

# Tidal Datums and Their Uses — A Summary

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## INTRODUCTION

**T**IDAL DATUMS are the fundamental base from which most coastal and marine boundaries are determined. They are also the fundamental references for sounding and depiction of the shoreline on all nautical charts. As such, they are intrinsic to the activities of coastal engineering, surveying, hydrography, and photogrammetry. The most important tidal datums are defined, amplified, and their specific uses listed in abbreviated outline form. The definitions are in terms of the procedures used in their computation.

As "tide authority" (in the international and legal sense) of the United States of America, the National Ocean Service (NOS)<sup>12</sup> of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, has statutory responsibility for tidal measurements, analyses, predictions, and datum determinations. Responsibility for tidal datums includes the development and any subsequent modifications of the methods of computation.

The method used for the computation of a tidal datum is specified in the official definition of that datum. The purposes of these "method definitions" are to:

1. ensure uniformity of computation among oceanographers,
2. ensure uniformity of computation among the various tidal regimes of the U.S.,
3. provide for comparisons with foreign datums,
4. enable outside scientific verification of results through duplication, and
5. provide precise terminology for judicial and legislative acceptance in cases involving coastal and marine boundaries.

The official definitions are promulgated in the *Tide and Current Glossary*, published by the Tides and Water Levels Branch, Ocean Requirements and Data Analysis Division, Office of Oceanography and Marine Services, NOS, NOAA, U.S. Department of Commerce. Between editions of the Glossary, major modifications are published in the *Federal Register*. A new edition of the *Tide and Current Glossary*<sup>8</sup> has recently (January 1984) been published by the Branch. It includes modifications to four key datums: mean higher high water, mean high water, mean low water, and mean lower low water.

The intent of this paper is to provide an abbreviated summary, in outline form, of tidal datums and their uses. In contrast with most papers on the subject, the

focus is on the datum, rather than the application. The author has drawn heavily on Graber<sup>9</sup> (beginning with 1980), Maloney and Ausness,<sup>10</sup> and Jacobson<sup>9</sup> for the "Uses" sections of this paper. However, every effort has been made to generalize in these sections. Therefore, the reader is referred to Graber's thorough series (in particular) for the numerous exceptions, qualifications, and refinements.

The "Definition" sections of this paper contain the official tidal datum definitions of NOAA. Certain policies and/or practices of the Tides and Water Levels Branch regarding datums are given in the "Amplifications" and "Comments" sections. However, the "Uses" sections are the result of experience, consultation, and current literature. As such, the statements made in the "Uses" sections are not necessarily the laws, regulations, definitions, interpretations, opinions, or policies of any court, legislative body, or executive agency of the Federal Government or any State Government.

Drawings, illustrating the various boundaries for the Atlantic coast and for the Pacific and Gulf coasts, comprise Figures 1 and 2, respectively. The author appreciates the help and many valuable suggestions provided by Joan M. Bondareff, Bria K. Connor, Charles E. Harrington, James R. Hubbard, Douglas M. Martin, William J. Monteith, Philip C. Morris, Glen R. Schaefer, William M. Stoney, and Carroll I. Thurlow. Peter H.F. Graber and Michael W. Reed are especially thanked for the large amount of time they spent in discussion and constructive criticism. The results were very beneficial. The author also thanks Pauly H. Plunkett for typing the manuscript together with its many revisions.

## MEAN HIGHER HIGH WATER MHHW

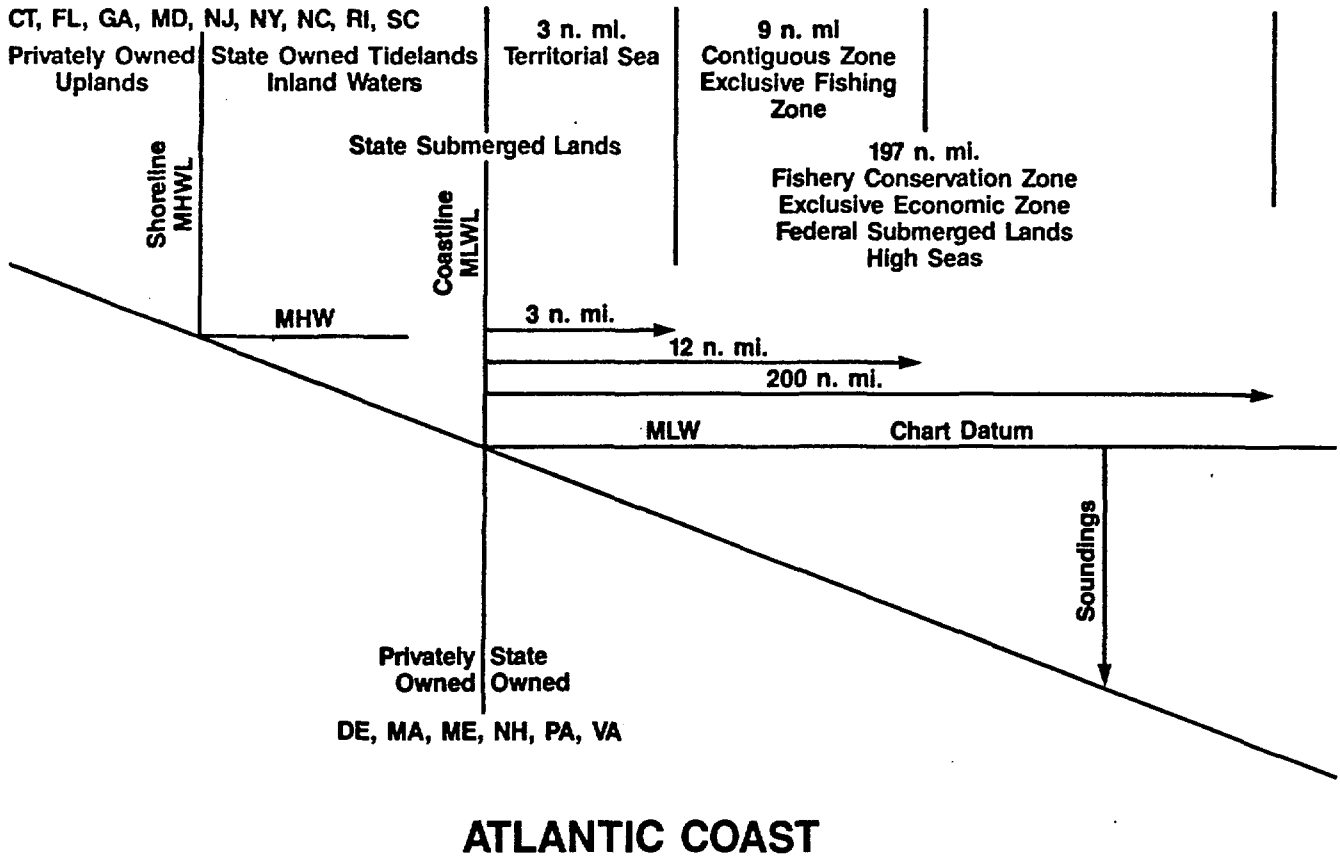
### Definition:

A tidal datum. The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch (Hicks<sup>8</sup> for all subsequent formal definitions in this paper).

### Amplifications:

The average is the arithmetic mean. To be counted, each higher high water must be 0.10 foot or more above,

To Doug with  
many thanks  
S. Steacy



## ATLANTIC COAST

Fig. 1. Idealized schematic (not drawn to scale) of tidal datum uses for the Atlantic coast of the U.S. Due to generalization of graphics, refer to text for specifics, exceptions, and qualifications.

and must occur 2.0 hours or more from, the adjacent low waters.

### Uses:

Mean higher high water is the water elevation used for the water-land intersection forming the mean higher high water line. This line is the property boundary between privately owned uplands and state owned tidelands for the State of Texas when the upland parcel's original source of title is a pre-1840 grant by Spain, Mexico, or the Republic of Texas.

Prior to November 28, 1980 the mean higher high water line (referred to as mean high water line) was delineated on nautical charts as the shoreline in areas of predominantly diurnal tides. Since that data (the beginning of the implementation of the National Tidal Datum Convention of 1980), the mean high water line has been delineated on nautical charts as the shoreline in these areas.

### Comments:

Although the "arithmetic mean" is used in the computation, "average" is retained in the definition to accommodate different types of means that may be used in the future. The definition of "higher high water" is: The highest of the high waters (or single high water) of any specified tidal day due to the declinational effects of the Moon and Sun. A "tidal day" is 24.84 hours in length. It should be noted that each individual higher high water must be identified as a tidal phenomenon,

albeit a major portion of the higher high water may be of meteorological, oceanographic, and/or hydrologic origin.

The "National Tidal Datum Epoch" is the specific 19-year period over which the high water heights are meaned. It is required for uniformity because:

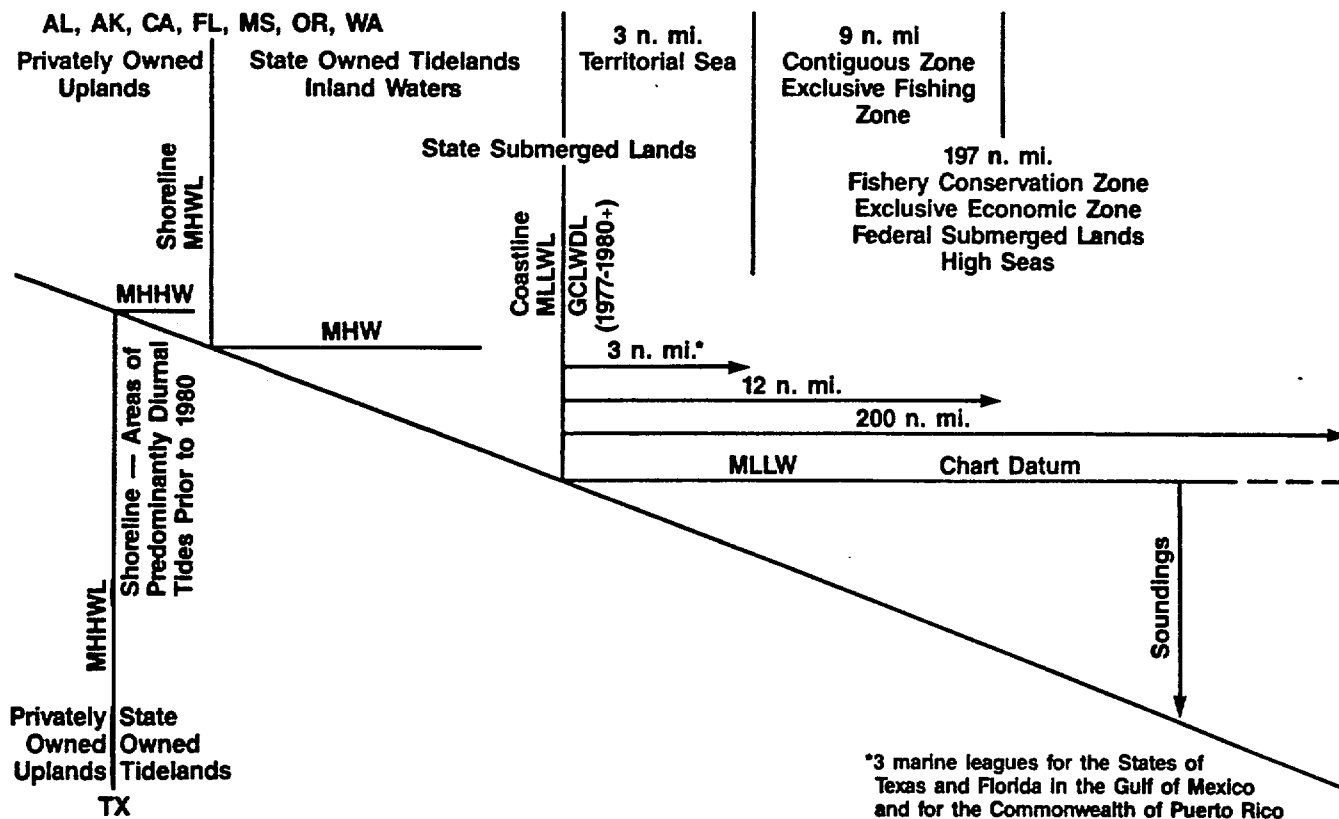
1. relative apparent secular sea-level changes are occurring,
2. the changes are not linear, and
3. the relative secular changes between stations are not coherent.

The statement concerning the method of "simultaneous observational comparisons" is included to inform the reader of the existence of a valid method to adjust an observational series of less than 19 years in length to an official equivalent tidal datum of mean higher high water.<sup>11</sup> The values "0.10 foot" and "2.0 hours" are arbitrary, subjective cutoffs. They are based on many years of experience and are valid by virtue of consistency.

## MEAN HIGHER HIGH WATER MHW

### Definition:

A tidal datum. The average of all the high water heights observed over the National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station



## PACIFIC AND GULF COASTS

Fig. 2. Idealized schematic (not drawn to scale) of tidal datum uses for the Pacific and Gulf coasts of the U.S. Due to generalization of graphics, refer to text for specifics, exceptions, and qualifications.

in order to derive the equivalent datum of the National Tidal Datum Epoch.

### Amplifications:

The average is the arithmetic mean. To be counted, each high water must be 0.10 foot or more above, and must occur 2.0 hours or more from, the adjacent low waters. The high waters must be apparently periodic, and continuous or regularly recurring. Periods shorter than semidiurnal are not used.

### Uses:

Mean high water is the water elevation used for the water-level intersection forming the mean (ordinary) high water (tide) line (mark). This line is the property boundary between uplands (littoral lands) owned by private parties, the Federal Government, or municipalities and other local government entities; and state owned tidelands (foreshore) for the States of Alabama, Alaska, California (generally), Connecticut, Florida, Georgia, Maryland, Mississippi, New Jersey, New York (uses line of vegetation), North Carolina, Oregon, Rhode Island, South Carolina, Texas (when the upland parcel's original source of title is a post-1840 grant by the Republic or State of Texas), and Washington (includes vegetation).

The mean high water line is delineated on nautical charts as the shoreline.

### Comments:

The definition of "high water" is: The maximum height reached by a rising tide. The high water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions. For tidal datum computational purposes, the maximum height is not considered a high water unless it contains a tidal high water.

The phrase, "all the high water heights," is used to provide a smooth, continuous transition of the tidal datum of mean high water from areas of semidiurnal tides, through areas of predominantly semidiurnal tides, to areas of predominantly diurnal tides. This concept was introduced in the National Tidal Datum Convention of 1980,<sup>6</sup> and was particularly applicable along the Gulf coast of the U.S. It eliminates abrupt vertical jumps in the mean high water and mean low water datums together with the concomitant horizontal discontinuities in their associated boundaries. It also created the datums of mean higher high water and mean lower low water in areas of predominantly diurnal tides.

Although higher harmonics are (by definition) periodic, they are frequently not regularly recurring. This is due, primarily, to variable hydrologic and meteorological factors affecting the higher harmonics directly as well as the secondary effects of these factors on the ratio of signal-to-noise. If not regularly recurring, these higher harmonics, if included, would markedly bias the

datum elevation. Therefore, higher harmonics are not used.

## MEAN LOW WATER MLW

### Definition:

A tidal datum. The average of all the low water heights observed over the National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch.

### Amplifications:

The amplifications of the definition of mean low water are analogous to those of mean high water.

### Uses:

Mean low water is the water elevation used for the water-land intersection forming the mean low water line. This line is the legal boundary between private and state property for the States of Delaware, Massachusetts (with qualifications), Maine (with qualifications), New Hampshire (with qualifications), Pennsylvania, and Virginia.

Along the east coast of the U.S., the mean low water line (as delineated on the official large-scale charts of NOS) is the boundary between inland waters and the territorial sea.

Along the east coast of the U.S., the mean low water line (coast line), as delineated on the official large-scale charts of NOS, is the baseline (or a baseline derived from or geographic points thereon) from which is measured:

1. the 3 nautical mile boundary between the territorial sea (marginal sea, marine belt, 3-mile limit) and the high seas,
2. the 3 geographical mile boundary between state submerged lands and federal submerged lands of the outer continental shelf.
3. the outer limit of the 12-mile (9-mile wide) contiguous zone,
4. the outer limit of the 12-mile (9-mile wide) exclusive fishing zone,
5. the outer limit of the 200 nautical mile (197-mile wide) fishery conservation zone, and
6. the outer limit of the 200 nautical mile (197-mile wide) exclusive economic zone.

Mean low water is the elevation used as chart datum for NOS nautical charts along the east coast of the U.S. Chart datum is the zero base from which soundings and isobaths on nautical charts and bathymetric maps are referred.

## MEAN LOWER LOW WATER MLLW

### Definition:

A tidal datum. The average of the lower low water height of each tidal day observed over the National

Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch.

### Amplifications:

The applications of the definition for mean lower low water are analogous to those of mean higher high water.

### Uses:

Along the west and Gulf coasts of the U.S., the mean lower low water line (as delineated on the official large scale charts of NOS) is the boundary between inland waters and the territorial sea.

Along the west and Gulf coasts of the U.S., the mean lower low water line (as delineated on the official large-scale charts of NOS) is the baseline (or a baseline derived from or geographic points thereon) from which is measured:

1. the 3 nautical mile boundary between the territorial sea and the high seas,
2. the 3 geographical mile (3 marine leagues for the states of Texas and Florida in the Gulf of Mexico and for the Commonwealth of Puerto Rico) boundary between state submerged lands and federal submerged lands of the outer continental shelf,
3. the outer limit of the 12-mile (9-mile wide) contiguous zone,
4. the outer limit of the 12-mile (9-mile wide) exclusive fishing zone,
5. the outer limit of the 200 nautical mile (197-mile wide) fishery conservation zone, and
6. the outer limit of the 200 nautical mile (197-mile wide) exclusive economic zone.

Mean lower low water is the elevation used as chart datum for hydrographic surveying and nautical charting along the west and Gulf coasts of the U.S. Chart datum is the zero base from which soundings and isobaths on nautical charts and bathymetric maps are referred.

Mean lower low water was authorized for use as chart datum for the east coast of the U.S. with the adoption of the National Tidal Datum Convention of 1980, on November 28, 1980.<sup>7</sup> However, implementation (changing chart datum from MLW to MLLW on NOS nautical charts and in the *Tide Tables* (NOS, annual)) has been delayed due to limited resources. Retabulation of stations listed in Table 2 of the *Tide Tables* and in the tide boxes and tide notes of nautical charts must be performed before implementation can begin. Mean low water remains chart datum along the east coast.

### Comments:

A marine league equals 3 nautical miles. A U.S. nautical mile is the same as a geographical mile. Since 1954, the international nautical mile (revised to 6,076.11549 international feet) has been used by the U.S. The 3 marine league boundary is labeled "Natural Resources Boundary" on the official large-scale charts of NOS. The 3 marine league Natural Resources Boundary is

measured from the historic coastline whenever the latter is landward of the mean lower low water baseline.

### GULF COAST LOW WATER DATUM GCLWD

#### Definition:

A tidal datum. Mean lower water when the type of tide is mixed and mean low water (pre-National Tidal Datum Convention definition, November 28, 1980) when the type of tide is diurnal.

#### Uses:

The elevation used as chart datum for hydrographic surveying and nautical charting along the Gulf coast of the U.S. from November 14, 1977, to November 28, 1980 (still being phased out by NOS).

#### Comments:

Gulf Coast Low Water Datum provides, for the first time, one continuous uninterrupted (without vertical jumps) chart datum for the entire Gulf coast of the U.S.<sup>4</sup> It also provides one uniform (without horizontal displacements) marine boundary line. Gulf Coast Low Water Datum does not affect, directly or by analogy, the mean high water line boundary between privately owned uplands and the state owned tidelands.<sup>5</sup>

### MEAN WATER LEVEL MWL

#### Definition:

The mean surface elevation as determined by averaging the heights of the water at equal intervals of time, usually hourly, over the National Tidal Datum Epoch. Mean water level is used in areas of little or no range in tide.

#### Amplification:

The mean is the arithmetic mean. The equal intervals of time are almost always hourly.

#### Uses:

Mean water level is offered for use as a substitute for MHHW, MHW, MLW, and MLLW whenever the mean range approaches one-tenth of a foot. Thus, for example, MWL (rather than MHW) is usually used for the shoreline in areas of extremely low range. Quantitatively, when the range in tide between adjacent high and low waters is less than one-tenth of a foot and/or the time between them is less than 2 hours, the high and low waters are not tabulated by NOS. If these eliminations amount to more than 3 consecutive or 5 total days, the month is invalidated for tidal datum computational purposes and only MWL computed and provided by NOS.

### MEAN SEA LEVEL MSL

#### Definition:

A tidal datum. The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; e.g., monthly mean sea level and yearly mean sea level.

#### Uses:

Monthly mean sea level series and yearly mean sea level series are used in climate monitoring, studies of such coastal processes as beach erosion, circulation determinations, vertical tectonic detections, and evaluation of change for revision considerations of the National Tidal Datum Epoch.

### LOW WATER DATUM LWD (Great Lakes)

#### Definition:

The dynamic elevation for each of the Great Lakes and Lake St. Clair and the corresponding sloping surfaces of the St. Marys, St. Clair, Detroit, Niagara, and St. Lawrence Rivers to which are referred the depths shown on the navigational charts and the authorized depths for navigation improvement projects. Elevations of these planes are referred to IGLD (1955)<sup>1</sup> and are Lake Superior—600.0 feet, Lake Michigan and Huron—576.8 feet, Lake St. Clair—571.7 feet, Lake Erie—568.6 feet, and Lake Ontario—242.8 feet.

#### Amplification:

For practical use, Low Water Datum becomes:  
Lake Superior, Low Water Datum 600.0 feet IGLD (1955)  
Lakes Michigan and Huron, Low Water Datum 576.8 feet IGLD (1955)  
Lake St. Clair, Low Water Datum 571.7 feet IGLD (1955)  
Lake Erie, Low Water Datum 568.6 feet IGLD (1955)  
Lake Ontario, Low Water Datum 242.8 feet IGLD (1955)

The dynamic elevation is the geopotential difference. The word "planes" should be replaced by the words "reference datums" in the definition.

#### Uses:

The elevations used as the chart datums for hydrographic surveying and nautical charting in the Great Lakes, Lake St. Clair, and the connecting rivers.

#### Comments:

The Low Water Datums are not local tidal datums, as are the marine datums of the U.S. They are geodetic datums measured in geopotential differences<sup>2</sup> from

International Great Lakes Datum (IGLD) (1955). The definition of "IGLD (1955)" is: Mean water level at Point-au-pere, Quebec, on the Gulf of St. Lawrence over the period 1941 through 1956, from which dynamic elevations throughout the Great Lakes region are measured. The term is often used to mean the entire system of dynamic elevations rather than just the referenced water level (see The Coordinating Committee (1979)).<sup>1</sup>

**LOW WATER DATUM  
LWD  
(Marine)**

**Definition:**

An approximation of mean low water that has been adopted as a standard reference for a limited area and is retained for an indefinite period regardless of the fact that it may differ slightly from a better determination of mean low water from a subsequent series of observations. Used primarily for river and harbor engineering purposes. Boston low water datum is an example.

A tidal datum which is 0.5 foot below mean water level. Used for chart datum in areas of little or no range of tide.

**MEAN TIDE LEVEL  
MTL**

**Definition:**

A tidal datum which is the arithmetic mean of mean high water and mean low water. Also called half-tide level.

**Uses:**

Mean tide level is used to compute the elevation of MHW above chart datum (MLLW) at stations along the west and Gulf coasts of the U.S. provided in Table 2 of the *Tide Tables*. One-half of the mean range is added to MTL to give MHW. Since bridge, cable, etc. clearances are printed on nautical charts as values above MHW, the mariner is thus able to compare his predicted height (above chart datum) with the value of MHW (above chart datum). The difference is the amount of reduced clearance (predicted greater than MHW) or increased clearance (predicted less than MHW).

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