UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

TIDAL RELATIONS IN THE SOUTH BISCAYNE BAY AREA, DADE COUNTY, FLORIDA

By

James J. Schneider

U.S. Geological Survey

OPEN FILE REPORT

Prepared by the
U.S. GEOLOGICAL SURVEY
in cooperation with
DADE COUNTY, FLORIDA

Tallahassee, Florida

January 1969

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER RESOURCES DIVISION
P.O. BOX 2315
TALLAHASSEE, FLORIDA 32304

February 12, 1969

Gentlemen:

Enclosed for your information is a copy of the open-file report, 'Tidal relations in the south Biscayne Bay area, Dade County, Florida", by James J. Schneider. The report describes the tidal fluctuations in Biscayne Bay, and relates the fluctuations recorded at long-term hydrographic stations to those measured at shorter-term stations during the course of the study. We think this report on tidal relations in Biscayne Bay area will be a valuable contribution to those concerned with tides in Biscayne Bay.

The report was prepared by the U. S. Geological Survey in cooperation with Dade County.

Sincerely yours,

Clyde S. Conover
District Chief

Enc.

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TIDAL RELATIONS IN THE SOUTH BISCAYNE BAY AREA, DADE COUNTY, FLORIDA

By

James J. Schneider

ABSTRACT

Development of the waterfront lands of southeast Dade County depends upon the construction of sea walls (bulkheads) and filling of the lowlying land. To assist Dade County officials in planning the development of the area, an investigation was made to determine the elevation of mean high water and tidal patterns in the south Biscayne Bay area. The results of the investigation are based on records collected from ten tide gages during the period July 1, 1967 through June 30, 1968. Prior records from most of the gages were available for correlation. The elevation of mean high water was 1.5 feet in central Biscayne Bay and 0.9 foot in the lower bays. The mean tidal range was 2.0 feet in central Biscayne Bay and 0.5 foot in the lower bays. The difference between mean half tide and mean water level was found to be negligible at all stations. The time lag for high and low tides, referred to Miami Beach, was approximately one hour in Biscayne Bay and 6 hours at Manatee Bay.

INTRODUCTION

The elevation of the undeveloped lower east coastal lands of Dade County is generally less than two feet above mean sea level (msl). Prior to this investigation there was little knowledge about the tidal affected water levels along this coastal area. Tidal information is needed by officials of Dade County to assist them in planning the orderly development of the area.

Officials of Dade County requested that the Geological Survey study the tidal fluctuations of lower Biscayne Bay, Card Sound, Barnes Sound and Manatee Bay (fig. 1). Approximately 35 miles of undeveloped mainland shoreline and more than 15 miles of island shoreline in Dade County are involved.

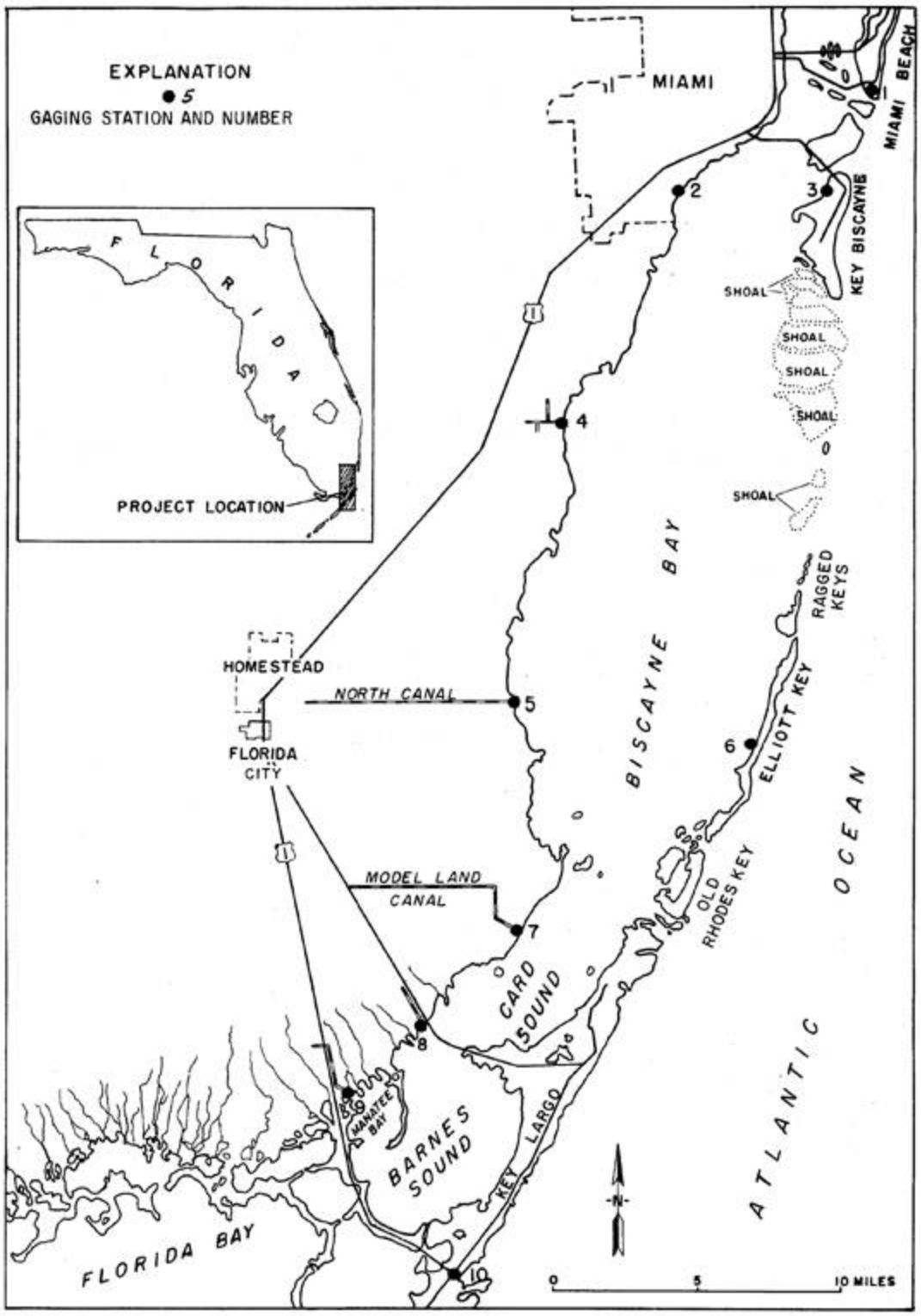

Figure 1.--Map of southeastern Dade County showing the area of investigation and location of gaging stations.

Biscayne Bay, Card Sound, Barnes Sound and Manatee Bay are shallow bodies of water separated by shoals, keys and mud flats. The shoals, keys, and mud flats retard the tidal induced movement of water from the ocean to the bay and between the bays and sounds. The area is bordered on the west by the mainland and on the east by the upper keys and the Atlantic Ocean. The southern embayments are separated from the Atlantic Ocean by northern Key Largo, Old Rhodes Key, and Elliott Key. The northern area is open to the ocean but shoals extend southward from the southern tip of Key Biscayne to the Ragged Keys.

In general, the purpose of the study was to determine the relation between ocean tides as recorded at Miami Beach and the tides in the south Biscayne Bay area and more specifically to determine values of: (1) mean high water; (2) mean low water; (3) mean half tide; (4) mean tidal range; and (5) average tidal lag in the area. A glossary of these terms is included at the end of this report.

ACKNOWLEDGMENTS

Appreciation is expressed for the cooperation of the U.S. Coast and Geodetic Survey and the Central and Southern Florida Flood Control District for supplying tidal records and to Dade County Parks Department for transportation to Elliott Key.

METHOD OF INVESTIGATION

This report is based on continuous tide records collected at ten sites (fig.1) during the period July 1, 1967 through June 30, 1968. The results are referred to mean sea level, 1929 datum. Records from the following long-term tide stations were available: Primary Tide Gage at Miami Beach estab. June 1931 (No. 1), Biscayne Bay at Coconut Grove estab. February 1959 (No. 2) and, Biscayne Bay near Homestead estab. February 1946 (No. 5). Records were also available from Cutler Drain Canal at Structure 123 (No. 4) and Manatee Bay at Canal 111 (No. 9) which were established shortly before the study period.

New tide gages were established during the latter part of 1966 and the early part of 1967 at the following locations: Biscayne Bay at Key Biscayne (No. 3), Biscayne Bay at Elliott Key (No. 6), Card Sound at Model Land Canal (No.7), Barnes Sound at Card Sound Road (No. 8) and, Garden Cove at Key Largo (No. 10). Garden Cove is located on the ocean side of Key Largo.

Because no bench marks were available, the datum of the Elliott Key station was approximated by comparing mean daily water levels with records from Biscayne Bay near Homestead, station no. 5. Ten selected days were used when the salinity control on North Canal was closed, winds were light, and tidal patterns were regular. The datum should be accurate within $\pm$ 0.05 foot.

A correlation with the means from the Card Sound gage to the north and the Manatee Bay gage to the south indicated that an adjustment of + 0.2 foot should be applied to the record of the Barnes Sound gage. The datum of this gage was determined from a bench mark established by an unchecked line of levels run by the Public Works Department of Dade County. An adjustment of + 0.2 foot was applied to the record.

RESULTS OF INVESTIGATION

The results of the investigation are summarized in Table 1. The table lists the mean values of high and low water, tidal range, half tide, and time lag at each station.

Tidal interchange between the ocean and Biscayne Bay and then southward into Card Sound, Barnes Sound, and Manatee Bay is progressively retarded by shoals and keys. This is shown by the curves of figures 2 and 3 which indicate a decrease in values for mean high water and mean tidal range, and an increase in the height of mean low water. Figure 3 also shows the seasonal variation.

Mean High Water

The elevation of mean high water along the west shore of Biscayne Bay was only slightly lower than at Miami Beach, however, at Card Sound and Manatee Bay it was 0.7 foot lower. At high tide the flooded shoals along the east side of Biscayne Bay and in the bay north of the Homestead station do not materially restrict the tidal flow as do the numerous islands in the channel connecting Biscayne Bay and Card Sound.

Table 1.--Mean values of, high and low water, tidal range, half tide and time lag observed during the period July 1, 1967 through June 30, 1968. Datum is mean sea level, datum of 1929.

No.	STATION	MEAN High Water	MEAN Low Water	MEAN Tidal Range	MEAN Half Tide	TIME LAG High Tide Hr.	TIME LAG High Tide Min.	TIME LAG Low Tide Hr.	TIME LAG Low Tide Min.
1.	Miami Beach Primary Tide Station (U.S. Coast & Geodetic Survey)	1.61 ft	-0.83 ft	2.44 ft	0.39 ft	--		--	
2.	Biscayne Bay at Coconut Grove	1.48	-0.54	2.02	0.47	1	20	1	40
3.	Biscayne Bay at Key Biscayne	1.37	-0.57	1.94	0.40	1	00	1	20
4.	Cutler Drain at Structure 123 1/ (Central and Southern Fla. Flood Control Dist.)	1.52	-0.40	1.92	0.56	1	30	2	00
5.	Biscayne Bay near Homestead 1/	1.42	-0.23	1.65	0.60	2	20	2	50
6.	Biscayne Bay at Elliott Key 3/	1.34	-0.20	1.54	0.57	2	10	2	40
7.	Card Sound at Model Land Canal	0.94	0.20	0.74	0.57	3	00	3	20
8.	Barnes Sound at Card Sound Road 2/	0.86	0.43	0.43	0.64	5	20	5	30
9.	Manatee Bay at Canal 111	0.89	0.42	0.47	0.66	5	40	6	00
10.	Garden Cover on Key Largo (ocean)	1.60	-0.46	2.06	0.57	0	20	0	40

Notes: 1/ Record affected by discharge through salinity control.

2/ An adjustment of +0.2 foot has been applied to the record.

3/ Datum approximated by correlating records, accuracy of determination ± 0.05 foot.

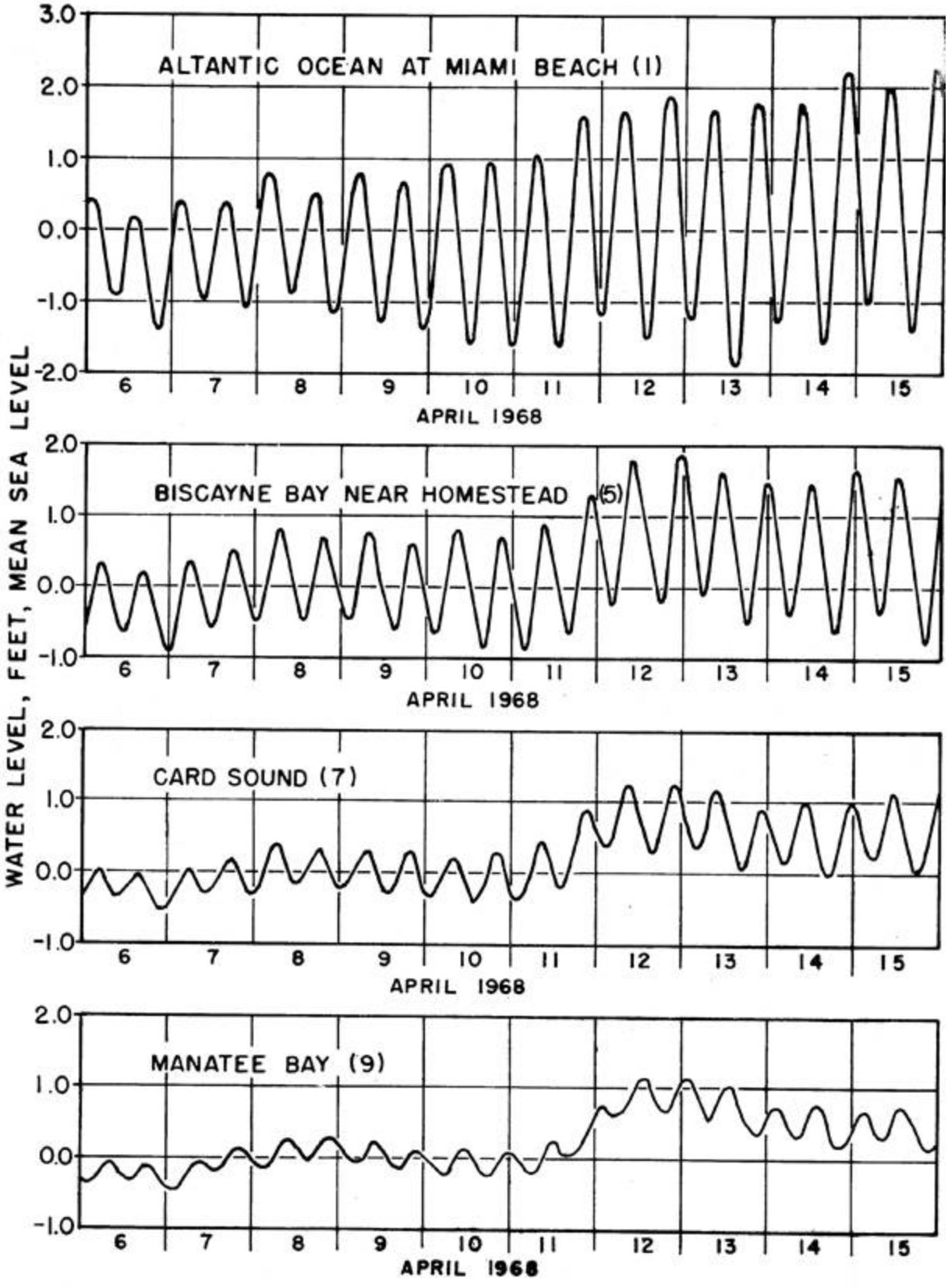

Figure 2.--Hydrograph showing typical tidal fluctuations at four locations, April 6-15, 1968.

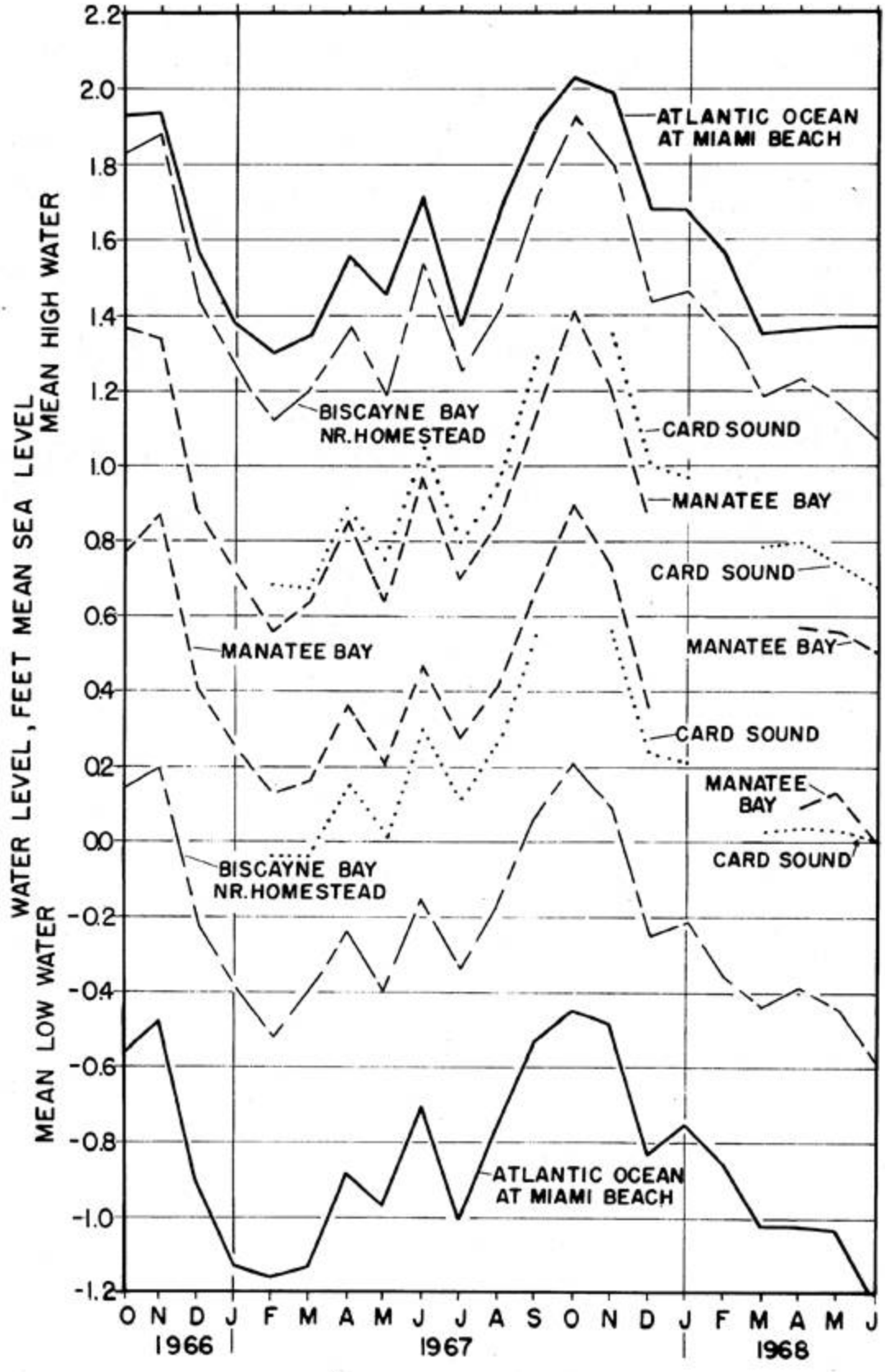

Figure 3.--Hydrograph showing the seasonal change of the monthly mean-high and mean-low water at four locations and the decrease in tidal range from open ocean to constricted bay.

The elevation of mean high water on the east side of the bay at Key Biscayne and Elliott Key was slightly lower than that along the mainland side. The prevailing easterly winds cause a slight pile-up of water along the west shore of the bay.

Mean Low Water

The elevation of mean low water showed a progressive rise from Miami Beach to Biscayne Bay and then southward to Manatee Bay where it was 1.25 feet higher than at Miami Beach. The change was about 0.5 foot. greater than it was for high water. At low tide the shoals along the east side of Biscayne Bay and in the bay north of the Homestead station offer greater retardation to the tidal flow than they do at high tide.

Mean Tidal Range

The decrease in the elevation of mean high water and the increase in the elevation of mean low water from Miami Beach to Manatee Bay is reflected in a 2-foot decrease in the tidal range between the two stations. The greater decrease in range, 0.9 foot, occurred between the adjacent embayments of Biscayne Bay and Card Sound.

Mean Half Tide

The elevation of mean half tide averages about 0.2 foot higher in Biscayne Bay than at Miami Beach. This is due primarily to the increase in the height of mean low water. Figure 4 is a hydrograph showing the seasonal variation in monthly mean half tide at four locations.

The maximum difference between mean half tide and mean water level at the ten stations was found to be 0.02 foot during the study period.

Tidal Time Lag

To determine the time of high or low tide at a selected station, the correction as shown in Table 1 should be added to the time of predicted high or low tide at Miami Beach. It is interesting to note that the tides at Manatee Bay lag those of Miami Beach by nearly 6 hours and thus are completely out of phase. Tidal lag also is shown in the hydrographs of daily fluctuations in figure 2.

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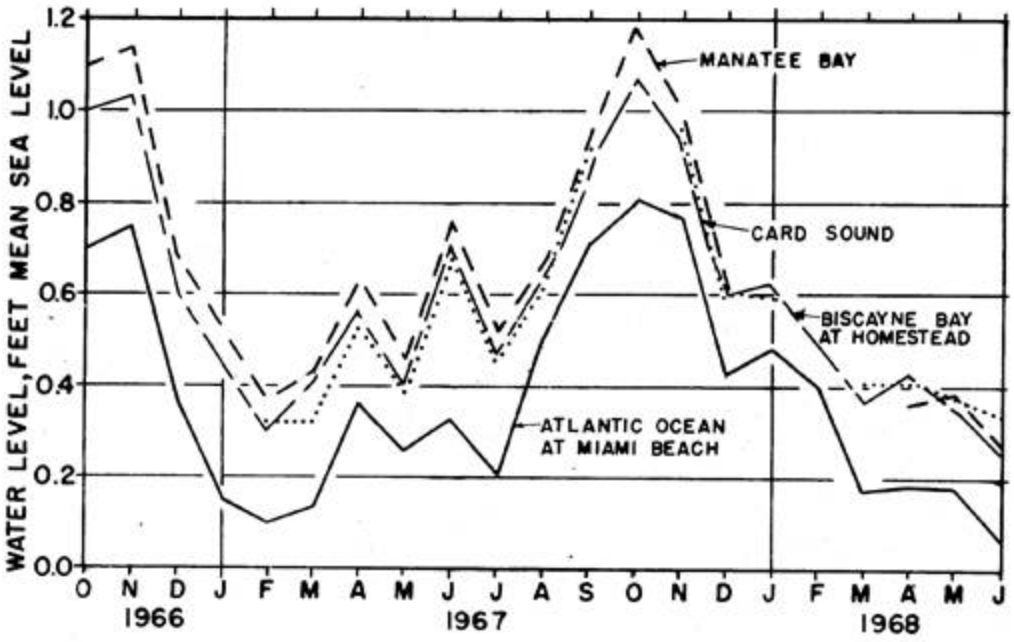

Figure 4.--Hydrograph showing seasonal change in the monthly mean half tide at four locations.

Wind Tides

During the study period only one tropical storm, Abby, affected the tides of the bay area. This storm affected the tides from June 3-5, 1968. The eye of Abby passed considerably to the west of Miami, moving in a northerly direction. Figure 5 shows the resulting tide patterns at four stations. The winds on June 3 were onshore switching to offshore that night and continuing offshore on the 4th and 5th. The effects of the storm can be seen in the rising tide levels on June 3, the falling tide level on the 4th and the low tide level on the 5th. The storm tides generated by Abby were relatively small by comparison with those of historic storms.

Rising Sea Level

The record from the tide station on Miami Beach shows a continually rising sea level. Figure 6 is a hydrograph of the yearly mean water levels recorded during the period 1932-67. The average rise amounts to approximately 0.01 foot per year. The mean water level at Miami Beach during the last 19 years of record (1949-67) was 0.34 foot. The mean water level at Miami Beach for the study period (July 1, 1967 to June 30, 1968) was 0.41 foot.

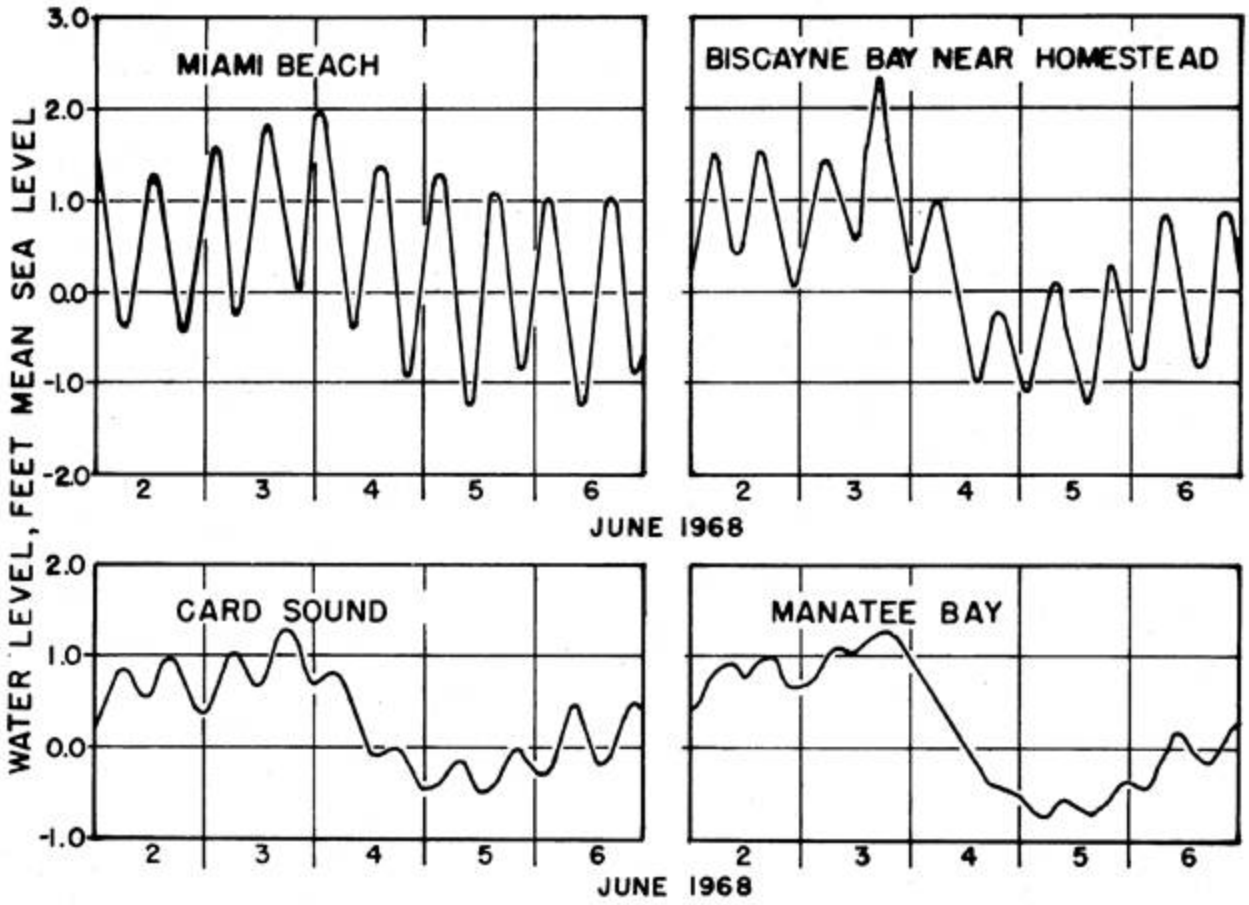

Figure 5.--Hydrograph showing the effects of tropical storm Abby (June 3-5, 1968) on tide patterns at four locations.

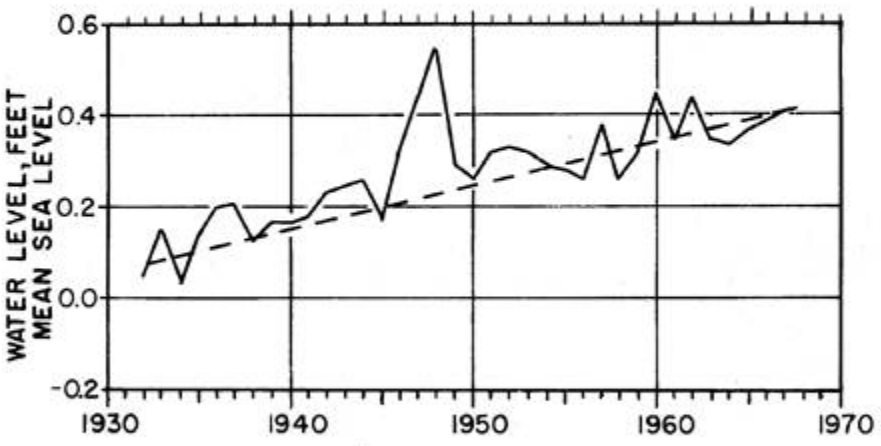

Figure 6.--Hydrograph of yearly mean water levels at Miami Beach, Fla. The dashed line represents the average rise in sea level.

GLOSSARY

Mean High Water: The average of all high waters of a series of observations.

Mean Low Water: The average of all low waters of a series of observations.

Mean Half Tide: The average of mean high and mean low waters of a series of observations.

Mean Water Level: The average water level of a series of observations.

Mean Tidal Range: The difference in elevation between the mean high and mean low water.

Note: For tidal waters normally the series of observations that are used to define mean high water etc. cover a 19 year period. For this report the series of observations are for a one year period unless otherwise specified.

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