

**Mound Study Project  
Cape Fear, North Carolina  
Initial Water Column Profiles and Sediment Grabs  
May 2001  
EHI Project No. 6000.21**



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By

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## 1. SUMMARY

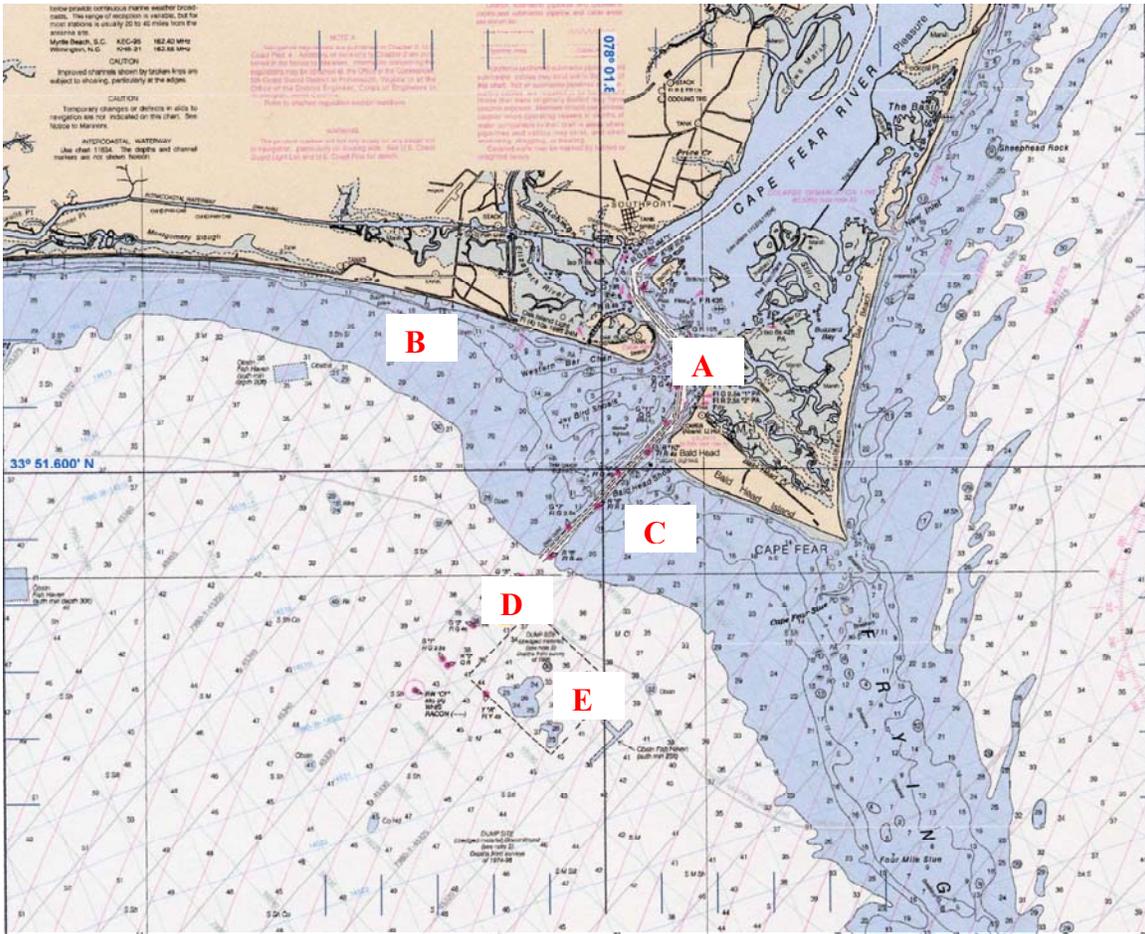
This work was conducted in support of an ongoing investigation on sediment dispersal and evolution of a mixed-sediment disposal mound off Cape Fear, NC, by the US Army Corps of Engineers (USACE) and Evans-Hamilton, Inc. (EHI), project number 6000.21. This was the first of three surveys performed by the Virginia Institute of Marine Science (VIMS), College of William and Mary, under the direction of Grace Battisto. The data collected in this survey provide an initial characterization of the bottom sediment and overlying water column before deployment of bi-pods equipped with Acoustic Doppler Current Profiler (ADCP) and Optical Backscatter Sensor (OBS) arrays by USACE and EHI on the site of the disposal mound and immediate vicinity as well as at Oak Island, Bald Head Island, the Harbor Station and 11-mile sites. In May 2001 at sites corresponding to these future bi-pod locations, water column profiles, suspended sediment concentration samples and bottom sediment grabs were collected.



**Figure 1.** Profiler ready for deployment

## 2. METHODS

For this survey, the R/V Langley was anchored at eight sites on May 1, 2001: One in the harbor, one off Oak Island, one off Bald Head Island, four on and around the dredge spoil disposal mound and one at the 11-mile site (Figure 2). The exact location of the vessel was documented by differential GPS while occupying each site (Table 1). At each site a profiler (Figure 1) equipped with a conductivity, temperature, and depth sensor (CTD), an OBS, a Laser *in-situ* Scattering Transmissometer (LISST-100), an Acoustic Doppler Velocimeter (ADV), a compass and a submersible pump were deployed in real-time mode for the data collection. Also at each site a bottom sediment sample was collected.



**Figure 2.** Section of NOAA chart 11536 (Approaches to Cape Fear River). Sites A through D represent the Harbor, Oak Island, Bald Head Island and, 11-Mile sites, respectively, visited during the first field survey in May 2001. Site E represents the four sites on and around the disposal mound.

**Table 1. Station Locations**

<b>Station</b>	<b>Latitude 33° N</b>	<b>Longitude 78° W</b>	<b>Depth (meter)</b>
<b>SEDIMENT GRAB LOCATIONS</b>			
<b>11-MileSite</b>	<b>49.392</b>	<b>3.544</b>	
<b>North of Mound</b>	<b>48.345</b>	<b>1.971</b>	
<b>East Crest</b>	<b>48.224</b>	<b>2.037</b>	
<b>West Crest</b>	<b>48.257</b>	<b>2.143</b>	
<b>South of Mound</b>	<b>48.130</b>	<b>2.154</b>	
<b>Bald Head Island</b>	<b>50.693</b>	<b>0.704</b>	
<b>Oak Island</b>	<b>53.641</b>	<b>4.946</b>	
<b>Harbor Station</b>	<b>53.054</b>	<b>0.085</b>	
<b>PROFILE LOCATIONS</b>			
<b>11-MileSite</b>	<b>49.392</b>	<b>3.544</b>	<b>10.3</b>
<b>North of Mound</b>	<b>48.325</b>	<b>1.952</b>	<b>10.6</b>
<b>East Crest</b>	<b>48.193</b>	<b>2.032</b>	<b>8.2</b>
<b>West Crest</b>	<b>48.235</b>	<b>2.144</b>	<b>10.5</b>
<b>South of Mound</b>	<b>48.109</b>	<b>2.170</b>	<b>12.0</b>
<b>Bald Head Island</b>	<b>50.690</b>	<b>0.699</b>	<b>6.2</b>
<b>Oak Island</b>	<b>53.669</b>	<b>4.945</b>	<b>6.5</b>
<b>Harbor Station</b>	<b>53.059</b>	<b>0.087</b>	<b>6.6</b>

## **2.1 Bottom Sediment**

A Smith-Mac sediment grab (Figure 3) was used to collect the top 5-10 cm of bottom sediment at each site in Table 1. The sediment was collected in a 5-gallon bucket for later analysis. The sample in the bucket was well mixed. Wet sieve methods were used to determine the percent fractions of mud (<63 microns), sand (63-2 mm) and gravel (> 2mm) for an aliquot of sample from each sub-core. Ten millimeters of a stock mesophosphate solution (0.3 g sodium carbonate and 51 g sodium mesophosphate / L de-ionized water) was added to each aliquot and put in a sonicator to prevent aggregation during the size separation process. Pipette analyses were used to separate the mud into



**Figure 3.** Smith-Mac bottom sediment grab used to collect an approximately 10 cm thick box core with the sediment- water interface left relatively intact.

clay and silt fractions. Percent by weight was determined for each fraction of the total weight of the aliquot.

The VIMS Rapid Sand Analyzer (RSA) was used to determine the size distribution of the sand portion from each site. The RSA, an instrument consisting of a cylinder of water of known depth and temperature with a weighing pan suspended near the bottom, utilizes the known fall velocities of natural quartz sand to classify the particles in the field sample into size classes. For evenly spaced intervals of  $\phi$ , where  $\phi = -\log_2 D$  and  $D$  is the intermediate grain diameter in millimeters, the fall velocity ( $W_n$ ) of natural grains in fresh water is:

$$W_n = 0.76 c D^2 \quad (2.1)$$

where  $c = 89.8$  at  $20\text{ }^{\circ}\text{C}$  for quartz particles (from Stokes Law), and  $0.76$  accounts for the effect of natural non-spherical shape of the particles. The RSA applies this relation at small grain sizes with an empirical correction for turbulent vortex shedding at larger grain sizes.

The sample particles are uniformly dispersed by the RSA sand release mechanism at the top of the 150 cm column of water. The particles fall onto a tared balance pan located near the bottom of the column. The cumulative weight of the particles is recorded over time at 1-second intervals. The weight of the particles that have fallen in the amount of time it would take a particle for each phi size class is subtracted from the cumulative weight and termed the immersed weight. Each progressively smaller grain size takes longer to fall the same distance than grains from a previous size class. A histogram of the immersed weight by phi class is then made to show the grain size distribution of the sample. The data are not converted to dry weight because the percent distribution of the total across all the size classes is more important than the dry weight of sand in any one size class.

## **2.2 Water Column**

The profiler with the various instruments was lowered from a near surface depth to a near bottom depth to collect a “profile” of the water column at the beginning of the station. The profiler was then raised from the bottom depth to about 1 meter above the bottom. The profiler was kept at this depth while at least 10 liters of water were pumped to the surface and collected in a churn splitter. An aliquot of the sample from the splitter was filtered through a 60-micron mesh filter (Figure 4). The filtrate was then filtered through a GF/F glass fiber filter (pore size  $\sim 0.7$  micron). The filters were kept on ice and transported back to the lab to be dried at  $103\text{-}105$  degrees C for total suspended solids for each fraction and then put in a muffle furnace at  $550$  degrees C to determine the fixed portion of each fraction. Additional samples at each site were taken at mid-depth and approximately 1 meter below the surface for a total of three samples per site.



**Figure 4.** Hunter Walker filtering suspended sediments on board R/V Langley

### **3. RESULTS**

#### **3.1 Bottom Sediment**

Table 2 and Figure 5 show the percent grain-size distribution by weight for each site. The sand fraction grain size distribution for each site measured by the RSA is shown in Figure 6.

### 3.2 Water Column

Table 3 and Figure 7 show the suspended solids concentrations in the water column for each fraction at each of the eight sites. The total suspended solids concentration for the water column can be found by adding the total solids for mud (0.7- 60 microns) and sand (> 60 microns) fractions. In Figure 7 only the total and fixed concentrations are graphed as the volatile solids concentrations are the difference between the two.

Figures 8.1-8.8 are the profile results measured by the various instruments for each of the eight water column sites.

Plots A and B are salinity and temperature profiles, respectively, as measured by the CTD plotted as a function of depth. Salinity is measured in practical salinity units (PSU) and temperature is measured in degrees Celsius.

Plots C and D are the velocity and the direction as measured by the ADV. Velocity is measured in centimeter per second (o and \* represent measurements in the x and y directions, respectively). Profiler direction is measured as uncorrected degrees. The profiler is turned to face into the current by the fin. When the currents are low (less than 20 cm/sec), they are not sufficient to keep the profiler steady. Therefore there is a lot of scatter in the velocity results as seen in all cases except the 11 mile and harbor station sites. The harbor station site has no ADV results because the currents were greater than the maximum range (150 cm/sec) of the instrument.

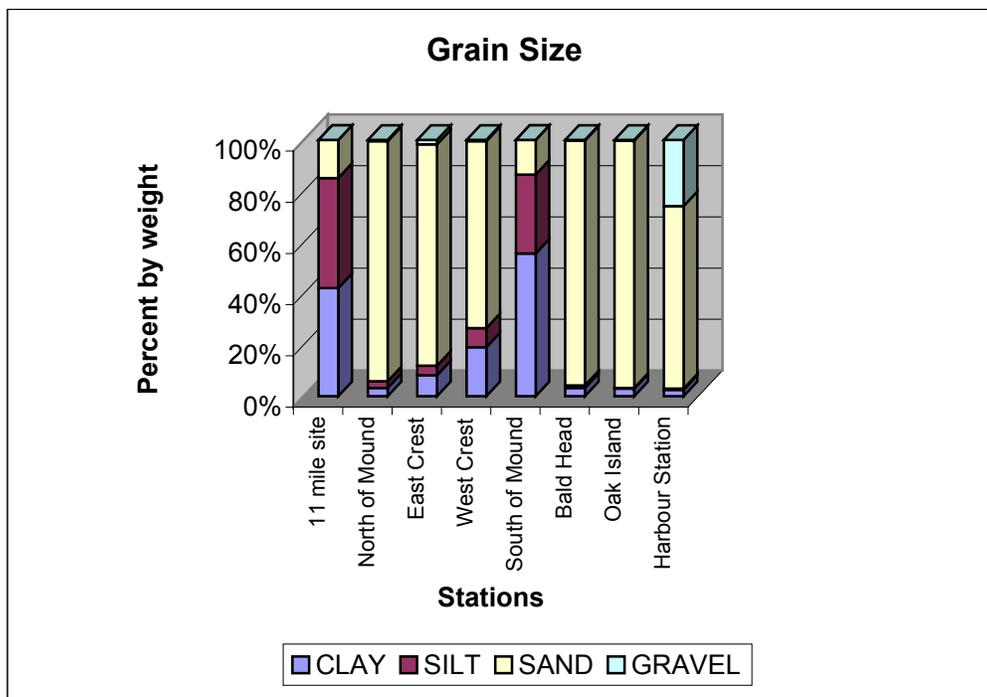
Plots E and F are the acoustic and optical backscatter, plotted as a function of depth, as measured by the ADV and OBS sensors, respectively. These are uncalibrated raw results.

Plot G is a contour plot of the suspended sediment the grain size distribution (5-500 microns), measured in volume concentration (micron liter/liter), as a function of depth measured by the LISST. Plot H is the same data plotted on a mesh graph without the bottom half to one meter of data to allow anomalies in the upper water column to be

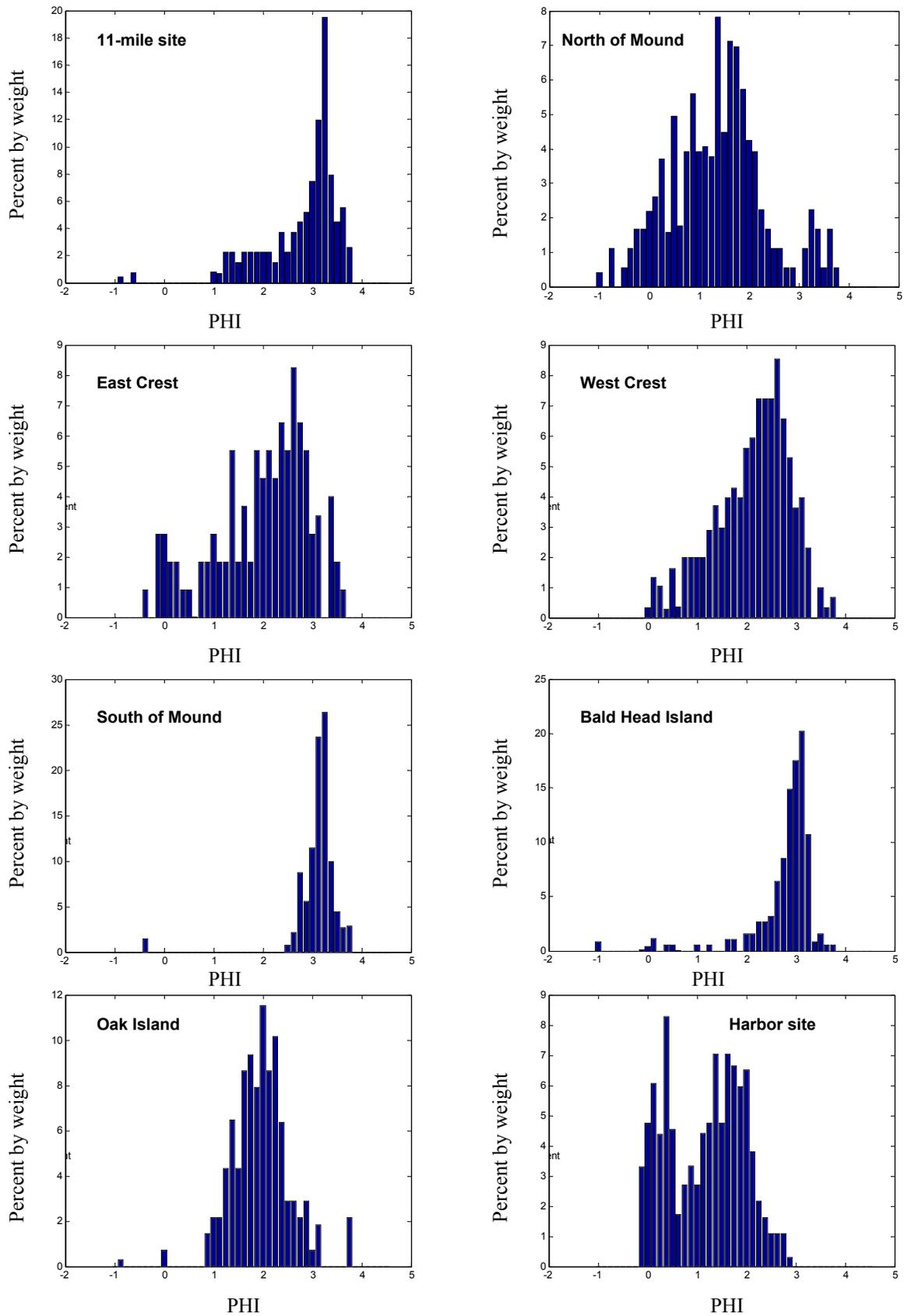
better displayed. These large particle size anomalies appear to be correlated with the pycnocline depth.

**Table 2. Bottom Sediment Grain Size Distribution**

	<b>%CLAY</b>	<b>%SILT</b>	<b>%SAND</b>	<b>%GRAVEL</b>
<b>11 mile site</b>	42.24	42.94	14.82	0
<b>North of Mound</b>	3.17	2.68	93.66	0.5
<b>East Crest</b>	8.17	3.75	86.31	1.77
<b>West Crest</b>	19.08	7.5	72.96	0.46
<b>South of Mound</b>	55.66	30.82	13.52	0
<b>Bald Head</b>	3.25	0.94	95.6	0.22
<b>Oak Island</b>	2.92	0.3	96.55	0.22
<b>Harbour Station</b>	2.53	0.43	71.23	25.82



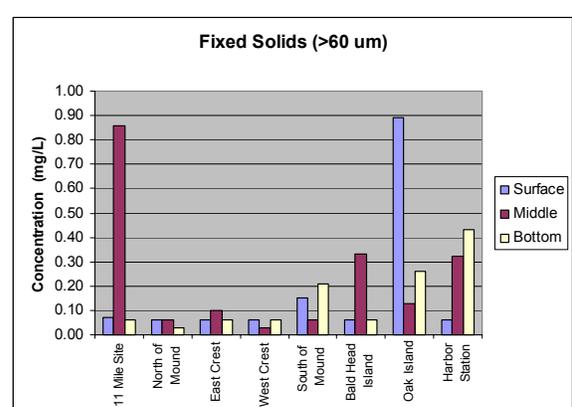
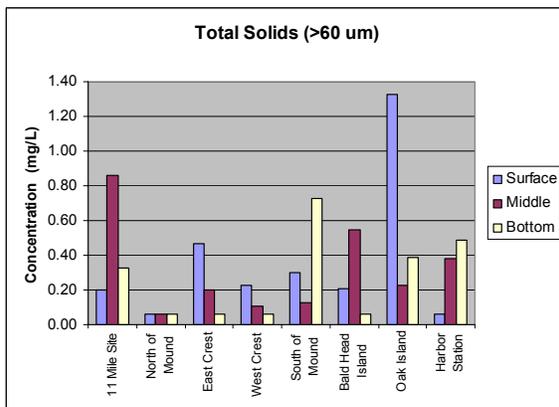
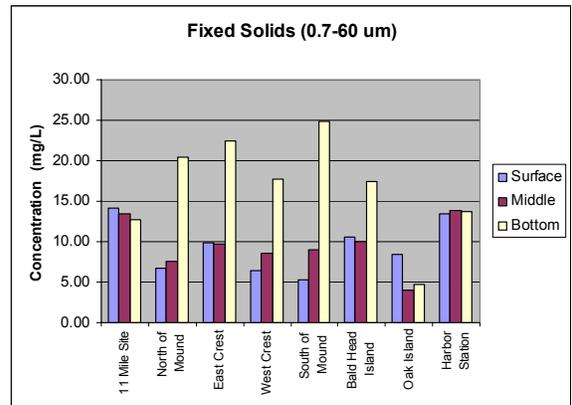
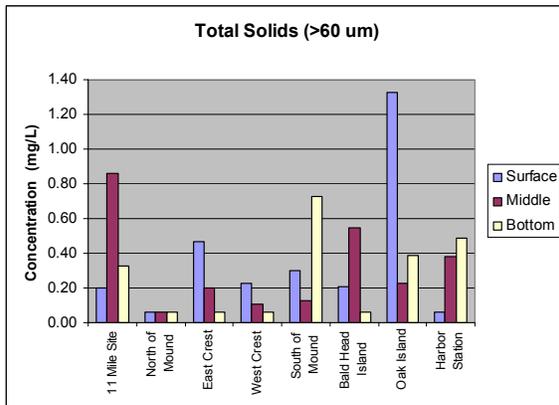
**Figure 5.** Sediment Grab Sample grain size distribution by weight.



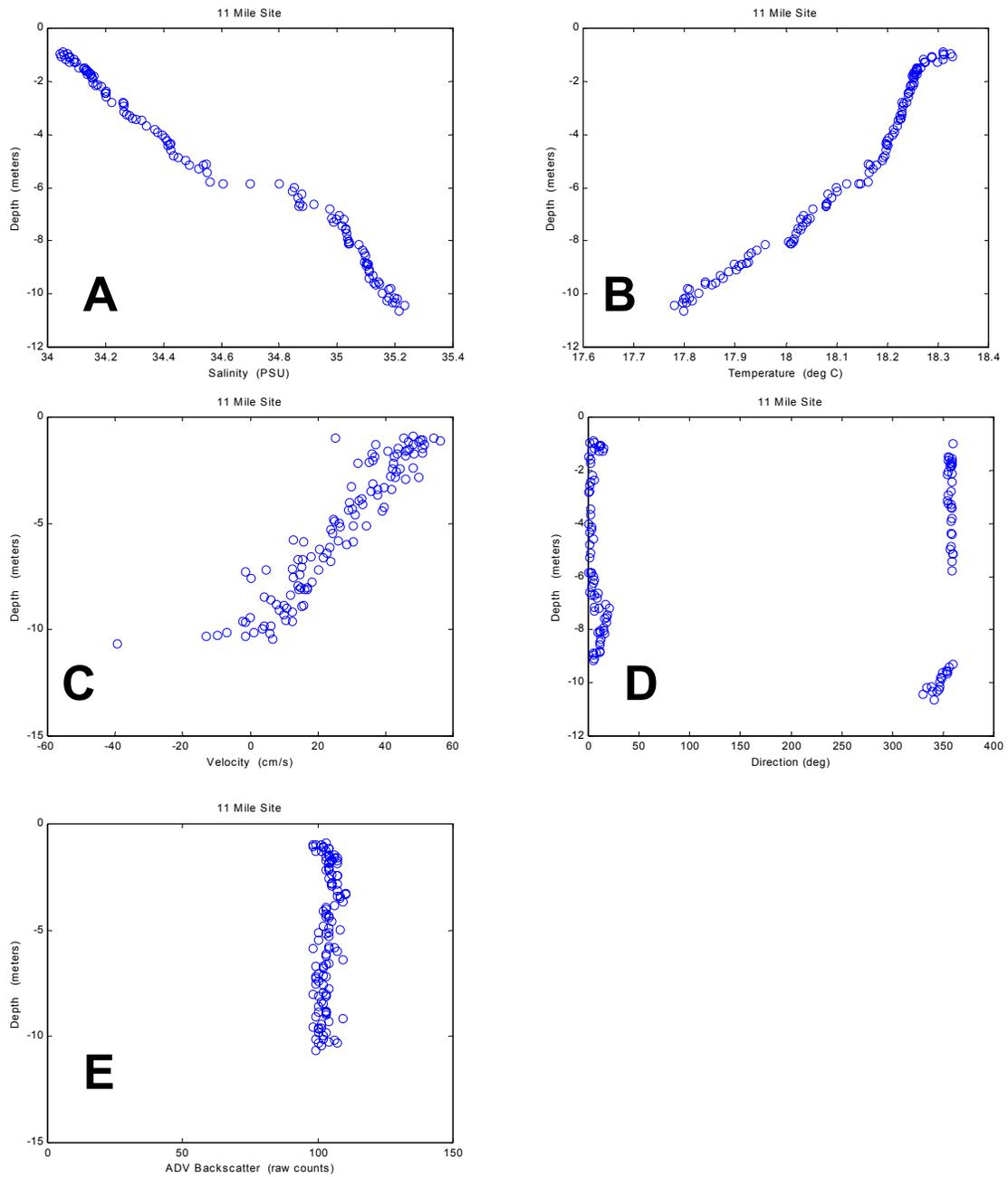
**Figure 6.** Rapid Sand Analysis histograms for sediment grab sand fraction samples (>60 microns to <2mm)

Table 3. Suspended Solids Concentrations

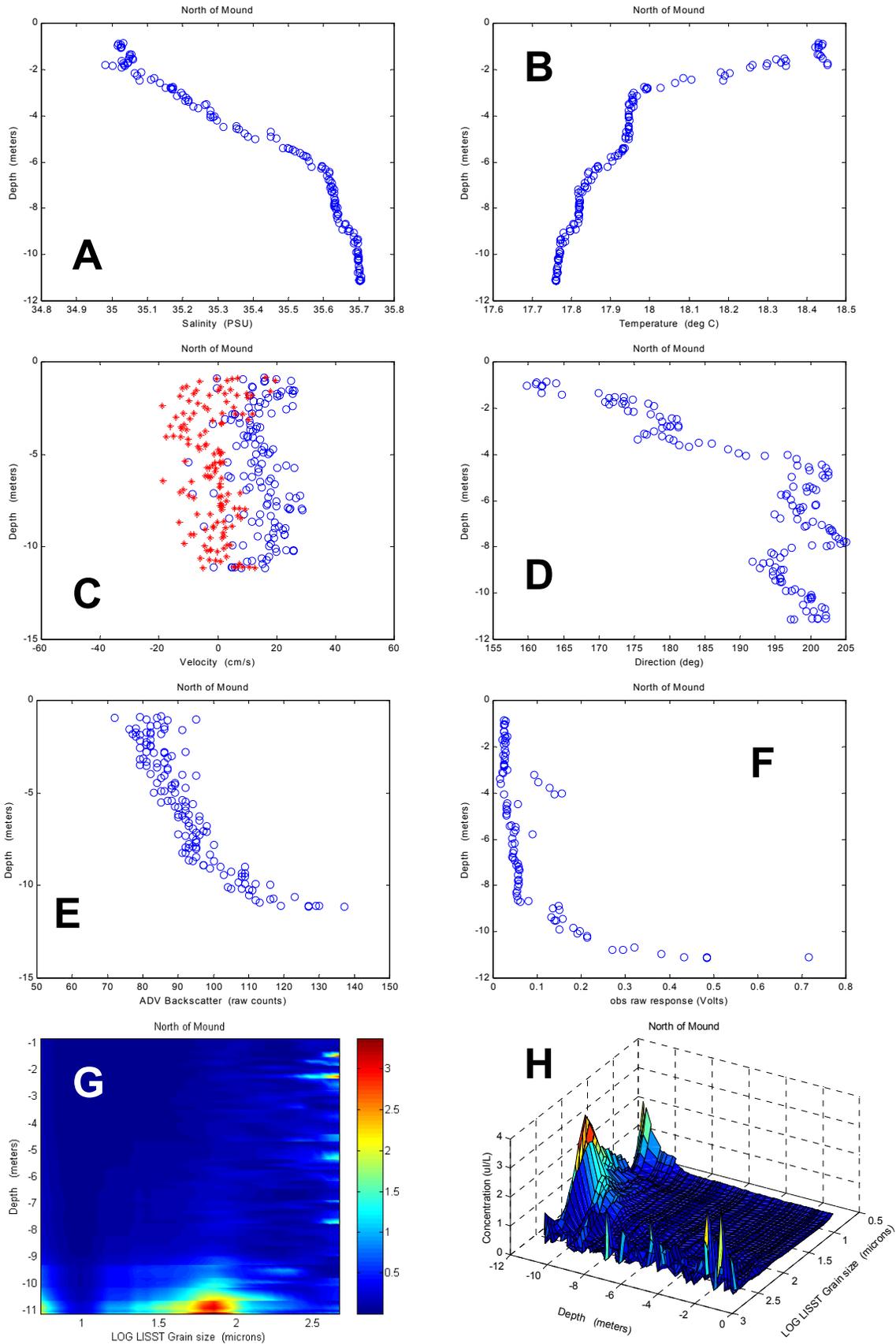
	0.7 - 60 um			>60 um		
	Total mg/L	Fixed mg/L	Volatile mg/L	Total mg/L	Fixed mg/L	Volatile mg/L
<b>Surface</b>						
11 Mile Site	16.70	14.10	2.60	0.20	0.07	0.13
North of Mound	7.80	6.70	1.10	<0.06		
East Crest	10.90	9.80	1.10	0.47	<0.06	0.47
West Crest	7.00	6.50	0.50	0.23	<0.06	0.23
South of Mound	5.80	5.30	0.50	0.30	0.15	0.15
Bald Head Island	11.80	10.60	1.20	0.21	<0.06	<0.06
Oak Island	9.90	8.40	1.50	1.38	0.84	0.54
duplicate				1.27	0.93	0.34
Harbor Station	15.80	13.40	2.40	<0.06		
<b>Middle</b>						
11 Mile Site	15.20	13.40	1.80	0.86	0.86	<0.06
North of Mound	8.50	7.60	0.90	<0.06		
East Crest	11.00	9.70	1.30	0.20	0.10	0.10
West Crest	9.80	8.60	1.20	0.11	0.03	0.08
South of Mound	10.10	9.00	1.10	0.13	<0.06	<0.06
Bald Head Island	11.00	10.00	1.00	0.55	0.33	0.22
duplicate	11.60	10.00	1.60			
Oak Island	5.70	5.10	0.60	0.23	0.13	0.10
duplicate	3.50	2.80	0.70	<0.06		
Harbor Station	16.60	13.90	2.70	0.38	0.32	0.06
<b>Bottom</b>						
11 Mile Site	16.50	12.70	3.80	0.33	<0.06	0.33
North of Mound	23.40	20.40	3.00	0.06	0.03	0.03
East Crest	26.10	22.50	3.60	<0.06		
West Crest	20.10	17.70	2.40	<0.06		
South of Mound	28.40	24.80	3.60	0.73	0.21	0.52
Bald Head Island	21.20	18.00	3.20	<0.06		
duplicate	20.50	17.00	3.50			
Oak Island	5.20	4.70	0.50			
duplicate				0.39	0.26	0.13
Harbor Station	16.30	13.70	2.60	0.49	0.43	0.06



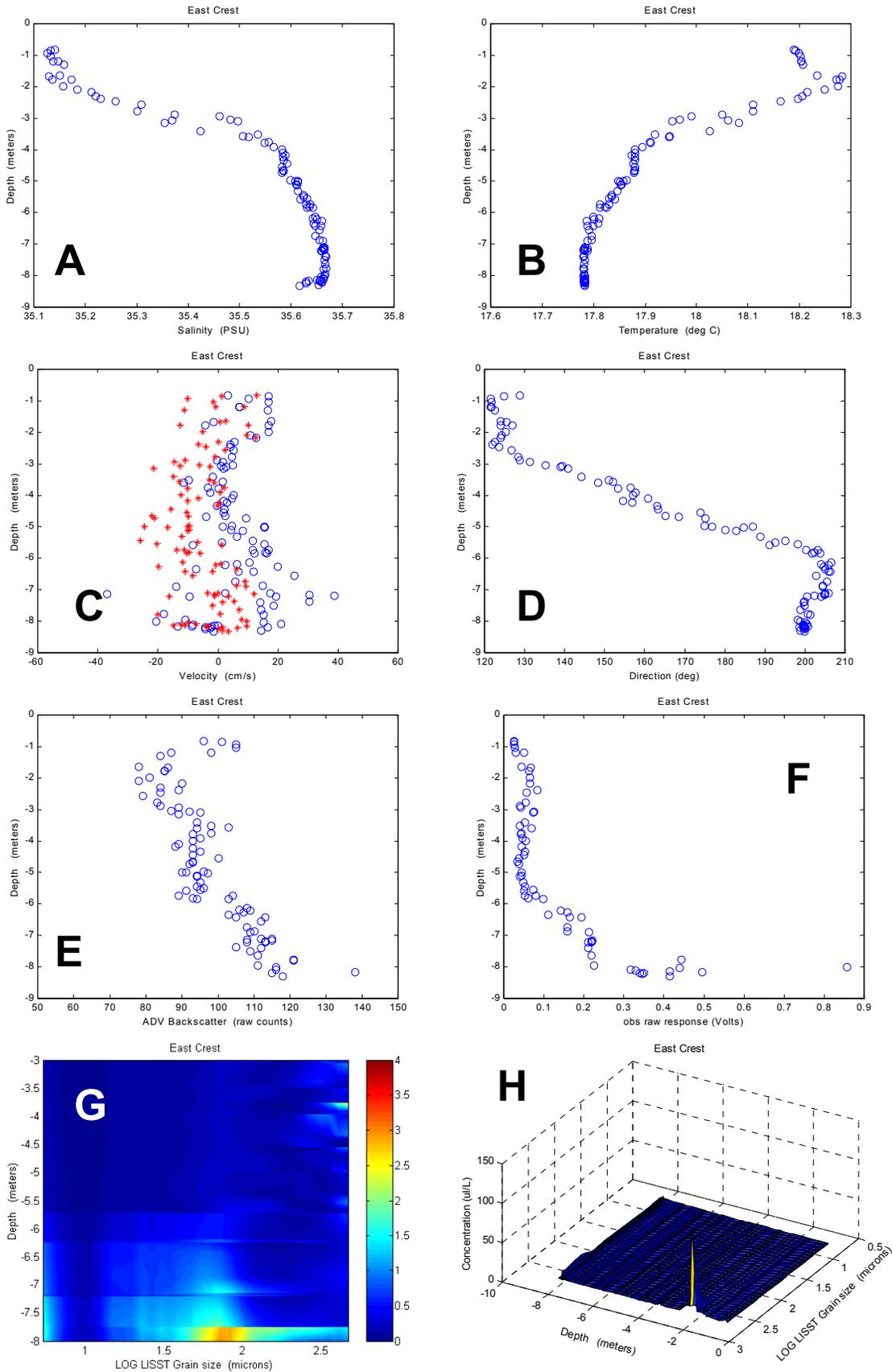
**Figure 7.** Total and fixed suspended solids concentrations for mud (0.7-60 microns) and sand (>60 microns) fractions.



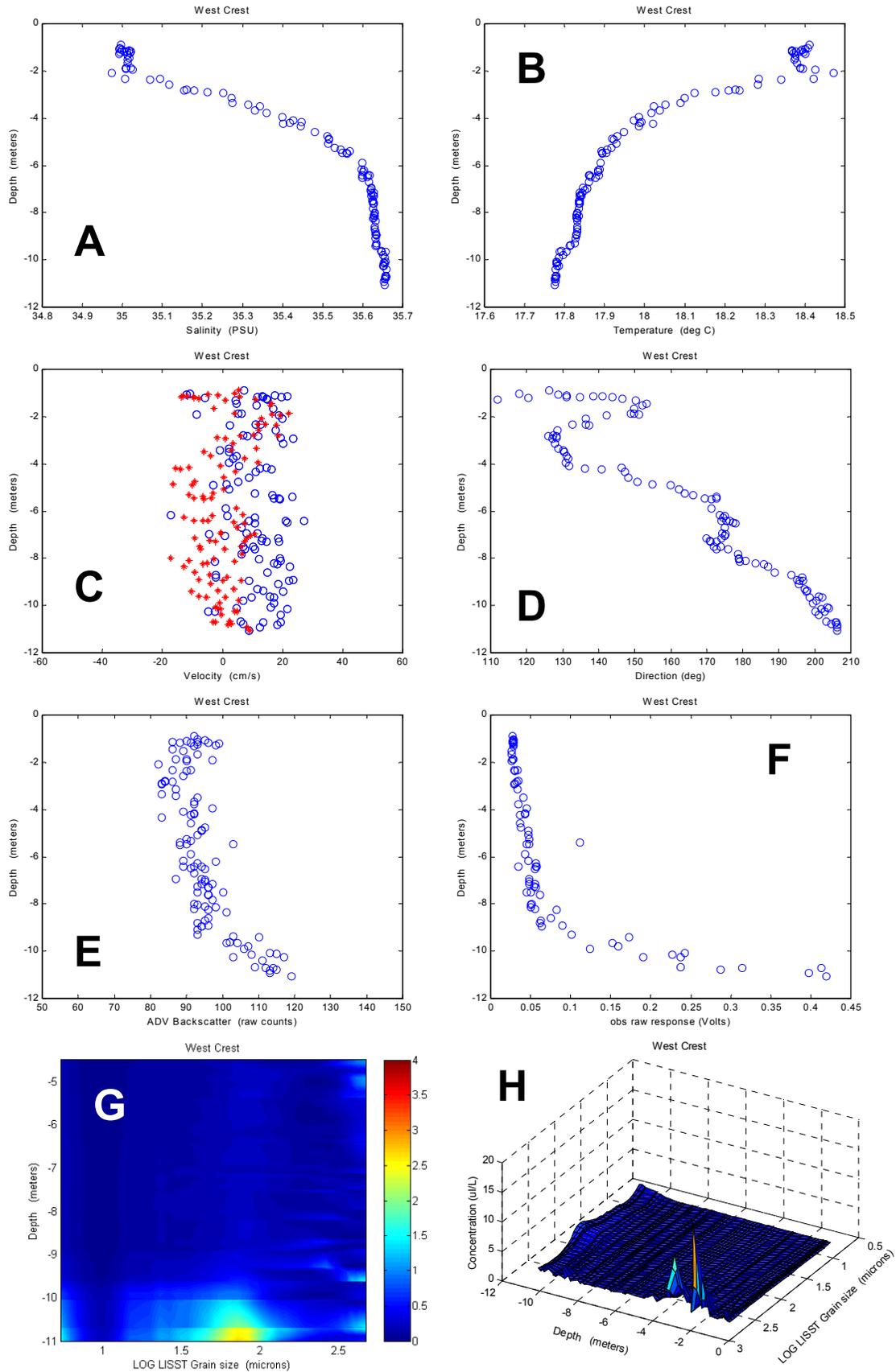
**Figure 8.1** 11-mile water column site profile results. No LISST or OBS data due to technical problems.



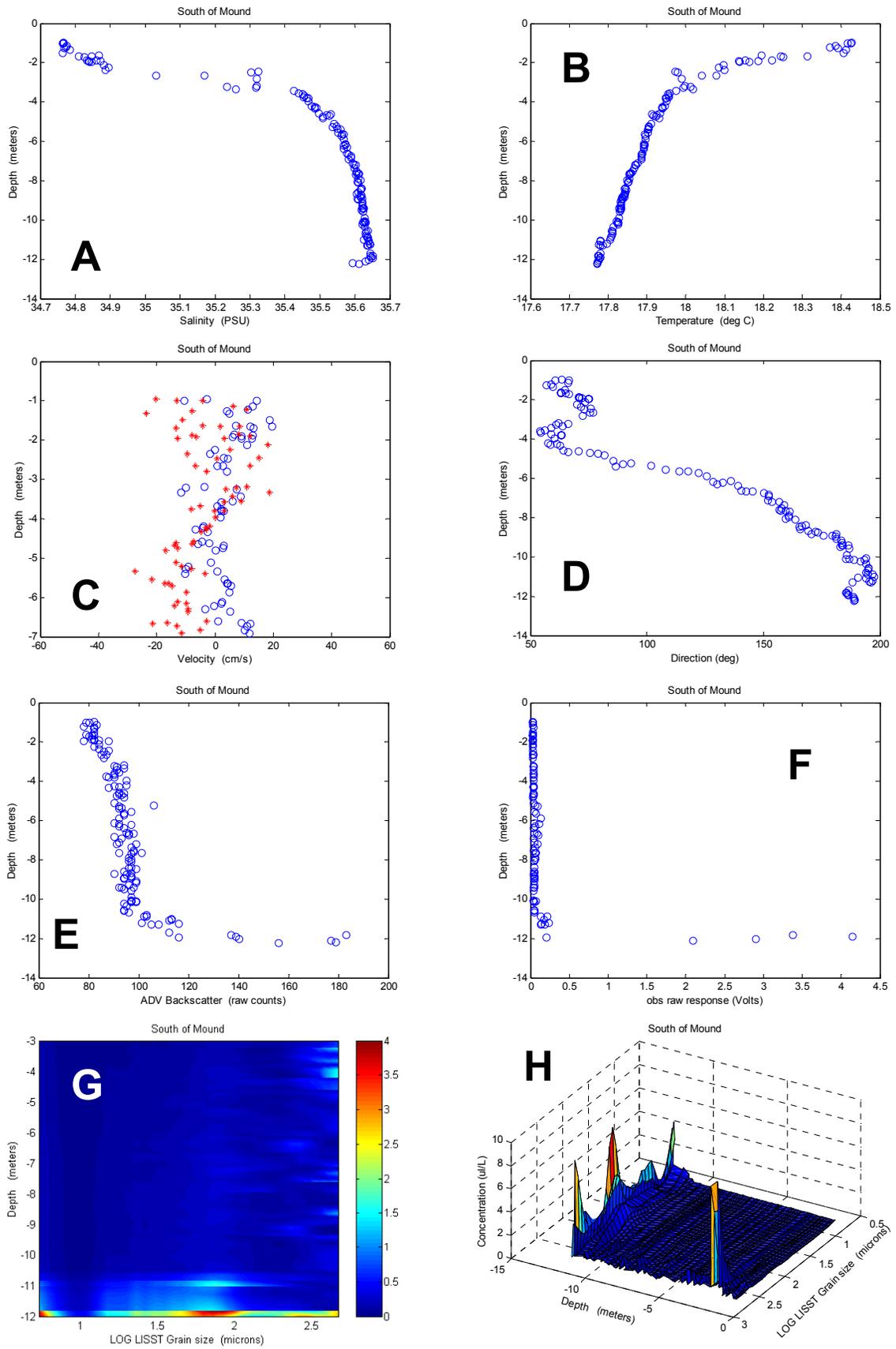
**Figure 8.2** North of Mound water column site profile results



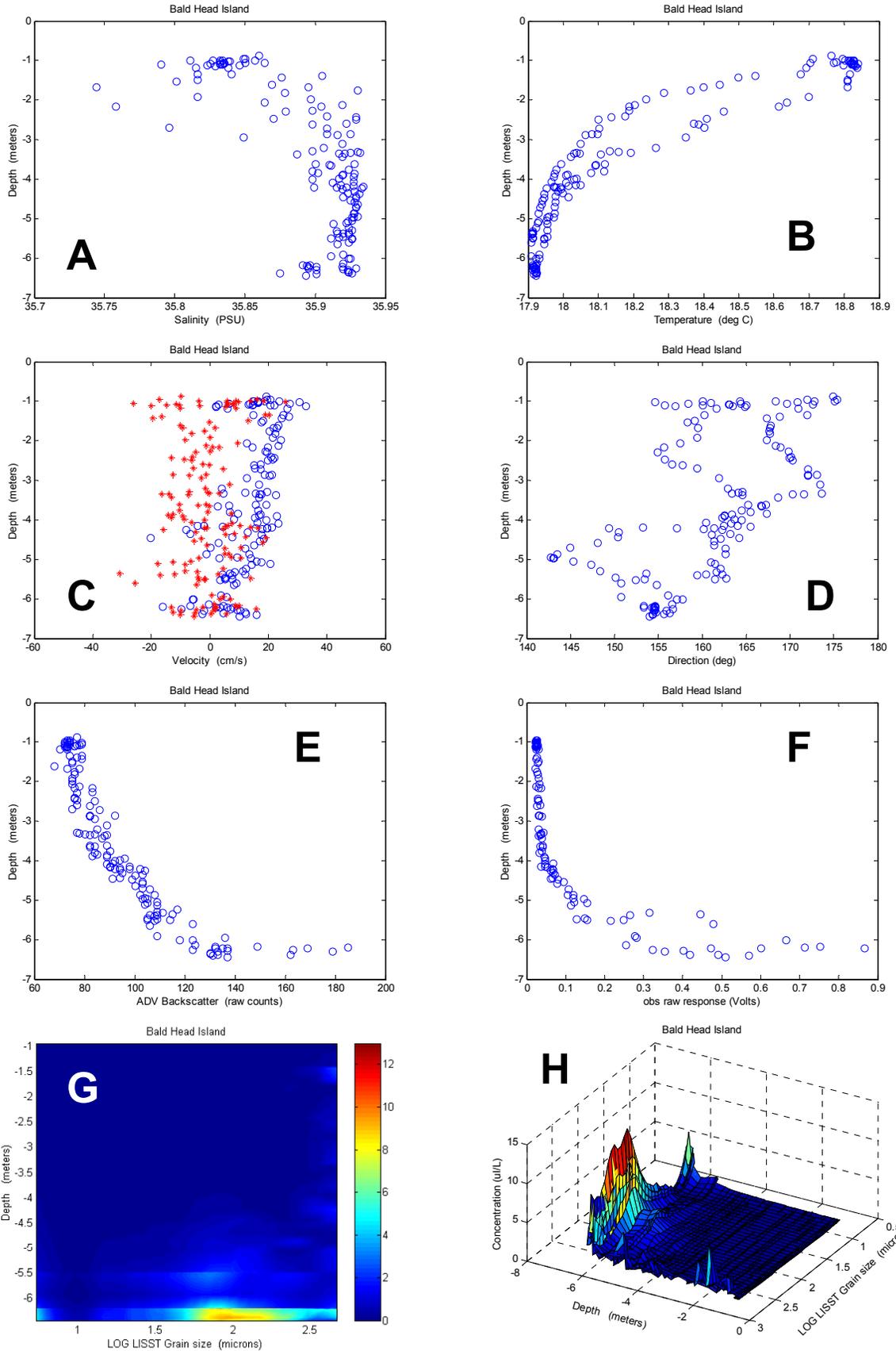
**Figure 8.3** East Crest water column site profile results



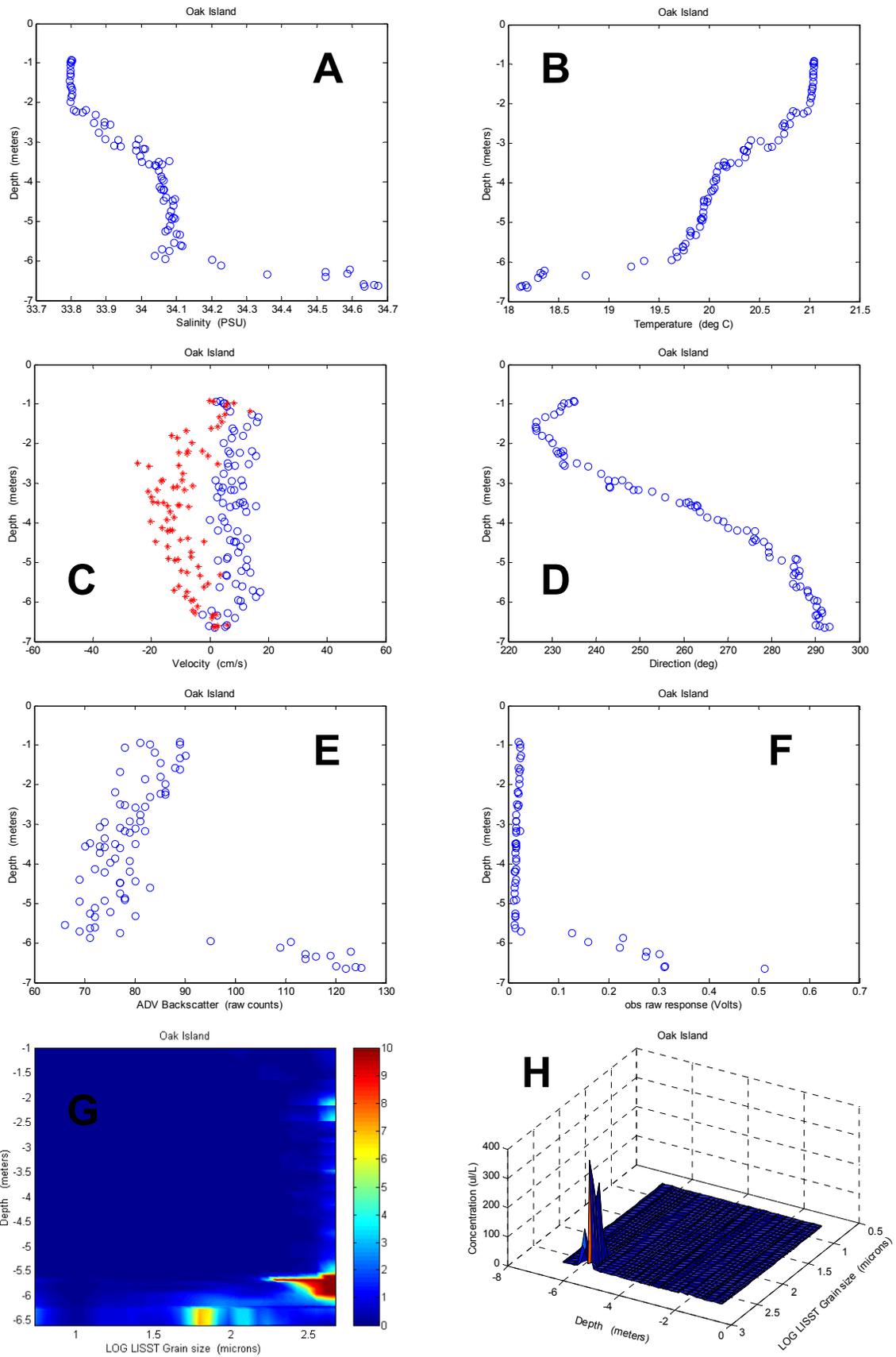
**Figure 8.4** West Crest water column site profile results



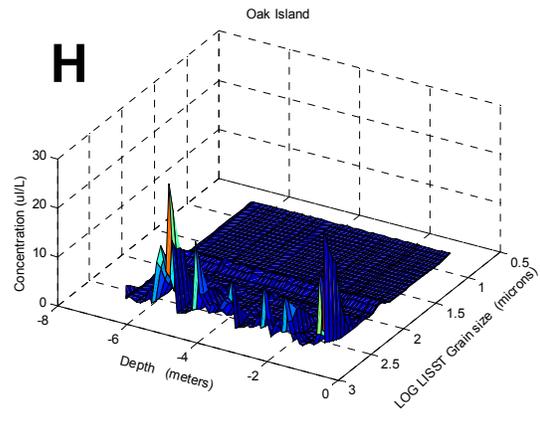
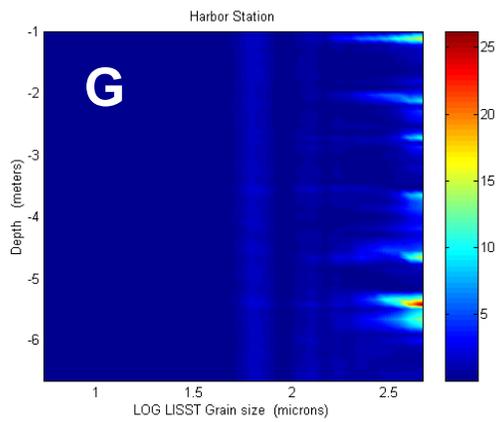
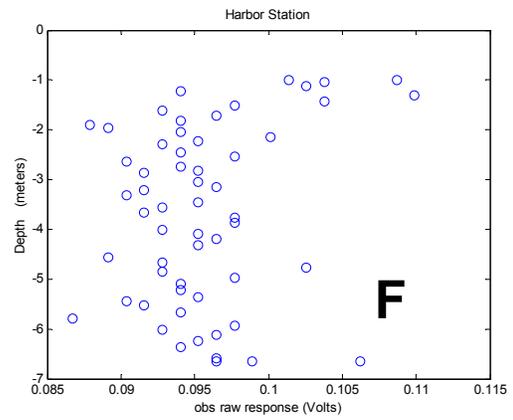
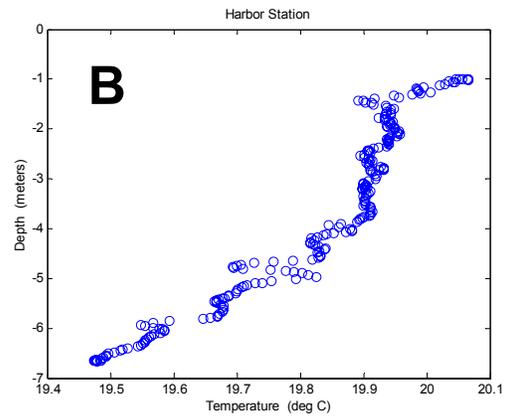
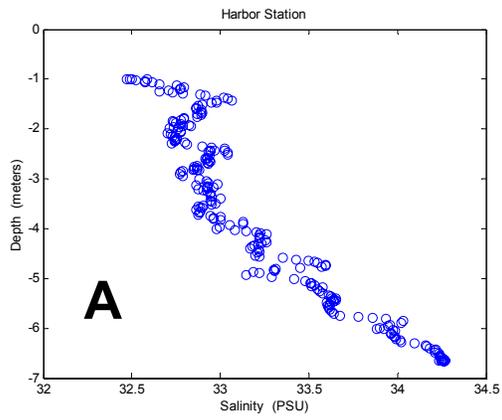
**Figure 8.5** South of Mound water column site profile results



**Figure 8.6** Bald Head Island water column site profile results



**Figure 8.7** Oak Island water column site profile results



**Figure 8.8** Harbor Station water column site profile results. No ADV results.