Chapter 20

HARBOR AND COASTAL PROBLEMS ON THE EAST GULF COAST

Berkeley Blackman and C. P. Lindner
Respectively, Chief, Planning and Reports Branch (Retired) and
Chief Engineer, South Atlantic Division, Corps of Engineers
Department of the Army, Atlanta, Ga.

DESCRIPTION

GENERAL FEATURES

The "East Gulf Coast" discussed herein embraces the coast of the Gulf of Mexico from Cape Sable, Florida, generally northerly and westerly to the Rigolets, Louisiana (See Figure 1). So far as concerns Federal waterway improvements, the section is under the jurisdiction of the South Atlantic Division, Corps of Engineers, U. S. Army, Atlanta, Ga. That section in Florida as far northward as the mouth of the Aucilla River is administered by the District Engineer, Jacksonville, Fla.; thence westerly to the Rigolets, by the District Engineer, Mobile, Ala.

With few exceptions, the mainland along that section of coast is monotonously low and flat. Except for the 180-mile stretch between Anclote Keys, Fla., and Apalachee Bay, Fla., the coast is generally characterized by a line of low, narrow, sandy offshore islands and peninsulas, which enclose and protect a chain of shallow coastal bays, sounds, and lagoons. Between Anclote Keys and Apalachee Bay, the Gulf bottom to 30 or 40 miles offshore is generally a soft limestone rock covered by a thin layer of sand; barrier islands are absent, and the bottom is very flat, 3-foot depth being reached from 1 to 4 miles offshore. Elsewhere the Gulf bottom is generally sandy, and slopes somewhat more rapidly into deeper water.

TIDES

Lunar tidal ranges are moderate, the mean range being generally between 2 and $3\frac{1}{2}$ feet between Cape Sable and Apalachee Bay, and thence less than 2 feet westward to the Rigolets. A peculiarity of the lunar tides along that reach is that they change gradually and progressively from a normal semidiurnal type at Cape Sable to a diurnal type at and west of St. Joseph Bay, Fla. Hurricane winds build up tides to an elevation of 6 feet or more above normal; northerly gales, occurring usually in winter, frequently lower the water surface by 1 or 2 feet, and occasionally by as much as 4 feet, correspondingly decreasing the depths in navigable coastal waterways below those based on mean low water.

WINDS AND STORMS

Between March and September, the prevailing winds along the east Gulf coast blow from the easterly to southerly quadrant and are usually moderate. During the late fall and winter, however, several polar air masses from the North American continent penetrate to the Gulf coast each year, bringing northerly winds up to over 50 miles an hour, locally known as "northers". Hurricanes, traveling usually northwesterly across Cuba and the southern tip of Florida, veer to the north and northeast and pass over the east Gulf coast, usually during August, September, or October. Winds to the east of

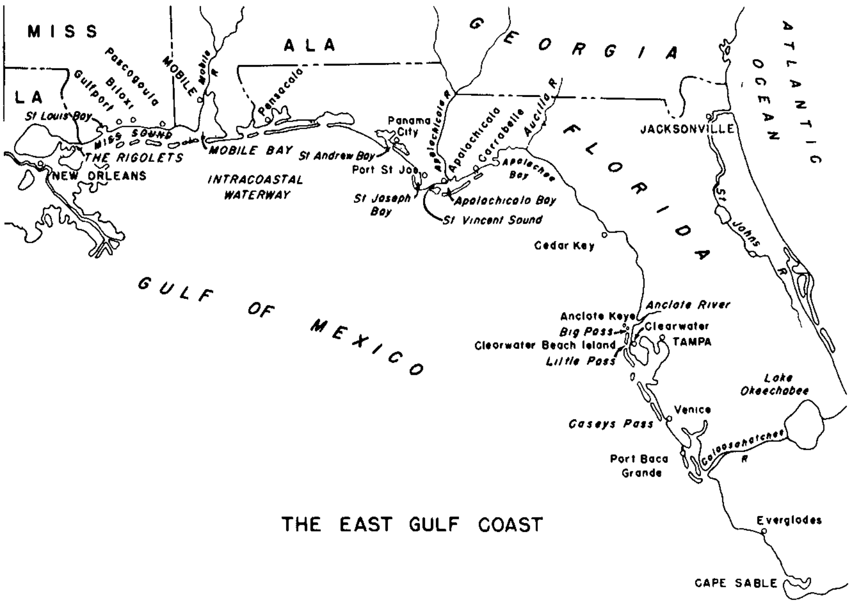
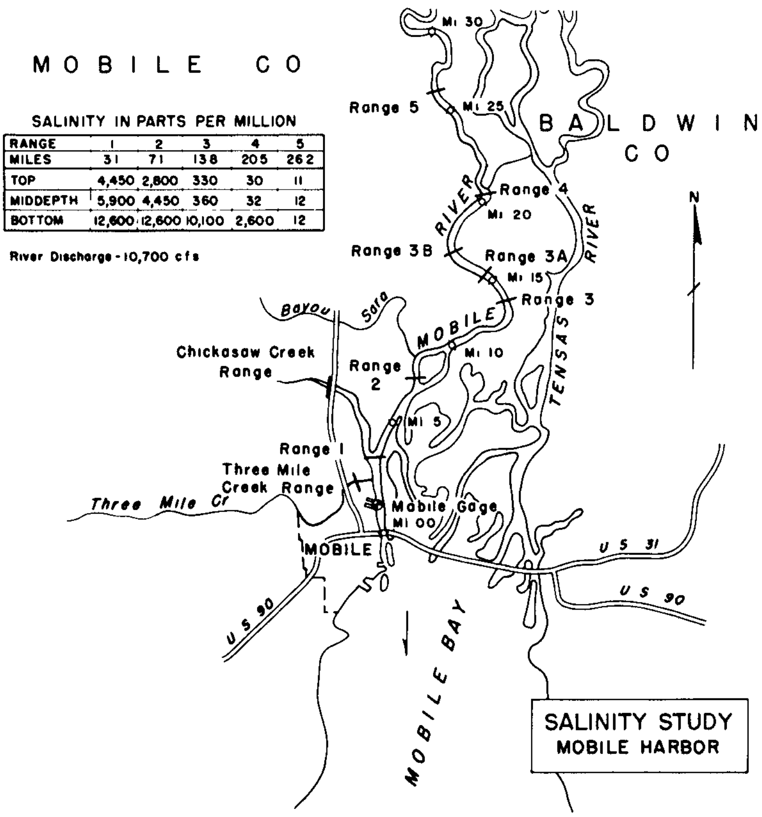


Fig. 1.



RANGE	1	2	3	4	5
MILES	31	71	138	205	262
TOP	4,450	2,800	330	30	11
MIDDEPTH	5,900	4,450	360	32	12
BOTTOM	12,600	12,600	10,100	2,600	12

Fig. 2.

the center, compounded of the velocity around the center and the rate of advance of the storm, blow toward the shore and do the most damage to coastal installations; winds west of the center blow offshore and do less damage. Maximum sustained wind velocities of record are about 84 miles an hour at Key west, 75miles an hour at Tampa, 55 miles an hour at Apalachicola, 91 miles an hour at Pensacola, 87 miles an hour at Mobile, and 66 miles an hour at New Orleans. Such hurricanes have often breached the barrier-island strip, creating new inlets, some of which have closed rapidly, others remaining open for many years. Hurricane attacks have also contributed to closing of inlets, and to their migration from one location to another.

WAVE ATTACK

The direction and intensity of wave attack on the shore varies with the winds, the trend of the shore line, and the steepness of the offshore bottom. Between Apalachee Bay and Anclote Keys, where the offshore bottom is very flat and rocky, storm waves break well offshore and are dissipated before they reach the coast. From Apalachee Bay west and from Anclote Keys south, where the mainland shore is generally protected by coastal islands, the principal wave attack is suffered by the seaward shores of the islands, although the bays and sounds in many places are of such expanse that regeneration of substantial waves occurs. These attack the mainland shore. Also storm tides and waves, particularly during hurricanes, often overtop the low barrier-beach islands and flow across into the coastal waterways. Generally, however, the wave attack on the mainland shore is comparatively light. The beach islands are at times subject to heavy wave attack and even overtopping and breaking during hurricanes. Where the islands have been improved, considerable damage results. Shore erosion, usually gradual, is in progress on many of the coastal islands and at several places on the mainland shore. There has been a considerable investment of local money in groins, sea walls, and other protective works, most of which have met with indifferent success in holding or building up the beaches, due chiefly to uninformed planning and to use of inadequate materials.

LITTORAL DRIFT

The trend of littoral drift along the east Gulf coast also varies with the wind and wave direction and intensity, and the trend of the shore. Between Apalachee Bay and Anclote Keys, where the waves are dissipated well offshore on the flat bottom, there is practically no littoral drift close to the shore line. As a result, that section of the coast is characterized by a lack of sand beaches, the salt marsh extending practically to the water's edge. West of Apalachee Bay the predominant drift is, with a few exceptions, from east to west; at the entrance to St. Andrew Bay a local reversal is indicated, and along the mainland shores of Mississippi littoral drift seems to be lacking. South of Anclote Keys the predominant drift appears to be from north to south, with exceptions such as at Little Pass at the south end of Clearwater Beach Island where the predominant movement is from south to north. At the entrance to Tampa Harbor, the predominant drift along the keys north of the entrance is from north to south, whereas that south of the entrance is from south to north. In fact this change in direction of along shore currents at one side of inlets and openings in the island chain is rather common. It is probably caused by flow of the tidal currents through such openings.

SALINITY AND TEMPERATURE

The salinity of Gulf water near the coast is in general less than the mean for sea water, and the average surface temperature is higher than along the Atlantic seaboard. The mean densities and surface temperatures of the water along the Gulf coast are typified by the following:

Place	Mean densities	Mean surface temperatures
Key West, Fla.	1.0270	79.5°
Cedar Key, Fla.	1.0194	72.4°
Pensacola, Fla.	1.0121	71.4°
Eugene Island, La.	1.0024	70.2°
Galveston, Texas	1.0170	72.8°
Port Isabel, Texas	1.0248	74.8°

It is apparent that the lowest salinity and surface temperatures are found at the mouth of the Mississippi River, and that they increase with increasing distance both east and west of that point.

DETERIORATION OF STRUCTURES

CORROSION

Because of the lower salinity of Gulf water and the less severe wave action with a correspondingly less intense abrasion by moving sand, the problem of corrosion and abrasion of steel in or exposed to Gulf water is in general not so extreme along the east Gulf coast as it is in many other locations on salt water. Furthermore, most of the steel structures subject to corrosion and abrasion are parts of harbor installations at the mouths of rivers or in indented bays, where salinity and wave action are even less than in the Gulf. Nevertheless, deterioration of steel must be expected in planning harbor structures. In recent years the tendency along the east Gulf coast has been to use creosoted timber or concrete rather than steel in coastal structures. But the development of cathodic protection has heightened the practicability of the use of steel. Some very interesting work on cathodic protection of steel structures has been done by oil companies in connection with drilling operations off the Gulf coast of Louisiana.

MARINE BORERS

The use of timber rather than steel or concrete is subject to the principal drawback that marine borers flourish in the warm waters along the Gulf coast. The most prolific species seem to be several types of Bankia, but limnoria, teredos, martesia, and sphaeroma are also found. The concentration of these organisms varies greatly from place to place and from time to time. Thus creosoted-wood bulkheads at Caseys Pass, Florida, constructed in 1937, were completely eaten away between mean low water and mean high water within 12 years, whereas a creosoted-timber retaining wall around the U. S. Engineer Reservation on Seddon Island in Tampa Harbor, built about 1921, is still in good condition after 30 years. The difference may be due to the comparative freshness of the water near the mouth of the Hillsboro River in Tampa Harbor, or to the fact that the harbor water at the engineer reservation is grossly polluted by sewage and industrial wastes, which have been found to repel the borers. A very complete account of marine borers and their activities is contained in a publication of the National Research Council entitled "Marine Structures, their Deterioration and Preservation", by Atwood and Johnson.

Untreated timber installed along the East Gulf Coast may be expected to be destroyed in about one year. Two principal methods of combatting such attacks on timber structures have been in use along the east Gulf coast. The usual method, as used by the Corps of Engineers, has been to impregnate the timber with coal-tar creosote to an absorption of 22 pounds of creosote to each cubic foot of timber. Depending on environmental conditions, this will delay attack until the creosote is leached out of the timber, which generally requires about 15 years. The average life of such treated timber has been found to be 12 to 15 years, although under more favorable conditions well-treated timber has lasted as long as 20 to 30 years. The other preventive method has been encasing the timber piles in cast-iron, concrete, or terra cotta pipes, from below the mud line to above normal high water which affords positive protection unless the casing is broken. Even with this method it is advisable to give the pile a preservative treatment to prevent the portion above the jacket from decaying before the remainder has deteriorated.

FEDERAL PROJECTS

The principal Federal projects along the east Gulf coast are the Gulf Intracoastal Waterway, the harbors at Port Boca Grande, Tampa, Port St. Joe, Panama City, Pensacola, Mobile, Pascagoula, and Gulfport, and the shore-protection works along the shore of Harrison County, Mississippi. Twenty-nine lesser projects have been authorized along that section of the Gulf coast. To June 30, 1950, the total Federal first cost for new work on all projects was over $23,000,000, and the total cost of maintenance nearly $20,000,000, a grand total of about $43,000,000.

THE INTRACOASTAL WATERWAY

The Gulf Intracoastal Waterway has been completed to 12 feet deep and generally 125 feet wide from Brownsville, Texas, to Carrabelle, Florida, a waterway distance of 1,073 miles. The waterway follows protected coastal sounds and connecting land cuts, and presents only the coastal-engineering features normally associated with such a waterway. Two additional sections of the waterway have been authorized but not yet provided - one from Carrabelle eastward to Apalachee Bay via Carrabelle, Crooked, and Ochlockonee Rivers, the other from Anclote River, Fla., south to the Caloosahatchee River (the latter section 9 feet deep and 100 feet wide). These also follow coastal waterways and connecting cuts, and present no unusual engineering problems.

The final link in the waterway, a channel 12 feet deep and 125 feet wide between Tampa Harbor and Apalachee Bay, is now under study. It presents the unique feature that, to avoid so far as practicable the large amount and excessive cost of rock excavation entailed by an inshore alinement through the coastal marsh, plans are being considered to aline about 180 miles of the channel generally along the 3-foot depth contour, from 1 to 4 miles offshore in the Gulf. To compensate for the absence of protective offshore islands, it is contemplated that the material dredged from the channel (about 53 percent rock) will be deposited offshore of the channel to create a breakwater parallel with the channel, with a crest elevation of 6 feet above mean low water, a crest width of 10 feet, and side slopes of 1 on 15. This plan may be found practicable because of the high percentage of rock in the breakwater and the usual minor nature of the waves and swells resulting from the wide expanse of shallow water along this portion of the coast. Gaps would be left in the breakwater at intervals sufficient to allow for outflow of water discharged by streams entering the Gulf in this stretch and to avoid a major dislocation of tidal and salinity conditions in the water between the breakwater and the shore. The 3-foot depth was selected for the channel because the material dredged from that depth would approximately equal that required for the breakwater. Preliminary cost estimates indicate that such a waterway would cost at least $15,000,000 or $20,000,000 less than an equivalent inshore route. There is, of course, no assurance that this interesting plan will be approved and installed.

HARBORS

The deep-water harbors along the Gulf coast are similar in their characteristics. In each case the Gulf entrance passes through an offshore bar and is shoaled by encroachment of littoral drift. Because of the moderate tidal ranges, wind and wave action, and littoral drift, entrance jetties have not been found necessary. Only one harbor (that at Panama City) has a jettied entrance, and the jetties there are only 700 feet long and spaced 1,500 feet apart. Project depths in the bar channels and in many of the inside channels have been maintained with sea-going hopper dredges at reasonable costs.

Only two streams along this section of the Gulf coast - the Apalachicola and Mobile Rivers -bring down appreciable quantities of silt into the coastal waterways. At the mouth of the Apalachicola, the river silt has built out a deltaic mud shoal into Apalachicola Bay; the silt not deposited in that shoal is carried westward by the prevailing easterly and southeasterly winds and waves, and deposited largely in St. Vincent Sound, which has maximum depths of about 5 feet. Maintenance of the project channels in Apalachicola Bay involves repeated dredging of this river-borne silt, and involves no special engineering problems.

The channels to the harbors at Mobile, Pascagoula, and Gulfport traverse the coastal waters of Mobile Bay or Mississippi Sound for considerable distances to their termini at the ports. In all cases fairly rapid shoaling occurs. These channels are maintained with hydraulic pipe-line dredges, the dredged material being deposited in the waters of the bay or sound some 1,200 to 1,500 feet from the channel. An interesting aspect of that dredging is that, despite the large amounts of material so deposited over the years, no considerable spoil banks or shoals have been created in the deposit areas; the light material is apparently picked up rapidly by waves and currents and redistributed over the bottom, probably in part back into the channels from which it was dredged.

SEAWALL, HARRISON COUNTY, MISSISSIPPI

Among the less-usual coastal-engineering problems encountered on the east Gulf coast was the study of beach erosion along the shore of Harrison County, Mississippi, between Biloxi, Miss., on the east and Henderson Point at the entrance to St. Louis Bay on the west - a distance of 27 miles. That section of shore faces on Mississippi Sound; the barrier islands and shoals separating the Sound from the open Gulf are from 8 to 12 miles offshore. U. S. Highway 90, the main artery for vehicular traffic between Jacksonville, Fla., and New Orleans, La., and points west, closely follows the mainland shore line throughout that reach. Shore property has been highly developed, and the reach is classified as an urban area by the Public Roads Administration.

Since 1893, fourteen hurricanes have struck the Gulf coast within 150 miles of Harrison County, an average of about one every four years. Only six of these were close enough and intense enough to cause major damage to the Harrison County water front. Under the impact of storm tides and waves, the shore line has been gradually receding for many years. In 1925-28, Harrison County built a sea wall along the entire 27-mile reach between Biloxi and Henderson Point, at a cost of some $3,400,000. Twenty-four miles of the sea wall is a concrete step-type structure; 1.31 miles is a concave-front type with a flanged sidewalk; and 0.65 miles is a convex-front type. The remainder consists of a small amount of masonry wall and harbor structures

When the sea wall was built, a beach from 80 to 200 feet wide was left between the wall and the water. With a few minor exceptions, that beach has disappeared, depriving the sea wall of such protection from wave attack as it originally afforded. Indications are that the beach material was moved offshore into deeper water of the sound rather than alongshore.

Disappearance of the protective sand beach exposed the concrete-sheet-pile curtain wall at the toe of the sea wall to direct wave action at all stages of tide. Corrosion destroyed reinforcing steel in numerous places where insufficient concrete cover had been provided. Settlement cracked the wall in many places. The hurricane of 1947 over-topped the sea-wall, breached the weakened wall in five places, destroyed the cut-off wall in several places, and washed out backfill, much through holes left by careless construction. U. S. Highway 90 was undermined, making it impassable at many points.

Largely because the extensive damage to U. S. Highway 90 established a considerable Federal interest in the repair and maintenance of the sea wall, a study of the requirements was made by the Corps of Engineers and a report, published in House Document No. 682, 80th Congress, 2d session, was made to Congress. As a result, the River and Harbor Act of June 30, 1948, adopted a Federal project authorizing the expenditure of $1,133,000 of Federal funds to aid in financing the repair of the sea wall and to provide a protective beach 300 feet wide at mean sea level along the entire sea wall, by pumping sand from 1,000 feet or more offshore in Mississippi Sound, on condition that local interests accomplish certain prescribed repairs of the sea wall and certain alterations in the drainage system. The work is under way, and is scheduled for completion about February 1952.

SALT WATER INVESTIGATION, MOBILE HARBOR

Another somewhat unusual coastal-engineering undertaking on the east Gulf coast was an investigation of the behavior of salt water in Mobile Harbor made by the Mobile District, Corps of Engineers, during 1945. The study was made at the request of local interests to determine the effect of salt water intrusion on the establishment along the harbor water front of industrial plants requiring fresh water. Fourteen sampling ranges were established - nine on the Mobile River between Mobile and the confluence of the Tombigbee and Alabama Rivers, one each on the Tombigbee and Alabama above their confluence, one on the Tensaw River near its source, one on Three Mile Creek, and one on Chickasaw Creek. The general features of the harbor and connecting streams and some of the more important sampling ranges are shown on Figure 2. Water samples were taken about once every two weeks; in the main river, nine samples were generally taken at each station at each sampling - one each at top, mid depth, and bottom on each of three verticals spaced one near each bank and one on the center line. The 2,320 samples were analyzed in the laboratory to determine their salinity, turbidity, color, hydrogen-ion concentration, and total hardness. The results were published in House Document No. 773, 80th Congress, 2d session.

The most extreme measured conditions of salt water intrusion during the study are shown by the samples taken on November 9, 1944, with a river discharge of 10,700 second feet. The results are tabulated on Figure 2. The figures represent parts per million of salt, measured as chloride.

The study resulted in the following findings:

a. Salt water penetrates into the river principally along the bottom, owing to its greater density.

b. Tidal fluctuation has little effect in varying the extent of salt-water intrusion in Mobile River, probably due to the small tidal range and the diurnal nature of the tide.

c. The upper limit of salt water intrusion moves up - and downstream with decrease and increase in fresh-water discharge.

d. With a fresh-water discharge of 50,000 second-feet or more, the salt-water wedge is pushed back to or beyond the mouth of the river, and the entire river is fresh.

e. As the fresh-water discharge falls below 50,000 second-feet, salt water enters the river and pushes its way upstream. When the discharge decreases to 10,000 second-feet (about the minimum daily discharge for an average dry period), the upper limit of the salt-water intrusion is about 21 miles above the mouth of the river. In unusually dry periods, the salt-water wedge would probably penetrate somewhat farther upstream.

COASTAL PROBLEMS REQUIRING IMPROVED METHODS

The preceding study, the investigations described, and consideration of other coastal engineering problems emphasizes the need for additional information, further research, and improved methods for deriving solutions. A relatively quick and economical method of measuring quantity of drift material, and information that will lead to an intelligent estimate of such material which will deposit in a dredged channel and will bypass such a channel are needed. At the present time dependence for obtaining these data must be placed in performance of actual structures usually situated elsewhere than the locale of the considered improvement. With this information a reasonably accurate conclusion can be drawn as to the need for jetties, and maintenance costs which affect, sometimes strongly, the economic practicability of a project can be correctly appraised rather than imagined. Moreover should it be possible to measure the quantity which moves in various strips along the bottom, the correct or economic length of jetties could be foretold. With an indication of the direction of movement as well as the quantity, a conclusion can be drawn as to whether or not one jetty will suffice rather than two.

The relatively short life of structures erected in sea water has been pointed out. Research should continue on means of preventing marine borer attacks, on methods of protection against corrosion, and on the development of low cost non-corrosive metals and alloys.

The procedure for determining salinity, turbidity, etc., is cumbersome and costly. Methods of simplification are badly needed to facilitate solution of many of our harbor problems.

Model studies should be used to a greater extent than in the past. At the present time their cost often prohibits their use in connection with small projects, but even if comprehensive tests cannot be justified, perhaps partial tests can furnish beneficial results. Model tests can show where dredge spoil should be placed to minimize its return to excavated channels. Without the use of models only the costly cut-and-try process is available, though this may be guided by a float study. This problem in general has not been attacked in a scientific manner.

The model may be able to give an indication of the value of overdepth dredging for advance maintenance purposes as well as the relative rate of shoaling to be expected when a channel is deepened. At present the engineer must wait until the job is done and then the conclusions are often masked by other changes which have been made.

Excellent information on salt water intrusion can be obtained from models. When there have been a large number of instances of verification with few or no failures, the engineer may develop sufficient confidence to depend upon the model for these results rather than to employ the costly method of sampling and chemical analysis.

It has been shown at times in the past that orientation of channels through bars affects the maintenance of the channels. The bar channels of the Mississippi River are outstanding examples of this. But a statement of principles and a method of analysis which will indicate expected shoaling on various alignments and relative permanence of those alignments are needed. In the absence of means of analysis, the model can be used, it is believed, to furnish qualitative answers.

The model can also show waves and surges to be expected in bays and harbors with various configurations and arrangements of inlets and inlet works as well as structures, needed to remedy unsatisfactory conditions. By permitting trials of various jetty designs and alignments it can reveal the plan most likely to require the least channel maintenance.

Though models can be used advantageously to a greater extent than in the past, they are not a cure-all. The results, at times, can be misleading. They should never be accepted without critical scrutiny. Instead all model tests should be carefully analyzed by engineers of appropriate training and experience. Each observed action should be explained so that the engineer is satisfied that corresponding causative influences exist in the prototype and similar effects may be expected. By close observation and correlation with hydraulic laws and principles, analytical methods may be developed which will permit dependable forecasting of many results without the use of models. This should be the aim, for with its consummation, the cost of arriving at correct problem solutions will be reduced, and coastal engineering will be placed on a rational rather than an empirical basis.

REFERENCES

Doremus, E. P., and Doremus, G. L. Cathodic Protection of Fourteen Offshore Drilling Platforms: Corrosion, Vol. 6, No. 7, National Association of Corrosion Engineers.

Atwood, W. G., and Johnson, A. A. Marine Structures; Their Deterioration and Preservation: National Research Council, Washington, D. C.

Larrabee, C. P. Corrosion of a Steel Pile During Twelve Years of Service at Pensacola, Florida: Carnegie-Illinois Steel Corporation.

Reports of the Corps of Engineers, U. S. Army