

Summary of Beach Nourishment along the U.S. Gulf of Mexico Shoreline

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ABSTRACT

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This paper expands and revises the original Gulf of Mexico beach nourishment database of DIXON and PILKEY (1989) by summarizing the beach nourishment experience up to 1996. Information is presented concerning 158 nourishment episodes along 60 beaches totaling over 78,000,000 cubic yards of emplaced sand from Corpus Christi, Texas to Marco Island, Florida. In recent years, the number, volume and average length of beach nourishments per year has increased.

ADDITIONAL INDEX WORDS: *Replenishment, erosion control, volume, funding.*



INTRODUCTION

The importance of beach nourishment as a coastal erosion management option for the Gulf of Mexico was discussed by DIXON and PILKEY (1989), "The Purple Report" USACE (1993) and the special NRC panel report on nourishment (NRC, 1995). Characterized as "soft stabilization", beach nourishment is often preferred to seawalls, groins and other "hard structures" which have been shown to have deleterious effects on beaches. The first attempts to document the full extent of beach nourishment were made by PILKEY and CLAYTON (1989), DIXON and PILKEY (1989) and CLAYTON (1989) and LEONARD, CLAYTON, DIXON and PILKEY (1989). Other attempts to document the extent of beach nourishment at a regional and national level have focused only on federally funded projects (SUDAR *et al.*, 1995 and IWR, 1993). This paper updates DIXON and PILKEY (1989) for projects from 1987 through 1996 with information (when available) on year, location, volume, length, cost and funding type for each project. Some gaps in the original database have been filled by the correction of inaccurate information on previously identified projects as well as through the addition of previously unknown project data. This research remains an open effort to refine and close gaps in the database.

For purposes of this study, the term *nourishment* has been taken to encompass all instances in which sand has been emplaced either by truck or dredge on beaches or within the nearshore. The term *project* is used to indicate the full series of individual nourishment events at a single location. *Episode* is used to refer to a single nourishment event on a given beach. Both projects with specifically designed life spans (*i.e.*, Federal Storm & Erosion) and nondesigned projects (*i.e.*, Federal Navigation) have been included in this database. Approximately 60 projects were identified as the site of at least

158 variously funded nourishment episodes (Table 1). Ninety-two of the 158 episodes are located on Florida's central to southern coast, especially within Pinellas County (Figure 1). Information on three projects (Panama City, Treasure Island, and Sand Key IV), planned for 1997 are included in the table but excluded from the graphs of cumulative volume (Figure 2) and decadal volume (Figure 3).

The variety of record keeping practices employed by funding and governing entities leads to variation in the extent, type and accuracy of data on any given project. Despite a clear shortage of information with regards to certain parameters (especially cost and length), this database represents the most complete collection of project information available. Some episodes may have been missed and possibly forever lost from all record keeping sources (especially small local and private projects). Additionally, factual discrepancies often exist between sources leaving the details of some projects forever in dispute. Taken in full, however, the data set presented herein gives a rather complete picture of the overall experience of beach nourishment along the Gulf of Mexico and will serve well as a starting point of discussion for all parties interested in examining its use as a coastal erosion management strategy.

METHODS

A variety of methods have been employed in obtaining the data presented in this paper. Information came from a wide array of sources as evidenced by the reference list. Useful information was obtained from U.S. Army Corps of Engineers officials, state and local coastal managers and permitting agents as well as both academic researchers and consulting engineers with projects in the region.

Whenever possible, primary sources (*i.e.* permit and project files, government reports, payment statements and personal communications) were utilized over secondary sources (brief

Table 1. List of beach nourishment projects along the Gulf of Mexico shoreline. "Type" refers to principle or sole funding category. For additional explanation of funding type, see text section Project Funding Categories.

Location	Year	Type	Volume (cubic yards)	Length (miles)	Cost (\$)	References
South Padre Island, TX	1989	Federal Navigation	1,300,000			138, 152, 153
	1997	Federal Navigation	500,000	1.3		138, 152, 153
GIWW Channel—Port Mansfield, TX	1986	Federal Navigation	73,000			138
	1988	Federal Navigation	132,000			138
Corpus Christi, TX	1978	Federal Storm & Erosion	871,000	1.4	3,087,000	10, 11, 12, 18, 147
	1985	Federal Storm & Erosion			4,415,000	11
	1986	Federal Storm & Erosion	38,000		399,000	147
Sargent Beach, TX	1988	Federal Navigation	150,000			138
Surfside, TX	1991	Federal Navigation	600,000			138
	1988	Federal Navigation	132,000			138
Galveston, TX	1985	Private	14,989	0.28	21,275	13
	1994–1995	State/Local	710,000	3.6	5,900,000	14, 15, 16, 17, 19
Rollover, TX	1956		6,000			151
	1997	Federal Navigation	100,000	0.1		153
Mermentau River, LA	1987	Federal Navigation	125,000			138
Isles Dernieres, LA	1985	State/Local	400,000		841,980	24, 27, 121
	1996	State/Local	100,000		450,000	121
Fourchon, LA	1986	State/Local	653,975			25
Grand Isle, LA	1954–1955	State/Local	1,150,000	1.4	188,000	20, 21, 22
	1957	Emergency	140,000	4.5	76,000	20
	1961–1962	State/Local	350,000	1.4	115,000	20
	1966	Emergency	550,000		447,000	20
	1972	State/Local	640,000		595,200	125
	1976	Emergency				23
	1983–1984	Federal Storm & Erosion	2,800,000	7.5	8,640,000	20, 23, 1
	1985	Federal Storm & Erosion	2,970,000	7	10,500,000	125, 147
1987	Federal Storm & Erosion				26	
1988	Federal Storm & Erosion	473,000		1,745,000	125	
1990–1991	Emergency	1,422,000		10,934,000	26, 125, 147	
1994	Federal Storm & Erosion	310,000		2,491,000	125, 147	
Waveland, MS	1994	State/Local	600,000	2	2,000,000	121
Harrison County, MS	1952–1953	Federal Storm & Erosion	7,004,000	26	3,001,800	1, 28, 29, 30, 31, 32, 147
	1962	Federal Storm & Erosion				147
	1964	Federal Storm & Erosion	200,000			31, 32
	1972–1973	Federal Storm & Erosion	1,923,443	26		1, 28, 30, 31, 147
	1988	Federal Storm & Erosion	1,500,000			147
City of Bay St. Louis, MS	1942	State/Local				33
City of Bay St. Louis, MS	1967	Emergency		6.1		33
West Ship Island, MS	1974	State/Local	500,000			34
	1980	State/Local	100,000			34
	1984	State/Local	210,000			34
	1991	State/Local	58,000	0.13		34
	1996	State/Local	55,000			35
Dauphin Island, AL	1996	Federal Navigation	20,000			35
Perdido Pass, AL	1986	Federal Navigation	660,000			138
Perdido Key, FL	1985	Federal Navigation	2,433,000	1		37, 39
	1989–1990	Federal Navigation	5,362,597	4.72		113
Pensacola Harbor, FL	1986	Federal Navigation	35,000			138
Santa Rosa Island, FL	1961	State/Local	75,300			40
Destin, FL	1986	State/Local	182,000			38, 138
	1987	State/Local	126,000			38, 138
	1988	State/Local	125,000			138
	1986	State/Local	500,000			138
Port St. Joe Harbor	1986	State/Local	500,000			138
Appalachicola, FL	1986	Federal Navigation	138,000			138
Panama City Beach, FL	1976	Emergency	232,000	5.06		71
	1982	Federal Navigation	347,000	1		38
	1984	Federal Navigation	320,000	1		38
	1986	Federal Navigation	221,000	1		38, 138
	1988	Federal Navigation	225,000			138
	1996	Federal Navigation	98,990			72
Panama City, FL—planned	1997–1998	Emergency	7,000,000	17.9	33,000,000	71
Mexico Beach, FL	1965–1970	State/Local	101,250	0.7	41,000	41, 42
	1971–1975	State/Local	100,000	0.6		41, 42
St. Joseph Spit, FL	1980	Federal Navigation	332,000	0.6		38
	1985–1986	Federal Navigation	500,000	0.6	80,000	38

Table 1. *Continued.*

Location	Year	Type	Volume (cubic yards)	Length (miles)	Cost (\$)	References
Honeymoon Island, FL	1969	State/Local	1,440,000			75, 76
	1989	State/Local	230,000	0.5		75, 76, 128, 129
Clearwater Beach, FL	1949-1951	State/Local	200,000			74
	1950	State/Local	150,000			43
Clearwater Beach, FL	1981	Federal Navigation	180,000	0.6		43
	1984	State/Local	80,000			77
Sand Key, FL North End	1973	Federal Navigation	126,000			77
	1977	Federal Navigation	186,000			77
	1981-1983	State/Local	600,000			77
	1984	State/Local	240,000			77
Belleair Beach, FL	1992-1993	State/Local	82,300			78, 79, 80
Sand Key Phase IV (planned)	1997	Federal Storm & Erosion	2,079,000		5,300,000	81
Indian Shores, Sand Key Phase-III	1992	Federal Storm & Erosion	480,000	2.2	14,300,000	82, 131, 132
Indian Rocks, Sand Key Phase-II	1990	Federal Storm & Erosion	1,300,000	2.6	14,150,000	83, 84, 113, 139, 140, 141, 142
North Redington Beach, FL	1981-1983	Federal Storm & Erosion	19,144	0.3	369,000	41, 42
	1986	Federal Storm & Erosion	30,000	0.07		85
Sand Key, FL Phase-I	1988	Federal Storm & Erosion	529,150	1.6		85, 86, 87, 88, 89, 128, 143
Madeira Beach, FL	1961	State/Local	30,000	2	300,000	43
Treasure Island, FL	1964	Federal Storm & Erosion	10,000		6,500	43
	1966	Federal Storm & Erosion				47
	1968	Emergency	120,000		114,000	127, 147
	1969	Federal Storm & Erosion	820,000	1.7	595,000	31, 32, 43, 44, 48, 147
	1971	Federal Storm & Erosion	76,000	0.3	216,000	1, 31, 44, 48, 147
	1972	Federal Storm & Erosion	150,000	0.4	185,700	1, 31, 43, 48, 51, 147
	1976	Federal Storm & Erosion	405,000	1.5	1,149,000	43, 51, 147
	1978	Federal Storm & Erosion	50,000	0.4	224,000	51, 147
	1981	Federal Navigation	70,000			51
	1983	Federal Storm & Erosion	220,000	0.8		51, 147
	1986	Emergency	555,000	1.7	3,500,000	1, 147
(planned)	1997	Federal Storm & Erosion	142,500		2,000,000	91
Upham Beach, FL	1968	State/Local	30,000			51, 52
	1975-1976	State/Local	80,000	0.5	230,000	31, 41, 43
	1979	State/Local	254,000	0.5		41, 42, 44
	1980	Federal Storm & Erosion	243,000	0.5	779,000	51, 93
	1986	Federal Storm & Erosion	175,000			1
	1996	Federal Storm & Erosion	230,000	0.4	2,200,000	92, 124, 133
St. Petersburg Beach, FL	1971-1975	State/Local	25,000	0.5	683,000	1, 41, 42
Mullet Key, FL	1964	State/Local	140,000	0.8	236,000	31, 54
	1972-1973	Federal Storm & Erosion	505,000	1.3	597,000	31, 44, 54
	1977	Federal Storm & Erosion				1, 47
Anna Maria Key, FL	1963	Federal Navigation				55
	1977-1978	Federal Navigation	206,000			51
	1985	Federal Navigation				1
	1993	State/Local	2,320,000	4.6	13,200,000	95
Longboat Key, FL	1977-1978	Federal Navigation	101,480			1, 98
	1982	Federal Navigation	100,000			98
	1993	Federal Storm & Erosion	3,130,000	9.28		96, 100, 101, 102, 132
Lido Key, FL	1964	Federal Navigation	123,000		69,000	50, 56, 103
	1970	Federal Storm & Erosion	350,000	1.2	333,000	1, 13, 56
	1974	Federal Storm & Erosion	250,000	1.2	458,000	50, 57, 58
	1977	Federal Storm & Erosion	350,000	1.2	610,000	41, 50, 56
	1980	Federal Navigation	185,000			44
	1982	Federal Navigation	92,000			44
	1985	Federal Navigation	239,000		886,000	56, 98
	1991	State/Local		0.75	1,500,000	96
Venice Beach, FL	1963	Federal Navigation				56
	1971-1975	State/Local				41, 42
	1979-1980	Emergency				56
	1994	Federal Storm & Erosion	902,254	3.2	19,000,000	96, 104, 123, 135, 136, 137
	phase1					
	1996	Federal Storm & Erosion		1.9		123, 135, 136, 137
	phase2					
Port Charlotte Beach, FL	1980	Federal Navigation	49,700	1.1		50, 59, 60
Gasparilla Island, FL	1981	Federal Navigation	264,000	3.6	3,800,000	61, 106
	1993	Federal Navigation		2	2,500,000	96

Table 1. *Continued.*

Location	Year	Type	Volume (cubic yards)	Length (miles)	Cost (\$)	References
Captiva Island, FL	1961	Federal Storm & Erosion				62
	1962	Federal Storm & Erosion				63
	1962-1963	Federal Storm & Erosion				64
	1963	Federal Storm & Erosion				63
	1964-1967	Federal Storm & Erosion				63, 65
	1965	Federal Storm & Erosion				63, 65
South Seas Plantation, FL	1988-1989	Federal Storm & Erosion	1,595,000	4.7		87, 109, 112, 143, 147
	1981	Private	655,500	1.9	3,600,000	87, 109, 127, 143
	1985	Emergency	3,300	0.9		1, 60, 66, 67, 68, 69
Sanibel, FL	1995	Private		4.9		133
	1995	State/Local		0.7		133
Fort Myers Beach, FL	1961-1987	Federal Navigation	767,000			61
	1986	Federal Navigation	119,000			138
Bonita Beach, FL	1976	State/Local				61
	1995	State/Local	198,000	0.776	1,100,000	118, 119, 120, 121, 133
Naples-Gordon Pass, FL	FY 1986	Federal Navigation	119,000			138
Barefoot Beach, FL	1991	Federal Navigation				144
Wiggins State Park, FL	1993	Federal Navigation	35,000			145
	1995	Federal Navigation				146
Vanderbilt Beach, FL	1983	Private	48,000			70
Vanderbilt Beach, FL	1995	Federal Navigation	42,000			116
Vanderbilt/Park Shore/Naples, FL	1996	Federal Storm & Erosion	1,132,000	5.71	10,000,000	114, 115, 116, 122
Keewaydin Island, FL	1963	Federal Navigation	524,000			70
	1964	Federal Navigation	10,000			70
	1968	Federal Navigation	8,800			70
	1970	Federal Navigation	140,000			70
	1980	Federal Navigation	235,000			70
	1985	Federal Navigation	120,000			70
Marco Island, FL	1989	State/Local	1,200,000	1.7	5,287,852	111, 116, 126
	1995	State/Local	2,400			110

references in literature or mass media articles). Additionally, whenever possible, the most recent data was always taken over pre-completion estimates especially in regards to volume and cost data. In a number of projects the only record came from either brief citations in professional literature or from the personal memories of professionals within the field.

The efforts of this study were encumbered by the scattered and incomplete nature of attainable data on nourishment projects. Project data parameters (location, date, volume,

funding type, length and cost) were chosen as those which would be of most interest to researchers as well as the most commonly recorded facts about a project. "Gaps" in the database (Table 1) abound; at the present time for the 158 identified nourishment episodes, cost is known for 56 episodes (35%), volume data for 131 episodes (83%), and length data for 64 episodes (40%). "Complete" records, those in which data on all parameters were known, occurred with only 39 episodes (25%). The record of beach nourishment projects

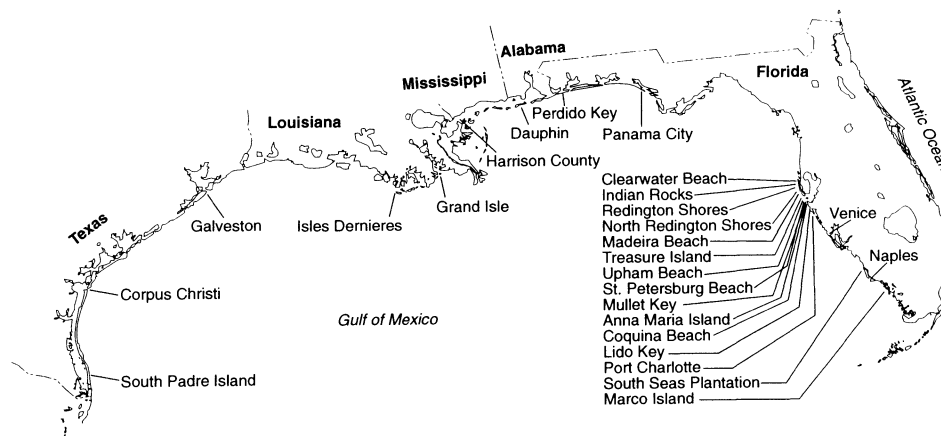


Figure 1. Index map of selected Gulf of Mexico nourishment projects. For a complete listing of projects see Table 1.

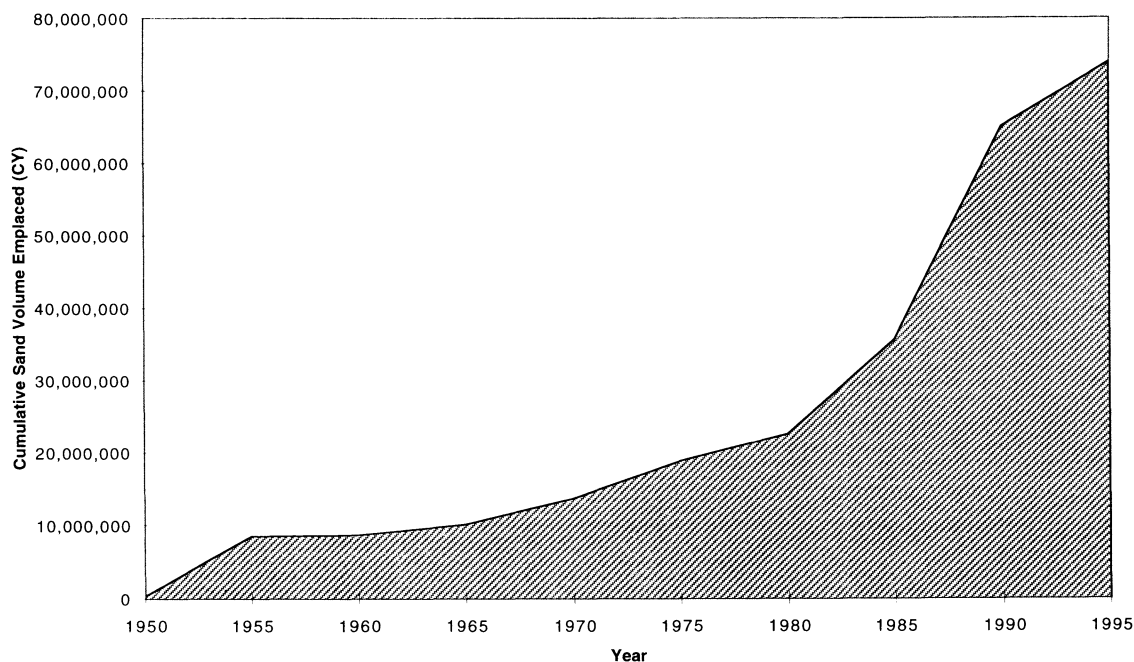


Figure 2. Cumulative volume of nourishment sand placed on US Gulf of Mexico shoreline.

(Table 1) is presented in geographical order progressing from West to East. For those unfamiliar with the Gulf Coast, the location of a selected number of projects is shown in Figure 1. The location of other projects may be estimated by locating projects with known locations.

The cost data presented in Figure 4 was arrived at by using a standard two step process. First all documented project costs were adjusted for inflation and converted to 1996 dollars using the cost update factors given by USACE (1996). As is noted above volume data is known more than twice as often as cost data. The second step in the cost analysis was to estimate the missing cost for projects in which volume was known. Average cost per cubic yard was determined for each funding type, from those projects with volume and associated cost data. Given the volume for a certain project and multiplying by the corresponding cost per cubic yard, we arrived at an estimated cost. After both documented and estimated costs were adjusted to 1996 dollars, they were graphed in decadal units (Figure 3).

In order to facilitate greater use of this database for managerial purposes, our records may be obtained by either contacting the authors directly or by downloading the files from our website at the following URL: <http://www.geo.duke.edu/pds.html>. Additionally, the authors gladly invite the submission of any corrections and additions to the database.

FUNDING CATEGORIES

Table 1 and Figure 5 illustrate the broad categories into which Gulf Coast nourishment projects fall. Occasionally through changes in project design or political conditions, projects will be funded under multiple sources throughout their

lifetime. For purposes of characterization, the dominating funding category has been chosen when multiple categories existed. Five basic funding types were established to characterize the Gulf nourishment experience. These were:

(1) *Federal Storm and Erosion*: These are planned congressionally approved projects designed to mitigate against future storm and/or erosion problems. Congress may authorize payment for up to 65 percent of the total cost with these projects. Federal Storm and Erosion projects dominate both the categories of cost and volume for nourishment projects along the Gulf Coast.

(2) *Federal Navigation*: These are projects designed to maintain federal navigation interests especially inlet channels in which adjacent beaches have been chosen as the disposal site. In theory, beach disposal of dredge material is only possible if it is the cheapest alternative. In practice, however, local interests often opt to foot the bill for the advantage of having spoil placed on adjacent beaches. Congressional review and approval, however, is required in order to receive federal cost-share assistance for the excess cost of adjacent beach disposal.

(3) *Federal Emergency*: These projects occur as the result of unexpected storm damage or immediate threat of erosion damage with the intent of protecting property from further or future damage.

(4) *State/Local*: These projects lack federal involvement and fall entirely under the funding of state and local governments.

(5) *Private*: In the four projects of this type, all funding came from private community groups seeking to protect property or restore a recreational beach.

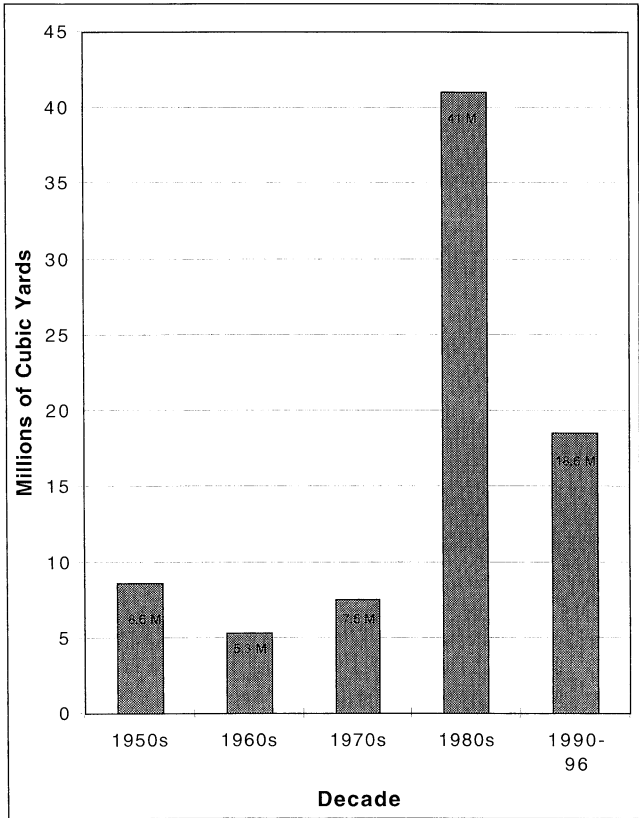


Figure 3. Total volume of nourishment sand placed per decade on US Gulf Coast.

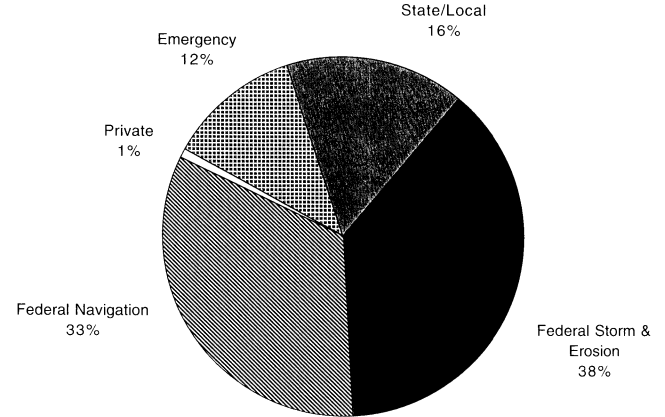


Figure 5. Funding sources of US Gulf Coast nourishment episodes based on percent of total sand volume.

FINDINGS

The growth of beach nourishment as an erosion control management tool is illustrated by Figures 2 and 3 which show the historical trends for cumulative nourishment volume and decadal nourishment volume respectively. A total of 158 beach nourishment episodes in 60 locations have been recorded. These episodes together account for over 78 million cubic yards of sand, making the Gulf of Mexico the third most highly nourished coastline in the country behind the East and Pacific coasts. Owing to the fact that sand volume figures were not known for all episodes, the exact cumulative volume can be expected to be much higher than that shown. However, Figure 2 serves as the most reliable proxy available for

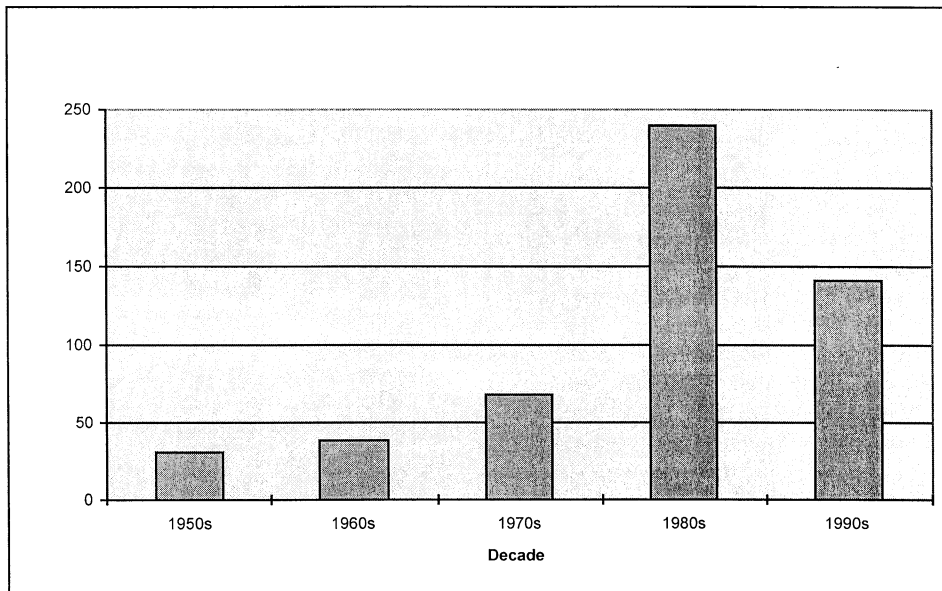


Figure 4. Total estimated cost of nourishing US Gulf Coast beaches per decade.

estimating the trend of beach nourishment activity through time. In particular Figure 2 shows a rapid increase in the total volume of sand emplaced along the Gulf Coast in the last twenty years. This curve is similar to the trend of beach nourishment along the East Coast over the same time period (see Figure 2 VALVERDE and PILKEY, this volume). Figure 3 indicates that since the 1950s, the sand placed on the Gulf Coast by various nourishment practices has increased with time. Note that approximately 25% of all the sand which has ever been placed on the Gulf Coast has occurred over just the last 6 years. Already the cost to maintain Gulf Coast beaches in the 90s is more than half of what was spent during the entire 1980s (Figure 4). The nineties clearly have been the most active time along the Gulf Coast for beach nourishment and we still have three more years to go! When projects of the 1980s are also considered, the shift towards greater beach nourishment is even more striking. Over 60% of all the sand known to have been placed along the Gulf Coast has occurred during the last 16 years. Within the span of one generation, a larger nourishment effort was undertaken than the previous two generations combined! This trend shows no sign of slowing down thus emphasizing the need for careful evaluation of the consequences and necessity of taking such action.

The importance of federal funding is illustrated in Figure 5. Federal Storm and Erosion Control projects alone account for the funding on over 38% of all known nourishment deposits along the Gulf Coast. When Federal Navigation and Emergency projects are added in as well, then federal involvement climbs to 83% of the total volume of emplaced material. Cooperative projects between state and local entities make up the bulk of the remaining funding (16%) and privately funded projects round off the list with a minor contribution (1%).

Although the overall increasing trend of reliance on beach nourishment can be expected to continue in the foreseeable future the mixture of funding types may be expected to change in response to the political climate and sediment availability. Actions of the current administration to cut the availability of federal funds has put a premium on state and local revenue sources. This situation was recently realized with the planned Panama City project in which the Mobile Corps District office was unable to obtain federal appropriations leaving the funding for what will be the largest and costliest project in Gulf Coast history entirely in the hands of state and local funding agencies. In an attempt to maintain federal involvement and save money, the State of Florida enacted some coastal legislation requiring all beach compatible navigation spoil to be placed on surrounding beaches. This law covers all navigation operations except at 13 specified inlets (WOODRUFF, 1997). The scarcity of beach compatible sand in many areas of the Gulf Coast (SPADONI, 1996) places an additional premium on the utilization of dredge spoil for nourishment purposes. Another option is the pursuit of Section 111 project status which requires Federal action to mitigate against the deleterious effects resulting from some previous shore protection project. Section 111 projects have been popular in the Great Lakes region (see O'BRIEN *et al.*, this issue) and may be explored as yet another way to maintain federal involvement in beach nourishment along the Gulf

Coast as well. In the absence of federal involvement, the cost of nourishment may drive some locations to further pursue hard stabilization alternatives.

Nourishment projects themselves may in the future be expected to fall into two major categories: gigantism and dwarfism. Gigantism is meant to describe the trend of fewer but bigger nourishment episodes. These projects combine several adjoining beaches into one nourishment package with a large initial fill and a long nourishment interval. The continuing Sand Key, FL project, the recent Vanderbilt/Park Shores/Naples, FL project and the planned Panama City, FL project all illustrate this trend (see Table 1 for data and Figure 1 for location). Dwarfism describes the move towards smaller and more frequently renourished episodes. Most of these smaller episodes are related to federal navigation projects.

Other observations on the nature of beach nourishment along the Gulf Coast include the following. There has been an increase in the total number of episodes, volume of emplaced material, and the total length of nourished beach since the 1950's. There was a sharp increase in activity occurring in the mid 1980's. Seventeen percent (23 episodes) involved the placement of over 1 million cubic yards of sand. The Harrison County, Miss. project of 1952 alone accounted for over 7 million cubic yards of sand. Sixty percent (78 episodes) involved the placement of between 100,000 to 1,000,000 cubic yards of sand. Together, over 75% of all known nourishment episodes entailed the disposal of over 100,000 cubic yards. Thus the typical Gulf Coast nourishment episode is both larger and more expensive than those in either New England or the Great Lakes but smaller and less expensive than East Coast nourishment episodes (see HADDAD, *et al.*, and VALVERDE *et al.*, this issue). The relationship between the size of Gulf Coast projects and those along other U.S. coastline is likely to remain the same.

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