Datum adequacy for assessing ownership of Alaska's coastal and marine resources, A Coast Surveyor's perspective.

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Alaska comprises approximately 33,000 miles of the United States coastline, 900,000 square miles of the US EEZ, and offers 55% of the US Long Term Potential Yield of fishery resources. Alaska also offers extensive oil and gas reserves and mineral deposits that either lie adjacent to navigable waters or require access to navigable waters to be commercially viable. Yet, the majority of Alaska remains poorly mapped to common horizontal and vertical datum, presenting challenges to stakeholders in the effort for sustaining local communities through resource development, conservation of the species under fisheries management plans, and preservation of lifestyles. This paper will define the terms of reference for horizontal and vertical datum and identify the history and adequacy of datums in Alaska as depicted in federal cartographic products and developed through federal programs. Limitations in distribution and duration of observations will be noted with regards to past and present survey efforts. Reference to ongoing geological processes, including erosion and accretion, crustal motion and plate tectonics, and significant seismic events will be noted as key factors limiting the value of historical measurements. More robust natural processes, particularly storm surge, slumping and glacial rebound, and thawing of permafrost, glaciers, and icecaps are accelerating the datum change. With improving technologies, including GPS, the changes are being documented. Yet, as documented, the question of adequacy and accuracy of existing datum, and their associated cartographic products, needs to be considered. The specific challenges with the "Dinkum Sands" decision will be reviewed along with comments on the datum challenges for determining the offshore boundary of Arctic National Wildlife Refuge, National Petroleum Reserve, Alaska, and other federal lands in western Alaska. A final perspective will be offered on the challenges of defining new boundaries under changing laws, including Article 76 of the United Nations Convention on the Law of the Seas.

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In these modern days of GPS it is quite simple to determine a location with a high degree of accuracy anywhere on the globe. This location can be referenced to specific features on the earth, i.e. distances from the coastline that are assumed to be accurate. This is correct in a relative sense, but not correct in a geodetic sense as major areas are constantly undergoing temporal variation of water level and long-term changes in position with geologic events and atmospheric processes. With the minimal data collection across the Arctic Ocean and Bering Sea and the increased meteorological activities and storm events, addressing these variations will be difficult. This paper will note the challenges of managing Alaska resources with ambulatory and fixed boundaries that depend on temporal non-standard datums in a data poor environment. Finding a common agreement to establishing boundaries for managing common properties will remain difficult.

In Alaska, as with many other locations in the arctic and sub-arctic, the accuracy of reference points is based on the best available data. From a land perspective, positions are generally well documented with geo-referenced satellite imagery being collected and improved upon annually. Much of this is also determined by onsite surveys, allowing sub-centimeter accuracy. However, it is at the boundary between land and water where the problems becomes greatest, as vertical and horizontal datums are brought together. In data rich areas, these problems are complex to resolve, as seen in the subsidence issues with the Mississippi Delta. In data poor areas, like Alaska's Arctic and sub-Arctic, these problems are almost impossible to resolve. Yet, the challenges remain to be addressed. Of particular note are the ambulatory boundary between the Beaufort Sea and the Arctic National Wildlife Refuge, the fixed boundary of the National Petroleum Reserve Alaska, and the common state-federal boundaries of the Bering Sea and its coastal plains.

The use of vertical datum for establishing boundaries is identified in Figure 1 (NOAA, 2003). Of particular relevance to Alaska is the generally accepted standard of State owned tidelands are between Mean High Water (MHW) and Mean Lower Low Water (MLLW) and State owned submerged lands are from MLLW offshore for a distance of 3 nautical miles. These standards are applied to the majority of Alaska's coastline. Yet, specific federal lands in Alaska, and particularly in north and west Alaska, are regulated by exception to this general standard. This establishes requirements to define terms of "extreme low water" for the Arctic National Wildlife Refuge; "highest high water mark" for the National Petroleum Reserve, Alaska; and generic descriptors like "whatever submerged islands, if any retained by the federal government at the time of statehood" for the Yukon Delta National Wildlife Refuge. It is these terms and designations that make resource management dependent upon data to define the specifics of horizontal and vertical datums.

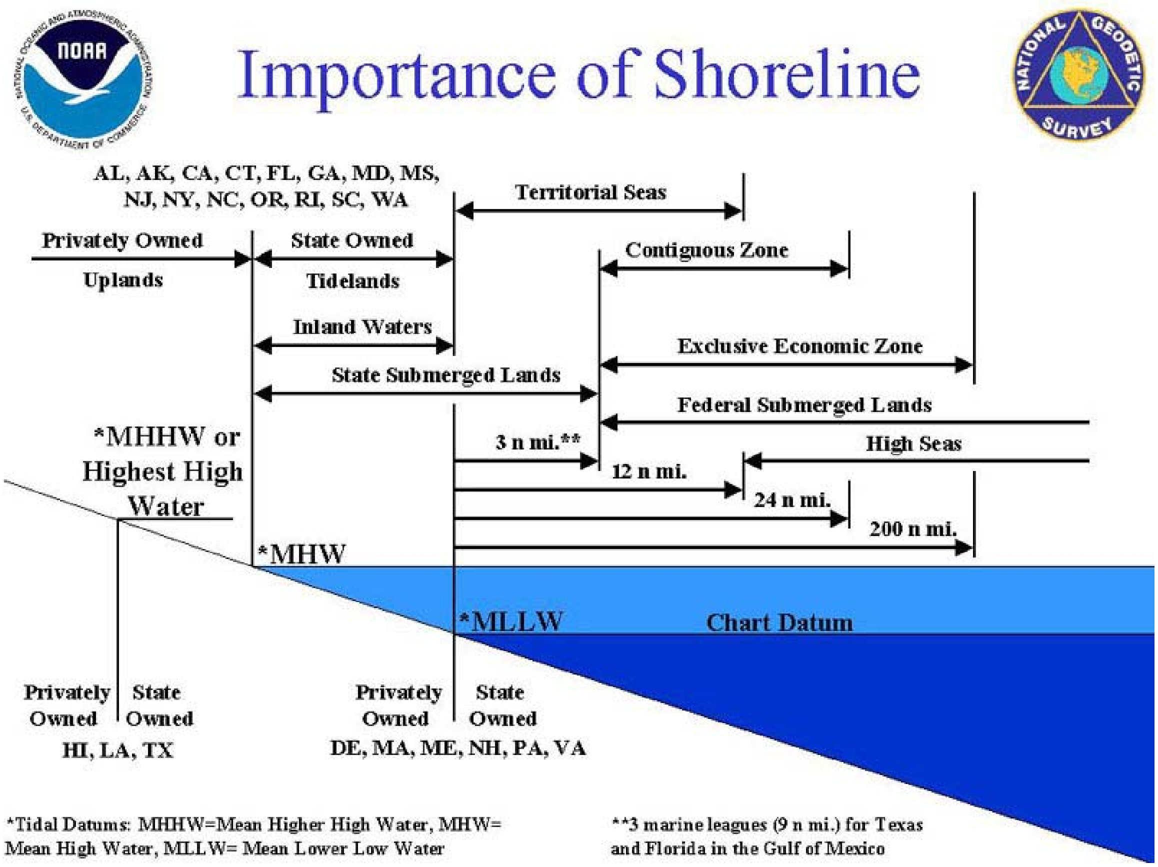

Figure 1. Graphic depicting the importance of shoreline in determining common property management (NOAA, 2003).

Each vertical datum has specific meaning and presumes accurate and adequate data to derive the datum from. Deriving the datum requires applying a specified tidal epoch of 19 years (covering the 18.6 years of tidal cycle) to specific site and adjusting the datum vertically to the mean of all observations. NOAA has the mandate to establish and maintain these tidal datums, with significant historical set of tidal benchmarks and primary, secondary, and tertiary stations referenced to the National Tidal Datum Epoch 1960-1978. NOAA has recently released the new National Tidal Datum Epoch 1983-2001 and will adjust a limited number of these positions based on newest data from improved technology. Appendix 1 provides the list of planned Alaska NTDE 1983-2001 benchmarks. Presently, there are only 3 tidal benchmarks in the Bering Sea and 1 in the Arctic, with the Aleutian Island sites of Adak and Dutch Harbor, the Bering Coast at Nome, and the Arctic Coast at Prudhoe Bay. As NTDE 2001 is fully applied, that will increase to 6 with datum established at Kivalina (the Red Dog Mine) and Village Cove of St Paul Island (Pribilof Islands).

In Alaska, there are 17 National Water Level Observation Network gauges, as depicted in Figure 2. Of these gauges, three are located in the Bering Sea (Unalaska, Adak, and Nome) and one in the Beaufort Sea (Prudhoe Bay). A fourth private gauge has been operating at the Red Dog mine port at Kivalina. These gauges provide the only long-term water level measurements that are able to establish the standard datum and document the non-standard events. The key question remains as to how accurate one control point is for such a large expanse of coastline, particularly for meteorological events causing tide setup with storm surge and ice jams or tide setdown with offshore winds and high pressure. Comparably, the Pacific Coast has 17 NWLON and Atlantic Coast has 36 NWLON on exposed coasts (NOAA, 2003), providing the data coverage needed to document localized impact of storms, tsunamis, and seismic events.

Figure 2. The National Water Level Observation Network showing minimal coverage for the Bering Sea and Arctic Ocean (NOAA, 2003).

Each NWLON station is precisely referenced to a specific datum. At this time, these stations are positioned with reference to the North American Datum of 1983 for the horizontal position and are being adjusted to the National Tidal Datum Epoch 1983-2001 for the vertical elevation. This allows projection of the measurements into models that determine the progression of time and height of tide at locations within the area, i.e. “co-tidal” and “co-range” lines. With multiple stations, tidal zones can be determined that show variation over distance. With single stations, mathematical models are needed. These models are adjusted with short-term measurements, usually associated with engineering or nautical charting studies.

Table 1. list the tidal datums established for the new Tidal Epoch for Adak Island (NOAA, 2003). What Table 1 shows is that the water level ranged from the highest level of 2.084 meters above mean lower low water to –0.873 meters or relatively consistent extreme range of approximately .9 meters on each side of an established datum (.953 meters above MHHW to –0.873 meters below MLLW). This is the value of long-term data.

Table 1. Tidal datums at ADAK ISLAND, SWEEPER COVE based on:

LENGTH OF SERIES:	19 Years	
TIME PERIOD:	January 1983 - December 2001	
TIDAL EPOCH:	1983-2001	
HIGHEST OBSERVED WATER LEVEL (12/28/1966)		= 2.084
MEAN HIGHER HIGH WATER (MHHW)		= 1.131
MEAN HIGH WATER (MHW)		= 1.055
MEAN SEA LEVEL (MSL)		= 0.649
MEAN TIDE LEVEL (MTL)		= 0.613
MEAN LOW WATER (MLW)		= 0.172
MEAN LOWER LOW WATER (MLLW)		= 0.000
LOWEST OBSERVED WATER LEVEL (11/11/1950)		= -0.873

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

The value of the data can be further understood by mapping the trend in sea level over the past 55 years, as depicted in Figure 3. In addition to the seismic change of 1957, there has been a general decreasing trend of the water level at –2.63 mm/year (NOAA 2003). This supports plate tectonics along the Aleutian chain and southern Alaska peninsula, where upthrust is raising the land and causing the appearance of a decreasing water level. This pattern is consistent at Dutch Harbor, with –6.44 mm/year and Kodiak with –12.88 mm/year (NOAA, 2003). It is a well-understood geological process and clearly marked by significant seismic activity.

Mean Sea Level Trend : 9461380 Adak Island, Alaska

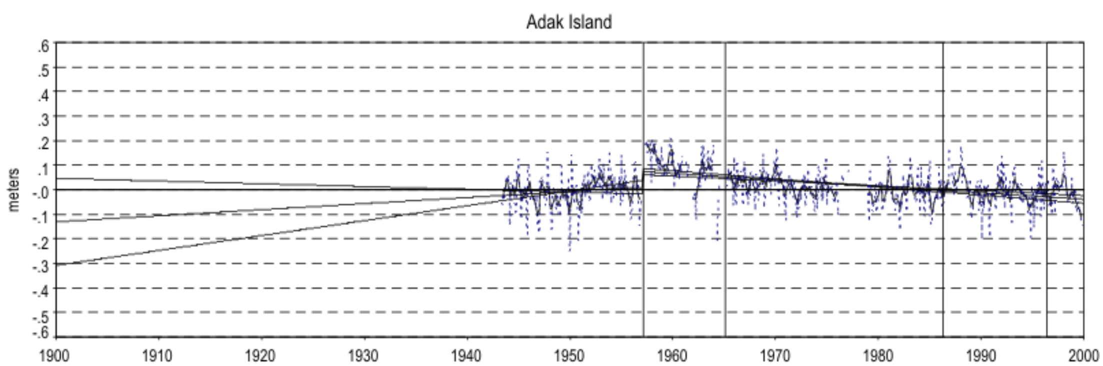

Figure 3. The mean sea level trend is -2.63 millimeters/year (-0.86 feet/century) with a standard error of 0.35 mm/yr based on monthly mean sea level data from 1957 to 1999.

As this area, the Aleutian Islands and the Alaska peninsula are predominately rocky headlands and offshore islands and islets, marked by significant baseline points, there is little controversy on where state and federal jurisdiction occur. Throughout this area and extending into the Gulf of Alaska, jurisdiction is based on a common tidal datum of MLLW, except where specific submerged lands of the Alaska Maritime Wildlife Refuge were set aside at the time of statehood, i.e. Kodiak and Afognak Island (ANILCA 303 1a).

Conversely, this is not the case for the Bering Sea, Chukchi Sea, and Arctic Ocean. These areas are marked with large distances of low coastal relief, shoals at river mouths, and dynamic areas of erosion and accretion. It is in these areas where determining jurisdiction will depend on finding mutually agreed methods to gather an acceptable level of data in a cost effective manner and find expert guidance in applying principles to the data that have been developed by legal findings, i.e. the "Dinkum Sands" decision.

An alternative is to simply accept the dynamics of the area and clarify boundaries on an issue-by-issue basis, collecting data where needed. This depends on stakeholder working groups, as has been conducted via groups like the DOI-State of Alaska Marine Boundary Working Group. Yet even this approach depends upon a mutually agreed upon baseline to measure against.

In Alaska, the "best available" coastline for western and northern Alaska is a compilation of data sets that result in a 1:250,000 projection that is not tide coordinated or resolved to a standard vertical datum. It is simply the best description to serve as a data layer in broad scale GIS applications. This provides visual resolution where 10 meter GPS positional accuracy translates to .04mm resolution on a 1 square meter basemap.

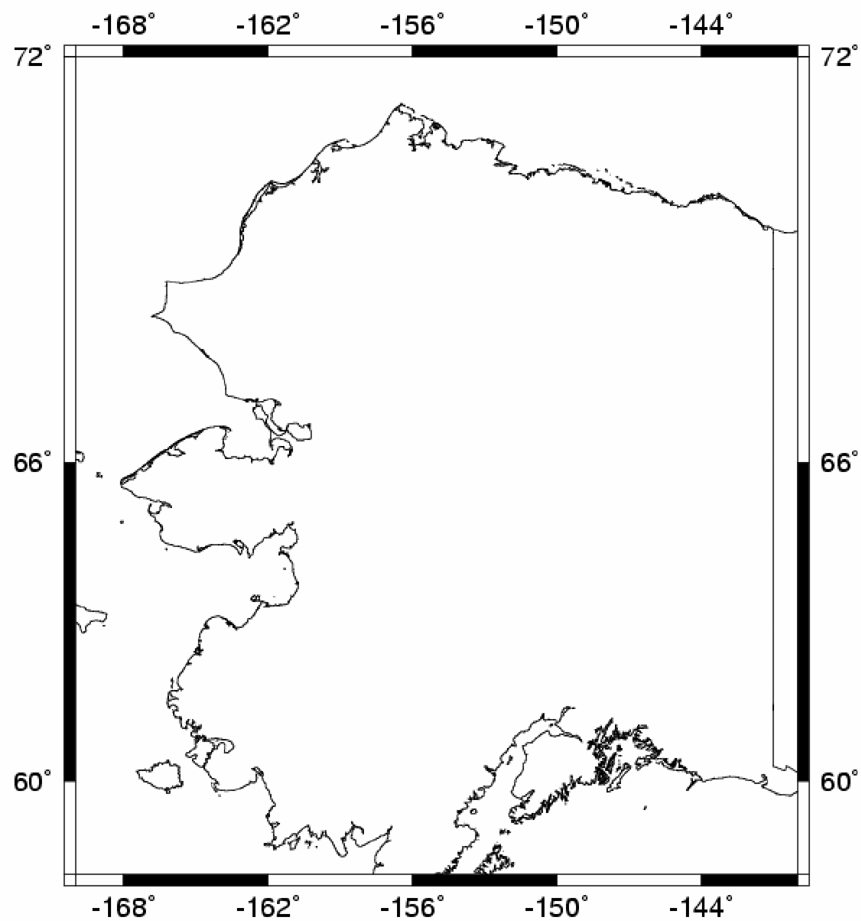

Figure 4. Compiled 1:250,000 shoreline data compiled for western and northern Alaska.

NOAA's effort to generate a "vector" shoreline based on tide-controlled photogrammetry further confirms this problem. In Figure 4, the purple areas are pre-1990 based on digitized analog images, while red is post-1990 digital data. The NPRA, eastern ANWR, Norton Sound, Yukon delta, and Bristol Bay are with either pre-1990 data or without adequate data to construct a shoreline and create an accurate jurisdictional boundary. When one factors in the rates of erosion and accretion, as well as single point of tidal information, it is safe to say that all of Western Alaska and majority of Northern Alaska is without adequate data, given the majority of the coastline data is greater than 15 years old, is analog, and is not linked to a tidal datum. What this means is that coastal boundaries can only be assumed in areas where they are not established, pending the data collection to establish the jurisdictional boundary.

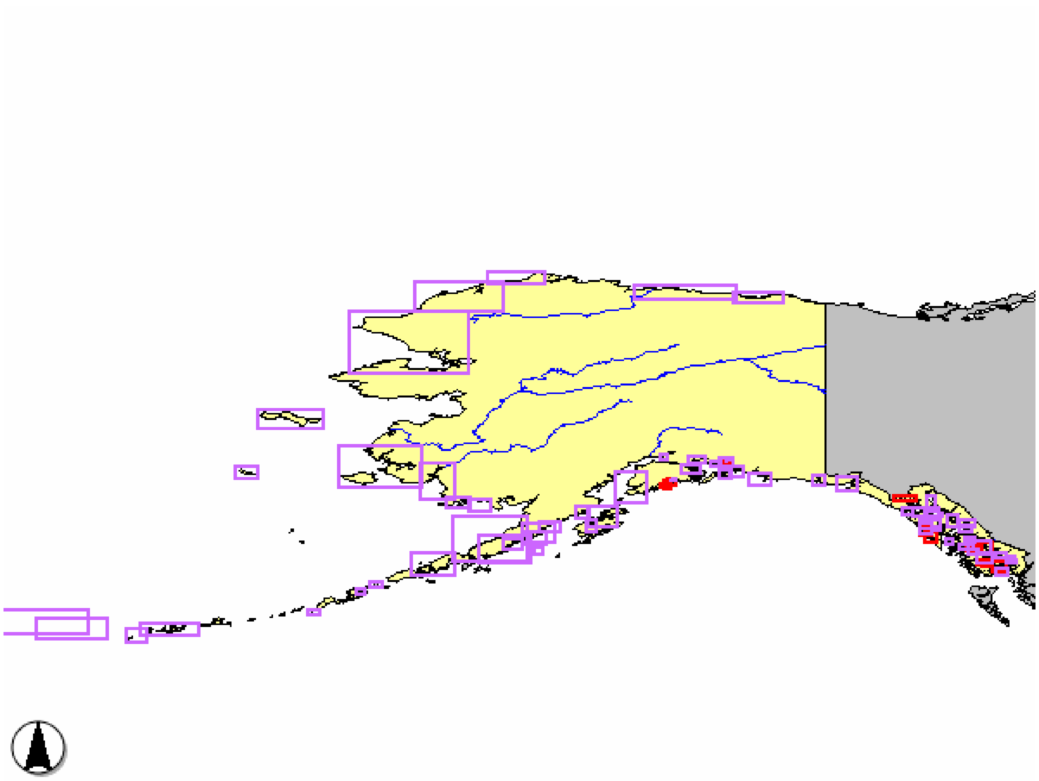

Figure 5. Vector shoreline data available for Alaska (NOAA, 2003).

The Arctic Coast

The Arctic Coast adjoining Prudhoe Bay is one of great interest, given the oil and gas reserves that are known and the infrastructure that is in place. However, the federal boundaries are based on both standard and non-standard terms of reference and supported by Supreme Court decisions and guidance, No. 84 Original, 1997. National Petroleum Reserve, Alaska (NPRA) has its border with the highest high water and although generally agreed to by the State and Federal parties, remains ambulatory. Arctic National Wildlife Refuge (ANWR) has an ambulatory boundary at the extreme low water mark. The relevance of the offshore bays and reefs has not been agreed upon. When analyzing the tidal datums at Prudhoe Bay, based on 10 years of published data (Table 2.) and inferring to the courts decisions, the following points can be made:

The determining factor for the state-federal submerged lands boundary offshore of ANWR, particularly in Camden Bay is 0.665 meters lower than required for Prudhoe Bay. Thus, if a submerged feature regularly comes to within .665 meters of the surface, it qualifies as a salient point based on 10 years of data. If a significant storm were to lower that water level further through atmospheric setdown, then the feature could be at an even greater depth. This is not as likely as the historical low waters have occurred during ice covered periods.

The NPRA boundary datum, if fixed at the present time, would be at the highest observed water level, would be 1.295 meters higher than the generally accepted state tidelands and be 1.472 meters higher than the determined boundary at Prudhoe bay as supported by the decision on Dinkum Sands. This boundary, if not fixed by agreement, will have the potential to see increased state tidelands as the boundary is set back with atmospherically driven high water events associated with increased fetch because of decreased ice cover.

The Prudhoe Bay fields are based on MLLW, as established through the Dinkum Sands decision. The gauge at Prudhoe Bay continues to collect data for completing a tidal epoch and establishing the full range of the water levels.

What is significant with the North Slope is the elevation difference between the boundaries of the 3 adjacent areas. Given ANWR extreme low water baseline, Prudhoe Bay's MLLW baseline, and NPRA highest observed water level, the state-federal boundary rises 2.137 meters over the North Slope, in incremental changes, then returns to MLLW for Barrow and the private in-holdings to the west.

Table 2. Tidal datums at Prudhoe Bay based on:

LENGTH OF SERIES:	10 Years
TIME PERIOD:	September 1993 - August 2002
TIDAL EPOCH:	1983-2001
HIGHEST OBSERVED WATER LEVEL (08/11/2000)	= 1.472
MEAN HIGHER HIGH WATER (MHHW)	= 0.209
MEAN HIGH WATER (MHW)	= 0.177
MEAN SEA LEVEL (MSL)	= 0.103
MEAN TIDE LEVEL (MTL)	= 0.100
MEAN LOW WATER (MLW)	= 0.023
MEAN LOWER LOW WATER (MLLW)	= 0.000
LOWEST OBSERVED WATER LEVEL (12/31/1993)	= -0.665

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in meters.

A second significant point is that atmospheric events will continue to impact the Arctic coast with the potential to further increase the vertical elevation between Highest Observed Water Level and MLLW. Just such an event occurred on July 30, 2003. However, the actual storm surge and Highest Observed Water Level could not be determined in NPRA, as there was no method for data collection. There was also no mechanism to document coastal erosion or accretion with this event. Under the existing definition, just such events provide relevant data to finalizing the exact location of the baseline. Until a fixed baseline is agreed upon, there will remain the potential for further investigation into determining the rights of ownership in the NPRA.

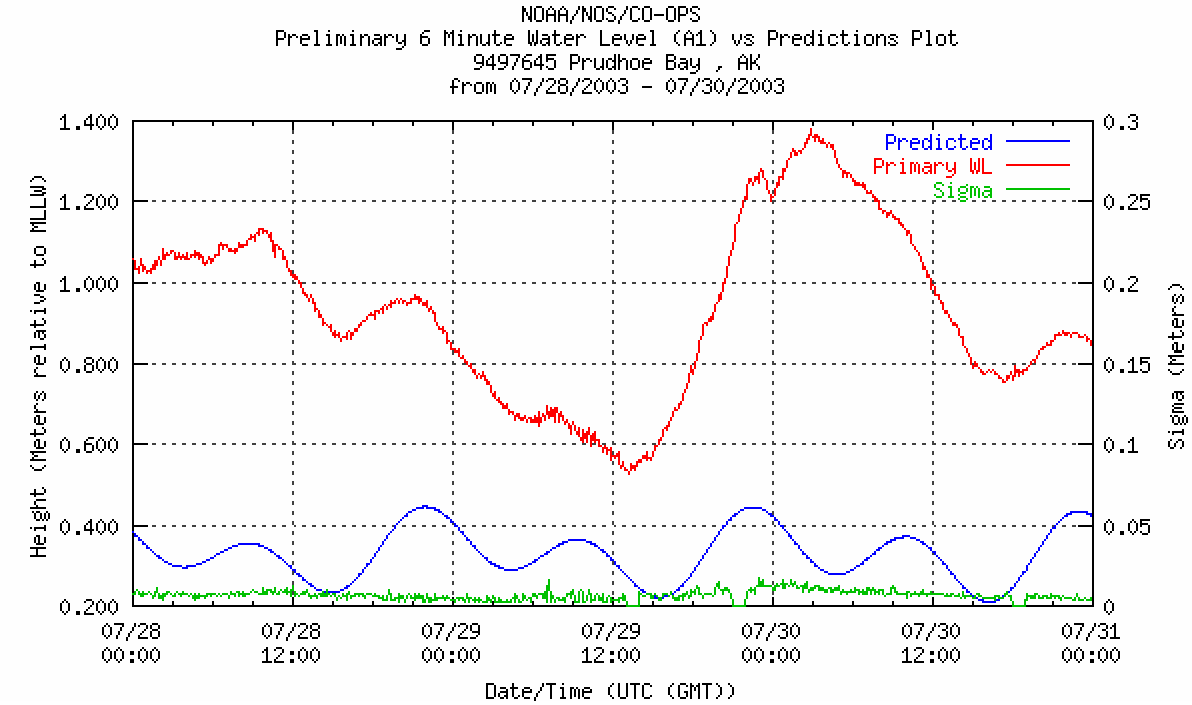

Figure 6. Preliminary storm surge of 7/30/2003 at Prudhoe Bay indicating difference between MLLW and atmospheric event, i.e. measurement related to Highest Observed Water Level.

Bering Sea and Locations

Bering Sea locations, including Norton Sound are referenced to to the NWLON station at Nome, Alaska (NOAA, 2003). This NWLON station is the only gauge in with relative measurements for the Yukon and Kuskokwim River deltas and the storm impacted islands of the northern Bering Sea.

Table 3. The tidal datums at Nome, Norton Sound are based on:

LENGTH OF SERIES:	5 YEARS
TIME PERIOD:	August 1997 - July 2002
TIDAL EPOCH:	1983-2001
HIGHEST OBSERVED WATER LEVEL (10/06/1992)	= 2.636
MEAN HIGHER HIGH WATER (MHHW)	= 0.468
MEAN HIGH WATER (MHW)	= 0.412
MEAN TIDE LEVEL (MTL)	= 0.253
MEAN SEA LEVEL (MSL)	= 0.252
MEAN LOW WATER (MLW)	= 0.093
MEAN LOWER LOW WATER (MLLW)	= 0.000
LOWEST OBSERVED WATER LEVEL (01/07/2001)	= -1.767

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in Meters.

This station, as with Prudhoe Bay, also provides the only information on the height of storm surge, as documented with the July 30, 2003 event.

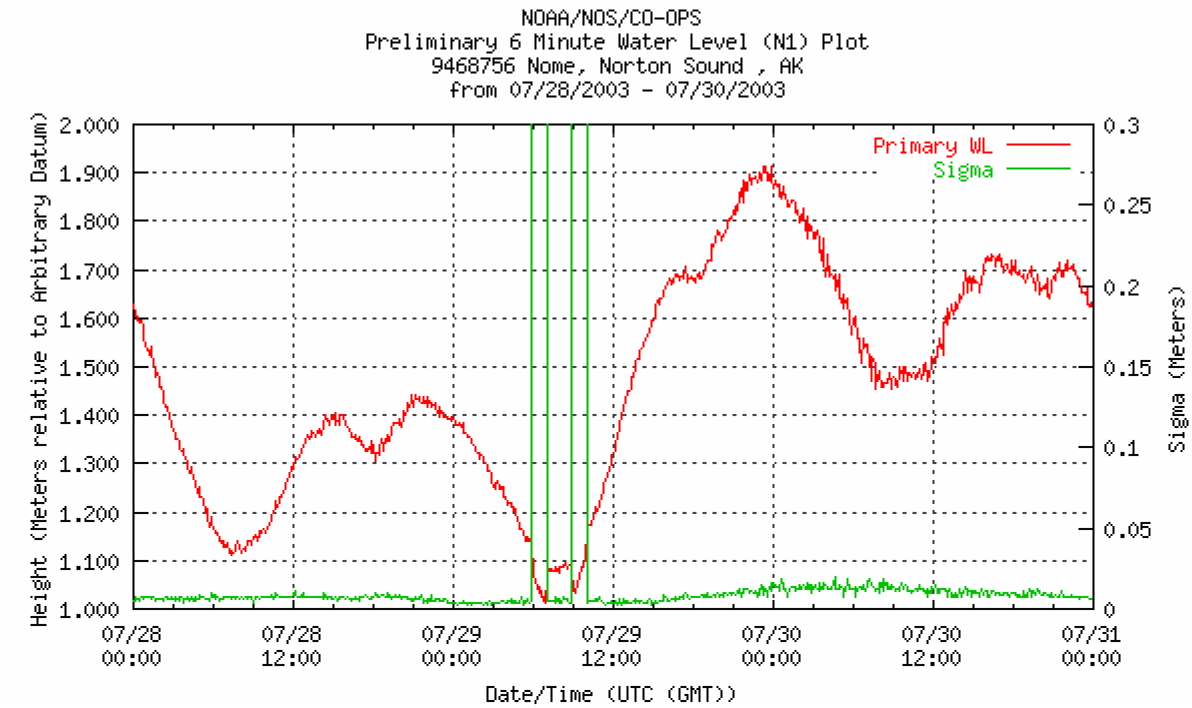

Figure 7. Preliminary storm surge of 7/30/2003 at Nome indicating strength of storm surge of 7/30/2003.

With regards to managing resources in the vicinity of the Bering Sea units of the Alaska Maritime Wildlife refuge, the definitions remain consistent with the standard datums as applied to pinnacles, spires, and offshore islands. These baseline points are dependent upon inference from the tidal models as projected from the NTDE 1983-2001 MLLW for the vertical datum and marginally positioned for geo-referencing, given the age and limited availability of cartographic coverage and vector shoreline. They also favor the idea of negotiating a commonly agreed upon boundary with data collection at stable locations.

The Yukon and Kuskokwim Delta areas are particularly difficult. These deltas lie within the Yukon Delta Wildlife Refuge and adjoin the Togiak Wildlife Refuge. The predominance of the coastline is featureless, with numerous uncharted bars and shoals offshore. This featureless area is commonly impacted with winter ice, heavy sediment transport with breakup, and summer-fall ocean storms. No relevant baseline can be established, as little accurate horizontal or vertical data exists. This is particularly apparent with the lack of shoreline and state-federal boundary on the nautical charts for the Yukon and Kuskokwim delta specifically. This is further complicated by the difficult task of identifying any submerged islands retained at statehood. It appears that the insurmountable task of mapping across these features would merit negotiating a commonly agreed upon boundary.

Inadequate vector shoreline for Pribilof Islands presently exists, although recent surveys have occurred. The 1 station at Village Cove will provide the NTDE 2001 datum for establishing shoreline and distances. This is not a significant issue at St Paul or St George, as distances can be maintained from the island to protect seabirds and fur seals. However, establishing the boundaries by distance measurement versus navigational measurement may prove a more effective means, given the generally steep terrain and limits in competing interests in access to resources.

The remainder of the Bering Sea, until adjoining the lower Alaska peninsula and Aleutian Islands merits consideration of managing resources on past established baselines, as developed from historical surveys by the NOAA and its predecessor, the US Coast and Geodetic Survey, and the US Geological Survey, and as accepted with Alaska statehood. These areas, although undergoing physical change, remain adequate for managing access to the surrounding resources, pending the opportunity to establish an accurate MLLW vertical datum.

UNCLOS Article 76

An alternative to establishing an international boundary based on distances from the baseline is being studied in Alaska and the Arctic. This approach to mapping the boundary of the US Exclusive Economic Zone is being conducted in accordance with Article 76 of the United Nations Conventions of the Law of the Sea. Article 76 allows a nation to extend its jurisdiction over the seabed to the foot of the continental slope if a complex set of criteria is met. These criteria include sediment thickness, as defined by a complex formula; water depth, including the 2500 meter contour; and seafloor shape as defined by geologic features that determine seabed elevations. Technologies are available to address these points, with a key tool being multi-beam echosounder hydrographic surveys, yielding accurate digital terrain models of the seabed.

Establishing Article 76 in Alaska, as well as the United States, is well detailed by "The Compilation and Analysis of Data Relevant to a U.S. Claim Under United Nations Law of the Sea Article 76" (Mayer, Jakobbson, and Armstrong, 2002). In Alaska, studies were identified for the Gulf of Alaska, Aleutian Basin of the Bering Sea, and Arctic Ocean with the Northwind Ridge and Chukchi Cap. Comparably Russia has identified adjoining areas of interest, particularly in the Arctic and Chukchi Cap, while Canada's interest appears to be more interested in the Flemish Cap and the Atlantic (Monahan, 2002).

A conference was held in early July in St Petersburg, Russia to specifically discuss the scientific information available on the "Morphology and Geological Nature of Deep Seabed and Submarine Elevations in the Arctic Basin" that will help define the future scientific studies to support Article 76 claims. The results of this conference will be relevant to the development of claims for deep-sea beds of common interests.

Recommendations

Management of common resources necessitates a general agreement on the base map to project resource distribution, ownership, and jurisdictional consideration. This can be established by agreement of the parties or documented with accurate data. In pursuit of agreement of the parties, 2002 federal and state legislation has been proposed with limited success. Federal and State of Alaska bills have proposed establishing a "Joint Federal and State Navigable Waters Commission" H.B. 4587 & S.2587 and State of Alaska H.B.266 and SB 219. Of this legislation, only S.B.219 passed, authorizing the establishment of Alaska Navigable Waters Commission, with authorities in determining compliance with the Submerged Lands Act. If the federal legislation becomes law, the Joint Federal and State Navigable Waters Commission would be convened. This would lead to specific actions to define jurisdictional boundaries in the coastal and riparian areas. Such activities would strengthen the past State of Alaska-Department of Interior Boundary working group, convened to address NPRA, Prudhoe Bay, and ANWR.

In western Alaska and the Arctic, the accuracy of the data is inadequate, given the breadth of area, lack of data collection points, and the overall requirement for standard and non-standard reference datums. As precise horizontal positioning is relatively easily obtained with GPS, determining the vertical elevation is the primary challenge in western Alaska and the Arctic. Federal initiatives are being pursued to increase the acquisition of tide-coordinated shoreline in order to assess coastal erosion and accretion. This will provide data to derive commonly accepted datums, although not to the NTDE standard. However, unless this program develops the appropriate relational models to the two existing NWLON stations, the ability to address the non-standard datums of "extreme low" and "highest observed" associated with atmospheric events can not be accomplished. It is hoped that a long-term program can be developed to establish the water levels in the Arctic and Western Alaska.

In a circumpolar sense, it remains important for the United States, through Alaska, to document the United States boundaries in Alaska. This includes providing the infrastructure to develop an up-to-date baseline for the demarcation of the federal/state territorial sea boundary and definition of the EEZ from shore. This also includes having adequate tidal zoning information to document the mapping of the continental slope and factors identified under Article 76, UNCLOS. To accomplish this, the United States should support an international program to implement advanced technologies to measure the water levels in both ice-free and ice-covered conditions.

Historically, the program existed under the Intergovernmental Oceanographic Commission (IOC) of UNESCO. In 1999, the IOC Group of Experts on Global Sea Level Observing System documented the trend away from Arctic measurements and recommended a network of evenly spaced stations across the Arctic (UNESCO, 2000). Such measurements would not only support the interest in defining boundaries. These measurements would also provide the critical data for engineering of Arctic infrastructure by documenting strength and frequency of significant variations in the Arctic sea level.

References

Alaska National Interest Lands Conservation Act. 1980. PL 96-487 Title III.

Mayer, Larry, Jakobbsen, M and Armstrong, A. 2002. The Compilation and Analysis of Data Relevant to a U.S. Claim under United Nations Law of the Sea Article 76. CCOM/JHC UNH.

Monahan, David. 2003. An Investigation of the feasibility in making an early initial claim to part of Canada's juridical continental shelf under Article 76 of the United Nations Convention of the Law of the Seas (UNCLOS). University of New Brunswick, CA.

U.S. Supreme Court. 1997. No. 84 Original, United States v. Alaska syllabus.

Plag, Hans-Peter. 2000. Arctic tide gauges: a status report. IOC/INF-1147. IOC/UNESCO.

Appendix 1. Alaska stations to be updated to NTDE 2001 (NOAA 2003)

9450254 KAH SHAKES COVE,REVILLAGIGEDO CHANNEL, AK
9450305 BOCA DE QUADRA, AK
9450970 ENTRANCE TO ZIMOVIA STRAIT, AK
9451037 VILLAGE ROCK, AK
9451124 STIKINE STRAIT, AK
9451204 WRANGELL, WRANGELL ISLAND, AK
9451409 MOUNTAIN POINT, (CANNERY), AK
9451422 LECONTE BAY, AK
9451497 SAGINAW BAY, KUIU ISLAND, AK
9451785 THE BROTHERS, STEPHENS PASSAGE, AK
9451906 CANNERY WHARF, GAMBIER BAY, AK
9451909 GOOD ISLAND, GAMBIER BAY, AK
9452067 HOLKHAM BAY, STEPHENS PASSAGE, AK
9452346 COVE POINT, BERNER'S BAY, AK
9452368 SWANSON HARBOR, AK
9453849 CAPE SAINT ELIAS, AK
9454381 BLIGH ISLAND, T-16, AK
9454713 LATOUCHE, AK
9455120 AGNES COVE, AK
9456901 AGUCHIK ISLAND, AK
9457261 PORT OF KODIAK, AK
9457283 KODIAK, ST PAULS HBR, AK
9458209 PUALE BAY, AK
9458762 UNAVIKSHAK ISLAND, AK
9458779 NAKCHAMIK ISLAND, PACIFIC OCEAN, AK
9458917 CHIGNIK, ANCHORAGE BAY, AK
9464212 VILLAGE COVE, ST. PAUL ISLAND, AK
9491253 KIVALINA, AK

Alaska stations that are not scheduled for NTDE of 2001

9451124 STIKINE STRAIT , AK
9451204 WRANGELL, WRANGELL ISLAND , AK
9451218 VANK ISLAND, SUMNER STRAIT , AK
9451224 POINT HOWE, SUMNER STRAIT , AK
9451277 CHATHAM STRAIT, KUIU , AK
9451285 BAY OF PILLARS , AK
9451353 ROWAN BAY , AK
9451422 LECONTE BAY , AK
9451497 SAGINAW BAY, KUIU ISLAND , AK
9451849 POINT SINBAD , AK
9451909 GOOD ISLAND, GAMBIER BAY , AK
9452067 HOLKHAM BAY, STEPHENS PASSAGE , AK
9452421 CHILKAT INLET , AK
9452434 TIAYASANKA HARBOR , AK
9452437 EXCURSION INLET (SOUTH END) , AK
9452441 HOONAH HARBOR PORT FREDERICK , AK
9452484 SALT LAKE BAY , AK
9453431 TYNDALL GLACIER, ICY BAY , AK
9454713 LATOUCHE , AK
9458762 UNAVIKSHAK ISLAND , AK
9458779 NAKCHAMIK ISLAND, PACIFIC OCEAN , AK
9458849 CHANKLIUT ISLAND , AK

Appendix 2. NOAA web links

Figure 1. NOAA. 2003. Importance of Shoreline. As posted at (http://www.ngs.noaa.gov/RSD/coastal/importance.html).

Figure 2. NOAA, 2003. NWLON Stations – Alaska. As linked at (http://www.co-ops.nos.noaa.gov/coastline.shtml?region=ak).

Figure 3. NOAA, 2003. Sea Level Trends – Adak. As linked at (http://www.co-ops.nos.noaa.gov/sltrends/sltrends_station.shtml?name=Adak+Island&state=Alaska&stnid=9461380&start_yr=1957&end_yr=1999&slt=-2.63&sterr=0.35).

Figure 4. NOAA.2003. Compiled 1:25,000 shoreline. As linked at (http://rimmer.ngdc.noaa.gov/cgi-bin/coast/get_coast.pl).

Figure 5. NOAA, 2003. Vector Shoreline Data. As linked at (http://www.ngs.noaa.gov/newsys_ims/shoreline/index.cfm).

Figure 6. NOAA, 2003. Prudhoe Bay Preliminary Water levels. As linked at (http://www.co-ops.nos.noaa.gov/cgi-bin/co-ops_qry_direct.cgi?stn=9497645+Prudhoe+Bay+%2C+AK&dcp=1&ssid=A1+-+Acoustic+WL&pc=W1&datum=MLLW&unit=0&bdate=20030728&edate=20030730&date=3&shift=0&level=-1&form=0&host=&addr=209.193.48.81&data_type=pwl&format=View+Plot)

Figure 7. NOAA, 2003. Nome Preliminary Water levels. As linked at (http://www.co-ops.nos.noaa.gov/cgi-bin/co-ops_qry_direct.cgi?stn=9468756+Nome%2C+Norton+Sound+%2C+AK&dcp=1&ssid=N1+-+Pressure+WL&pc=W1&datum=MLLW&unit=0&bdate=20030728&edate=20030730&date=3&shift=0&level=-1&form=0&host=&addr=209.193.48.81&data_type=pwl&format=View+Plot

Table 1. NOAA, 2003. Adak Tidal Datums. As linked at (http://www.co-ops.nos.noaa.gov/benchmarks/9461380.html).

Table 2. NOAA, 2003. Prudhoe Bay Tidal Datums. As linked at (http://www.co-ops.nos.noaa.gov/benchmarks/9497645.html).

Table 3. NOAA, 2003. Nome Bay Tidal Datums. As linked at (http://www.co-ops.nos.noaa.gov/benchmarks/9468756.html).

Appendix 1. NOAA, 2003. NTDE update. As linked at (http://co-ops.nos.noaa.gov/cgi-bin/epoch_bm_to_update.cgi)