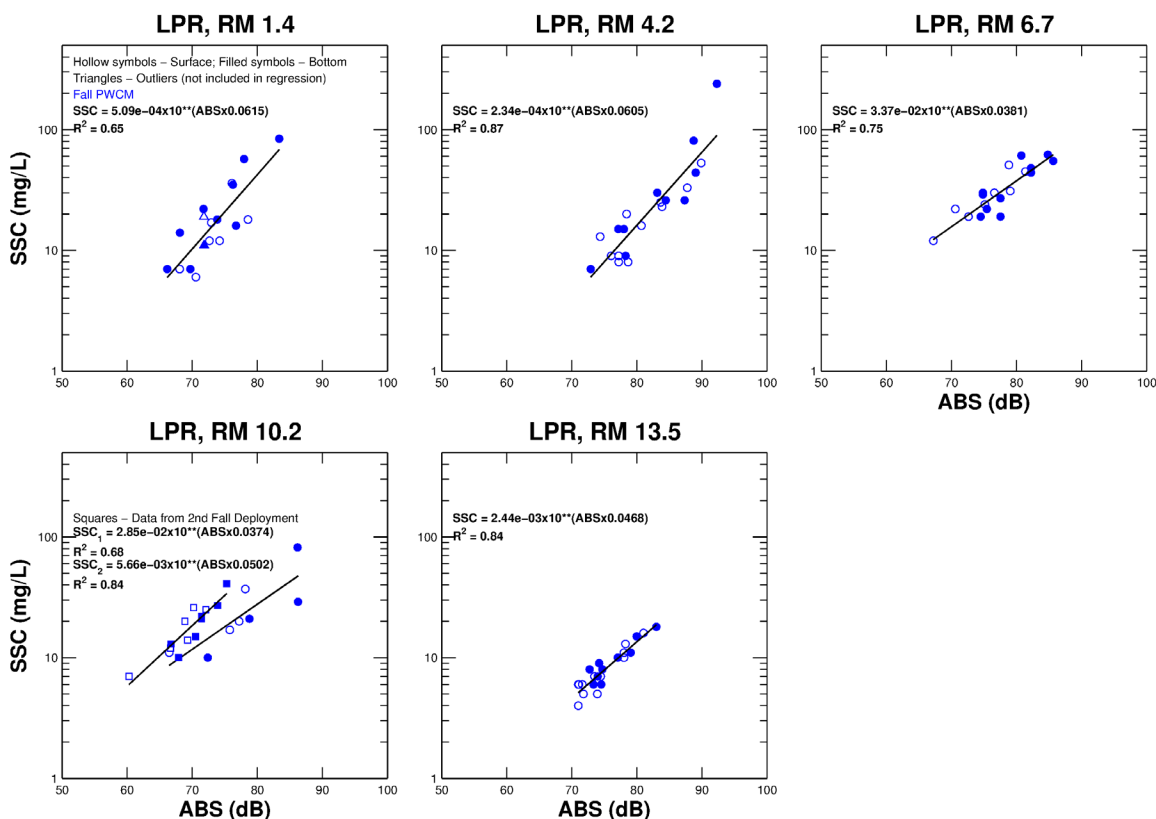


Figure 4. ABS-SSC relationship using the Fall 2009 PWCM data.

Figure 5 shows the location-specific ABS-SSC relationships derived using the water samples and mooring ABS measurements from the 2010 Spring deployment. In contrast to the Fall 2009 dataset, the Spring 2010 dataset shows more variability in the relationship of ABS and SSC. With the exception of RM 1.4, this variability manifests itself in a temporally varying ABS-SSC relationship at most locations. For instance, at RM 4.2, the relationship for the water sample data collected prior to May 3 (referred to as the high-flow data and relationship; blue symbols and line in Figure 5) is seen to be somewhat different from the relationship for the water sample data collected from May 19 through the end of the deployment (referred to as the low-flow data and relationship; red symbols and line in Figure 5). For a given ABS measurements, the low-flow relationship suggests about a factor of 3 lower SSC than the high-flow relationship. Similar temporally distinct relationships are also seen at RM 6.7 (before and after May 3), and at RM 10.2 and RM 13.5 (before and after May 24 for both locations). As mentioned previously, the Spring 2010 deployment started about 1 week following a relatively extreme discharge event (16,000 cfs on March 16, 2010, a 1 in 25 year event), with discharge the deployment, discharge declining from a peak of about 10,000 cfs in late March to about 200 cfs at the end of the deployment. It is possible that some of the variability in the ABS-SSC relationships may be related to potential differences in the size and density of the particles in suspension as a function of discharge. Even though no such temporal dependence was identified at RM 1.4, the ABS-SSC pairs are quite variable, with correlation R^2 of only

0.53. Despite the use of temporally-varying ABS-SSC relationships, the correlation R^2 ranges from a low of 0.48 to 0.84.

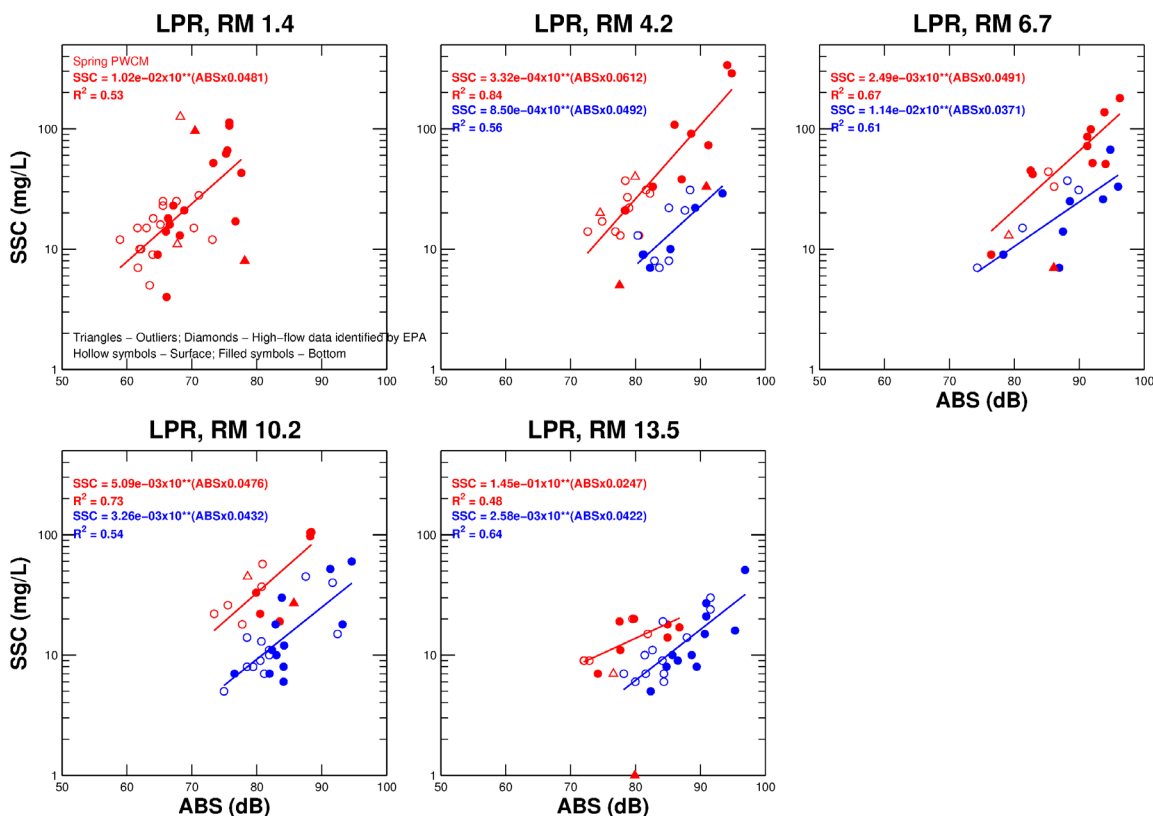


Figure 5. ABS-SSC relationship using the Spring 2010 PWCM data. At RMs 4.2, 6.7, 10.2, and 13.5, red symbols and red line indicates low-flow data and corresponding regression; blue indicates the same for high-flow.

A.4 Application of ABS-SSC Regressions to ABS Time-Series

The OBS-SSC and ABS-SSC relationships described in the preceding sections were used to estimate SSC time-series using the OBS and ABS time-series measurements. The OBS-derived SSC time-series for both Fall and Spring and the ABS-derived SSC time-series for Fall were derived in a relatively straight-forward manner, using their respective relationships. The ABS-derived SSC time-series for the Spring 2010 PWCM involved the implementation of the time-dependent high- and low-flow regressions, with a transition period in between the two. The use of a transition period avoids a sudden increase in SSC (factor of 3 in the example of RM 4.2 described previously) that would result from the use of the high- and low-flow relationship absent a transition period. It is also worth noting that the SSC time-series estimated from the OBS measurements do not show such a sudden increase, rather a linear transition over time. Accordingly, a procedure was developed for the implementation of the time-dependent ABS-SSC relationships. The

high-flow relationship was applied for the ABS measurements prior to April 8, April 12, May 10, and May 10 at RM 4.2, 6.7, 10.2, and 13.5, respectively. The low-flow relationship was applied from May 12 onwards at RMs 4.2 and 6.7, and from May 30 onwards at RMs 10.2 and 13.5. In the period between the high- and low-flow relationships, referred to as the transition period, SSC is calculated as a function of the fluvial and tidal influences on ABS at the given location. The methodology implemented for the transition period also included comparisons with the OBS-estimated SSC as an additional check.

A.5 Comparison OBS-derived and ABS-derived SSC

Since the ABS-SSC relationships tend to be somewhat poorer than the OBS-SSC relationships, the ABS-derived SSC time-series was compared against the OBS-derived SSC as an additional check. Prior to performing this comparison, time-series of turbidity measured by the OBS were screened and filtered to exclude data considered to be affected by fouling (typically seen as a high-frequency oscillation in the measured signal with no coherence or structure with respect to the tide, velocity, or Dundee Dam discharge, and also inconsistent with the ABS time-series).

As mentioned previously, the OBS sensors were deployed 3' above the bed and below the water column surface. However, the ADCPs were mounted on a tripod, about 1.5'-2' above the bed. In addition, the ADCPs do not measure a certain depth interval near the transducer face. As a consequence, about 3-4' at the bottom of the water column, the depth interval containing and measured by the OBS, is not measured by the ADCP. In other words, the bottom-most ADCP bin is located higher in the water column than the OBS sensor. Another relevant point in reviewing these comparisons is the fact that the OBS measurement reflects a point (in depth) measurement of the turbidity field whereas the ABS measurement reflects an average signal over the ADCP bin depth (0.5 m). Both of these factors are expected to bias the OBS-derived SSC estimates high compared to the ABS-derived SSC estimates for the comparisons at the bottom of the water column. A similar issue exists with the comparisons at the surface of the water column – the ABS profile at the surface of the water column is usually screened to filter out the effect of waves, bubbles, etc, because of the ABS profile sometimes does not extend to same depth-intervals as the OBS sensor.

Figure 6 through Figure 10 show the resulting comparison at the individual locations for the Spring 2010 data (upper row), and the Fall 2009 data (bottom row), and at the bottom of the water column (left panels), and at the surface of the water column (right panels). In general, the ABS-estimates are within a factor of two of the OBS-estimates (a factor of two is roughly the variability seen around the OBS-SSC and ABS-SSC regressions in Figure 2 through Figure 5). As expected, at the upper end of the range of the OBS-derived SSC values, ABS tends to be biased low at several locations. These likely reflect erosional conditions, when the vertical gradient in SSC is expected to be large biasing the ABS-estimates low. On average, the ABS-derived and OBS-derived SSC estimates are comparable, thus providing confidence in the ABS-derived SSC time-series.

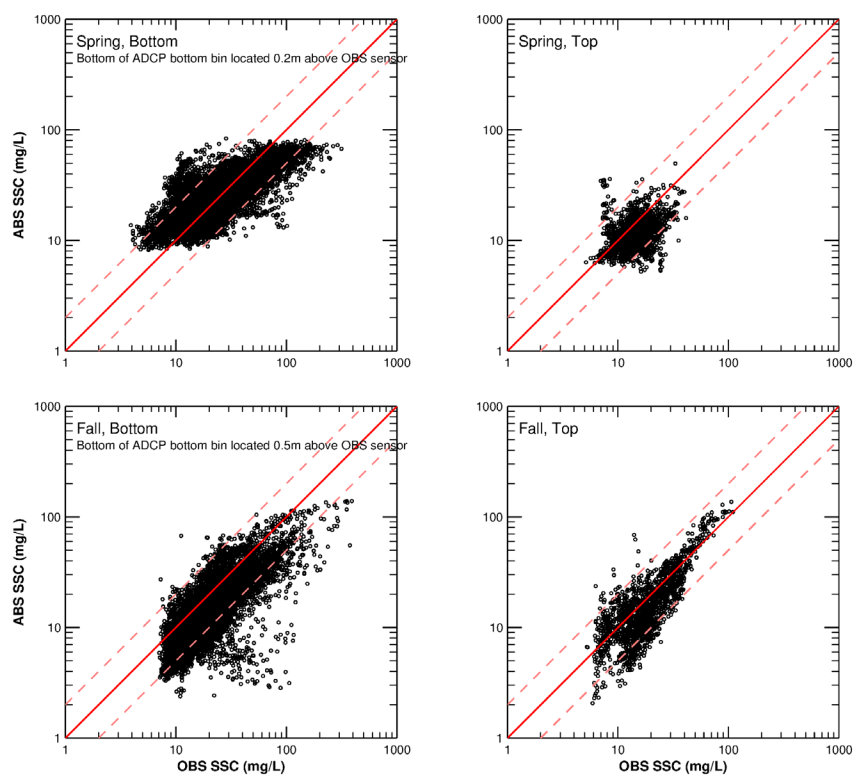


Figure 6. Comparison of OBS-derived and ABS-derived SSC at RM 1.4

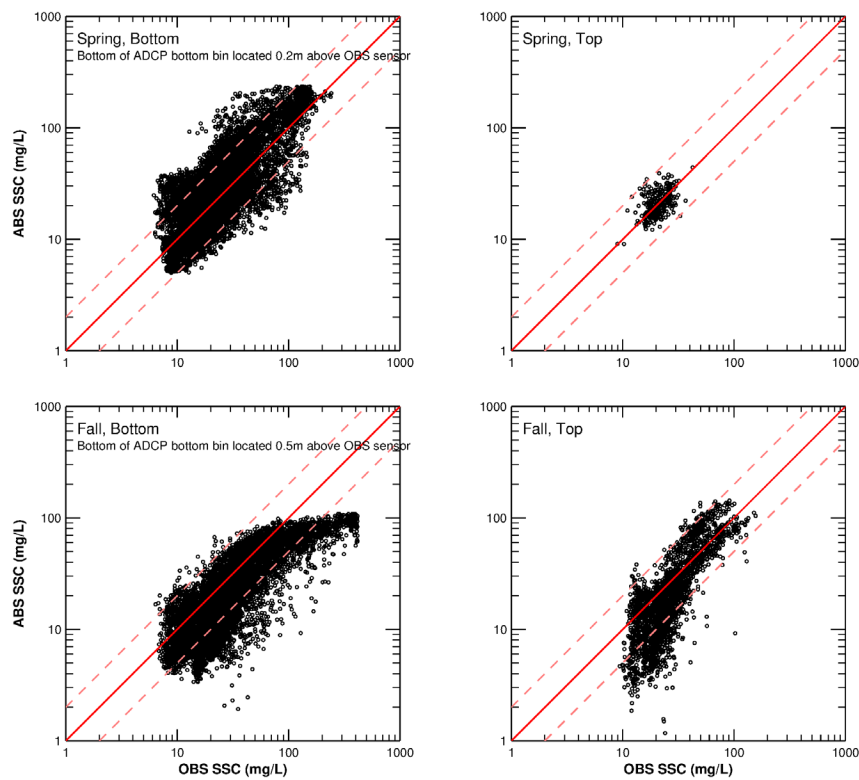


Figure 7. Comparison of OBS-derived and ABS-derived SSC at RM 4.2

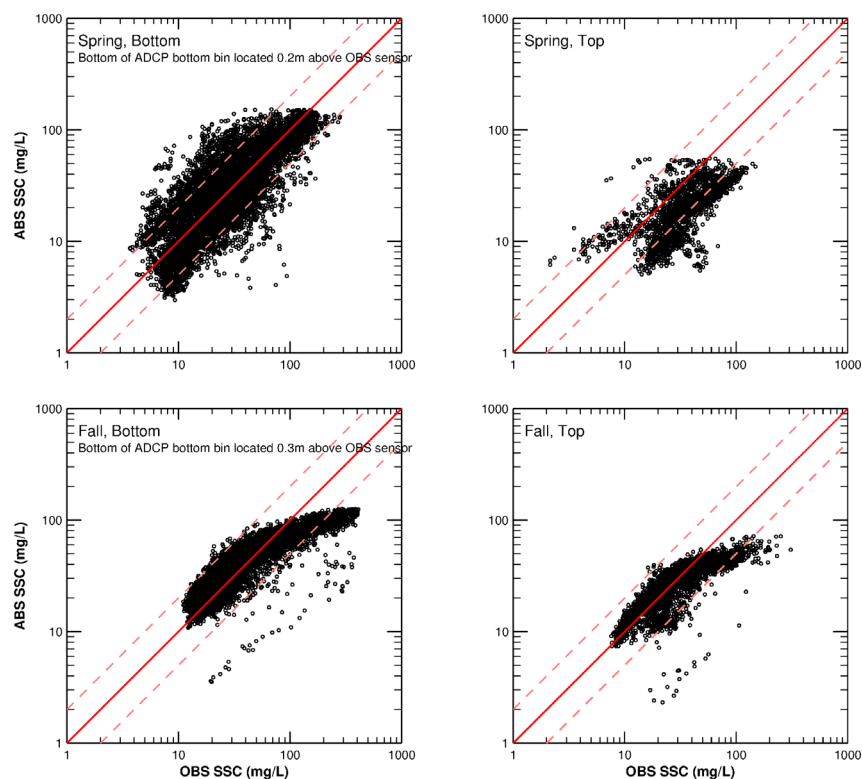


Figure 8. Comparison of OBS-derived and ABS-derived SSC at RM 6.7

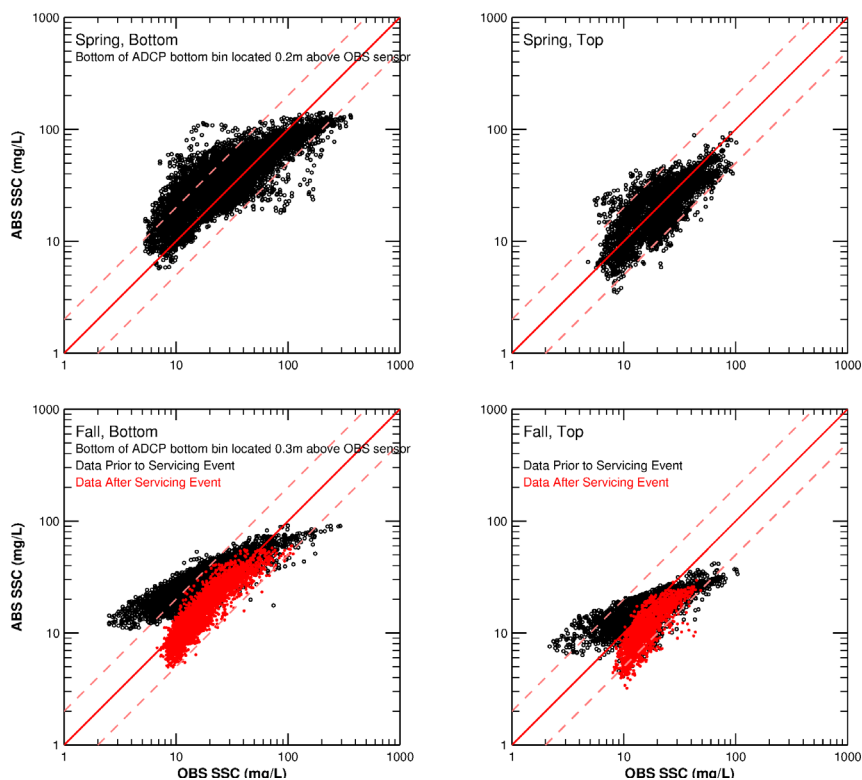


Figure 9. Comparison of OBS-derived and ABS-derived SSC at RM 10.2

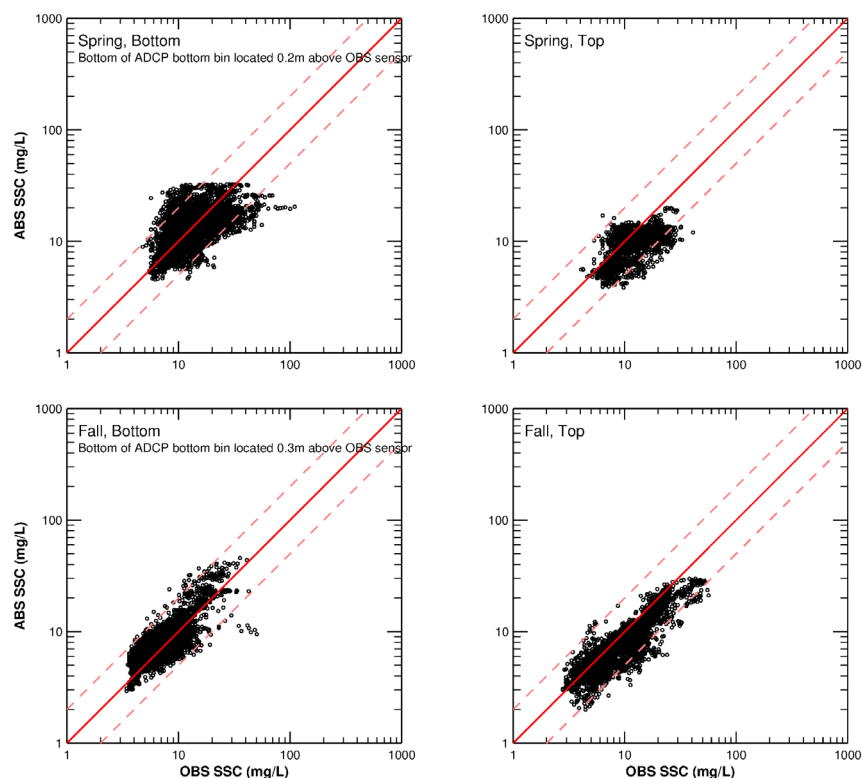


Figure 10. Comparison of OBS-derived and ABS-derived SSC at RM 13.5

A.6 References

Deines, K.L., 1999. Backscatter Estimation Using Broadband Acoustic Doppler Current Profilers. In Oceans 99 MTS/IEEE Conference Proceedings, September 13–16, 1999, Seattle, WA.

Wall, G. R., Nystrom, E. A., and Litten, S. (2006). Use of an ADCP to Compute Suspended-Sediment Discharge in the Tidal Hudson River, New York. USGS SIR 2006-5055.