

Hunting for Sea Levels in Alaska

NGS Height Modernization Webinar – April 10, 2014

DGGS Coastal Program

Fairbanks, Alaska

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907-451-5026



Coastal Program at DGGS



Engineering Geology Section, Division of Geological & Geophysical Surveys



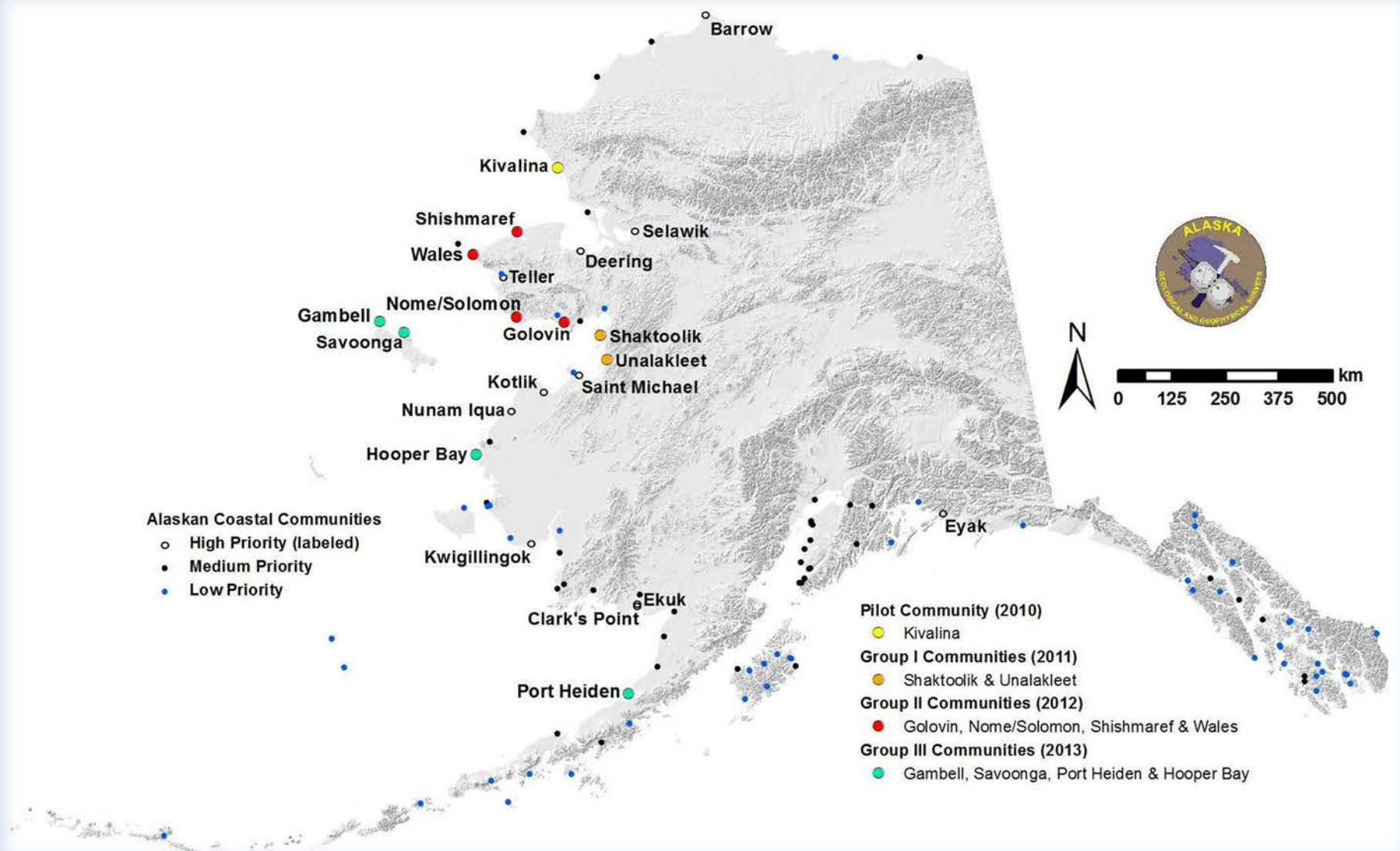
Launched in 2011 with a multi-year project funded by the Coastal Impact Assistance Program to conduct geohazard evaluations and geologic mapping for coastal communities

Available to field information request from the general public (several weekly)

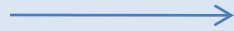
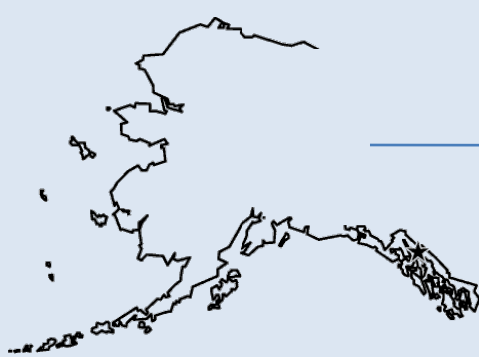
Broad Program Objectives

- Promote access to quality baseline measurements of the Alaska coast
- Develop statewide tools for coastal science, education and planning
 - Community-scale vulnerability maps (flooding and erosion focus)
 - Refine understanding of coastal geomorphology/processes
- Encourage the development of resources that meet the specialized needs in our state

Project Locations (2010-2013)



The Coast of Alaska



~ 6,600 mile coastline
> 40,000 mile tidal shoreline

64% of Alaska residents live in coastal communities

“Less than 10% of Alaska has contemporary shoreline data [1960 or newer] and less than 1% is mapped annually.” – *National Geodetic Survey, Coastal Mapping Program, 2012*

Alaska has 26 active tide stations in the entire state

Alaska no longer participates in the Coastal Zone Management Program; the Alaska Coastal Management Program, designed to oversee the responsible development of coastal uses and resources, sunset in July of 2011

12% of communities do not participate in the National Flood Insurance Program

Coastal Hazards in Alaska



Erosion

Kivalina, AK

(Kinsman 2010)



Ivu (Ice Push)

Nome, AK - May 2004

(Tom Busch)



Storm Surge Flooding

Golovin, AK – July 2011

(John Peterson)



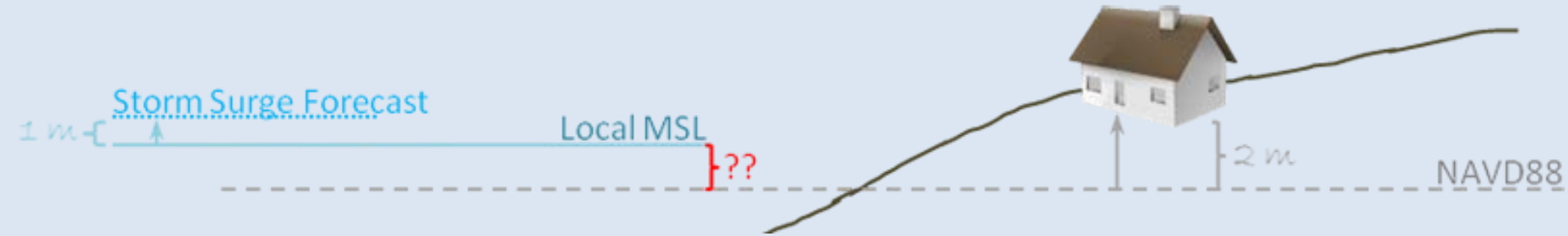
Tsunami Damage

Kodiak, AK – March 1964

(NOAA archive)



Why Vertical Matters at the Coast



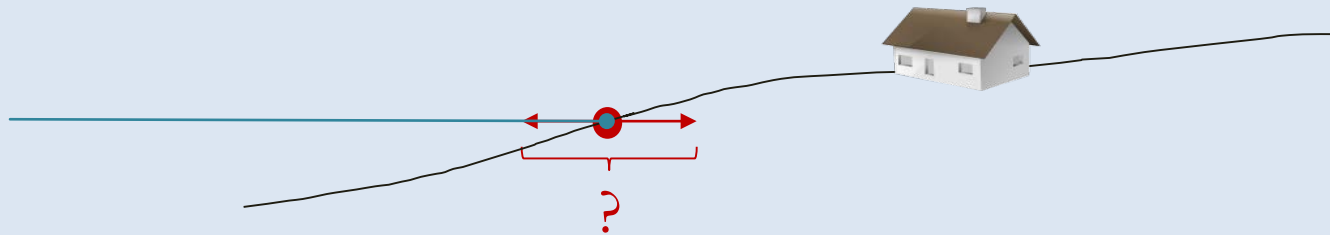
For:

- Vulnerability maps (inundation/erosion)
- Community planning (design heights)
- Emergency response

Need:

- Accurate elevation surfaces
- Established tidal datums
- Measured or modeled extreme water level events (storms, tsunami)

Shoreline Position:



In low-grade beach environments, uncertainty can translate into pronounced horizontal errors in the mapped shoreline position

Example: On a beach with a 1.9° slope, a 50 cm vertical error in the position of MHW translates to a 15 meter error in the horizontal position of the legal shoreline

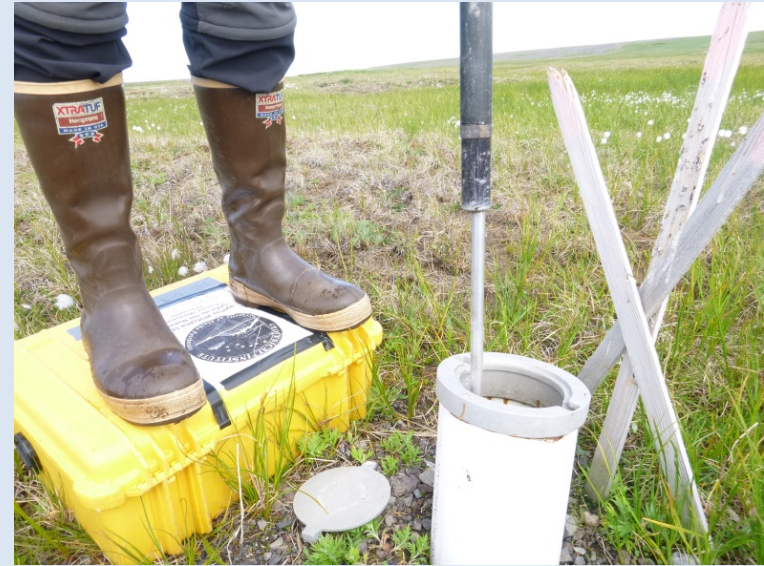
Example - Shaktoolik



Remote Field Areas & 'Alaska' Problems



- Small planes, boats, 4-wheelers and sleds limit equipment and drive up logistical costs



- We use DGPS and RTK GPS to collect elevation (and bathymetry) measurements of coastal features, document extreme events and establish ground control
- Inquisitive kids, inquisitive animals and permafrost...
- During fall storm season the daylight hours are limited and cold weather can cause electronics to malfunction.



Existing Topo-Bathy Surfaces in Alaska



Limited.

The National Elevation Dataset is a 2-arc-second product for most of Alaska

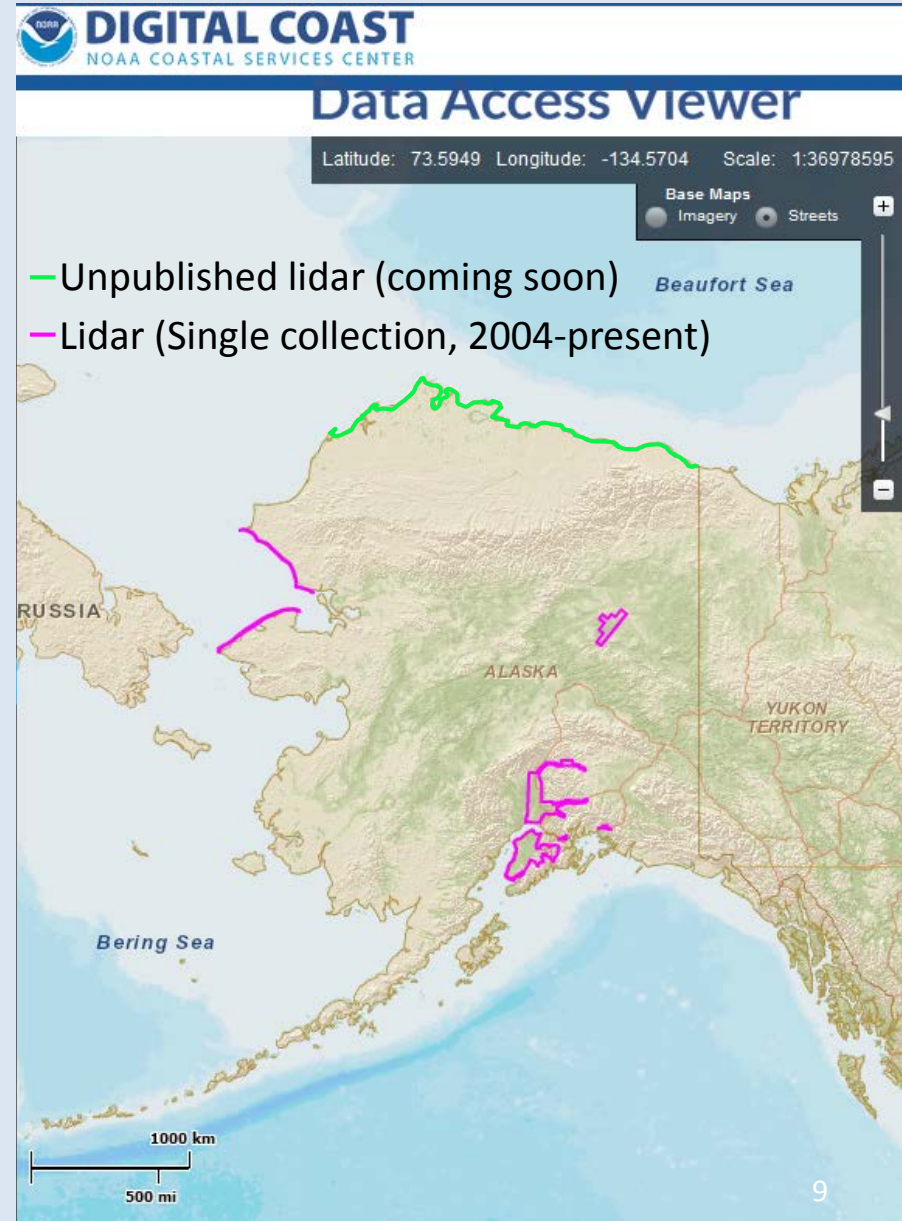
New IfSAR data has a vertical LE90 of 3 m

Limited nearshore bathymetry or lidar coverage exists →

There is very little ground control, particularly in rural areas

Local digital surface models are in assorted vertical datums; NGVD29 ↔ NAVD88 requires constant value offsets (beyond the edges of VERTCON)

The Geoid12A model is not very good in Alaska (GRAV-D will improve it)





Tide Stations in Alaska

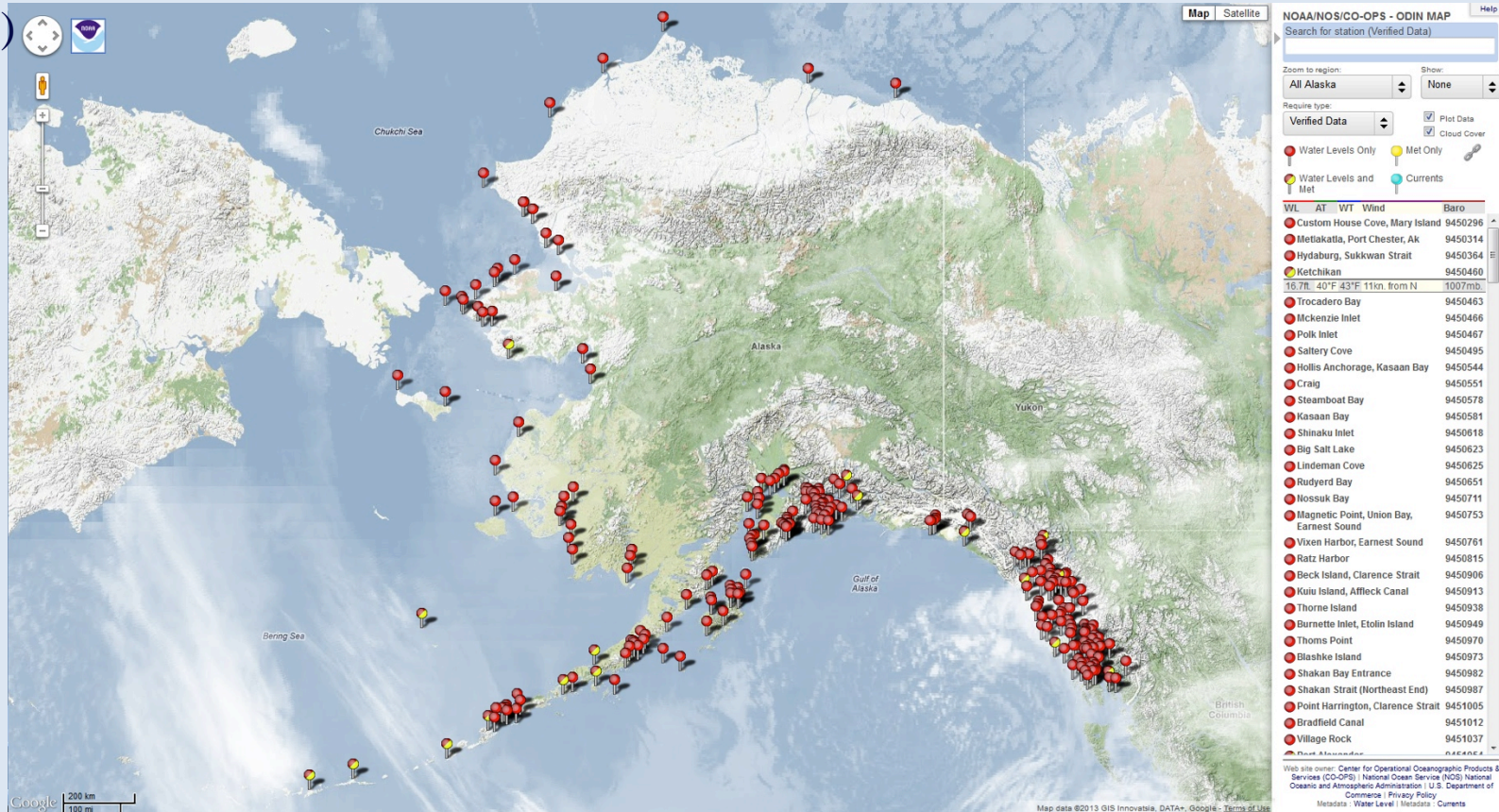
26 active stations

Delaware has 3 gauges along 30 miles of coastline

Northwest Alaska has 3 gauges along 2,000+ miles of coastline

~140 harmonic stations (& declining)

987 total tide gauge locations on record – earliest is July 1900 (few repeat = limited SL trends)



Tidal analysis of harmonic constituents by NOAA = Tide Predictions

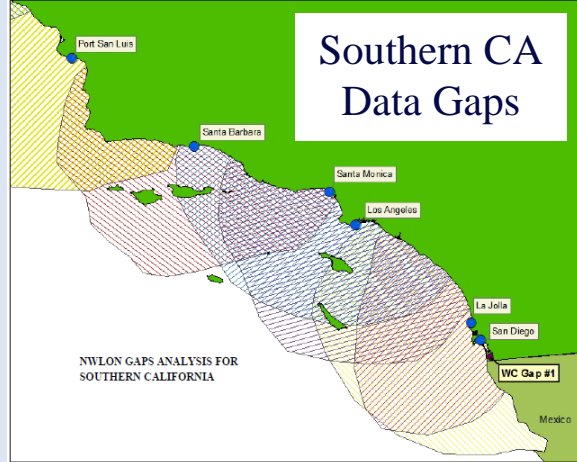
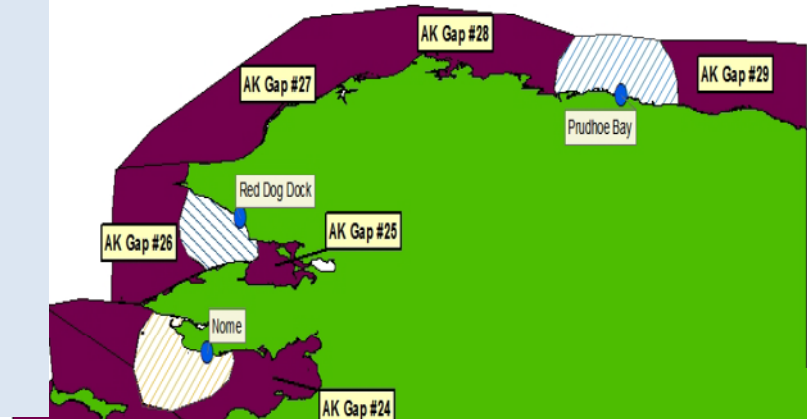
Available at: <http://www.tidesandcurrents.noaa.gov>



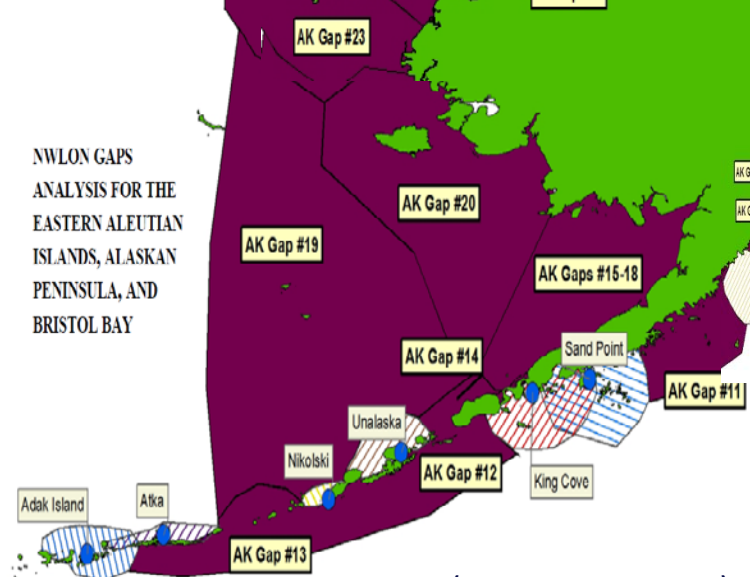
National Water Level Observation Network

Alaska Data "Gaps"

NWLN GAPS ANALYSIS FOR THE CHUKCHI SEA AND NORTH SLOPE, ALASKA



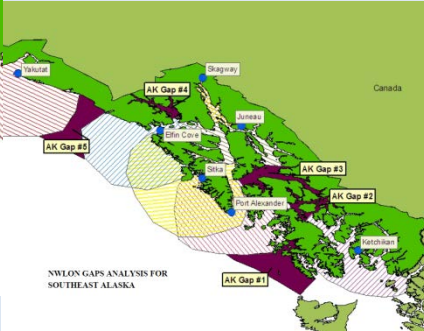
NWLN GAPS ANALYSIS FOR THE EASTERN ALEUTIAN ISLANDS, ALASKAN PENINSULA, AND BRISTOL BAY



NWLN GAPS ANALYSIS FOR THE NORTHERN GULF OF ALASKA



NWLN GAPS ANALYSIS FOR SOUTHEAST ALASKA



(NOAA NOS, 2008)



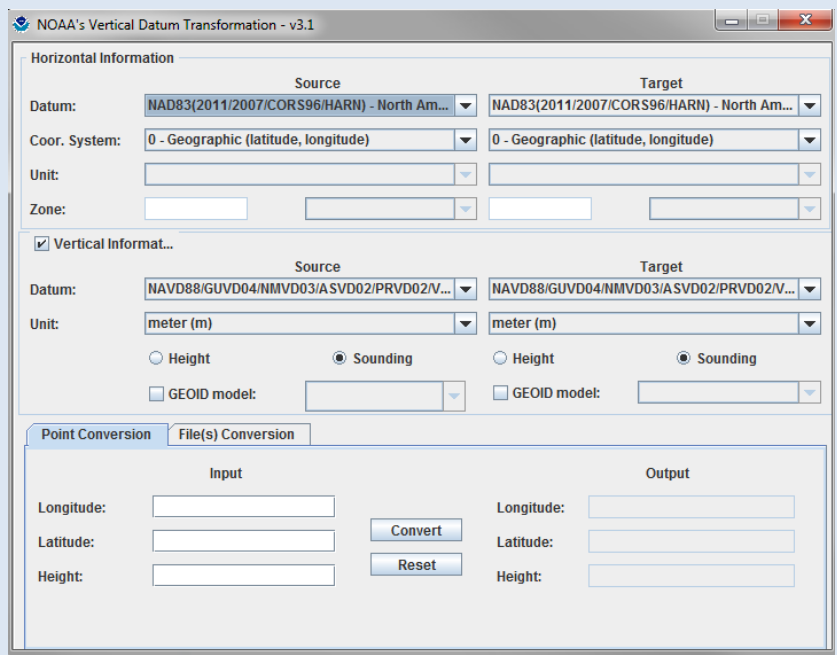
Datum Conversions at the Coast

In most of USA

NOAA's VDatum tool

Uses a continuous sea surface grid (TSS) to make transformations

Available in all contiguous states, Puerto Rico and the US Virgin Islands

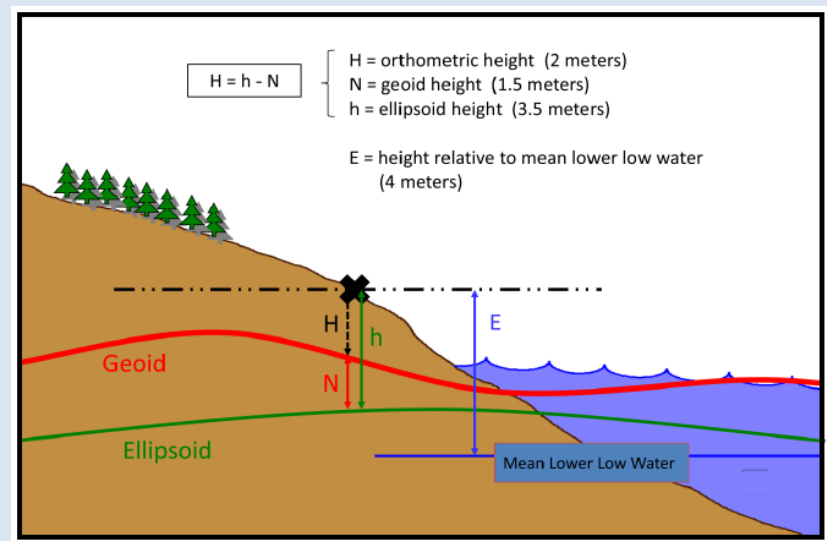


In Alaska

Sole-station offset transformations

Require:

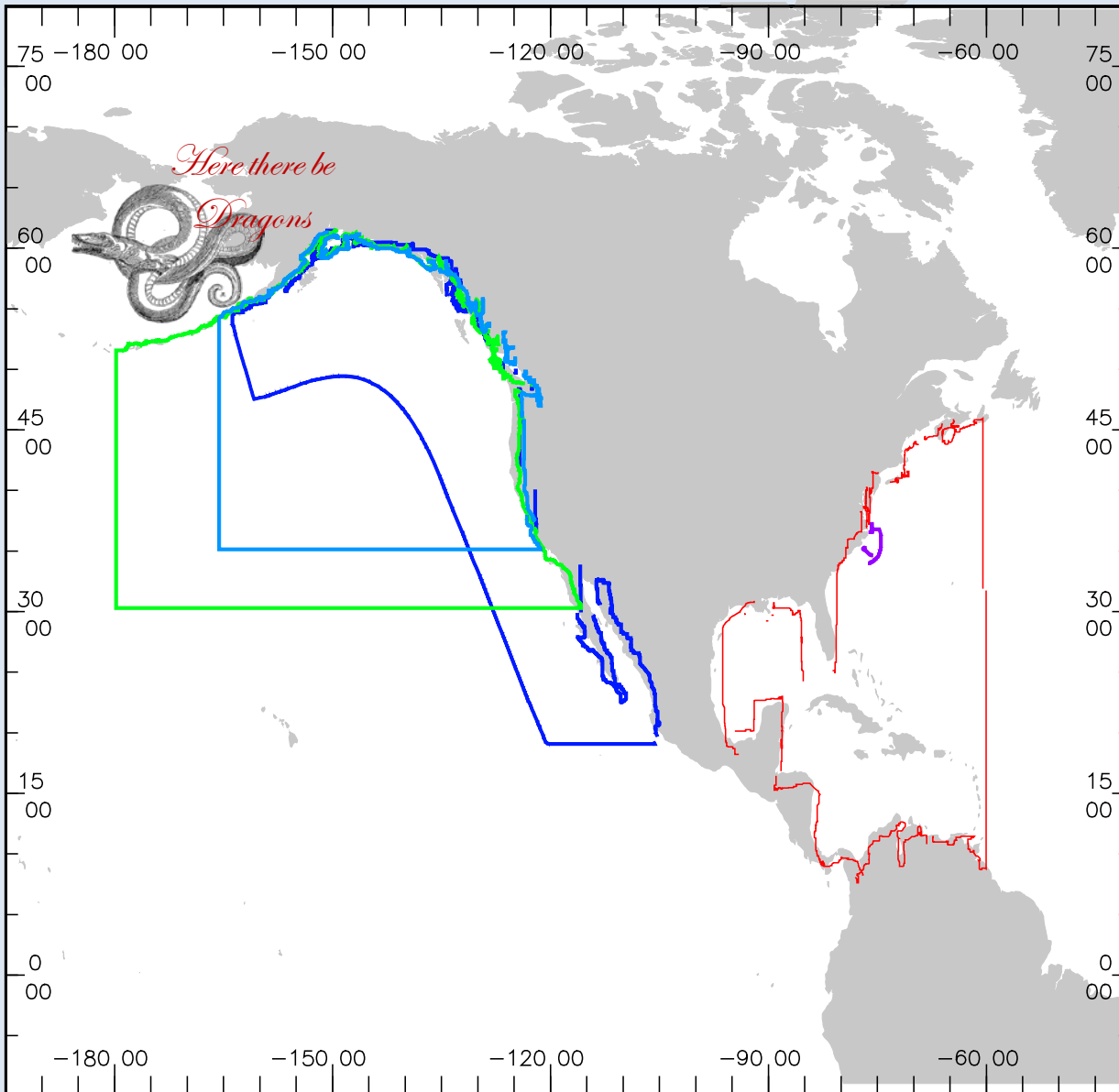
- Tidal Datums
- Tidal Benchmarks w/ published geodetic heights



NOTE: elevations obtained using this method are only valid in the immediate vicinity of the original tide station



Off the VDatum Map



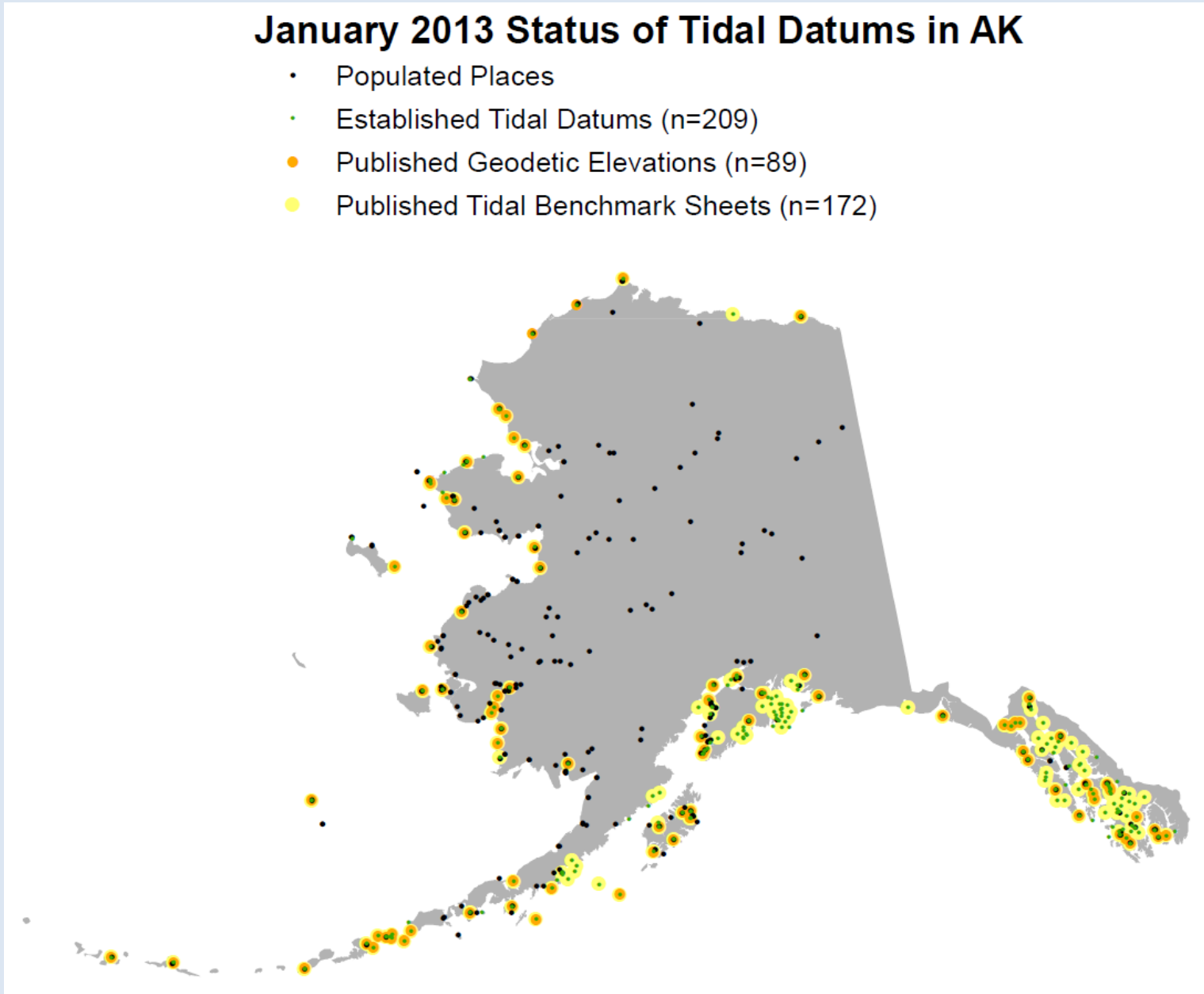
“Historically, the need to supply a tidal datum offset for a given location was met by simply using the offset at the nearest water level station. This approach assumes that the offsets are spatially constant, when it is known that each offset, much like the tide range, varies from place to place” (CSDL, 2012)

Areas covered by tidal databases available at CSDL (VDatum manual for development and support of NOAA's Vertical Datum Transformation tool, 2012)



January 2013 Status of Tidal Datums in AK

- Populated Places
- Established Tidal Datums (n=209)
- Published Geodetic Elevations (n=89)
- Published Tidal Benchmark Sheets (n=172)



Proxy Tidal Datum Estimates

Temporary Tide Gauge



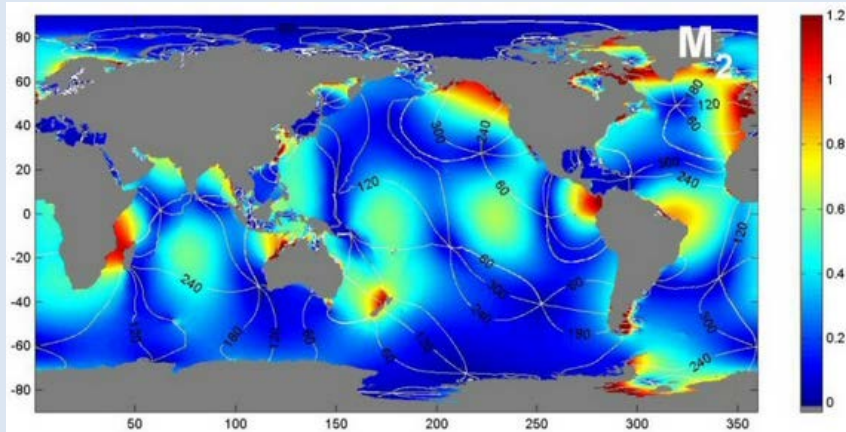
Measurement of Foreshore Features

For example:

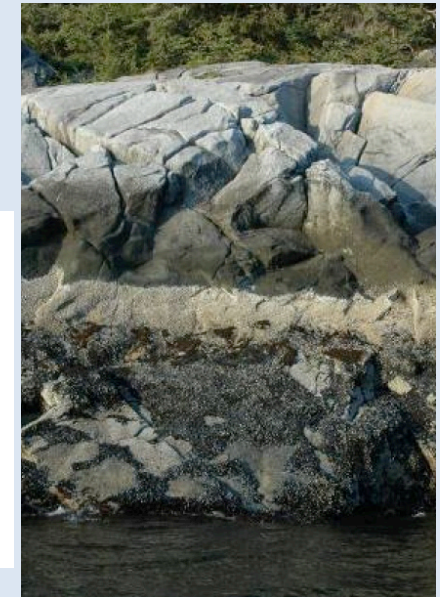
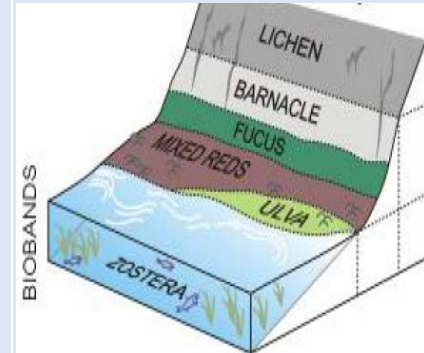
Strandlines



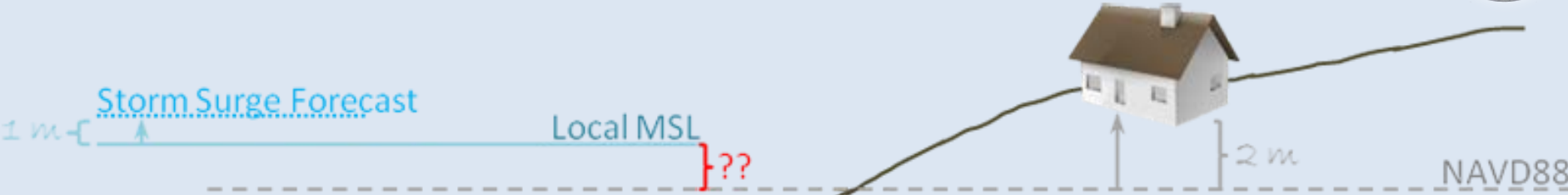
Modeled Value



Biobands

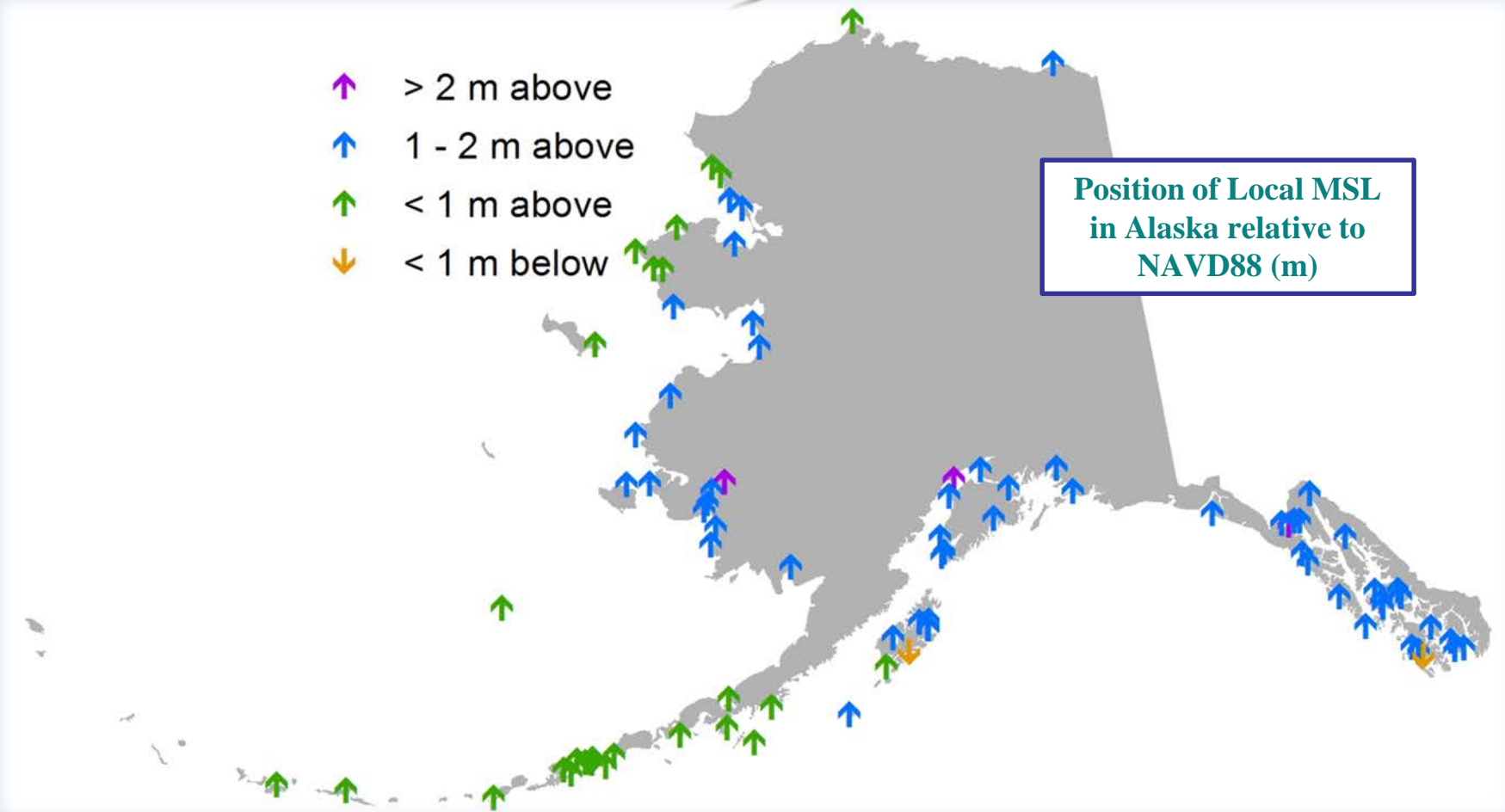


Geoid12A ortho-hts. vs. local MSL



- ↑ > 2 m above
- ↑ 1 - 2 m above
- ↑ < 1 m above
- ↓ < 1 m below

Position of Local MSL in Alaska relative to NAVD88 (m)



Stop-Gap measures and ongoing work



- Datum offset conversion tool
- Color-indexed community elevation maps
- Supplemental and opportunistic water level measurements
- Storm surge documentation
- Improved elevation data
- Outreach and education



Alaska Department of Natural Resources Division of Geological & Geophysical Surveys

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Alaska Tidal Datum Portal

The Alaska Division of Geological & Geophysical Surveys (DGGS) has a coastal community geohazards evaluation and geologic mapping program that is funded through the federal Coastal Impact Assistance Program (CIAP). Since this program was launched in 2010, fieldwork has been conducted in seven coastal communities and includes field efforts to rapidly document the impacts of severe storms on Alaska's coastline. Accurate vertical datums in the coastal environment are critical to the evaluation of natural hazard vulnerability in support of local and regional planning. Appropriate tidal data must be considered in the siting, design, construction, and operations of development projects to ensure protection of human life, property, and the coastal environment.

- [About the Alaska Tidal Datum Portal](#)
- [Frequently Asked Questions \(FAQ\)](#)
- [The Alaska Tidal Datum Calculator](#)
- [Recommended External Resources](#)

The values in this conversion calculator were last updated January 2013.

Location: Adak Island

Geodetic Elevation: 1 (meters) NAVD88(GEOID12A), Orthometric

Local Tidal Elevation: 1.266 (meters) MLLW

A summary of relevant information, including links to all of the published values included in this calculator, can be found in the [reference table document](#). The table includes all Alaska tide stations with published local datums as of January 2013, however, tidal benchmarks or NAVD88(GEOID2012) tidal benchmark elevations are not available for all locations.

The development of this site was partially funded with qualified outer continental shelf oil and gas revenues by the Coastal Impact Assistance Program, Fish & Wildlife Service, and U.S. Department of the Interior. The views and conclusions contained herein are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. government.

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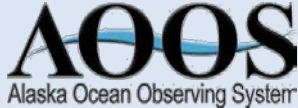
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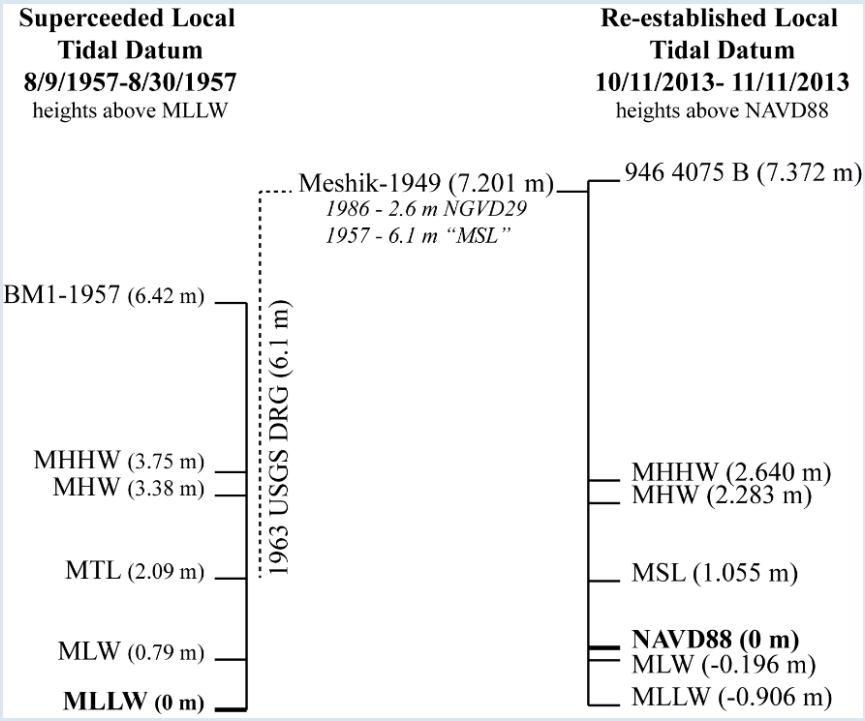


DGGS Data Collection: Tide Gauges

- Contracted with JOA Surveys, LLC in cooperation with UAF research intern (Kimber Tweet)
- Installation from September-October, 2013 (NOAA Spec)
- Live-streamed to AOOS portal



- Retrieval combined with DGGS data collection



DGGS Data Collection: Other Water Levels



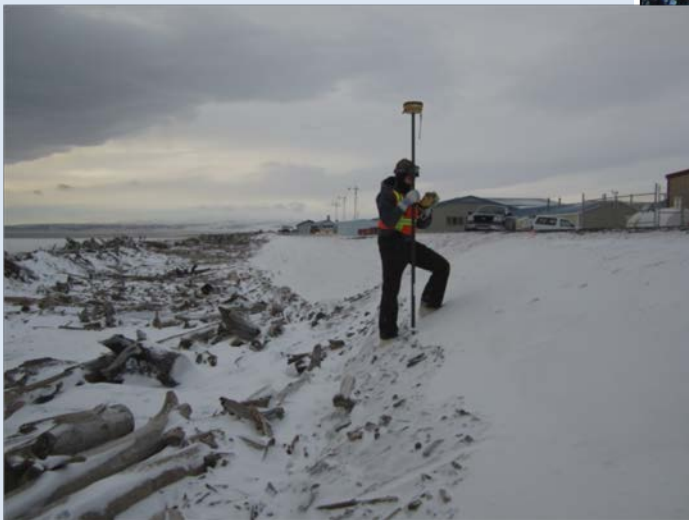
- DGGS partners with local and regional efforts to ensure that pressure transducers in coastal waters are tied to benchmarks with known geodetic heights
- We capture vertical measurements of water level indicators, such as wrack lines



DGGS Data Collection: Storm Response

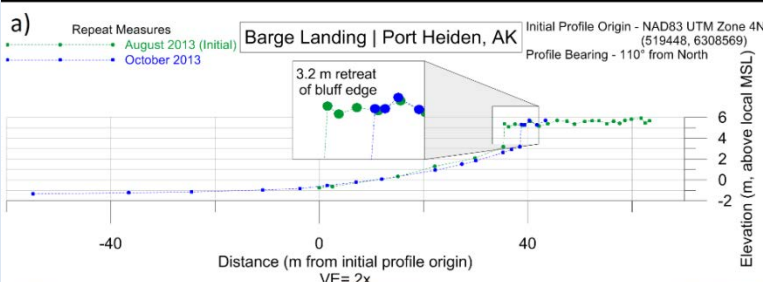


- Measurements of flood inundation extents (as strandlines, frozen swash, truncated snow banks)



DGGS Data Collection: Other

- Nearshore bathymetry and repeat coastal elevation profiles



- DEMs from lidar (large 2014/15 collection), traditional photogrammetry and new 'Structure From Motion' technology
- Geodetic benchmark campaigns for land motion component of relative SL trends (Jeff Freymueller and Kimber Tweet)
- Reoccupation of tidal benchmarks (shared OPUS solutions for these and others) →

SURVEY DATASHEET (Version 1.0)

PID: BBDG96
Designation: 946 4075 B
Stamping: 4075 B 2013
Stability: Monument will probably hold position well
Setting: Stainless steel rod in sleeve (10FT- or 3.048M+)
Description: The station is a stainless steel rod driven to a depth of 19.5 m (64 ft), encased in a PVC pipe with NOS logo cover set at the south end of the old Meshuk village, 93 m (305 ft) ESE of the high water and cliff line, 72.72 m (238.6 ft) SSW of bench mark 946 4075 C, 45.46 m (149.1 ft) SW of the SW corner of a shed to the south of a red building with a fuel tank, 40.69 m (133.5 ft) SE of the NE corner of a concrete slab fuel tank foundation with no tank, and 10 cm (0.3 ft) below grade.
Observed: 2013-09-07T23:07:00Z
Source: OPUS - page5 1209.04



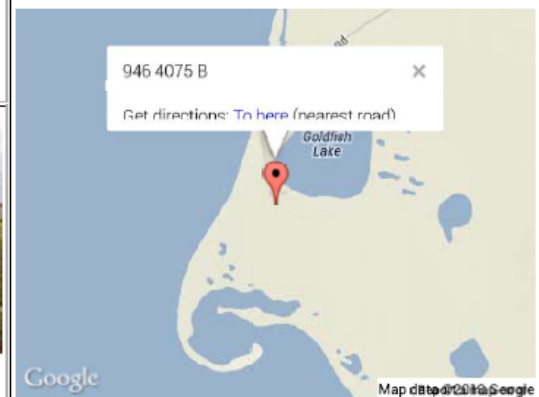
4075 B 2013, 1,20131012
Close-up View

| | | | | | |
|---|----------------------------|---|--------------------|--------------------|----------------|
| REF_FRAME: NAD_83(2011) | EPOCH: 2010.0000 | SOURCE: NAVD88 (Computed using GEOID12A) | UNITS: m | SET PROFILE | DETAILS |
| LAT: 56° 54' 31.09738" ± 0.004 m LLN: -158° 41' 0.62039" ± 0.003 m ELL HT: 20.812 ± 0.037 m X: -3251730.357 ± 0.018 m Y: -1268875.217 ± 0.010 m Z: 5320369.595 ± 0.031 m ORTHO HT: 7.372 ± 0.063 m | | UTM 4 SPC 5006(AK 6) NORTHING: 6307260.620m 323999.573m EASTING: 519273.409m 458364.693m CONVERGENCE: 0.26516009° -0.57264990° POINT SCALE: 0.99960456 0.99992125 COMBINED FACTOR: 0.99960130 0.99991799 | | | |

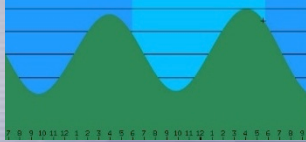
CONTRIBUTED BY

[jon roder](#)
 [John Oswald and Associates, LLC](#)

4075 B 2013,3N,20130909
Horizon View



The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.



In Summary



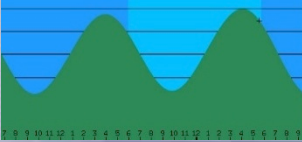
The DGGS Coastal Program faces day-to-day challenges that stem from vertical datum issues in Alaska

In lieu of tools such as VDatum, or an improved geoid model, we are continuing to think strategically about new ways to meet Alaska needs

The State of Alaska is looking forward to working more closely with NOAA in the coming years to better tailor products for our residents and to help develop long-term solutions

Beyond datums, we are also interested in sea level trends and extreme water levels associated with storm events

*For publications and online tools please visit:
<http://www.dggs.alaska.gov/>*



Parting Questions



Should there be an NGS liaison for Alaska?

Is there a way to relax tidal benchmark standards in Alaska?

Is there a way to serve up ‘pseudo’-VDatum values for Alaska communities?

How can the DGGS Coastal Program collect additional data in support of NOAA projects in Alaska?

Are there other stop-gap measures that could be taken to fill some of the short-term needs for the Alaska coast?

Others?