

Atlantic Coast of Maryland Shoreline Protection Project: General Reevaluation Study

Overview of Study and Reconsideration of Ebb Shoal as Sand Source for Ocean City

Introduction

The ongoing general reevaluation of the authorized Atlantic Coast of Maryland Shoreline Protection Project is seeking to select additional sources of sand for Ocean City. Based on recent beach nourishment work completed to date, it is estimated that 800,000 cubic yards of sand every 4 years will be needed to maintain existing conditions at Ocean City through the 50 year economic life of the project which ends in 2044. Identified sand sources in state waters are forecast to be exhausted after about 2010; following that, it is anticipated that sand from Federal waters would provide the majority of the material needed for beach nourishment work. Total routine sand needs barring emergencies for the 34 year period from 2010 through 2044 would be 6,800,000 cubic yards. However, it is likely that up to an additional 2,000,000 cubic yards of sand could be needed to undertake emergency repairs. Accordingly, it is forecast that about 8,800,000 cubic yards of sand would be needed after about 2010 to maintain the Ocean City beaches with both routine and emergency nourishment sand through the end of the project's economic life in 2044.

Ocean City is of such economic and social importance that beach nourishment activities are forecast to continue for the foreseeable future, whether implemented by federal, state, county, or city governments. Because of the nature of Maryland coastal geology combined with economic, engineering, and environmental factors, the optimal sources of sand for this purpose are contained in oceanic shoals. Study efforts to date have focused on shore-detached offshore shoals in Federal waters. Previous USACE study reports completed in 1980, 1989, and 1998 considered the ebb shoal as a source of sand for Ocean City. USACE (1989) rejected it out right, while USACE (1998) allowed for dredging of a minor amount of sand from the ebb shoal for Ocean City. This document provides an overview of information relevant to revisiting the issue of whether the ebb shoal can be utilized as a source of sand to meet a more substantial portion of Ocean City's future needs.

Sand of Ocean City Beach

The optimum grain size distribution for nourishment sands typically approximates the grain size distribution that naturally occurs on the beach. If sand placed on the beach is finer than the native sand and or has a significantly different distribution, a larger

replenishment volume will be required. If sand of too coarse a grain size is placed, the beach may assume a steeper profile. The overfill factor is an estimated measure of the number of cubic yards of borrow material required to produce one cubic yard of beach material when the beach profile reaches equilibrium. Overfill factors equal to or slightly greater than 1 are optimal.

Historically from 1929 to 1954 prior to major beach nourishment efforts, median grain size of beach sand at the Maryland/Delaware border was found to range from 2.24 to 1.3 phi (0.20 to 0.41 mm) (USACE, 1966 cited in Ramsey, 1999) (Table 1). Beach sand median grain-size at the Md./Del. boundary was determined to be 2.24 phi (0.212 mm) in 1964 (USACE, 1966 cited in Ramsey, 1999), following major beach nourishment operations that utilized material from bayside sources in 1962 and 1963 (USACE, 1998). Variability in sampling methods, sample location on the beach profile, textural analysis methods, formulas used, and time of year of sampling can limit the ability to directly compare modern data to historic data. Accordingly, historic data although characterizing the beach at the time of sampling should be considered only an approximation of beach sand texture at that time (Ramsey, 1999).

In 1986, prior to regular beach nourishment utilizing offshore sand that began in 1988, Ocean City beach sand was found to have a mean grain size of 1.45 phi (0.36 mm) (USACE, 1989). Following major beach nourishment actions in 1988, 1991, and 1992, sand of the constructed Ocean City beach was found to have a mean grain size of 1.22 phi (0.43 mm) in 1993 (USACE, current study). The historic texture characterizations and 1986 samples when compared to samples taken following regular beach nourishment indicate that beach nourishment has coarsened the beach at Ocean City over its historic condition.

Table 1: Historic beach sand grain-size data from samples at Maryland/Delaware boundary (USACE, 1966 cited in Ramsey, 1999).

Year	Median phi	Median grain size mm	Beach Site
1929	1.75	0.297	Mean high water
1936	1.5	0.354	Mid tide
1950	2.32	0.200	Mean high water
1954	1.3	0.406	Across profile

Currently, the District is striving to identify sand sources that would have an overfill ratio value of from 1.0 to 1.3, provided that the mean grain-size of the placed material is not too coarse. Preliminary analyses (USACE, current study) have determined that sands with a mean grain size greater than 0.45 mm would possibly be considered too coarse when compared to the 1993 samples; sand with a grain size greater than 0.38 mm would be considered possibly too coarse when compared to the 1986 material.

Shore-Detached Offshore Shoals: Regional Context

There are 22 detached offshore shoals that have been inventoried by Maryland Geological Survey in coastal ocean waters off Maryland (Table 2 and Figure 1).

Table 2: Shore-detached offshore and nearshore shoal geomorphic characteristics*. Shoals presented geographically from north (top) to south (bottom). Data not yet compiled for blank table cells.

Tally	Shoal (N to S)	Distance Offshore - Centroid (mi)	Total Sand (yd ³)	Base Water Depth (ft)	Area (mi ²)	Base Length (mi)	Maximum Width (mi)	Shoal Crest Water Depth (ft)	Relief (ft)
1	Fenwick	6.8	211,000,000	-60	10.5		2.5	-12	48
2	Borrow Area 3	3.1							
3	Borrow Area 8	1.5							
4	Weaver	7.2	93,000,000	-60	3.8	4.1	1.4	-24	36
5	Borrow Area 9	3.1							
6	Isle of Wight	7.2	136,000,000	-60	5.5	4.9	1.6	-18	42
7	Borrow Area 2	2.5							
8	E	6.4	31,000,000						
9	A	9.6	103,000,000	-60		3.7	1.5	-32	28
10	Little Gull Bank	3.0	50,000,000	-43	2.9		0.9	-16	27
11	B	11.0	50,000,000	-60	4.4	4.7	1.2	-27	33
12	C	11.3	8,000,000	-60	0.7		0.6	-33	27
13	D	13.1	24,000,000	-60	2.5		0.9	-36	24
14	Great Gull Bank	4.5	63,000,000	-50	2.8		0.9	-17	33
15	Charlene	2.2							
16	F	4.2	55,000,000	-53	5.9	7.0	1.2	-28	25
17	K	8.6	139,000,000	-70	8.5	6.5	1.9	-21	49
18	M	4.6	20,000,000	-55	1.5	2.0	0.9	-19	36
19	H	2.3	42,000,000	-54	4.4	6.9	1.1	-23	31
20	I	3.1	65,000,000	-54	5.1	5.6	1.3	-27	27
21	J	5.9	63,000,000	-63	4.1	3.7	1.5	-22	41
22	L	9.8	72,000,000	-70	4.2	3.4	1.7	-26	44

*Information compiled from a variety of sources, including Conkwright and Gast (1994), Conkwright and Williams (1996), Conkwright and others (2000), MGS (2004), and Wells (1994).

Candidate Shoals and Dredging Impacts

Four detached offshore shoals are currently being considered as sources of sand for Ocean City beginning after about 2010 and continuing through the year 2044 (Table 3 and Figure 1). These shoals were selected from among those off the Maryland coast based upon proximity to Ocean City, and potential for producing an adequate quantity of sand with an appropriate grain-size distribution (however, the grain size of sand within these shoals is generally coarser than that of Ocean City beach). Within these shoals,

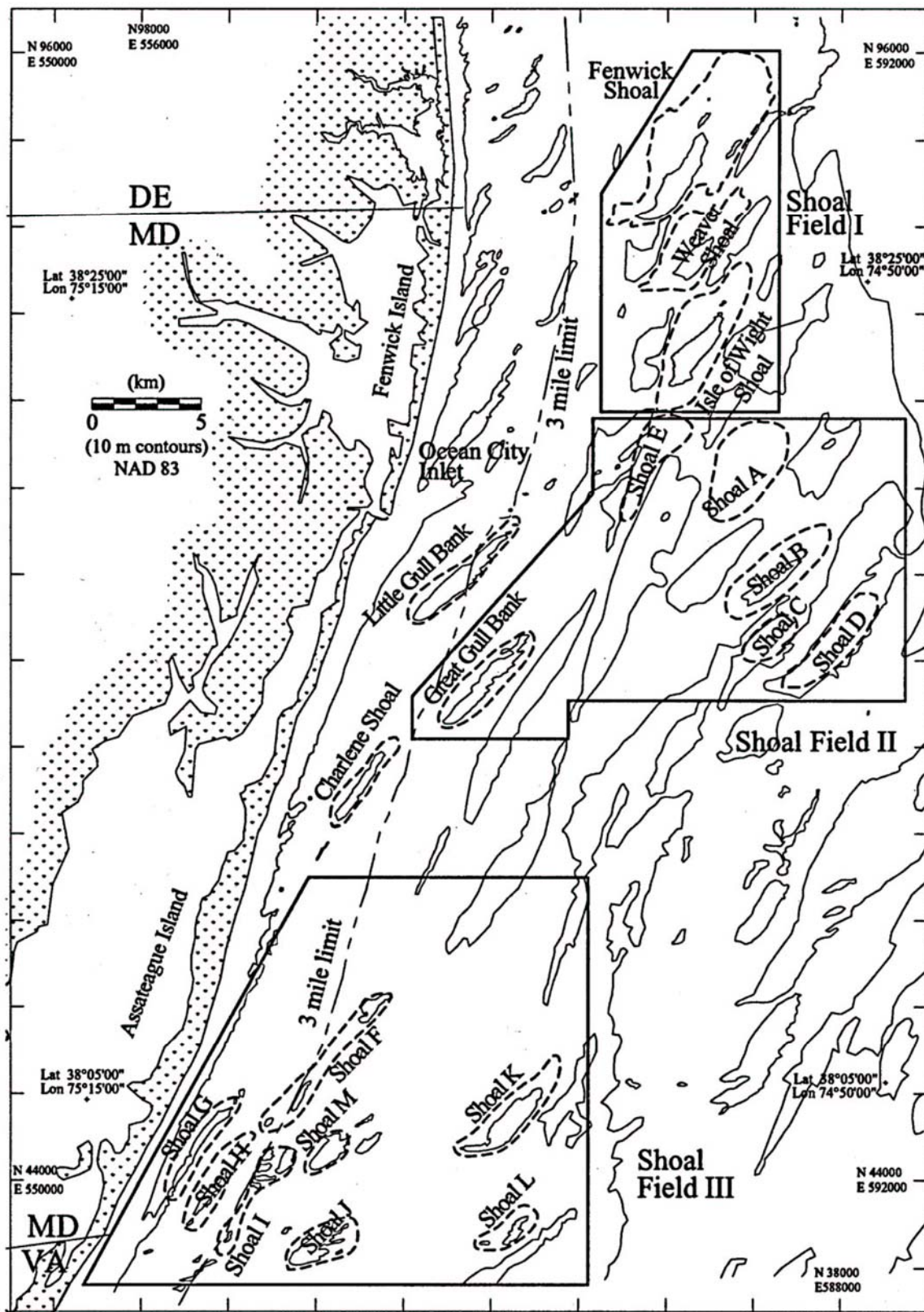


Figure 1: Maryland Geological Survey index of shoal fields.
Grid: MD State Plane Coordinates, NAD 1983, meters.

sub-areas have been preliminarily delineated as potential target borrow areas based on grain-size of sand and lack of artificial reefs.

Table 3: Sands of candidate borrow areas from shoal surface to -60 ft NGVD currently under consideration as sources of sand for Ocean City through 2044.

Shoal (N to S)	Sub-Area	Grain-size range (phi) (means of core intervals)	Grain-size range (mm) (means of core intervals)
Weaver	II	1.11 to 0.80	0.463 to 0.574
Isle of Wight	I	1.72 to 0.56	0.304 to 0.678
	II	0.93 to 0.48	0.525 to 0.717
A	I	1.76 to 1.15	0.295 to 0.451
	III	1.12 to 0.51	0.460 to 0.702
	IV	1.93 to 1.37	0.262 to 0.387
B	I	1.16 to 0.90	0.448 to 0.536

The candidate offshore shoals are natural geologic features that are in a presumed dynamic equilibrium with physical environmental conditions. From this perspective, they can effectively be considered as nonrenewable resources. The offshore shoals are believed to have important habitat functions for marine life (USACE, 1998). Research underway sponsored by the Minerals Management Service is currently investigating the relative importance of several offshore shoals in the study area as habitat for highly mobile finfish and epibenthic invertebrates. Some of the offshore shoals are recognized to be important fishing grounds. However, this may be a product of the presence of artificial reefs rather than of the character of the shoals themselves. Currently, the offshore shoals off Delaware are considered to be of such high value as habitat for finfish that Philadelphia District USACE is being effectively required by the National Marine Service to focus investigations to identify future beach nourishment sand sources on non-shoal areas of the seafloor (Steve Allen, Philadelphia District, personal communication).

The volume of sand the offshore shoals contain is substantially greater than that required to maintain Ocean City. A significant quantity of sand from each of these areas has a grain-size distribution such that an overfill ratio of between 1.0 and about 1.3 would be realized. Dredging plans have not yet been finalized, although several preliminary plans have been given some consideration. If dredging is apportioned among three or four of the shoals, total volume removed would constitute 3% or less of the total volume of any given shoal (Table 4).

Ebb Shoal

USACE (1998) documented evolution of the ebb shoal to -43 ft (-13 m) NGVD from 1933 to 1995. The ebb shoal grew rapidly in size from 1933 to 1962, but from 1962 through 1995 was relatively stable in size. The ebb shoal volume continuously increased from 1933 through 1995, however the rate was most rapid immediately following

Table 4: Provisional Alternative Dredging Plans and Their Impacts to Candidate Borrow Sites4:

			Shoal			
			Weaver	Isle of Wight	A	B
		Total Pre-Project Volume (yd3) (a)	93,000,000	136,000,000	103,000,000	50,000,000
Dredging Alternative	Dredging Description (b)	Dredging Impact				
1	Proportional Removal of 2.6% from Each Candidate Shoals (c)	Shoal Volume Dredged (yd3)	2,400,000	3,500,000	2,700,000	1,300,000
		Shoal Volume Remaining (yd3)	90,600,000	132,500,000	100,300,000	48,700,000
2	Proportional Removal of 3.0% from Weaver, Isle of Wight, and A. No Removal from Shoal B (d)	Shoal Volume Dredged (yd3)	2,800,000	4,100,000	3,100,000	0
		Shoal Volume Remaining (yd3)	90,200,000	131,900,000	99,900,000	50,000,000
3 a-d	All 10,000,000 yd 3 from Individual Candidate Shoal	Percentage of Total Shoal Volume Removed	10.8	7.4	9.7	20.0
		Shoal Volume Remaining (yd3)	83,000,000	126,000,000	93,000,000	40,000,000
4a	Proportional Removal from Weaver and Isle of Wight Shoals Only (No Dredging of A or B)	Percentage of Total Shoal Volume Removed	4.4	4.4	0	0
		Shoal Volume Remaining (yd3)	88,939,000	130,061,000	103,000,000	50,000,000
4b	Proportional Removal from Weaver and A Shoals Only (No Dredging of A or B)	Percentage of Total Shoal Volume Removed	5.1	0	5.1	0
		Shoal Volume Remaining (yd3)	88,255,000	136,000,000	97,745,000	50,000,000
4c	Proportional Removal from Isle of Wight and A Shoals Only (No Dredging of Weaver or B)	Percentage of Total Shoal Volume Removed	0.0	4.2	4.2	0
		Shoal Volume Remaining (yd3)	93,000,000	130,310,000	98,690,000	50,000,000
a) From MGS website:	http://www.mgs.md.gov/coastal/osr/mosr5.html. "Offshore Sand Resources Study Results." July 28, 2004					
b) To allow for uncertainty,	round 8,400,000 yd3 forecast need up to 10,000,000 yd3.					
c) 10,000,000/382,000,000 = 2.6%, thus 2.6% dredged from each						
d) 10,000,000/(382,000,000 - 50,000,000) = 3.0%, thus 3.0% dredged from each						

stabilization of the Ocean City Inlet (Table 5). The ebb shoal is still growing. The ultimate equilibrium volume of the ebb shoal has not yet been determined, but could well be in excess of 4,000,000 yd³ additional sand to -23 ft (-7 m) beyond its 1995 volume; this volume could perhaps be reached in about the year 2040 (Kraus, 2000). Assuming the 1995 growth rate determined in USACE (1998) held constant through the present, ebb shoal volume to -43 ft would have been about 14,430,000 yd³ in October 2004. Implementation of dredging for the LTSM project will likely reduce the rate at which sand is bypassed from the ebb shoal complex to Assateague Island (Kraus, 2000).

Ebb shoal sands were investigated in USACE (1989). Mean sand grain size was found to be 1.89 phi (0.270 mm). This mean is 25% finer than that of the pre-nourishment beach in 1986, and 37% finer than that of the constructed Ocean City beach in 1993. Although the ability to directly compare modern data to historic data is limited as was discussed previously, it is possible that ebb shoal sand mean grain size is within the range of historic beach grain size median data from 1929 to 1954 recorded at the Maryland/Delaware border prior to major beach nourishment efforts.

Table 5: Ebb Shoal volume, area, and growth rate since inlet stabilization to -43 ft.

Date*	Volume (yd ³)	Area (acres)	Volume Increase yd ³ /yr
June 1933	0	0	0
March 1937	1,700,000	203	415,000
May 1962	5,700,000	825	161,000
January 1978	11,700,000	907	379,000
October 1995	13,500,000	899	103,000

*The data presented for January 1978 is derived from surveys conducted in August 1977 and October 1978. The data presented for October 1995 is derived from surveys conducted in July, October, and December of that year.

The ebb shoal is considered to be of lower habitat value for marine life than the offshore shoals because of its highly dynamic conditions. There is little fishing activity focused on the ebb shoal itself, however recreational clammers do access the ebb shoal by boat to clam there (George Ruddy, USFWS, and Jim Casey, Md. DNR, personal communication).

Dredging the Ebb Shoal to Provide Sand for Ocean City

The ebb shoal was considered as a source of sand for Ocean City in several USACE reports (USACE 1980, 1989, and 1998). The ebb shoal was preliminarily identified as one of three potential shoal sources in USACE (1980). Dredging of the ebb shoal to provide sand for Ocean City was considered in greater detail in USACE (1989). Dredging of the ebb shoal for Ocean City was rejected entirely in USACE (1989) because of several major concerns. 1) Potential detrimental impacts to northern Assateague Island could result from increased wave energy. 2) There was a potential for increased shoaling in the inlet vicinity because of the larger volume of sand from the ebb shoal that

would have to be used to compensate for the finer grain size of its sands than of the Ocean City beach. 3) The state of coastal engineering was considered too rudimentary to predict these impacts with any certainty.

Subsequently, USACE (1998) provided for limited dredging of comparatively small amounts of sand ($\sim 20,000 \text{ yd}^3/\text{yr}$) from the ebb shoal for Ocean City under the Long-Term Sand Management (LTSM) project. This dredging would be done in accompaniment with thorough monitoring that would allow for impacts of the project to be carefully evaluated. In the event unacceptable impacts were identified, dredging would be modified to avoid or minimize those unacceptable impacts. The LTSM was implemented in 2004, $\sim 77,100 \text{ yd}^3$ of sand was taken from ebb shoal. Most of this was placed on Assateague, however some went to 33rd St. in Ocean City

Current Reevaluation Study

The current study has not undertaken new detailed investigations of the ebb shoal as a source of sand for Ocean City. However, it is necessary to again give some consideration to the ebb shoal since conditions have fundamentally changed from those of USACE (1989) and USACE (1998). These changes include:

- 1) The Short-term Restoration of Assateague project was completed in 2002 and restored a portion ($1,800,00 \text{ yd}^3$) of the sand lost to the island since inlet stabilization. This has presumably restored a substantial measure of geologic stability to Assateague.
- 2) The Long-Term Sand Management program was implemented in 2004 and is targeted to provide $189,000 \text{ yd}^3/\text{year}$ of sand for the next 25 years from a variety of inlet area sources to northern Assateague. Assuming that this is successfully implemented, this can prevent future losses of sand to Assateague from the stabilized inlet.
- 3) Coastal engineering modeling and forecasting capabilities have increased substantially since 1989. These capabilities are being used currently to evaluate and plan dredging activities of the LTSM, as well as of other coastal engineering activities in the inlet vicinity.
- 4) Ongoing ERDC monitoring and modeling efforts of the inlet area have greatly increased our understanding of sediment transport processes and wave energies in the area; future monitoring and modeling efforts are expected to further increase this knowledge base. The inlet is now among the best-studied in the world.
- 5) Oceanic shoals will be dredged for borrow; whatever is not taken from the ebb shoal will be taken from other shoals. Thus not dredging the anthropogenic, growing ebb shoal would require dredging of nonrenewable features believed to have greater habitat value for marine life.

6) The ebb shoal poses some hazard to navigation in and out of the inlet (the offshore shoals do not pose a navigation hazard).

It has not yet been determined whether dredging the ebb shoal would be cost-effective versus dredging the offshore shoals. The ebb shoal is closer on average to Ocean City than any of the four candidate offshore shoals (Table 6); this factor would serve to reduce costs. However, larger volumes of sand would have to be dredged because of the finer grain size; this would serve to increase costs. It needs to be determined whether large dredges can work the ebb shoal or not; for now it is assumed that only small dredges like the Currituck can operate there well. Limited availability of the Currituck to implement the LTSM is a concern to successful implementation of the project, and could be a great concern if the ebb shoal were to be relied upon as a source of a substantial portion of Ocean City's sand needs. The requirement to use small dredges could reduce production efficiency, requiring many more trips to transport sand than would be required of a larger dredge. The period of the year during which dredging can take place is limited by rough seas during cold weather months and need to not interfere with beach use during warm weather months. The slower sand production rate of small dredges would require that work occur over a much longer period of time, perhaps over multiple consecutive years rather than one effort every several years, or that multiple dredges be used simultaneously, to meet Ocean City sand needs. The costs of alternative plans that could be formulated combining these various factors have not yet been determined. Although the concerns listed above indicate that use of the ebb shoal is problematic currently, it is important to recognize that dredging technology is likely to evolve over time, and that capabilities to acquire sand from the ebb shoal would likely improve in the future.

Table 6: Volume of sand and distance offshore of candidate shoals.

Shoal (N to S)	Total Sand (yd ³)*	“Beach Quality” Sand (yd ³)**	Distance Offshore of Shoal Centroid to Beach at Ocean City (miles)		
			Md./Del. Boundary	Centroid of Ocean City	Southern End of Ocean City
Weaver	93,000,000	82,000,000	7.0	8.3	11.5
Isle of Wight	136,000,000	71,000,000	8.0	7.8	10.2
A	103,000,000		11.0	9.4	10.0
Ebb	13,500,000		9.1	4.7	0.3
B	50,000,000	39,000,000	13.8	11.4	11.0

*For all but ebb shoal information is from MGS. Ebb shoal information is from OCWR 1998.

**Information for E, A, and Ebb Shoal from USACE. Other volumes from MGS

Major concerns remain however, that would require resolution prior to determining that the ebb shoal could be used to provide large quantities of sand to Ocean City. It is anticipated that it would take at least several years to perhaps a decade(s) to collect

sufficient information to make this determination. Major concerns requiring careful consideration include magnitude of:

- 1) Impacts to northern Assateague environmental character and stability from increased wave energy and potential reduction in sediment delivered via natural bypassing.
- 2) Altered wave energies and bathymetries in the vicinity of the inlet and potential impacts to navigation.
- 3) Increased deposition of finer-grain sand impacting environment of inlet vicinity, with those to the coastal bays perhaps being of greatest concern.

Conclusion

It might be determined that the ebb shoal could be safely and economically mined to provide substantial quantities of sand for Ocean City. As long as impacts to the vicinity of the inlet and Assateague are acceptable, and the costs are comparable to that of mining the offshore shoals, there is no clear reason why the ebb shoal could not be mined at a non-renewable rate (i.e., more quickly than it is building up).

References

Conkwright, R.D., and R.A.G. Gast. 1994. Potential offshore sand resources in northern Maryland shoal fields. Coastal and Estuarine Geology File Report No. 94-8. Maryland Geological Survey.

Conkwright, R.D., and C.P. Williams. 1996. Offshore Sand Resources in Central Maryland Shoal Fields. Coastal and Estuarine Geology File Report No. 96-3. Maryland Geological Survey.

Conkwright, R.D., C.P. Williams, and L.B. Christiansen. 2000. Offshore Sand Resources in Northern Maryland Shoal Fields. Coastal and Estuarine Geology File Report No. 00-2. Maryland Geological Survey.

Kraus, N. 2000. Reservoir model of ebb-tidal shoal evolution and sand bypassing. Journal of Waterway, Port, Coastal, and Ocean Engineering, 126(3): 305-313.

Maryland Geological Survey. 2004. "Offshore Sand Resources Study Results" website.<http://www.mgs.md.gov/coastal/osr/mosr5.html>. Accessed July 28, 2004.

Ramsey, K.W. 1999. Beach sand textures from the Atlantic coast of Delaware. Delaware Geological Survey, Open File Report No. 41. 7 pages.
<http://www.udel.edu/dgs/Publications/pubsonline/OFR41.pdf>

U. S. Army Corps of Engineers. 1966. Beach erosion control and hurricane protection along the Delaware Coast: U. S. Army Corps of Engineers, Philadelphia District.

U.S. Army Corps of Engineers. 1980. Atlantic Coast of Maryland and Assateague Island, Virginia Feasibility Report and Final Environmental Impact Statement. Baltimore District. 84 pages plus appendices.

U.S. Army Corps of Engineers. 1989. Atlantic Coast of Maryland Hurricane Protection Project Final General Design Memorandum. Final/August 1989. Baltimore District. Pagination by Chapter, plus appendices.

U.S. Army Corps of Engineers. 1989. Atlantic Coast of Maryland Hurricane Protection Project Renourishment Borrow Study. Final/August 1989. Baltimore District. 7 pages plus appendices.

U.S. Army Corps of Engineers. 1998. Ocean City, Maryland, and vicinity water resources study- final integrated feasibility report and Environmental Impact Statement. U.S. Army Corps of Engineers, Baltimore District.

Wells, D.V., 1994, Non-energy resources and shallow geologic framework of the inner continental margin off Ocean City, Maryland: Maryland Geological Survey Open File Report No. 16, Baltimore, MD.