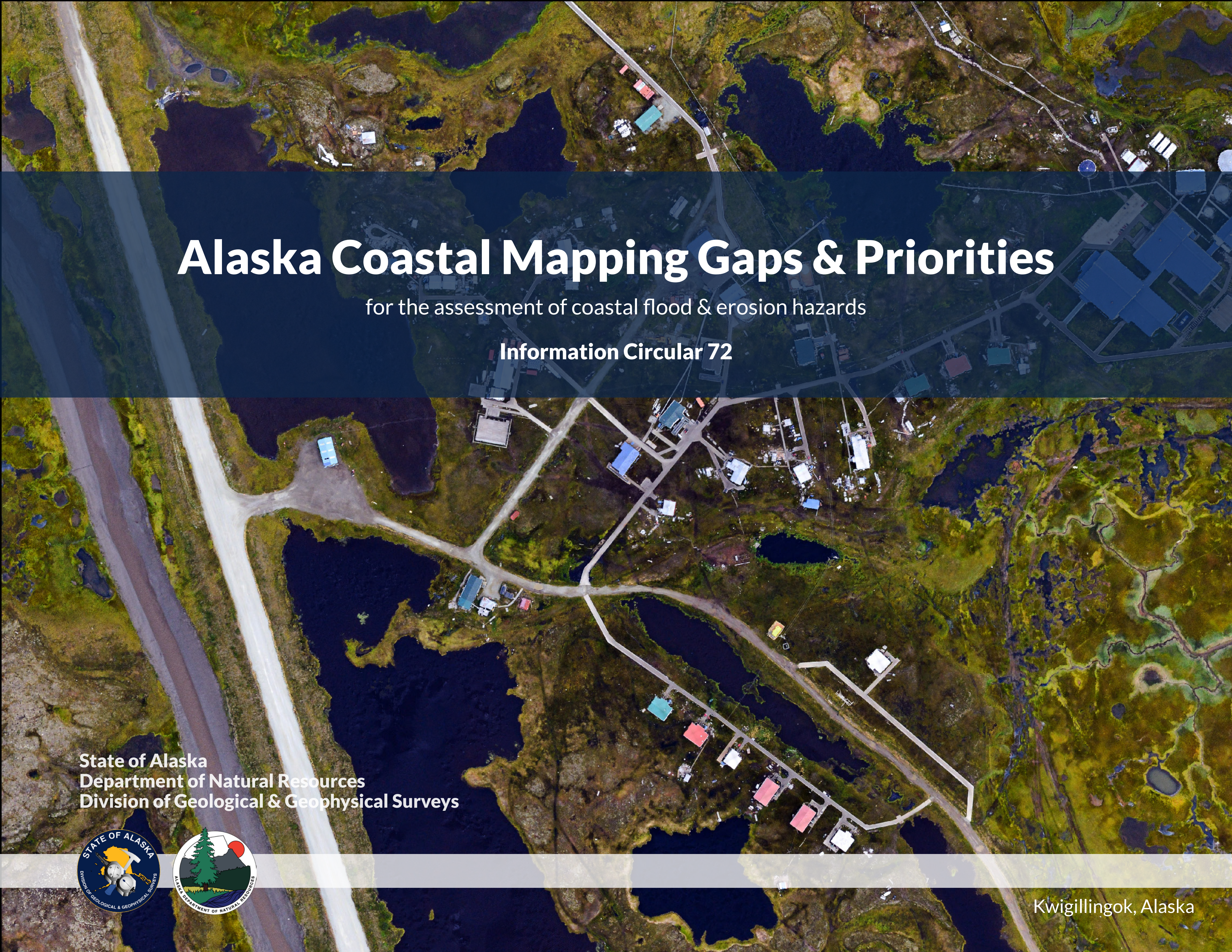
# Alaska Coastal Mapping Gaps & Priorities

for the assessment of coastal flood & erosion hazards

**Information Circular 72**

State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys



Kwigillingok, Alaska

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**DEPARTMENT OF NATURAL RESOURCES**
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**Suggested citation:**
Overbeck, J.R., ed., 2018, Alaska coastal mapping gaps & priorities, Alaska Division of Geological & Geophysical Surveys Information Circular 72. http://doi.org/10.14509/30096

# Contents

# State of Alaska Coastal Hazards Program

The State of Alaska established the Division of Geological & Geophysical Surveys (DGGS) to carry out Alaska Statute 41.08.020:

"Determine the potential of Alaskan land for production of metals, minerals, fuels, and geothermal resources, the locations, and supplies of groundwater and construction material, and the potential geologic hazards to buildings, roads, bridges, and other installations and structures."

Within the DGGS mission, the Coastal Hazards Program (CHP) is engaged in ongoing investigations that expand our understanding of how the coastline has evolved and how it will respond to hazardous events and long-term changes. CHP studies focus on the impacts of flooding and erosion on Alaska's coastal communities from coastal storms, sea level rise, permafrost thaw, and changing ocean conditions. The northern and western coasts of Alaska are particularly vulnerable to these hazards. Throughout the document, a greater focus is put on these regions of Alaska. DGGS programs that focus on other coastal hazards (for example: Tsunami) as well as other geographies of Alaska are not covered here.

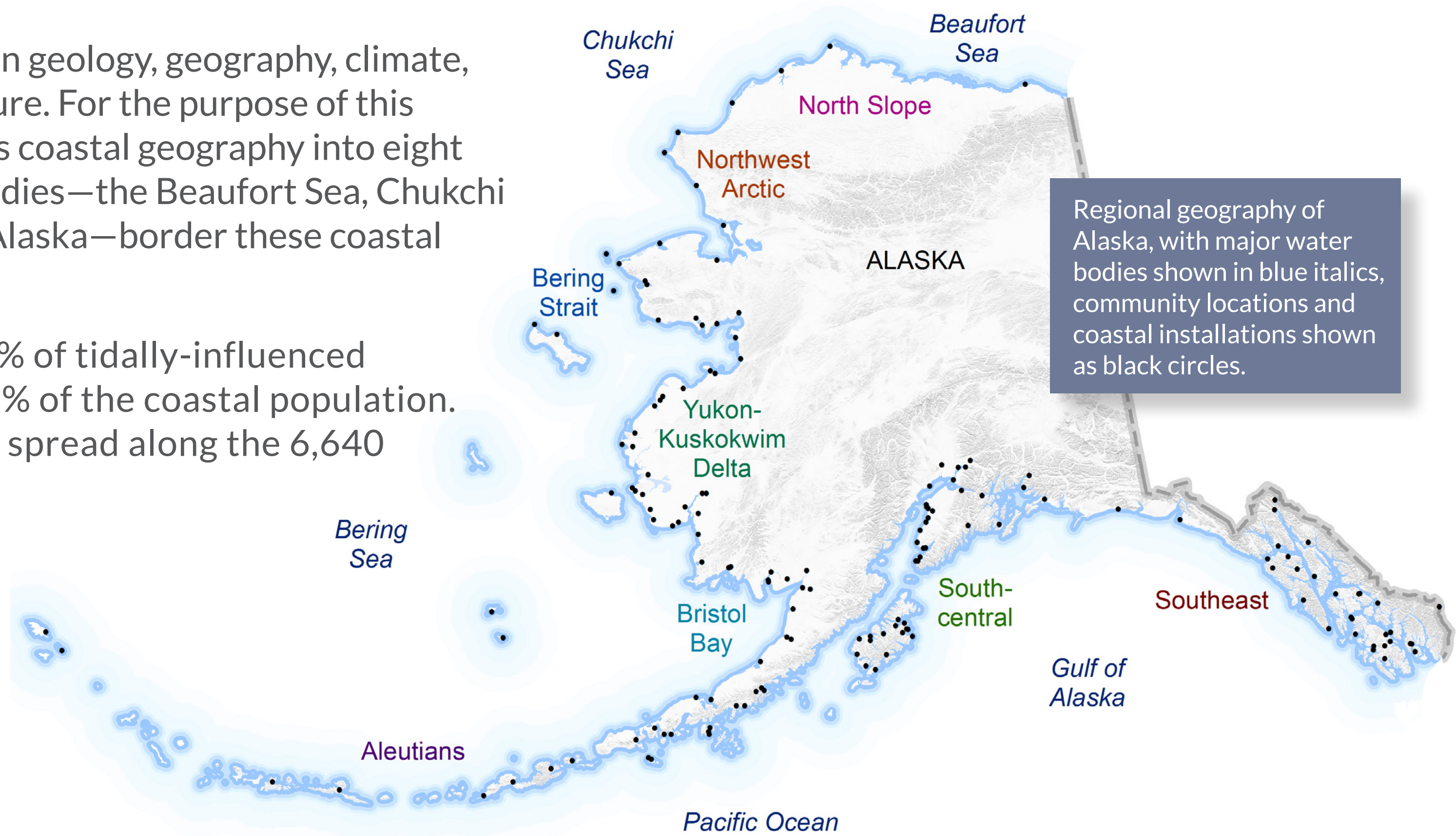
CHP is dedicated to fostering partnerships that improve the quality and quantity of critical coastal baseline data that are necessary to inform decision making throughout the state. This document is meant to define coastal baseline data, provide guidance on which communities in Alaska still lack baseline data, what data are missing, and the decision-making products to which baseline data can contribute.

# Alaska's Shoreline

## Populated Places

Alaska's shoreline is diverse in geology, geography, climate, vegetation, wildlife, and culture. For the purpose of this discussion, we divide Alaska's coastal geography into eight regions. Four major water bodies—the Beaufort Sea, Chukchi Sea, Bering Sea, and Gulf of Alaska—border these coastal regions.

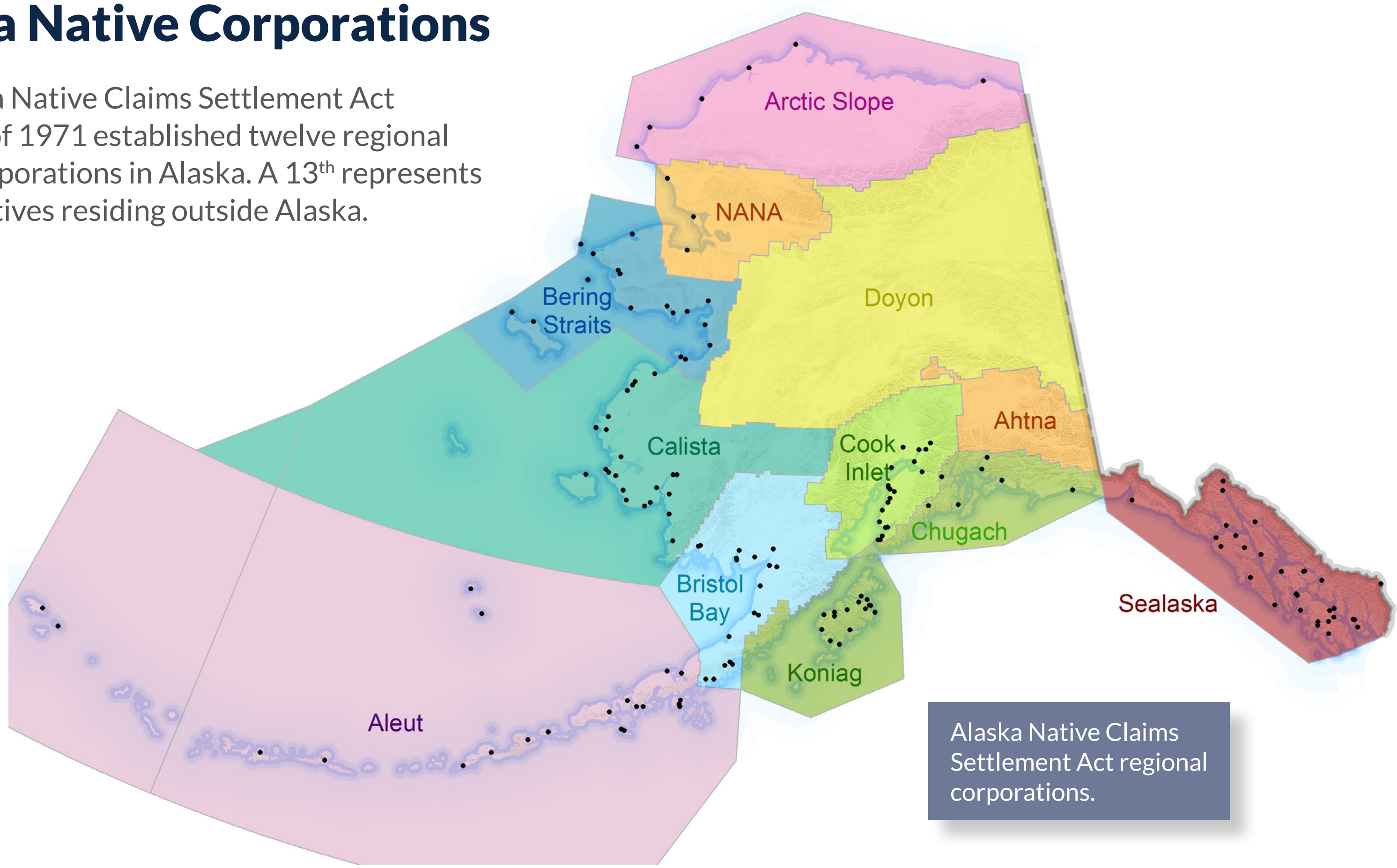
Alaska comprises nearly 40% of tidally-influenced shoreline in the U.S. and 0.5% of the coastal population. There are 159 communities spread along the 6,640 miles of the Alaska coast.




Regional geography of Alaska, with major water bodies shown in blue italics, community locations and coastal installations shown as black circles.

# Alaska Native Corporations

The Alaska Native Claims Settlement Act (ANCSA) of 1971 established twelve regional Native corporations in Alaska. A 13th represents Alaska Natives residing outside Alaska.

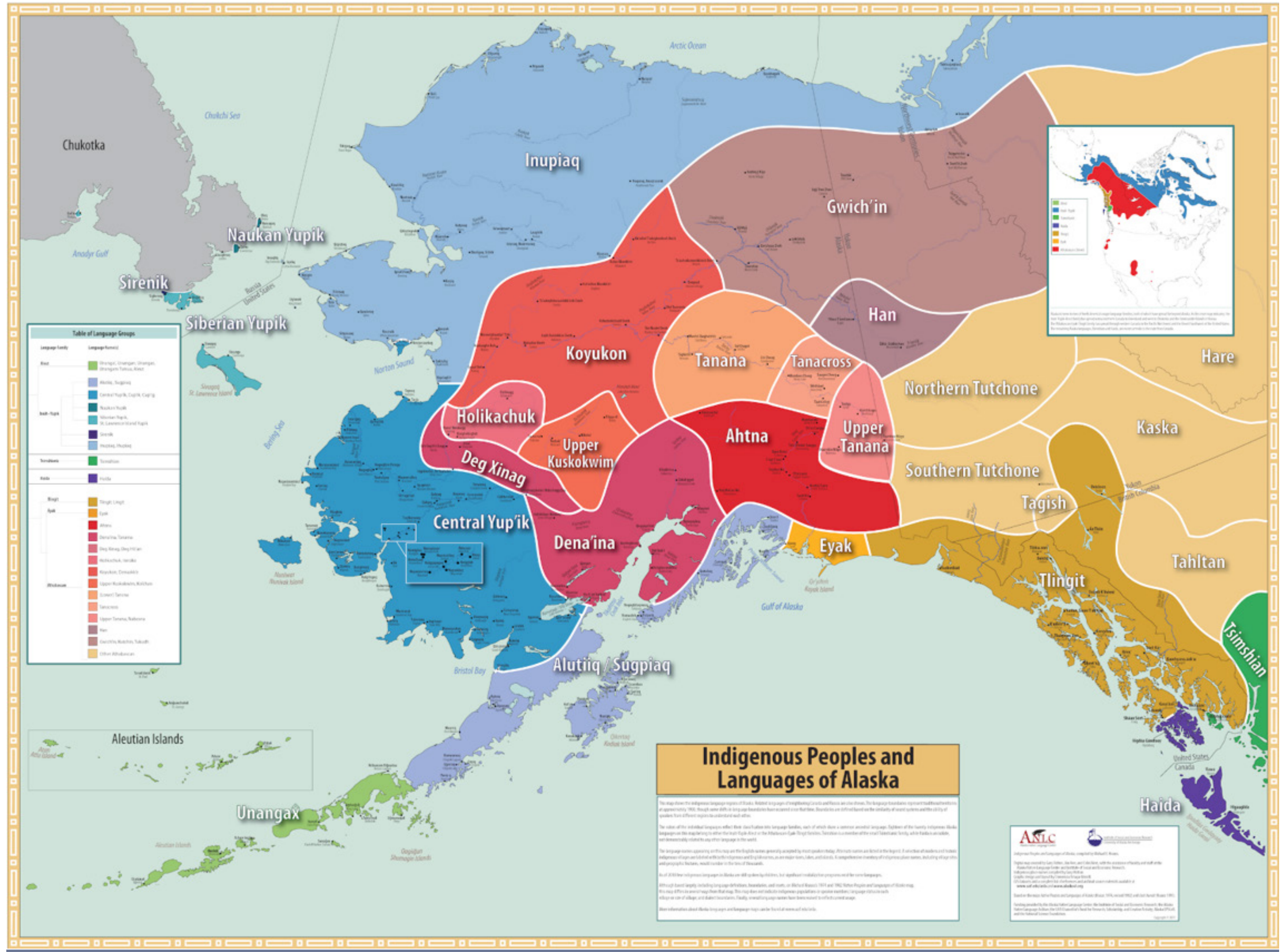



Alaska Native Claims Settlement Act regional corporations.

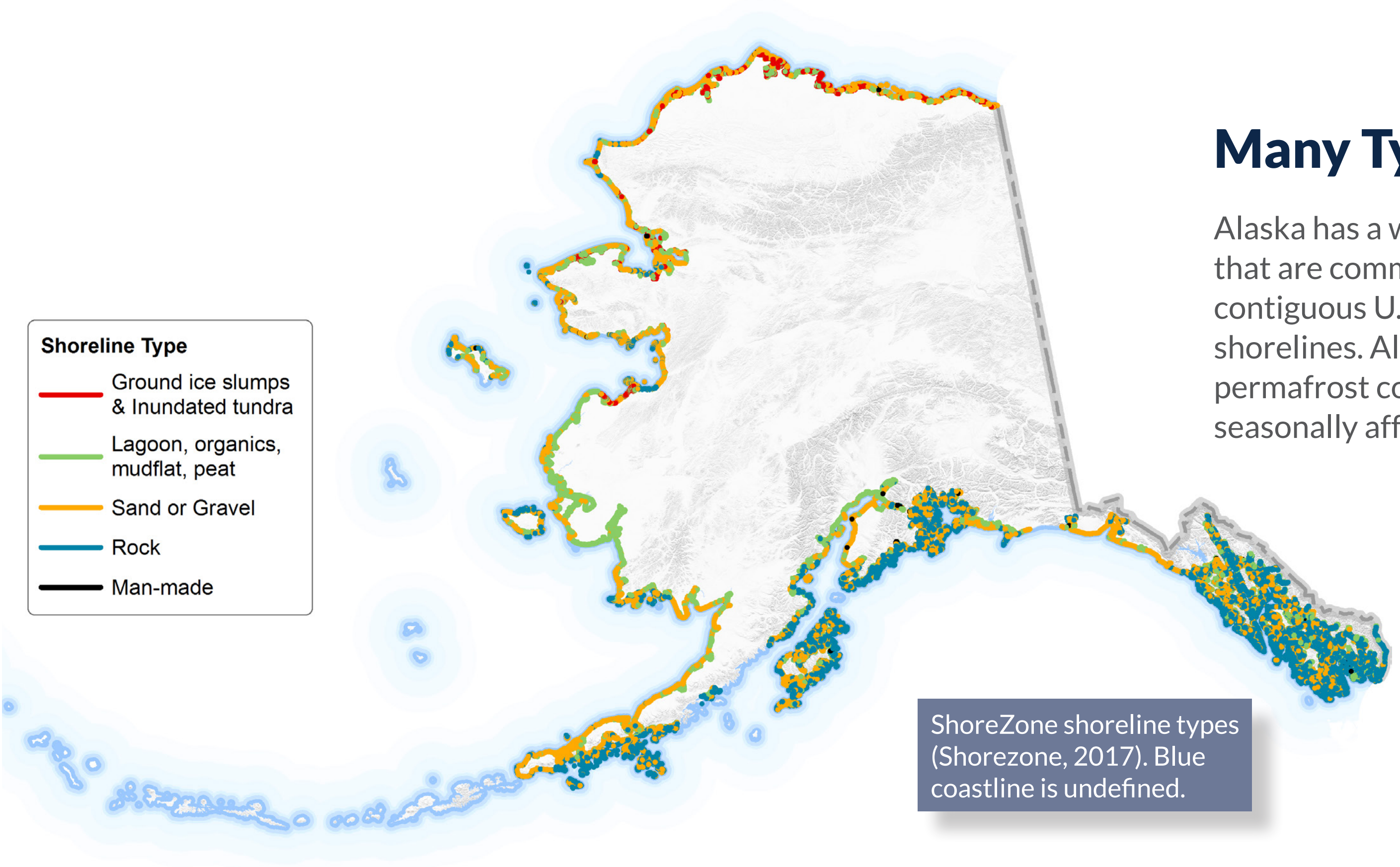
## Cultural Diversity

The regions span a rich traditional cultural and linguistic diversity. Ten of the regional native corporations represent coastal areas, and include the greatest number of communities and largest rural population.

Salmonberries near Kotzebue




Map of indigenous peoples and languages of Alaska (Krauss and others, 2011).




ShoreZone shoreline types (Shorezone, 2017). Blue coastline is undefined.

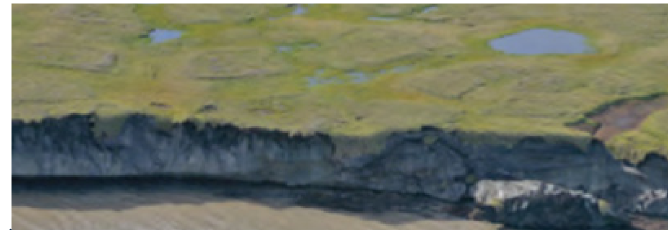
# Many Types of Shorelines

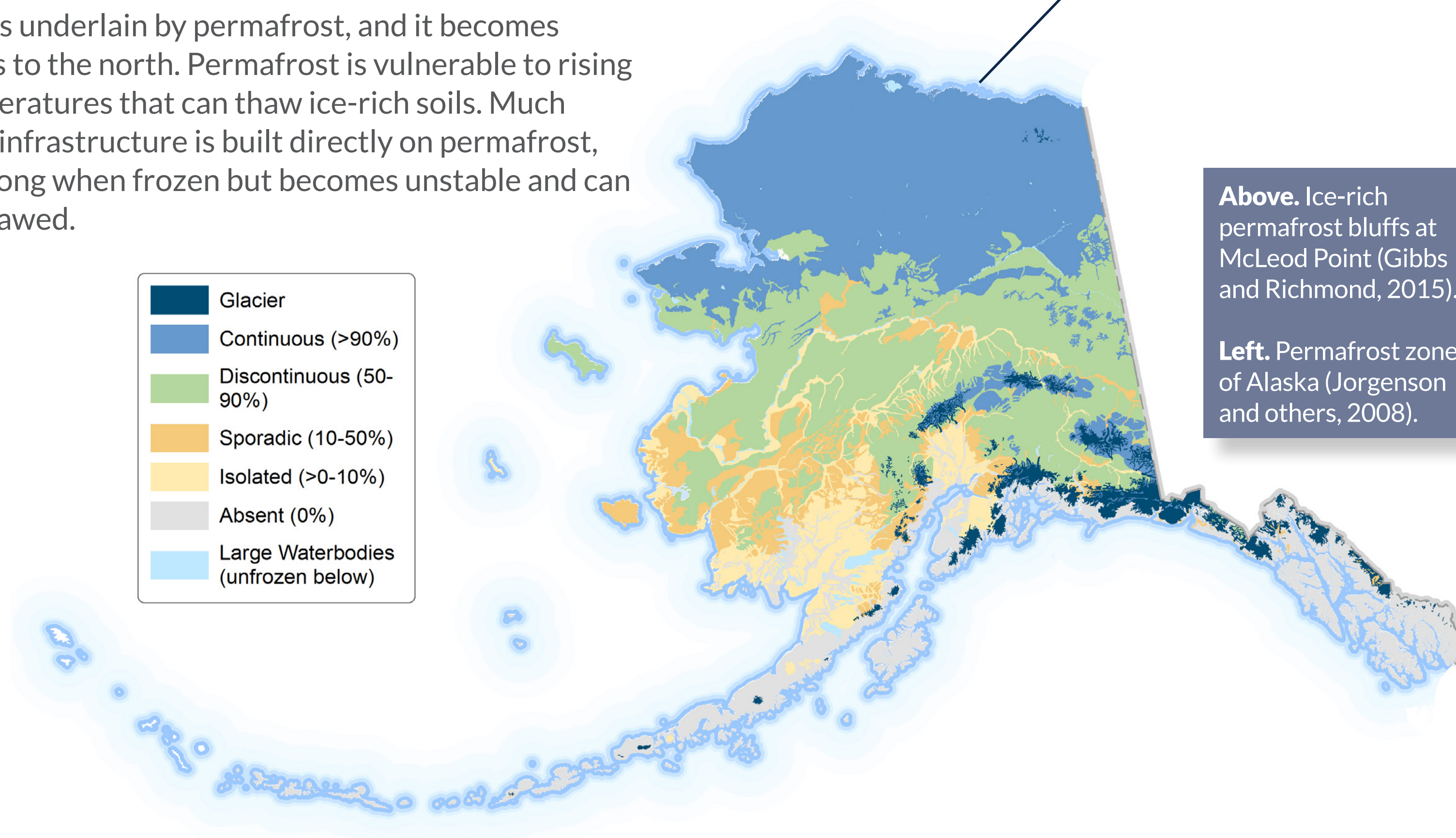
Alaska has a wide variety of shoreline types that are common along the coast of the contiguous U.S., as well as some unique Arctic shorelines. Alaska’s cold climate results in permafrost coastlines as well as coastlines seasonally affected by Arctic sea ice.

# Permafrost

> *Ground with a temperature that remains below 32°F (the freezing point of water) for two or more consecutive years.*

Much of Alaska is underlain by permafrost, and it becomes more continuous to the north. Permafrost is vulnerable to rising air and sea temperatures that can thaw ice-rich soils. Much of Alaska's rural infrastructure is built directly on permafrost, which is very strong when frozen but becomes unstable and can subside when thawed.



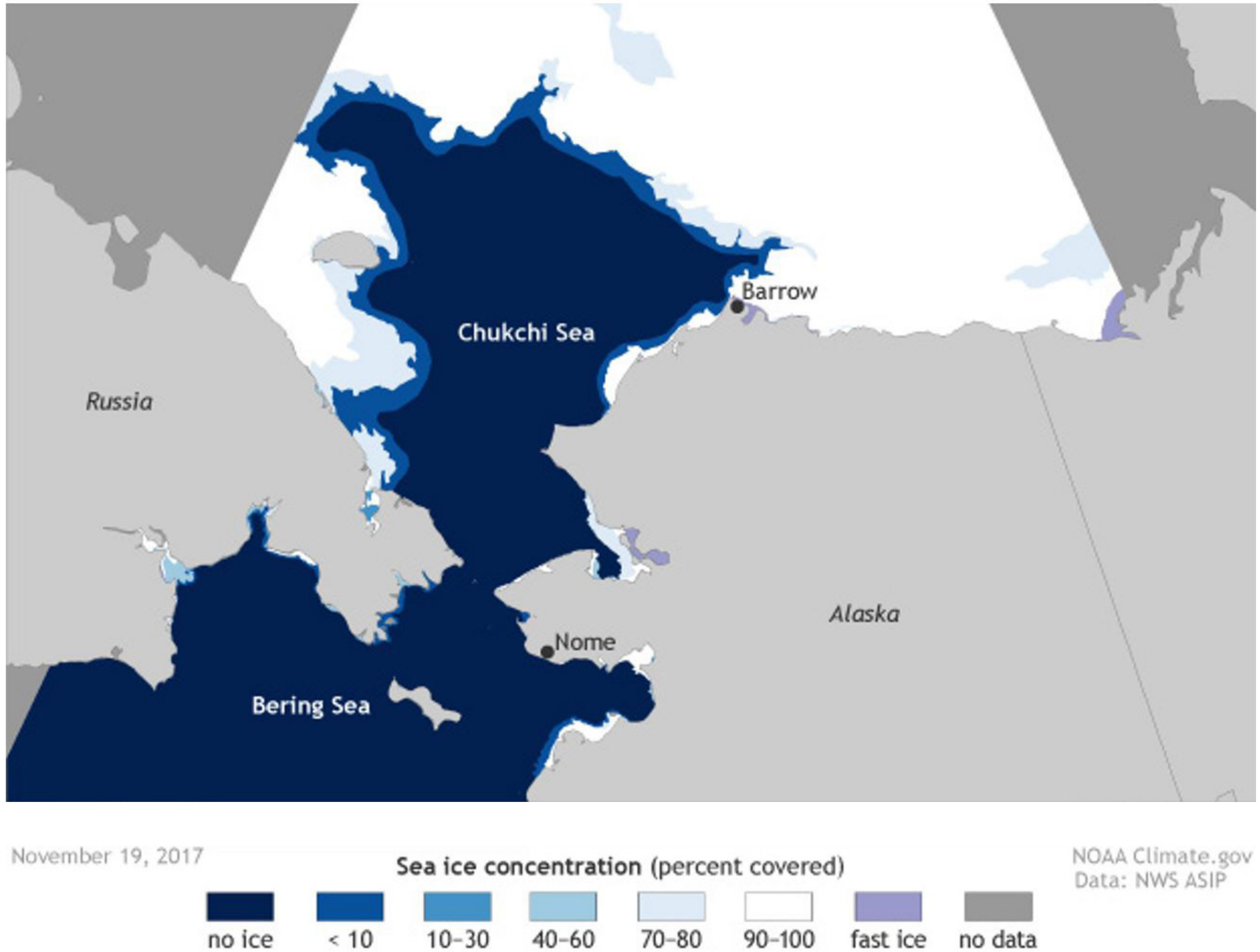


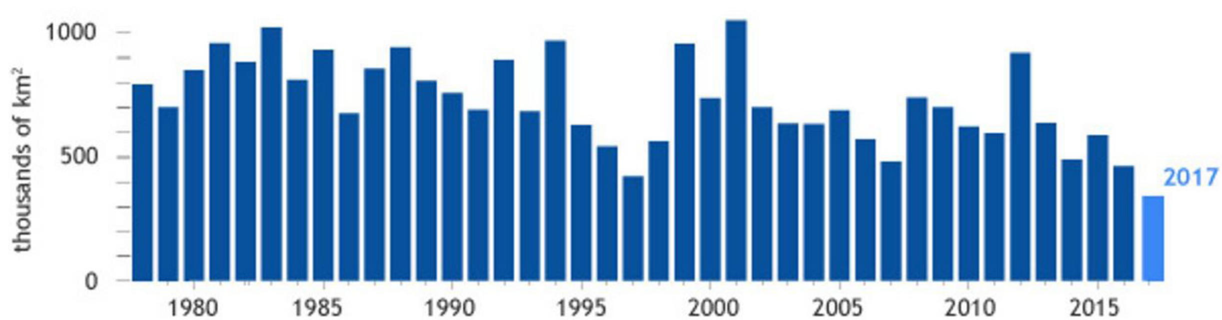

**Above.** Ice-rich permafrost bluffs at McLeod Point (Gibbs and Richmond, 2015).

**Left.** Permafrost zones of Alaska (Jorgenson and others, 2008).

## Sea Ice

Sea ice forms offshore of Alaska's northern and western coasts in winter, creating extreme seasonal differences in ocean conditions. Sea ice can dampen ocean conditions—such as wind-driven waves, currents, and storm surge—that cause coastal erosion and flooding. In recent years, however, the **extent and thickness of sea ice during the fall storm season has been at record lows**.



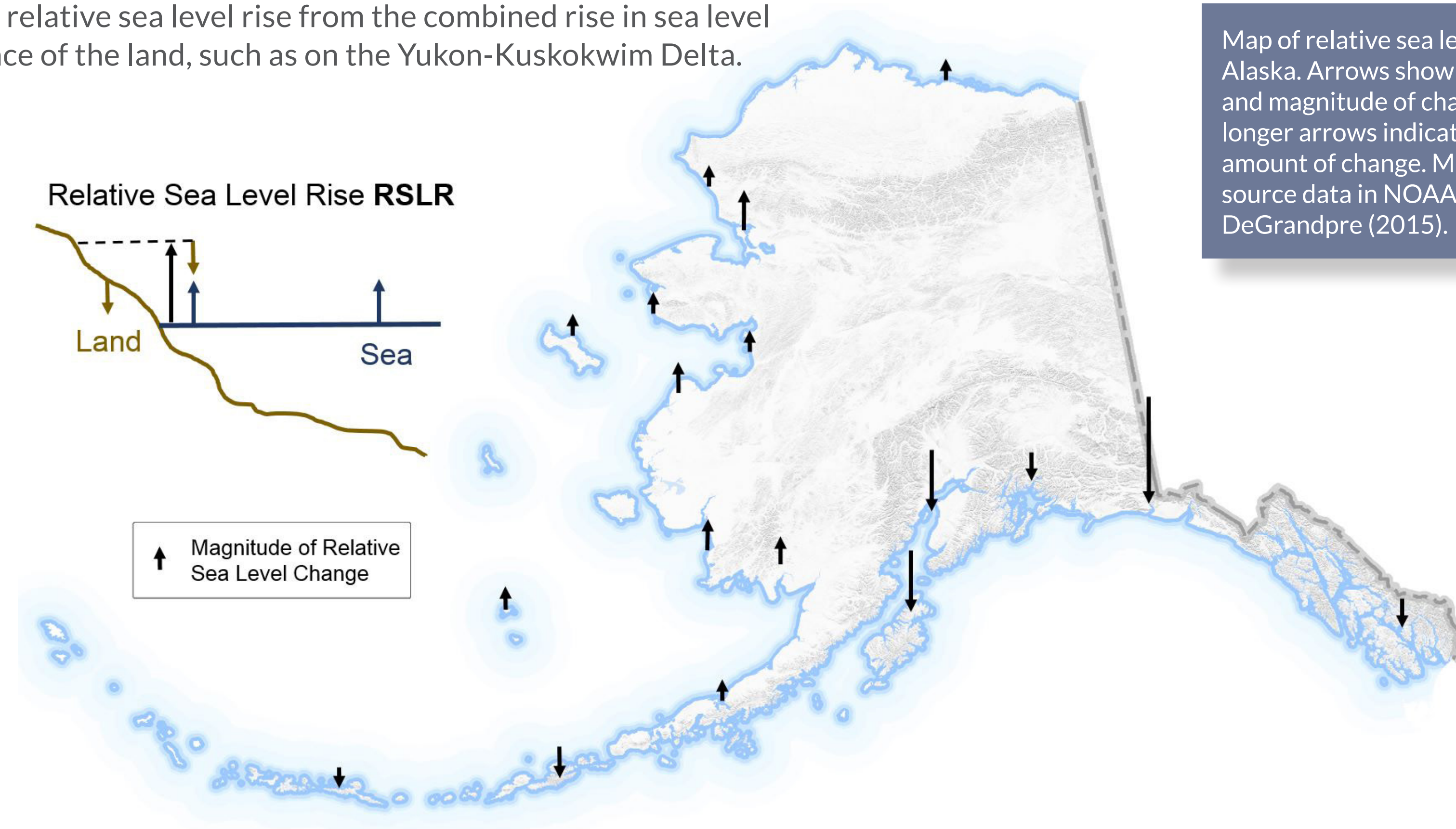




The bar chart demonstrates the 2017 record low Arctic sea ice extent in Alaska's Bering and Chukchi seas. The map shows sea ice extent on November 19, 2017. Figures from Thoman (2017) at www.climate.gov.


# Relative Sea Level Change

*The combined vertical motion of land and sea level, resulting in inundation or exposure of the coast.*

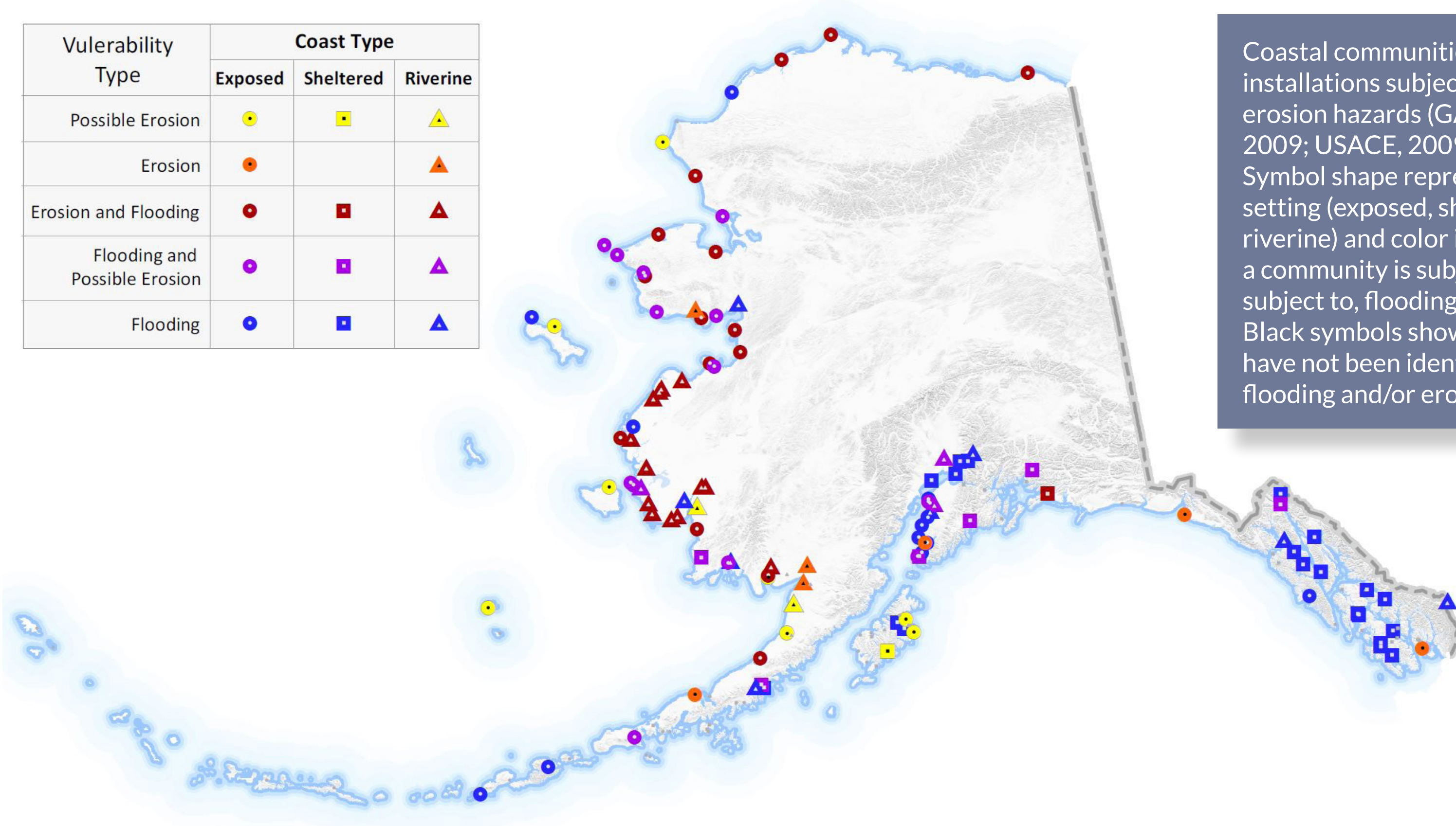
Sea levels are falling relative to the land in some regions of Alaska where uplift of the land is outpacing global sea level rise. In Southeast Alaska, isostatic rebound—the rising of land masses that were depressed by the huge weight of ice sheets during the last glacial period—is lifting the coast out of the water. Other regions in Alaska are experiencing relative sea level rise from the combined rise in sea level and subsidence of the land, such as on the Yukon-Kuskokwim Delta.




Map of relative sea level change in Alaska. Arrows show the direction and magnitude of changes, with longer arrows indicating greater amount of change. Map created from source data in NOAA (2017f) and DeGrandpre (2015).

# Coastal Hazards

Coastal flooding and erosion resulting from naturally occurring coastal processes, changes in ocean conditions from reduced sea ice during fall and winter storm seasons, thawing coastal permafrost, and relative sea level rise impact coastal infrastructure and cultural resources of Alaska Native communities and other installations.




Coastal communities and installations subject to flood and/or erosion hazards (GAO, 2003; GAO, 2009; USACE, 2009; IAWG, 2009). Symbol shape represents the coastal setting (exposed, sheltered, or riverine) and color identifies whether a community is subject to, or possibly subject to, flooding and/or erosion. Black symbols show locations that have not been identified as subject to flooding and/or erosion.

# Coastal Data

## Baseline Coastal Data

In order to assess Alaska's coastal erosion and flooding hazards, major gaps in baseline coastal data must be filled. Progress has been made over the last several years, but the extensive shoreline and rapidly changing environment require that these datasets not only be collected for the first time but also be updated or continually monitored. The main data types used for assessing coastal flood and erosion hazards listed to the right are summarized in the following pages.

High tide at Quinhagak

**Orthoimagery**

**Topography**

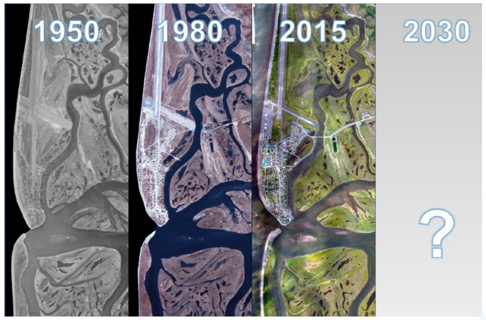
**Bathymetry**

**Water Levels**

**Sea Ice**

**Waves**

**Continually Operating Reference Systems (CORS)**

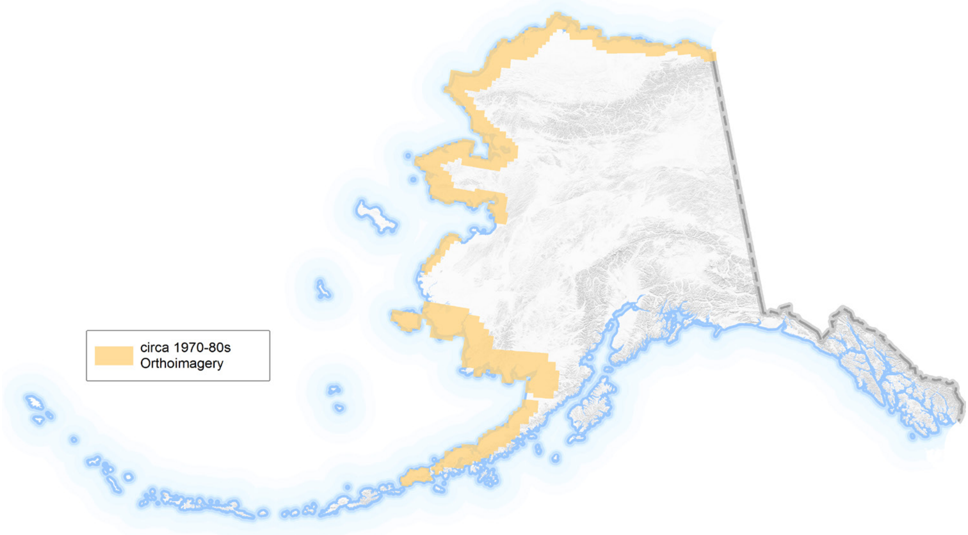



Orthoimagery of Unalakleet from 1950, 1980, and 2015 used to delineate shoreline positions through time and project potential future shoreline positions.

# Orthoimagery

*Aerial photographs or satellite images that have been geometrically corrected ("orthorectified") to fit the earth's irregular surface such that the scale is uniform and the image has the same lack of distortion as a map.*

Orthoimagery can be used to identify and delineate changing shoreline positions through time. **From these datasets, rates of shoreline change are calculated and shoreline positions projected for future dates.** Projected shorelines can show areas where infrastructure and economically valuable land may be at risk of future erosion.


# Historical Orthoimagery

Aerial photographs were collected over most of Alaska during the 1940s–1950s and 1970s–1980s for the purpose of creating topographic maps. These film images have been scanned to make digital images, but most of them have not been orthorectified. Several large swaths of coast have been orthorectified in recent years. Areas of Alaska that have historical imagery but have not been orthorectified, may require further ground control points to ensure the accuracy of the data.

**Ground control point (GCP)** – points on the surface of the earth with precisely known locations used to georeference data. Points are either surveyed using global positioning systems (GPS) or can be identified on a different orthoimage (aerial or satellite) that already has an established level of accuracy.

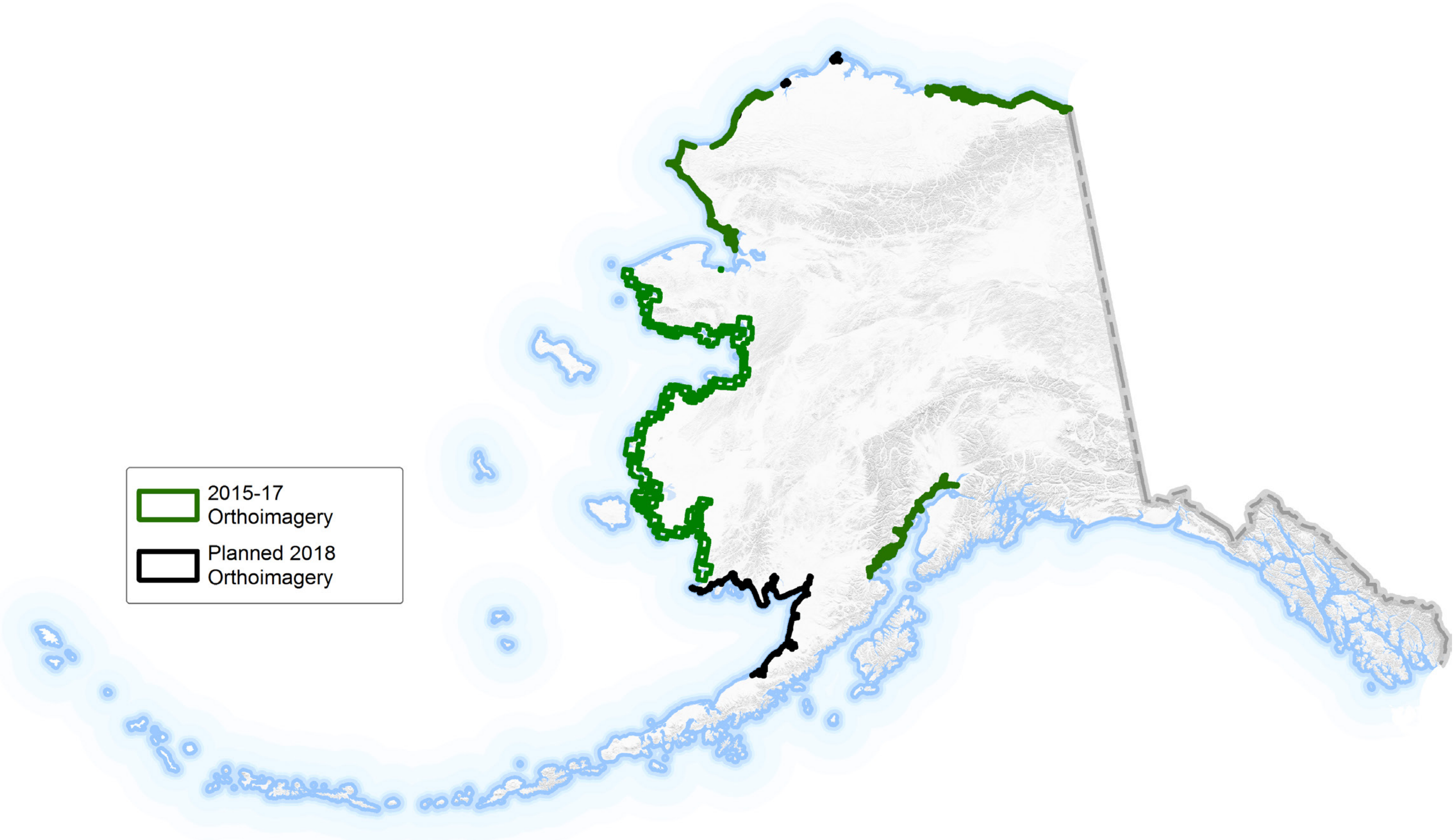
**Above.** Orthoimagery collected ca. 1940-50's used to determine rates of shoreline change shown in red.

**Below.** Orthoimagery collected ca. 1970-80's used to determine rates of shoreline change are shown in orange.

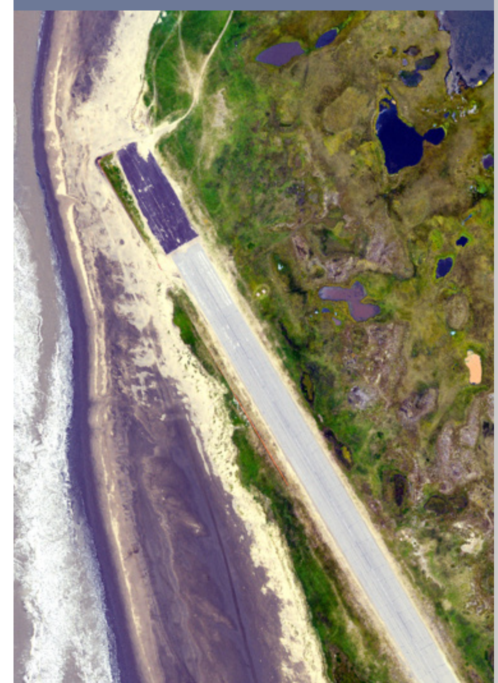
# Current Orthoimagery

Advances in processing digital aerial photographs using "Structure-from-Motion" (SfM) computer algorithms have lowered the barriers to producing high-resolution orthoimagery.

Small fixed-wing aircraft and drones can be used to collect high-resolution aerial imagery, particularly in remote regions of Alaska that have been logistically challenging to reach.




Between 2015 and 2017, the State of Alaska Department of Natural Resources, USGS, and NOAA undertook major efforts to collect high-resolution orthoimagery along the Alaska coast. The extent of coastal orthoimagery collected in this campaign is shown in green on the map to the left. In 2018 NOAA's Office for Coastal Management has planned orthoimagery collections at North Slope communities and in Bristol Bay shown in black. Shorelines have been delineated from portions of these data, and are shown on page 18.

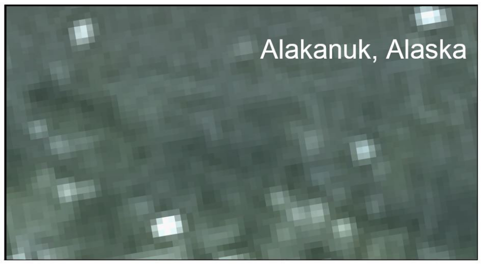


Example of high resolution orthoimagery at Hooper Bay airport, Alaska.

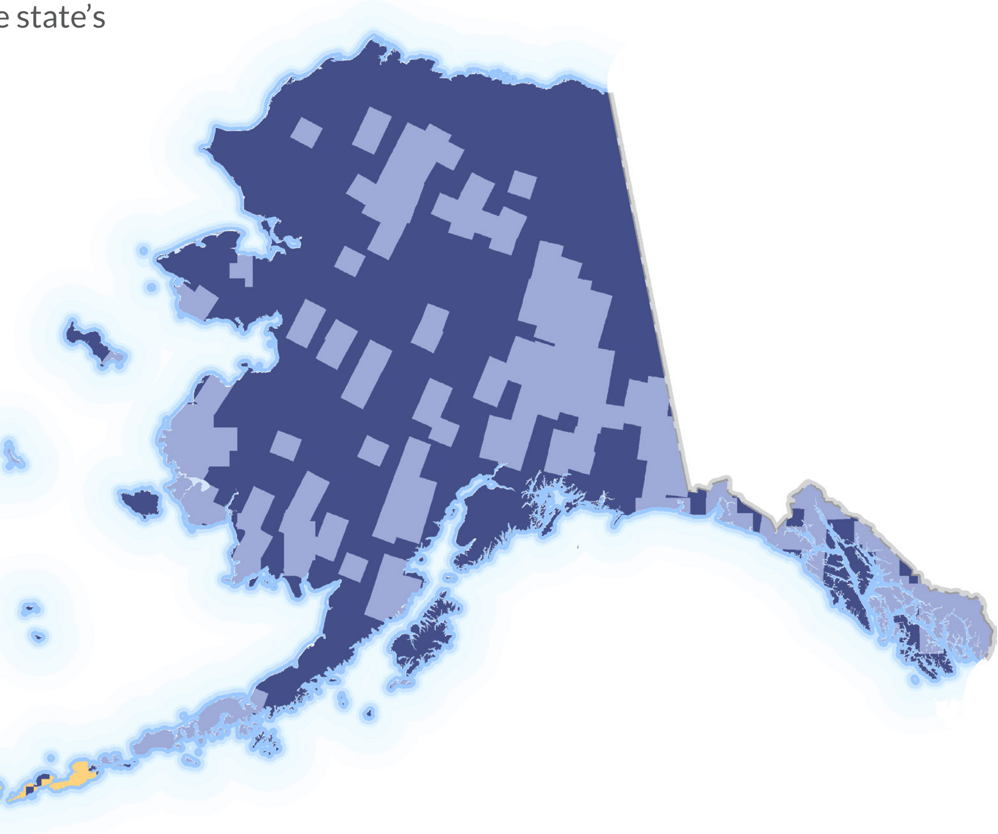
# Current Orthoimagery

Orthoimagery can also be obtained from satellites. The lower resolution of many of these datasets is not ideal for detailed coastal mapping, but the imagery can provide important information for coastal management. The State of Alaska is committed to collecting and processing satellite imagery to develop the state's continually-updated "Best Data Layer" (BDL) of orthoimagery.


High-resolution, high-accuracy aerial image




SDMI satellite image





**Above.** High resolution and high-accuracy aerial image compared to SDMI satellite image at Alakanuk, Alaska.

**Right.** The completion status of Statewide Digital Mapping Initiative (SDMI) best data layer of orthoimagery. Data are considered complete if they were collected within 5 years of the current date. Nearly 70 percent of the state is currently in need of refreshed data.

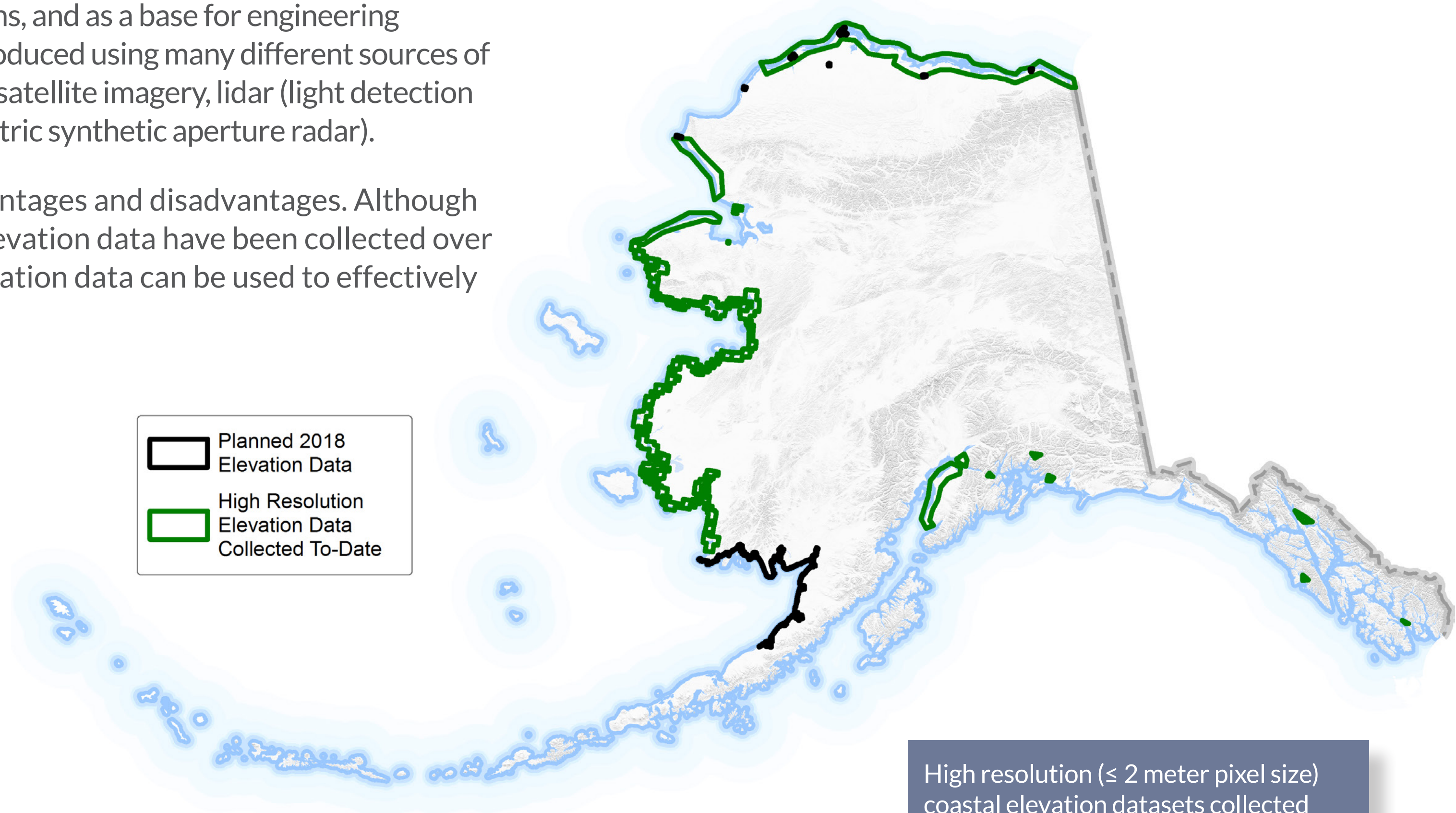
# Topography

## Digital Elevation Model (DEM)

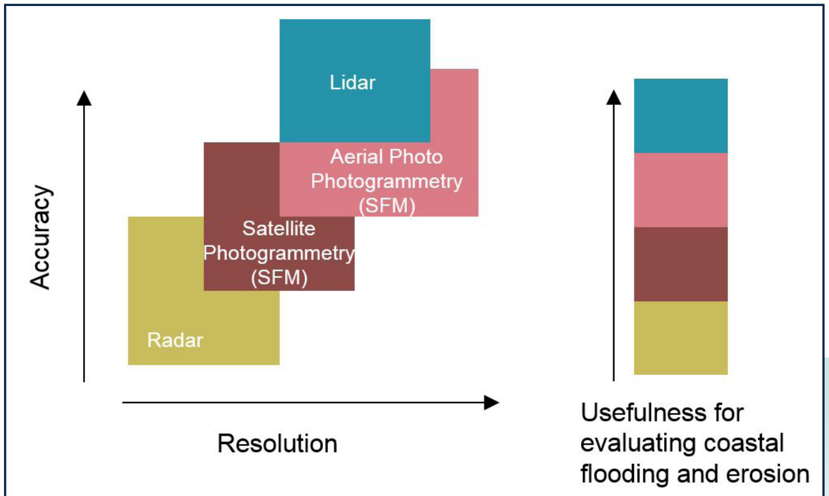
*Three-dimensional representation of the earth's surface created from elevation data.*

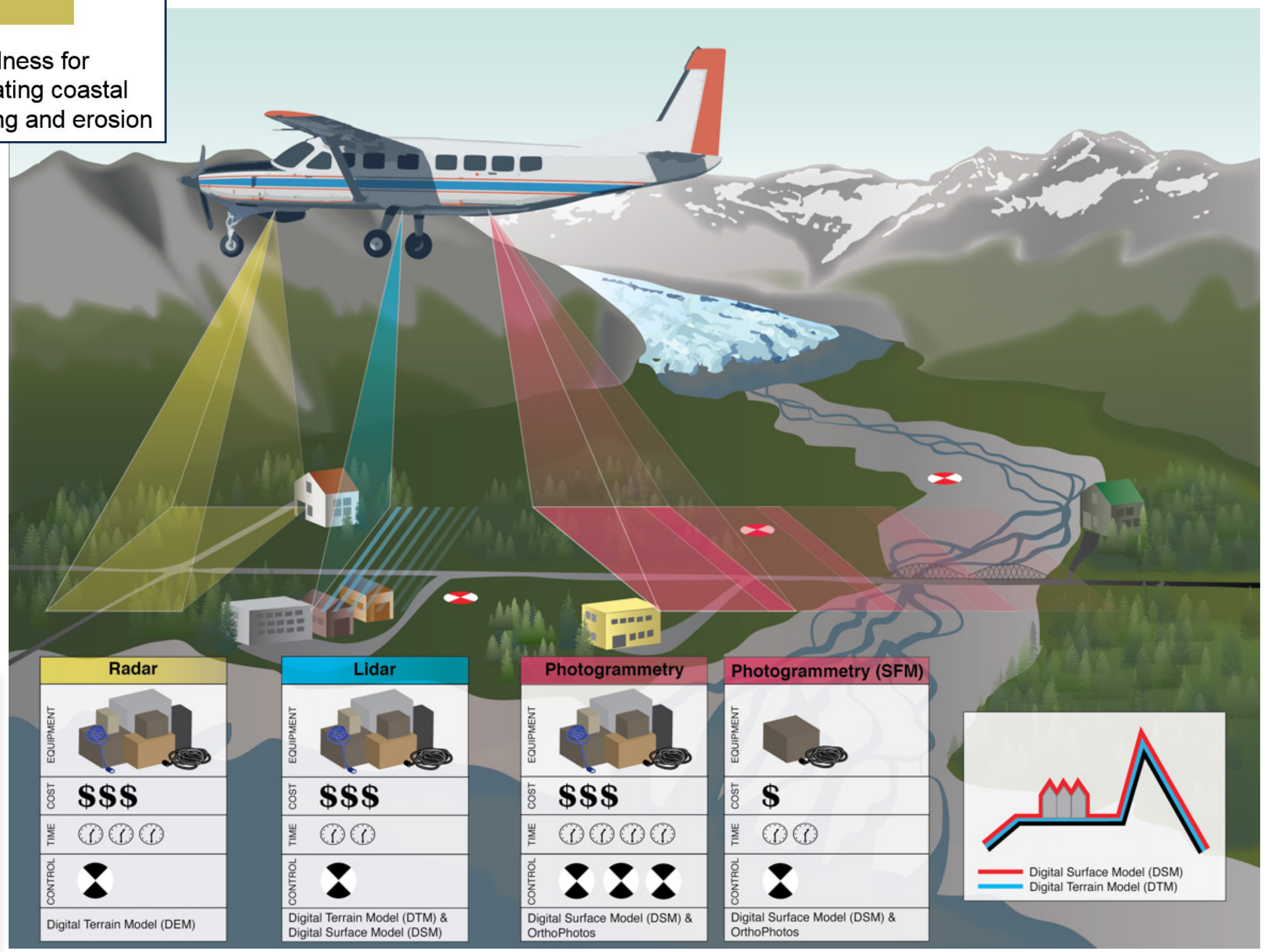
DEMs are used to determine flood zones, project or forecast flood elevations, define shoreline positions, and as a base for engineering studies or designs. DEMs can be produced using many different sources of elevation data, including aerial and satellite imagery, lidar (light detection and ranging), and ifsar (interferometric synthetic aperture radar).

Each type of data source has advantages and disadvantages. Although different resolutions of coastal elevation data have been collected over Alaska in recent years, not all elevation data can be used to effectively map flooding and erosion.




High resolution (≤ 2 meter pixel size) coastal elevation datasets collected to-date in Alaska shown in green. Planned high resolution elevation data collection efforts shown in black.



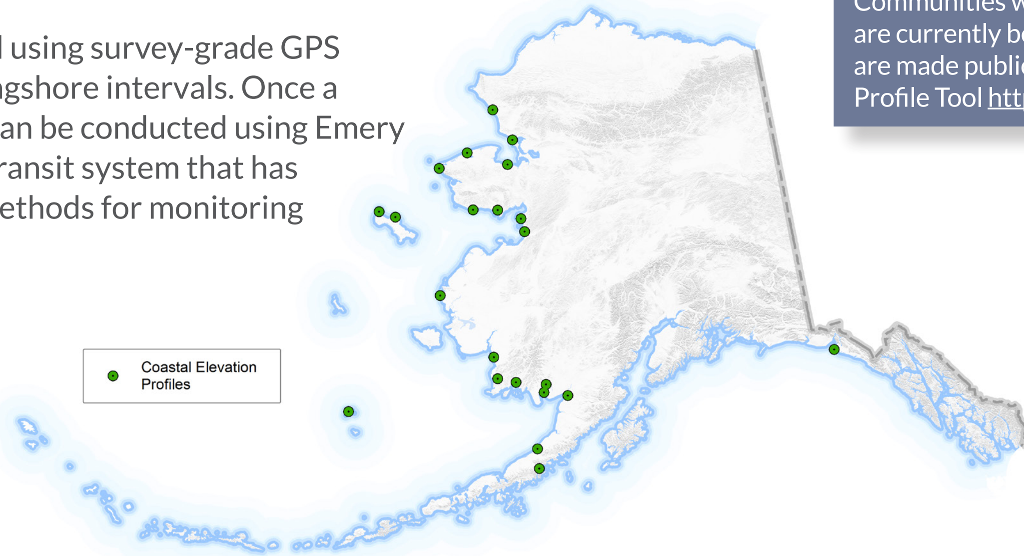

**Above.** Schematic of elevation data usefulness for evaluating coastal flooding and erosion by data type.

**Right.** Schematic of elevation data collection methods and cost created by Scenarios Network for Alaska + Arctic Planning and DGGS.

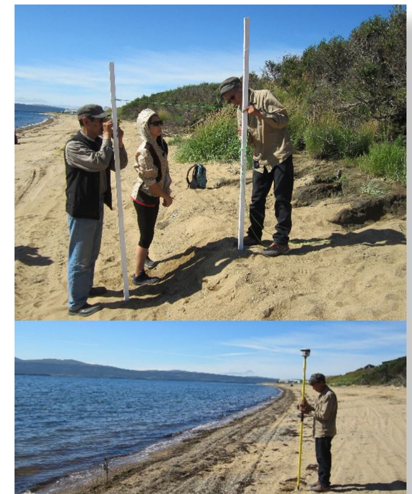
# Coastal Elevation Profiles

Coastal elevation profiles are collected using survey-grade GPS in cross-shore transects at regular alongshore intervals. Once a profile is collected, follow-up surveys can be conducted using Emery rods. Emery rods use a basic rod-and-transit system that has been employed in community-based methods for monitoring coastal dynamics.

A toolkit can be provided to a local observing group and observations made at a much greater frequency than DEMs or GPS data can be collected.




Communities where coastal elevation data have or are currently being collected shown in green. Data are made publicly accessible on the Alaska Coastal Profile Tool http://maps.dggs.alaska.gov/acpt/.

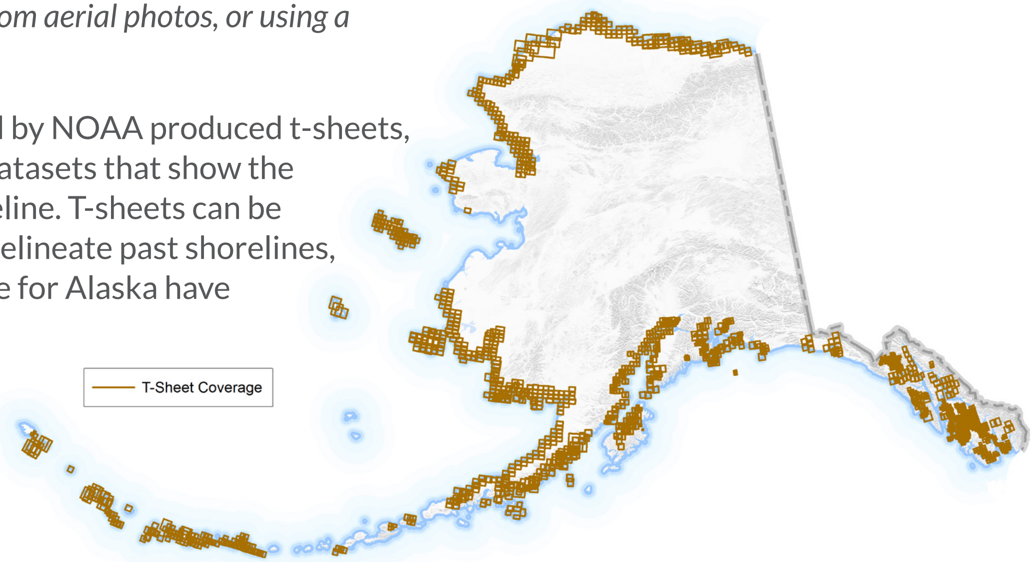


Jack Fagerstrom, Toby Anungazuk Jr. (Chinik Eskimo Community), and Denise Pollock (Alaska Institute for Justice) collecting Emery rod (top) and GPS (bottom) profiles at Golovin.

# T-Sheets

*Coastal topographic map sheets compiled from maps derived in the field with a plane table, in the office from aerial photos, or using a combination of the two methods.*

Historical shoreline surveys conducted by NOAA produced t-sheets, making them some of the oldest map datasets that show the elevation-derived position of the shoreline. T-sheets can be digitized, georeferenced, and used to delineate past shorelines, however, many of the t-sheets available for Alaska have not been processed in this way.

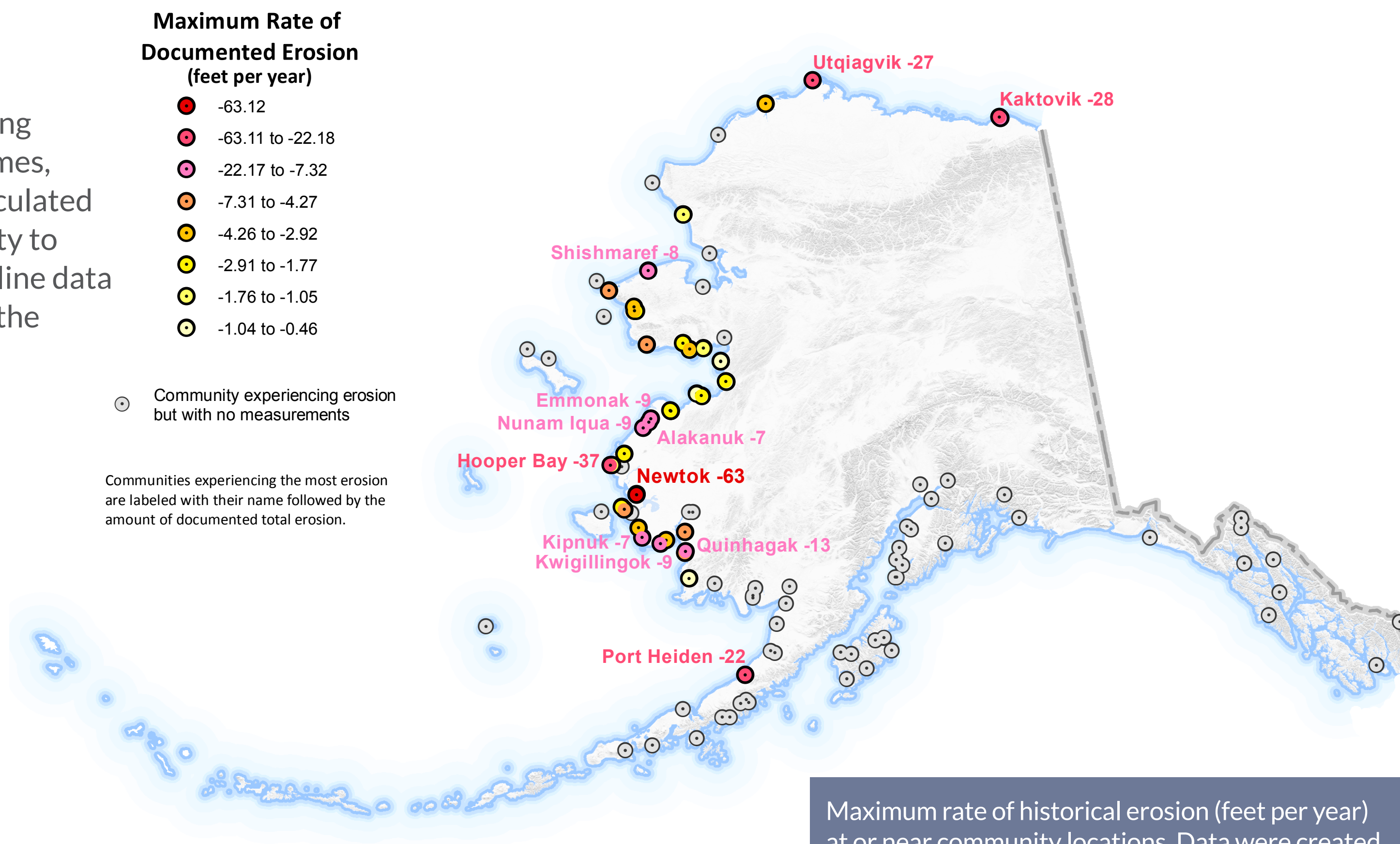



Coverage of T-Sheets in Alaska, not all T-sheets have been georeferenced.

# Shoreline Change

**Shoreline** – *the line along which a tidally influenced body of water meets the land.*

Shorelines can be delineated from orthoimagery, elevation data, or georeferenced t-sheets. By comparing shorelines representing different times, rates of shoreline change can be calculated to document alongshore vulnerability to erosion based on past trends. Shoreline data available for Alaska are viewable in the Alaska Shoreline Change Tool.




Maximum rate of historical erosion (feet per year) at or near community locations. Data were created by DGGS, USGS, and NPS using orthoimagery or topography through time. Communities that were listed by the U.S. Army Corps of Engineers as having erosion issues, but where no data exist are shown as gray circles (USACE, 2009).

# Comparing Geospatial Datasets

Coastal elevation and orthoimagery are the geospatial datasets that form the primary baselines for assessing flood and erosion hazards. Coastal geospatial datasets collected by state and federal agencies in the contiguous U.S. (CONUS) and Hawaii are compared datasets available in Alaska (table 1), along with idealized data quality and refresh rate for continued assessment of coastal flooding and erosion.

Table 1. Geospatial dataset specifications.

| Collection Entity/ Type | Geospatial Data Type | Geospatial Coverage | Ground Sample Distance (Pixel Size) | Horizontal Accuracy | Vertical Accuracy | Refresh frequency | Coastal Hazard Use |
|---|---|---|---|---|---|---|---|
| National Geospatial Datasets—Not Including Alaska | | | | | | | |
| NOAA NGS Remote Sensing Division Pre-storm Imagery (King Air, Oblique) (NOAA, 2016) | Orthoimagery | CONUS | 15-35 cm | 5-10 m; not assessed using check points | – | – | Emergency Response |
| NOAA NGS Remote Sensing Division Post-storm Imagery | Orthoimagery | CONUS | 35-50 cm (for datasets collected between 2011 and 2017) | Not assessed | – | On-storm basis | Emergency Response |
| NOAA T-Sheets (georeferenced topographic map sheets dating back to the 1800s) | Ground Mapping Elevations | CONUS + Hawaii | – | Varies | Varies; approximately ≤1.5 m | 10-20 years | Shoreline Change Studies |
| FEMA | Lidar Elevations | CONUS + Hawaii | QL2 ≤ 2 m | – | 18.66 cm for flat terrain<br>37.32 cm rolling hilly terrain | – | Flood Studies |
| US Army Corps of Engineers JALBTCX and US Oceanographic Office CHARTS | Lidar Elevations | CONUS | QL2 ≤ 2 m | – | ≤9.25 cm RMSEz | 5 years | Shoreline Change Studies; Flood Studies |

Table 1, continued. Geospatial dataset specifications.

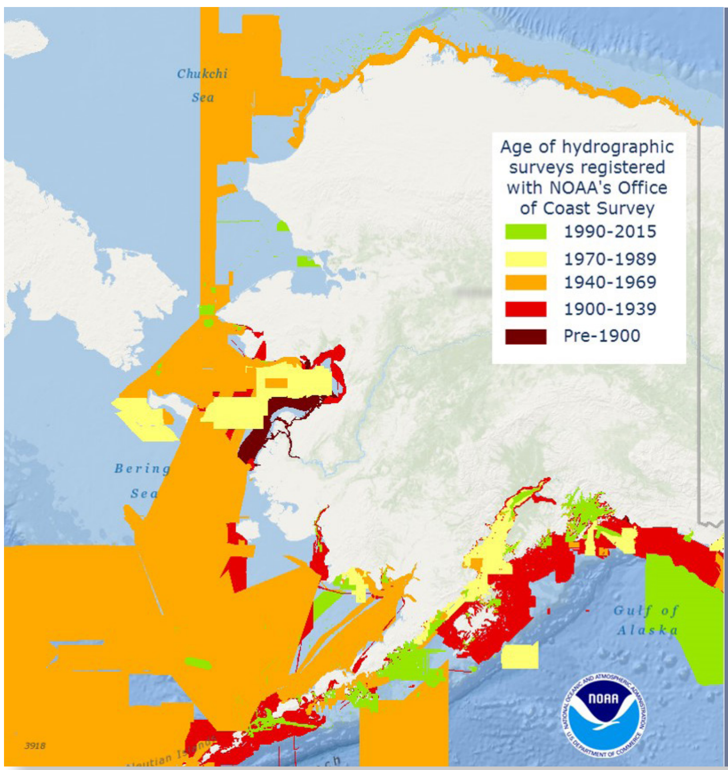
| Collection Entity/ Type | Geospatial Data Type | Geospatial Coverage | Ground Sample Distance (Pixel Size) | Horizontal Accuracy | Vertical Accuracy | Refresh frequency | Coastal Hazard Use |
|---|---|---|---|---|---|---|---|
| **Geospatial Datasets Available in Alaska** | | | | | | | |
| Historical Aerial Imagery (circa 1950s–1980s) | Orthoimagery | Northern and Western Coast Alaska | 1-2 m | 1.6-12.2 m (90% confidence; USGS, 1947) | – | – | Shoreline Change Studies |
| Statewide Digital Mapping Initiative | Orthoimagery | Statewide | 2.5 m | 12.2 m (90% confidence; USGS, 1947) | – | 3-5 years | – |
| Recent Aerial Imagery (DGGS and USGS) | Orthoimagery and Surface Elevations | Western Coast Alaska | QL4 ≤40 cm | ≤ 0.5 m (95% confidence; ASPRS, 2014) | 46.3-139 cm RMSEz | – | Shoreline Change Studies; Flood Studies |
| National Mapping Initiative for Alaska | Ifsar Elevations | Statewide | QL5 ≤5 m | – | 92.7-185 cm RMSEz (+/- 1.67-meters) | – | – |
| 3DEP Lidar (USGS) | Lidar Elevations | Mid-Yukon-Kuskokwim Delta Alaska | QL2 ≤2 m | – | ≤9.25 cm RMSEz | – | Shoreline Change Studies; Flood Studies |
| ArcticDEM | Surface Elevations | Statewide | 2 m and 5 m | Varies | Varies | Multi-year, not set | – |
| **Ideal Geospatial Datasets for Alaska for the Assessment of Coastal Flooding and Erosion** | | | | | | | |
| – | Orthoimagery and Surface Elevations | Statewide | 35-50 cm | ≤ 0.734 m (95% confidence; ASPRS, 2014) | 46.3-139 cm RMSEz | 10 years | Shoreline Change Studies |
| – | Orthoimagery | Statewide | 35-50 cm | ≤ 0.5 m (95% confidence; ASPRS, 2014) | – | On-storm basis | Emergency Response |
| – | Lidar Elevations | Statewide | QL1-QL2—2 m | – | ≤9.25 cm RMSEz | 10 years | Shoreline Change Studies; Flood Studies |

# Bathymetry

*The measurement of water depth in oceans, seas, or other large bodies of water.*

Nearshore bathymetric data in Alaska is critical for the accuracy of coastal models used to forecast flooding and erosion. Available data are currently limited, with most being collected by NOAA's Office of Coast Survey (Coast Survey) to chart features for safe navigation of maritime commerce.

For northern and western Alaska, much of the data are either historic (1890s–1930s) or were collected as part of defense efforts during World War II (1930s–1950s). Bathymetric data collected by the Coast Survey only extend up to the 4-meter (13-foot) depth contour, which leaves a significant data gap in the surf zone.




Extents and dates of nearshore and non-nearshore bathymetric data provided by NOAA's Office of Coast Survey.

Example of shallow water bathymetry data collection as part of an isolated effort at Shishmaref, Alaska, conducted by the Alaska Division of Geological & Geophysical Surveys.

Due to the risks of collecting data in this shallow zone, there have been no large-scale efforts to map bathymetry above this depth contour. Only a few isolated projects in Alaska have generated this type of data. The lack of data in this critical zone greatly reduces the effectiveness of nearshore coastal models of flooding and erosion, particularly in northern and western Alaska, where the limiting depth contour can be far from the coastline and coastal storms regularly impact communities.

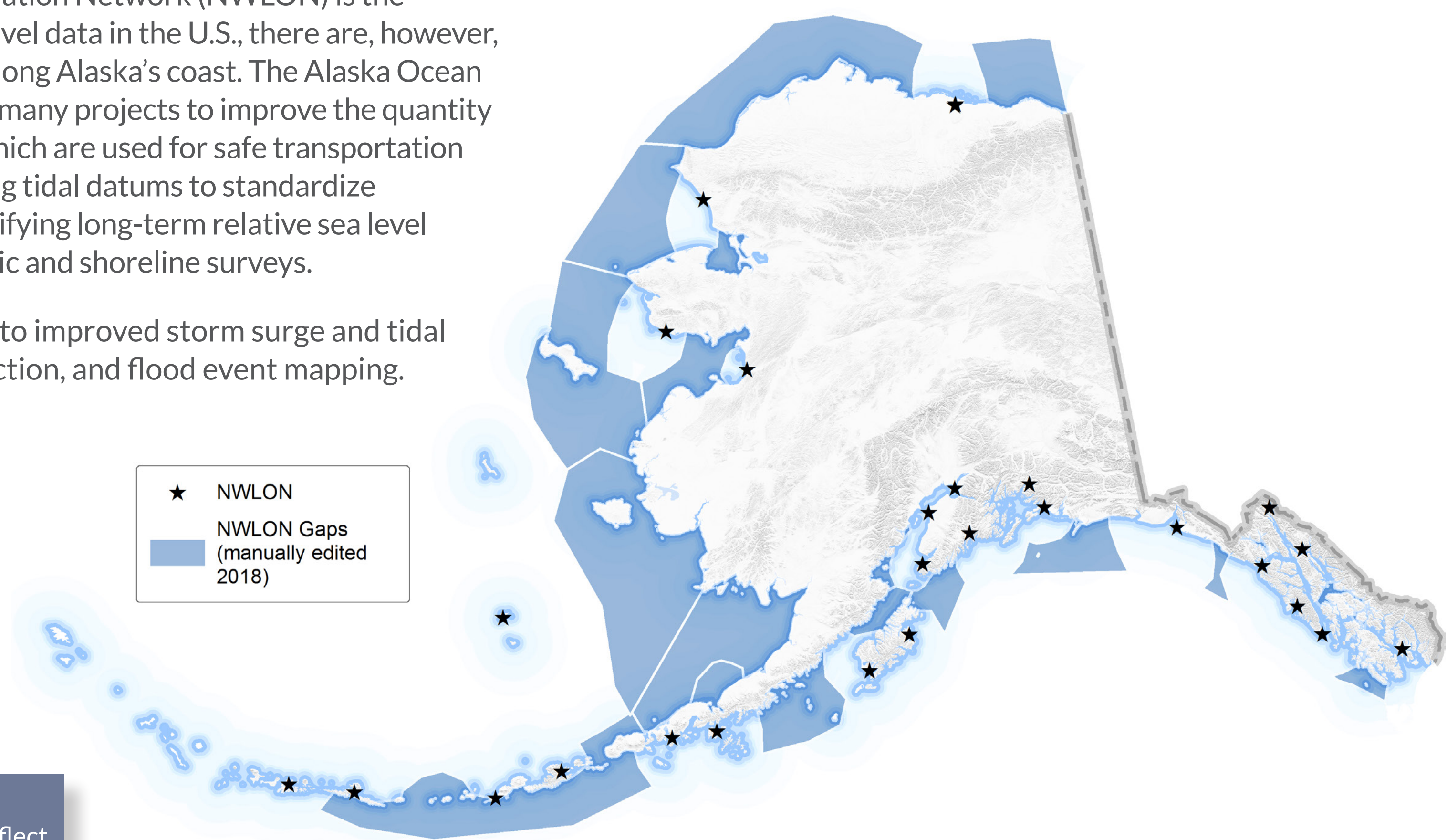
Advances in technology (e.g., topo-bathy lidar and satellite-derived bathymetry) are providing new opportunities to collect bathymetry in shallow water, but have yet to be significantly implemented in Alaska.

# Water Levels

*The elevation of the free surface of a water body relative to a specified vertical datum.*

The National Water Level Observation Network (NWLON) is the backbone of high-quality water level data in the U.S., there are, however, large gaps in NWLON coverage along Alaska's coast. The Alaska Ocean Observing System (AOOS) funds many projects to improve the quantity and quality of water level data, which are used for safe transportation in the nearshore zone, establishing tidal datums to standardize vertical reference systems, quantifying long-term relative sea level trends, and correcting bathymetric and shoreline surveys.

Water level data also contribute to improved storm surge and tidal models for accurate storm prediction, and flood event mapping.

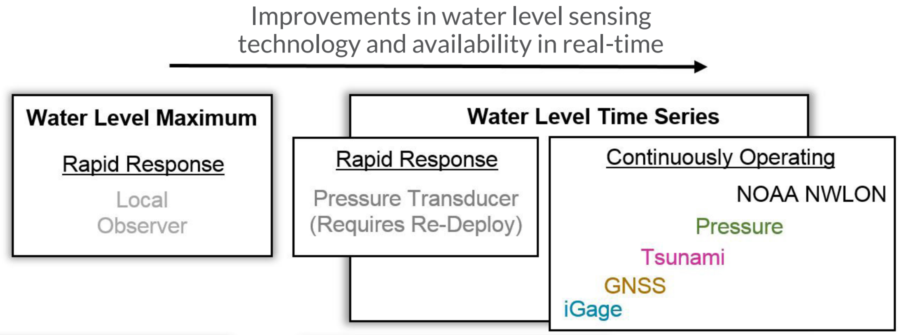


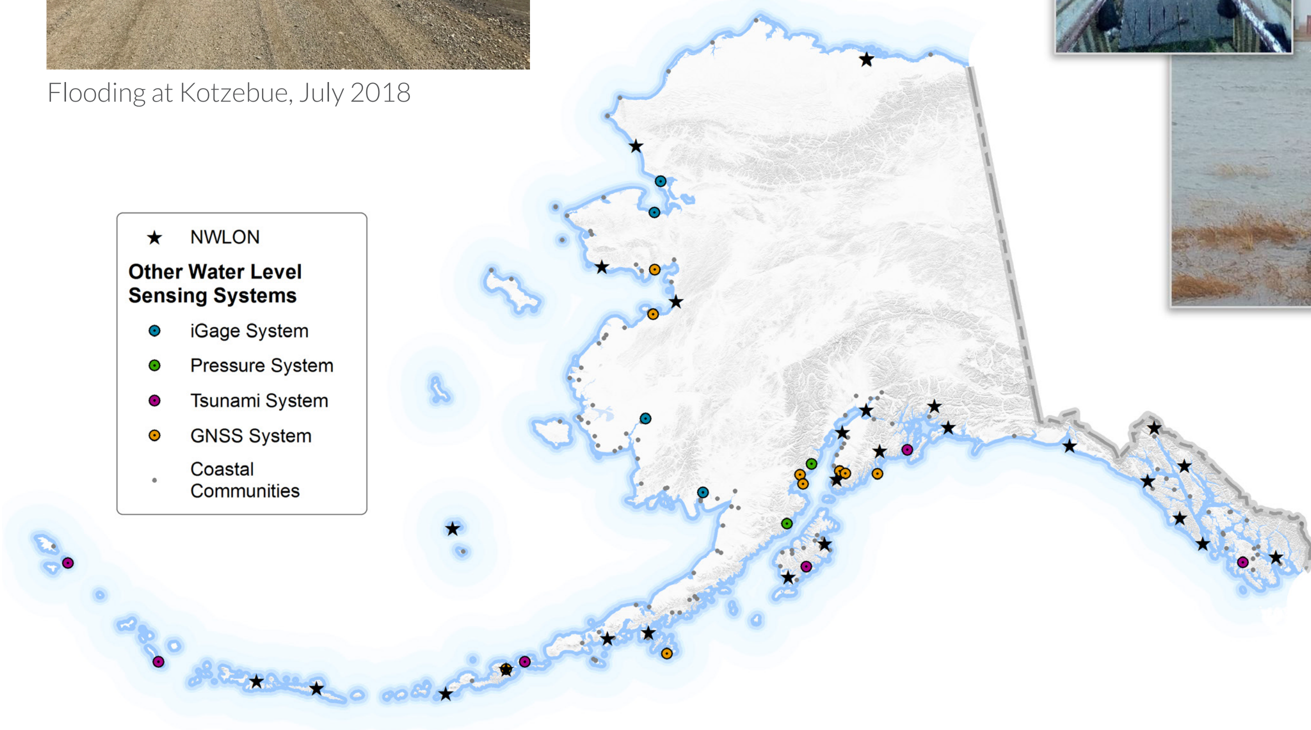

National Water Level Observing Network Gaps (manually edited to reflect installation of Unalakleet gauge and destruction of Port Moller gauge).

# Alaska Water Level Watch

*The Alaska Water Level Watch (AWLW) is a collaborative group working to improve the quality, coverage, and accessibility to water level observations in Alaska's coastal zone. More information can be found here: [https://www.aoos.org/alaska-water-level-watch/](https://www.aoos.org/alaska-water-level-watch/)*

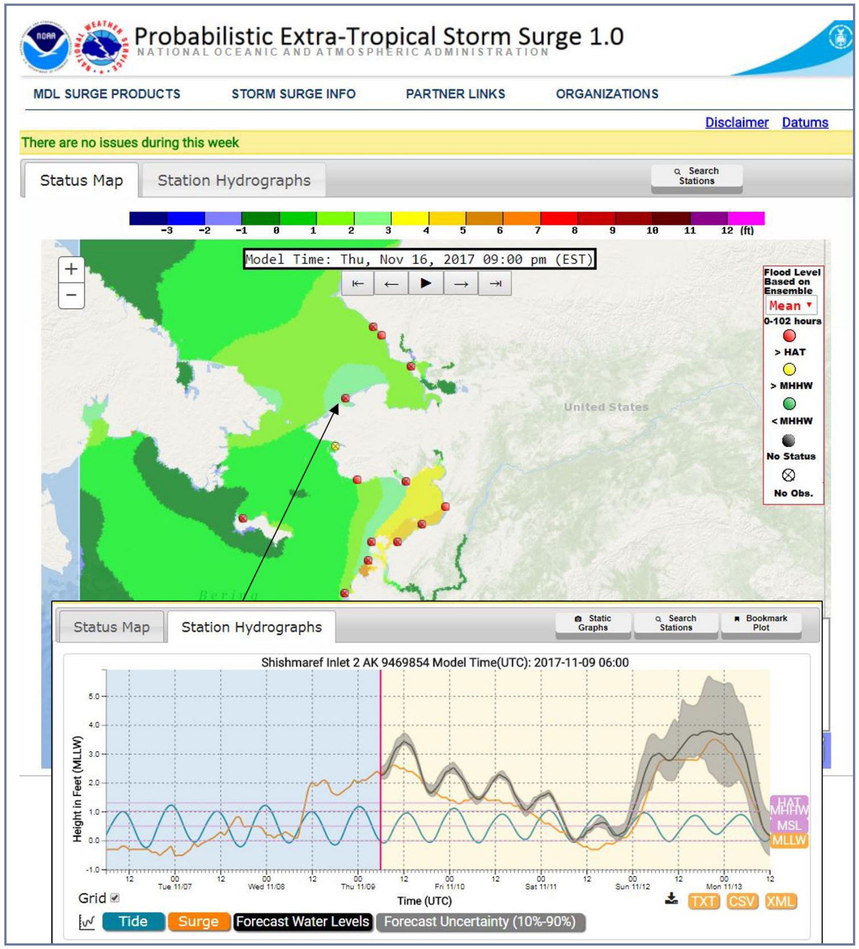
Flooding at Kotzebue, July 2018




**Above.** Right. Schematic showing the types of sensors associated with improvements in technology and real-time capabilities.

**Left.** Water levels sensors that use alternate technologies to the NOAA-NWLON. Sensors installed and operated by collaborative partners, including: National Tsunami Warning Center, National Park Service, State of Alaska, Alaska Ocean Observing Systems, research groups, and others.




**Above.** National Center for Environmental Prediction probabilistic extratropical storm surge model website graphic, http://slosh.nws.noaa.gov/etss/station/petss1.0esri/ (NOAA, 2017e).

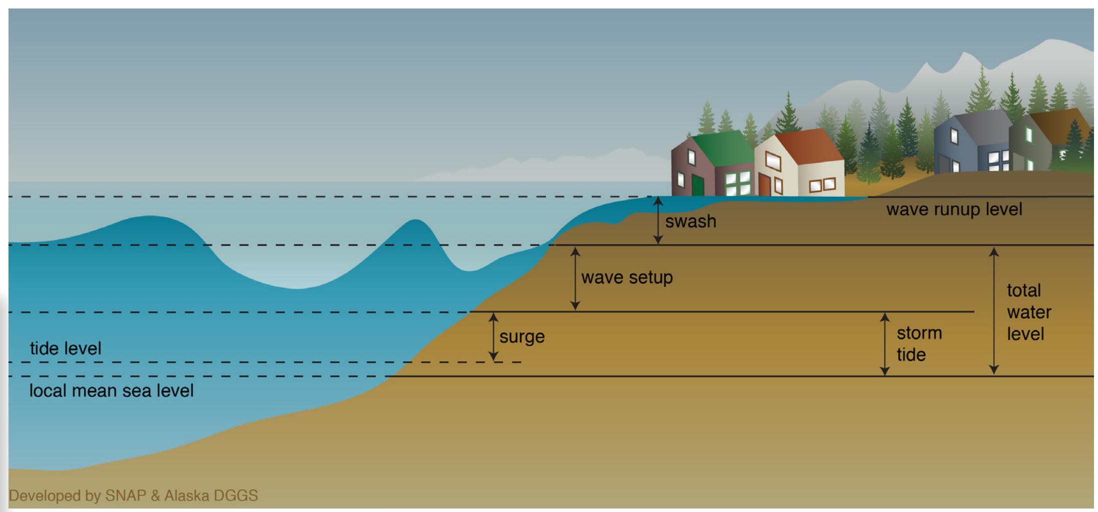
**Right.** Schematic of Marine Total Water Level, showing each component that adds up to inundation of the coast.

# Water Level Models

## Marine Total Water Level

> *Sum of water level components that results in an elevation of water level at the shore.*

Operational water level models compute components of the Marine Total Water Level (MTWL). NOAA's National Centers for Environmental Prediction (NOAA-NCEP) models the tide and storm surge components of MTWL, however, the locations of stations do not cover all Alaska communities. Model predictions are also not validated for most stations. Wave-induced water levels are not included in the NOAA-NCEP model, nor do any other models run for Alaska.

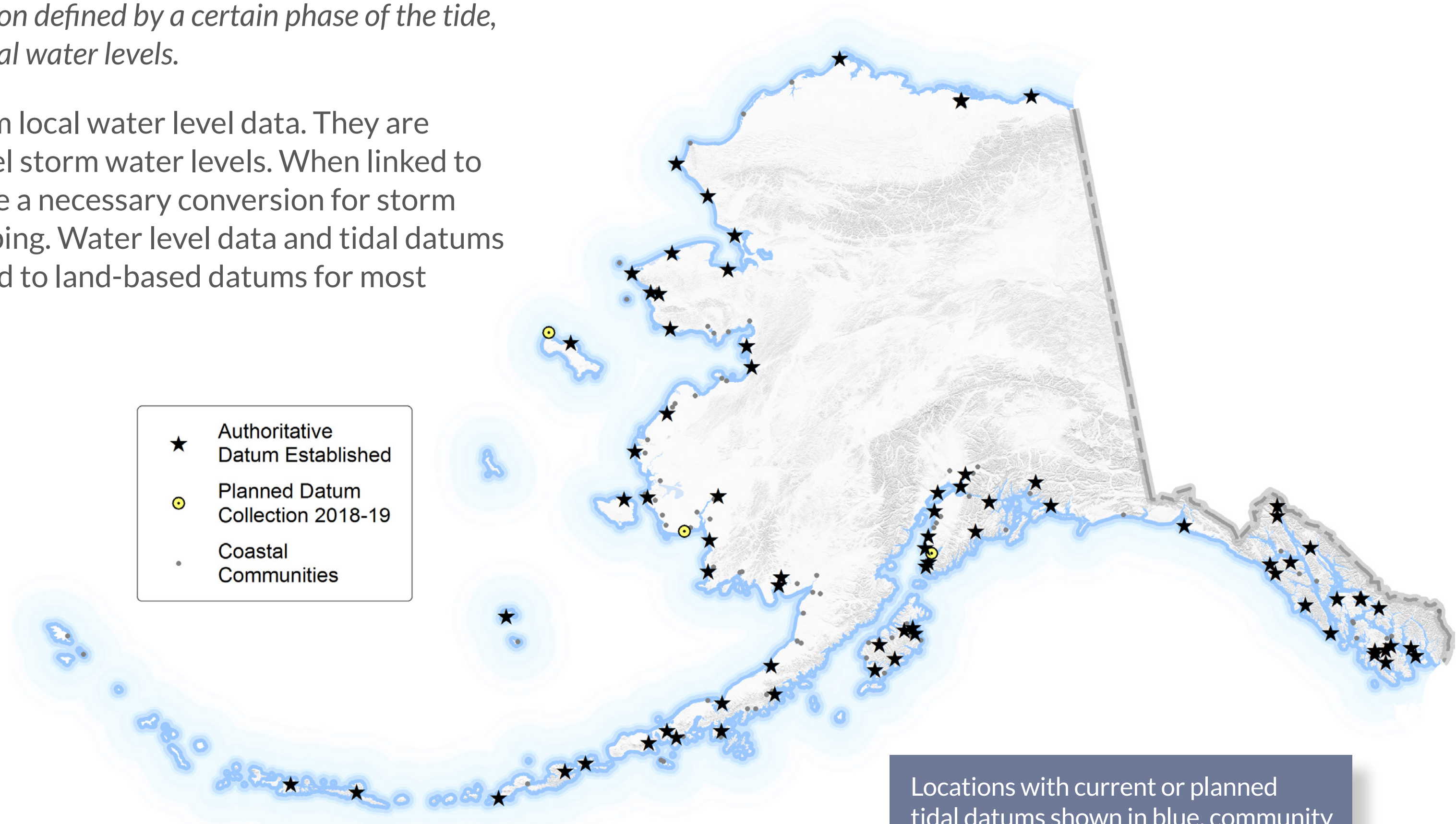


# Tidal Datums

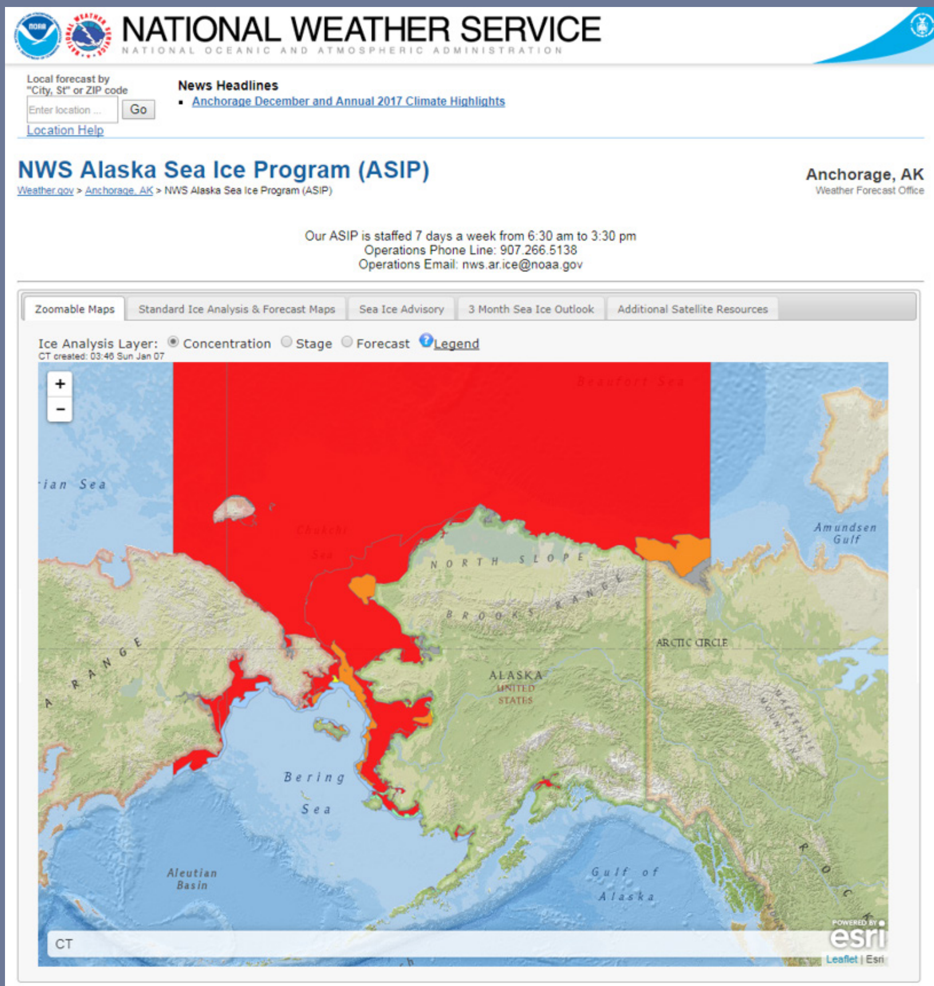
**Datum –** *A reference point from which to measure position, including heights or depths.*

**Tidal Datum –** *a standard elevation defined by a certain phase of the tide, used as a reference to measure local water levels.*

Tidal datums are calculated from local water level data. They are used in flood prediction to model storm water levels. When linked to land-based datums, they provide a necessary conversion for storm forecasting and floodplain mapping. Water level data and tidal datums have not been collected or linked to land-based datums for most communities in western Alaska.




Locations with current or planned tidal datums shown in blue, community or installation locations without tidal datums shown as gray circles.




National Weather Service Alaska Sea Ice Program website graphic, https://www.weather.gov/afc/ice (NOAA, 2017a).

# Sea Ice

Sea ice can help mitigate flood and erosion hazards by providing protection against incoming waves and dampening wave and surge development offshore. The ice-free ocean season is expected to continue expanding throughout the 21st century (Douglas, 2010). Ice-free conditions during the regular fall and winter storm season allow waves and surge to develop and damage land and infrastructure in Alaska coastal communities.

# Sea Ice Analysis

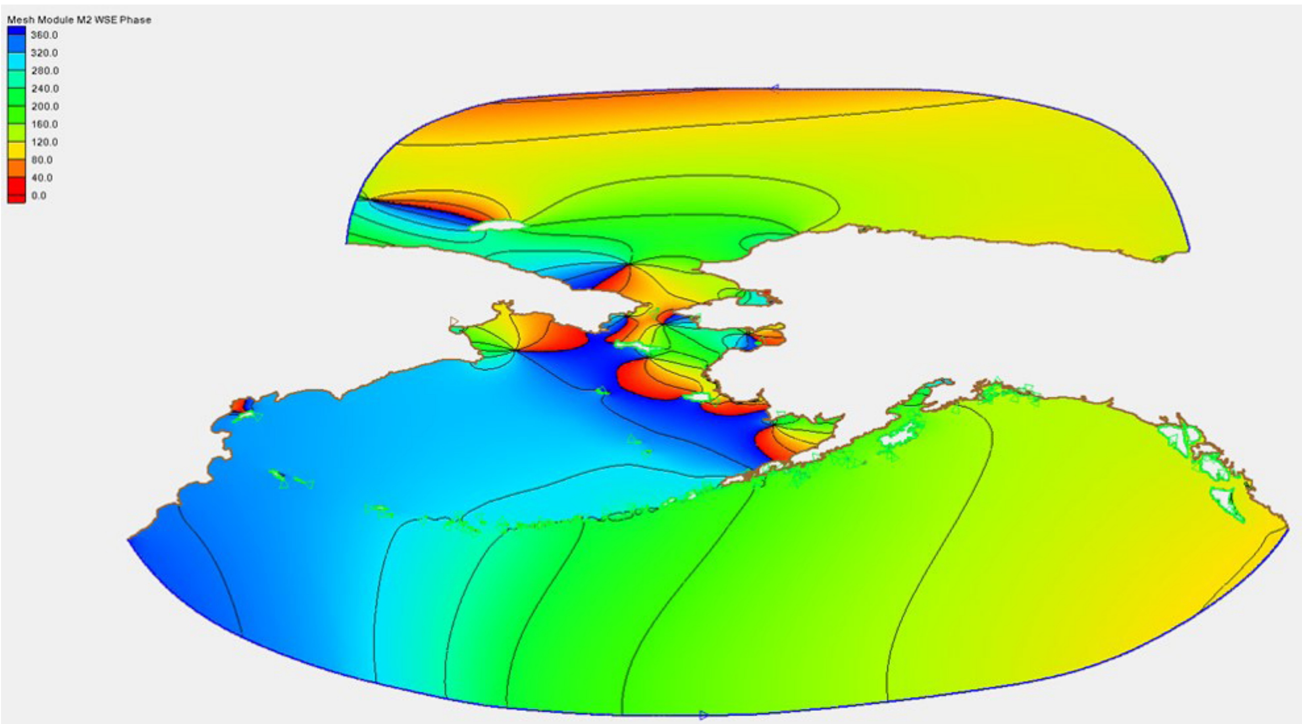
The National Weather Service maintains a daily sea ice analysis mapping service that provides near real-time updates of sea ice conditions. The National Snow and Ice Data Center has been cataloging sea ice extent since 1971. These are critical datasets used to model Alaska storm surge. Most satellite data can be hampered by cloud cover, and there are few local ice condition observations available to ground truth forecasts.

Sea ice analysis data sources.

| Primary Data Sources | Additional Data Souces |
|---|---|
| Synthetic Aperture Radar (SAR) from National Ice Center (NIC) | Operational vessel observations (USCG, Healy, and others) |
| SAR wind data from the NOAA National Environmental Satellite, Data, and Information Service | NWS Weather Station Office field observations |
| Satellite Data (Worldview, MODIS, Suomi NPP, and NASA MODIS) | Nearshore webcams and radar (Utqiagvik) |
| NIC marginal ice zone daily analysis | Canadian Ice Service graphical ice analysis |
| | Seasonal field research and observations |
| | Local resident observations and communications |

# Coupled Sea Ice-Water Level Models

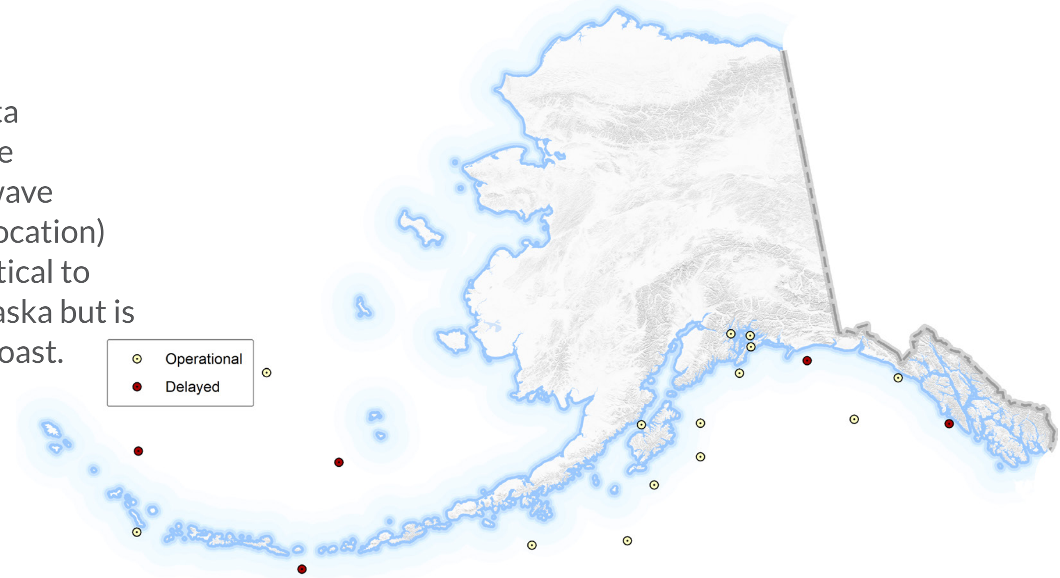
There are many poorly understood processes important for modeling sea ice-water level interactions. The operational model for water levels, Probabilistic ExtraTropical Storm Surge (P-ETSS), does not accurately model these interactions. This leads to anomalous forecasts during times when sea ice is either fully or partially covering the offshore or nearshore regions of Alaska. More research and observations of sea ice-water level interactions are needed to effectively forecast flooding from coastal storms during Alaska's fall and winter storm season.




Tide nodes in model domain from tide and storm model developed by Computational Hydraulics Laboratory at the University of Notre Dame https://coast.nd.edu/projects.html. The multiple tide nodes around Bering Strait show how complex tides are in the region.

# Waves

Wave data are collected by real-time operational buoy systems, data are available through the National Buoy Data Center (NBDC). Wave data are used to construct wave climatologies (the distribution of wave characteristics averaged over a period of time and for a particular location) and model storm impact potential. Real-time wave data are also critical to marine traffic, which has historically been dominant in southern Alaska but is increasingly moving through Bering Strait and along the northern coast.




# Wave Models

Wave data are used to inform wave models, which provide wave data over a much larger and continuous area.

The U.S. Army Corps of Engineer's Wave Information Studies (WIS) includes most of western Alaska. Available data include yearly wave height time series, wave climate, and extreme wave analysis. These data are available for approximately 20–50 m (66–164 ft) water depth, which does not allow the user to look at waves in the nearshore.

Nearshore wave models are necessary for real-time or hindcast modeling of flooding and erosion and are not readily available for most of the state.


**Top.** National Data Buoy Center operational and delayed (in need of repair) buoy stations. No stations are operated north of the Bering Sea, http://www.ndbc.noaa.gov/ (NOAA, 2017d).

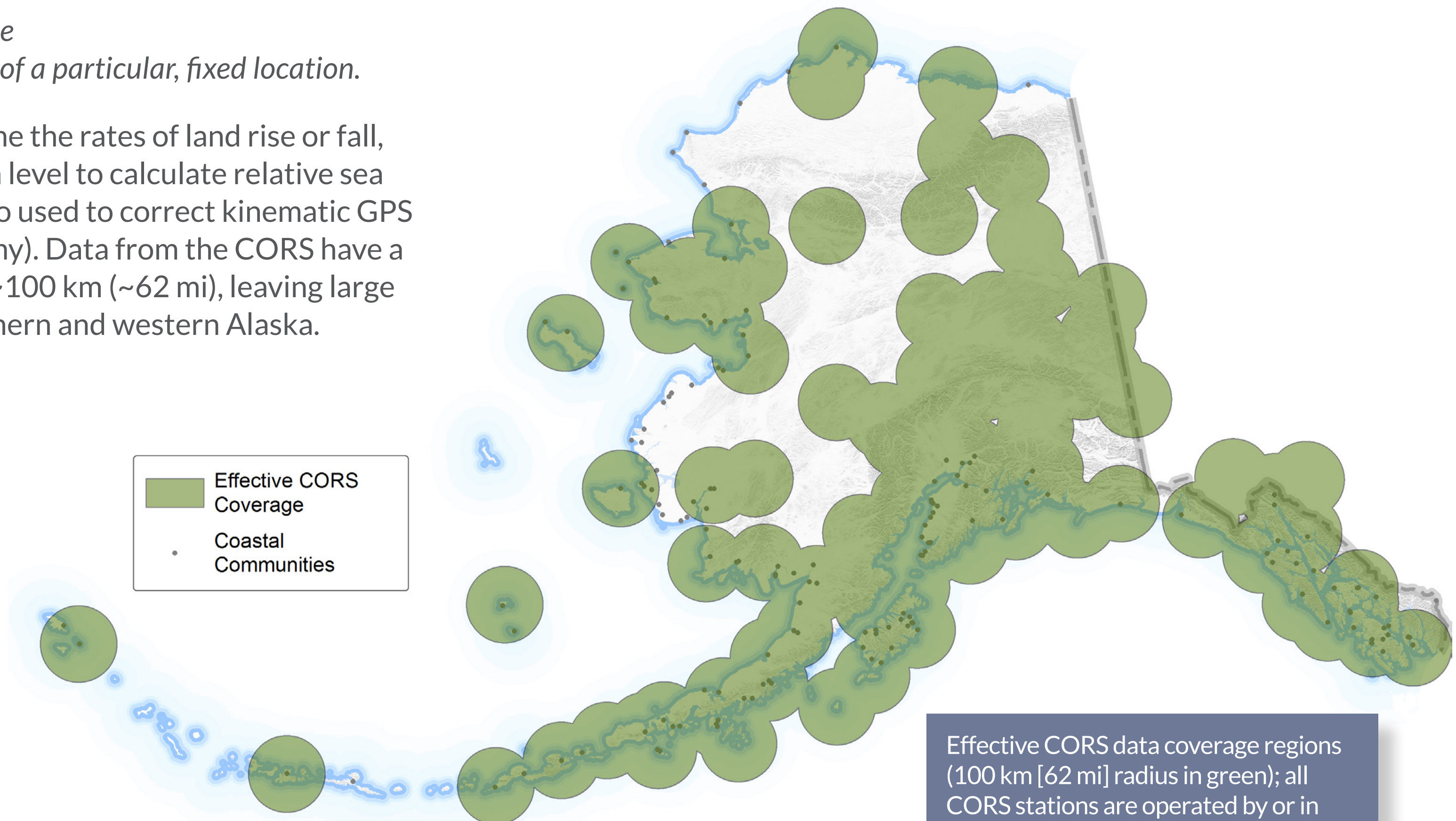
**Right.** Wave Information Studies (WIS) data sites. Numbers inside colored circles show the number of WIS sites available when zoomed into that region, http://wis.usace.army.mil/ (USACE, 2017).

# Continuous GPS Sites

### Continuously Operating Reference Stations (CORS)

*GPS stations that establish the known x, y, and z coordinates of a particular, fixed location.*

CORS data are used to determine the rates of land rise or fall, which are compared to local sea level to calculate relative sea level change. CORS data are also used to correct kinematic GPS surveys (bathymetry/ topography). Data from the CORS have a recommended usable range of ~100 km (~62 mi), leaving large coverage gaps throughout northern and western Alaska.




Effective CORS data coverage regions (100 km [62 mi] radius in green); all CORS stations are operated by or in contract with NOAA-NGS, https://www.ngs.noaa.gov/CORS/ (NOAA, 2017c). Map layers provided by JOA Surveys, LLC.

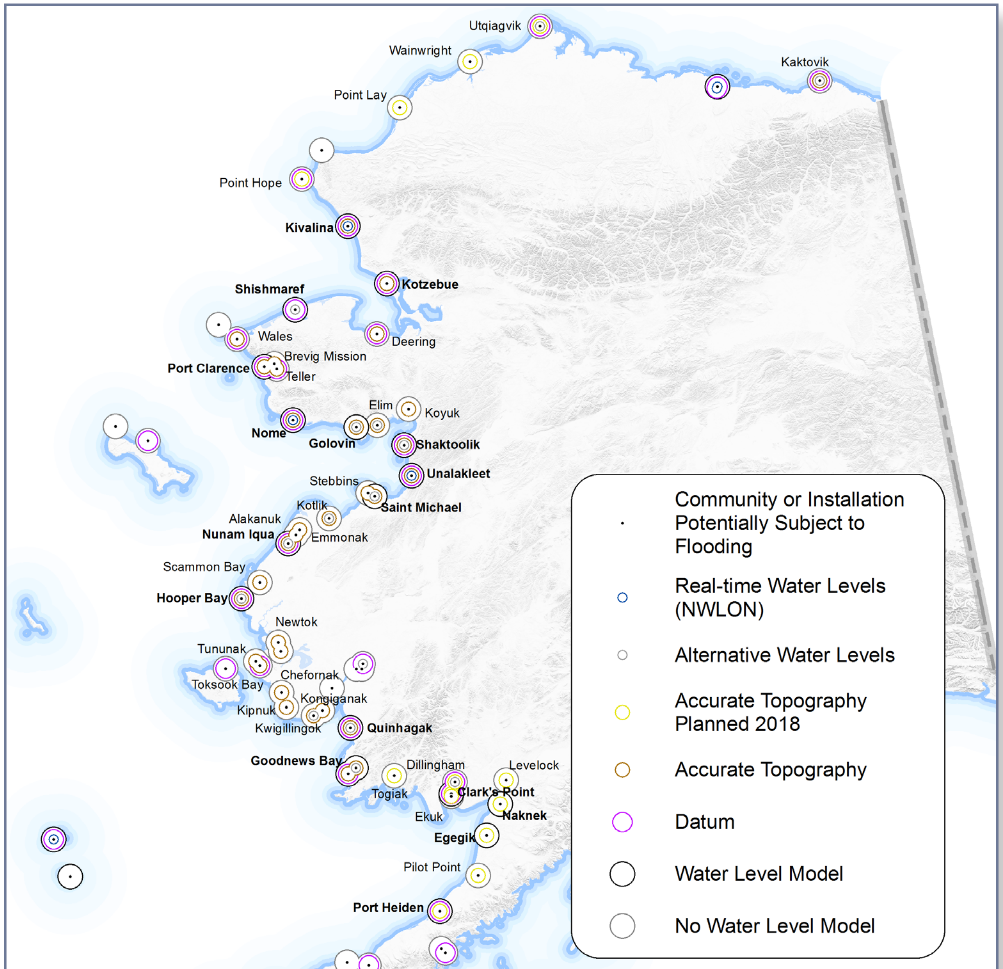
# Summary

## Baseline Data Needs

| Data Need | Category |
|---|---|
| Orthorectify additional historical aerial datasets over northwest and north slope regions | Orthoimagery |
| New orthoimagery over northwest Alaska | |
| Plan to refresh high resolution orthoimagery, optimally every 5 years over regions with high rates of shoreline change and 10 years over regions with lower rates of shoreline change | |
| Delineate shorelines on all orthoimagery datasets for shoreline change studies and shoreline boundaries | |
| Targeted high resolution elevation data and necessary ground control and check points over remaining communities (including lidar where communities have high density of vegetation) | Topography |
| Cross-shore elevation profiles for community-based monitoring | |
| Nearshore bathymetric data from the swash zone to the 40-m (130-ft) depth contour approaching community locations | Bathymetry |
| Geodetically reference water level station occupations at community locations to establish tidal datums | Water Levels |
| Continuously operating or ice-free seasonally operating water level stations | |
| Additional community-based monitoring of water level maximums from storms | |
| Storm surge water level model output at all Alaska communities | |
| Predictive model of wave-induced water levels | |
| Cloud cover-capable satellite data | Sea Ice |
| Additional localized (vessel, field, and community-based) observations of sea ice | |
| Research to understand sea ice-water level interactions and how to model them | |
| Wave buoys in and north of Bering Sea | Waves |
| Nearshore wave models for northern and western Alaska | |
| Onshore wave measurements at multiple communities representing different coastal settings | |
| Fill gaps between CORS stations in northern and western Alaska | CORS |

# Flood Mapping & Forecasting

Flood mapping and forecasting use layers of baseline data stacked together to interpret local flood vulnerability. Each data layer depends on the other layers to be accurate and usable for these purposes.



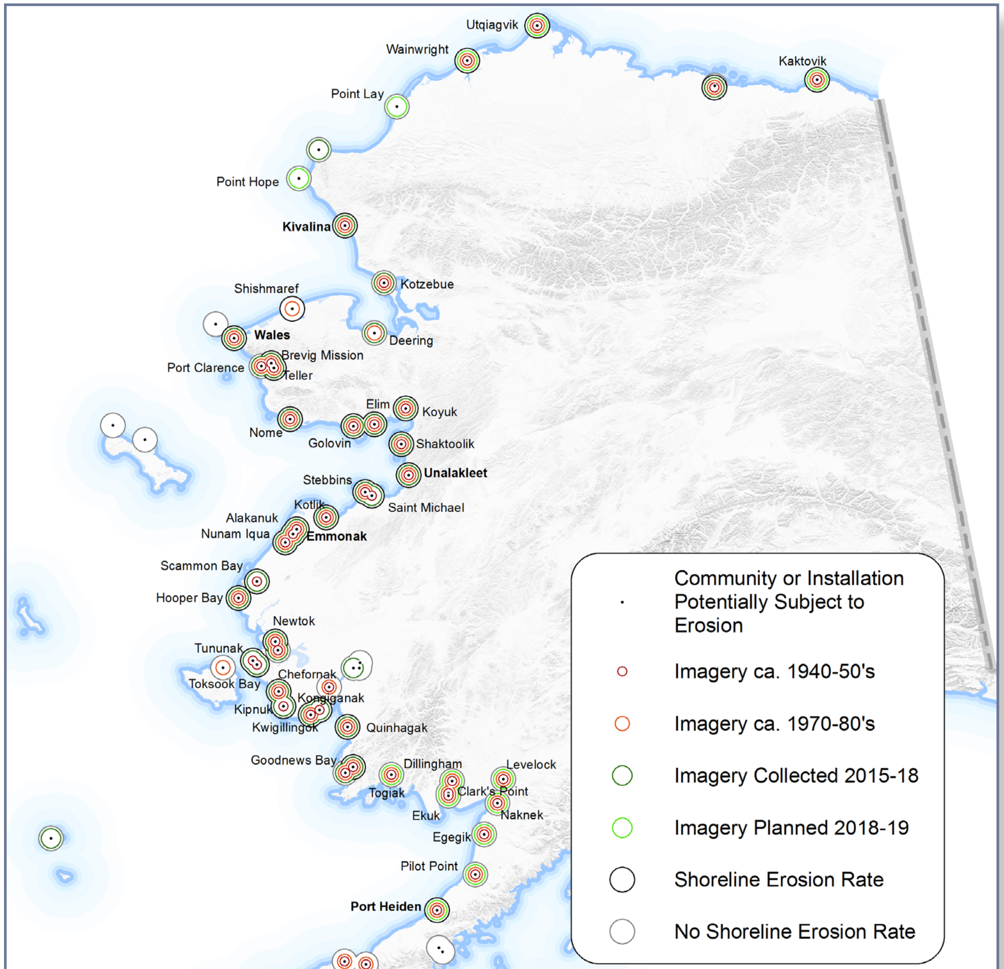

Baseline data layers currently available for flood mapping and forecasting in northern and western Alaska communities.

Percentage of communities with baseline foundational data and model data necessary for erosion mapping and forecasting. The total number of communities includes those located on the northern and western coastlines (total of 63).

| | Dataset | Percentage of Communities or installations |
|---|---|---|
| **Model Data** | Wave Runup Model | 0% |
| | Nearshore Wave Model | 0% |
| | **Storm Surge Model** | **27%** |
| **Baseline Foundational Data** | Sea Ice Interaction Observation | 0% |
| | Wave Observation | 0% |
| | Nearshore Bathymetry | 10% |
| | Water Level Observation | 10% |
| | Accurate Topography | 71% |
| | Tidal Datum | 44% |

# Erosion Mapping & Forecasting

Similarly, erosion mapping and forecasting use layers of baseline data stacked together to interpret local vulnerabilities to erosion.




Baseline data layers currently available for shoreline change mapping and forecasting in northern and western Alaska communities.

Percentage of communities with baseline foundational data and model data necessary for erosion mapping and forecasting. The total number of communities includes those located on the northern and western coastlines (total of 63).

| | Dataset | Percentage of Communities or installations |
|---|---|---|
| Model Data | **Projected Shoreline Position** | 8% |
| | Shorline Erosion Rate | 54% |
| Baseline Foundational Data | Imagery ca. 1940–1950s | 75% |
| | Imagery ca. 1970–1980s | 70% |
| | Recently Collected or Planned Imagery | 79% |

## Benefits for Alaskans

Effective flood and erosion mapping

Continous and consistent flood and erosion forecasting

Accurate flood and erosion modeling and prediction

→

Informed state, regional, and community climate adaptation planning

Effective engineering in the coastal zone

Disaster preparation and mitigation

→

**Stable, safe, and resilient communities**


Recommended building elevation in Deering, surveyed July 2018

## Acknowledgments

This document was written with contributions from public and private experts of Alaska coastal studies, sea ice, hydrographic survey, coastal community resilience, and geospatial data.

**Contributors:** Bart Buesseler (NOAA Office of Coast Survey), Ann Gibbs (U.S. Geological Survey), Michael Hendricks (Alaska Department of Natural Resources), Rebecca Heim (NOAA National Weather Service), Davin Holen (Alaska Sea Grant), Nicole Kinsman (NOAA National Geodetic Survey), Anne Johnson (Alaska Department of Natural Resources), Mary-Beth Schreck (NOAA National Weather Service), Richard Thoman (NOAA National Weather Service), and Nathan Wardwell (JOA Surveys, LLC).

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