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EROSION PROTECTION FOR FORT MASSACHUSETTS
SHIP ISLAND, MISSISSIPPI

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AUTHORITY AND PURPOSE

1. This report has been prepared pursuant to a request for technical assistance from the National Park Service to assess the erosion problems occurring around Fort Massachusetts on Ship Island, Mississippi, and to determine practical measures for protection. The purpose of investigations was to identify both emergency temporary and long term permanent measures for protecting the fort from erosion damage. The depth and scope of this report are limited to that which could be ascertained from a 4 January 1979 onsite inspection and generally available information. Investigations and resulting estimates were prepared by a multidisciplinary study team within the Mobile District Office of the Corps of Engineers. Studies were coordinated and this report compiled by the Navigation and Coastal Branch, Planning Division, Mobile District Office.

DESCRIPTION AND BACKGROUND INFORMATION

LOCATION

2. Fort Massachusetts is located on the northwest shore of West Ship Island, about 12 miles off the Mississippi Gulf Coast, south of the city of Biloxi, Harrison County, Mississippi. Ship Island is one of a series of 5 barrier islands that extend westward from the mouth of Mobile Bay separating Mississippi Sound from the Gulf of Mexico.

3. Although broken by previous hurricanes, prior to Hurricane Camille in 1969, Ship Island was a single island about 7 miles long. Hurricane Camille severed it into three sections. Sand accretion since 1969 has resulted in the lengthening of West Ship Island and the merging of the eastern two islands to form East Ship Island. West Ship Island, whereon

Fort Massachusetts is located, is now 3.7 miles long and 0.16 to 0.34 miles in width. When initially constructed, Fort Massachusetts was located along the center of the island on its western extremity. However, due to a southerly and westerly migration of the island, the fort is now located on the extreme north shoreline of the island about .85 miles from its western end. The study area is illustrated on Nautical Charts 11372 and 11373, U.S.G.S. Quadrangle Sheet "Ship Island" and the plates accompanying this report.

HISTORY

4. Ship Island has historically played a key role in the development of the Mississippi Coast and adjoining area. The island was used first as a base by the French explorer D'Iberville in the late 1600's and later as a fort to protect the French settlement at Biloxi in 1721. The island became a port for colonists arriving from Europe and by 1750 had become a thriving seaport serving both the Mississippi Coast and the New Orleans area. The island served as a military base for the British in the War of 1812 and later became a U. S. military reserve. Construction of the present fort was authorized in 1856 and initiated in 1857. The uncompleted fort was utilized by both sides during the Civil War and gained its name as the result of its occupation by Federal forces from the U.S.S. Massachusetts.

5. Throughout the 19th century Ship Island continued to be an important transfer port for oceangoing commerce originating or destined for the Mississippi area. However, the island diminished in importance following the construction of a deeper channel from the Gulf of Mexico through Mississippi Sound to the present site of Gulfport, Mississippi in 1902. The island has since remained essentially undeveloped and was incorporated as a part of the Gulf Island National Seashore in 1971.

HISTORIC STRUCTURES

6. A map of the Fort Massachusetts area dated February 13, 1866, indicates the presence of 48 buildings, 2 piers, and the fort. Due to the migration of the island, most of the area is now underwater. No trace of the French settlement remains aboveground, but Fort Massachusetts still stands in reasonably good condition.

7. The exterior of the fort is made of two colors of brick--the lower half and front face are a tan brick, and a red brick was used in the upper portion of the fort. Granite capstones top the fort's walls. A grasslike vegetation covers the terreplein and is also growing through the cracks in the concrete capping between the gun emplacements and the outer curtain. In the courtyard there is a unique freestanding circular stairway that is architecturally interesting.

8. About 2,000 feet east of the fort, on the sound side of the island, is the site of the old lighthouse. Following destruction of this facility by fire several years ago, a steel-frame beacon light was built in the location.

9. Several revetments have been constructed along the sound side of the island for stabilization purposes. Local citizens constructed a 400-foot-diameter rock revetment in a ring around the fort to stabilize it. It has been inadequate to provide complete protection. Another revetment was constructed in the vicinity of the lighthouse about 50 years ago. Although in disrepair, this marina-shaped revetment has proved successful in stabilizing the shoreline at the lighthouse and is utilized by local persons as a harbor area.

10. Although the interior structures, brickwork, and gun emplacement facilities of Fort Massachusetts are in remarkably good condition, the structural stability of the overall foundation is in serious question.

In particular, the dynamics of the top of Ship Island are such that at the time of initial construction the fort was centrally located very near the extreme west tip of the island, but the island has shifted west and south and now the fort, on the north shoreline, is essentially exposed to tides and waves on three sides. This erosion was temporarily delayed by the deposition of a large volume of dredged fill excavated from the Gulfport Ship Channel in 1974. This work was performed by the Corps of Engineers at the request of the National Park Service. The extent of foundation failure during the period the fort has been actually exposed to the sea is not known.

EXISTING AND PLANNED FACILITIES

11. West Ship Island became a part of the Gulf Islands National Seashore (hereafter referred to as the Seashore) upon its establishment on 8 January 1971, by Public Law 91-660. The island forms the westernmost boundary of the park.

12. The Seashore is situated in the northeastern portion of the Gulf of Mexico and includes a widely spaced chain of barrier islands extending nearly 150 miles from West Ship Island in Mississippi to the eastern end of Santa Rosa Island in Florida. Other islands in this chain include Horn, Petit Bois and East Ship Islands in Mississippi, and a section of Perdido Key in Florida. The Seashore also includes mainland tracts: The Pensacola Forts and Naval Live Oaks Reservation near Pensacola, Florida, and Davis Bayou, adjacent to Ocean Springs, Mississippi.

13. The established purposes of the Seashore are as follows:

a. To preserve for public use and enjoyment certain areas possessing outstanding natural, historic, and recreational values;

b. To conserve and manage the wildlife and natural resources;

c. To preserve as wilderness any area within the Seashore found to be suitable and so designated in accordance with the provisions of the Wilderness Act (78 Stat. 890); and

d. To recognize, preserve, and interpret the national historical significance of Fort Barrancas Water Battery, (Battery San Antonio), Fort Barrancas, and Advanced Redoubt of Fort Barrancas at Pensacola Naval Air Station, Fort Pickens on Santa Rosa Island, Florida, Fort McRee site, Perdido Key, Florida, and Fort Massachusetts on Ship Island, Mississippi, in accordance with the Act of August 21, 1935 (49 Stat. 666). That act states that "it is a National policy to preserve for public use historic sites, buildings, and objects of National significance for inspiration and benefits of the people of the United States."

14. The Seashore's most outstanding recreational resources are its wide, gently sloping beaches of unusually fine white sand and clear blue-green water, coupled with a mild climate. The four islands in the Mississippi District of the Seashore constitute virtually all of the naturally maintained sandy shoreline on Mississippi's Gulf Coast, since most mainland sandy beaches are maintained by periodic dredging.

15. West Ship Island receives the heaviest beach use of any of the offshore Mississippi islands. Visitor use is restricted to day use only. From April to November, two concessioner boats (capacity 224 to 250) take four groups to the island daily from Biloxi and Gulfport. This 13-mile (one-way) trip requires about 1-1/2 hours. Visitors arrive at the island by private boat as well. Arriving boats utilize an existing wooden pier which is about 10 feet wide and 600 feet long and is located in front of Fort Massachusetts. The water depth at the pier is marginal for the docking of the concessioner boats (5 to 7 feet deep). Some dredging is required at two- to three-year intervals.

16. Near Fort Massachusetts are several structures including a concessioner building, a ranger station, showers, and a maintenance building. The utilities in the unit consist of two 9-inch-diameter wells, a portable generating facility, an 800-gallon elevated water storage tank, and a septic tank. Presently visitors may stop at the fort for an interpretive tour or walk along a boardwalk system across the island to the gulf about one-third of a mile away.

17. In addition to beach recreation potential, all four Mississippi islands offer natural history interpretive opportunities which are in strong contrast to adjacent mainland habitat. These same Mississippi islands, since they are not linked to the mainland by road, still provide a degree of primitive undeveloped character which is considered remarkable in a public parkland so close to intensely developed and populated areas. This uniqueness has been recognized by the U. S. Department of the Interior, which is nearing completion of a formal wilderness study of these islands.

18. West Ship Island is expected to continue as the primary destination point for persons seeking a day-use beach recreation experience on the offshore Mississippi islands. According to plans developed by the Park Service, large tour boats from Gulfport and Biloxi will continue to provide mass transportation for day-use beach recreationists. The boat dock for loading/unloading of tour-boat passengers will be relocated from the present site, adjacent to Fort Massachusetts, to the site of the old lighthouse complex. The dock will provide space for two tour boats and 10 to 15 private boats. Adjacent to the dock, a safe boat refuge will be constructed in the area inscribed by the old revetment west of the lighthouse complex.

19. Other facilities ultimately planned by the Park Service are described below.

a. A system of 6-foot-wide boardwalk trails, 7,200 feet in length, will link the docking area with the day-use facility, Fort Massachusetts, and the beach. Four boardwalk trails will provide access to gulf-side beaches, thus spreading out use along the shore. Just behind the primary dune at three of these crossover points, portable comfort facilities will be located along the boardwalk.

b. An unmanned wayside exhibit in an observation tower will be located along the trail. This observation tower will serve as a navigational aid for boats headed for the island and will provide an overview of island resources for visitors.

c. All buildings will be removed from the immediate vicinity of Fort Massachusetts, and a new day-use facility and ranger residence will be constructed.

d. About 1,200 feet southeast of the docking area, a 3,000-square-foot day-use facility will be constructed, which will include a bathhouse, concession space for food sales and rental of beach-related supplies, a visitor contact/first-aid station, and equipment storage space. The lifeguarded beach area will be located immediately south of the day-use facility.

e. A new 3,500-square-foot dormitory will be constructed along the sound, approximately 750 feet east of the docking area.

f. A 30-site, walk-in campground will be developed approximately 1,500 feet east of the docking area on about 3.5 acres. Individual sites will be scattered among the dunes and equipped with sufficient facilities to provide a relatively comfortable camping experience. Facilities will include one 900-square-foot comfort station/shower building, as well as a fire pit, a picnic table, and a shelter at each site.

g. An extended aeration-activated sludge treatment plant will be constructed 4,000 feet east of the campground to handle all wastewater produced on the island. Additional electrical generators will be installed to handle the increased use.

ENVIRONMENTAL SETTING AND NATURAL FORCES

NATURAL SETTING

20. The isolated nature of the Mississippi islands provides habitats and ecosystems which through the protection of the park will remain undisturbed by man if properly cared for and can become natural laboratories for observing the impact of relatively rapid natural changes on populations of animals and plants, both genetics and behavior. The isolation of the islands has provided a degree of protection for a variety of wildlife species which, although not necessarily rare, are facing rapid habitat reduction in other parts of their range or which are especially intolerant of human presence. For example, East Ship, Horn, and Petit Bois Islands support more nesting osprey than anywhere else along the whole Louisiana and Mississippi coasts combined. Wintering ducks and geese still favor these offshore islands due to lack of predator populations and relative freedom from human disturbance; even the magnificent frigate bird ventures this far north during summer months.

21. The varied environments of the Seashore provide habitat for the following wildlife species currently listed as "endangered" by the U.S. Fish and Wildlife Service:

eastern brown pelican, Arctic peregrine falcon, southern bald eagle, red-cockaded woodpecker, Mississippi sandhill crane, American alligator, leatherback turtle, Atlantic Ridley turtle, and manatee.

22. Dominant vegetation in the vicinity of Fort Massachusetts on Ship Island includes beach panic grass, sea oats, sea oxeye and saltmarsh *fimbristylis*. A large black rush marsh located south of the fort was silted in by the 1974 beach nourishment, thus leaving the marsh landlocked. Presently the marsh exports only after heavy rains. The boardwalk that traverses the island has also severed the marsh at its crossing. However, the marsh appears healthy although tidal exchange has been closed. The sandy nature of the dredged material apparently minimized physical and chemical water quality degradation in the marsh.

23. The gulf-side beaches on Ship Island are generally wide and gently sloping, yet with gradients steep enough offshore to result in near-shore surf, attractive to body surfers and active swimmers. Beaches facing the Mississippi Sound side are typically narrow and in some cases eroding and steep, but the slope offshore is very gentle, reflecting the lower wave energies approaching this shore.

24. The Seashore includes important portions of the historic coastal defense system of the United States covering the period from the Spanish American War through World War II. Fort Massachusetts on West Ship Island is so designated and is listed on the National Register of Historic Places.

GEOLOGY

25. West Ship Island is a member of a linear chain of elongated islands and submarine shoals referred to as barrier islands. Barrier islands represent one of the most rapidly changing landforms on earth and protect 10 to 13 percent of the world's shorelines.

26. The most widely accepted theory for barrier island formation was proposed by Hoyt (1967) who theorized that islands were formed by submergence. This theory bases formation of barrier islands on significant worldwide

fluctuations in sea level. At any sea level, the sea meets the land at the shoreline where wind and wave action combine in the formation of a topographic ridge of sediments along the shoreline. If, following the formation of this ridge, there is a significant rise in sea level, the area landward of the ridge will be flooded and a barrier island will be formed. The four North American ice ages have produced dramatic sea level fluctuations during the last million years. As extensive amounts of seawater have been alternately frozen and released by thawing from the polar ice caps, the sea level is estimated to have been as much as 200 feet higher and 350 feet lower than the present-day sea level. The present trend is a rising sea level.

27. An additional geological phenomenon in the study area is the general subsidence of land areas. This subsidence is attributed to the weight of the sediments of the Mississippi River Delta. The subsidence is acknowledged to be occurring between Texas and Alabama and is very pronounced on some of the offshore islands and the immediate study area.

TIDES AND CURRENTS

28. Tides in Mississippi Sound are diurnal. At Ship Island Pass the mean tidal range is 1.7 feet and the extreme, except during storms, is about 3.5 feet. Since 1947 three hurricane tide elevations in excess of 10 feet have been recorded with the highest of these being 20.1 feet during Hurricane Camille in 1969. Since tidal flows into and out of Mississippi Sound take place through numerous inlets, current and circulation patterns are complex. However, currents are generally low except through the passes between the barrier islands during ebb and flood tides.

WIND AND WAVES

29. Winds in the study area determine the direction and extent of wave action. The winds are influenced predominantly in spring and summer by

tropical air masses and in late fall and winter by cold masses from the continent. The winds are variable in both strength and direction but are predominantly from the south and southeast in the summer and from the northeast in the winter. Monthly wind roses based on observations made at Keesler Air Force Base are considered good indicators of near shore and Mississippi Sound winds in the study area. These roses for January and July, which are indicative of the biannual seasons, are shown in figures 1 and 2.

30. Normal wind conditions are not reflective of the extremes that have been produced in the study area by hurricanes and tropical disturbances. The highest sustained winds in the study area during Hurricane Camille in 1969 were estimated at 160 miles per hour. However, these most severe winds generally approach Ship Island from a southerly direction and do not impinge waves directly against the Fort Massachusetts area.

31. Waves in the study area are relatively moderate to mild in both the gulf and sound areas and are directly related to wind speed and direction. The wave climate most pertinent to the erosion problems confronting Fort Massachusetts is that of Mississippi Sound. Unfortunately, little detailed information on waves in Mississippi Sound exists. However, it can be surmised from the wind roses (figures 1 and 2) that waves may approach Fort Massachusetts from any northerly direction from west to northeast. As also indicated by the wind roses, the maximum and predominant waves would approach the fort from northerly directions in the winter season. What may be considered the normal wave climate, like wind, does not reflect the severe conditions that can result during hurricanes. However, Fort Massachusetts' location on the north shore of Ship Island generally protects the fort to a considerable degree from these severe wave conditions as it does from the hurricane winds.

JANUARY

AVERAGE WIND SPEED IN KNOTS
FOR EACH DIRECTION
(CENTER VALUE ALL DIRECTIONS)

PERCENT FREQUENCY OF EACH DIRECTION
(CENTER VALUE LESS THAN FOUR KNOTS)

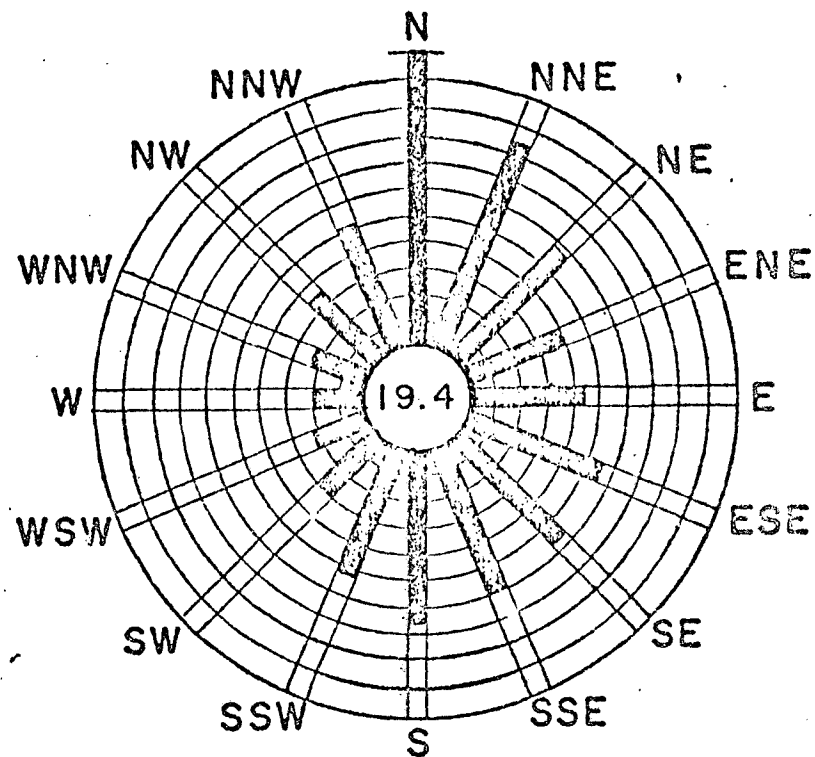
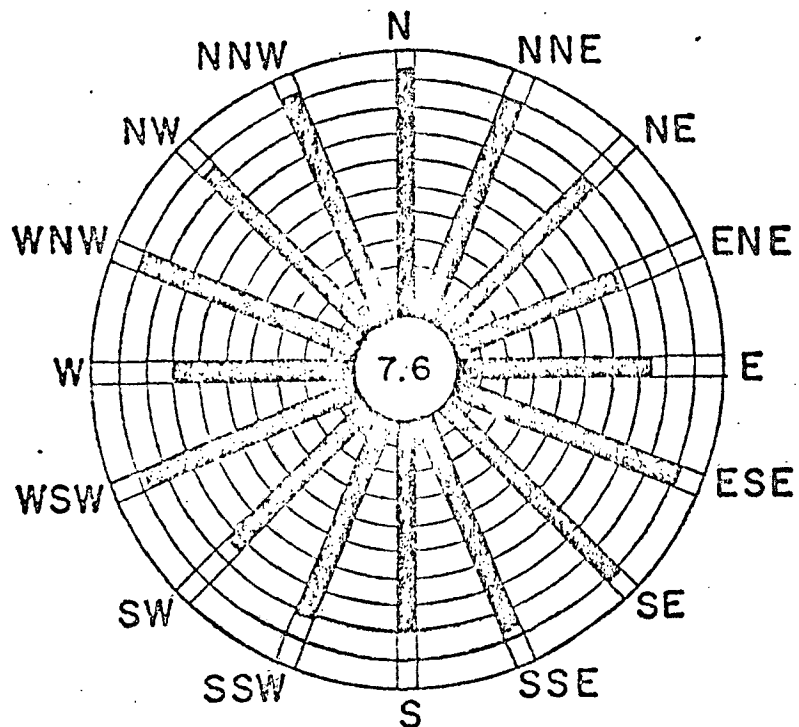
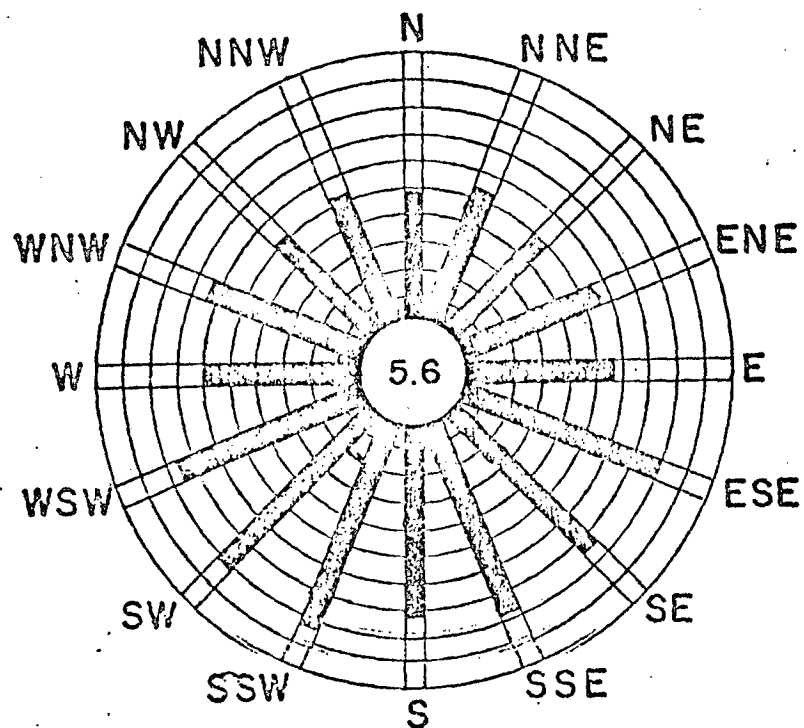


Fig. 1 Wind roses for January at Keesler Air Force Base. Department of the Air Force, Det. 22, 24th Weather Squadron (MAC), Keesler Air Force Base, Mississippi.

JULY

AVERAGE WIND SPEED IN KNOTS
FOR EACH DIRECTION
(CENTER VALUE ALL DIRECTIONS)



PERCENT FREQUENCY OF EACH DIRECTION
(CENTER VALUE LESS THAN FOUR KNOTS)

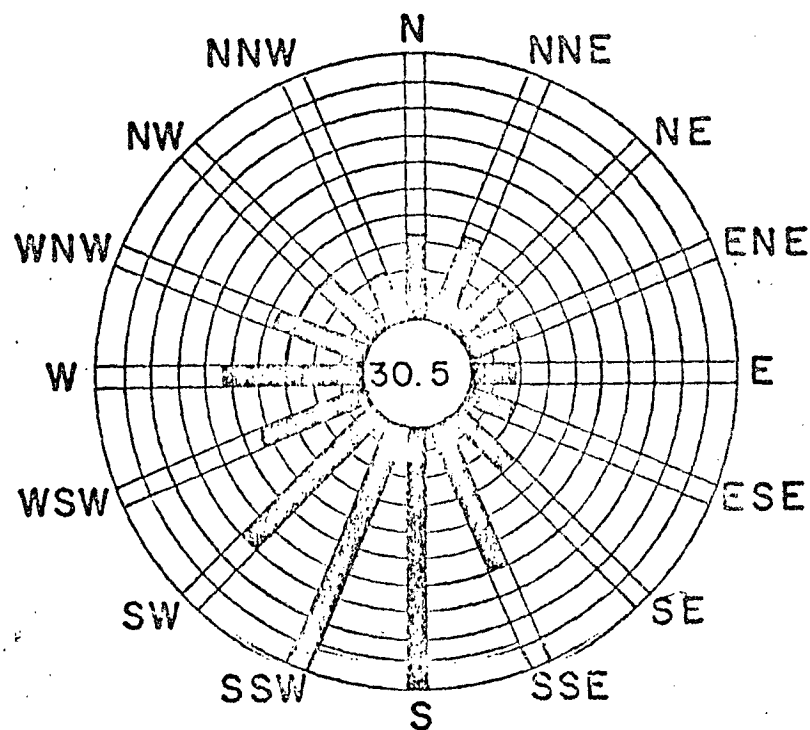


Fig. 2 Wind roses for July at Keesler Air Force Base. Department of the Air Force, Det. 22, 24th Weather Squadron (MAC), Keesler Air Force Base, Mississippi.

SHORE PROCESSES

32. Due to the active littoral forces and resulting shore processes, the barrier islands are not maintained in a steady state, but undergo continual metamorphosis. The existence of the barrier islands is dependent upon interaction between climate and five sand-moving processes--littoral drift, onshore bottom currents, wind, overwash, and inlet formation. Littoral drift is the process with the greatest effect on the dynamics of the Seashore islands; however, all natural processes are essential if the island is to continue to exist in dynamic equilibrium with the sea level, which is rising at about 1.2 feet per 100 years (Shepard, 1960).

33. The littoral current, or littoral drift, is a current which carries sand parallel to the beach. The strength of the littoral drift is dependent upon wave strength and the configuration and bearing of the shore. Because the direction of the littoral current is dependent upon the wind direction, it varies seasonally with the wind regime. The predominant southeast wind and wave direction in the eastern part of the Gulf of Mexico results in a westward littoral drift along the southern shore. The predominant winter wind and waves from the north and northeast also produce a net westerly drift along the north shore of the islands. Accordingly, subtidal and intertidal beach deposits are transported in a westward direction along both the northern and the southern shores. This process has produced an overall westerly migration of all the barrier islands. West Ship Island, following this trend, is eroding on the east end and along most of its north and south shorelines and accreting on the west end. When Fort Massachusetts was completed in 1859 it lay some 400 feet from the shoreline in each of three directions, toward the Gulf of Mexico, the western tip, and Mississippi Sound. Today the fort is awash in Mississippi Sound, the western tip is about 4,500 feet away and the gulf is about 1,500 feet south.

PROBLEMS AND NEEDS

34. The basic problem confronting the structural integrity of Fort Massachusetts is that of exposure and undermining of its foundation. This problem is the result of shoreline erosion along the north shore of Ship Island and the general dynamic nature of the barrier islands. Due to the migration of Ship Island westwardly and, in particular, southward, Fort Massachusetts is now located on the north shoreline and exposed to eroding wave action essentially from three directions. The critical erosion is precipitated by the prevailing north and northeasterly winds during fall and winter seasons. The material eroded is apparently moved offshore by the impinging waves and displaced to the west during these seasons. The effects of any reversals in this process are not evident. This assumption is supported by the lack of any significant catches or fillets of material on either side of Fort Massachusetts or other littoral obstructions.

35. Prior actions to abate erosion in the vicinity of the fort have not been successful in providing a permanent solution. Such efforts have included the construction of jetties, rock armoring and renourishment of the shoreline with hydraulic fill. Either because of design or construction deficiencies, lack of maintenance or the very nature of the works, in the case of the hydraulic fill, the protective measures are now ineffective. While stabilization of West Ship Island as a whole is not considered practical, adequate works or a continuing program is needed to stabilize and protect the area including Fort Massachusetts and its adjacent facilities.

ALTERNATIVE SOLUTIONS

DESIGN CRITERIA

36. In order to formulate plans for erosion protection and/or control for Fort Massachusetts, certain basic criteria upon which to establish designs are necessary. Due to the dearth of site specific information available for this study, criteria were assumed on the basis of the general information outlined above. These assumptions are generally outlined below.

a. All estimated quantities were based upon 1974 hydrographic surveys of the study site. These survey findings are indicated on Plate 2. This survey was made in connection with the hydraulic fill placed in the area at that time. Although the 1974 fill has eroded to become ineffective for protection of Fort Massachusetts, much of it continues to remain in place along the adjacent shoreline. Accordingly, this assumption should produce conservative estimates.

b. Based upon available wind data and the apparent erosion process along the north shore of West Ship Island in the vicinity of Fort Massachusetts, a storm with winds of 40 knots from a northerly direction was selected as a basis for determining a design wave height. Weather records indicate the greater frequency of strong winds during winter months is from the northern quadrant and that winds in excess of the 34-47 knot speed range are rare.

c. Based upon the preceding assumption, an effective wave fetch of 12.7 miles was determined. Thusly, a design wave was computed having a "significant wave height" of 4 feet. Wave determination was computed in accordance with procedures outlined in the Corps of Engineers "Shore Protection Manual" (SPM) for forecasting shallow-water waves.

POSSIBLE SOLUTIONS

37. Protection of Fort Massachusetts from eroding forces could be accomplished by directly armoring the foundation of the fort and the adjacent shoreline or through a continuing program of nourishing the shore area as was accomplished in 1974. Shoreline armoring could be achieved by the use of gabions, grout-filled nylon bags, concrete armor units, interlocking concrete blocks, revetment or through the construction of various types of seawalls. Based upon generalized cost data for the construction of such works for this geographic area, a rock revetment of seawall section was considered the most economical means for permanently armoring the shoreline against erosion. A typical rock seawall section is illustrated on Plate 2. Utilizing this type section two alternatives were evaluated for armoring the shoreline. These are referenced herein as "Alternative S1" and "Alternative S2." While an infinite number of configurations for these plans would be possible, those selected herein for evaluation are also generally illustrated on Plate 2. In addition to these plans, an alternative for continued beach nourishment was also evaluated either as a temporary measure or as a continuing permanent solution.

38. Alternative S1. Alternative S1 would provide essentially permanent protection for Fort Massachusetts and a large section of the adjoining shoreline that has experienced severe erosion and a relatively rapid southerly retreat in recent years. The plan would provide for a stone seawall extending from a point immediately west of the proposed lighthouse marina to a point on the island about 1,200 feet west of the fort. The plan would provide a minimum wall height of 4 feet above mean low water (MLW) except for a 300-foot section immediately adjacent to the fort that would have a height of 7.2 feet MLW. Based upon the design wave, the 4-foot wall would be subjected to overtopping from wave runoff which could result in occasional loss of some backfill material with returning waters. This loss would be minimized by covering the inland side of the wall with filter cloth. Losses would not be estimated to be significant

and the additional cost of a higher wall to avoid this loss would not be considered warranted. The 7.2-foot wall height in the vicinity of the fort where more complete protection would be considered more crucial would not be overtopped under normal conditions.

39. Construction of Alternative S1 would require the placement of about 31,000 tons of quarry-run stone and cap rock, plus appropriate amounts of filter cloth and bedding material. The plan would also require approximately 120,000 cubic yards of backfill material. It was assumed that backfill material could be excavated by hydraulic dredge from undesignated nearby areas or accomplished in connection with maintenance dredging of the nearby Gulfport Ship Channel. Total first cost for construction of Alternative S1 is estimated at about \$1,500,000. Utilizing a percentage factor typical for rock structures of this type, annual maintenance costs are estimated at \$75,000. Including maintenance and interest and amortization of the initial investment and utilizing the presently accepted Federal long term interest rate of 6-7/8 percent and a 50-year period of economic analysis, total annual charges would be about \$180,000.

40. Alternative S2. Alternative S2 would provide for a stone seawall 7.2 feet high and 1,470 feet long essentially protecting only Fort Massachusetts and immediately adjacent facilities. The wall height would be sufficient to prohibit wave overtopping under normal conditions. The seawall under this plan would tie into higher ground about 200 feet east of the fort and south of the fort immediately north of the natural tidal inlet for the marsh located further south and east of the fort.

41. Construction of this alternative would require the placement of about 13,500 tons of quarry-run stone and cap rock with filter cloth and bedding material. This plan would require backfill estimated at about 34,000 cubic yards. Total first cost for construction of Alternative S2

is estimated at about \$600,000. Maintenance cost is estimated to average about \$30,000 annually. Total annual charges including maintenance, interest and amortization are estimated at about \$75,000.

42. Beach Nourishment. Alternatives considered for beach nourishment were keyed to the 1974 work performed by the Corps of Engineers for the Park Service. At that time approximately 335,000 cubic yards of suitably sandy material were dredged from an area near the Gulfport Harbor Ship Channel near the west end of Ship Island. Dredge pumping distance during that operation ranged up to about 6,500 feet. The 1974 work was accomplished in connection with maintenance dredging of the Gulfport Ship Channel.

43. Much of the material deposited on the shoreline adjacent to Fort Massachusetts in 1974 remains. However, that immediate to the fort has eroded to a point that again allows exposure of the fort foundation to eroding waves during high tides. Assuming a somewhat greater concentration of material immediately adjacent to the fort and considering the rate of loss of the 1974 deposit, it is estimated that comparable amounts of similar fill placed on a regularly programmed basis could provide adequate protection for intervals of 6 years between necessary renourishments.

44. In an effort to minimize cost a renourishment program incorporated with the Corps of Engineers' maintenance operations for the Gulfport Ship Channel was investigated. However, an examination of dredging records for the Gulfport channel indicates that although maintenance of some portion of the channel is required annually, the maintenance material removed from the channel near the west end of Ship Island is not of sufficient quantity nor performed with sufficient frequency to provide the renourishment needs for Fort Massachusetts. Therefore, while common material may be available occasionally, it would not be available for planning purposes. Utilization of a common dredge in one contract would

effect an overall saving, primarily by eliminating extra mobilization and demobilization costs.

45. Since the composition of materials at locations other than at the west end of Ship Island is unknown, it is assumed herein that all materials for the renourishment around Fort Massachusetts would be excavated from that general area. Estimated first cost, utilizing a 27-inch hydraulic dredge typical of that used for maintenance of the ship channel, would be about \$575,000. This estimate reflects a savings of about \$125,000 in the cost for each renourishment operation through utilization of the same dredge in the same contract for channel maintenance. The average annual equivalent cost in 1979 dollars for a continuing renourishment program providing 335,000 cubic yards of fill initially and at 6 year intervals for a period of 50 years at an interest rate of 6-7/8 percent would be about \$120,000.

CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

46. A comparison of estimated first cost and annual equivalent charges for each of the three structural plans for erosion control at Fort Massachusetts is given below. It should be noted for programming purposes, that Federal contracts are considered awardable if within 25 percent of their base estimate.

<u>Plan Considered</u>	<u>First Cost</u>	<u>Annual Charges</u>
Stone seawall:		
Alternative S1	\$1,500,000	\$180,000
Alternative S2	600,000	75,000
Beach nourishment	\$575,000	\$120,000

47. It should be reemphasized that each of the above estimates is based upon relatively conservative assumptions due to the lack of detailed site-specific data. Under the given conditions the assumptions and estimates herein are considered appropriate; although, more accurate data could possibly result in significant estimate reductions. Pursuit of either alternative should be preceded by a more detailed investigation of hydrographic and subsurface conditions, wind and wave conditions and borrow sand sorting characteristics.

48. Estimates for the beach nourishment alternative were derived from the cost incurred to accomplish the 1974 nourishment work and based upon the stated assumptions. They are considered relatively good indicators of costs that could be expected to implement that alternative. However, it should be noted that under different assumptions there is a potential for substantial cost reductions (as much as 50 percent) that could produce a more competitive plan from an economic viewpoint. If it were determined that sand deposits suitable for nourishment material existed closer to Fort Massachusetts than near the western end of the island, several factors would be introduced that would reduce dredging cost. Under such a condition pumping distance and necessary pipelines would be reduced. Further, a more protected area north of the island would reduce operating hazards to the dredge and permit longer daily production for essentially the same daily operating cost. Another factor that should be considered with respect to the nourishment plan is that due to the sorting action of wave wash over the deposited sand, an increasing amount of coarser material should be left on the shoreline after the erosion of each new deposit. This should result in a decreasing amount of material required by each successive renourishment activity. The lack of available data did not permit the consideration of these factors in the preceding estimates.

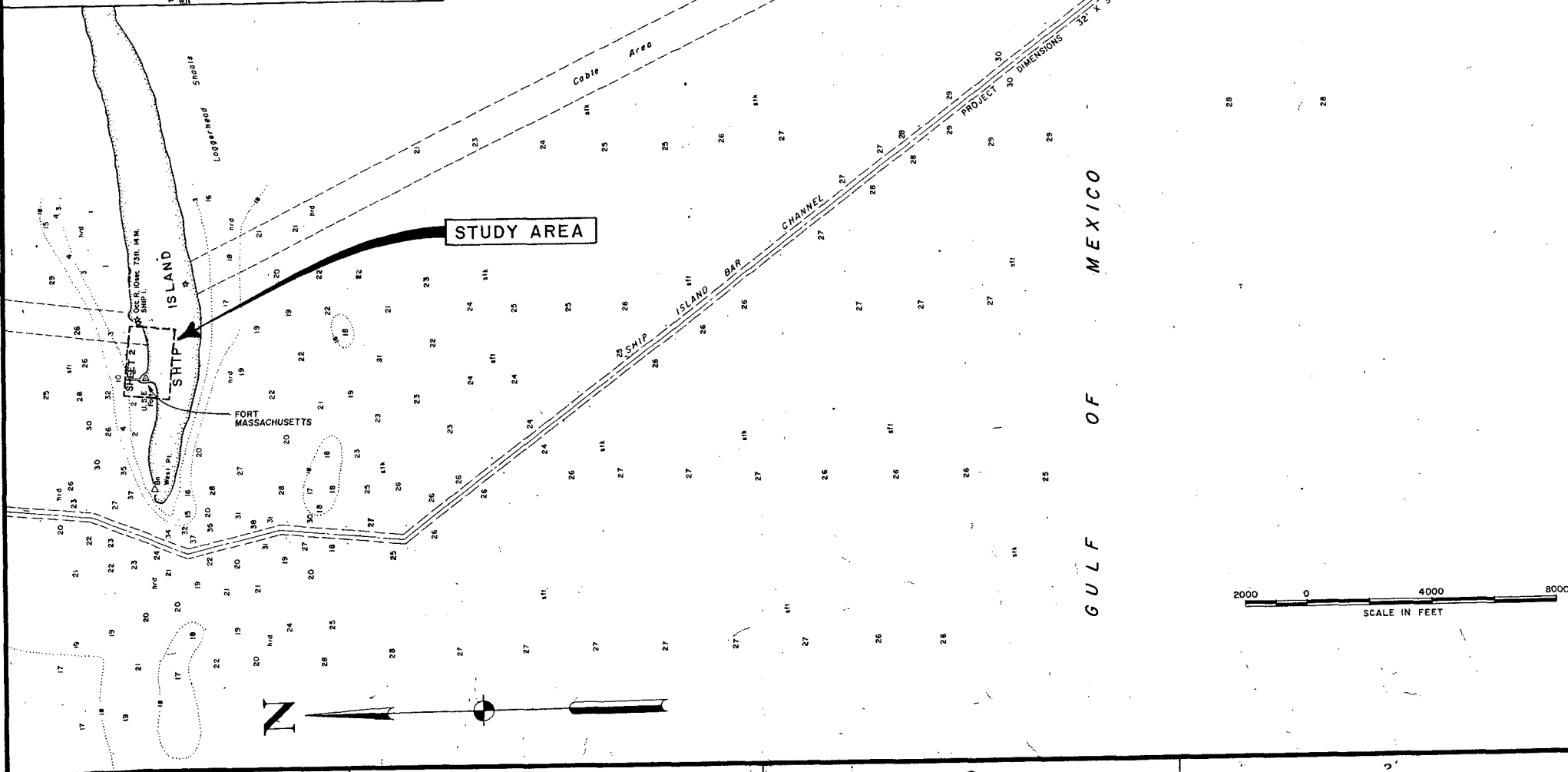
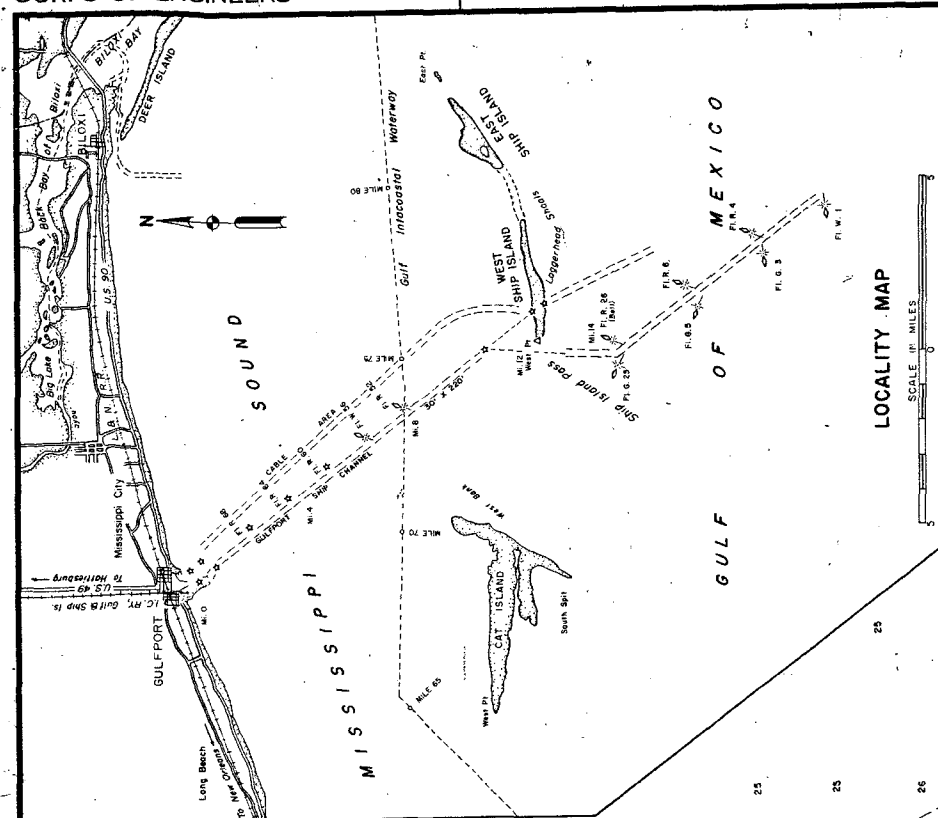
49. Factors other than economics should also be considered in review of the evaluated alternatives. The stone seawall alternative would offer

the greatest degree of stabilization. Alternative S2 would result in the least amount of work and alteration of the natural setting of the island and fort. This alternative would also provide for tidal interchange between the waters of Mississippi Sound and the island marsh located north of Fort Massachusetts. Alternative S1 would restore and provide permanence to a large area adjacent to the fort that is needed for planned facilities within the island park but would convert substantial submerged beach areas into fast land and would permanently seal the tidal interchange between the island marsh and Mississippi Sound. The nourishment plan would produce effects similar to those created by the 1974 filling operation. Inherent in such operations are the disruption of bottom organisms in the areas dredged and certain turbidities at both the dredging site and adjacent to the deposition site during actual construction. This plan would also seal the marsh interchange. However, the direct dredging effects are temporary and the indicated frequency required for renourishment is such that areas directly affected should fully recover between operations. Although the marsh inlet would be sealed, this condition has existed since the 1974 operation without any apparent critical damage to the marsh area. Overall the renourishment alternative would produce the most aesthetic plan having the appearance of a natural formation. Beaches would also be preserved throughout the affected area.

RECOMMENDATION

50. Based upon the limited investigations presented herein, a permanent solution to erosion problems for Fort Massachusetts will be necessary to preserve the integrity of the structure. In view of the historical significance of the fort and its importance as an attraction within the Gulf Islands National Seashore Park, its preservation is considered warranted and is recommended. Preliminary cost estimates for three possible solutions have been identified herein. The decision with respect to the appropriate type of protection should consider environmental

impacts and the compatibility of the action with the goals and established objectives of the Park Service for the preservation and development of the park system in addition to the economics. Accordingly, the decision with respect to the future action to be taken for control of erosion threatening Fort Massachusetts is the responsibility and choice of the U. S. Park Service.



STATION	LATITUDE	LONGITUDE	NORTH	EAST
DIR LIGHT			206,320.37	452,625.85
U.S.E. FORT			198,317.16	456,190.18
U.S.E. QUAR.			203,817.87	479,698.97
P.I.			189,960.53	450,819.32

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

FORT MASSACHUSETTS
SHIP ISLAND, MISSISSIPPI
GENERAL MAP

DATE JANUARY 1979 SHEET 1 OF 2

