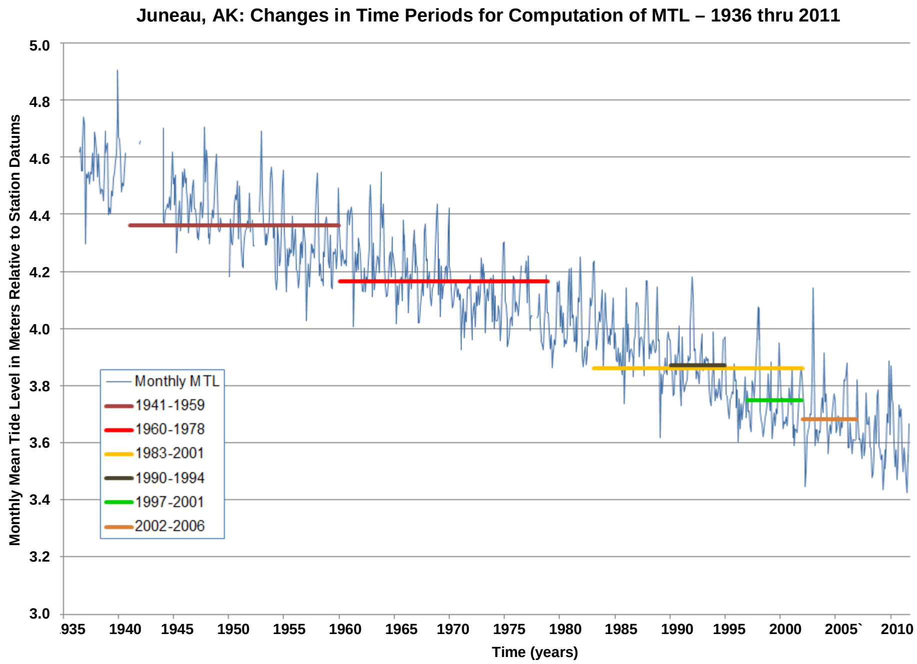
NOAA Technical Report NOS CO-OPS 068

Implementation of Procedures for Computation of Tidal Datums in Areas with Anomalous Trends in Relative Mean Sea Level



Silver Spring, Maryland
March 2014

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) provides the National infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and tidal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), a national network of Physical Oceanographic Real-Time Systems (PORTS®) in major U. S. harbors, and the National Current Observation Program consisting of current surveys in near shore and coastal areas utilizing bottom mounted platforms, subsurface buoys, horizontal sensors and quick response real time buoys. The Center establishes standards for the collection and processing of water level and current data; collects and documents user requirements which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products.

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Implementation of Procedures for Computation of Tidal Datums in Areas with Anomalous Trends in Relative Mean Sea Level

Stephen Gill

Gerald Hovis

Kelly Kriner

Michael Michalski

March 2014

US DEPARTMENT OF COMMERCE
Penny Pritzker, Secretary of Commerce

National Oceanic and Atmospheric Administration
Dr. Kathryn D. Sullivan,
Undersecretary of Commerce for Oceans & Atmosphere & NOAA Administrator

National Ocean Service
Dr. Holly Bamford, Assistant Administrator

Center for Operational Oceanographic Products and Services
Richard Edwing, Director

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NOS	National Ocean Service
CO-OPS	Center for Operational Oceanographic Products and Services
NOAA	National Oceanographic and Atmospheric Administration
NWLON	National Water Level Observation Network
PORTS	Physical Oceanographic Real-Time Systems
MSL	Mean Sea Level
MTL	Mean Tide Level
NTDE	National Tidal Datum Epoch
DTL	Diurnal Tide Level
Mn	Mean Range of Tide
Gt	Great Diurnal Range of Tide
MLLW	Mean Lower Low Water
MHW	Mean High Water
USACE	U.S. Army Corps of Engineers
MLW	Mean Low Water
GCOS	General Counsel of Ocean Services
CGSA	Coast and Geodetic Survey Act
FRED	First Reduction
MRR	Modified Range Ratio
MHHW	Mean Higher High Water
DHQ	Mean Diurnal High Water Inequality
DLQ	Mean Diurnal Low Water Inequality
SOP	Standard Operating Procedure
OCS	Office of Coast Survey
DOC	Department of Commerce

EXECUTIVE SUMMARY

NOAA has typically updated tidal datum elevations for the nation to new National Tidal Datum Epoch (NTDE) time periods every 20-25 years. Updates at this frequency are necessary due to long-term global sea level change. In 1998, NOS recognized the need for a modified procedure that utilized more frequent time period updates, for determination of tidal datums for regions with anomalously high rates of local relative sea level change. These localized effects in relative sea level trends are typically due to different forces other than those responsible for global trends which can vary significantly from global trends in both time scales and magnitude. This modified procedure is necessary at selected stations to ensure that the tidal datums accurately represent the existing stand of sea level relative to land on which these datums are held fixed. Bench mark monuments are typically used as reference points for numerous applications requiring tidal datum references. The modified procedure is limited only to those stations with documented anomalous relative sea level trends due to high rates of vertical land motion. Anomalous relative sea level trends are seen along the central Louisiana, the southern Cook Inlet, and the southeastern Alaska coasts. For example, the magnitude of the sea level trends in these areas are +9.24 mm/yr at Grand Isle, LA; -9.45 mm/yr at Seldovia, AK; and -12.92 mm/yr at Juneau, AK. Following the first implementation of the modified procedure in 1998, using the time series for tidal datum computation of 1990-1994, sea level analyses in these anomalous regions are now conducted approximately every five (5) years to identify stations that require datum updates using the modified procedure.

NOAA's mission is to provide the latest up-to-date tidal datum information available for applications that are essential to supporting Federal, State and private sector coastal zone activities. These include activities such as hydrographic surveying, coastal mapping, and the resulting nautical charts, general navigational safety, wetland restoration, marine boundary determinations, coastal engineering, storm warnings and hazard mitigation, emergency management, and multi-use hydrodynamic modeling.

For the 20th century, updates to the NTDE every 20-25 years constrained tidal datum elevation changes to 0.03m - 0.05m (0.10ft – 0.16ft) between epochs at most locations. To meet this objective at locations with anomalous rates of relative sea level change, tidal datum elevation updates must occur more frequently. In general, the vertical changes in datum elevations resulting from these more frequent 5-year special tidal datum updates are kept as close to the 0.03m - 0.05m (0.10ft – 0.16ft) objective as possible. Initially, the threshold used for determining which stations needed a 5-year update was >5.0mm/yr relative sea level trend, along with a threshold change of >0.03m (0.10ft) in mean sea level datum. More recent evaluations have suggested that these criteria may not adequately account for natural multi-year variability in monthly mean sea level versus change due to vertical land motion. For this update, a threshold for relative sea level trend of >= 9.0 mm/yr, and a threshold change of >0.05m (0.16ft) in mean sea level datum was used to better constrain the procedure to only those stations with dominant vertical land movement . For this Modified Procedure, the 19-year NTDE computational period for the mean ranges of tide was used (for both Mean Range (Mn) and Great Diurnal Range (Gt)), but for the mean tide level datums, a shorter, more recent 5 year computational period is used to better reflect the current local elevations relative to the land. Consequently, tidal datums at stations exhibiting anomalous trends are computed using Mean Sea Level (MSL), Diurnal Tide Level (DTL), and Mean Tide Level (MTL) values for the most recent 5 year time period, and tidal ranges (Gt and Mn) based on the most recent full 19 year NTDE at stations. It must be recognized, however, that this special method remains a departure from the standard 19-year Tidal Datum Epoch method, and is applied only on a limited basis.

In comparison to the overall accuracy of hydrographic-cartographic processes needed to develop the required scale, resolution, and accuracy of soundings presented on the NOAA nautical charts, these elevation changes will not require the need to correct or update nautical charts every time a datum update is issued. For the most part, since the elevation changes are small, depending on the chart scale, the shoreline position, depth sounding values, isobaths, etc., are not significantly modified as a result of tidal datum updates. However, in regions that have experienced rapid vertical land movement, the changes to actual soundings and shoreline depiction may be required to be updated on the next regularly scheduled chart edition. Although depictions of the datum changes will not be evident on the largest scale NOS nautical charts, the datum changes will be noticeable when establishing or re-occupying tide stations using accepted surveying techniques and updating elevations on tidal bench marks provided by NOS Center for Operational Oceanographic Products and Services (CO-OPS).

The purpose of this technical report is to document the Modified Procedure that has been used by CO-OPS to compute accepted tidal datums for selected regions having anomalously high rates of local relative sea level change. Additionally, the report provides an update on near-term plans for continuing to implement the procedure.

1.0 BACKGROUND

The NOAA National Ocean Service (NOS) is the national authority and expert in determination of tidal datums and is the source for official U.S. Government information on tides and tidal datums. Information, products and services provided by NOS are often used in international, national, state, and local legal applications and disputes (NOAA, 2001).

The NOS Center for Operational Oceanographic Products and Services (CO-OPS) has the responsibility to define, establish and maintain the standards for the computation and preservation of official tidal reference datums, and to ensure the nation has access to the latest and most up-to-date, accurate tidal datum elevations for all coastal regions. The tidal datums of Mean Lower Low Water (MLLW) and Mean High Water (MHW) are the official datums depicted on NOAA nautical chart products and official tidal prediction tables. The intersection of the tidal datums with the land often determines the landward edge of a marine boundary (NOAA, 2001). Tidal datum elevations often serve as the legal regulatory and property ownership boundaries under law. Other Federal and State agencies recognize NOS' expertise in the computation of tidal datums and currently have or have had cooperative agreements with NOS to provide them with tidal datums. CO-OPS routinely provides training and technology transfer to government and non-governmental entities. For instance, the U.S. Army Corps of Engineers (USACE) also operate water level stations, but the USACE continues to rely on NOS' expertise regarding tidal waters and rely on NOS expertise and standards. CO-OPS maintains, updates, and disseminates appropriate manuals, technical reports and publications as official reference material for tidal datum determination for all users.

Normal Tidal Datum Epoch Updates

Figure 1 illustrates the fundamental requirement for defining tidal datums using an 18.6 year period. The figure shows an 18.6 year repeat cycle caused by declinational changes in the plane of the moon's orbit called the regression of the Moon's nodes (Parker, 2007). As illustrated, this change in declination results in slowly varying cycles in the mean range of tide (differences between Mean High Water (MHW) and Mean Low Water (MLW)). In practice, tidal datums for control stations are computed over 19-year periods defined as a National Tidal Datum Epoch (NTDE). If a station does not have continuous observations over the 19year NTDE time period, the station is considered a subordinate station, and the datums are computed using a control station to produce 19-year equivalent datums (NOAA, 2003). It is not immediately obvious from Figure 1 why tidal datums need to be updated at all if the effects of the declination cycle are basically repeatable over time. As discussed in subsequent sections, the fundamental reason tidal datums are updated to new NTDE time periods is to account for relative sea level change. In some instances, changes in tidal hydrodynamics of a river system due to dredging for instance results in the need to update tidal datums as well. Significant changes in mean sea level may also change tidal hydrodynamics over time.

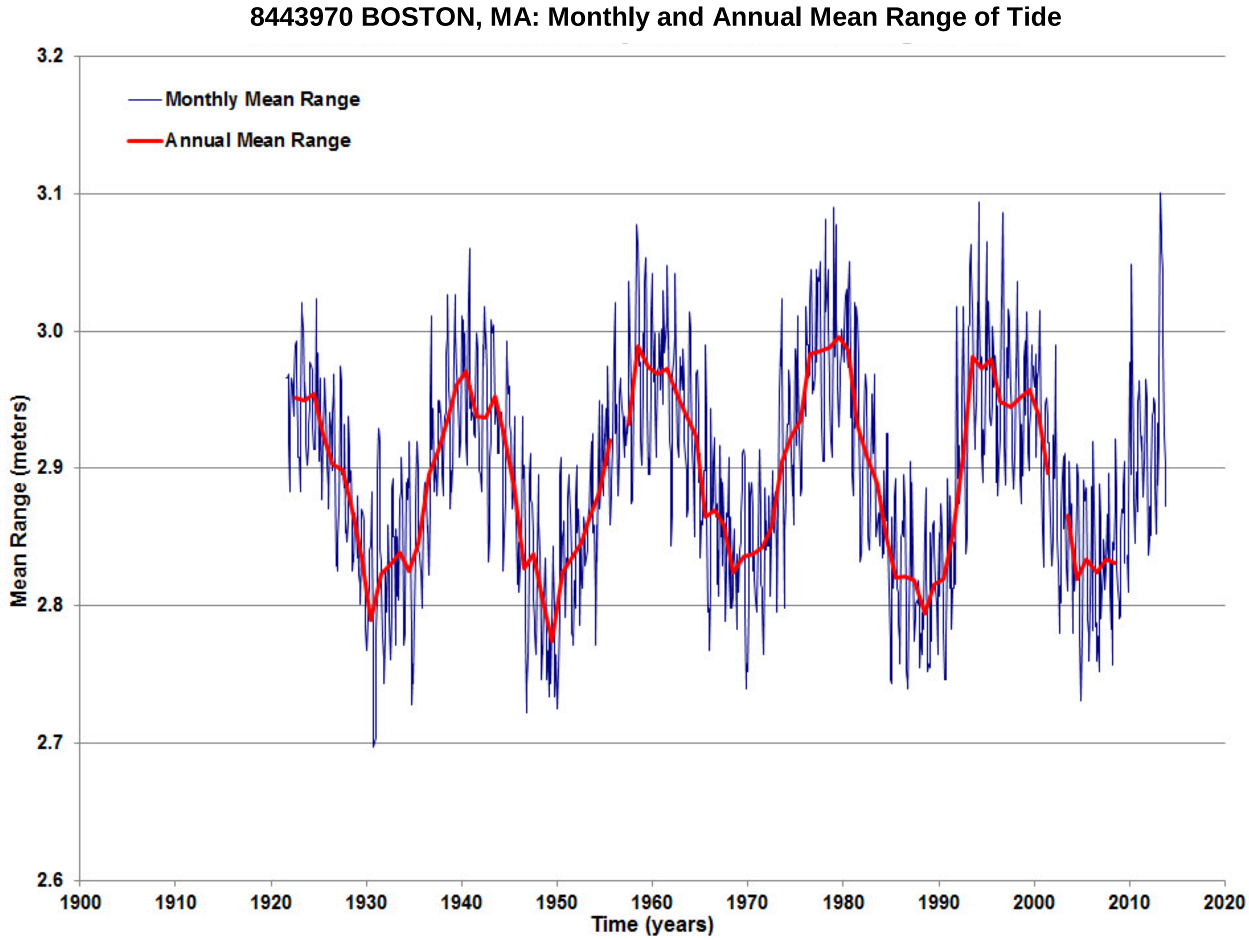

Figure 1. Variations in monthly and annual mean range of tide at Boston, MA; 1920 - present

Relative mean sea level (MSL), which is a term used to denote the average height of the ocean relative to land, can vary by location and over time and is not the same at all locations relative to a common land-based datum. It is determined by averaging the observed hourly heights at a tide station over a 19-year period. The specific 19-year period selected by NOAA becomes the National Tidal Datum Epoch (NTDE). It is the normal policy of NOS to consider a revised NTDE every 20-25 years in order to take into account relative sea level changes caused by global sea level change and the effects of long term regional and local land movement (Hicks 1980). Previous tidal epochs were determined for the periods 1924-42, 1941-59, and 1960-78. The present NTDE of 1983-2001 was adopted so that all tidal datums throughout the United States will be based on one (and most recent) specific common reference period (Figure 2). It is not necessary that the NTDE's be consecutive 19-year periods. The change in relative mean sea level drives the timing. The exact timing of the operational implementation is dependent upon when the significant volume of historical datums can be prepared for update.

The National Water Level Observation Network (NWLON) plays a key role in NTDE updates and continuous station operation is required to obtain the most accurate updated elevations. Figure 2 shows the average difference between MSL datum NTDE elevations for a common set of 32 NWLON tide stations in operation across the entire time period from 1924. The average absolute difference between NTDE time periods across the nation of 0.03m (0.10 ft.) is generally used as the threshold difference to warrant consideration of a NTDE update. This threshold is generally commensurate with the accuracy of tidal datums at subordinate stations. With the present 20th century average rate of sea level change (global), the 20-25 year review cycle has been adequate to capture the changes of 0.03-0.04m for most locations. Recent climate models such as (IPCC, 2007) show an accelerated rate of sea level rise by 2100. The requirement for datum updates shorter than the present 20-25 year review period will be continually evaluated and it is possible that overlapping 19-year time periods will be required.

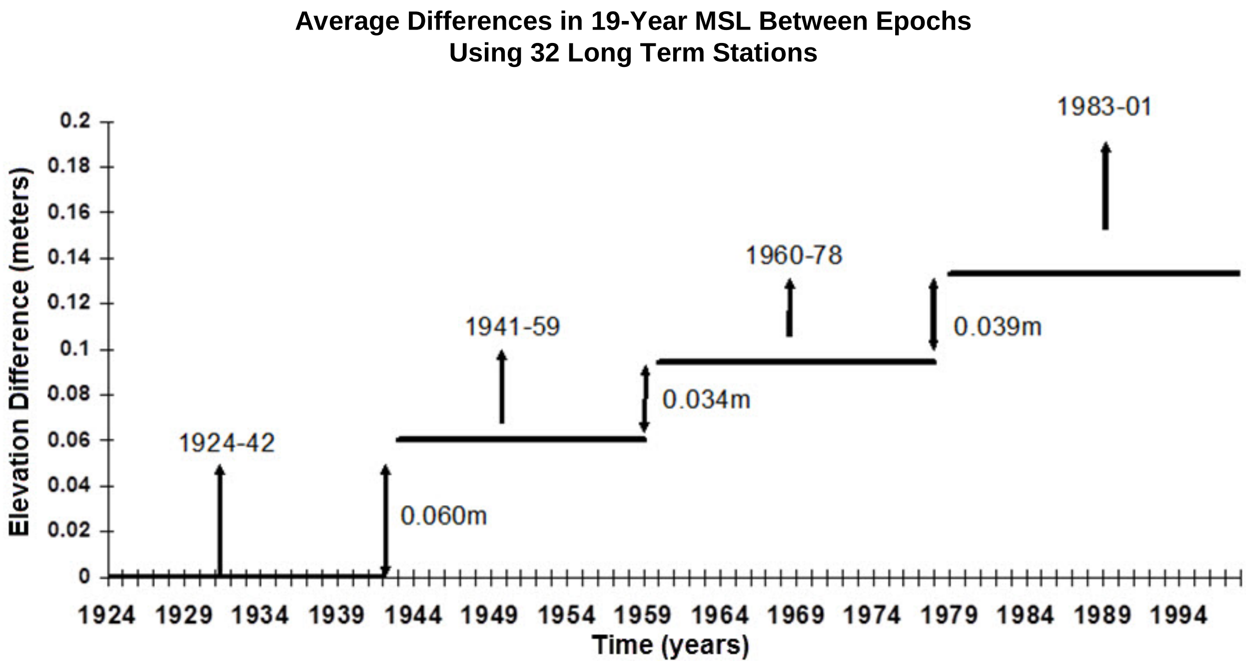

Figure 2. Average changes in tidal datum elevation of Mean Sea Level (MSL) for a common set of 32 NWLON stations.

While MSL is the commonly used reference when evaluating sea level change, MTL is generally used when referring to tidal datum trends since MTL is a base datum used for datum computations. MTL is the average of MHW & MLW, and generally follows closely to MSL which is the mean of hourly heights (NOAA, 2001). Figure 3 is an example plot of actual changes in NTDE periods for the tide record at Boston, Massachusetts. The current NTDE is 1983-2001 and Boston datum elevations will be updated when the next NTDE period is established. The requirement for updating NTDE's for sea level change over time is clearly seen with the timing of the updates in response to the relative sea level rise. Updates are required so that tidal datum elevations accurately reflect the most current elevations relative to the land.

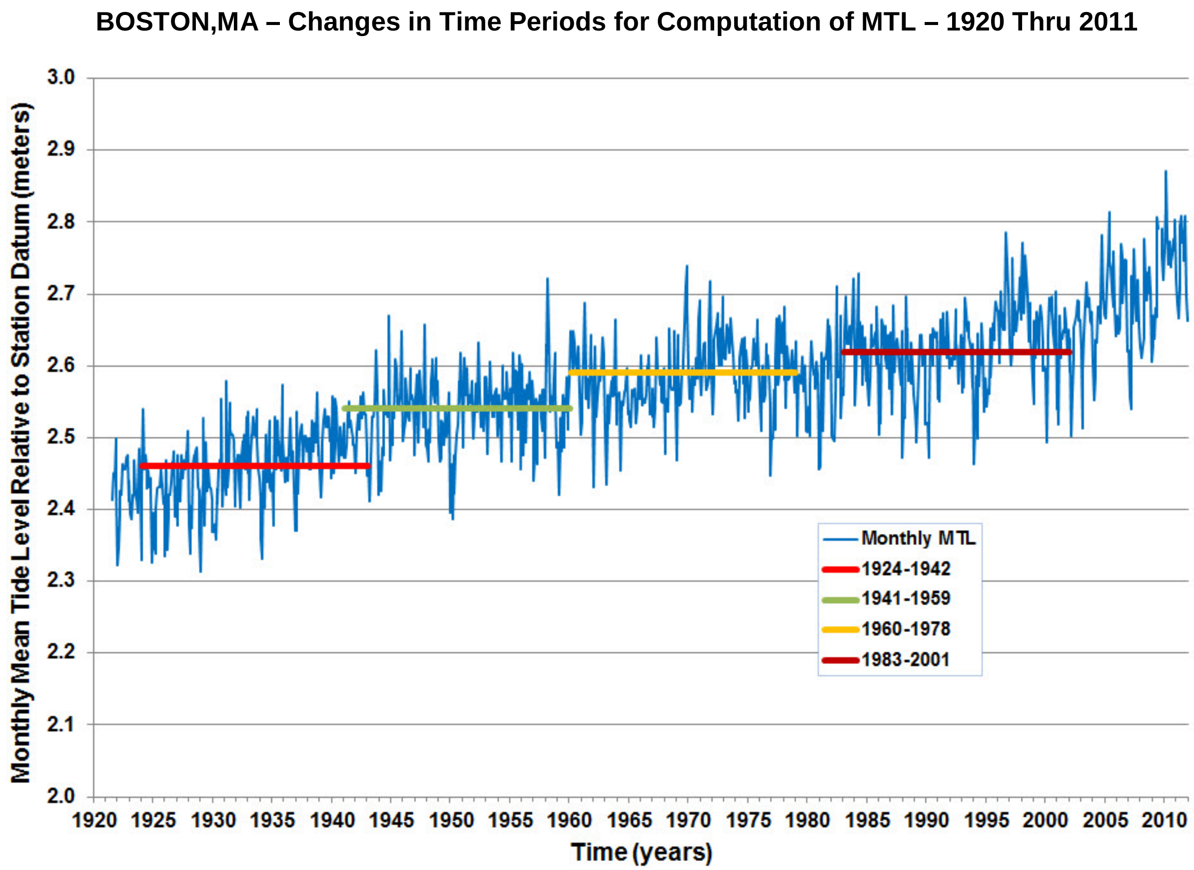

Figure 3. Changes in Time Periods for Computation of NTDE MTL at Boston, MA

2.0 THE REQUIREMENT FOR A MODIFIED PROCEDURE

The NTDE updates have been made historically using almost sequential non-overlapping 19-year observational periods. For the 20th century, updating the NTDE every 20-25 years has been adequate in most areas for meeting the goal of constraining datum elevation changes in mean sea level to around 0.03 to 0.05m. As seen in Figure 3 above for Boston, the 20-25 year update frequency was found to be adequate given the rates of sea-level change during the 20th century for the vast majority of coastal areas. However, NOAA has recognized that in some areas, relative sea level has changed so rapidly that alternative, more frequent, procedures are necessary to meet the objective of limiting datum changes to 0.03m - 0.05m (0.10ft – 0.16ft) at locations with anomalous rates of sea level change.

In 1998 NOS adopted a Modified Procedure for computing tidal datums for regions with anomalous sea level trends and has adopted a 5-year computational period for mean tide levels to better reflect the current mean sea level datum. Consequently datums for control stations are computed from MTL and DTL values for the most recent 5 year period and tidal ranges are based on current 19-year NTDE where stations exhibit anomalous trends. This is necessary to ensure that the tidal datums accurately represent the existing sea level elevations. The subordinate stations that use Modified Procedure control stations for their datum computations will also have the more accurate elevations reflected in their 19-year equivalent datums (NOAA, 2003). The first 5-year period used at some of the stations was 1990-1994 and was first implemented for accepted datums in 1999 (see Appendix).

Figure 4 shows the distribution of the absolute values of the trends for the 128 stations currently reported in NOAA's sea level publications (Zervas, 2009). The Modified Procedure described in this report specifically addresses how to handle datum computation procedures for stations with

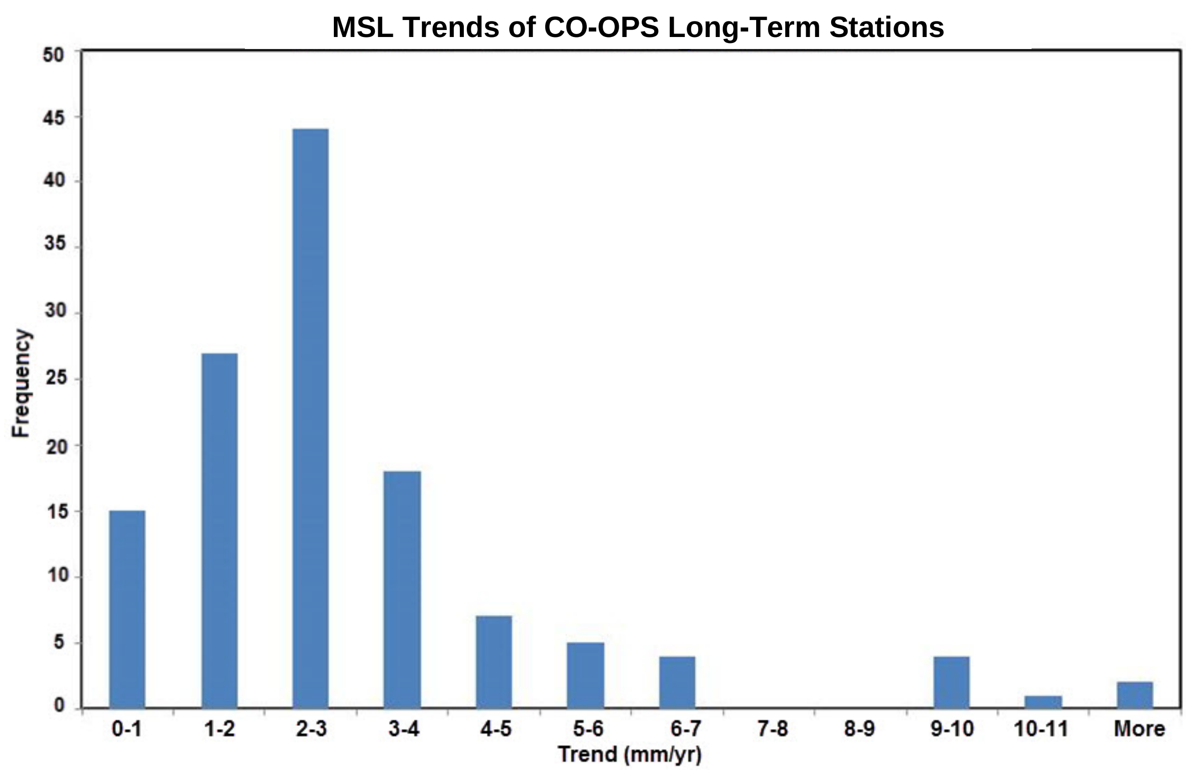

Figure 4. Relative MSL trends (absolute value) for NOAA tide stations through 2006.

only the highest rates of change as shown in the right-hand bins in the figure (i.e. >9.0mm/yr). Previously, the threshold used to identify stations needing a 5-year update cycle were those having >5.0mm/yr trends in relative sea level change. However, use of that threshold did not adequately distinguish stations with a long-term change due to vertical land motion from those with high natural multi-year variability over annual to decadal time scales. The average of the absolute values of the trends for the 128 stations is 3.1mm/yr.

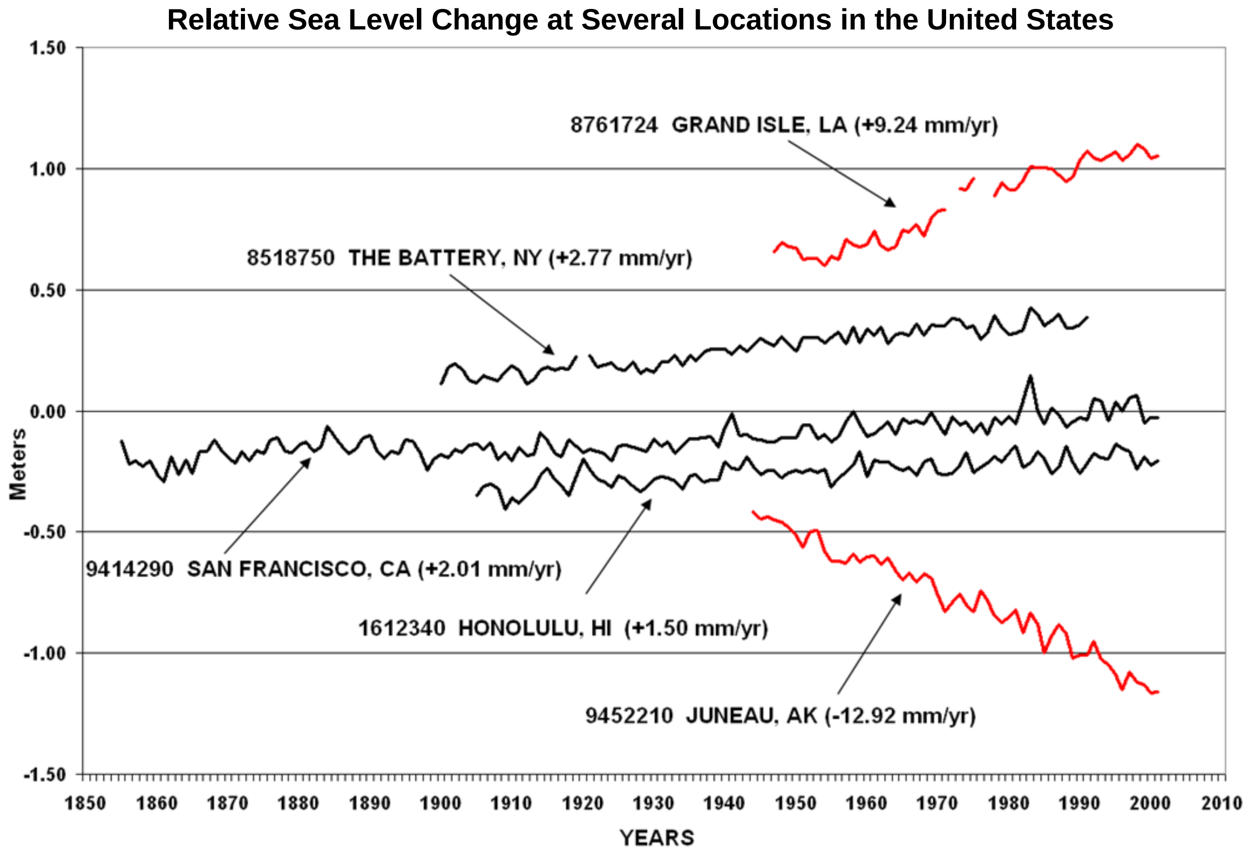

Figure 5. Relative sea level trends showing the variation around the U.S. highlighting the anomalous trends in Louisiana and Alaska. Data have been offset for better visualization of the relative changes.

Areas of the U.S. Gulf Coast and portions of Alaska are known to have extreme rates of relative sea level change (Figure 5). These extreme rates are due to local and regional vertical land movement. In the northern Gulf centered on Louisiana, this is mainly due to land subsidence due to the regional sediment load from the Mississippi River, compaction of surface layers with no added sediment, and local withdrawal of oil and water from sediment layers (Shinkle and Dokka (2004). In the Houston-Galveston, Texas area land subsidence is mainly from oil and water withdrawal from the region. In Southeast Alaska, land uplift due to post-glacial isostatic rebound is the main source for relative sea level change (Larsen *et al*, 2005), while post-1964 earthquake deformation is the main cause in Prince William Sound and Cook Inlet regions. These anomalous areas show rates of sea level variation from -17.12 mm/yr (-0.056 feet/yr) at Skagway in South East Alaska (relative sea level fall) to + 9.24 mm/yr (+0.030 feet/yr) near Grand Isle, Louisiana in the Gulf of Mexico (relative sea level rise).

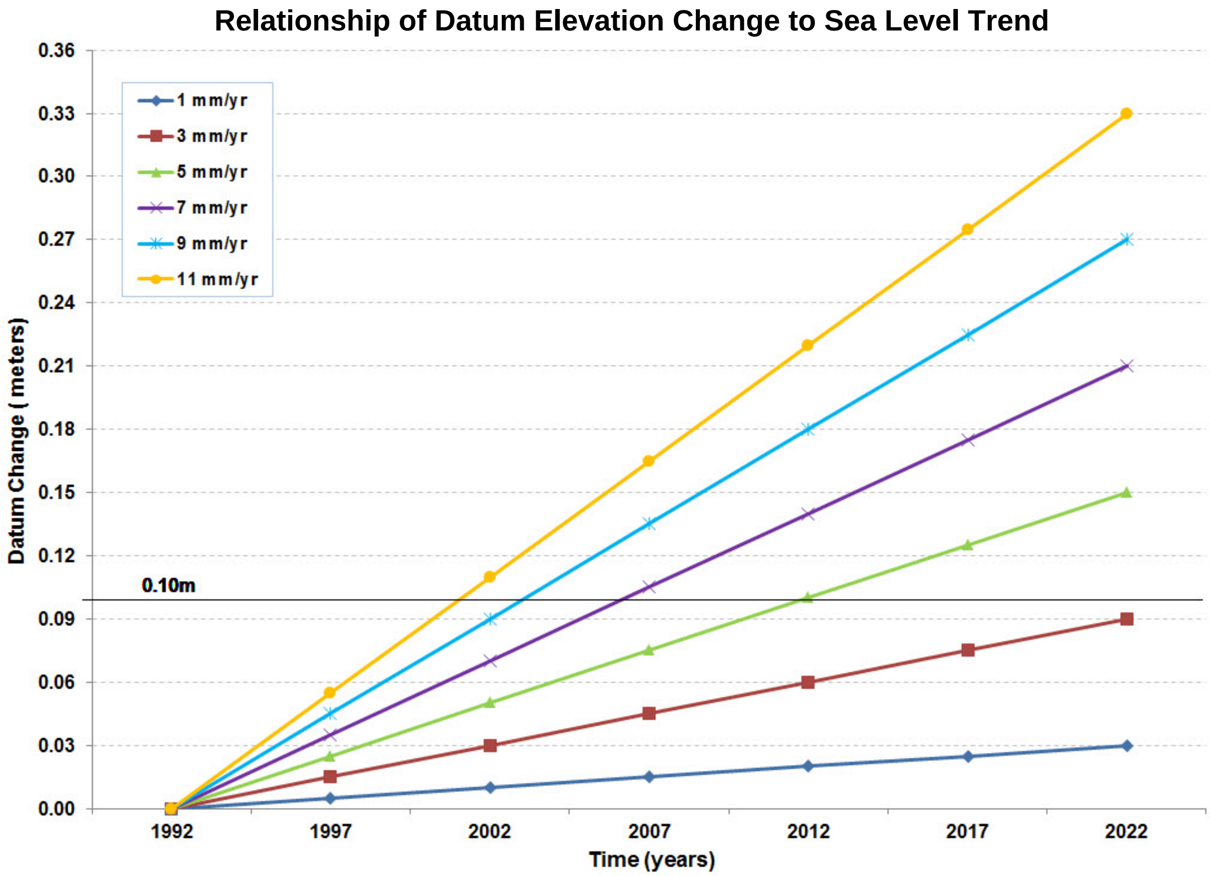

Figure 6. Relationship of datum elevation change to sea level trend.

Because of these large rates of sea level change, the mean sea level computed using the normal 19 year NTDE time step does not reflect the observed rapid changes in the elevations of tidal datums relative to the land in these locations. Figure 6 demonstrates the theoretical relationship between a change in the elevation of a tidal datum relative to the land and the rate of relative sea level change. The starting point for the graph on the time axis is the center point of the 1983-2001 NTDE (1992). The center point for the next NTDE would be 2011 if NOAA chooses to sequence the NTDE update using the 2002-2020 time period. The horizontal black line denotes an elevation change of 0.10m. For example, the plots shows that within 15 years from 1992, the elevation change in datums would be greater than 0.10m for the higher sea level trend rates of 7mm, 9mm and 11 mm/yr. This illustrates how fast datum elevations can become "out-of-date" when attempting to meet program application requirements in areas of rapid relative sea-level change. If left un-adjusted, tidal datum elevations relative to the land quickly might become several tenths of a meter out-of-date over a 19-year period.

Figure 7 illustrates the elevation change for Monthly Mean Tide Level from the 1983-2001 NTDE to the present for 2007-2011 Modified Procedure datum for Juneau AK. For stations similar to Juneau with trends greater than 9mm/yr the datums become out-of-date by well over 0.10m (0.32ft) before the end of the 19-year NTDE period. The tide levels are falling rapidly so that the 1983-2001 NTDE MTL does not reflect actual tide levels at the end of the 1983-2001 period and continue to be even lower for the 2007-2011 time period. Figure 7 shows that the

NTDE 1983-2001 MTL at Juneau is approximately 0.25m (0.8 ft.) higher than the Modified Procedure 2007-2011 updated value.

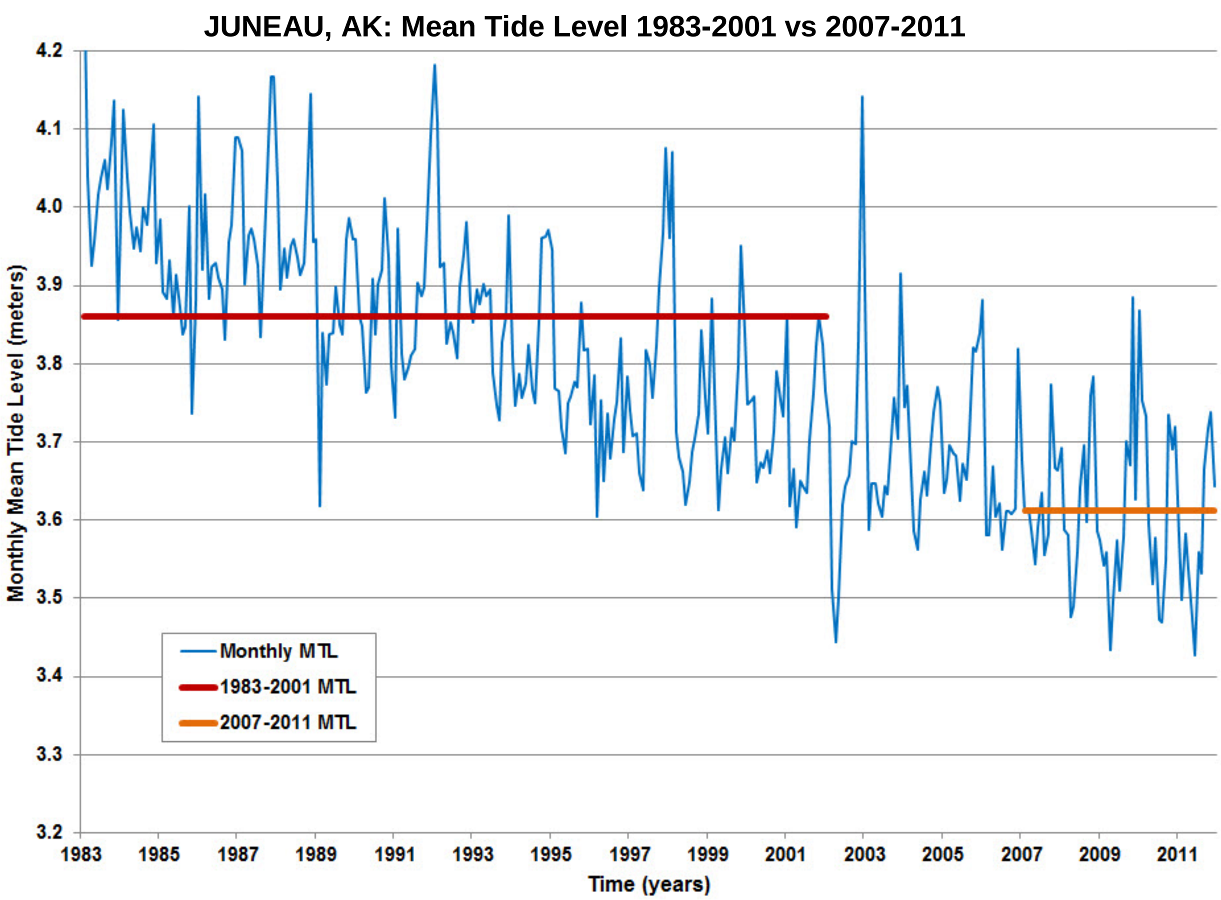

Figure 7. Illustration of the large difference between the normal 19-year NTDE value for MTL and the Modified Procedure value using the latest 5-year time period.

3.0 DISCUSSION OF THE MODIFIED PROCEDURE CONCEPT

Under the Coast and Geodetic Survey Act of 1947, NOAA is required to provide products for safe maritime commerce and navigation. This act also authorizes NOAA/CO-OPS, as the recognized expert in tide and current data analysis, to disseminate the data in a way that is beneficial to the public. While the use of the 19 year NTDE provides the most beneficial products in most cases, CO-OPS is authorized based on its expertise, to use an alternate timeframe as appropriate to provide the most beneficial products (see the NOAA office of General Counsel of Ocean Services (GCOS) review letter in Appendix 4)

It is important for any datum computation procedure to retain relationship to the 18.6-year nodal cycle and the legal standing of 19-year tidal datum epoch concept (Shalowitz, Vol.1, 1962). The "*California Case*" discussed by Shalowitz requires a tidal datum to be derived from observations made over a period of 18.6 years *(Borax Consol., Ltd. v. Los Angeles*, 296 U.S. 10, 26-27). As shown previously in Figure 1, the significant variation on the tides over an 18.6-year period is the cyclic change in the amplitude of the range of tide caused by the slow variation on the declination of the moons orbit. Thus, even though mean elevations (MSL,MTL,DTL) are computed on a more recent time period for the Modified Procedure, means for the ranges of tide are still based directly on observations over the full 19-year NTDE.

Observed variations in local MSL are not strongly correlated with the 18.6-year declinational cycle as the tide-producing force at that frequency can be outweighed by the effects of regional and local oceanographic circulation changes, meteorological and hydrological variations, and vertical land movement. Even though NTDE MSL is normally computed using 19-years of observations, variations in observed MSL are not as closely dependent on the long period astronomical forces as tidal ranges are. Figures 8a, 8b, and 8c illustrate this for Boston, MA, Juneau AK and Grand Isle, LA using simultaneous plots of the mean range of tide and monthly computed mean sea level. In each instance there is a clear correlation of changes in the range of tide with the 18.6 year declination cycle, however the variations in mean sea level are dominated by a long-term trend and other non-periodic variations in response to meteorological variations and decadal climate variations.

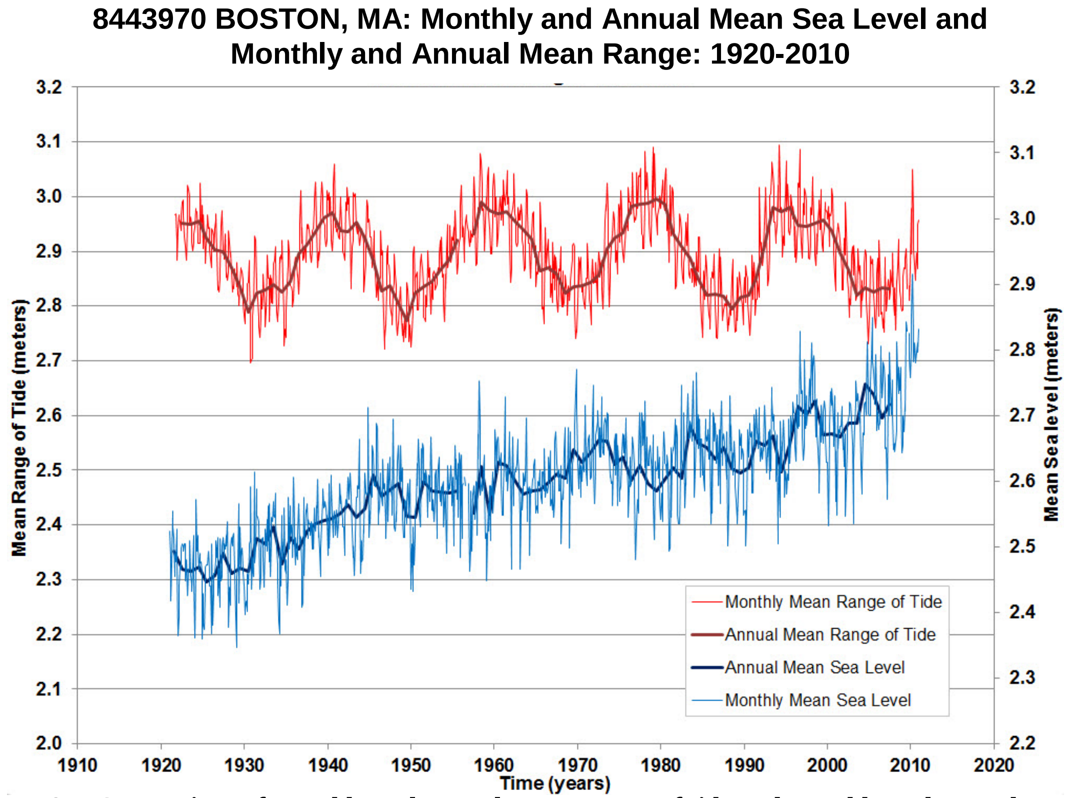

Figure 8a. Comparison of monthly and annual mean ranges of tide and monthly and annual mean sea level at Boston, MA.

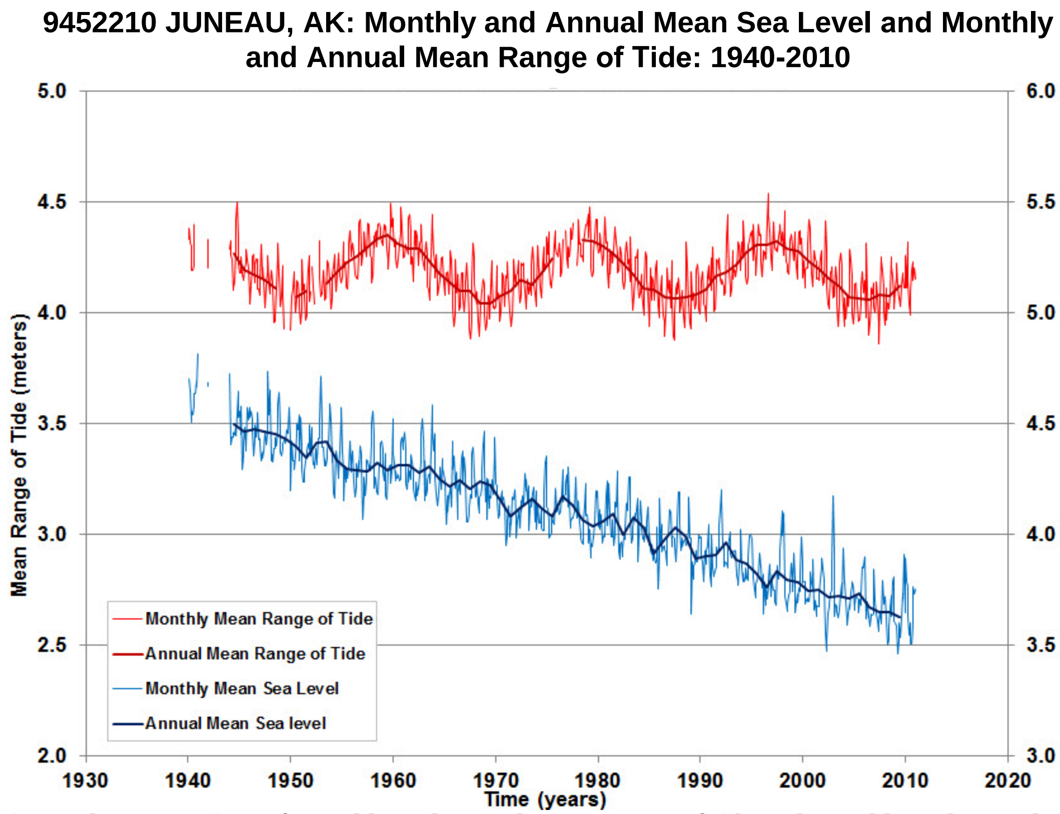

Figure 8b. Comparison of monthly and annual mean ranges of tide and monthly and annual mean sea level at Juneau, AK.

GRAND ISLE: Long Term Trends in Annual Mean Sea Level and Annual Diurnal Range of Tide 1948 - 2012

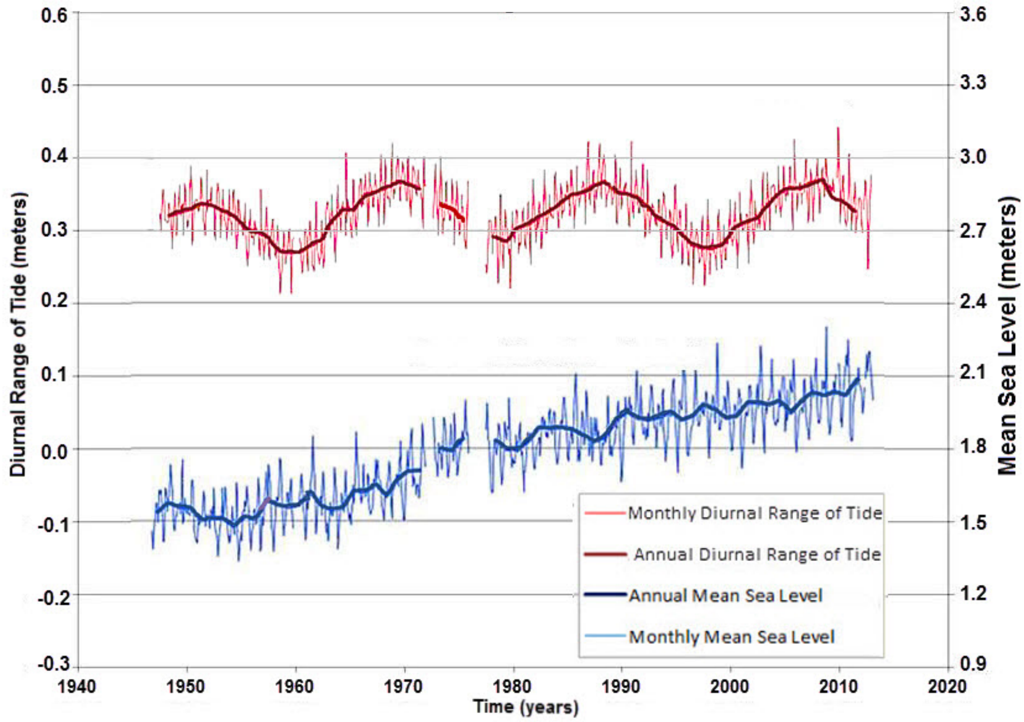

Figure 8c. Comparison of monthly and annual mean diurnal ranges of tide and monthly and annual mean sea level at Grand Isle, LA.

For the Modified Procedure, observations of the range of tide (Mn & Gt) over the 19-year NTDE are used, in conjunction with the most recent 5-years of MTL and DTL to compute the final datums for these anomalous regions. The tide level datums of MTL and DTL are the basic datums from which the other datums are derived using the method of comparison of simultaneous observations (NOAA, 2003). Figures 9a and 9b show the strong correlation of trends and variations between MSL and MTL and DTL. Although there is some correlation of the differences between the tide levels and mean sea level due to the 18.6 year nodal cycle, the amplitude of this astronomically-driven periodicity in the differences is <= 0.01m. Variations and trends in MSL are operationally used as the indicator for a need to use the Modified Procedure, but the tide levels (MTL and DTL) are used as base datums in the actual datum determinations through accepted computational procedures (NOAA, 2003). The use of the 5-year Modified Procedure mitigates the large changes in datums that would normally occur between 19-year NTDE's and keeps tidal datum elevations up-to-date to reflect ongoing relative sea level change.

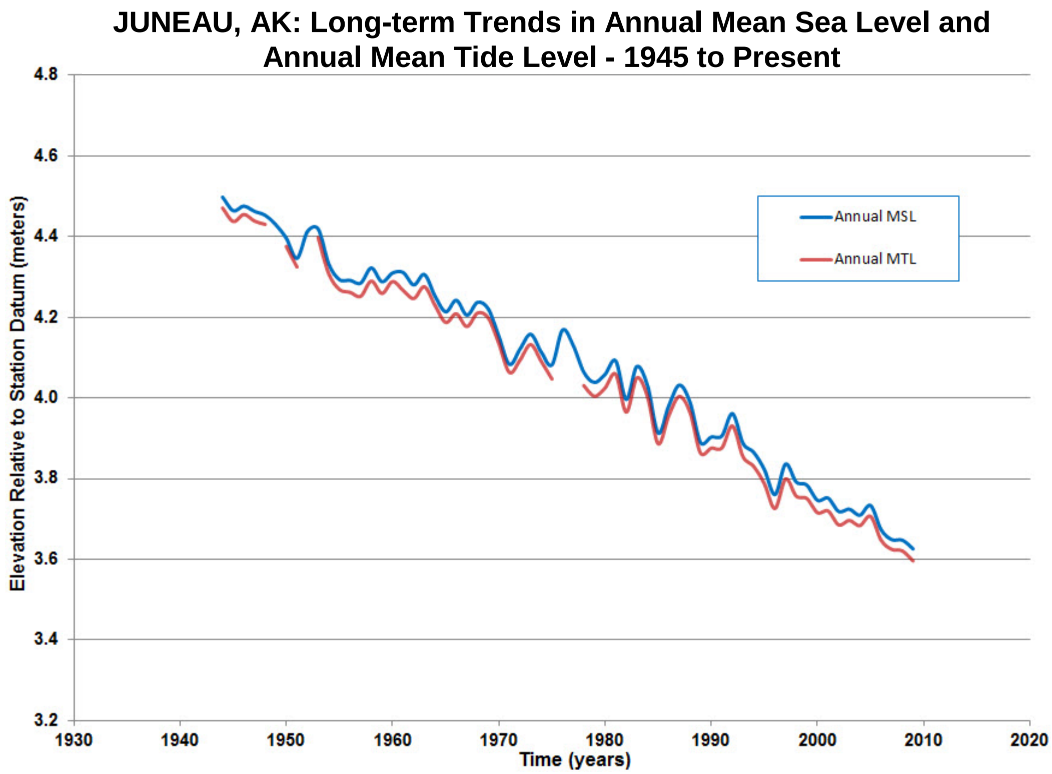

Figure 9a. Comparison of MSL and MTL long-term variations at Juneau, AK

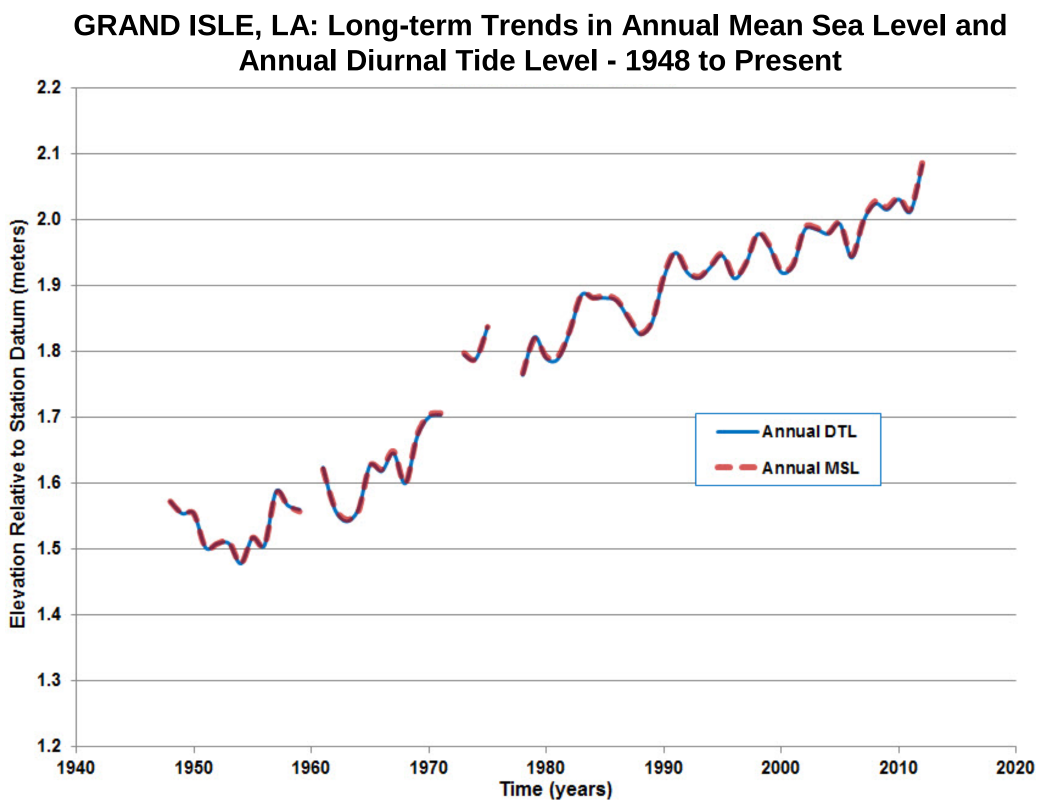

Figure 9b. Comparison of MSL and DTL long-term variations at Grand Isle, LA

The next two figures show the impact of using the 19-year NTDE and the 5-year Modified Procedure and the dependence on the rate of sea level change. Figure 10 shows how the Modified Procedure has been implemented for Juneau, AK over the period of record after the initial use of two sequential 19-year periods. Earlier in the last century, tidal datums were computed using averages over a 19-year NTDE. These time periods are shown on the graph for the 1941-59 NTDE and the 1960-78 NTDE. The first use of the 5-year Modified Procedure at Juneau occurred prior to the implementation of the 1983-2001 NTDE. The modified procedure used tide ranges observed over the established NTDE at the time which was 1960-78, and tide levels over the 5 year series of 1990-94. The last two updates used tide ranges observed over the 1983-2001 NTDE and tide levels over the 1997-2001 and 2002-2006 time series. The next update for Juneau will use tide ranges over the current NTDE of 1983-2001, and tide levels over the 2007-2011 time series.

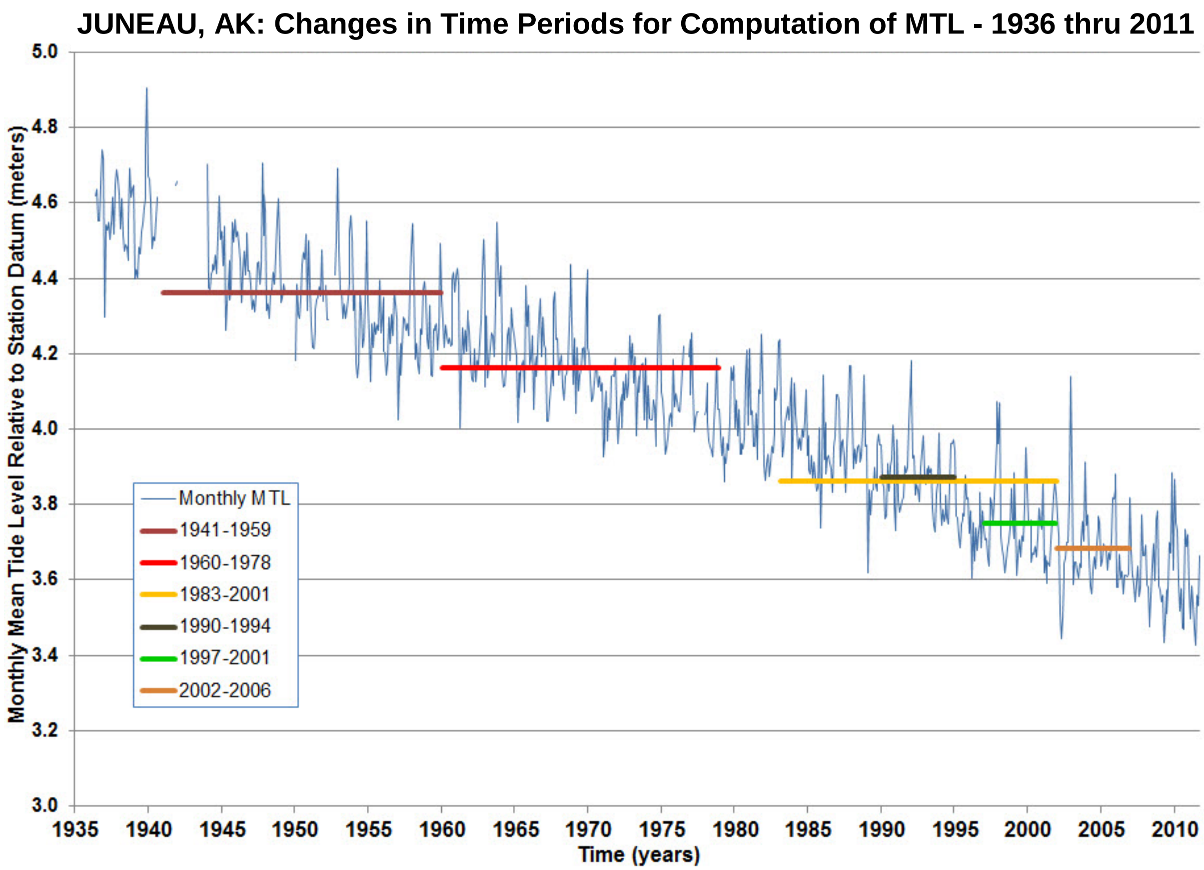

Figure 10. Changes in time periods used for MTL datum computation over the period of record for Juneau, AK.

Figure 11 is a similar plot for DTL at Grand Isle, LA for the period of record showing the progression in the changes of NTDE's and use of the 5-year Modified Procedure. The datums were computed using first reduction procedures over the standard 1960-78 NTDE. Because of the high rate of relative sea level rise due to subsidence, the 5-year 1990-94 time period was then used with the ranges of tide from the 1960-78 NTDE. The latest published tidal datums for Grand Isle will be based on using the 5-year 2007-2011 time period for DTL and MTL with the ranges of tide determined from the current 19-year 1983-2001 NTDE.

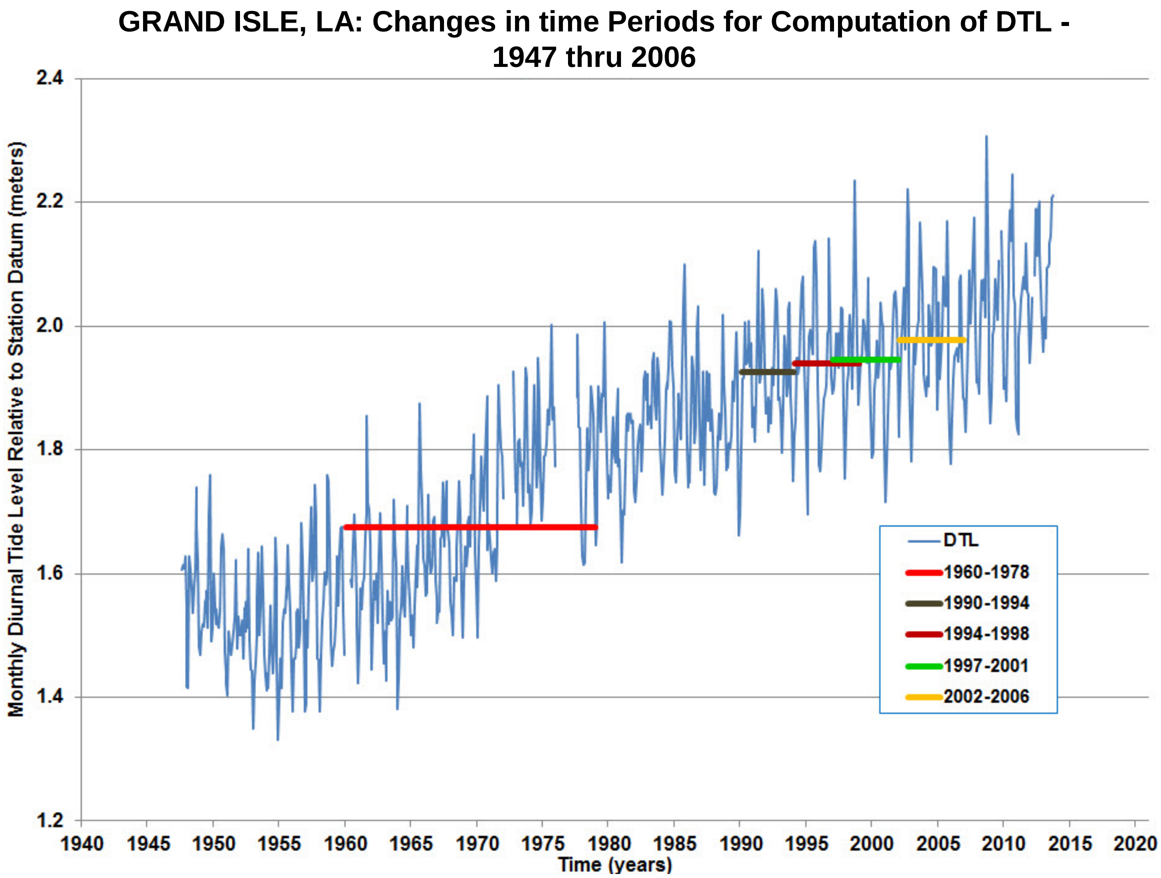

Figure 11. Changes in Time periods for Computation of DTL at Grand Isle, LA

Table 1 below summarizes the differences between the 1983-2001 NTDE elevations of MSL and the 2007-2011 five-year time period MSL for the stations considered for the next Modified Procedure update. Table 2 shows the differences found at other NWLON stations for context only, as the Modified Procedure was not used for these stations because their relative sea level trends do not exceed 9mm/yr.

Table 1. Differences in the NTDE 1983-2001 MSL and MSL for the time period 2007-2011 for stations considered for the next Modified Procedure update

Station	MSL Datum 1983-2001 meters	MSL Datum 2007-2011 meters	MSL Datum difference meters	MSL Trend mm/yr
Yakutat, AK	2.306	2.046	-0.260	-11.54
Seldovia, AK	5.173	4.937	-0.236	-9.45
Skagway, AK	3.754	3.396	-0.358	-17.12
Kodiak, AK	9.249	9.077	-0.172	-10.42
Juneau, AK	3.891	3.641	-0.250	-12.92
Grand Isle, LA	1.910	2.015	0.105	9.24

Table 2. **Differences in the NTDE 1983-2001 MSL and MSL for the time period 2007-2011 for other NWLON stations**

Station	MSL Datum 1983-2001 meters	MSL Datum 2007-2011 meters	MSL Datum difference meters	MSL Trend mm/yr
Boston. MA	2.660	2.751	0.091	2.63
Battery, NY	1.785	1.864	0.079	2.77
Baltimore, MD	1.495	1.565	0.070	3.08
Hampton Roads, VA	1.748	1.847	0.099	4.44
Charleston, SC	1.733	1.766	0.033	3.15
Key West, FL	1.662	1.706	0.044	2.24
St. Petersburg, FL	1.394	1.436	0.042	2.36
Dauphin Island, AL	1.049	1.094	0.045	2.98
Port Isabel, TX	1.423	1.516	0.093	3.64
Pier 21, TX	1.558	1.635	0.077	6.39
Rockport. TX	1.914	2.050	0.136	5.16
Sabine Pass. TX	1.316	1.377	0.061	5.66
Seattle. WA	4.444	4.443	-0.001	2.06
Ketchikan, AK	4.345	4.331	-0.014	-0.19
Valdez, AK	4.035	3.876	-0.159	-4.92
Sand Point, AK	10.482	10.484	0.002	0.92
Unalaska, AK	1.449	1.391	-0.058	-5.72
San Juan, PR	1.266	1.298	0.032	1.65

4.0 COMPUTATIONAL STEPS FOR THE MODIFIED PROCEDURE

Control Station Data Review & Qualification

The affected NWLON stations are determined based on their having relative sea level trends >9.0 mm/yr. The latest relative sea-level trends for NWLON are obtained from the CO-OPS web-site: http://tidesandcurrents.noaa.gov/sltrends/index.shtml in order to determine which stations exceed the 9mm/yr threshold. Sea level records will continue to be evaluated every 5 years for these stations as the need for 5 year datum updates continues to be necessary. As of 2013, the NTDE 19-year period was 1983-2001, though the next future 5 year evaluation around 2017-2020 will likely coincide with the establishment of a new 19-year NTDE period. The last 5-year modified procedure time series was 2002 – 2006. Updates using 2007 – 2011 5-year period are now underway at CO-OPS.

The data review process preceding a Modified Procedure 5 year datum update includes the following steps to determine which stations should be included in the update:

First obtain the following information to be included in the review:

1) Presently accepted datums for all stations in areas known to be experiencing rapid land movement (i.e. Central Louisiana, the southern Cook Inlet, and the southeastern Alaska coasts) that have been continuously collecting tidal observations over the entire 19-year NTDE (currently 1983-2001) through the most current 5 year period as of the time the review process is started (in this case 2007-2011). These stations are considered control stations since they have continuous observations over the entire 19-year NTDE period.
2) The latest relative sea-level trends for the above control stations from the CO-OPS web-site: http://tidesandcurrents.noaa.gov/sltrends/index.shtml.
3) Observed monthly means associated with next 5 year period to be used for the Modified Procedure (in this case 2007-2011) for each identified control station above.
4) Preliminary datum computation using the First Reduction algorithm (FRED) (NOAA, 2003) for the new 5 year time period on all identified control stations. This datum is not the final modified procedure computation, but will be used for data evaluation purposes and will be used in part for the final Modified procedure datum computation procedure described in the next section. A FRED datum computation is the average of tidal observations over the time series used, as opposed to other datum computation methods used for stations operating for a shorter time that require comparison with another longer running control station (NOAA,2003).
5) The MSL difference between the 5-year period preliminary datum computation and the presently accepted datum.

Then review the above collected information to determine which control stations require a 5 year update. Stations showing a relative sea level trend >9mm/yr, and stations showing a difference in MSL between the currently accepted datum and the new 5-year preliminary datum computation greater than 0.05m, should be reviewed in detail. More weight is given to the sea level trend threshold of 9mm/yr than the MSL datum computation difference of 0.05m as there can be some natural variation that may cause datum differences greater than the 0.05m in the short term that are not considered a long term trend.

Once the control stations are identified that should have the Modified Procedure 5-year datum update, new datums should be computed and accepted following the procedure described below, and new benchmark sheets should be published reflecting the newly accepted datums. Also, all subordinate stations that use the above identified control stations as controls for their datums should have new datums computed following the normal procedures for updating subordinate datums (NOAA, 2003).

Stations that previously received a 5-year Modified Procedure datum that do not meet the criteria for the current Modified Procedure 5-year update will keep its' currently accepted datum without being updated, until either it meets the criteria for the next 5-year Modified Procedure time period, or until the next 19-year NTDE datum update period.

Necessary computational steps for a Modified Procedure datum update

The steps for updating a control station datum using the 5-year Modified Procedure are detailed below. There are two variations to the Modified Procedure, depending on tide type and resulting datum computation method. The first one, for stations having a semi diurnal, diurnal, or mixed-diurnal tide type, which require the datum computation method Modified Range Ratio (MRR), applies to stations in Central Louisiana. The second one for stations having a mixed tide type, which require the Standard Method for datum computation, applies to those stations in Alaska. For more detailed information on datum computation methods and tide types see NOS CO-OPS 2 at http://tidesandcurrents.noaa.gov/publications/Computational Techniques for Tidal Datums handbook.pdf

A. Modified Procedure for Control Stations with semi diurnal, diurnal and mixed-diurnal tide type (those that require Modified Range Ratio (MRR) Method)

1) Compute a 5-year FRED datum using the current Modified Procedure time series (2007-2011) for a specific control station. Subsequent datum values in these steps with a subscript 5 denote a value obtained from this 5-year FRED computation.
2) Compute a 19-year FRED datum using the current NTDE time series (1983-2001). Subsequent datum values in these steps with a subscript 19 denote a value obtained from this 5-year FRED computation.
3) Remove all datum values from the above computed 5-year FRED with the exception of the DTL_5, MTL_5 and $MSL_{5.}$
4) Add to the above 5-year FRED (now modified) the Gt_{19}, and Mn_{19} datum values from the above 19-year FRED.
5) Using the following equations, compute the remaining datums and add them to the above 5-year FRED (now modified). The result is the final updated 2007-2011 Modified Procedure datum.

$$MLW = MTL_5 - 1/2\ Mn_{19} \quad (1)$$

$$MHW = MLW + Mn_{19} \quad (2)$$

$$MLLW = DTL_5 - 1/2\ Gt_{19} \quad (3)$$

$$MHHW = DTL_5 + 1/2\ Gt_{19} \quad (4)$$

$$DHQ = MHHW - MHW \quad (5)$$

$$DLQ = MLW - MLLW \quad (6)$$

B. Modified Procedure for Control Stations with mixed tide type (those that require use of the Standard Method):

1) Compute a 5-year FRED datum using the current Modified Procedure time series (2007-2011) for a specific control station. Subsequent datum values in these steps with a subscript 5 denote a value obtained from this 5-year FRED computation.
2) Compute a 19-year FRED datum using the current NTDE time series (1983-2001). Subsequent datum values in these steps with a subscript 19 denote a value obtained from this 5-year FRED computation.
3) Remove all datum values from the above computed 5-year FRED with the exception of the DTL_5, MTL_5 and $MSL_{5.}$
4) Add to the above 5-year FRED (now modified) the DHQ_{19}, DLQ_{19}, Gt_{19}, and Mn_{19} from the above 19-year FRED.
5) Using the following equations, compute the remaining datums and add them to the above 5-year FRED (now modified). The result is the final updated 2007-2011 Modified Procedure datum.

$$MLW = MTL_5 – 1/2\ Mn_{19} \quad (7)$$

$$MHW = MLW + Mn_{19} \quad (8)$$

$$MHHW = MHW + DHQ_{19} \quad (9)$$

$$MLLW = MLW - DLQ_{19} \quad (10)$$

5.0 HISTORY OF USE OF MODIFIED PROCEDURE

The following is a list of the NWLON control stations and the 5-year time periods for which the Modified Procedure was used for determination of accepted tidal datums.

1990-1994

8721450 Galveston Pier 21, TX
8721510 Galveston Pleasure Pier, TX
8761724 Grand Isle, LA
9453220 Yakutat, AK (used a 1989-1993 time period)

1994-1998

9452210 Juneau, AK
9452400 Skagway. AK
9453220 Yakutat, AK
9455500 Seldovia, AK
9457292 Kodiak Island, AK

1997-2001

8721450 Galveston Pier 21, TX
8721510 Galveston Pleasure Pier, TX
8761724 Grand Isle, LA
9452210 Juneau, AK
9452400 Skagway, AK
9453220 Yakutat, AK
9455500 Seldovia, AK
9457292 Kodiak Island, AK

2002-2006

8761724 Grand Isle, LA
8774770 Rockport, TX
9452210 Juneau, AK
9452400 Skagway, AK
9453220 Yakutat, AK
9455500 Seldovia, AK
9457292 Kodiak Island, AK

2007-2011

8761724 Grand Isle, LA
9452210 Juneau, AK
9452400 Skagway, AK
9453220 Yakutat, AK
9455500 Seldovia, AK
9457292 Kodiak Island, AK

6.0 ISSUES, RECOMMENDATIONS AND NEXT STEPS

Issues

This process has the same challenging effect on nautical charting as the standard NTDE epoch updates, where various historical hydrographic data sets with older Epoch datum references are merged with newly acquired data that is referenced to newer epochs. Without an operational mechanism to update all of the historical sounding data on that same chart by the amount of the respective datum changes over time, the soundings will have disparate uncertainties and references based on age. For some recent applications (for instance with VDatum models), efforts are made to correct soundings to account for disparate datum references to various NTDE for use in the model grids (for example, see Hess et al, 2005).

The effects of an accelerated time scale of datum updates described in this report will amplify the uncertainty of the accuracy of soundings presented on each chart covered by the selected tide stations. The actual impact of reference datum changes on soundings will depend on their age, numerical resolution, and accuracies. From Table 1, the datum differences between the 1983-2001 NTDE, and latest 2007-2011 5-year Modified Procedure updates, are less than 0.50m. This is equal to the 95% Confidence Interval of most soundings (NOS, 2012), however, cumulatively over several sequential 5-year updates, the datum changes will exceed these sounding uncertainties unless the charts are updated with new soundings.

There are similar issues with the depiction of the shoreline on nautical charts, as the shoreline surveys occur over time and may be tide coordinated with stations using various datum references. For appropriate usage and application of tidal datum elevations, the time period of the NTDE or Modified Procedure time period used should always be displayed on any map product. This is especially important for marine boundary surveys, where the desired accuracy is much tighter than for nautical charts (NOAA, 2001).

Recommendations

It is recommended that this Modified Procedure continue to be used for computing tidal datums in areas with anomalous rates of sea-level rise in order to provide the most accurate and up-to-date datum elevations in those areas. The Modified Procedure process should only be used for those stations with dominant vertical land movement as evidenced by relative sea level trends of >= 9.0 mm/yr. NOAA has determined that the advantages of using the Modified Procedure in very limited areas overrides the drawbacks of not using a full 19-years of observed monthly mean sea level. Nineteen (19) years of observed monthly mean tidal ranges are still used. Limitations and constraints will be documented in operational Standard Operating Procedures (SOPs).

Next Steps

The proposed next steps for the 2007-2011 update:

1) Perform the necessary computations and compilations using the 2007-2011 data.
2) Complete the Federal Register Notice Process (Federal Register, 2003)
3) Inform NOS Office of Coast Survey (OCS) of up upcoming change.
4) Complete an updated Notice to Mariners

5) Update all affected Accepted Tidal Datums and Published Bench Mark Sheets
6) Alert partner agencies.
7) Provide notice on CO-OPS web-site
8) Prepare presentation for future US HYDRO Conference.
9) Re-evaluate datum updates using the Modified Procedure.

The next review for an update of the full 19-year NTDE will occur after 2020. At that time, there may be a need to consider updating NTDEs for the entire network at a higher rate than every 20-25 years due to acceleration in global sea level rise projected by climate models (NOAA 2012).

ACKNOWLEDGMENTS

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Appendix 1:

STATION LOCATIONS

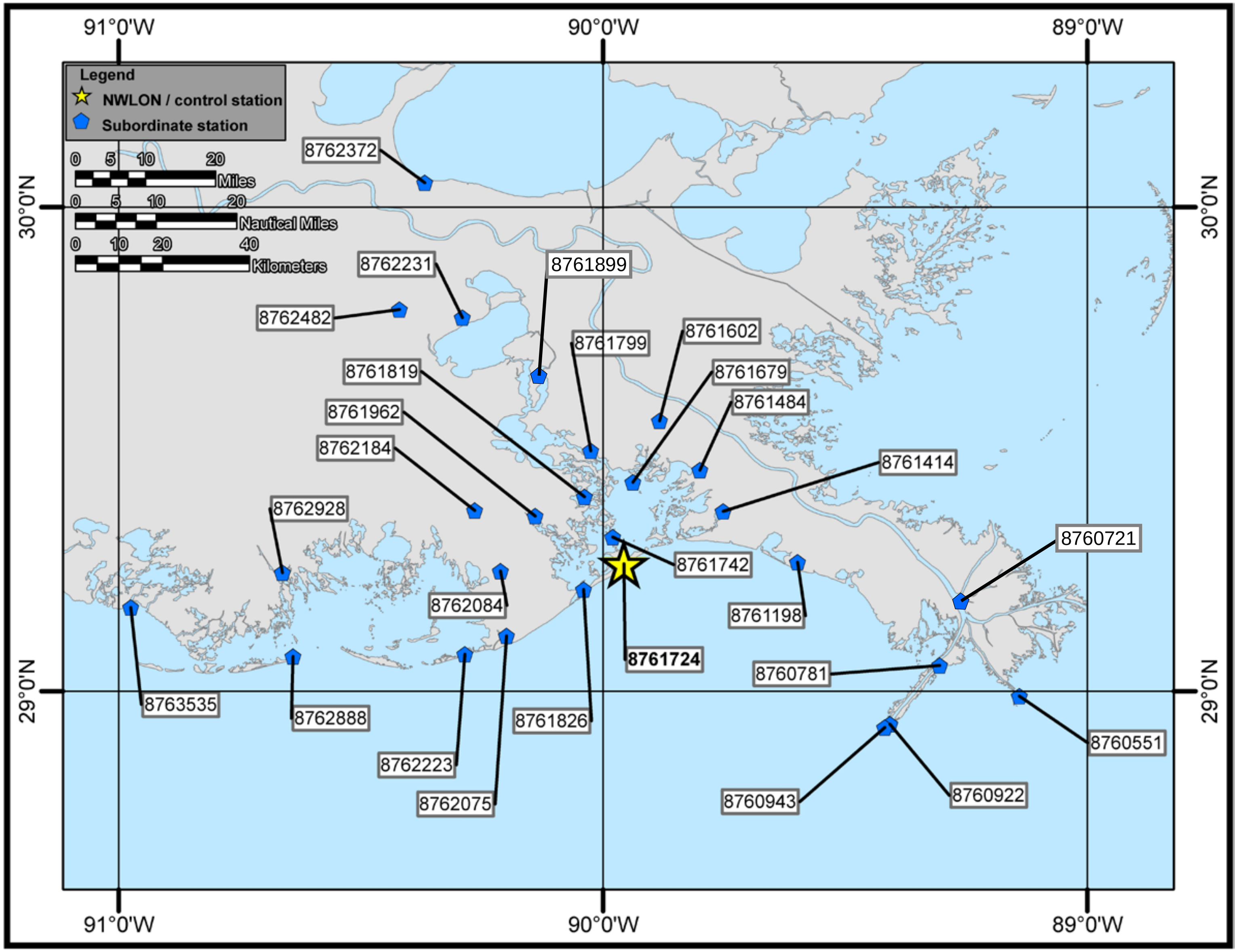

Image A1a: Location of control station and subordinate station for South East Louisiana.

Table A1a: Control station and subordinate station for South East Louisiana.

STATION ID	NAME	ST	Latitude	Longitude
8761724	**GRAND ISLE, EAST POINT**	**LA**	**29.26333**	**-89.95666**
8762482	WEST BANK 1, BAYOU GAUCHE	LA	29.78855	-90.42019
8762928	COCODRIE, TERREBONNE BAY	LA	29.24500	-90.66166
8762075	PORT FOURCHON, BELLE PASS	LA	29.11425	-90.19925
8760922	PILOTS STATION EAST, SOUTHWEST PASS, LA	LA	28.93220	-89.40750
8762372	EAST BANK 1, NORCO, BAYOU LABRANCHE	LA	30.05033	-90.36800
8761484	LEASE VB #4, BAYOU DULAC	LA	29.45670	-89.80000
8762888	E. ISLE DERNIERES, LAKE PELTO	LA	29.07166	-90.64000
8763535	TEXAS GAS PLATFORM, CAILLOU BAY	LA	29.17333	-90.97500
8762231	SALVADOR WMA, LAKE SALVADOR	LA	29.77170	-90.29000
8760781	SHELL OIL, EAST BAY	LA	29.05330	-89.30500
8761198	CHEVRON STATION 289, PELICAN ISLAND	LA	29.26670	-89.59830
8761602	LAKE JUDGE PEREZ, HERMITAGE BAYO	LA	29.55830	-89.88330
8761819	TEXACO DOCK, HACKBERRY BAY	LA	29.40170	-90.03830
8761826	CHENIERE CAMINADA, CAMINADA PASS	LA	29.21000	-90.04000
8762184	GOLDEN MEADOW, PLAISANCE CANAL	LA	29.37330	-90.26500
8761962	TEXACO GAS EXPLORATION DOCK, BAY RAMBO	LA	29.36170	-90.14000
8762223	EAST TIMBALIER ISLAND, TIMBALIER BAY	LA	29.07670	-90.28500
8761742	MENDICANT ISLAND, BARATARIA BAY	LA	29.31830	-89.98000
8761679	ST. MARYS POINT, BARATARIA BAY	LA	29.43170	-89.93830
8761414	BILLET BAY COMMUNITY, BILLET BAY	LA	29.37170	-89.75170
8761799	M.V. PETROLEUM DOCK, BAYOU ST DENIS	LA	29.49670	-90.02500
8760943	PILOT STATION, SW PASS	LA	28.92500	-89.41830
8762084	LEEVILLE, BAYOU LAFOURCHE	LA	29.24830	-90.21170
8760551	SOUTH PASS	LA	28.99000	-89.14000
8761899	LAFITTE, BARATARIA WATERWAY	LA	29.66670	-90.11170
8760721	PILOTTOWN	LA	29.17830	-89.25830

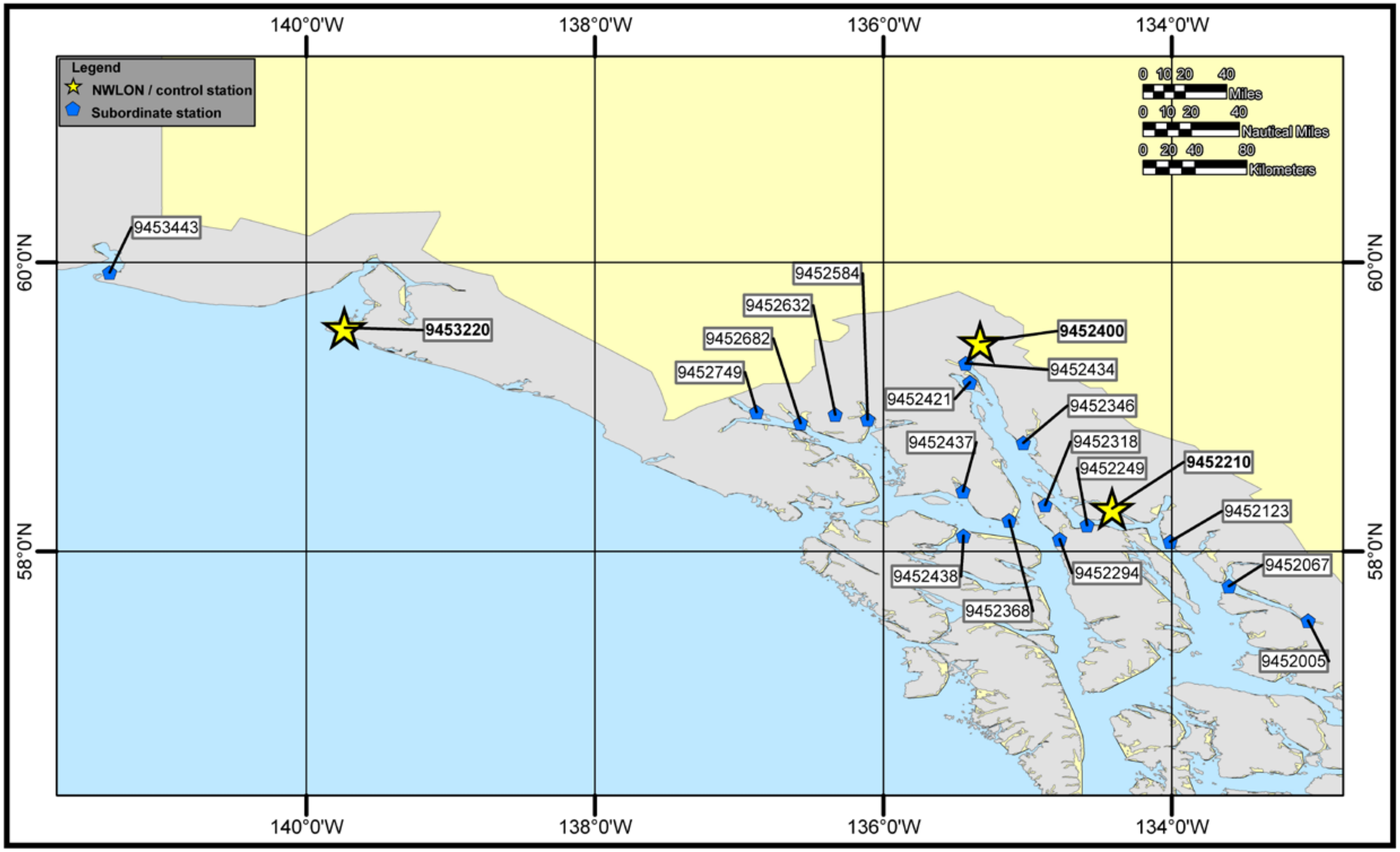

Image A1b: Location of control station and subordinate station for South East Alaska.

Table A1b: Control station and subordinate station for South East Alaska.

STATION ID	NAME	ST	Latitude	Longitude
9452210	**JUNEAU, GASTINEAU CHANNEL, STEPHENS**	**AK**	**58.29830**	**-134.41200**
9452294	HAWK INLET ENTRANCE	AK	58.08500	-134.77700
9452318	BARLOW COVE, LYNN CANAL	AK	58.32170	-134.87800
9452123	TAKU HARBOR	AK	58.06833	-134.01167
9452249	YOUNG BAY	AK	58.18330	-134.58700
9452368	SWANSON HARBOR	AK	58.21500	-135.12700
9452005	NORTH SHORE UPPER ENDICOTT ARM	AK	57.52170	-133.05500
9452437	EXCURSION INLET (SOUTH END)	AK	58.41670	-135.44700
9452067	HOLKHAM BAY, STEPHENS PASSAGE	AK	57.76000	-133.60300
9452400	**SKAGWAY, TAIYA INLET**	**AK**	**59.45000**	**-135.32700**
9452438	HOONAH	AK	58.10755	-135.44419
9452584	MUIR INLET, GLACIER BAY	AK	58.91330	-136.10800
9452346	COVE POINT, BERNER'S BAY	AK	58.75170	-135.02800
9452632	WACHUSETT INLET, GLACIER BAY	AK	58.94670	-136.33300
9452682	COMPOSITE ISLAND, GLACIER BAY	AK	58.88830	-136.57300
9452749	TARR INLET	AK	58.96477	-136.87750
9452434	TAIYASANKA HARBOR	AK	59.30170	-135.42800
9452421	CHILKAT INLET	AK	59.17000	-135.40000
9453220	**YAKUTAT, YAKUTAT BAY**	**AK**	**59.54850**	**-139.73340**
9453443	MORAINE BAY, ICY BAY	AK	59.93000	-141.36333

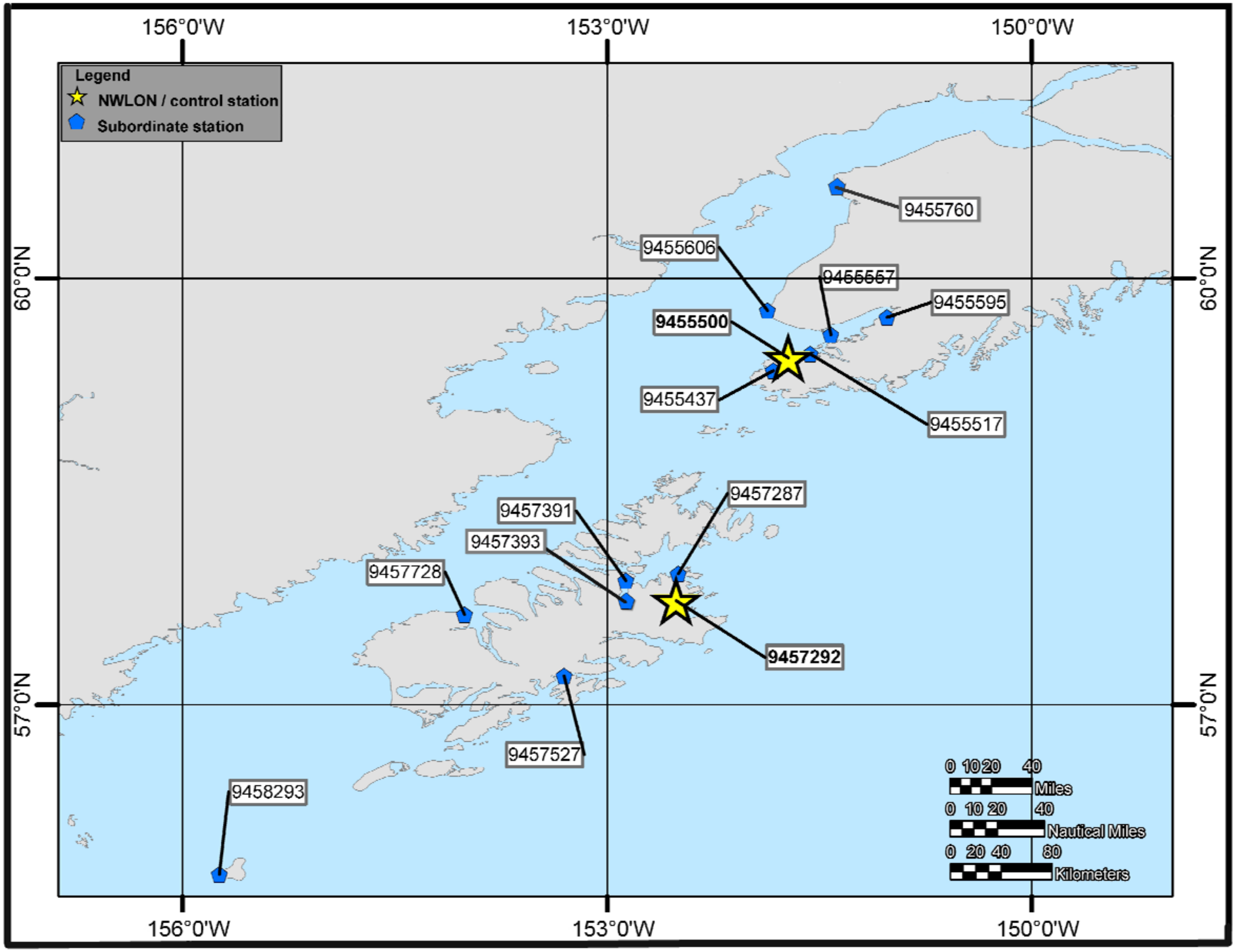

Image A1c: Location of control station and subordinate station for Central Alaska.

Table A1c: Control station and subordinate station for Central Alaska.

STATION ID	NAME	ST	Latitude	Longitude
9455500	**SELDOVIA, COOK INLET**	**AK**	**59.44052**	**-151.71994**
9455760	NIKISKI, COOK INLET	AK	60.68330	-151.39800
9455606	ANCHOR POINT	AK	59.77197	-151.86702
9455437	PORT GRAHAM	AK	59.35000	-151.82666
9455517	KASITSNA BAY, KACHEMAK BAY	AK	59.46833	-151.56500
9455557	HOMER	AK	59.60330	-151.42000
9455595	BEAR COVE, KACHEMAK BAY	AK	59.72500	-151.02300
9457292	**KODIAK ISLAND, WOMENS BAY**	**AK**	**57.73170**	**-152.51200**
9457728	UYAK (CANNERY DOCK), UYAK BAY	AK	57.63500	-154.00700
9458293	CHIRIKOF ISLAND, SW ANCHORAGE	AK	55.80830	-155.74000
9457527	OLD HARBOR	AK	57.20277	-153.30388
9457287	OUZINKIE	AK	57.92170	-152.49800
9457391	PORT LIONS, KODIAK ISLAND	AK	57.87347	-152.86711
9457393	DOVOLNO POINT	AK	57.73944	-152.87472

Appendix 2:

FEDERAL REGISTER NOTICE

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration Notice of Change to the Nation's Tidal Datums with the Adoption of a Modified Procedure for Computation of Tidal Datums in Area of Anomalous Sea-Level Change

AGENCY: National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA), Department of Commerce (DOC).

ACTION: Notice to advise the public of periodic updates to tidal datums due to the adoption of modified procedures for computation of accepted tidal datums in areas of anomalous relative sea-level trends using a 5-year time period for determination of tide level datums.

SUMMARY: NOAA has typically updated tidal datum elevations for the nation to new National Tidal Datum Epoch (NTDE) time periods every 20-25 years. Updates are necessary due to long-term sea level change. In 1998, NOS recognized the need for a modified procedure for determination of tidal datums for regions with anomalously high rates of relative sea level change. This modified procedure is necessary at selected stations to ensure that the tidal datums accurately represent the existing stand of sea level. The procedure is limited only to those stations in areas with high rates of vertical land motion that have documented anomalous relative sea level trends exceeding 9.0mm/yr. Sea level analyses in these anomalous regions are conducted approximately every five (5) years to determine if the MSL difference exceeds the established threshold tolerances in order to qualify for a special update. Anomalous relative sea level trends are seen along the western Gulf Coast, southeast Alaska, and southern Cook Inlet,

AK. For example, the magnitude of the sea level trends in these areas are +9.24 mm/yr in Grand Isle, LA; -12.92 mm/yr in Juneau, AK; and -9.45 mm/yr in Seldovia, AK

This procedure is necessary to provide the most accurate information available for applications that are essential to supporting Federal, State and private sector coastal zone activities, including hydrographic surveys and coastal mapping, navigational safety, wetland restoration, marine boundary determinations, coastal engineering, storm warnings and hazard mitigation, emergency management, and hydrodynamic modeling.

While maintaining the 19-year NTDE computational period for mean ranges of tide (both mean range (Mn) and Diurnal Range (GT)), a shorter more recent 5 year computational period is used to compute the mean tide level datums to better reflect the current elevation of mean sea level relative to the land. Consequently, tidal datums at stations exhibiting anomalous trends are computed from Mean Sea Level, Diurnal Tide Level (DTL) and Mean Tide Level (MTL) values for the most recent 5 year time period, and tidal ranges (GT and MN) based on the most recent full 19 year NTDE at stations.

The average absolute difference between 19 year NTDE time periods across the nation of 0.03m (0.10 ft.) is generally used as the threshold difference to warrant consideration of a 19 year NTDE update, and a 20-25 year review cycle has been adequate to capture the changes of 0.03-0.04m for most locations. To meet this target at locations with anomalous rates of sea level change, tidal datum elevation updates must occur more frequently. In general, the vertical changes in datum elevations which result from these more frequent special tidal datum updates every 5-years are kept as close to the 0.03m (0.10 foot) to 0.05m target as possible. In comparison to the overall accuracy of hydrographic-cartographic processes and scale and resolution and accuracy of soundings on the NOAA nautical charts, these elevations changes will not require then need to correct or update charts every time a datum update is issued. For the most part, since the changes are small the shoreline, depth soundings values, isobaths, etc., are not significantly modified as a result of tidal datum updates, depending upon chart scale. However, in regions that have experienced rapid land movement, the changes to actual soundings and shoreline depiction may be required to be updated on the next regularly scheduled chart edition. Although depictions of the datum changes will not be evident on the largest scale NOS nautical charts, the datum changes will be noticeable when establishing or re-occupying tide stations using accepted surveying techniques and updating elevations on tidal bench marks provided by NOS' CO-OPS. Appropriate outreach will be conducted per office guidelines prior to performing each update.

FOR FURTHER INFORMATION: Visit the NOS' CO-OPS Web site (http://www.tidesandcurrents.noaa.gov) or contact the CO-OPS office at the following address: NOAA, National Ocean Service, CO-OPS, Oceanographic Division, 1305 East-West Highway, Silver Spring, MD 20910-32821, U.S.A., Telephone: 301-713-2890 x149, Fax: 301- 713-4437, E-mail: Tide.Predictions@noaa.gov.

SUPPLEMENTARY INFORMATION:

Dated: October 18, 2013.

(Signature) Holly A. Bamford

Assistant Administrator for Ocean Services and Coastal Zone Management.

[FR Doc. 2013-25139 Filed 10-24-13; 8:45 am]

Appendix 3:

DRAFT NOTICE TO MARINERS

NOTICE TO MARINERS

Issued By:

CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS & SERVICES

SSMC BLDG. # 4 – ROOM 7124
1305 East-West Highway
Silver Spring, MD 20910-3281
301-713-2815
301-713-4500 (24 hour fax)
Tide.Predictions@noaa.gov
<http://tidesandcurrents.noaa.gov>

SPECIAL UPDATE OF ACCEPTED TIDAL DATUMS IN AREAS WITH ANOMALOUS SEA LEVEL TRENDS

NOAA’s National Ocean Service, Center for Operational Oceanographic Products and Services (CO-OPS) has updated the tidal datums for long-term control stations exhibiting anomalous relative sea level trends using a modified procedure for computing accepted tidal datums based on observations between the years 2007-2011. The areas of anomalous sea level trends include portions of Alaska that are experiencing rapid land uplift, and portions of Louisiana and Texas that are experiencing rapid land subsidence. The previous 5-year time period used in the modified procedure for computing accepted tidal datums for these areas was 2002-2006.

The following long term control stations have updated tidal datums using the 2007-2011 modified procedure for computing accepted tidal datums. The observed changes in Mean Sea Level (MSL) relative to the land from the previously accepted datum to the 2007-2011 modified procedure for computing tidal datums are as follows: (Positive values indicate a relative sea level rise, while negative values indicate falling relative sea level.)

8761724 Grand Isle, LA: +0.034m
9452210 Juneau, AK: -0.071m
9452400 Skagway, AK: -0.098m
9453220 Yakutat, AK: -0.113m
9455500 Seldovia, AK: -0.083m
9457292 Kodiak, AK: -0.083m

Changes in other tidal datums such as Mean High Water (MHW) and Mean Lower Low Water (MLLW) are approximately equal to those for MSL. Tidal datums at all historical subordinate stations that use the above stations for datum reference and control have also been updated.

Due to the small changes which result from these tidal datum updates, in comparison to the overall accuracy and scale of the NOAA nautical charts, there are no anticipated changes to charts due to these adjustments.

Water level data and tidal predictions displayed on the CO-OPS website are generally referenced to MLLW, which for the above mentioned stations have been updated to reflect these relatively minor changes. There are no changes required to the NOAA tidal prediction products distributed by NOAA as a result of these updates.

The two major products updated for these stations are the published tidal datums: http://tidesandcurrents.noaa.gov/stations.html?type=Datums, and the published tidal bench mark sheets: http://tidesandcurrents.noaa.gov/stations.html?type=Bench+Mark+Data+Sheets

Updating the tidal datums in these areas using the modified procedure is necessary to provide the latest up-to-date information available for applications that are essential to supporting Federal, State and private sector coastal zone activities, including hydrographic surveys and coastal mapping, navigational safety, wetland restoration, marine boundary determinations, coastal engineering, storm warnings and hazard mitigation, emergency management, and hydrodynamic modeling.

A detailed report explaining this modified procedure for computing tidal datums can be found in the publications section of the CO-OPS Tides & Currents website at http://tidesandcurrents.noaa.gov.

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Appendix 4:

GENERAL COUNSEL OF OCEAN SERVICES (GCOS) REVIEW LETTER

"NOAA/COOPS has the authority to produce products and services based on the accelerated revision of the NTDE, under the Coast and Geodetic Survey Act (CGSA). The authority provides NOAA with the mission of providing data for scientific and other uses. Implied in this authority is the ability for NOAA to make decisions on the appropriate way to produce and disseminate accurate data. Federal courts have supported the use of a 19-year NTDE based on the support of experts such as NOAA as to the 19-year epoch's accuracy, and not upon a static belief in the timeframe's infallibility. Production by NOAA/CO-OPS of products and services based on an alternative timeframe in order to ensure accuracy is supported by the statute.

CO-OPS has clear statutory authority to calculate and publish MSL data. Pursuant to the Coast and Geodetic Survey Act (CGSA), CO-OPS' is authorized to acquire hydrographic and related data. 33 U.S.C. 833a. The Act also provides CO-OPS the authority to conduct the following activities: (1) Analysis and prediction of tide and current data; (2) Processing and publication of data, information, compilations, and reports…" 33 U.S.C. 883b.

CO-OPS therefore has a mission to acquire geophysical measurements and information, analyze them, and produce and disseminate useful data for the public. The mandate in the statute is not to copy existing products but to acquire information, make determinations and provide useful data for "engineering and scientific purposes and for other commercial and industrial needs." Inherent in this direction from Congress is the mandate that NOAA make decisions in its collection and analyses of the data, in order that the information disseminated be beneficial to the public. CO-OPS has carried out the mandate of the CGSA as exemplified by its creation and distribution of the products depicting tide levels and high and low water levels *(See* http://tidesandcurrents.noaa.gov/products.html for examples).

While NOAA/CO-OPS has generally calculated tide levels and water levels applying the 19-year NTDE, it has done so based on its expert judgment that the use of the 19-year NTDE yields an accurate result in dissemination of its products and data. NOAA/CO-OPS and its predecessor agency (the Coast and Geodetic Survey) have a long history of using the 19-year tidal datum; at least since the early 20th Century, according to CO-OPS staff. The U.S. Supreme Court supported the use of the 19-year NTDE, based not upon the inherent correctness of a 19-year epoch, but because the Coast and Geodetic Survey, as a recognized expert, utilized it. *Borax Consol., Ltd. v. Los Angeles*, 296 U.S. 10, 26-27. Federal courts have continued to reference the 19-year NTDE, owing to the 19-year epoch's general acceptance as an accurate benchmark, based on recommendations by experts. *See, e.g. U.S. v. California*, 381 U.S. 139 (1965) (19-year epoch recommended by Special Master, accepted by the Court); *Meche v. Richard*, 2007 U.S. Dist. Lexis 17898 (W.D. La., 2007) ("…this Court will look to an historical consideration of 18.6 years, which was the period of time over which the experts on behalf of plaintiff and defendant both agreed, to resolve the issue of navigability.").

While NOAA/COOPS is supported by its statutory authority in the use of a 19-year NTDE in the production of most applicable data and products, CO-OPS may also use an alternative time frame, based on NOAA's expert opinion that such an alternate time frame is appropriate."