Flocculation in the Pearl River Estuary – Particle Size Variations in a Circumneutral pH River System with High Colloidal Iron

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Abstract:

Variations in temperature, ionic strength, pH, and other factors influence partitioning of reactive constituents within the river-littoral zone. This alters the effective particle size spectrum and therefore determines net dispersion, distribution, and transport. In July-August, 2011, an experiment was conducted in the Pearl River estuary, Gulf of Mexico (GoM), to resolve the size spectrum of suspended matter through the estuary and to investigate factors controlling this distribution. Water samples were collected from the near-surface, mid-depth, and near-bottom of the estuary at eight stations along salinity gradient. Current velocities were determined with a downward-looking ADCP. Particle size distribution in each sample was determined in the laboratory using a Zeta-sizer to evaluate the nm-range size fraction and a Cilas Particle Size Analyzer to evaluate larger size fractions up to 1 mm. The pH of the river was circumneutral, ranging from 7.0 to 7.6. Particulates, colloidal and aggregate, ranged in size from 0.020-1.2 mm. Results suggest ionic strength was a dominant factor influencing the particle size distribution in the Pearl River estuary and that pH played a lesser role.

Study Area and Methods:

Figure 1: Pearl River estuary study area located on the border of Mississippi and Louisiana, USA. Along the Gulf of Mexico coast. On July, 29, 2011, Acoustic Doppler Current Profiler (ADCP) current data and water column samples (surface, middle, bottom) were collected from Stations PR1 (low salinity) – PR 8 (high salinity) along the estuarine salinity gradient.

The Pearl River is a small, black-water river (2 × 10^3 km^3 drainage area) that empties into Mississippi Sound in the Northern Gulf of Mexico (**Fig. 1**). It is characterized by high dissolved organic carbon (DOC), high colloidal iron, circum-neutral pH, and relatively low turbidity and alkalinity (*Shiller et al., 2006; Duan et al., 2007a,b*).

Discreet water samples were collected at each station (PR1 - PR8) from near-surface, middle, and near-bottom depths in rinsed LDPE bottles (**Fig. 1**). Current data was collected using a Teledyne River Ray ADCP. The salinity (conductivity), pH (pH probe), and particle size distribution in each sample was measured in the laboratory using a well-mixed sample at a temperature between 21-25°C. A Malvern Nano ZetaSizer (ZS) was used to evaluate the particle size distribution of smaller size particles (<1 mm). A Cilas 1190 Laser Particle Size Analyzer (LPSA) was used to evaluate larger size fractions 0.04 mm up to 2500 mm and was also used to investigate the effects of turbulence on floc size.

Results:

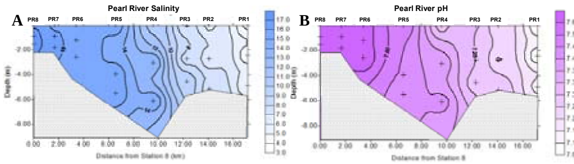

Figure 2: (**A**) Salinity and (**B**) pH contours (referenced to Station 8) along the main channel of the Pearl River estuary between stations PR1 – PR8. Contour plots were derived from salinity and pH measurements of discreet samples collected from the surface, middle, and bottom of the water column at each station. Sampling locations and depths are indicated by the symbol (+).

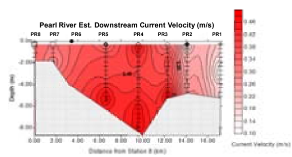

Figure 3: Estimated downstream current velocity derived from Teledyne River Ray ADCP data collected along the main channel of the Pearl River estuary between stations PR1 – PR8. Results may have been influenced by different position in the river between stations with respect to the main, central channel and possible drifting during data collection.

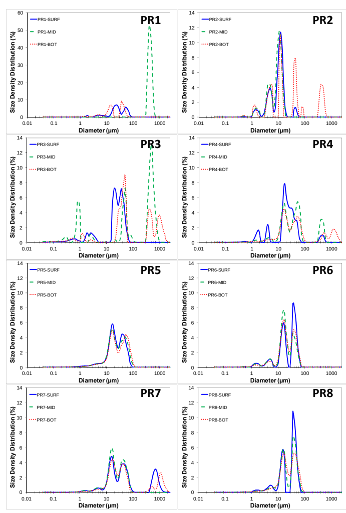

Figure 4: Comparison of particle size distributions (Cilas 1190 LPSA, wet dispersion mode, fast speed) for surface (S, SURF; blue solid line), middle (M, MID; green dashed line), and bottom (B, BOT; red dotted line) water column samples at each station PR1 – PR8.

Particle size distribution at stations PR5 - PR8 showed little change with depth while distributions at stations PR1 - PR4 varied between S, M, and B waters (**Fig. 4**). Stations PR1 - 4 had lower salinities (<15) and significant variations in salinity with depth while PR5 - 8 had higher salinities (14-18) that were relatively uniform with depth. Water column pH exhibited a similar pattern between stations but less variability with depth (**Fig. 2 A & B**). Differences in current downstream current velocities between depths and between stations may have also influenced particle size distributions (**Fig. 3**).

Discussion:

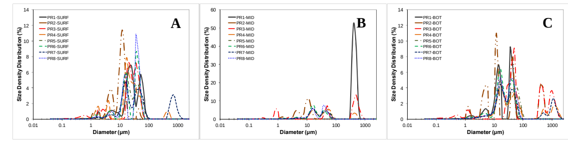

Figure 5: Comparison of particle size distributions for station PR1 – PR8 water samples collected from: (**A**) near-surface (S, SURF; blue solid line); (**B**) middle-depth (M, MID; green dashed line), and (**C**) near-bottom (B, BOT; red dotted line) (**Table 1**). Data are for samples run on a Cilas 1190 LPSA in the wet dispersion mode, fast speed.

There were significant differences in particle size distributions between surface, middle, and bottom waters at lower-salinity estuarine stations that exhibited variability in salinity (and pH) with depth (**Fig. 4**). Likewise there were differences in the particle size distribution in surface, middle, and bottom waters along the estuarine salinity (and pH) gradient (**Fig. 5**). A consistent shift or trend in particle size distribution with increasing/decreasing salinity or pH was not noted.

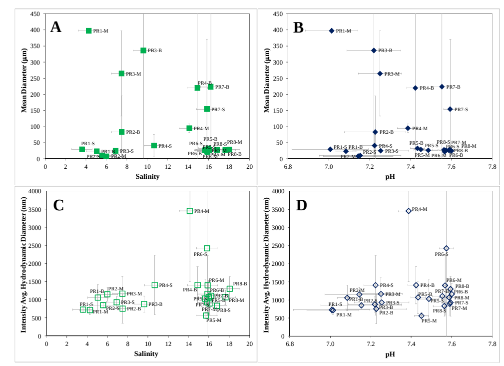

Figure 6: (**A**) Mean particle diameter (µm) vs. salinity and (**B**) vs. pH for samples analyzed using a Cilas 1190 LPSA. (**C**) Intensity averaged hydrodynamic diameter (nm) vs. salinity and (**D**) vs. pH for samples analyzed using a Malvern Nano ZS. Each sample is identified by a Sample ID.

Conclusions:

Variations in ionic strength (salinity), and to a lesser degree pH, with depth and along the estuarine salinity gradient likely has a strong influence on particle size distributions in the Pearl River. The degree to which these and other factors influence specific flocs and/or flocculation processes in the Pearl River estuary or other littoral systems is uncertain and is an area of future research.

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