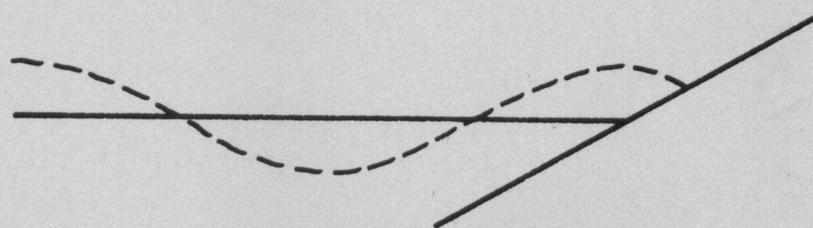
The National Tidal Datum Convention of 1980

May 1980



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Survey

NOAA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

The National Tidal Datum Convention of 1980

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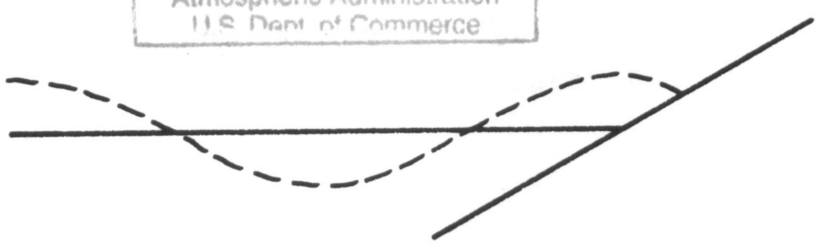
Office of Oceanography
Tides and Water Levels Division
May 1980



U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

National Ocean Survey
H.R. Lippold, Jr., Director

STATEMENT OF INTENT

It is the intention of the National Ocean Survey, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, to:

1. compute the tidal datums of Mean High Water and Mean Low Water as the arithmetic means of all the high and low water heights, respectively, observed over the accepted National Tidal Datum Epoch for all coasts of the United States, its possessions, and U.N. Trust Territories under its jurisdiction;

2. change Chart Datum from Mean Low Water to Mean Lower Low Water along the Atlantic coast of the United States;

3. update the National Tidal Datum Epoch from the 1941 through 1959, 19-year series, to the 1960 through 1978, 19-year series; and

4. begin phasing in the name, "Mean Lower Low Water," for the name, "Gulf Coast Low Water Datum," after implementation of the new Mean High Water computational method in all Gulf Coast States with predominantly diurnal tides (and using the Mean High Water Line as their State-private property boundary).

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4. begin phasing in the name,

the name, "Gulf Coast Low Water Datum."

High Water computational method

predominantly diurnal tides (and

Water Line as their State-private property boundary).

SUMMARY

1. Use of the proposed method for computing the tidal datum of Mean High Water will provide one uniform and continuous Shoreline for all nautical charts and bathymetric maps of the National Ocean Survey.

2. Changing Chart Datum from Mean Low Water to Mean Lower Low Water along the Atlantic coast will provide one uniform and continuous Chart Datum for all nautical charts and bathymetric maps of the National Ocean Survey.

3. Updating the National Tidal Datum Epoch from 1941 through 1959 to 1960 through 1978 will provide a more realistic reference for all tidal datums in view of the continuing change in apparent secular sea level.

4. The special name, "Gulf Coast Low Water Datum," will no longer be necessary after those Gulf Coast States with predominantly diurnal (once daily) tides (and using the Mean High Water Line as their State-private property boundary) implement the tidal datum of Mean High Water based on the proposed computational method.

5. The lowering of Mean High Water in the areas of predominantly diurnal tides of the Gulf (due to the proposed computational method) will be largely offset by the elevation of Mean High

Water (due to the rise in apparent secular sea level) with updating the National Tidal Datum Epoch.

6. The lowering of Chart Datum from Mean Low Water to Mean Lower Low Water along the Atlantic coast will be more than offset by the elevation of Mean Lower Low Water (due to the rise in apparent secular sea level) with updating the National Tidal Datum Epoch.

7. The Shoreline, Chart Datum, offshore boundaries (and their baselines), sounding figures, and isobaths as depicted on National Ocean Survey nautical charts and bathymetric maps will not be changed with the acceptance of any provision of this Convention. This lack of change is due to:

a. the offsetting effects of rising apparent secular sea level with updating the National Tidal Datum Epoch vs., the Mean High Water computational drop or the new Chart Datum lowering;

b. the thickness of lines on nautical charts and bathymetric maps; and

c. roundoff procedures and accuracies in datum determinations, hydrographic surveying, and nautical charting.

8. However, changes in the location of tidal datum lines (such as the Mean High Water Line, etc.) can be detected "on the ground" using accepted surveying techniques, tidal bench marks, and the numerical relationships provided by the National Ocean Survey. Gulf Coast States implementing the Mean High Water Line

as their State-private property boundary (using the proposed Mean High Water computational method) can expect a small seaward displacement of the boundary in areas of highly diurnal tides.

9. The purpose of this Convention is to provide one uniform and continuous Shoreline (at Mean High Water by the proposed computational method) and one uniform and continuous Chart Datum (at Mean Lower Low Water) for all appropriate National Ocean Survey marine products (nautical charts, bathymetric maps, tide tables, etc.) covering the coasts of the United States, its possessions, and U.N. Trust Territories under its jurisdiction. Also, States with predominantly diurnal or diurnal and mixed tides will be provided one uniform and continuous Mean High Water Line.

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PREFACE

This document presents and explains the provisions of The National Tidal Datum Convention of 1980. The conclusions and recommendations, expressed as "intentions," are issued under the authority of Cdr. Ralph J. Land, NOAA, Chief, Tides and Water Levels Division (T&WL), Office of Oceanography. The Convention is sponsored by Capt. Wesley V. Hull, NOAA, Associate Director, Office of Oceanography, National Ocean Survey (NOS), National Oceanic and Atmospheric Administration (NOAA).

The author acknowledges with appreciation the assistance provided by Dolores G. Selby, Office of Oceanography, Pauline H. Plunkett, T&WL, and Robert J. McClain, Quality Control Section, Requirements Branch, T&WL.

The idea for the new Atlantic Chart Datum has been the long-standing and persistent verbal and written proposal (Swanson, et al., 1976; and Swanson and Thurlow, 1979) of: Capt. R. Lawrence Swanson, NOAA, Director, Office of Marine Pollution Assessment, NOAA; Carroll I. Thurlow, Office of the Chief Scientist, NOS; and Cdr. Carl W. Fisher, NOAA, Chief, Operations Division, Atlantic Marine Center, NOS. The origination and development of the new

Mean High Water computational method was provided by: Carroll I. Thurlow; Bernard D. Zetler, Institute of Geophysics and Planetary Physics, Scripps Institution of Oceanography, University of California, San Diego; James R. Hubbard, Chief, Tidal Datums and Information Branch; and Jack E. Fancher, Chief, Tidal Analysis Branch; both of T&WL.

CONTENTS

FIGURES

I. INTRODUCTION

Boundaries are as old as civilization itself. The first, and still the most common, are those defined by geological conformations; including such features as mountain ridges, cliffs, rivers, and ocean shores. The usual requirement is to be easily recognizable by all parties concerned and to be relatively permanent. Their origin, at least, was intrinsically involved with defense. In recent centuries, series of artificial markers, parallels of latitude, meridians of longitude, and other lines recoverable by surveying techniques were added. However, by far the oldest, and seemingly the most logical, are boundaries associated with the line where land and water meet.

The word "seemingly" is very important. While land-water boundaries are so very logical on first assessment, their logic rapidly becomes more vexing when <u>in situ</u> and map (and chart) positioning accuracy, precision, recoverability, and etymology are concerned.

Since the water (and land) moves up and down in both periodic and nonperiodic motions, the location of the land-water intersection line moves up-the-beach-landward and down-the-beach-seaward as a function of time. If this intersection is to be used as a boundary (or the source of a boundary), it must be stopped from this horizontal movement; that is, it must be mathematically "fixed" by man. It follows that to fix the land-water intersection line in its landward-seaward movement, the up-down motion of the water must likewise be mathematically "fixed."

It is also desirable to fix the up-down motion of the water surface to obtain a reference for depths and depth contours on nautical charts and bathymetric maps; and, finally, a reference is needed for elevations of the predicted tide.

A mathematically fixed elevation of the ocean surface is known as a tidal datum. It is fixed through officially adopted definitions and procedures of the National Ocean Survey. The definitions and observation-based procedures are a function of the type of tide prevailing in the area of consideration.

The consistency of the types of tide on the west and east coasts of the United States precludes significant problems. However, along the Gulf coast the type of tide varies both in time and distance. Exact knowledge of these differences and changes has been accumulating very slowly as the network of National Ocean Survey tide stations has progressively expanded over the years. As a result of this slow accumulation of tidal data, the tidal datum decisions were made with the best knowledge available at the time. Thus, conflicting concepts which inadvertently developed over the years have contributed to confusion in several subject areas of land-ocean boundaries and depth references.

II. TYPES OF TIDE

There are three basic types of tides: semidiurnal (semi-daily), mixed, and diurnal (daily).

A. The first type, semidiurnal (figure 14), has two high waters (high tides) and two low waters (low tides) each tidal day. A tidal day is the time of rotation of the Earth with respect to the Moon, and its mean value is approximately equal to 24.84 hours. Qualitatively, the two high waters for each tidal day must be almost equal in height. The two low waters of each tidal day also must be almost equal in height.

B. The second type, mixed (figure 13), is the same as the semidiurnal except that the two high waters and/or two low waters of each tidal day must, qualitatively, have marked differences in their heights. An example (the actual tide curve at Clearwater Beach, Florida, for April 1975) is shown in figure 3. The location of Clearwater is shown in figure 1. When there are differences in the heights of the two high waters, they are designated as higher high water and lower high water; when there are differences in the heights of the two lows, they are designated higher low water and lower low water. If there are marked inequalities in both the high and low waters, the sequence of tide can either be higher high, higher low, lower high, lower low; or higher high, lower low, lower high, higher low.

C. The third type, diurnal (figure 13), has one high water and one low water each tidal day. (See figures 1 and 4.)

The type of tide can vary both with time at a single location and in distance along the coast. (See figures 1, 2, and 5.) The transition from one type to another is gradual.

Each year the Earth and Sun revolve around their common center of mass in a plane called the ecliptic. Each month the Moon and Earth revolve around their common center of mass in a plane inclined about 5 degrees to the ecliptic. Since the Earth is tipped about 23-1/2 degrees to the ecliptic, the Moon's orbit will always be inclined to the equatorial plane (obliquity of the Moon's orbit) of the Earth. Thus, the Moon will have an apparent motion both north and south of the equator every month. The north and south excursion is known as lunar declination and is largely responsible for the "time" transition in type of tide from semi-diurnal to mixed to diurnal. This is because the tide generating forces deviate from a symmetrical orientation about the equator during these two periods every month. Since a point rotates each day parallel to the plane of the equator, it experiences these asymmetrical tide generating forces which cause more and more diurnal inequality with greater and greater declination until, in extreme, diurnal tides may finally result.

The declinational effect for Blackburn Point, Florida, is shown in figure 5 (see figure 1 for location). The Moon's maximum north declination occurred on April 16 and its maximum south, on April 1 and 28. On the 2nd through the 5th, and the 17th and 18th, the mixed tide became diurnal. The opposite extreme is shown in figure 4 for Pensacola, Florida (see figure 1 for location). The Moon was over the equator on April 9 and 22, 1975. On and just before these dates of minimum declination, the diurnal tide became semidiurnal.

Because the plane of the Moon's orbit <u>pivots</u> on the ecliptic, the Moon's maximum declination will occur alternately in and out of phase with the direction of the Earth's inclination to the ecliptic. This pivoting, known as the regression of the Moon's nodes, is westward and takes 18.61 years to complete. As a consequence, the semimonthly declination of the Moon will vary from 28-1/2 degrees (23-1/2 degrees + 5 degrees) to 18-1/2 degrees (23-1/2 degrees - 5 degrees) and back again over the 18.61-year period. Reckoning convention is such that when the longitude of the Moon's ascending node is zero (at the vernal equinox), maximum declinations are experienced, while at 180 degrees minimum declinations occur.

The nodal effect is illustrated by comparing figure 6 with figure 7. Figure 6 shows a predominatly mixed tide at Cedar Key, Florida, when the longitude of the Moon's node is zero degrees. As seen, the tide is diurnal. For the same station at 180 degrees, the tide remains mixed (figure 7). Additional predominantly mixed tide examples from other areas of the Gulf when the Moon's node is zero degrees are given in figures 10 and 11.

Figures 8 and 9 show a tide at St. Petersburg, Florida. At zero degrees, the diurnal aspect is dominant while at 180 degrees the tide has become almost exclusively mixed.

The Sun is an additional, although smaller, tide producing body. This is because the Sun is at a much greater distance from the Earth than the Moon, and because the tide generating force varies inversely as the cube of the distance between the Earth and these bodies. Since the Earth is inclined about 23-1/2 degrees to the ecliptic, a maximum solar declinational effect will be experienced at the beginning of winter and summer.

In summary, the maximum declinational effect (i.e., the tendency of a tide to have greater diurnal inequality and finally become diurnal) would occur:

A. at the maximum semimonthly declination of the Moon north and south of the equator,

B. when the longitude of the Moon's ascending node is zero degrees, and

C. at the beginning of winter or summer when the Sun is at its maximum declination.

Conversely, the tendency of a diurnal tide to become semidiurnal and to have less diurnal inequality would occur:

A. semimonthly as the Moon passes over the equator,

B. when the longitude of the Moon's ascending node is 180 degrees, and

C. at the beginning of spring and fall when the Sun is over the celestial equator.

Because of bottom friction, viscosity, presence of continents, irregular oceanic basins, nonuniform depth, reflections, and interferences, certain oceanic regions tend to respond differently to the same tide generating forces. Some areas of the Gulf of Mexico are particularly sensitive to diurnal tendencies, giving rise to areas with predominantly mixed and diurnal tides.

III. TIDAL DATUMS

A datum is a reference base from which measurements are made. A vertical datum is, as the name implies, a reference base from which elevations and depths are measured. A tidal datum is a vertical datum defined in terms of an observed tidal phenomenon. Although there are many tidal datums, this report is concerned with: Mean Higher High Water, Mean High Water, Mean Lower Low Water, and Gulf Coast Low Water Datum along the Gulf coast, and Mean Low Water and Mean Lower Low Water along the Atlantic coast (Schureman, 1975).

Mean Higher High Water is presently defined as:

The arithmetic mean of the higher high water heights of a mixed tide (figure 13) observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Only the higher high water of each pair of high waters of a tidal day is included in the mean. For stations with shorter series, simultaneous observational comparisons are made with a primary control tide station in order to derive the equivalent of a 19-year value.

Mean High Water is presently defined as:

The arithmetic mean of the high water heights observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observational comparisons are made with a primary control tide station in order to derive the equivalent of a 19-year value. Use of the synonymous term, mean high tide, is discouraged.

For a semidiurnal or mixed tide (figure 13), the two high waters of each tidal day are included in the mean. When any lower high water is indistinct, it is determined by record examination. For a diurnal tide (figure 13), the one high water of each tidal day is used in the mean. In the event a second high water occurs, only the diurnal high water is included. So determined, this Mean High Water, based on the diurnal tide, is the equivalent of Mean Higher High Water of a mixed tide.

Mean Low Water is presently defined as:

The arithmetic mean of the low water heights observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observational comparisons are made with a primary control tide station in order to derive the equivalent of a 19-year value. Use of the synonymous term, mean low tide, is discouraged.

For a semidiurnal (figure 14) or mixed tide, the two low waters of each tidal day are included in the mean. When any higher low water is indistinct, it is determined by record examination (figure 5). For a diurnal tide, the one low water of each tidal day is used in the mean. In the event a second low water occurs, only the diurnal low water is included (figure 4). So determined, this Mean Low Water, based on the diurnal tide, is the equivalent of Mean Lower Low Water of a mixed tide.

Mean Lower Low Water is presently defined as:

The arithmetic mean of the lower low water heights of a mixed tide observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Only the lower low water of each pair of low waters of a tidal day is included in the mean. For stations with shorter series, simultaneous observational comparisons are made with a primary control tide station in order to derive the equivalent of a 19-year value.

Gulf Coast Low Water Datum is defined as:

Mean Lower Low Water when the type of tide is mixed and Mean Low Water when the type of tide is diurnal (figure 13).

A 19-year Metonic cycle is used in order to include all possibly significant tidal cycles through the 18.6-year period for the regression of the Moon's nodes (node cycle) while still terminating on a complete yearly (much larger) cycle. As there are irregular (in time and space) apparent secular trends in sea level (figure 12), a specific 19-year cycle (the National Tidal Datum Epoch) is necessary so that all tidal datum determinations throughout the United States will have a common reference. The National Tidal Datum Epoch officially adopted by the National

Ocean Survey is presently 1941 through 1959. In summary, tidal datums are defined in terms of a method designed to mathematically "fix" the vertical oscillations of the sea relative to the land.

IV. THE TIDAL DATUM OF MEAN HIGH WATER ALONG THE GULF COAST

Along the east coast of the United States, the type of tide is semidiurnal with two high waters (on the average) each tidal day (24.84 hours). Along the west coast, the tide is almost always mixed, again with two high waters (albeit frequently very unequal in height) each tidal day.

However, along the Gulf coast of the United States, the tide is mixed in some areas and diurnal in others. Essentially, it is considered mixed from Key Largo to Apalachicola with some diurnal tides in the Tampa Bay and Charlotte Harbor areas. It is chiefly diurnal from Apalachicola to the Rio Grande, except for the Sabine and Calcasieu Passes areas where it is mixed (figure 1). In addition to these generalizations, there are many others associated with islands, distances up bays and estuaries, and within lagoons (figure 2).

The presence of diurnal tides in the Gulf, and especially the fact that they do not stay purely diurnal at any one place (as explained in detail in Chapter II), causes a tidal datum of Mean High Water (as presently defined) to be nonuniform and discontinuous (figure 13). This is because Mean High Water of the mixed tide includes both high waters of each tidal day in the mean, while Mean High Water of the diurnal includes only the one high water of each tidal day in the mean, <u>regardless</u> of the fact that there are always portions of the month when a diurnal tide has <u>two</u> high waters per tidal day! Likewise, the Mean High Water Line along the Gulf (as presently defined) is nonuniform and discontinuous since it, in turn, is the intersection of the land with the ocean surface at the tidal datum elevation of Mean High Water.

Thus, in order to provide a uniform and continuous Mean High Water Line, it is intended that all (except in <u>very</u> special cases) high waters appearing with adjacent ranges equal to or greater than 0.1 foot be used in the mean for the datum of Mean High Water regardless of type of tide. For the Mean Higher High Water Line, the one high water of a diurnal tidal day and the diurnal (or highest) high water of a multiple high water tidal day (semidiurnal, mixed, third-, fourth-, and/or sixth-diurnal) will be used in the mean for the datum (figure 13).

Conversely, the Mean Low Water Line and Mean Lower Low Water Line would be determined by similar computations of their respective datums.

Since the Shoreline, as depicted on National Ocean Survey nautical charts and bathymetric maps, is the Mean High Water Line, the new computational method provides one uniform and continuous Shoreline along all coasts of the United States, its possessions, and U.N. Trust Territories under its jurisdiction. Although of great importance along the Gulf coast, it is also applicable to areas where the tide goes diurnal in California, the Northwest, Alaska, Hawaii, Puerto Rico, Virgin Islands, and the Trust Territory of the Pacific Islands.

Finally, and probably of greatest importance, is its use by States that have designated the Mean High Water Line as the boundary between private and State land and have one, three, four, and/or six tides per tidal day along part (or all) of their coast, and two tides along the rest. When these States implement the tidal datum of Mean High Water based on the proposed computational method, they will possess one uniform and continuous boundary between their private and States lands.

The Shoreline, as depicted on National Ocean Survey nautical charts and bathymetric maps, would be adjusted, theoretically, on the States of Florida (west coast), Alabama, Mississippi, Louisiana, Texas, and parts of Alaska, Puerto Rico, and the Virgin Islands. However, only Florida, Alabama, Mississippi, and Alaska could take advantage of the new Mean High Water computation method (without changing their law significantly), since they already use the Mean High Water Line for their State-private property boundary (Maloney and Ausness, 1974). The status of Puerto Rico and the Virgin Islands, in this respect, is unknown at this time.

V. MEAN LOWER LOW WATER AS CHART DATUM ALONG THE ATLANTIC AND GULF COASTS

Chart Datum along the Pacific coast is Mean Lower Low Water. Chart Datum along the Gulf coast is Gulf Coast Low Water Datum (Hicks, 1977). Gulf Coast Low Water Datum is Mean Lower Low Water when the type of tide is mixed and Mean Low Water (present definition) when the type of tide is diurnal (figure 13). As such, Gulf Coast Low Water Datum is a uniform and continuous Mean Lower Low Water (by the proposed definition), as the latter is on the west coast. To continue this uniformity of Chart Datum, it would be desirable to lower Chart Datum from Mean Low Water to Mean Lower Low Water along the Atlantic coast (figure 14).

Gulf Coast Low Water Datum was created in order to:

1. provide a uniform and continuous Chart Datum,
2. be independent of any tidal type classification system,
3. not affect any high water datum directly or by inference,
4. not affect any State-private property lines,
5. not create or eliminate any present datums, and
6. not change any datum name or definition.

With the use of the proposed computational method for the tidal datum of Mean High Water (by States using the Mean High Water Line as the boundary between private and State lands), Gulf

Coast Low Water Datum could be phased out. This would be accomplished by merely changing the name, "Gulf Coast Low Water Datum," to, "Mean Lower Low Water."

However, this name change could not begin until after the proposed Mean High Water computational method has been implemented. To illustrate the reason, a hypothetical scenario follows. A piece of private land fronts the Gulf of Mexico in a State where the Mean High Water Line is the boundary between private and State property. Also, the type of tide in front of this property is predominantly diurnal. If the name, "Gulf Coast Low Water Datum," were to be changed to, "Mean Lower Low Water," without acceptance by the State of the proposed computational method for Mean High Water, then the private property owner might easily speculate that the present Mean High Water is completely analogous (computationally) to the proposed Mean Lower Low Water in front of the property and; therefore, Mean High Water is really Mean Higher High Water. Since the deed reads to the Mean High Water Line, the property line is a small but measurable distance seaward. With the proposed computational method for Mean High Water, this hypothetical situation would not exist.

VI. THE NATIONAL TIDAL DATUM EPOCH

As stated in Chapter III, the National Tidal Datum Epoch needs to be revised from time to time in order to take into account trends in apparent secular sea level (figure 12). The word "apparent" is used to indicate that the change in sea level could be truly secular (nonperiodic) or only a segment of a much longer unknown oscillation.

Long-period trends in apparent secular sea level are, in addition to variabilities, composed of eustatic (worldwide) changes and the vertical component of tectonic movement. The variability is due to meteorological, oceanographic, and hydrological effects (both periodic and random). The value of the eustatic rate (the average of several authors) is +1.0 to +1.1 mm per year (Lisitzin, 1974). Using selected data from the continental United States (except Alaska), Hicks (1978) obtained a mean value of +1.5 mm per year. The vertical component of the tectonic motion at any location is the difference (with regard to sign) between the eustatic rate and the observed long-period apparent secular sea level trend at that same location.

The maximum positive rate of the apparent secular trend, as determined by a straight line of regression through annual means of hourly heights, is +6.3 mm per year (±0.3 mm per year, standard error of slope determination) from 1909 through 1975 at Galveston

(Pier 21), Texas. The maximum negative rate is -13.4 mm per year (±0.5 mm per year) from 1936 through 1975 at Juneau, Alaska. The value for San Francisco, California, of +1.5 mm per year from 1940 through 1975, coincides with the eustatic rate derived from the mean of United States gages.

Since sea level series are not strictly linear, it is more realistic to take a common series length when comparing station rates. However, the maximum positive rate and maximum negative rate still happen to be at Galveston and Juneau with the same values respectively. The stations with maximum nonlinearity are Boston, Massachusetts, and Honolulu, Hawaii. From 1922 through 1975, sea level rose 2.8 mm per year at Boston; but from 1940 through 1975, the rate was only 1.5 mm per year. From 1905 to 1975, the rate was 1.6 mm per year at Honolulu, while it decreased to only 0.3 mm per year from 1940 through 1975.

Even though the specific 19-year average of the National Tidal Datum Epoch reduces the magnitude of the rates stated in the previous paragraphs, the 19-year average differences finally do become significant. The Epoch must then be revised by updating to the most recent values in order to provide a legally defensible datum system.

VII. RECOMMENDATIONS

The following definitions are recommended:

Mean High Water (MHW)--The arithmetic mean of all the high water heights observed over the National Tidal Datum Epoch. To be counted, each high water must be 0.1 foot or more above the highest adjacent low water, apparently periodic, and continuous or regularly reoccurring. For stations with shorter series, simultaneous observational comparisons are made with a primary control station in order to derive the equivalent of the National Tidal Datum Epoch value.

Mean Higher High Water (MHHW)--The arithmetic mean of the highest high water height of each tidal day observed over the National Tidal Datum Epoch. To be counted, each high water must be 0.1 foot or more above the highest adjacent low water, apparently periodic, and continuous or regularly reoccurring. For stations with shorter series, simultaneous observational comparisons are made with a primary control station in order to derive the equivalent of the National Tidal Datum Epoch value.

Mean Low Water (MLW)--The arithmetic mean of all the low water heights observed over the National Tidal Datum Epoch. To be counted, each low water must be 0.1 foot or more below the lowest adjacent high water, apparently periodic, and continuous or regularly reoccurring. For stations with shorter series, simultaneous observational comparisons are made with a primary control station in order to derive the equivalent of the National Tidal Datum Epoch value.

Mean Lower Low Water (MLLW)--The arithmetic mean of the lowest low water height of each tidal day observed over the National Tidal Datum Epoch. To be counted, each low water must be 0.1 foot or more below the lowest adjacent high water, apparently periodic, and continuous or regularly reoccurring. For stations with shorter series, simultaneous observational comparisons are made with a primary control station in order to derive the equivalent of the National Tidal Datum Epoch value.

Simultaneous observational comparisons will continue to be made by the standard National Ocean Survey method. However, when the tide at the control station is predominantly diurnal and when there is a significant difference in the total number of highs (or lows) between the control and subordinate station, the following procedural departure would be adopted.

The mean of the diurnal high water inequalities would be computed <u>without adjustment</u> at the subordinate (1-year minimum) station. This value would then be subtracted from the adjusted (to the control station) Mean Higher High Water to give the datum of Mean High Water at the subordinate station. Likewise, the unadjusted diurnal low water inequality would be added to the 19-year adjusted value of Mean Lower Low Water to give Mean Low Water at the subordinate station. This method is considered the most accurate and consistent procedure possible with the given restraints. Theoretically, the accuracy and consistency would increse as the length of series at the subordinate station approached 19 years.

For clarifying information on this subject, the following definitions will be retained:

High Water (HW) -- The maximum height reached by a rising tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions.

Low Water (LW) -- The minimum height reached by a falling tide, etc.

VIII. IMPACTS

The greatest decrease in the tidal datum of Mean High Water due to employment of the proposed computational method would be 0.37 foot at St. Petersburg, Florida. A drop of about 0.35 foot is to be expected in the Tampa Bay and Charlotte Harbor areas. In Mississippi, a decrease of 0.26 foot would occur at Rotten Bayou and 0.28 foot at the Jourdan River. In contrast, Mean High Water at Galveston, Texas, would lower only 0.12 foot.

However, these values would be mitigated by the increase due to the revised National Tidal Datum Epoch. The datum at St. Petersburg would actually drop only 0.27 foot (-0.37 + 0.10), Fort Myers, Florida, and the Charlotte Harbor area, about 0.25 foot (-0.35 + 0.10), while Galveston will experience a net rise of 0.21 foot (-0.12 + 0.33).

Actually, when combined with the results of Gulf Coast Low Water Datum (Hicks, 1977; Gleiter, 1977), the States in question would neither gain nor lose State lands, although they would be shifted slightly seaward. Private property owners in the subject areas would gain a very small amount of land. The Federal Government has already lost a very small amount of land to the States with implementation of Gulf Coast Low Water Datum. The amount of land lost by the Federal Government is equal to the amount that would be gained by the private property owner with this convention.

Representative decrease estimates from Mean Low Water to Mean Lower Low Water for Chart Datum along the Atlantic coast are:

Eastport	-0.4 foot,
Boston	-0.3 foot,
Atlantic City	-0.2 foot,
Norfolk	-0.1 foot, and
Charleston	-0.2 foot.

With revision of the National Tidal Datum Epoch, the net estimate values become:

Eastport	-0.17 foot (-0.4 + 0.23),
Boston	-0.24 foot (-0.3 + 0.06),
Atlantic City	+0.05 foot (-0.2 + 0.25),
Norfolk	+0.14 foot (-0.1 + 0.24), and
Charleston	-0.07 foot (-0.2 + 0.13).

No impact would be realized on the west coast of the United States. Representative values due to Epoch revision are: San Diego, California, +0.07 foot; San Francisco, California, +0.10 foot; Crescent City, California, -0.07 foot; and Neah Bay, Washington, -0.11 foot.

Summary

With acceptance of the Conventions for revising the National Tidal Datum Epoch and the proposed method of computing Mean High (and Low) Water, the datum values will vary from a maximum drop of about 0.27 foot at St. Petersburg to a maximum rise in the localized Galveston area of about 0.21 foot.

Since the net amount of datum change is within the accepted accuracy of hydrographic surveying, no revision of printed numerical sounding values or isobaths would be necessary on nautical charts or bathymetric maps with the Conventions of revising the National Tidal Datum Epoch and changing Chart Datum from Mean Low Water to Mean Lower Low Water along the Atlantic coast.

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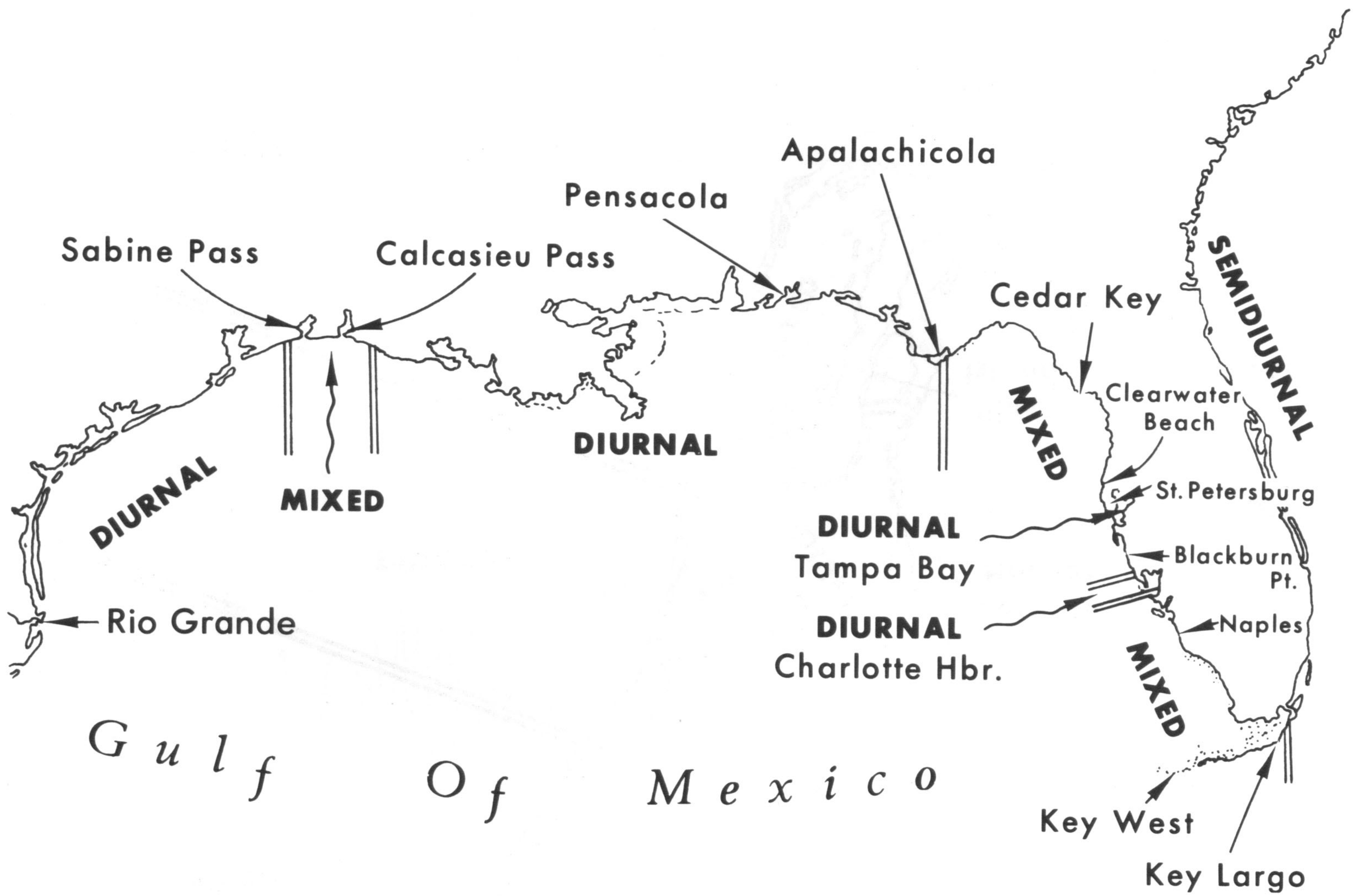


Figure 1.--Areal extent of tidal types and locations of stations with illustrated tide curves

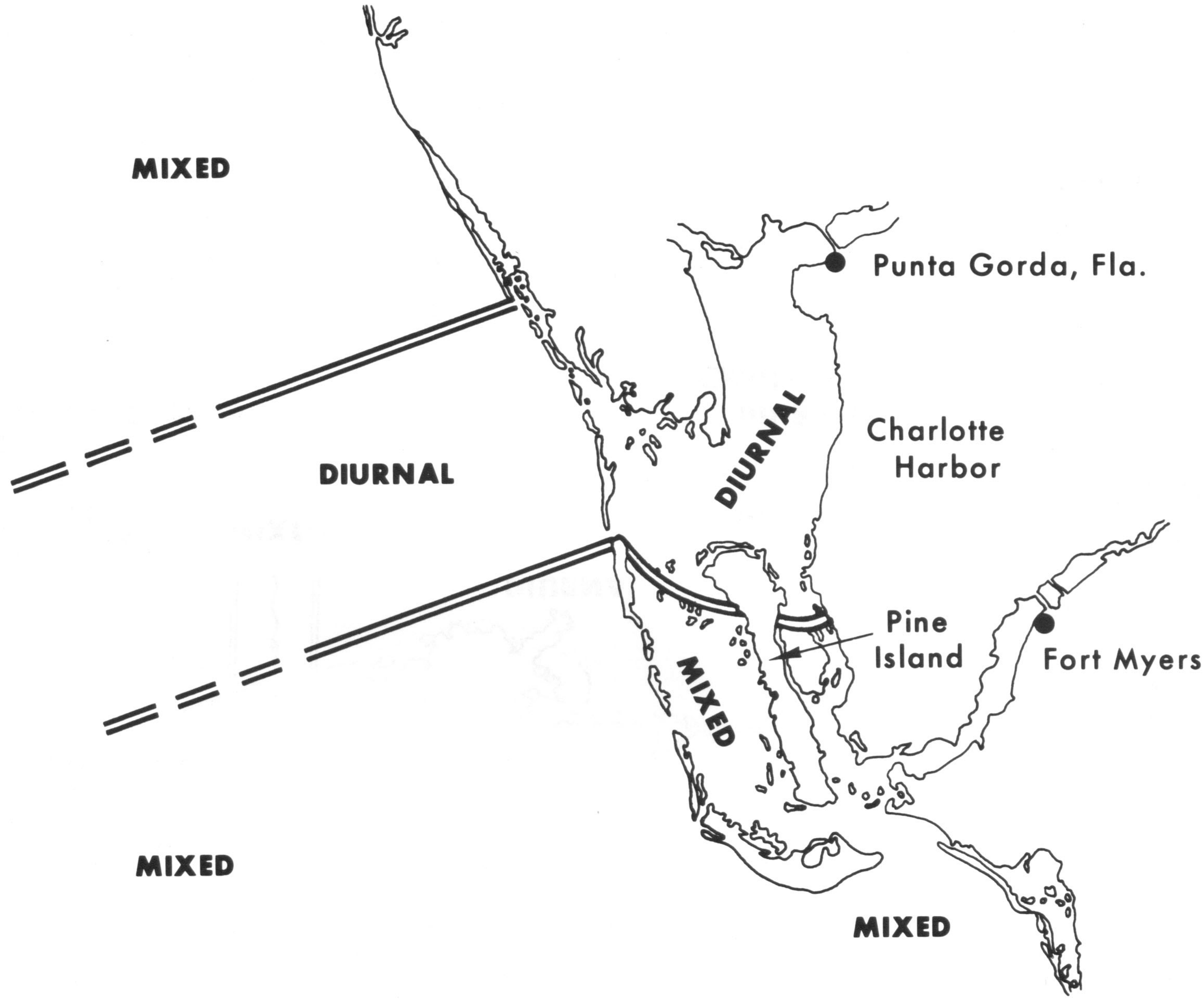


Figure 2.--Charlotte Harbor, Florida, detail of small area of Gulf Coast with several changes in tidal types

Figure 2.--Charlotte Harbor, Florida, detail of small area of Gulf Coast with several changes in tidal types

Figure 3.-- EXAMPLE OF MIXED TIDE
CLEARWATER BEACH, FLORIDA APRIL 1975
PLOT OF HOURLY TIDAL HEIGHTS

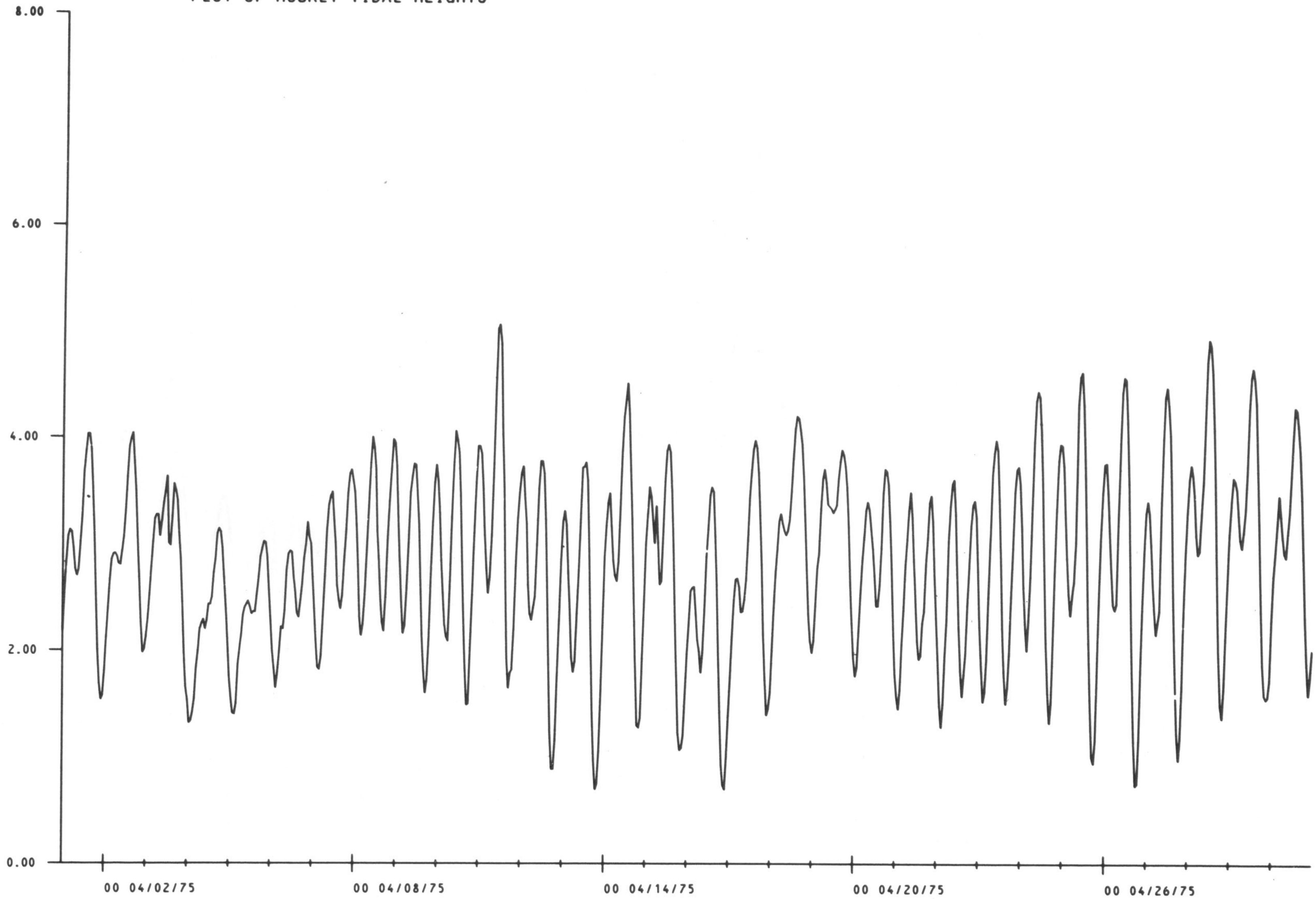


Figure 4.-- EXAMPLE OF DIURNAL TIDE
PENSACOLA, FLORIDA APRIL 1 - 30, 1975
PLOT OF HOURLY TIDAL HEIGHTS

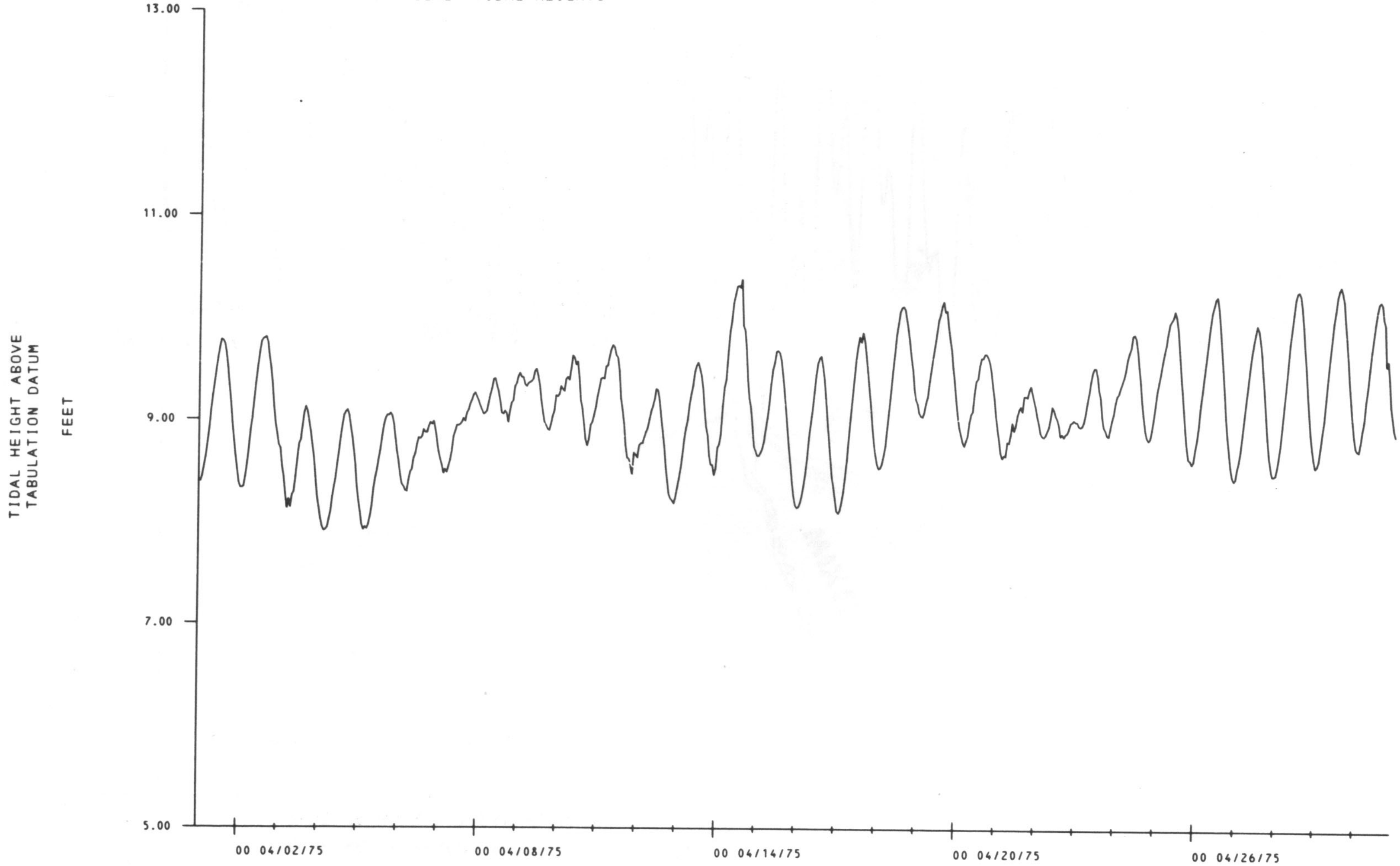


Figure 5.-- EXAMPLE OF MIXED TIDE
BLACKBURN POINT, CASEY BAY, FLORIDA APRIL 1975
PLOT OF HOURLY TIDAL HEIGHTS

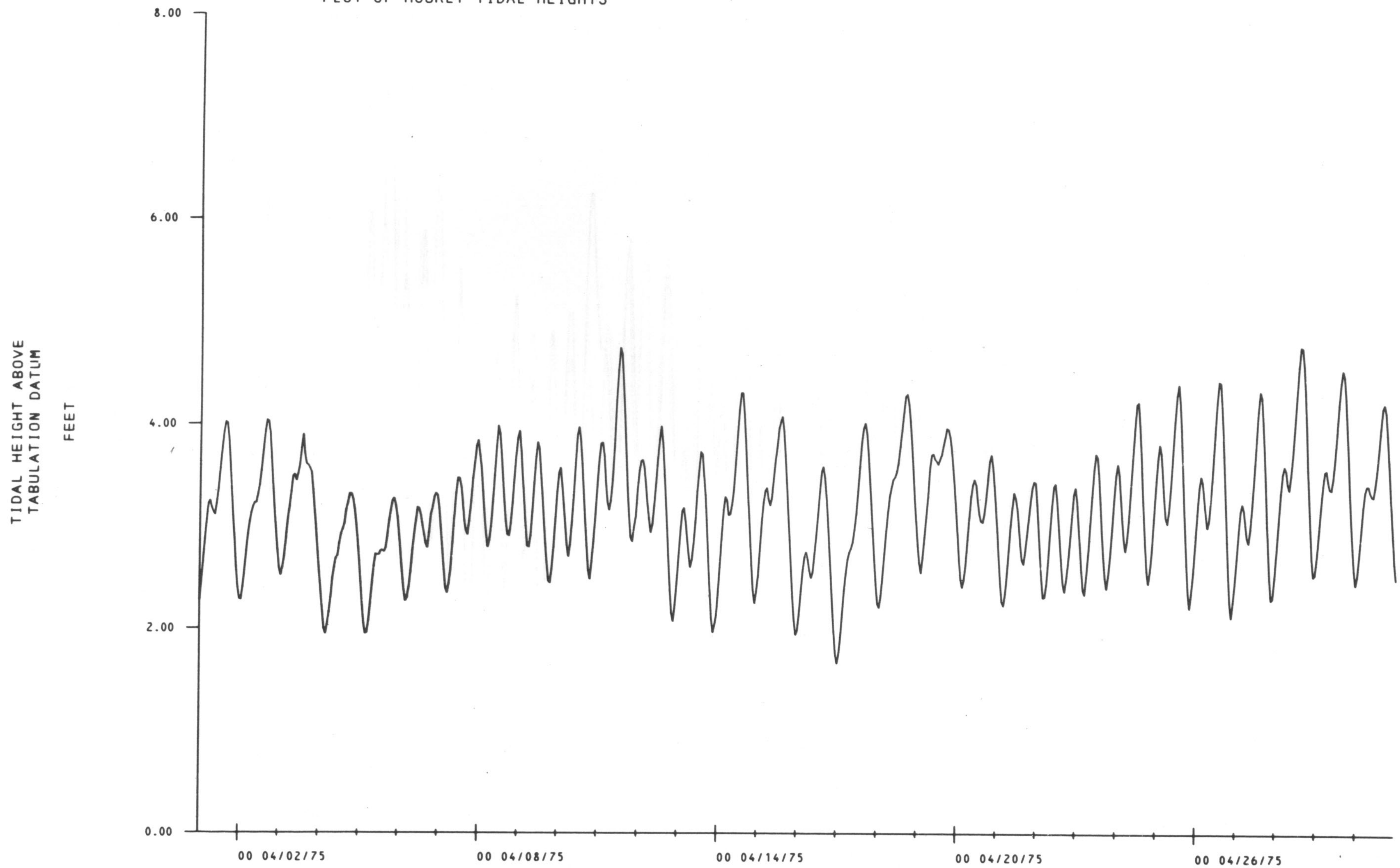


Figure 6.-- EXAMPLE OF MIXED TYPE OF TIDE BECOMING DIURNAL WHFN LONGITUDE OF MOONS NODE IS ZERO DEGREE
CEDAR KEY, FLORIDA FEBRUARY 1969
PLOT OF HOURLY TIDAL HEIGHTS

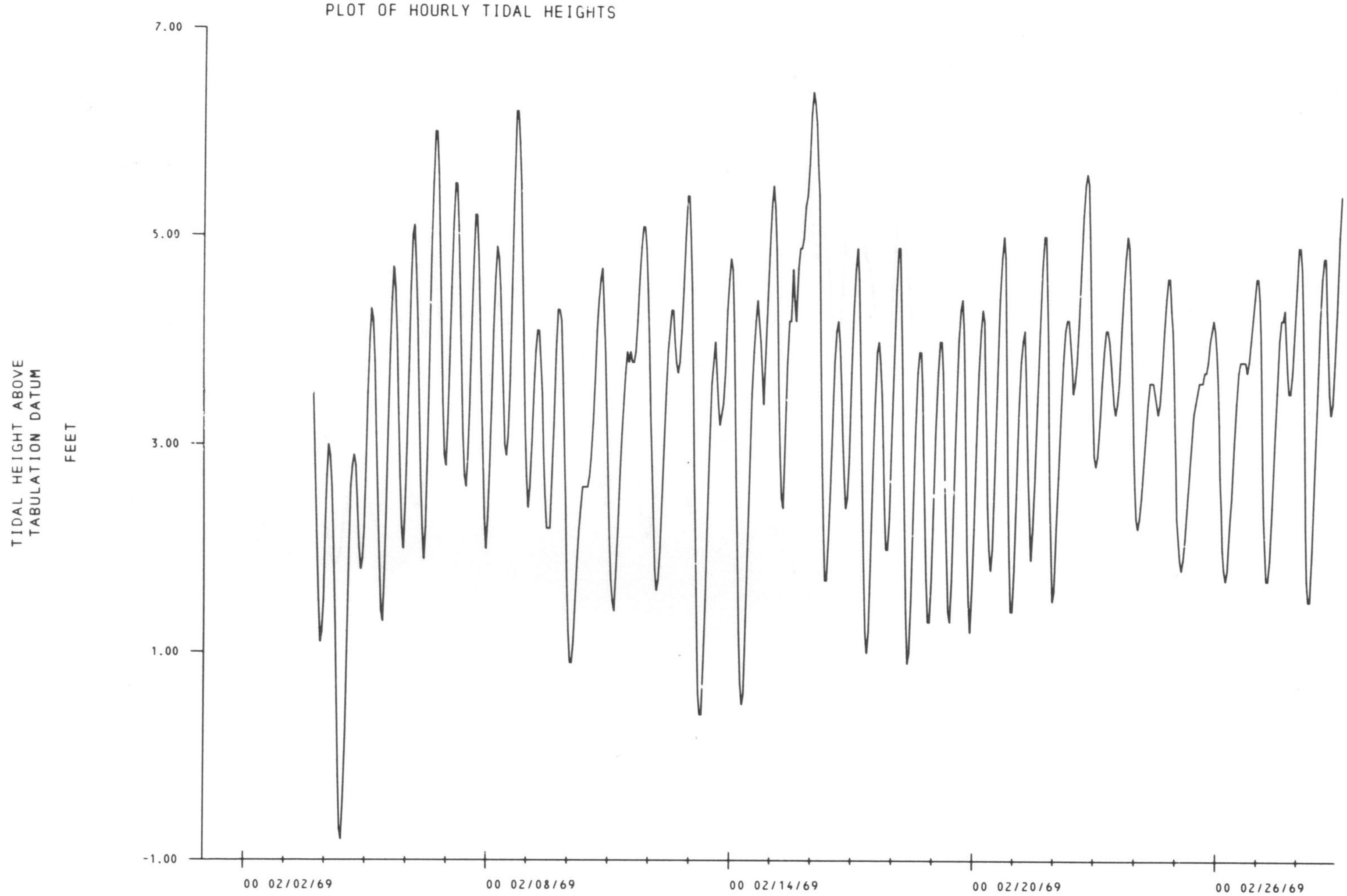


Figure 7.-- EXAMPLE OF MIXED TYPE OF TIDE WHEN LONGITUDE OF MOONS NODE IS 180 DEGREES
CEDAR KEY, FLORIDA NOVEMBER 1959
PLOT OF HOURLY TIDAL HEIGHTS

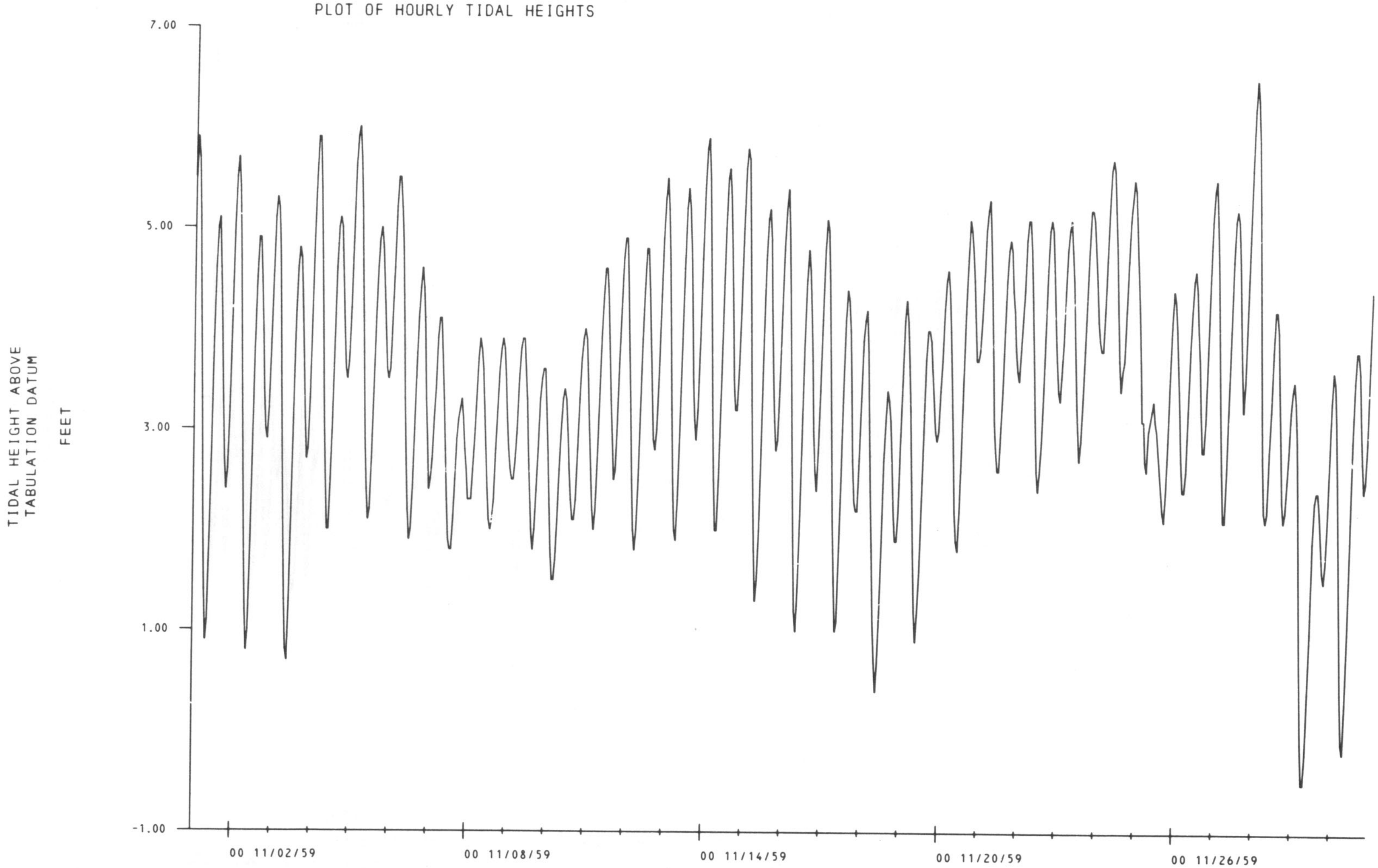


Figure 8.-- EXAMPLE OF DIURNAL TYPE OF TIDE WHEN LONGITUDE OF MOONS NODE IS ZERO DEGREES
ST PETERSBURG, FLORIDA FEBRUARY 1969
PLOT OF HOURLY TIDAL HEIGHTS

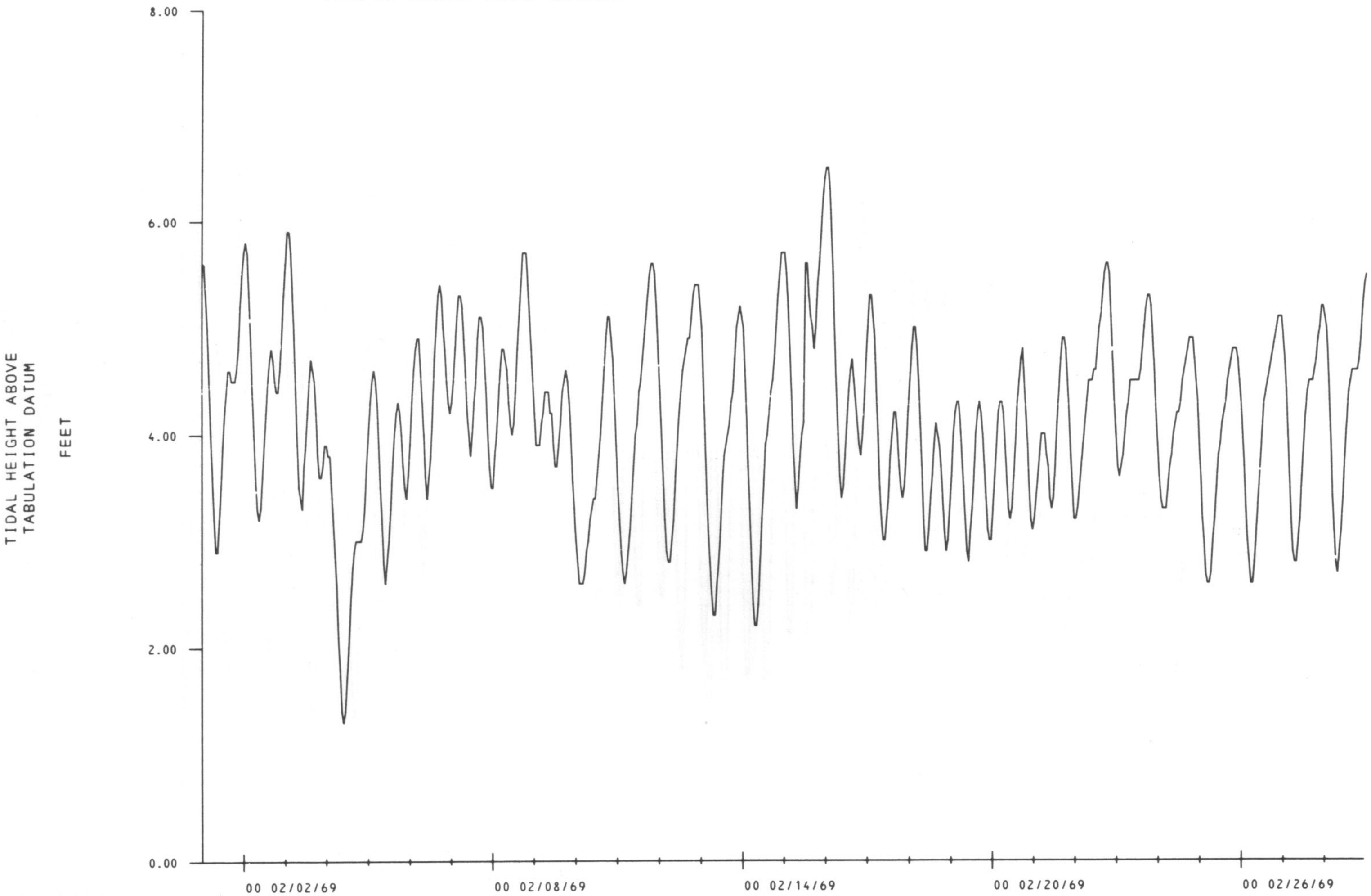


Figure 9.-- EXAMPLE OF DIURNAL TYPE OF TIDE WHEN LONGITUDE OF MOONS NODE IS 180 DEGREES
ST PETERSBURG, FLORIDA NOVEMBER 1959
PLOT OF HOURLY TIDAL HEIGHTS

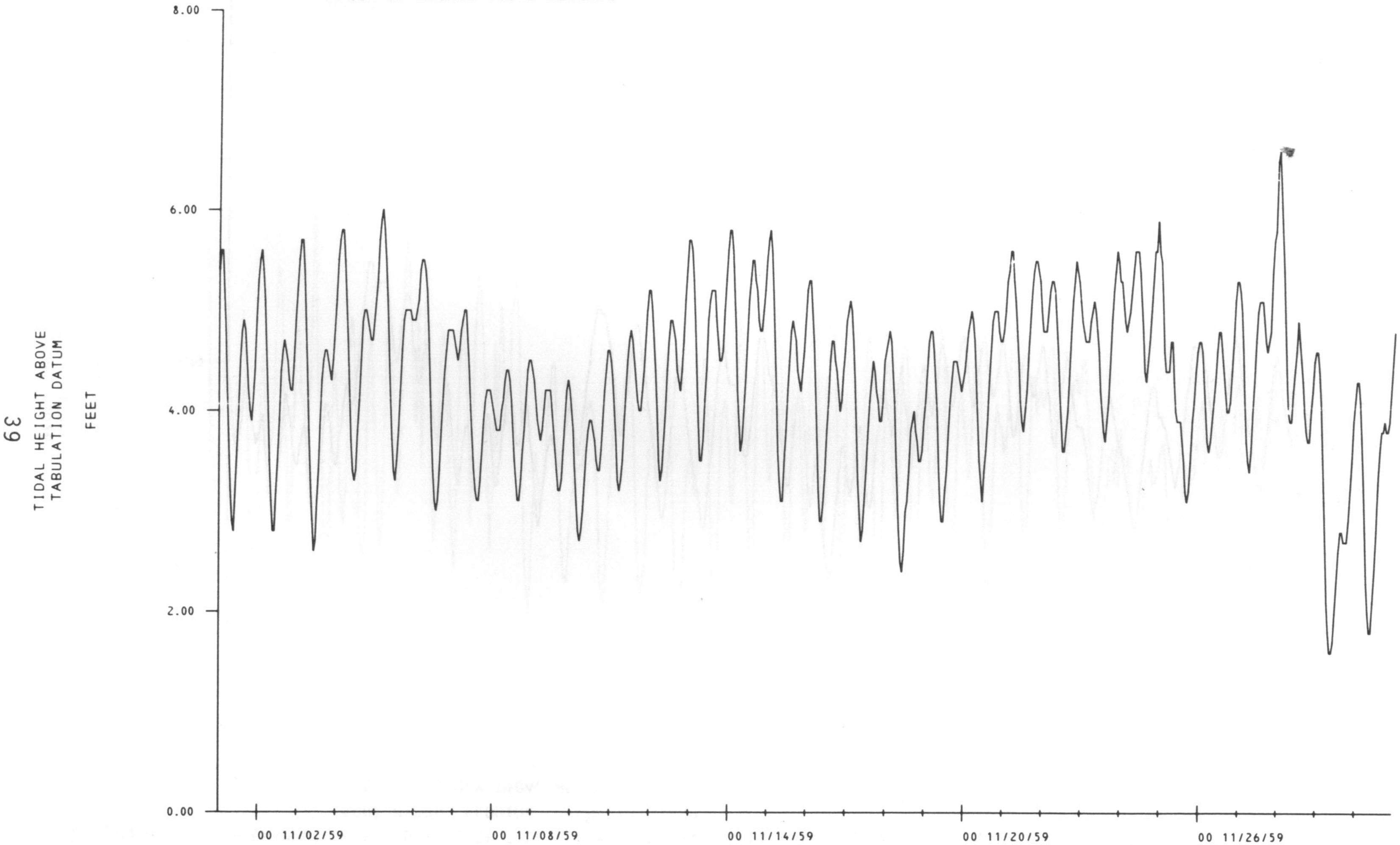


Figure 10.-- EXAMPLE OF MIXED TYPE OF TIDE BECOMING DIURNAL WHEN LONGITUDE OF MOONS NODE IS ZERO DEGREE
FORT MYERS, FLORIDA FEBRUARY 1969
PLOT OF HOURLY TIDAL HEIGHTS

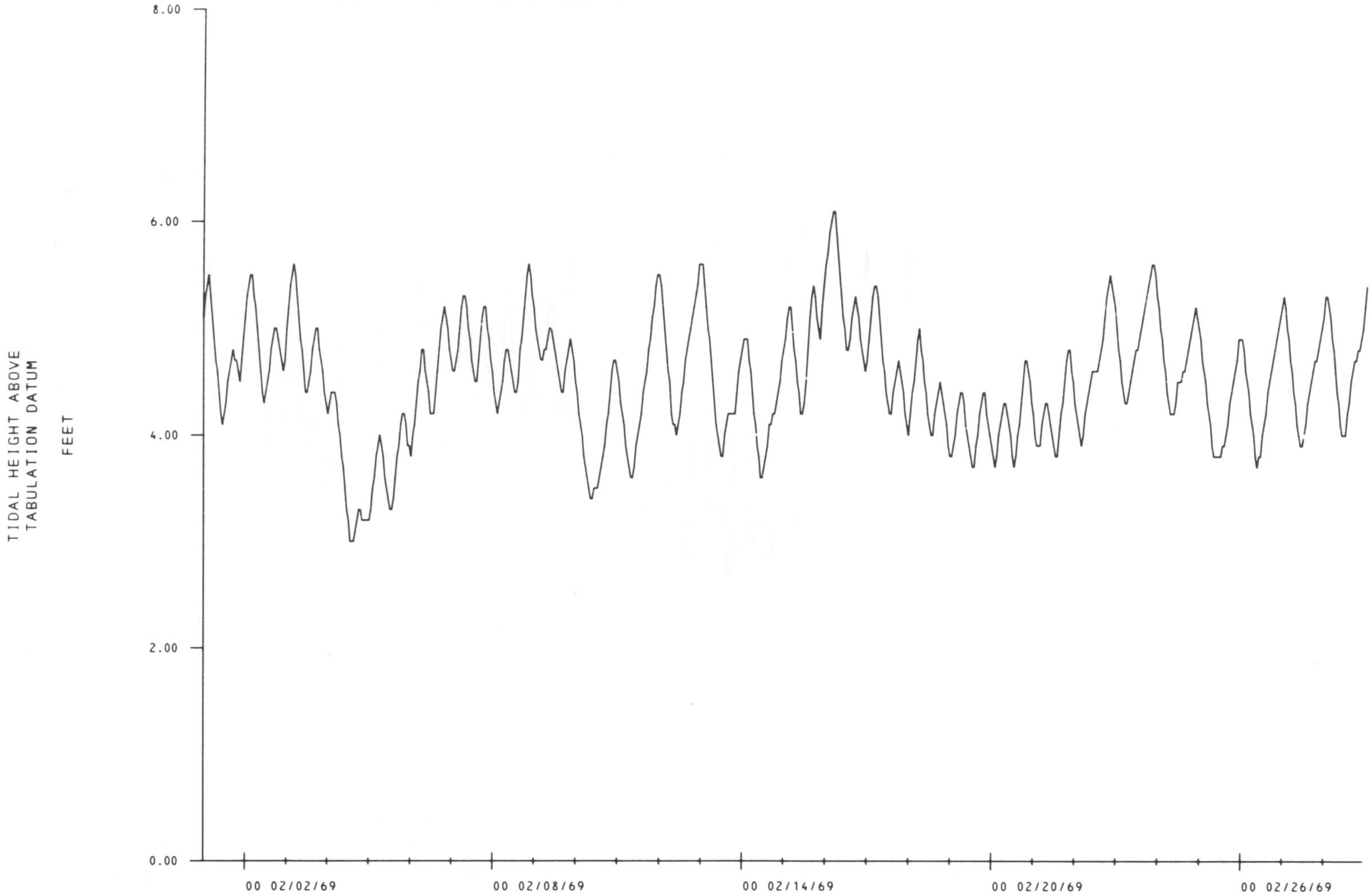
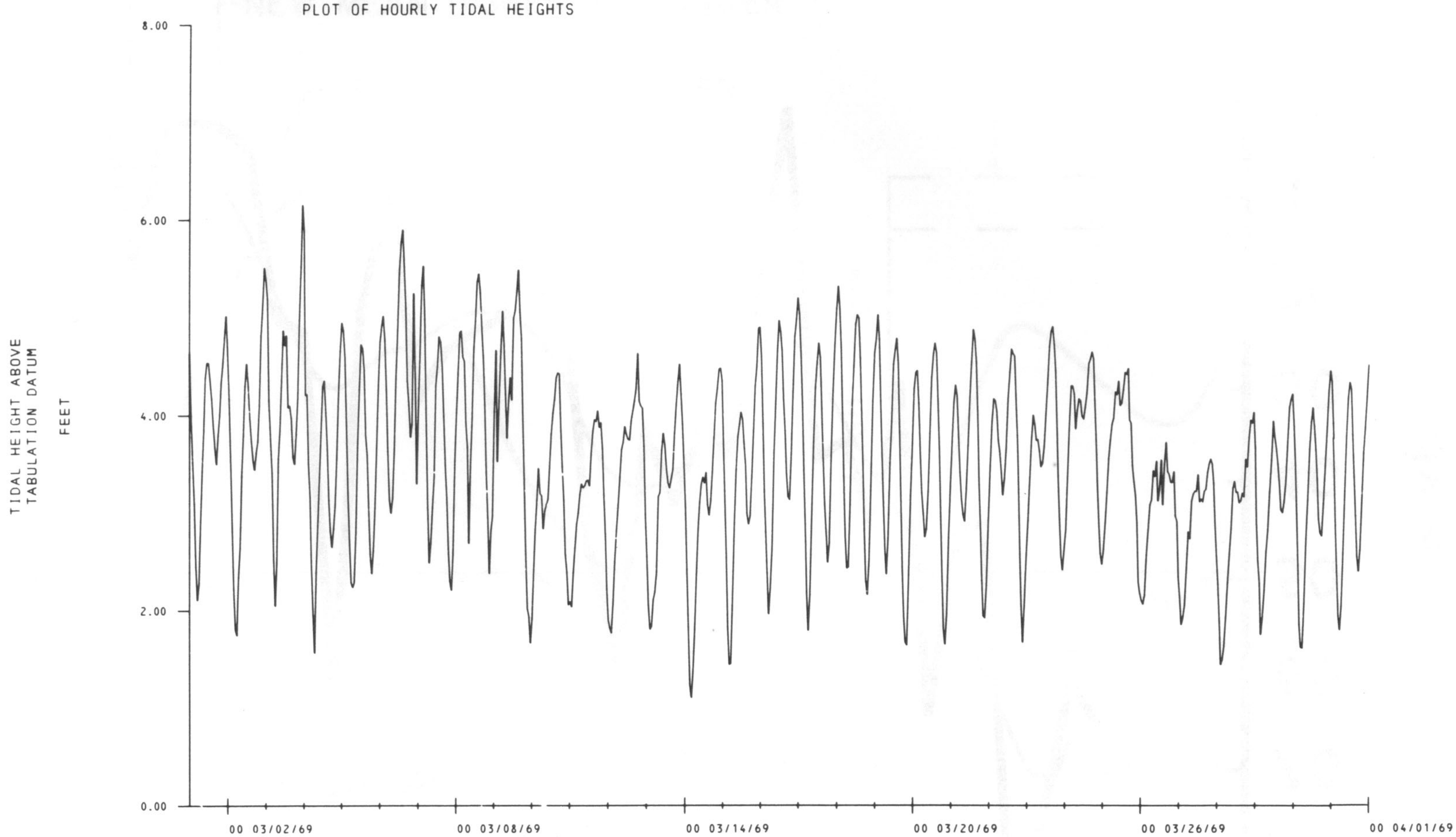


Figure 11.-- EXAMPLE OF MIXED TYPE OF TIDE BECOMING DIURNAL WHEN LONGITUDE OF MOONS NODE IS ZERO DEGREE
NAPLES, FLORIDA MARCH 1969
PLOT OF HOURLY TIDAL HEIGHTS



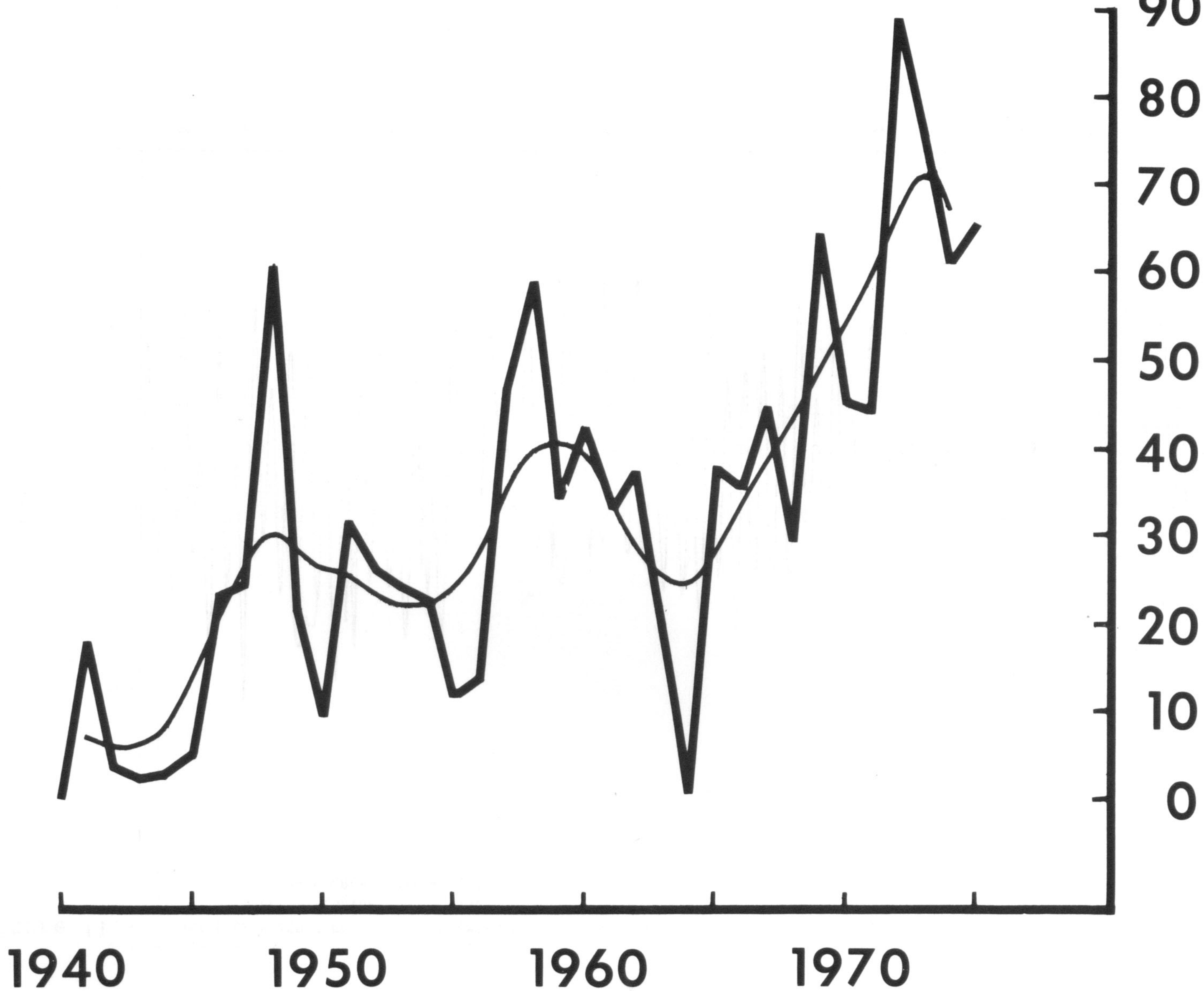


Figure 12.--Averaged sea-level series and curve for the United States (except Alaska and Hawaii)

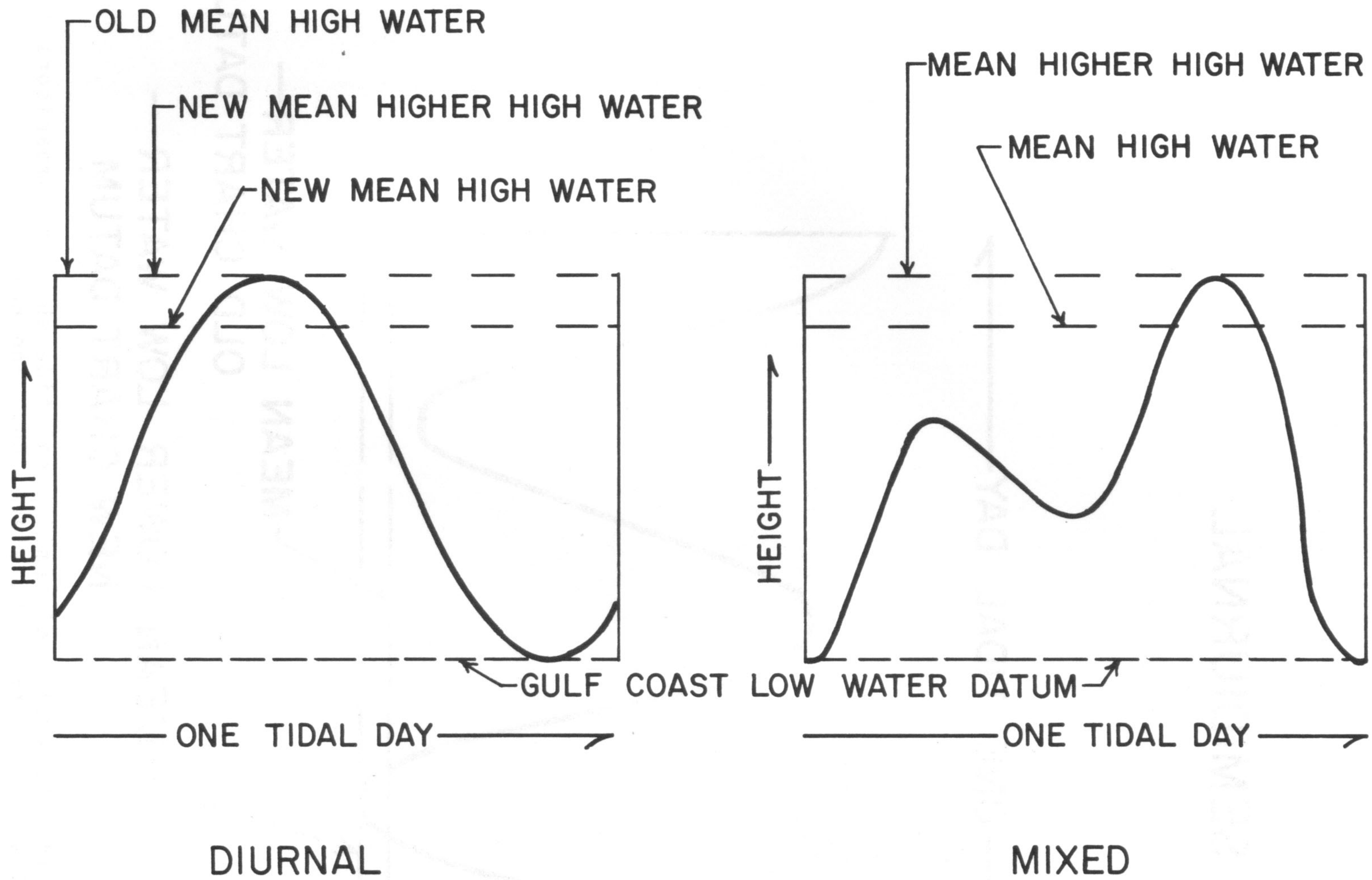


Figure 13.--Schematic of diurnal and mixed tides showing comparisons of tidal datum concepts, elevations, and names

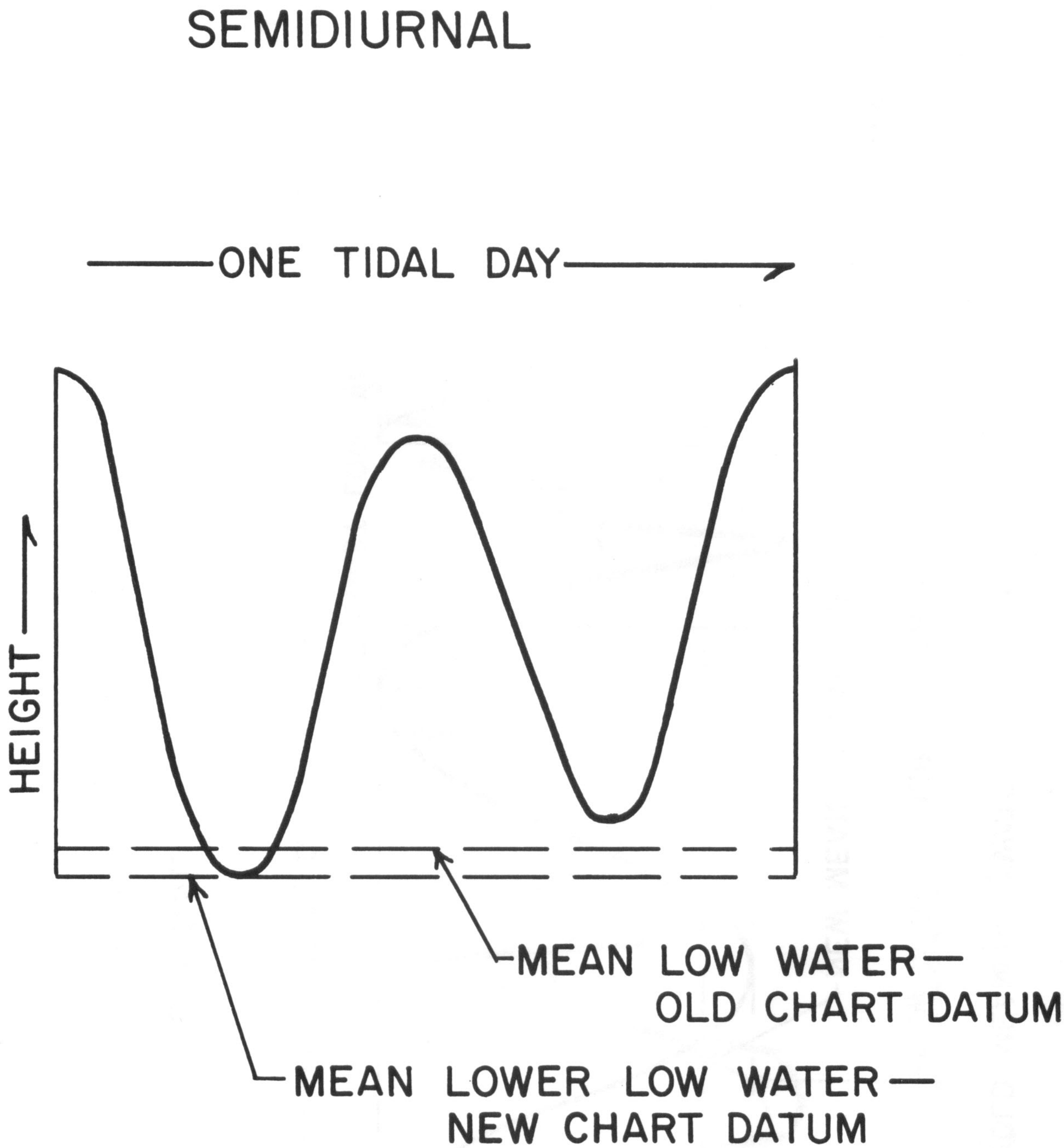


Figure 14.--Schematic of semidiurnal tide showing comparisons of tidal datum concepts, elevations, and names

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