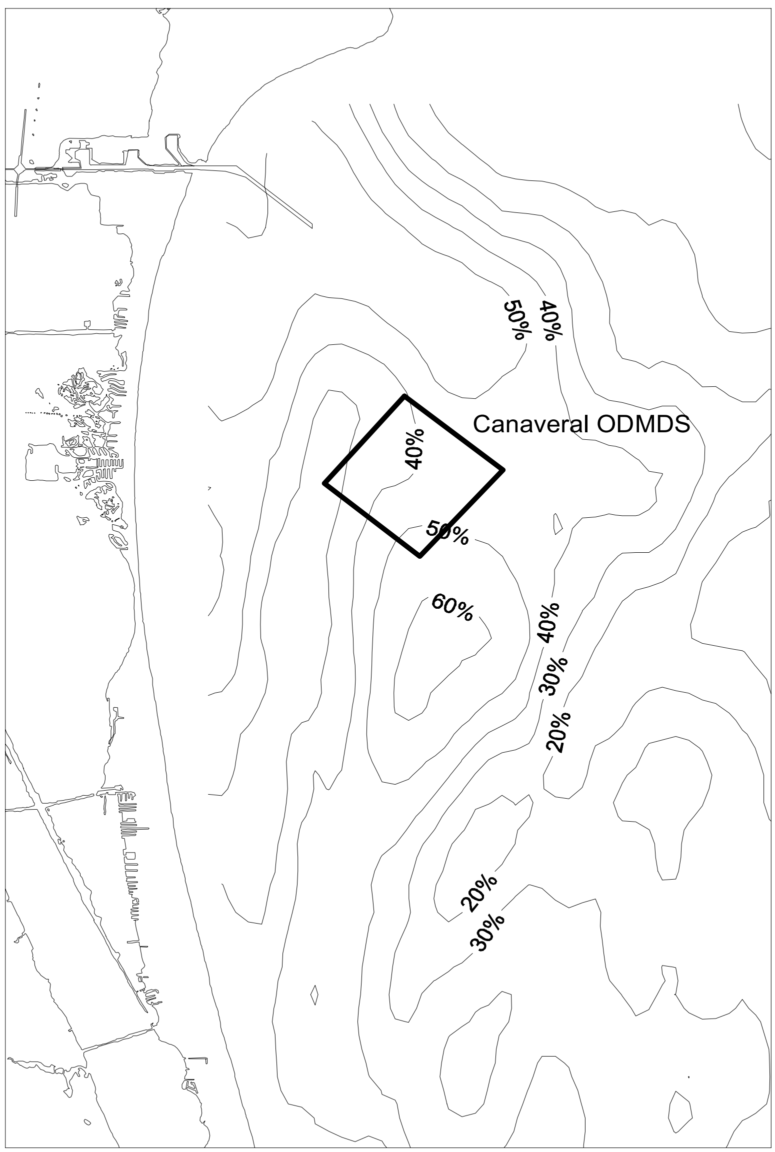
Spatial Analysis of Sediment Grain Size in the Vicinity of the Canaveral Harbor Ocean Dredged Material Disposal Site



EPA-904-R-05-002
January 2005

Spatial Analysis of Sediment Grain Size in the Vicinity of the Canaveral Harbor Ocean Dredged Material Disposal Site

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with funding from:
U.S. Army Corps of Engineers
Jacksonville District
Under Interagency Agreement #RW-96-94593601
MIPR #W32CS530026705

U.S. Environmental Protection Agency Region 4
Atlanta, Georgia

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1.0 INTRODUCTION

It is the responsibility of the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) under the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972 to manage and monitor each of the Ocean Dredged Material Disposal Sites (ODMDSs) designated by the EPA pursuant to Section 102 of MPRSA. MPRSA, the Water Resources Development Act (WRDA) of 1992, and a Memorandum of Agreement between EPA and COE require the joint development of site management and monitoring plans (SMMP) to specifically address the disposal of dredged material at ODMDSs. Additionally, the Memorandum of Understanding (MOU) between EPA Region 4 and the COE South Atlantic Division specifies that it is in the best interest of the EPA and the COE to act in partnership concerning the management and monitoring of all ODMDSs.

Management of ODMDSs involves regulating the times, the quantity, and the physical/chemical characteristics of dredged material that is dumped at the site; establishing disposal controls, conditions, and requirements to avoid and minimize potential impacts to the marine environment; and monitoring the site environs to verify that unanticipated or significant adverse effects are not occurring from past or continued use of the site and that permit terms are met.

A SMMP was developed and finalized by the EPA and COE for the Canaveral ODMDS in October 2001. The SMMP outlines strategies for monitoring the ODMDS and provides as an appendix a Long-Term Monitoring Strategy (LTMS) for the ODMDS. A study of the areal impact of disposal on grain size was included as part of the Canaveral ODMDS SMMP and Long-Term Monitoring Strategy (LTMS) to address concerns that disposal at the site had significantly altered the percentage of fines offshore Cocoa Beach, Florida. A study conducted by Julie Vann (1995) at the Florida Institute of Technology concluded that disposed dredged material has dispersed to cover a 600 square kilometer area resulting in a potentially negative impact on offshore mineral resources (beach quality sand). The area extends 28 km to the south, 12 km to the north and up to 18 km east to the 18 meter isobath (see figure 1). The Florida Geologic Survey as part of a cooperative agreement with the Minerals Management Service (MMS) has studied the sand resources in the area and has determined that there exists two prospective sand source areas (reserves) in the vicinity of the Canaveral ODMDS (see figure 2). Reserves in the northern area are estimated at 115 million cubic yards and in the southern area at 49.5 million cubic yards (FGS, 2002). 40 CFR 228.6(a)(8) requires that EPA consider in selection of its disposal sites, potential impacts on mineral extraction. Sand and gravel is considered an offshore mineral resource according to MMS.

In February 2003, EPA Region 4 and the COE Jacksonville District entered into a joint agreement to jointly manage and monitor the Canaveral ODMDS. Task 1, subtask B of the agreement was to conduct a study of the Canaveral area offshore Cocoa Beach, Florida to document the distribution of fine grained material through collection of samples for grain size analysis. This report details the results of that study.

2.0 METHODS

2.1 Survey/Sampling Methods

The survey area was defined based on the conclusions of Vann (Vann, 1995). It was defined to the north by the Southeast shoal of Cape Canaveral, by the west by the 30 foot contour, by the east by the longitude 80º20.6' W to insure inclusion of the 18 meter (60 feet) contour and to the south by the latitude 28º0.1' N. Vann predicted that the 18 meter contour is a natural eastern boundary due to the location of the Gulf Stream currents. The southern boundary was based on Vann's prediction of a southern extent of the dispersion area to be located 26 km south of the ODMDS. The southern boundary of the survey area lies approximately 35 km south of the center of the ODMDS.

Station locations were established utilizing a federally sponsored software program called Visual Sample Plan (2002, Battelle). The stations were established in a statistically valid, single stratum, evenly distributed triangular grid pattern, determined by the area to be surveyed and number of samples desired (500). This produced approximately 500 total sample sites equally spaced at approximately 1,524 meters (5,000 feet). The sample station locations are shown in figure 3. Station locations were established in the field utilizing a Differential Global Positioning System (WGS84, NAD83). Sampling was conducted from the EPA Ocean Survey Vessel (OSV) Peter W. Anderson, except for 17 stations where were sampled from a small boat as they were too shallow for the OSV Anderson. Samples were collected at a minimum of within 45 meters (150 feet) of the pre-established station location.

Samples collected from the OSV Anderson were collected from February 5, 2003 to February 13, 2003. Samples were collected utilizing a Young Grab. A 1.5x12 inch acrylic core tube was used to sub-sample from the grab for grain size analysis. The core tube was inserted to the point of refusal (approximately 15 cm). The samples were stored frozen. Sampling from the small boat in the shallow areas occurred on April 27 and July 12, 2003. Sampling was conducted via divers. A single core tube was inserted directly into the sediment to the point of refusal (approximately 15 cm).

2.2 Grain Size Analysis

Samples were analyzed through a combination of wet sieve method and laser diffraction method. The laser diffraction method utilized the Coulter LS200 which provides a particle size distribution (volume fraction) for all particles less than 2 mm in size. 2 mm corresponds to the differentiation between very fine gravel and very coarse sand. Therefore, the samples must first be wet sieved to determine the size fraction greater than 2 mm. (EPA, 2001)

The percent of sediment less than 63 :m (percent fines) was used to describe sediment grain size. The less than 63 :m fraction was determined from the wet sieving and laser particle size analyzer results utilizing the following equation:

$$\% Fines \cong V_{63mm} \times W_{2mm}$$

where: $V_{63:m}$ = volume fraction less than 63 :m
W_{2mm} = weight fraction less than 2 mm

This assumes that all particles in the less than 2 mm size class are of equal density.

2.3 Grain Size Data Analysis

Data was analyzed, gridded and plotted with the Surfer® grid based graphics program utilizing three methods: 1) no-interpolation; 2) triangulation; and 3) kriging. The first method of analysis utilized no interpolation. A grid approximately equal to the sample station spacing was established and the nearest neighbor value for each grid point was selected and plotted. Contour levels were then smoothed by applying a constrained spline algorithm to interpolate additional contour intervals using a high smoothing factor. In the second method, Delauney triangulation was used with no smoothing. The original data points are connected to make predictions of values between data points. In these first two methods, original data is honored very closely.

The third method used to grid the data was kriging, which makes predictions based upon a weighted mean of sample values. Leecaster (2003) found the kriging method to be a better predictor of grain size in marine sediments than triangulation and to provide accurate predictions. Directional variograms (values of distance and variance between pairs of points at each distance) were developed (see figure 4). The variograms showed the data to be anisotropic (variations are dependent on direction), with an anisotropy ratio of 2 and angle of 95 degrees. This indicates that the variability is greater in the east/west direction than in the north/south direction. The variagrams were used to optimize the interpolation mapping by fitting a mathematical model to the observed data. An exponential model was found to provide the best fit (r^2=0.96). The exponential model has been found to be useful for fitting variograms of soil data (Jongman et. al; 1987). A least squares method was used to fit the data and is shown in figure 4. A nugget effect (small-scale variation) of 205 was specified in the model. A grid spacing of approximately 475 meters was used.

3.0 RESULTS

Percent fines results for each station is presented in figure 5. The grain size data for each station is presented in Appendix A. Gridded data with no interpolation is presented in figure 6. Interpolated data using triangulation and kriging is presented in figures 7 and 8, respectively. Kriging resulted in significant smoothing of the data, but provides better representation of overall trends in the data. Figure 9 shows a comparison of the results to data collected by the Florida Geological Survey in 1995 (FGS, 2002).

The highest percentage of fines occur near the outer reaches of the entrance channel, and approximately two nautical miles (3.7 km) south of the Canaveral ODMDS. An area of coarser material exists in the northwest portion of the ODMDS and to the west and south of the ODMDS. A lens of coarser material running northeast and southwest is evident along a slight ridge near the center of the survey area. Sediments were mostly sandy in the northern and southern portions of the survey area. Hard bottom was encountered at two stations (475, 495) near the southern boundary and no sample could be collected.

4.0 DISCUSSION

Overall, results of the sampling are consistent with that collected by Vann (1995). High silt/clay content (>40%) are found in the vicinity of the Canaveral Harbor Entrance Channel and around the Canavaral ODMDS in both this and Vann's sampling. A narrow north/south running area of lower silt/clay content (<20%) is located to the west and south of the ODMDS in both efforts. Figure 10 shows a comparison of the 20% fines contour for the two studies. However due to the sampling design, Vann's study did not detect the area of fines in the in the southeast portion of the study area. This indicates that the fine grained material is not restricted to the vicinity of the Canaveral ODMDS.

The areas with the highest percentage of fine grained material are associated with the entrance channel and an area just south of the Canaveral ODMDS. The high percentage of fines near the entrance channel could be an effect related to the channel, ie. the dredging of the channel has exposed layers of finer material. However, as can be seen in figure 5, samples with high percentages of fine material are not limited to the channel itself. Fines may be captured within the shadow of the Cape as littoral drift in the area is generally to the south (FGS, 2002).

Vann (1995) determined that the highest percentage of fine grained material occurs within the Canaveral ODMDS (see figure 1). We have shown this not to be the case. The highest concentrations occur almost due south of the ODMDS. It could be hypothesized that the fine grained material in the disposed dredged material is being transported south by the prevailing currents. However, a years worth of current measurements at the Canaveral ODMDS has shown that the currents are overwhelmingly predominantly in the northerly direction (see figure 11). This is true for both the surface and near bottom currents (EPA, 2005). Therefore, it is unlikely that dredged material is being transported south from either the disposal plumes or from subsequent erosion from the disposal mound.

As discussed in section 1, the Florida Geological Survey has identified an area adjacent and to the southeast of the Canaveral ODMDS as a possible sand reserve for beach restoration material (see figure 2). Sands suitable for beach restoration material meet the requirements of section 5J of the Florida Administrative Code. This rule stipulates among other criteria that the material not contain greater than 5% fines. The possible sand reserves were identified based on results from a single vibracore sample and the aerial extent of the reserves was determined solely by subsurface acoustic profile character (FGS, 2002). Our results and the grab sample results of the Florida Geological Survey collected in 1995 (see figure 9) seem to indicate that the southern area would not be suitable for beach restoration due to the high fine content.

5.0 CONCLUSIONS

Results from this survey are consistent with past surveys in the area (see Vann, 1995 and FGS 2002). However, the fine grain material in the vicinity of the Canaveral ODMDS does not appear to be originating from the ODMDS. The Florida Geological Survey has identified possible sand reserves adjacent to the Canaveral ODMDS. Our results to do indicate that material in this area is suitable for beach restoration projects. However, EPA and the COE should initiate discussions with the Florida Geological Survey and MMS to minimize any interference of ocean disposal activities with offshore mineral extraction and to possibly pool resources in future sample collection activities in the area. The Canaveral ODMDS SMMP LTMS recommends repeating this survey on a ten year interval. Based on the results of this survey, additional surveys may not be warranted. It is recommended that a decision regarding the need for future surveys wait until the SMMP is reviewed in 2011 and upon consultations with MMS.

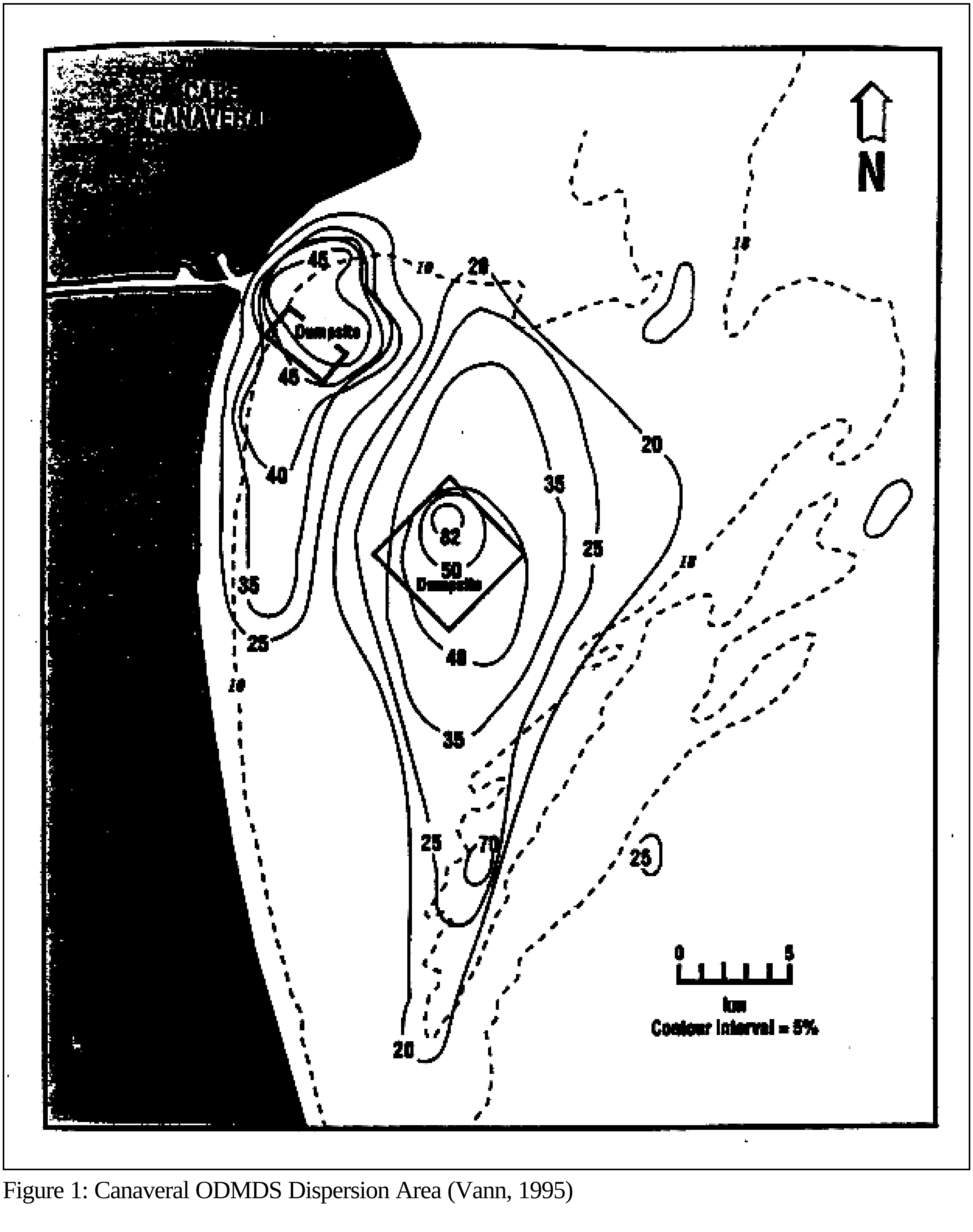

Figure 1: Canaveral ODMDS Dispersion Area (Vann, 1995)

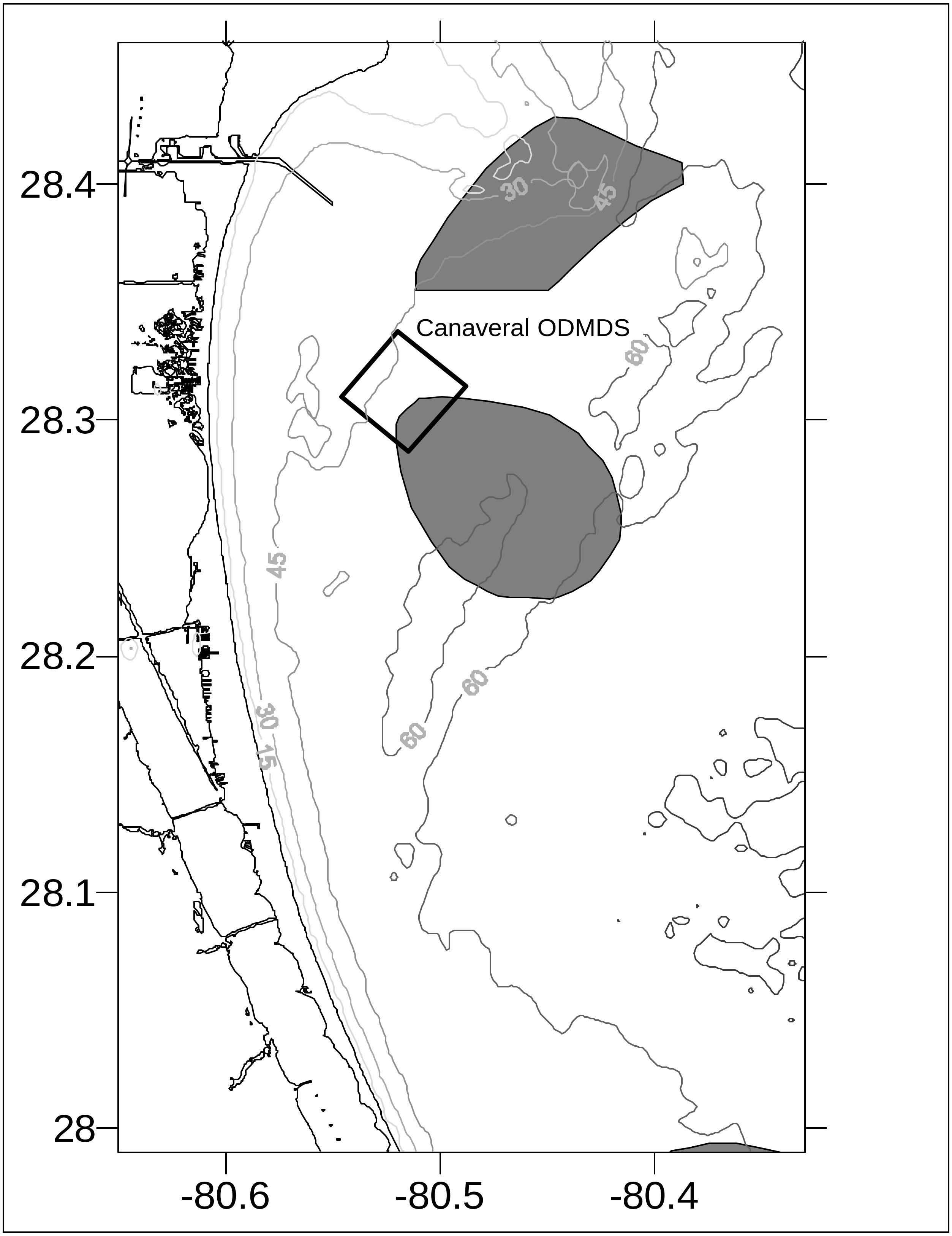

Figure 2: Identified possible sand reserves (FGS, 2002)

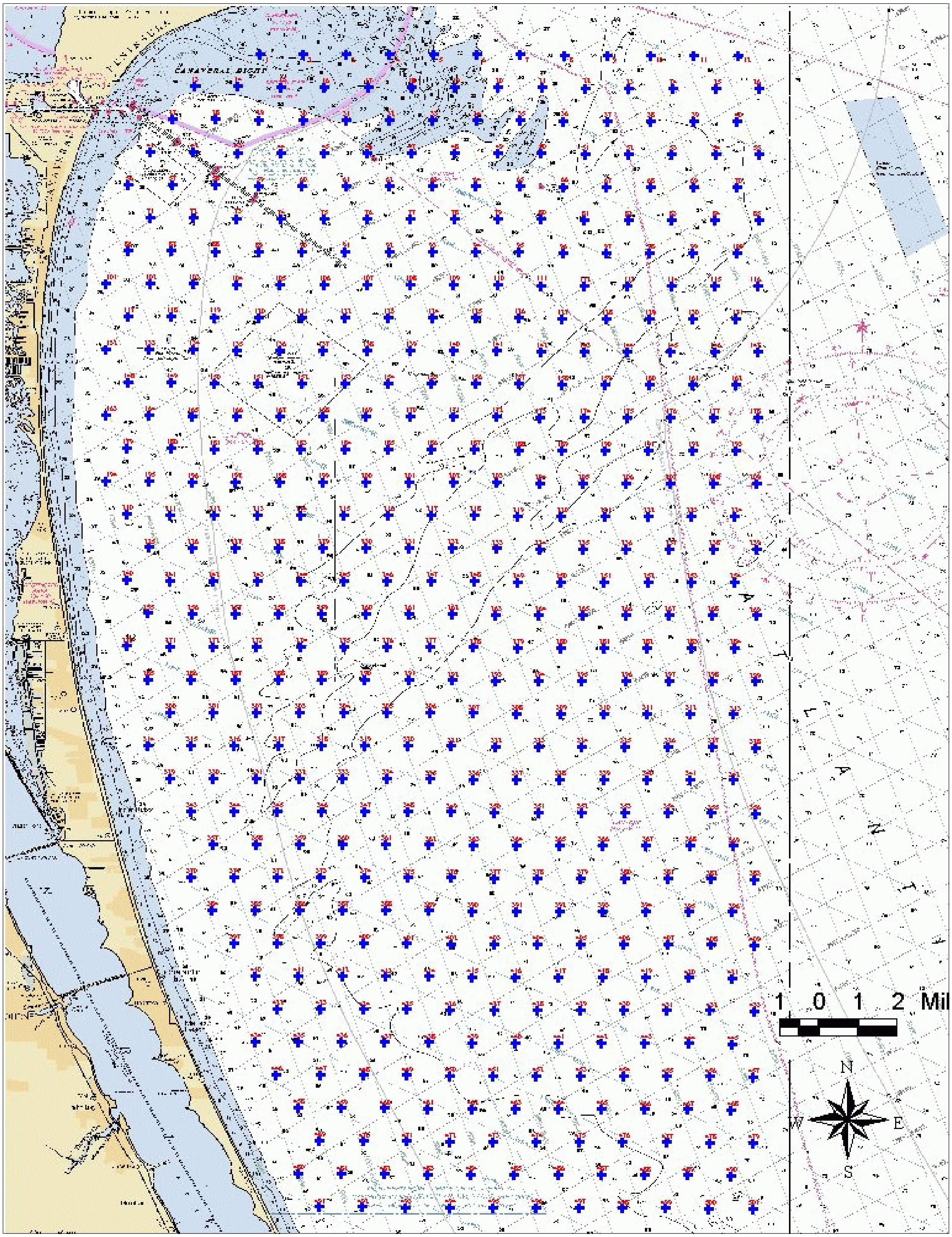

Figure 3: Grain size sample station locations

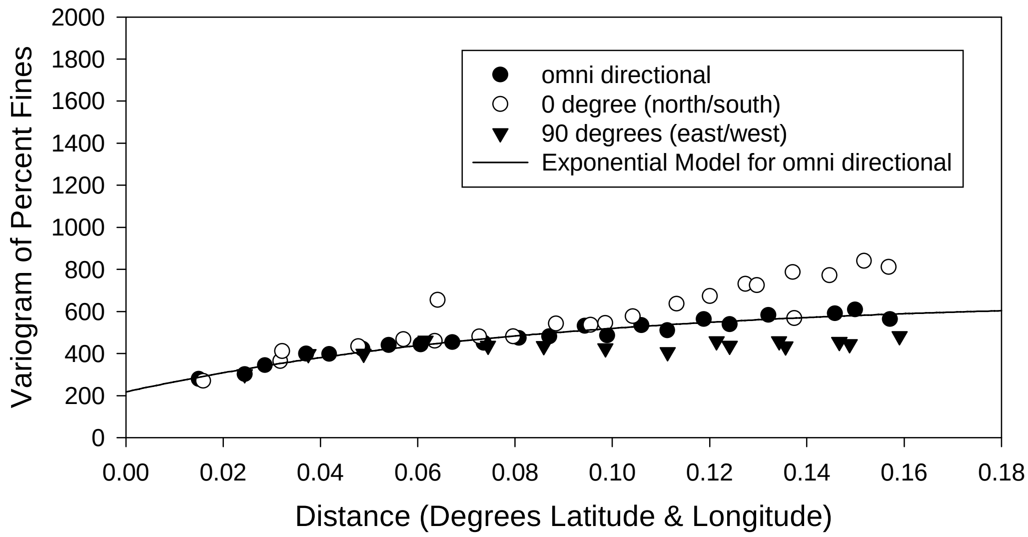

Figure 4: Empirical variogram of residuals and exponential model estimates.

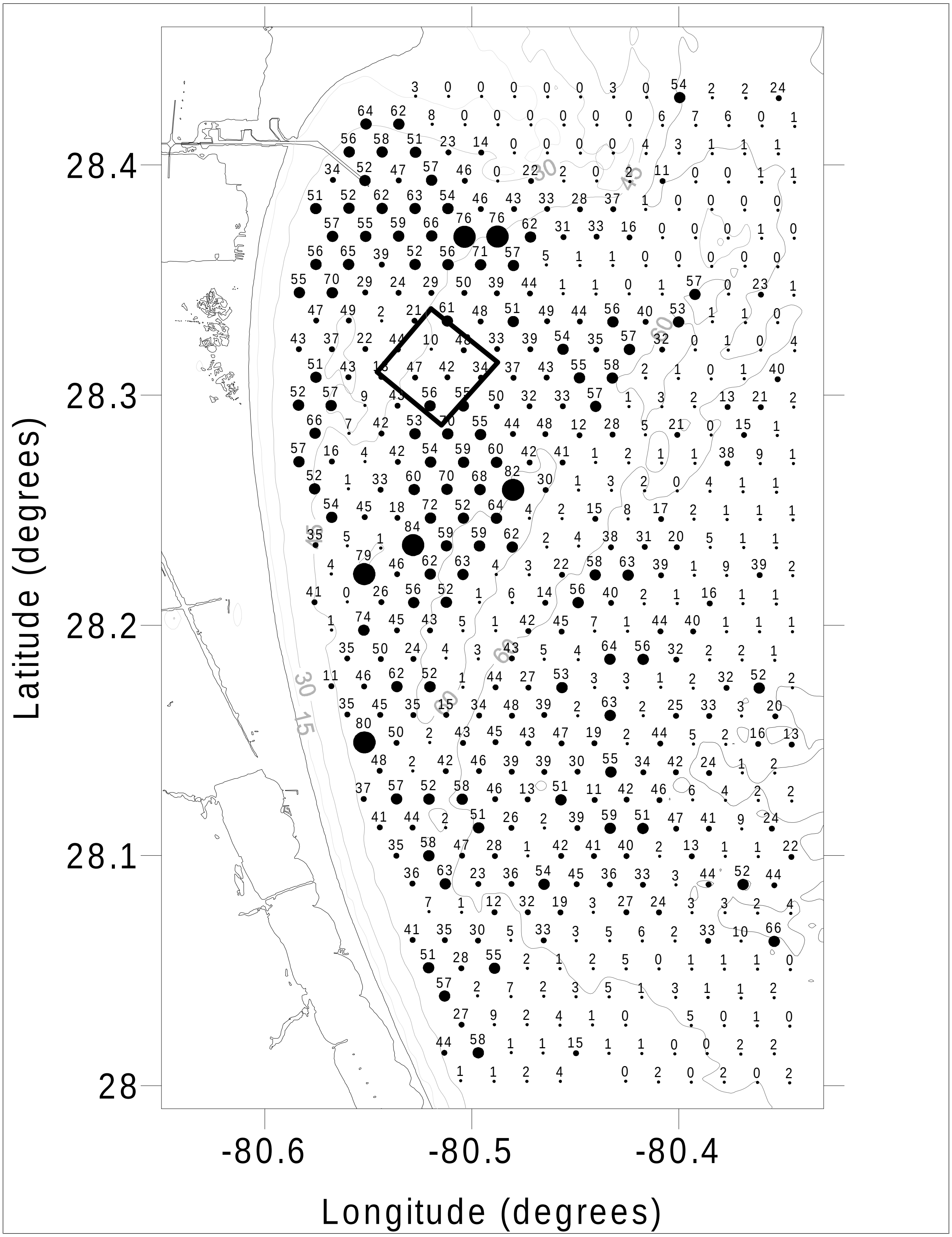

Figure 5: Plot of grain size (percent fines).

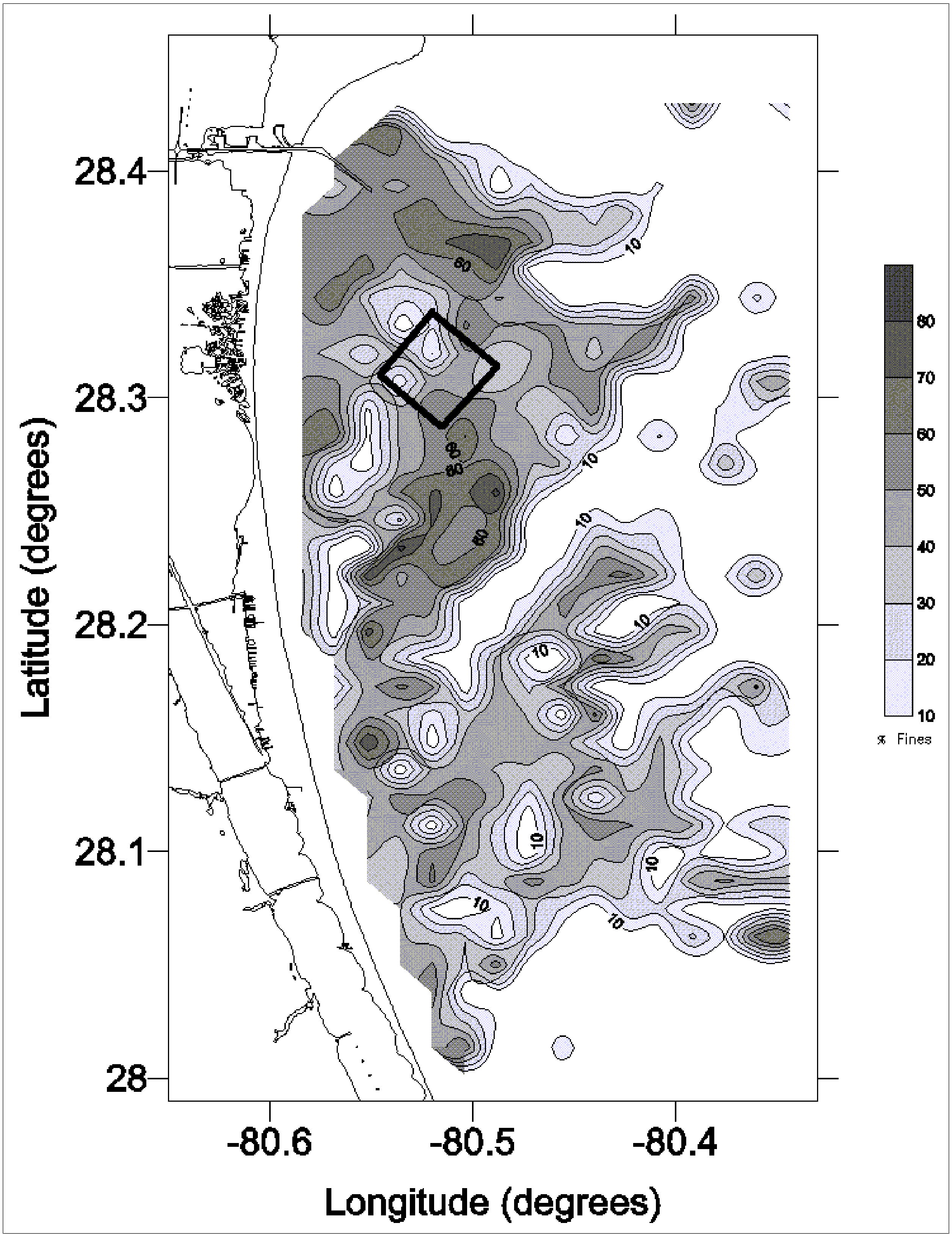

Figure 6: Gridded data (percent fines)

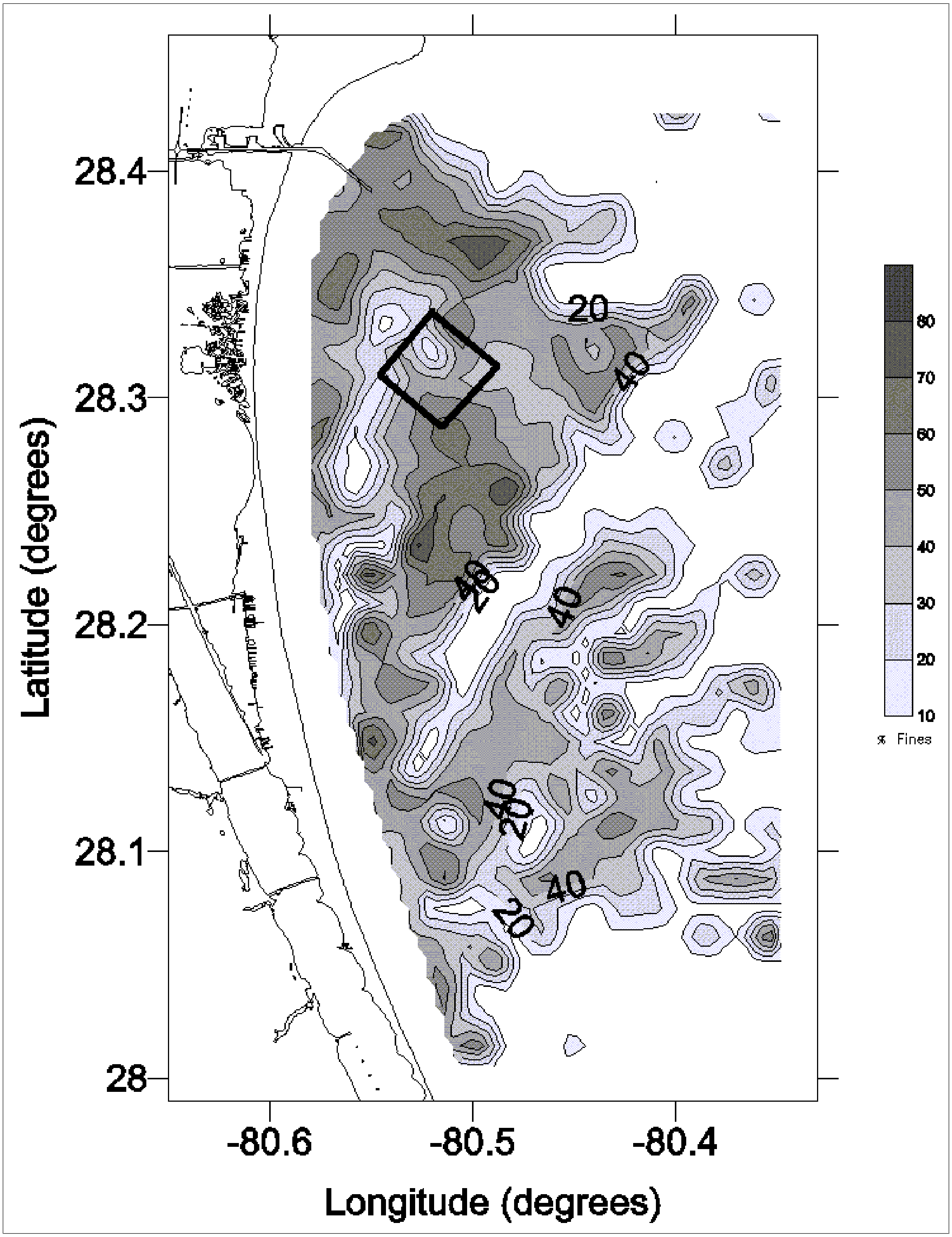

Figure 7: Triangulation method (percent fines)

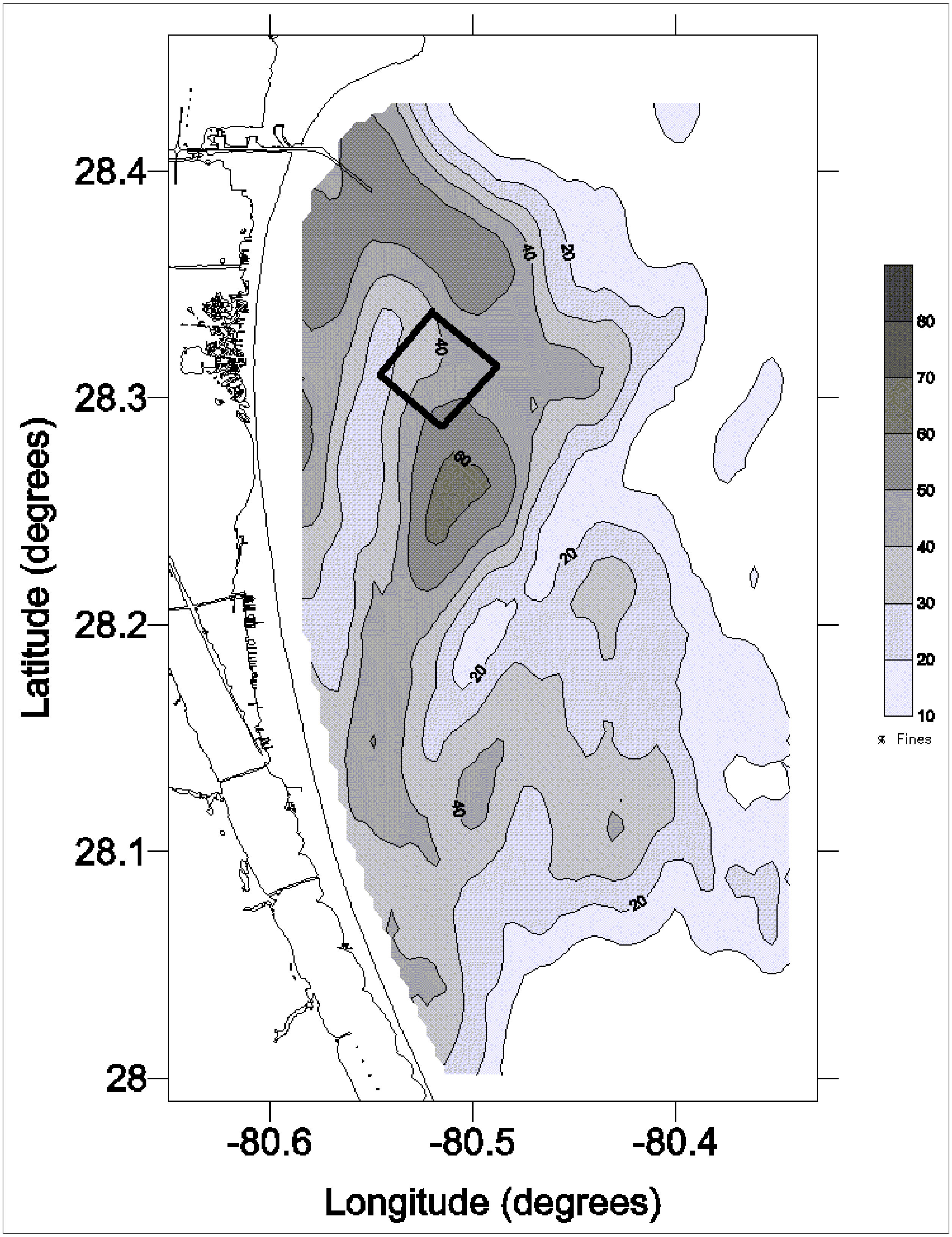

Figure 8: Kriging method (percent fines)

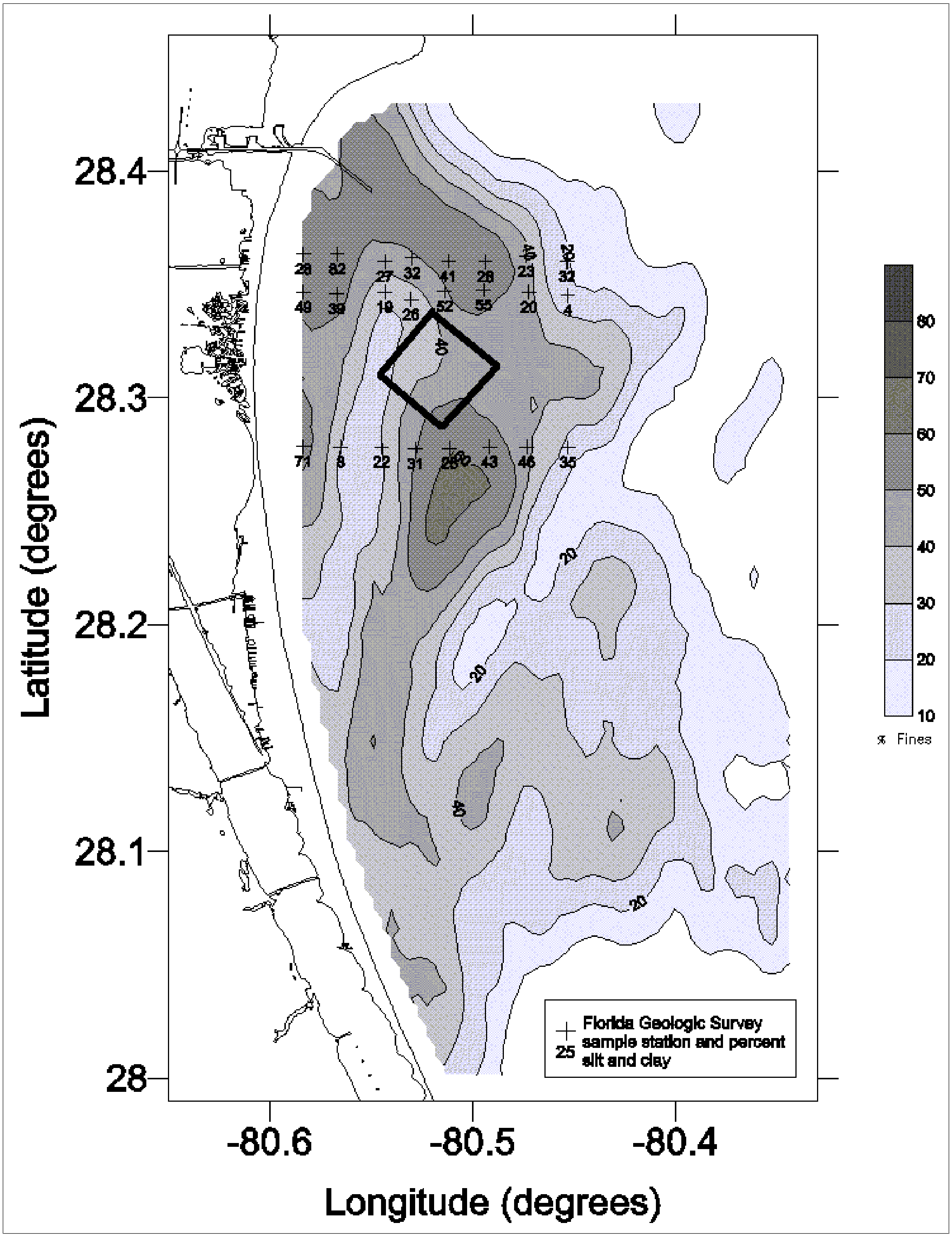

Figure 9: Florida Geological Survey 1995 grain size results and EPA kriging prediction.

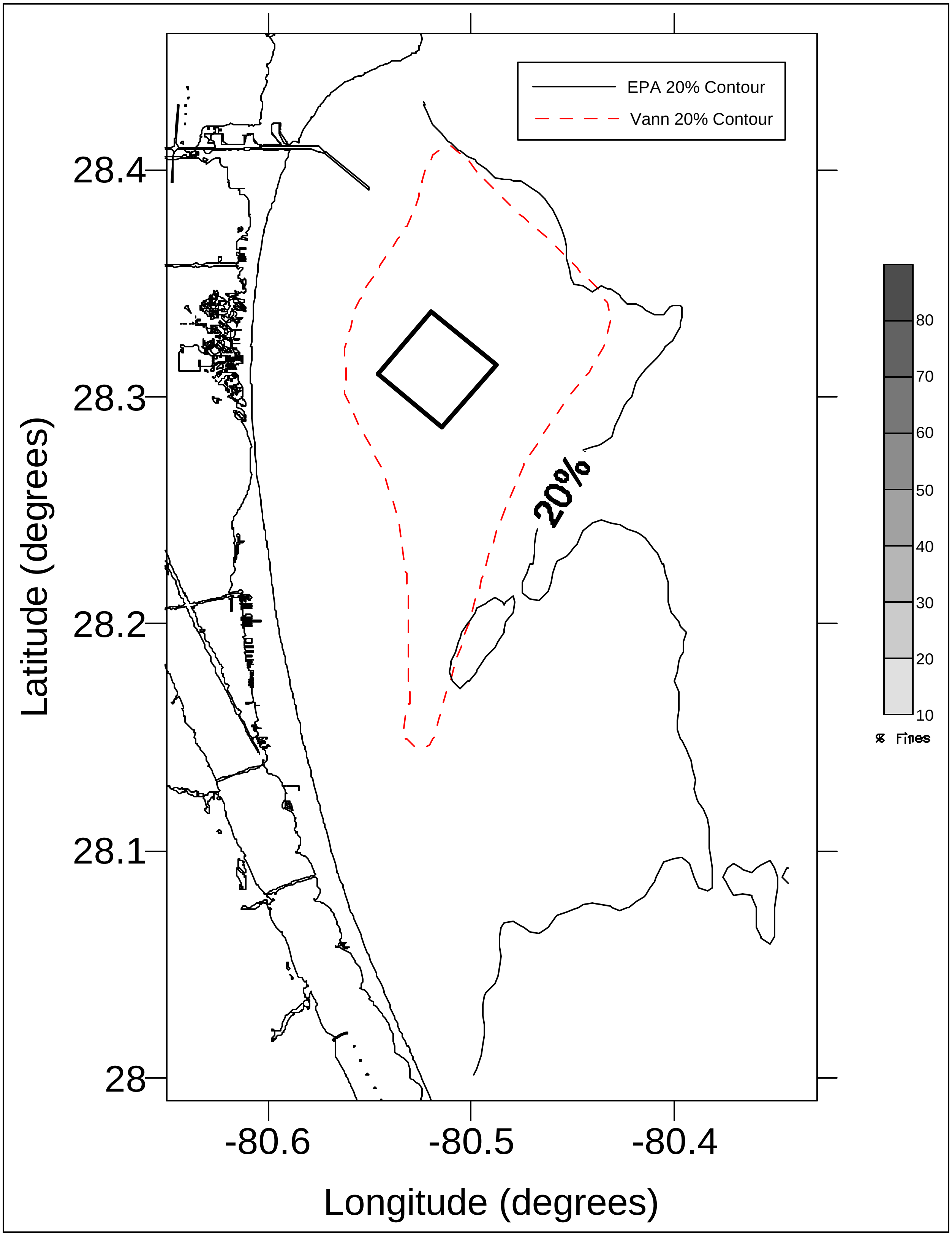

Figure 10: Comparison of the 20% fines contour, EPA versus Vann (1995)

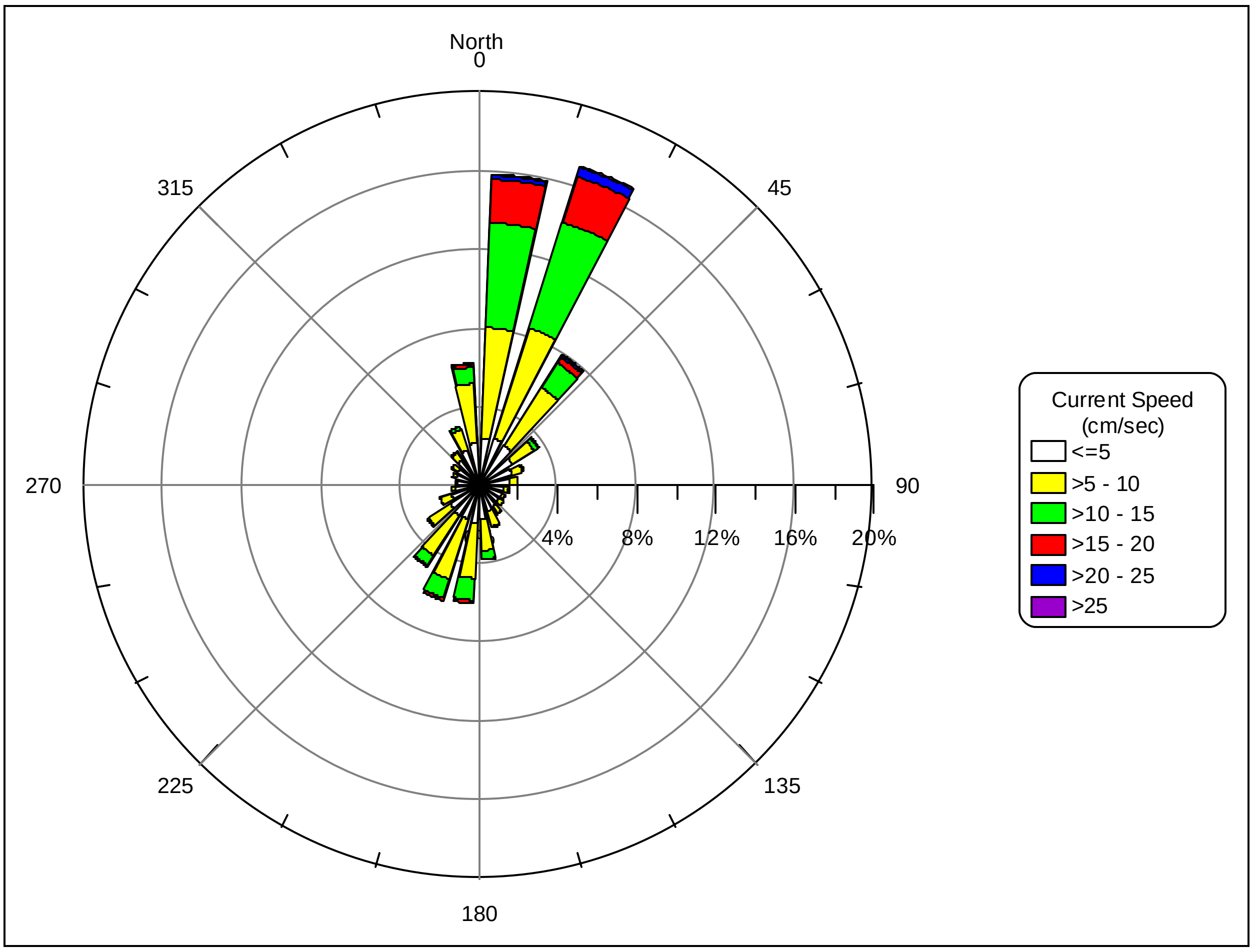

Figure 11: Depth Average Current Rose at the Canaveral ODMDS (EPA, 2004).

6.0 REFERENCES

Florida Geological Survey (2002) *A Geological Investigation of Sand Resources in the Offshore Area Along Florida's Central-East Coast* Final Summary Report, submitted to U.S. Dep. of Interior, Minerals Management Service. August, 2002.

Jongman, R.H.G., C.J.F. ter Braak and O.F.R. van Tongeren, eds. (1987) *Data analysis in community and landscape ecology*. Pudoc Wageningen, Netherlands.

U.S. EPA Region 4 (2001), *Standard Operating Procedure (SOP) for the Determination of Particle Size Class Distribution - Wet Sieve*, Oct. 2001.

U.S. EPA Region 4 (2005), *Ocean Currents and Wave Measurements at the Canaveral Harbor Ocean Dredged Material Disposal Site*, EPA-904-R-05-001. January 2005.

Leecaster, Molly (2003), *Spacial analysis of grain size in Santa Monica Bay* Marine Environmental Research, 56, 67-78.

Vann, Julie. E. (1995) *A Study of Dredged Material Dispersion on the Inner Continental Shelf, Cape Canaveral, Florida* [thesis]. Melbourne, FL; Florida Institute of Technology; 1995.