U. S. Minerals Management Service/
State of North Carolina
Sand Resources Task Force

Preliminary Assessment of Potential Sand Resource Areas Offshore of Nags Head, Kitty Hawk, and Kill Devil Hills, North Carolina

Charles W. Hoffman
North Carolina Geological Survey
Division of Land Resources
Department of Environment and Natural Resources

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Executive Summary

Four areas with the potential for sand resources are identified in federal waters offshore of Dare County, North Carolina. The total sand volume is very roughly estimated as being as much as 77 million cubic yards. The density of data is such that this is only a reconnaissance-level assessment. Considerably more detailed surveys and significantly more sampling is required to "prove" any resources.

Potential sand resources occur in a seismically transparent unit that underlies NE-SW oriented linear topographic highs (shoals) through the southern part of the MMS project area. Seven areas are identified. Three of these, however, are not considered significant due to their distance from the proposed fill areas and the water depths in which these are located. These distal areas are not used in volume estimates.

Vibracores into the seismically transparent unit generally were sandy in the upper 2-4 m (mostly fine- to medium-grained sand). Some muddy intervals were present within the upper parts of these cores; but mud is more common in the lower parts where an underlying, muddier sequence is present. Locally, the transparent seismic facies contains reflectors that indicate it includes channel fill deposits. Vibracore evidence suggests that such fill is usually muddy and not suitable as beach-fill material.

Future studies should focus on the four primary target areas with the goal of developing a more refined geologic model that will permit better assessment of the sand resource. Additional geophysical surveys (seismic and side scan) and closer space core sampling would be the tools employed in such studies.

Introduction

This work is being conducted under a cooperative agreement (# 14-12-0001-30348) between the U. S. Minerals Management Service (MMS) and the State of North Carolina Department of Environment and Natural Resources. Approximately 640 kilometers of shallow, high-resolution seismic data were collected in 1994 by S. W. Snyder of North Carolina State University with colleagues at NCSU and at the North Carolina Geological Survey (NCGS). Interpreted seismic sections were delivered to the NCGS in early 1998 by Snyder and were used by the author for this report. Fifty-seven vibracores totaling about 300 meters (maximum length of 6 meters for each core) were taken in the study area during 1996 by the NCGS. These cores are still undergoing processing and analysis at the time of this report, but textural analyses have been completed for the cores most applicable to the areas initially identified from the seismic data as being of interest. Gridded bathymetric data were provided by Mark Byrnes of Woods Hole Group via FTP. The bathymetric grid spacing is 50 m and the data set includes approximately 275,000 values (about 60 percent of the nodes).

Potential sand resource areas were initially identified through preliminary review of processed seismic data and qualitative classification of vibracores by Boss and Hoffman (1997). That report identified a relatively large part of the Sand Resources Task Force project area as having the potential for sand resources. It identified a geologic unit that seemed to be widespread through the southern part of the MMS study area as being prospective based on its occurrence at the top of the section, somewhat tabular geometry, and the number of "good" cores that occurred within this unit.

The purpose of this report is to refine that initial assessment by reviewing the interpreted seismic data along with descriptions and textural analyses of the vibracores. The timing of this report is being driven in large part by the need for a well defined sand resource area by the contractor who will be conducting baseline environmental surveys for MMS beginning in May 1998. Completion of the data analysis and compilation and considerably more workup of the data are required before the reconnaissance assessment is as complete as it could be. That may occur as a specific task or as part of the more comprehensive framework interpretation that is scheduled to be performed later.

Methods/Results

Figure 1 shows the distribution of project data in the study area and the four potential resource areas (numbered 1 through 4) identified by this study. Three proposed beach fill areas and five potential borrow areas identified by the U. S. Army Corps of Engineers as part of the Northern Dare Project (a cooperative project between the COE, Dare County, and the State) are also shown. The Northern Dare potential borrow sites are as reported by the COE to the NCGS in March of 1997. These are expected to be revised as that project continues.

The potential sand resource areas of this study were identified by tracing a transparent seismic facies through the seismic grid in the southern part of the MMS Task Force area. This part of the study area was emphasized because of the earlier review of the data which indicated a generally more consistent shallow sub-bottom geology versus the northern part of the study area which is characterized by large-scale channeling and a more complex facies architecture. The transparent unit is the same unit as was identified by Boss and Hoffman (1997) as their principle “target” unit. Figure 2 illustrates several seismic cross-sections through identified sand resource areas. Given that the target unit forms topographic highs, the bathymetry data were highly useful in confirming or inferring the continuity of the unit from one seismic line to the next.

The transparancy of the unit may be attributed to either or both of two characteristics. One is that the unit is homogeneous and there is not sufficient internal lithologic variation to produce seismic reflections. Secondly, compacted sand or mud at the surface might have the effect of “masking” any reflections from the initial several meters. In this later case, the true character of the unit is not revealed in the seismic data. The sections illustrated in Figure 2 show differing amounts of internal reflectors within the upper transparent unit. This difference may reflect variation in the seismic data quality as well.

Internal seismic character reflecting interbedding of lithologies or the presence of paleochannels, or at least a significant amount of it, seems to be a negative factor in terms of sand resource potential. Numerous core locations specifically targeted channels in order to test their sand resource potential. One example shown in Figure 2 is core MMS-007, located in a small channel on line SE94-124. Samples from the upper 2 meters of this core contained over 85 percent mud. The overall core averaged more than 30 percent mud.

Cores MMS-014, -014A, -015, -016, -017, and -018 were likewise targeted in a channel complex (Figure 3) that turned out to be of generally poor quality in terms of sand (40-70+ percent mud for whole core). The upper meter of core MMS-017 was in the thinning target unit and analyzed well for sand. Similarly, Core MMS-012 contained good sand in its upper 2.5 m, but was muddy below this depth. Figure 3 clearly illustrates that this core penetrates through the transparent

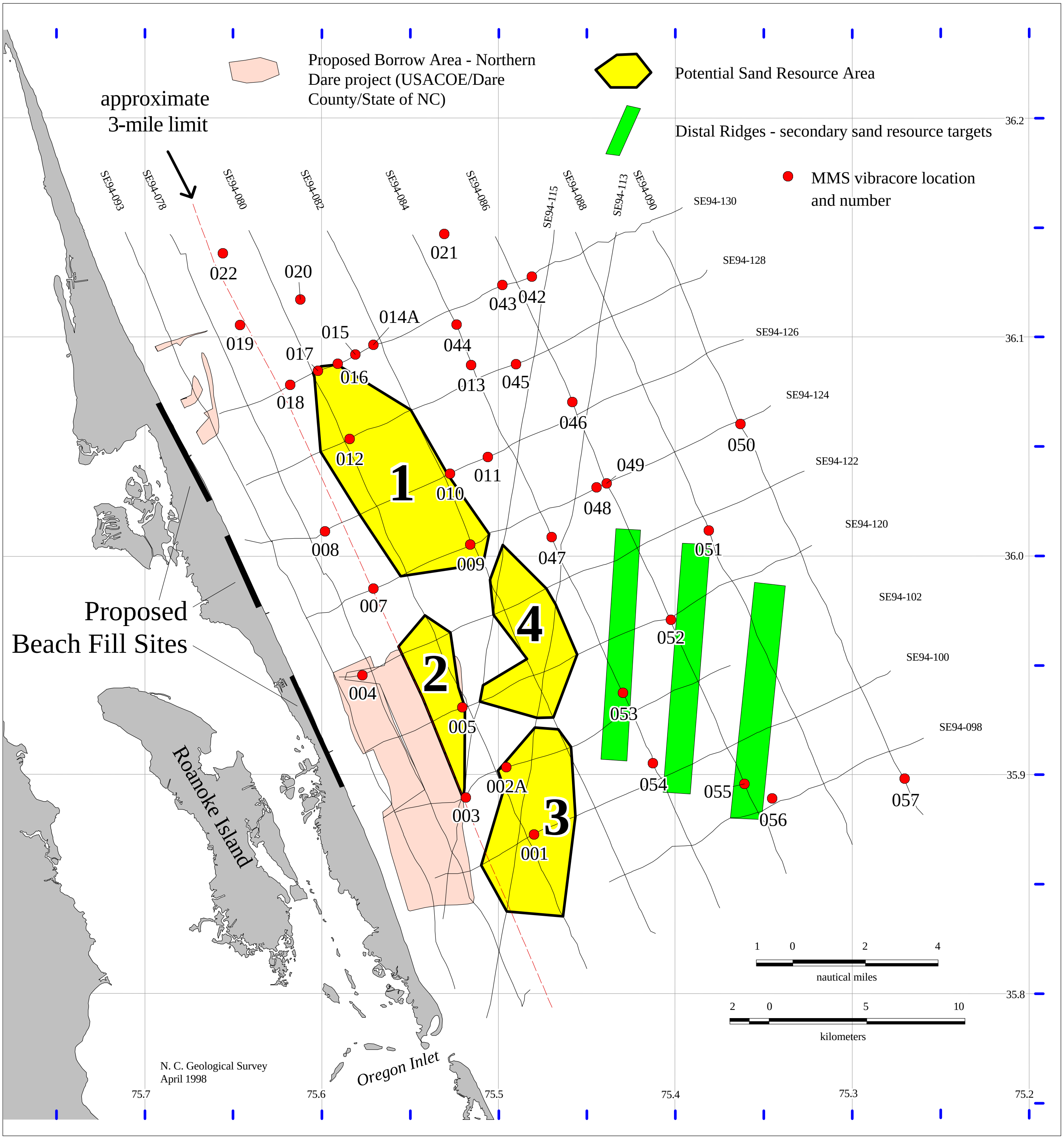


Figure 1. Location map showing project data and potential sand resource areas.

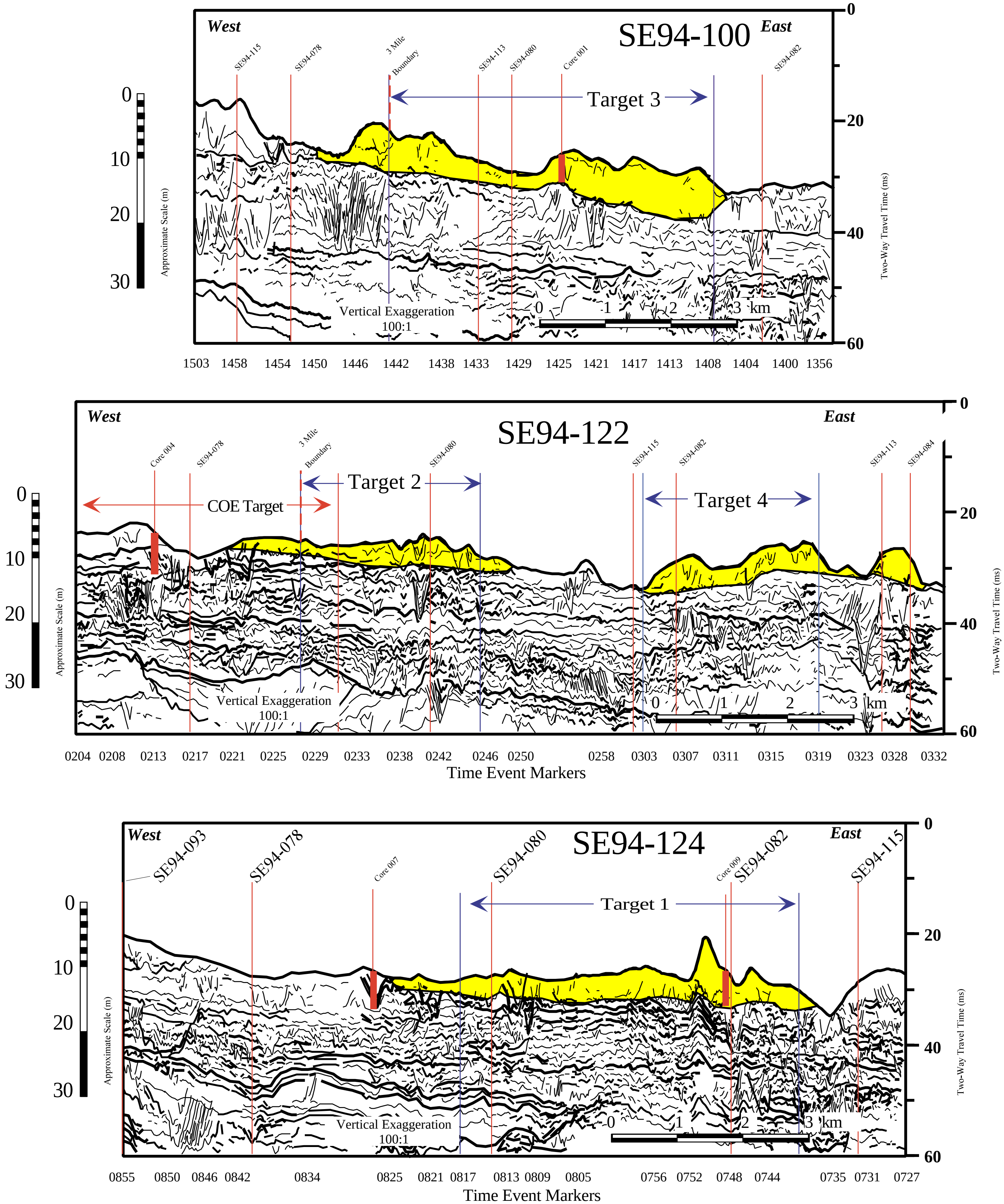


Figure 2. Example seismic sections crossing prospective sand resource areas (targets). See Figure 1 for location information. The seismically transparent unit is shown in yellow.

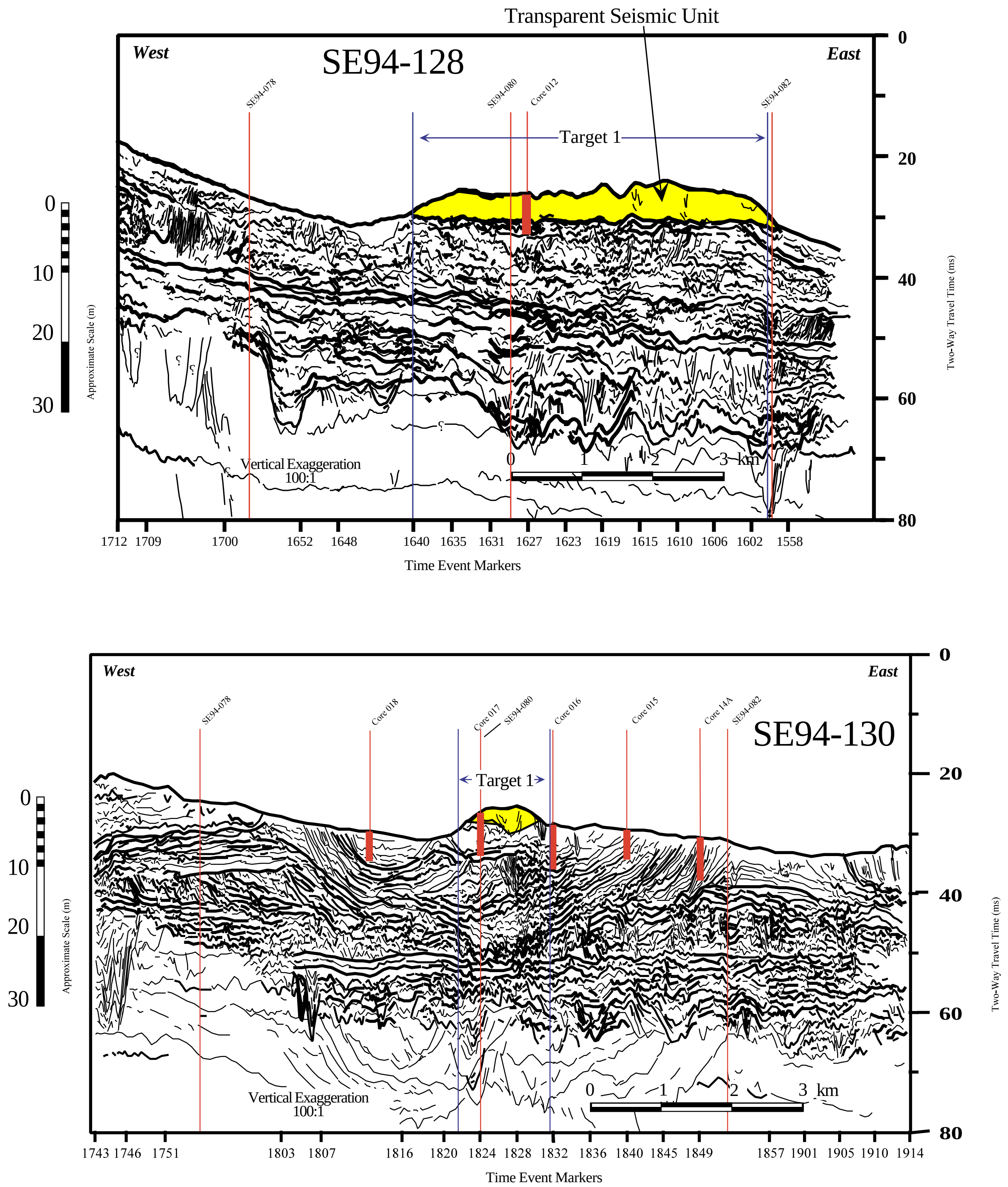


Figure 3. Segment of seismic lines SE94-128 and SE94-130 crossing potential sand resource area 1 (Target 1). Core MMS-012 was logged as 2.5 m of fine- to medium-grained quartz sand overlying interbedded sand and mud (see textural analyses in Table 1). Except for the upper part of Core MMS-016, all the cores shown along line SE94-130 were taken in channel fill facies and contained significant amounts of mud. The seismically transparent facies is highlighted in yellow.

unit into an underlying sequence.

Summary textural data for the cores located within the potential sand resource areas are given in Table 1 and Figure 4. Averages are calculated in the table for the whole core in all cases, and for just the upper portion in those cores where there appears to be a lithologic break in the lower part of the core.

Table 1. Grain size data for vibracores located in identified potential resource areas. Percentages are in weight percent. A medium-weight line (versus the heavier line at the base of the subsample data) marks the break between the resource unit and an underlying unit where applicable. The "Upper" core average is the average values from those samples above this lithologic break.

The < 200 mesh value was generated specifically for comparison with ASTM standards. The material was sieved at standard Ø (= $-\log_2$ diameter (mm)) size intervals (Folk, 1974). The following scale provides guidance in converting Ø units to standard grain size nomenclature:

Gravel = > -1.0 Ø (10 mesh); very coarse sand = -1.0 Ø -0.0 Ø (10x18 mesh); coarse sand = 0.0 Ø - 1.0 Ø (18x35 mesh); medium sand = 1.0 Ø -2.0 Ø (35x60 mesh); fine sand = 2.0 Ø -3.0 Ø (60x120 mesh); very fine sand = 3.0 Ø -4.0 Ø (120x230 mesh); mud = < 4.0 Ø (<230 mesh)

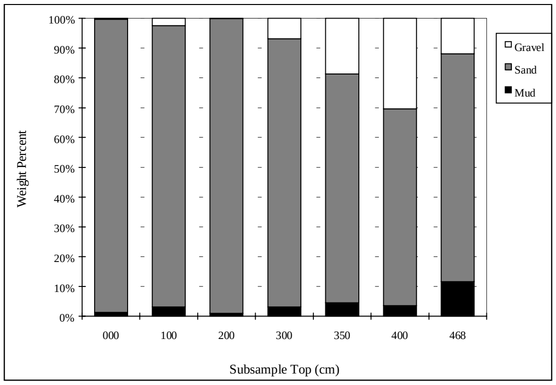
Core	Interval (cm)	<200 mesh	Mud	Sand	Gravel	Mean (Ø)	StDev (Ø)
MMS-001	0 – 5	1.54%	1.34%	99.27%	0.31%	2.23	0.77
	100 – 105	3.40%	3.17%	93.64%	2.43%	2.08	1.05
	200 – 205	1.54%	0.91%	98.15%	0.06%	2.50	0.52
	300 – 305	3.41%	3.07%	89.59%	6.88%	1.63	1.35
	350 – 355	5.58%	4.52%	76.41%	18.59%	1.11	1.79
	400 – 405	4.84%	3.50%	65.85%	30.31%	0.85	1.86
	468 – 473	12.73%	11.52%	76.14%	11.85%	1.23	1.81
Whole Core Average		4.72%	4.01%	85.58%	10.06%	1.66	1.31
"Upper" Core Average		3.38%	2.75%	87.15%	9.77%	1.73	1.22
Length of "upper" interval (m) - 4.3							
MMS-002	000 – 005	1.34%	1.27%	98.13%	0.87%	2.11	0.66
	100 – 105	2.08%	2.04%	95.80%	1.90%	2.05	0.68
	200 – 205	1.48%	1.26%	97.75%	0.11%	2.16	0.61
	300 – 305	1.49%	1.48%	97.80%	0.37%	2.25	0.63
	383 – 388	55.76%	51.69%	47.81%	0.02%	3.60	1.03
	428 – 433	2.13%	1.78%	93.45%	4.54%	2.09	0.80
	470 – 475	3.17%	2.84%	46.27%	50.66%	0.67	1.09
	516 – 521	2.25%	1.98%	48.05%	49.86%	0.47	1.02
Whole Core Average		8.71%	8.04%	78.13%	13.54%	1.92	0.82
"Upper" Core Average		same as whole core					
Length of "upper" interval (m) - 5.2							

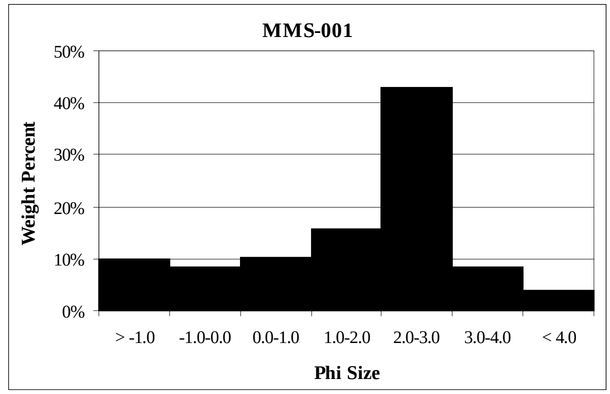
Table 1 (continued)

Core	Interval (cm)			<200 mesh	Mud	Sand	Gravel	Mean(Ø)	StDev(Ø)
MMS-002A	0	–	5	0.81%	0.77%	97.08%	1.58%	1.65	0.90
	100	–	105	2.28%	1.94%	97.69%	0.01%	2.27	0.62
	200	–	205	2.78%	2.51%	97.32%	0.11%	2.26	0.66
	300	–	305	3.16%	2.26%	95.47%	1.35%	2.23	0.90
	346	–	351	1.10%	1.02%	92.05%	6.50%	1.10	1.18
	400	–	405	1.33%	1.17%	94.09%	3.76%	1.57	1.10
	445	–	450	72.84%	72.45%	27.36%	0.11%	3.85	1.15
	500	–	505	4.99%	4.36%	57.16%	38.38%	-0.04	1.52
	564	–	569	14.32%	9.88%	70.85%	18.87%	1.11	1.93
Whole Core Average				11.51%	10.71%	81.01%	7.85%	1.78	1.11
“ Upper” Core Average				1.91%	1.61%	95.62%	2.22%	1.85	0.89
Length of “upper” interval (m) - 4.2									
MMS-005	0	–	5	2.08%	1.94%	96.78%	1.16%	1.92	1.00
	100	–	105	3.03%	2.75%	77.15%	19.96%	1.26	1.55
	200	–	205	1.04%	1.01%	97.77%	0.45%	1.73	0.63
	300	–	305	1.54%	1.44%	76.06%	22.15%	0.52	1.32
	400	–	405	1.77%	1.63%	50.79%	47.66%	-0.18	1.33
	471	–	476	16.39%	15.16%	82.33%	2.02%	2.32	1.35
Whole Core Average				4.31%	3.99%	80.15%	15.56%	1.26	1.20
“Upper “ Core Average				1.89%	1.75%	79.71%	18.27%	1.05	1.17
Length of “selected” interval (m) - 2.5									
MMS-009	0	–	5	1.01%	1.01%	98.61%	0.05%	2.29	0.55
	100	–	105	1.31%	1.31%	98.07%	0.05%	2.45	0.52
	200	–	205	1.58%	1.58%	98.07%	0.02%	2.35	0.62
	300	–	305	1.84%	1.83%	97.46%	0.14%	2.20	0.76
	400	–	405	5.04%	5.03%	94.37%	0.14%	2.68	0.71
	500	–	505	19.91%	19.90%	78.21%	1.38%	2.75	1.16
	558	–	563	9.46%	9.45%	89.12%	1.01%	2.62	1.03
Whole Core Average				5.74%	5.73%	93.42%	0.40%	2.48	0.76
“Upper” Core Average				2.16%	2.15%	97.32%	0.08%	2.39	0.63
Length of “upper” interval (m) - 4.5									
MMS-012	0	–	5	1.24%	1.24%	98.05%	0.10%	1.81	0.74
	100	–	105	2.23%	1.48%	98.05%	0.04%	2.37	0.64
	200	–	205	2.48%	2.47%	96.54%	0.50%	2.19	0.88
	300	–	305	43.21%	33.54%	60.57%	5.68%	3.07	1.68
	400	–	405	91.25%	91.24%	8.87%	0.03%	4.25	0.88
	530	–	535	6.99%	5.43%	35.14%	59.41%	-0.04	1.89
Whole Core Average				24.57%	22.57%	66.20%	10.96%	2.27	1.12
“Upper “ Core Average				2.36%	1.98%	97.29%	0.27%	2.28	0.76
Length of “upper “ interval (m) - 2.5									
MMS-017	0	–	5	3.02%	2.65%	96.55%	0.18%	1.86	0.80
	100	–	105	7.97%	5.23%	89.12%	5.16%	2.63	1.15
	200	–	205	55.91%	45.56%	53.52%	0.42%	3.78	0.91
	300	–	305	80.84%	72.71%	26.92%	0.00%	4.20	0.50
	400	–	405	91.58%	85.50%	14.10%	0.05%	4.32	0.45
	500	–	505	93.05%	89.16%	10.92%	0.00%	4.36	0.47
	590	–	595	20.91%	19.67%	78.99%	1.07%	2.17	1.39
Whole Core Average				50.47%	45.78%	52.87%	0.98%	3.33	0.81
“Upper” Core Average				7.97%	5.23%	89.12%	5.16%	2.63	1.15
Length of “upper” interval (m) - 1.5									

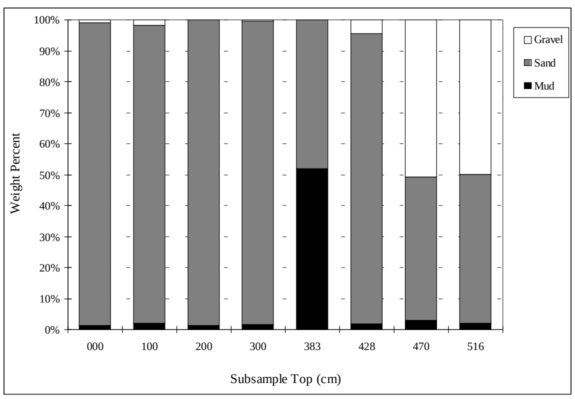
Figure 4. Mud/Sand/Gravel plots for individual subsamples and histograms of average grain size data for all subsamples of given vibracores from the identified sand resource areas. See caption to Table 1 for conversion of phi units to common grain size terms.

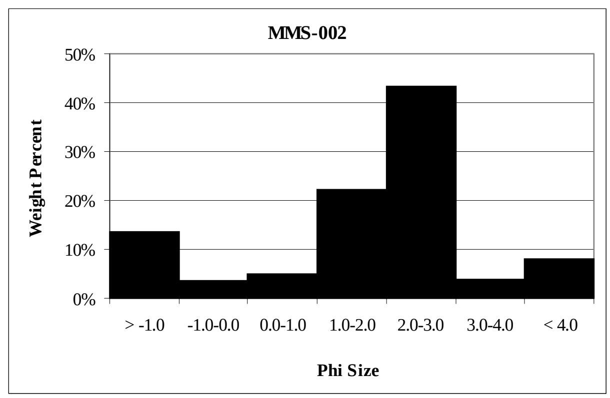
MMS-001





MMS-002





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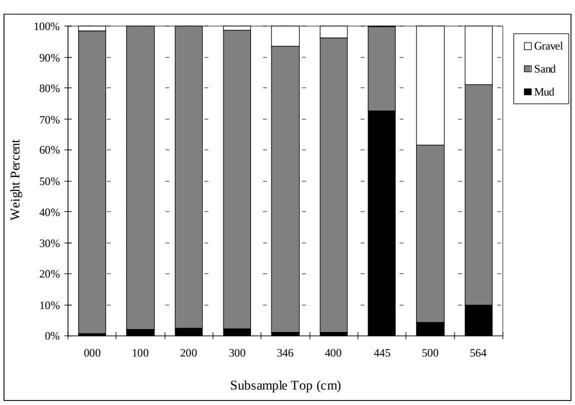


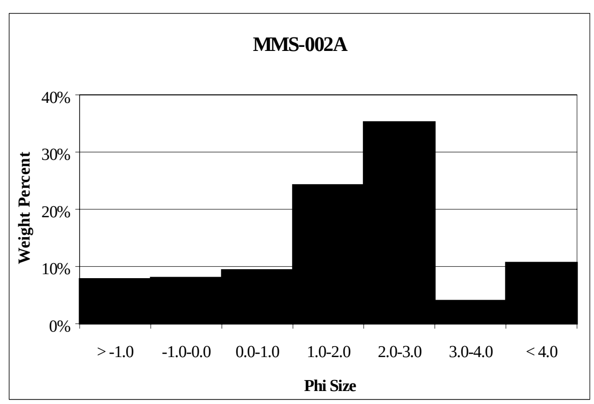
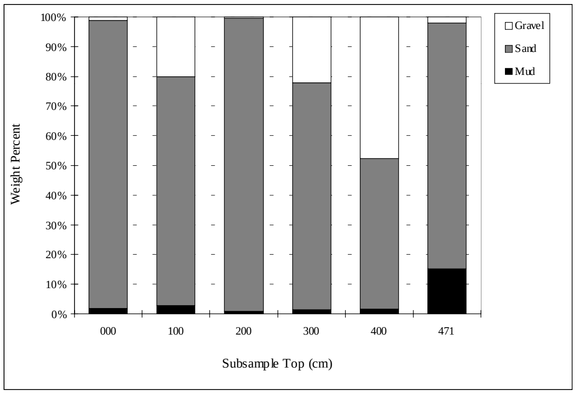
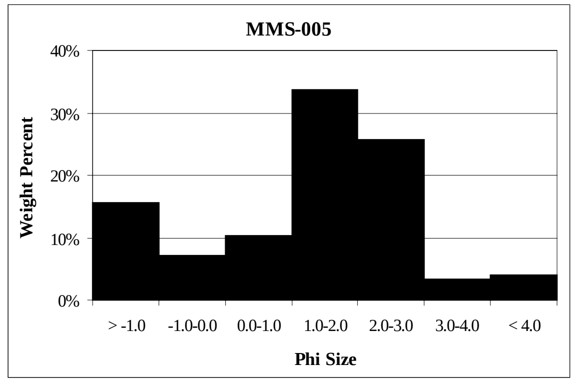


Figure 4 (continued)

MMS-005





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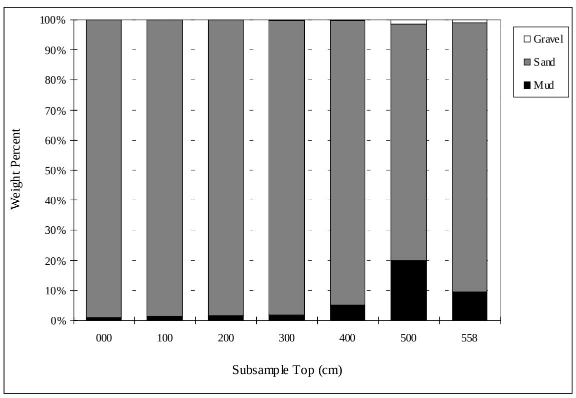
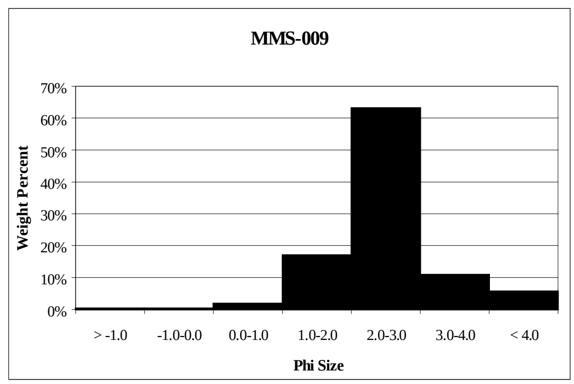
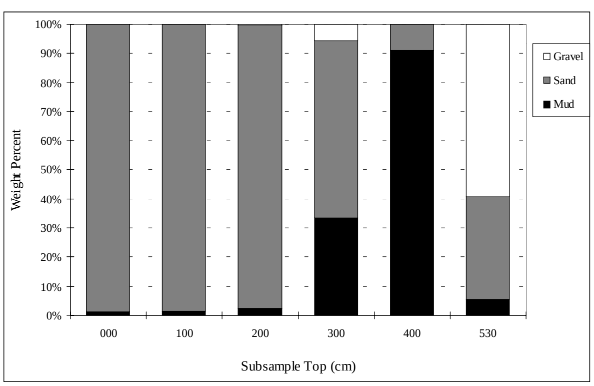




MMS-012



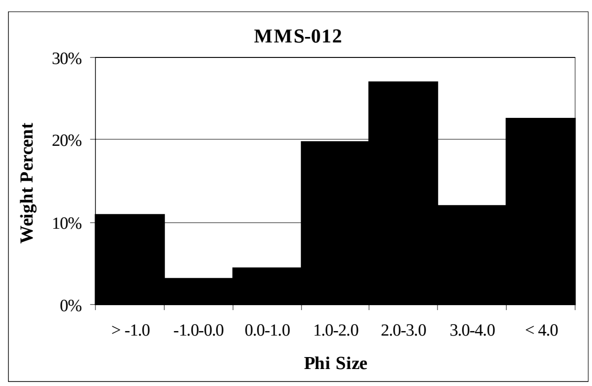
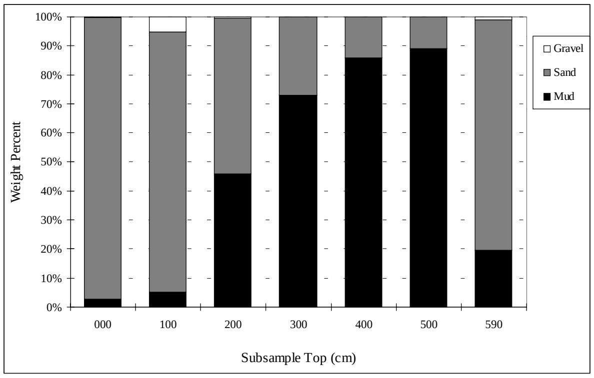
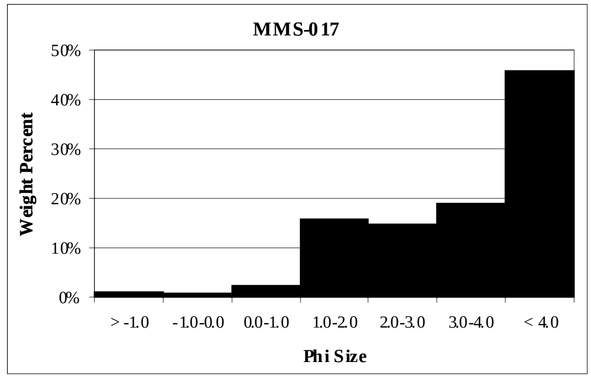


Figure 4 (continued)

MMS-017





Sand Resource Assessment

Assessing the potential for sand resources from such widely-spaced and only preliminarily analyzed data is inexact to say the least. The characteristics of the geology, although tested somewhat by the vibracore data, are “inferred” at best. Textural analyses require a more thorough workup than was possible prior to production of this report. Nevertheless, two iterations of reviewing the seismic data (Boss and Hoffman, 1997; this report) reach basically the same conclusions. The unit being targeted here is the same unit targeted by the COE in the Northern Dare study. Further refinement of the potential resource areas would be likely with additional work and with additional data, but the basic model and approach probably will not change significantly.

Table 2 shows volumetric estimates of the sand resources contained in each of the four potential sand resource areas. The area (in square miles) of each potential resource area was generated directly from the GIS software in which the map was prepared. A thickness of the sand was estimated through review of the seismic sections. As the upper surface is irregular and we have only a few transects across the area, this is a fairly subjective estimate. It was made very conservatively and should be considered a minimum number.

The next step was to further reduce the volumetric estimate to account for further limitations that are expected to restrict minability of the resource. Specific limitations are unknown at this point. As an attempt to ensure that potential resources are not over estimated, the total volume (already conservative because of the minimal thickness value applied) was reduced by 75 percent to arrive at the sand resource estimate. The amount of reduction was arbitrarily chosen and may be way off. It would be misleading, however, to not reduce the total volume by some amount in order to emphasize the fact that probably much less than 100 percent of these areas will contain extractable, suitable sand.

Table 2. Estimates of sand resource volumes within the study areas.

	Area 1	**Area 2**	**Area 3**	**Area 4**
Square Miles	20.0	5.5	13.2	9.3
Square Nautical Miles	15.1	4.2	10.0	7.0
Estimated Average Thickness(ft)	6	8	6	6
Total Volume (M yd^3)	123.9	45.4	81.8	57.6
Estimated Sand Resource* (M yd^3)	31.0	11.4	20.4	14.4
Total of 4 areas ====>	77.2			

* The estimated sand resource is arbitrarily set at 25% of the total volume. This reduction is done to account for operational and geological limitations that are expected to limit the amount of minable material.

One limiting factor will be maximum dredge depth – 60-75 feet is conventionally cited as the limiting operating depth for dredging. The very conservative thickness estimates was intended to account for this limitation, but uncertainties in converting seismic travel time to depth limit the accuracy of the sections in terms of sub-sea depth to the base of a given unit.

Sand quality is another factor that likely will limit how much of these potential resources actually prove out. Even from this preliminary review of the textural data, it is apparent that mud layers and lenses are fairly common within the target unit. Determining the distribution of this undesirable material – whether dispersed or concentrated geographically or startigraphically – is critical to the detailed assessment that remains to be done. It will be important to use the proper tools and techniques to get at this information in any further study. Environmental considerations may also emerge as factors that will limit what areas may or may not be dredged. MMS is just this year beginning to collect baseline environmental data within these areas. Shipwrecks, livebottom areas, impacts from sediment suspended during dredge operations, and fisheries are but a few of the potential limiting environmental factors that may emerge from review of the non-geologic and non-engineering aspects of extracting offshore sand.

Finally, economic feasibility is a significant factor when resources lying in relatively deep water 4 nautical miles and more from the proposed fill sites are being considered. The distal sand ridges identified in Figure 1 are relegated to secondary target status primarily because of their greater distance from shore versus targets 1 through 4. If sufficient sand is present closer to the areas of need (inside of the 3-mile boundary), the sand identified under this study likely would not be used. On the other hand, the Northern Dare Project has yet to identify sufficient sand resources within their study area to sustain a long-term beach nourishment program (David Timpy, personal communication, 1997).

Acknowledgements

Bob Brooks and Bronwyn Kelly, geologic technician and geologist, respectively, with the NCGS Coastal Plain Office, have contributed significantly to this project in generating the core data and assisting with the seismic review and report preparation.

References Cited

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Folk, Robert L., 1974, Petrology of sedimentary rocks, Austin, Texas, Hemphill Publishing Co., 184p.

Appendix A

GIS coordinants for potential sand resource areas. Values are in degrees negative longitude west and latitude north (NAD83 datum).

Area 1

-75.55483	35.99082
-75.50827	35.99647
-75.50498	36.01024
-75.52826	36.03727
-75.54910	36.06677
-75.59079	36.08755
-75.59992	36.08668
-75.60450	36.08380
-75.60369	36.08186
-75.60018	36.04777
-75.57811	36.01895
-75.55483	35.99082

Area 3

-75.46316	35.83563
-75.45609	35.88118
-75.45804	35.90717
-75.45865	35.91282
-75.46585	35.92085
-75.47901	35.92174
-75.49998	35.90211
-75.49644	35.89397
-75.50936	35.85885
-75.49486	35.83771
-75.46316	35.83543
-75.46316	35.83563

Area 2

-75.51948	35.88941
-75.51875	35.89427
-75.51863	35.93096
-75.52216	35.94023
-75.52679	35.96516
-75.54118	35.97299
-75.55608	35.95880
-75.54240	35.93523
-75.53691	35.92432
-75.51948	35.88941

Area 4

-75.46853	35.92628
-75.45502	35.95502
-75.46727	35.97798
-75.47262	35.98529
-75.49707	36.00511
-75.50435	35.98929
-75.50248	35.97324
-75.48351	35.95308
-75.50831	35.94101
-75.51007	35.93353
-75.47781	35.92608
-75.46853	35.92628