

# Understanding Rates of Shoreline Change

A Guide for Alaskans



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National Ocean Service  
National Geodetic Survey

# OUTLINE



1. The Shoreline

2. Types of Shorelines

3. Types of Shoreline Change Calculations

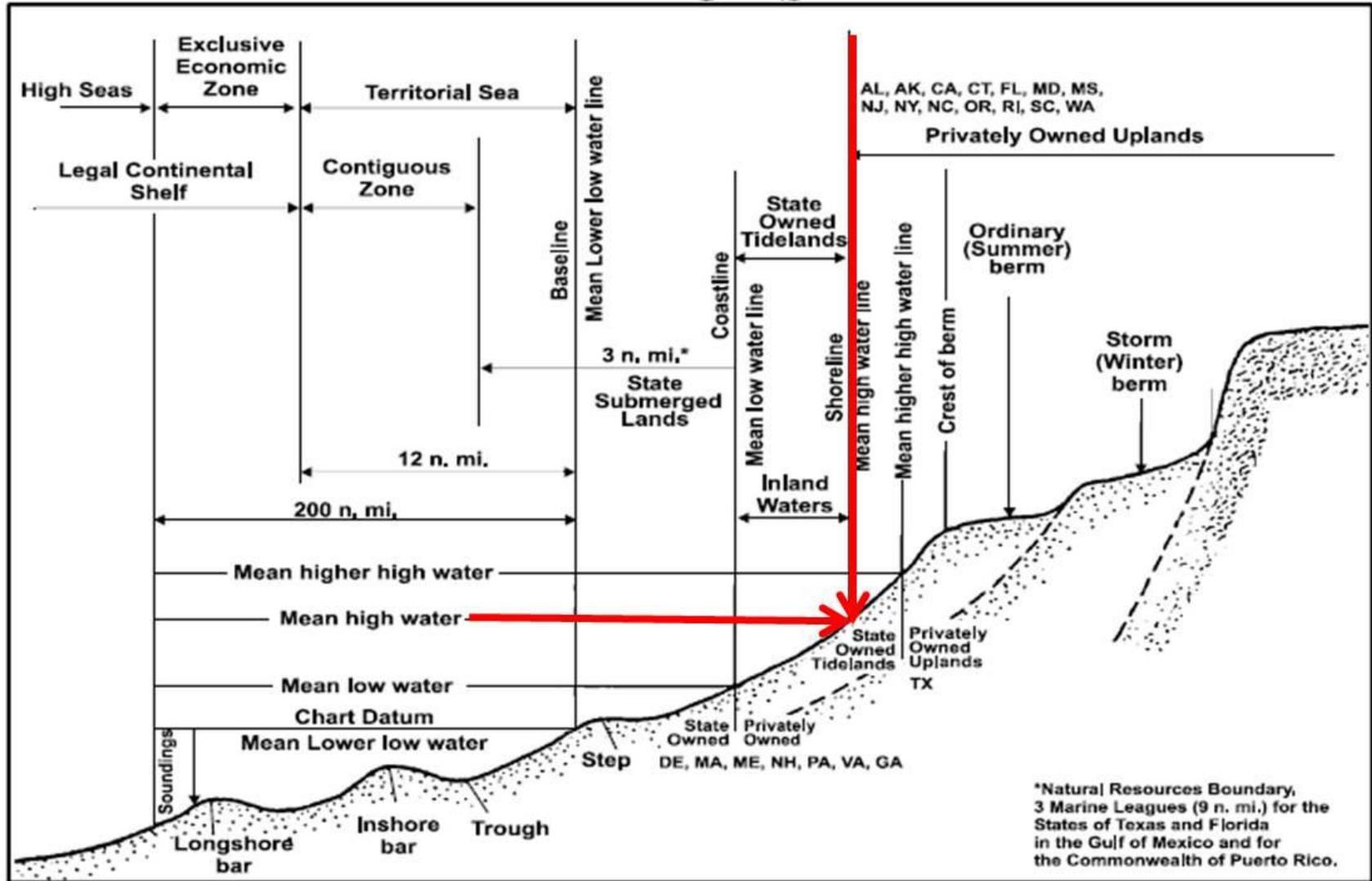
4. Projected Shorelines

5. Summary Considerations for Coastal Planning

# THE SHORELINE



# REGULATORY SHORELINES



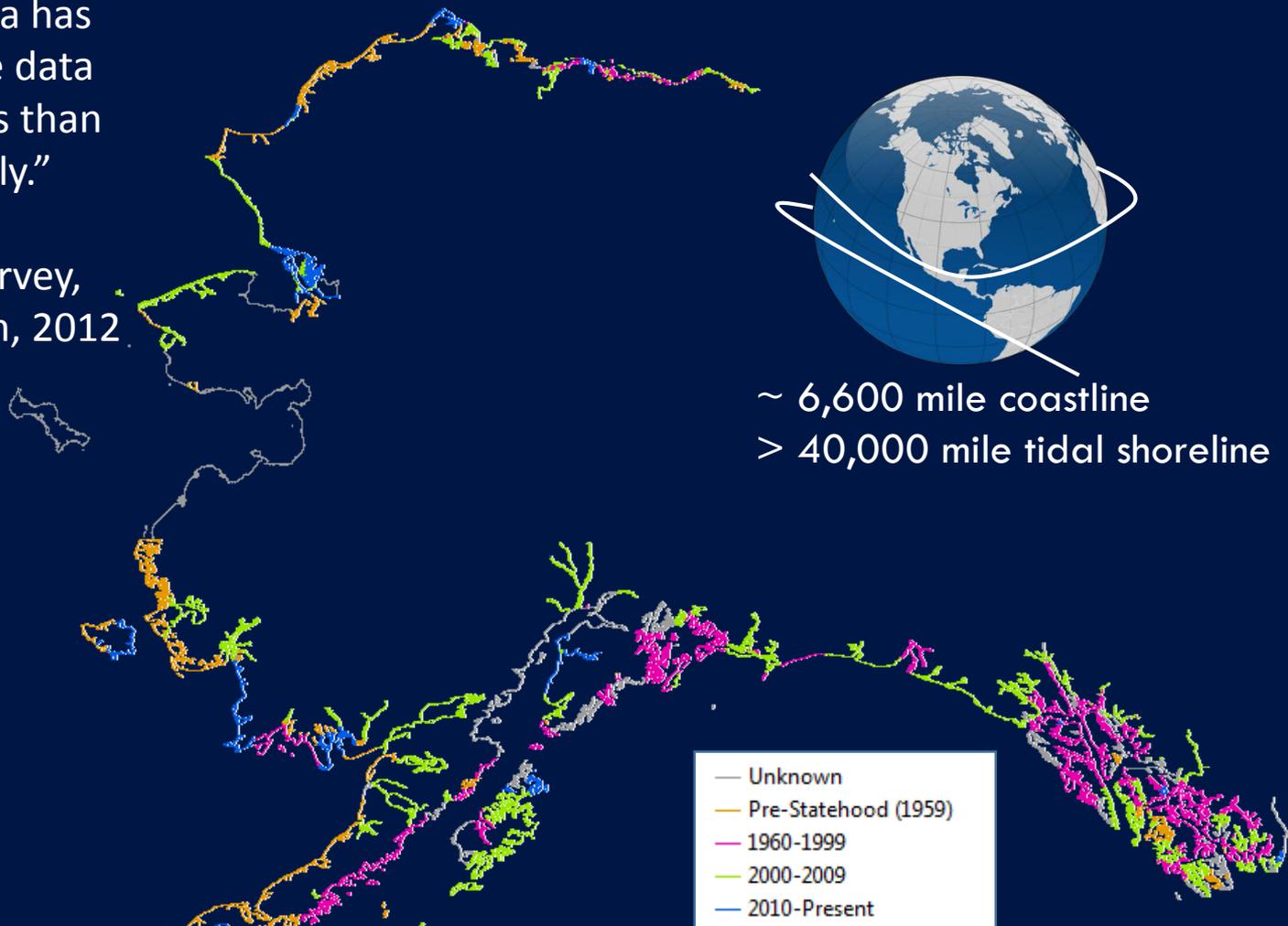
# STATUS OF NOAA SHORELINE IN ALASKA



“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.

- MHW/MLLW
- Regulatory product



Last updated: April 2015  
POC: Doug Graham

# FUTURE NOAA SHORELINE IMPROVEMENTS



“Joint effort among NOAA, USGS and the State of Alaska to coordinate on satellite imagery analysis and other technologies for shoreline and near-shoreline coastal mapping, critical for safe navigation and to observe climate change in action.”

– *National Ocean Service, 2016 GLACIER Commitment*



# WAYS OF DEFINING SHORELINES



## Datum-Based

HAT

MHW

MHHW

IWL

TWL

## Feature-Based

Vegetation Line

Wet/Dry Line

Wrack Line

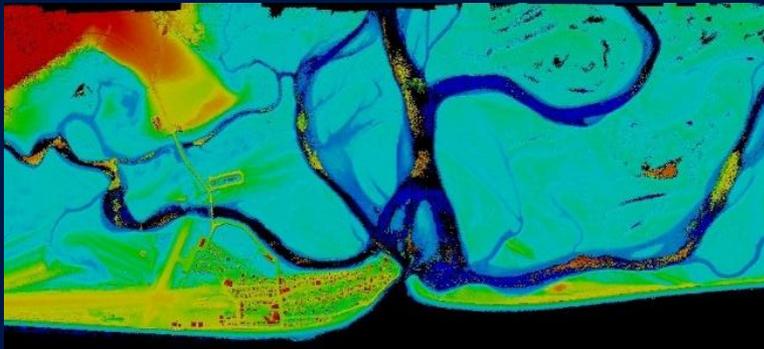
Water Line in Photo

Storm-Debris Line or Wrack Line

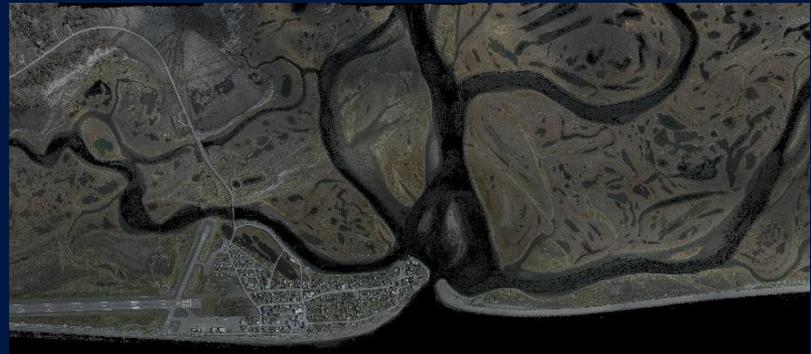
Bluff/Cliff Top

Bluff/Cliff Toe

Elevation Data



Orthorectified Aerial Photography



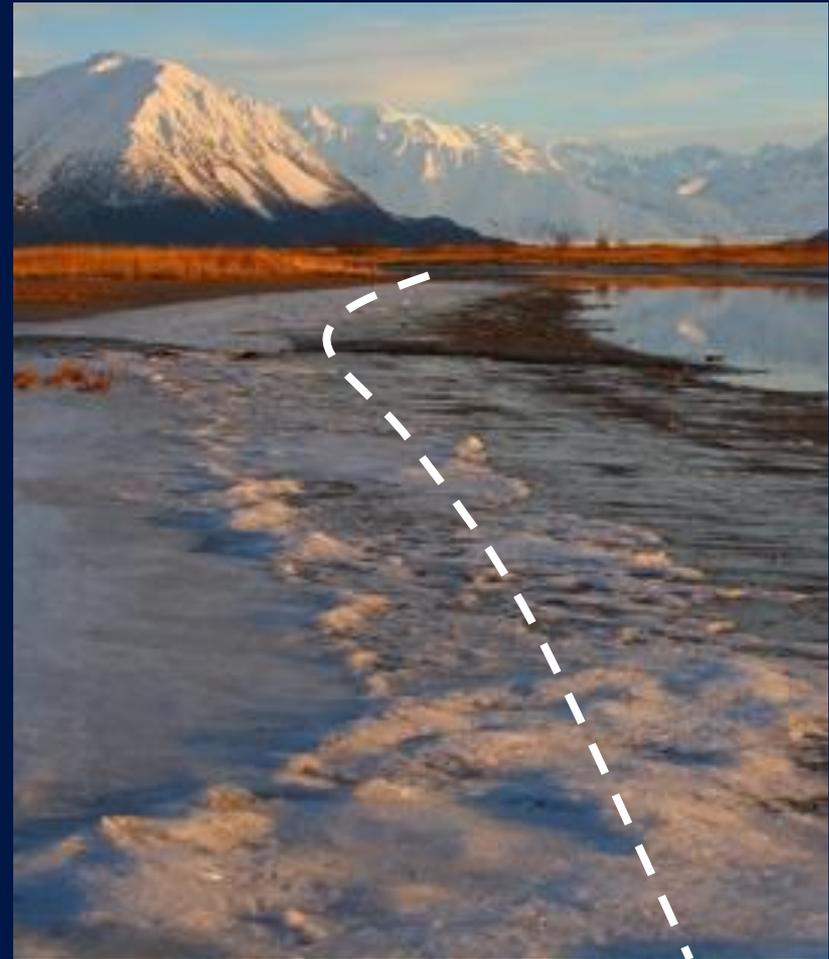
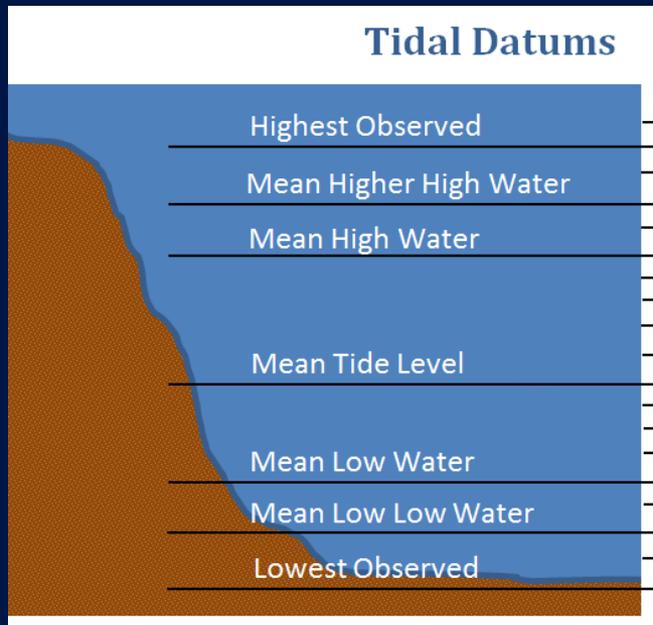
# DATUM-BASED SHORELINES



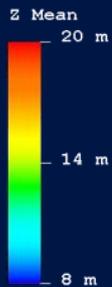
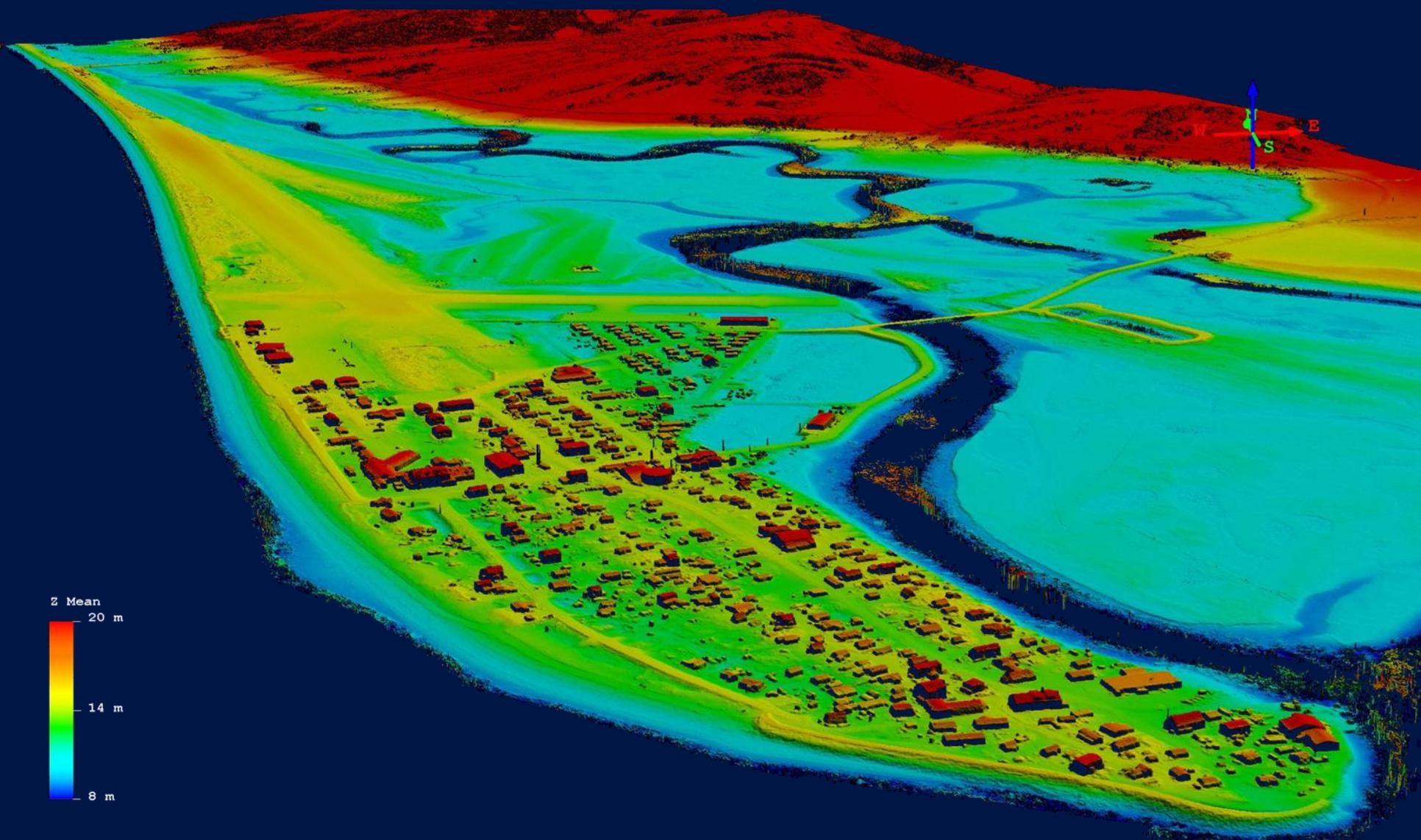
intersection =  
shoreline position

land surface

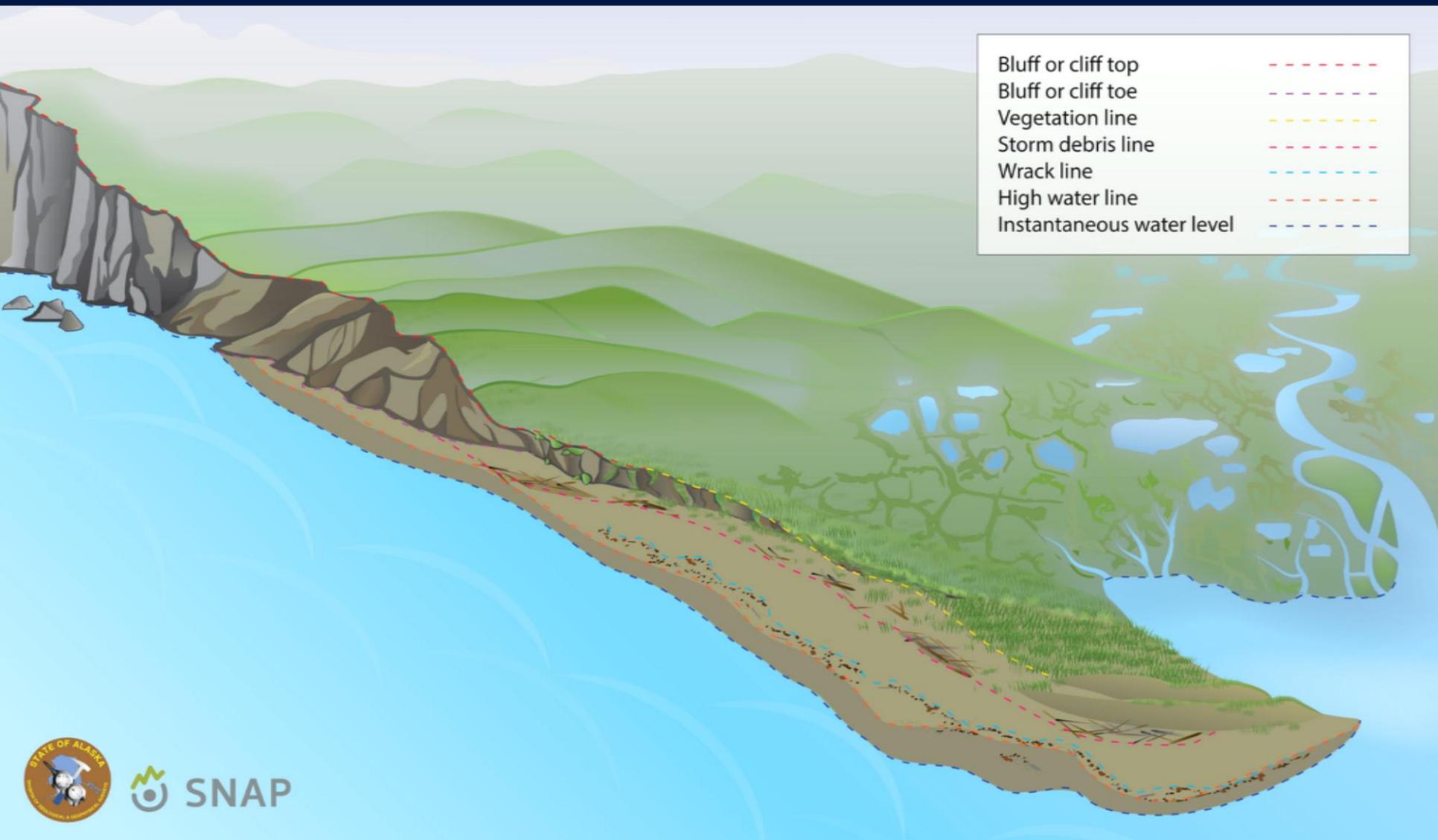
water level



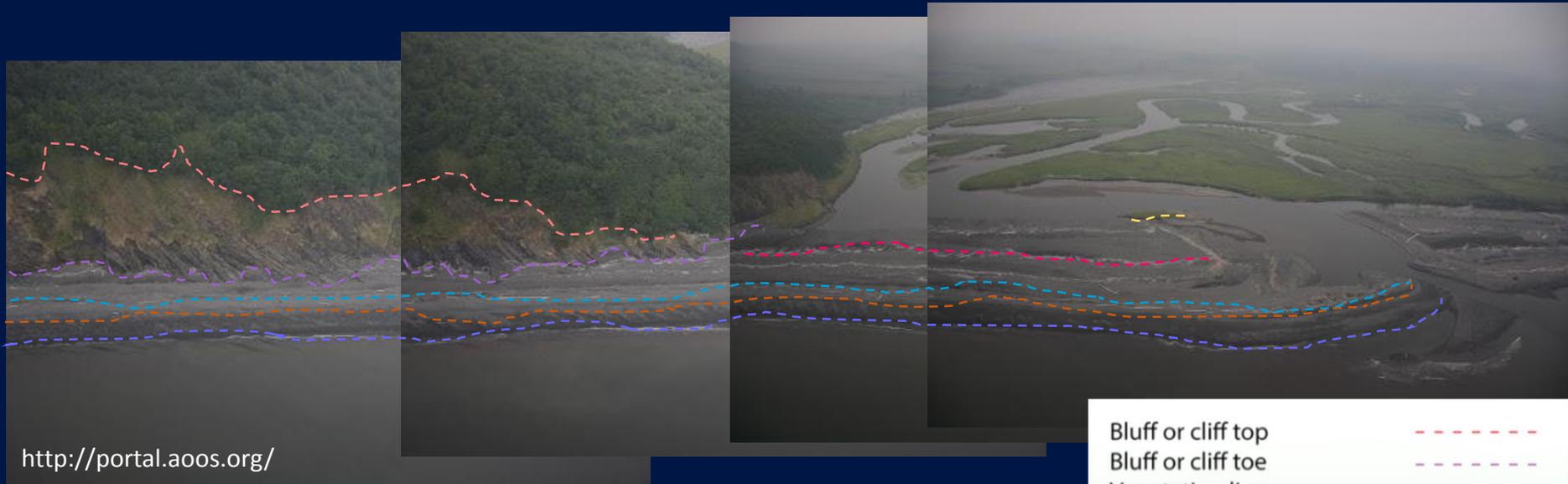
# DATUM-BASED SHORELINES



# FEATURE-BASED SHORELINES



# FEATURE-BASED SHORELINES



<http://portal.aaos.org/>

Bluff or cliff top	-----
Bluff or cliff toe	-----
Vegetation line	-----
Storm debris line	-----
Wrack line	-----
High water line	-----
Instantaneous water level	-----

*Coastal setting and available data drive which shoreline indicator is used*

# FEATURE-BASED SHORELINES - FIELD



Nome



Cross-shore measurements



Wet/Dry Line



Vegetation Line

# FEATURE-BASED SHORELINES - FIELD



Lagoon near Wales



# FEATURE-BASED SHORELINES - FIELD



Golovin



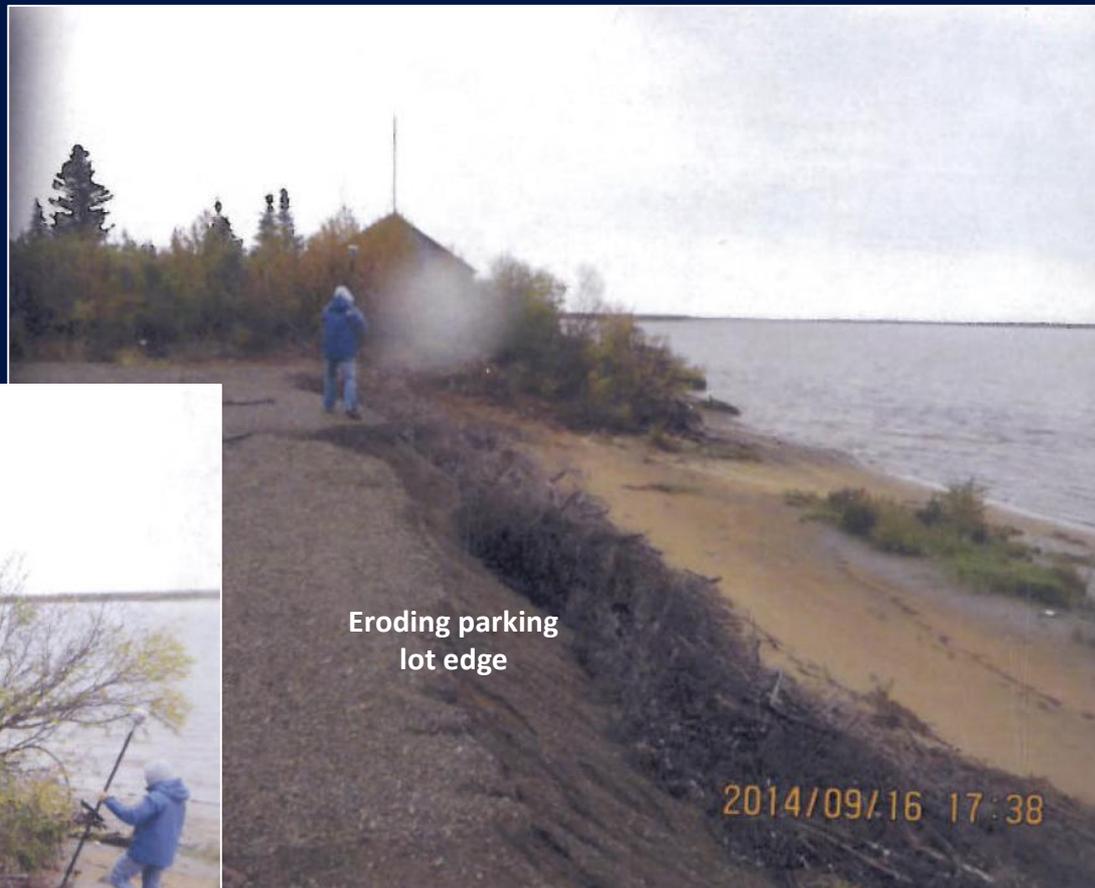
Wrack/Debris Line

# FEATURE-BASED SHORELINES - FIELD



Levelock

Riverine Erosion



Eroding parking lot edge

2014/09/16 17:38

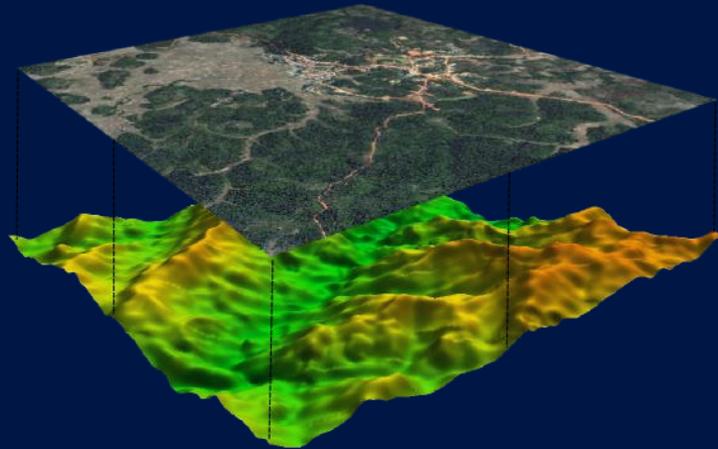
(HDR inc., 2015)



Vegetation line

2014/09/16 17:39

# AERIAL IMAGERY SOURCES (Plane/Satellite)



*Orthorectified* Aerial Imagery

# FEATURE-BASED SHORELINES - AERIAL



30 meters

# SOURCES OF SHORELINE POSITION ERROR



**Image alignment  
Ground Control**



**Feature Identification  
Digitizing Error**

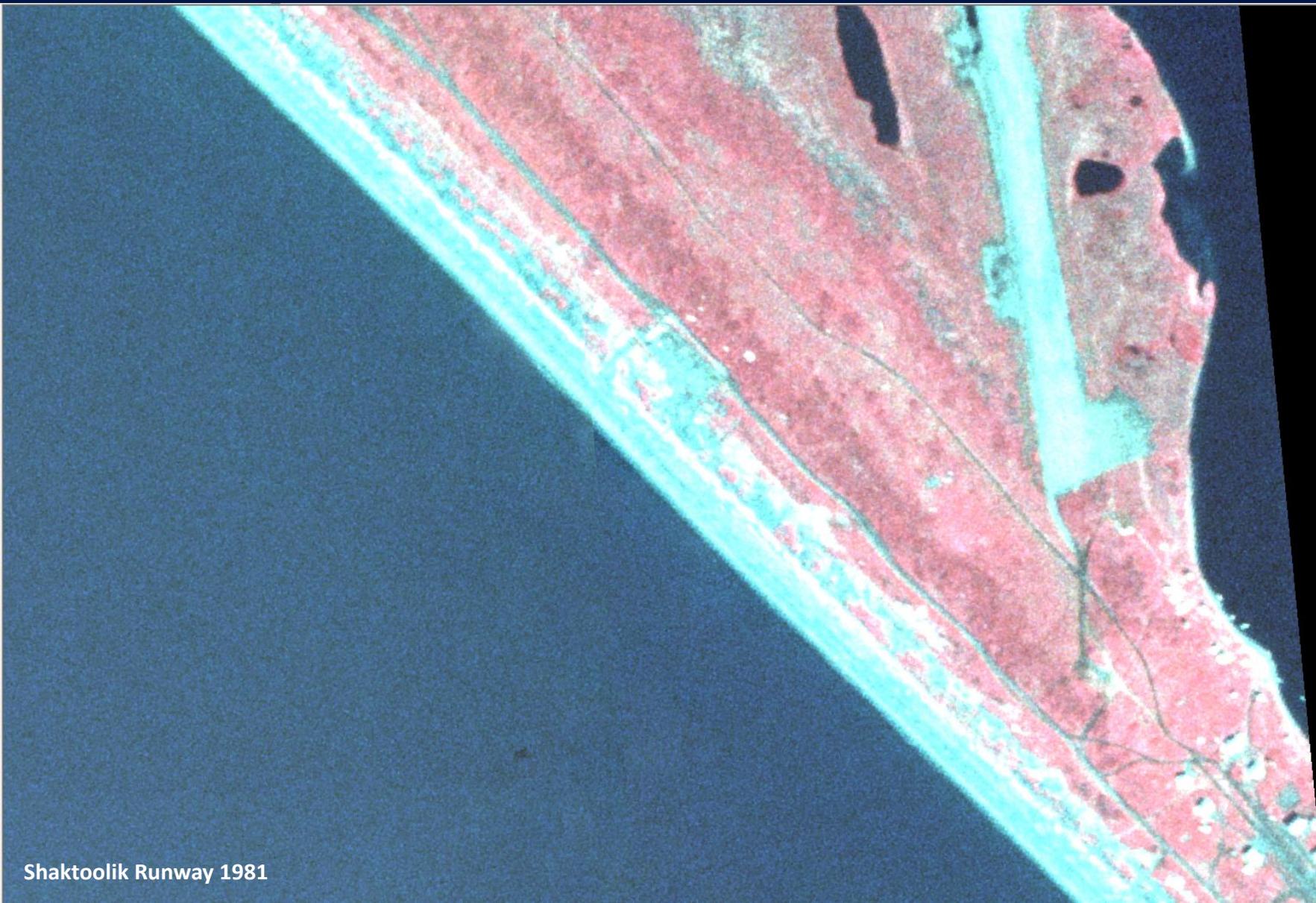


**Image Clarity,  
Scale, Resolution**



**Image Distortion**

# EXAMPLES OF SHORELINES



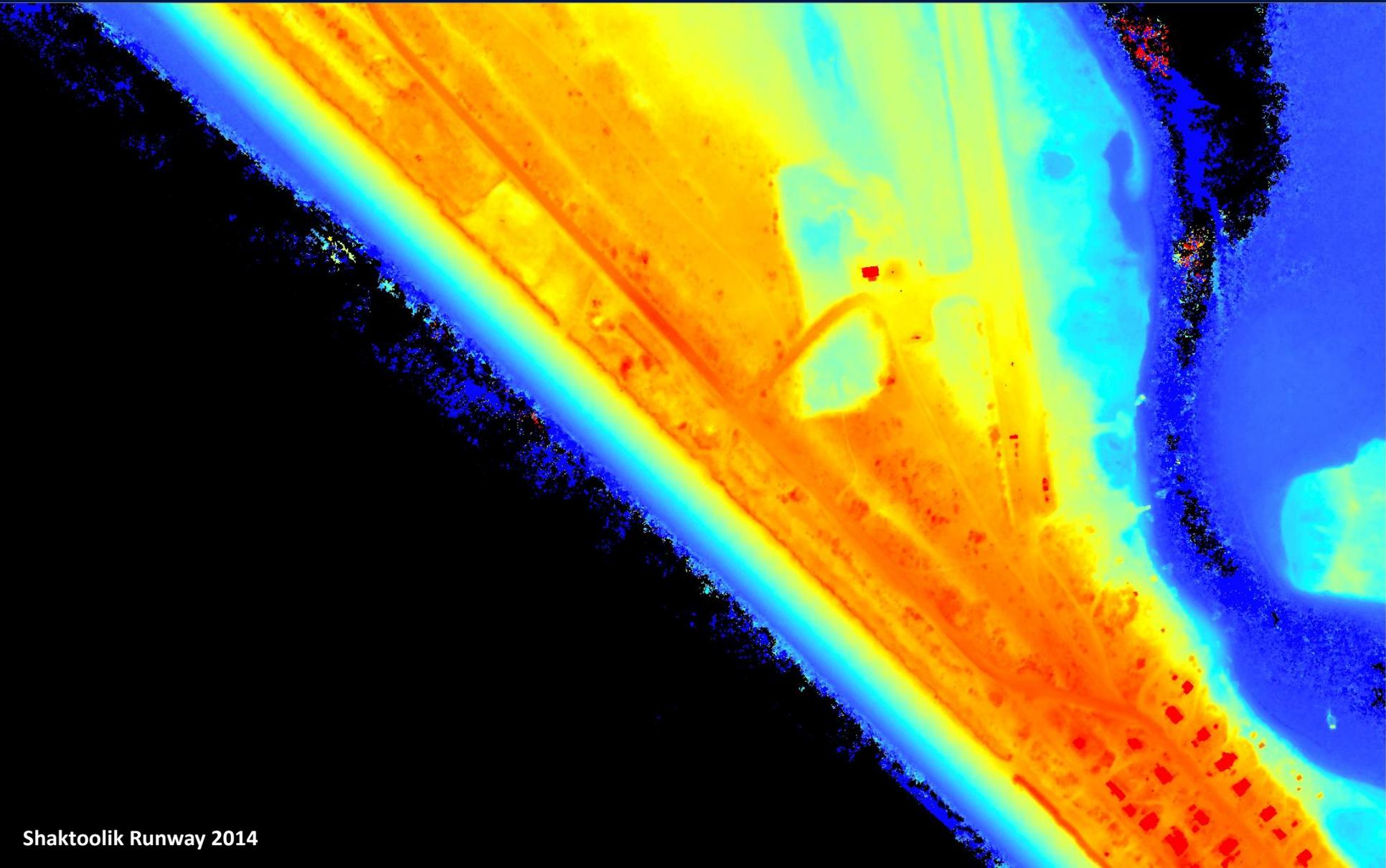
Shaktoolik Runway 1981

# EXAMPLES OF SHORELINES



Shaktolik Runway 2007

# EXAMPLES OF SHORELINES



# EXAMPLES OF SHORELINES



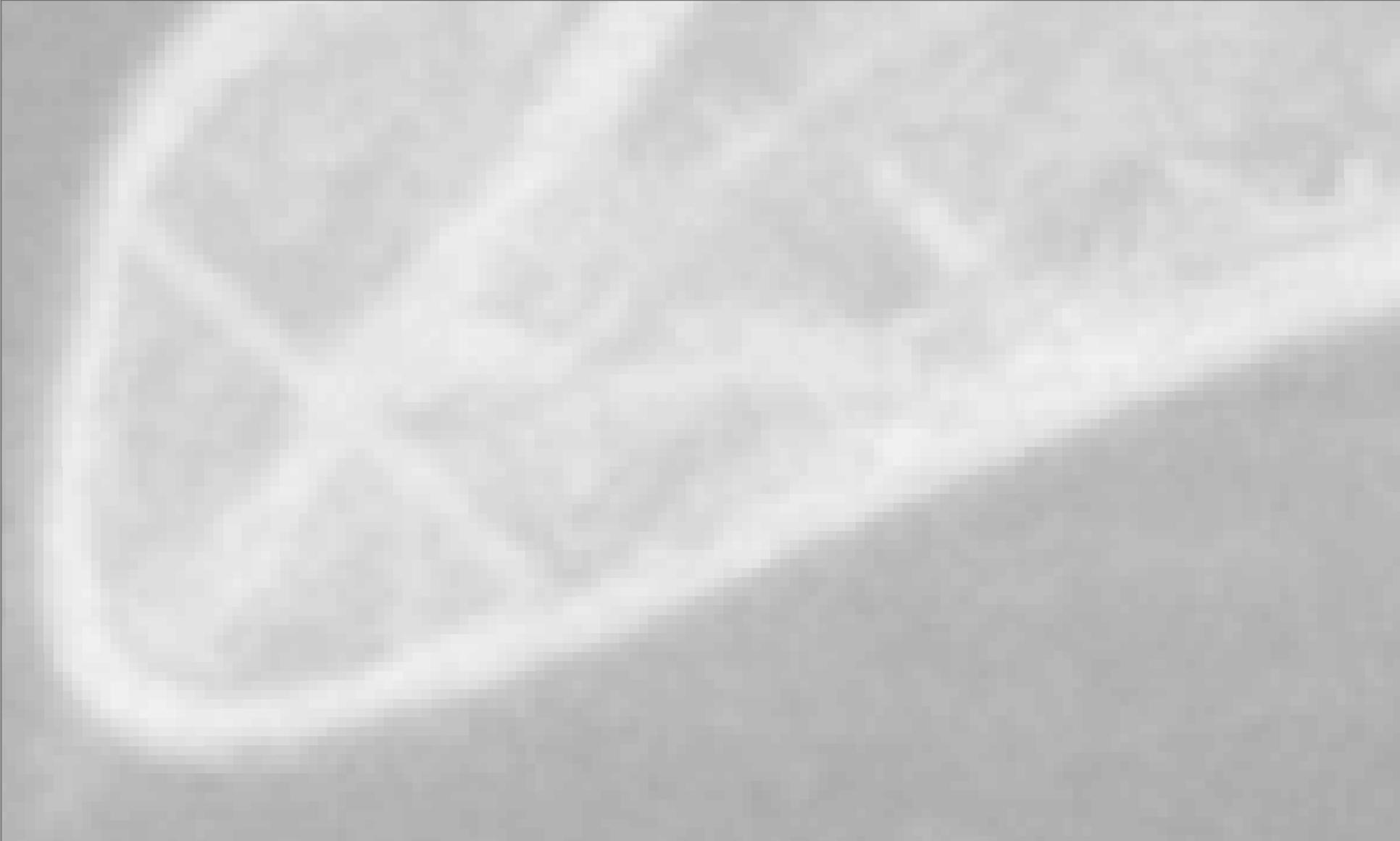
Golovin 1955



# EXAMPLES OF SHORELINES



Golovin 1972



# EXAMPLES OF SHORELINES



Golovin 2004

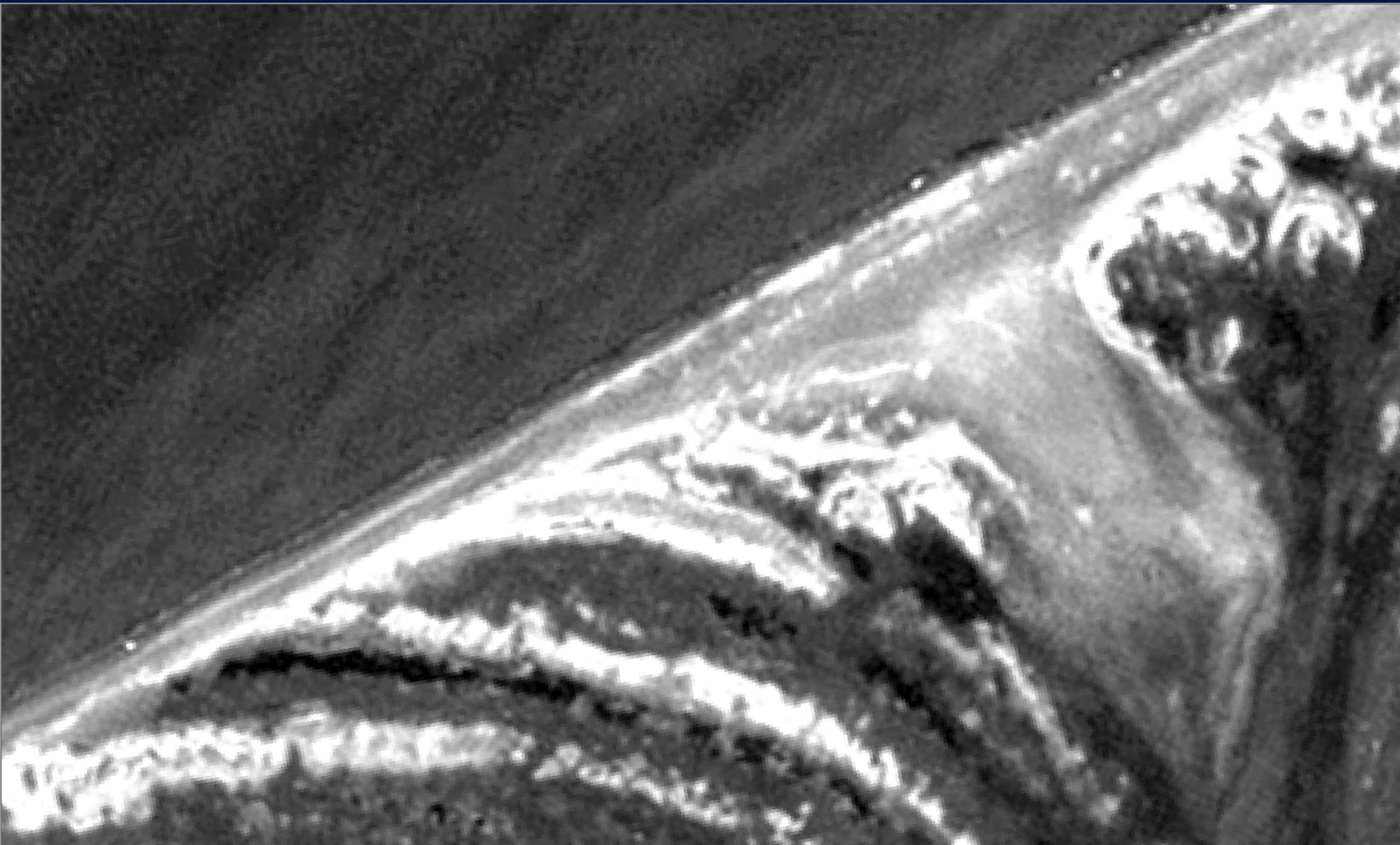


# EXAMPLES OF SHORELINES



2009

South of Shishmaref



# EXAMPLES OF SHORELINES



2010

South of Shishmaref



# TYPES OF SHORELINE CHANGE



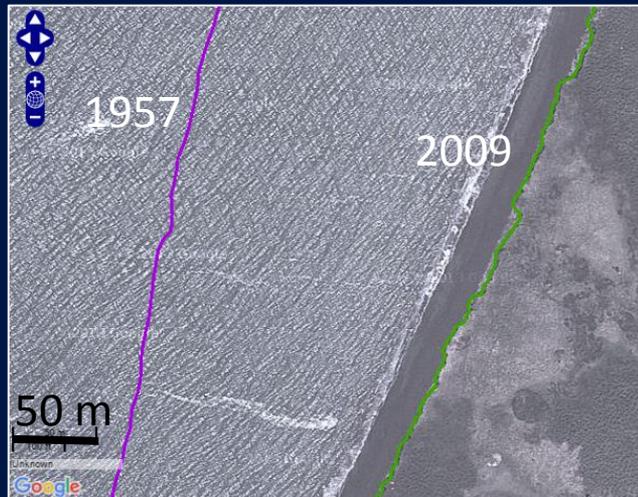
## Event Specific Change

*Scientists use rates of shoreline change to understand how shorelines evolve.*

## Seasonal Change



## Long-term Change



## Non-linear Change



# REPORTING EVENT-SPECIFIC EROSION



Kivalina

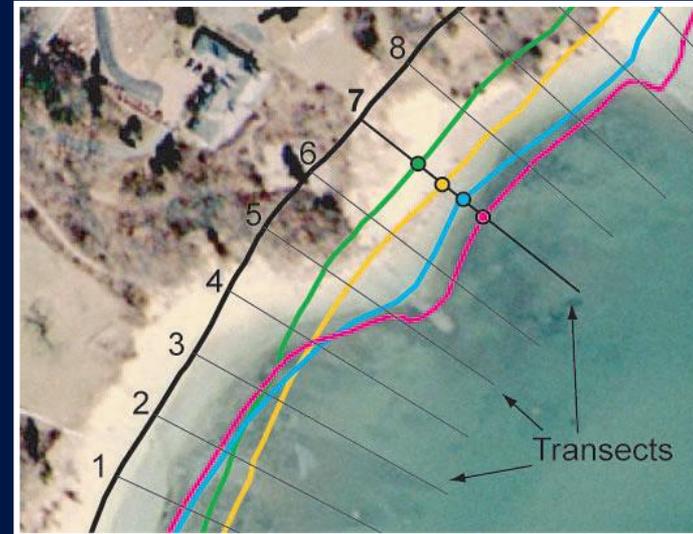
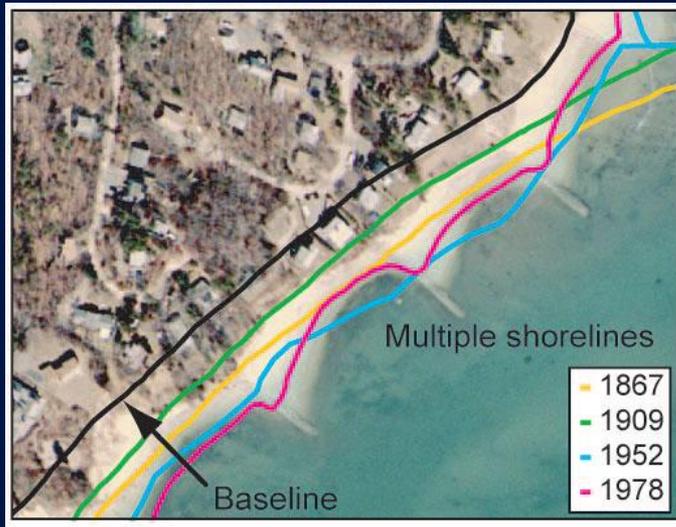
# REPORTING TRENDS IN SHORELINE CHANGE



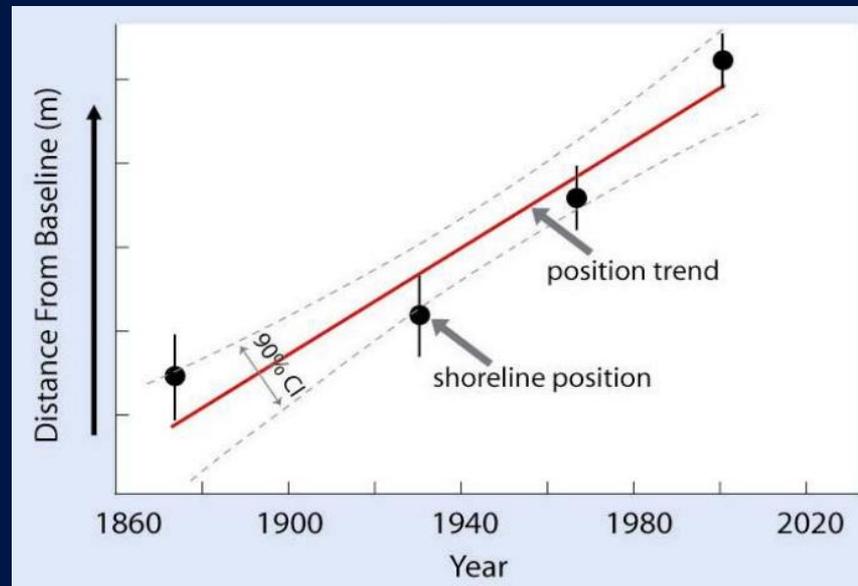
~ 1.1 feet/year  
(AK DOT&PF)

$$\text{RATE} = \frac{\text{DISTANCE}}{\text{TIME}}$$

# SHORELINE CHANGE CALCULATIONS

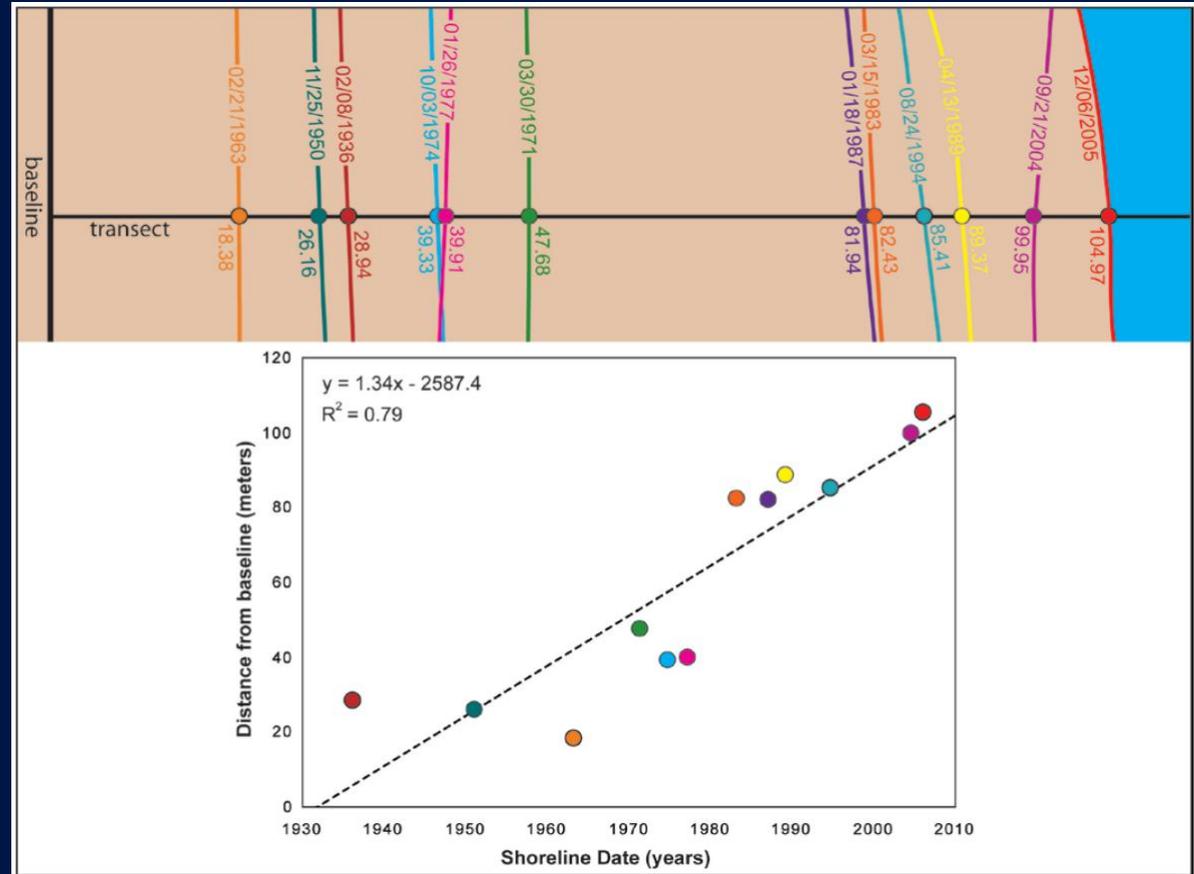


*Multiple shoreline positions through time, allow scientists to calculate rates of shoreline change.*



# TYPES OF SHORELINE CHANGE CALCULATIONS

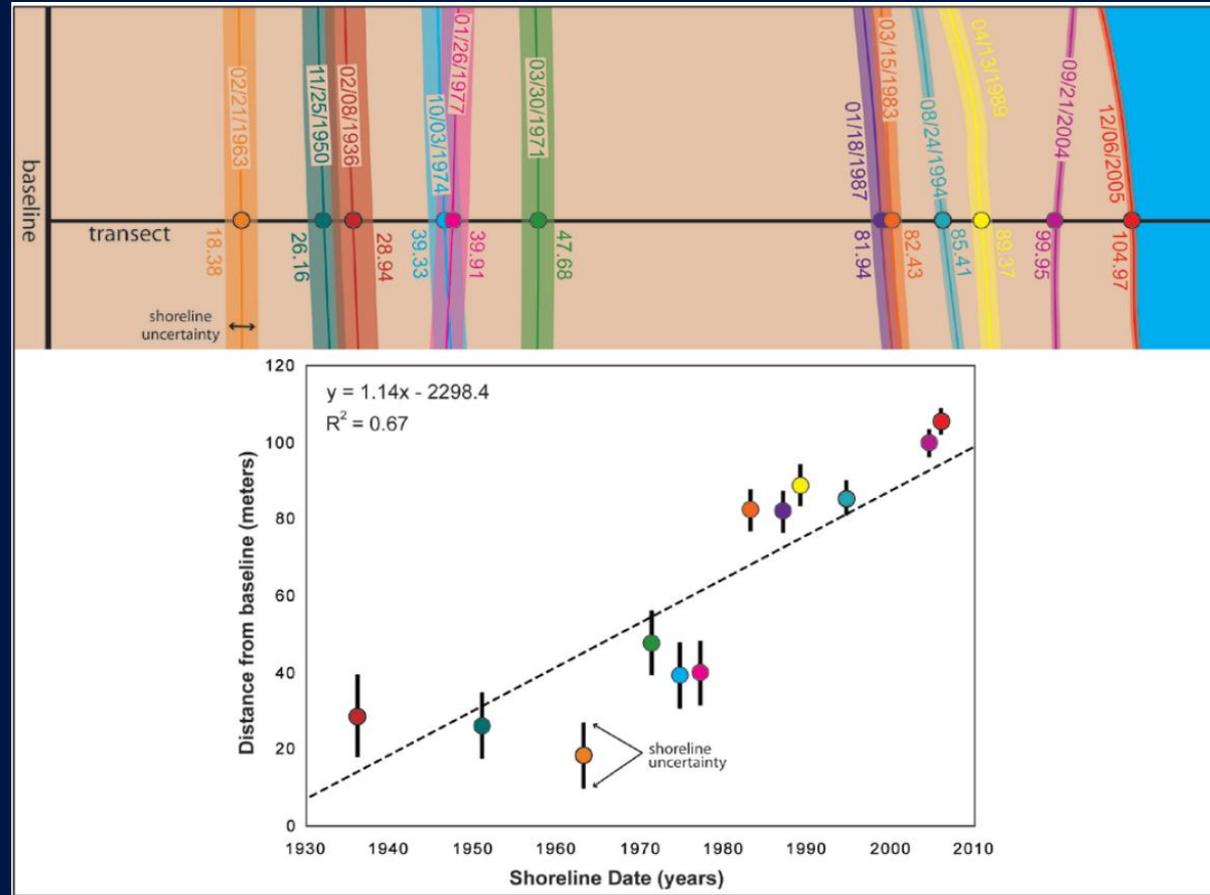
- Linear Regression
- Weighted Linear Regression
- End-point rate
- Least median of squares
- Kalman Filter/AOR



(Himmelstoss et al., 2009)

# TYPES OF SHORELINE CHANGE CALCULATIONS

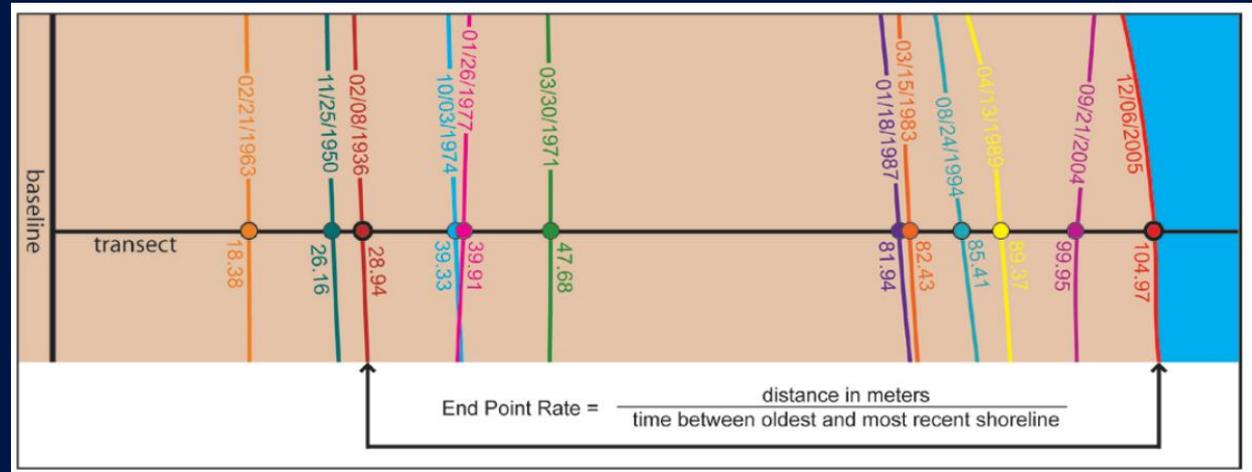
- Linear Regression
- Weighted Linear Regression
- End-point rate
- Least median of squares
- Kalman Filter/AOR



# TYPES OF SHORELINE CHANGE CALCULATIONS



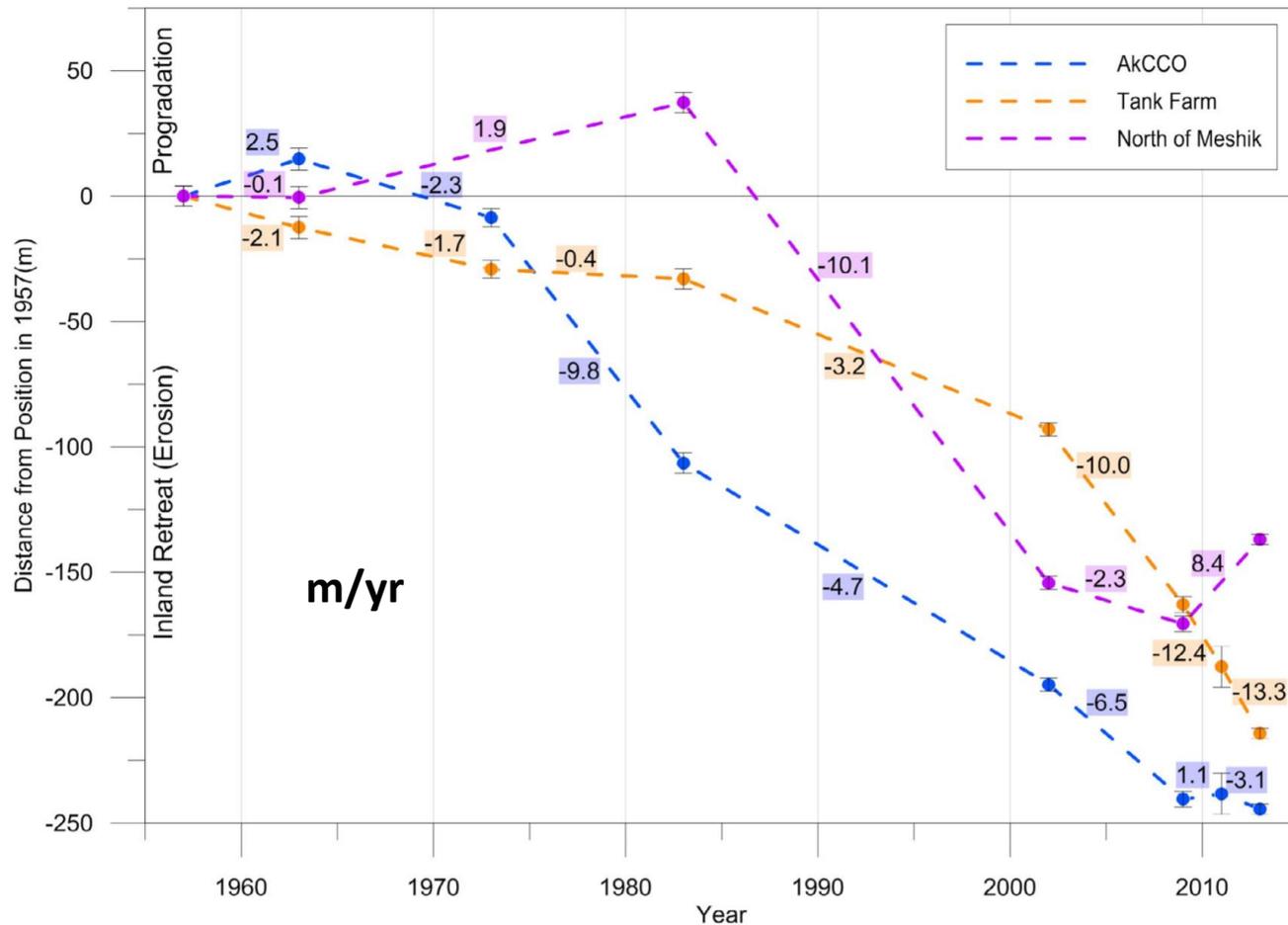
- Linear Regression
- Weighted Linear Regression
- **End-point rate**
- Least median of squares
- Kalman Filter/AOR



(Himmelstoss et al., 2009)

# TYPES OF SHORELINE CHANGE CALCULATIONS

Changes in Shoreline Position (1957-2013)



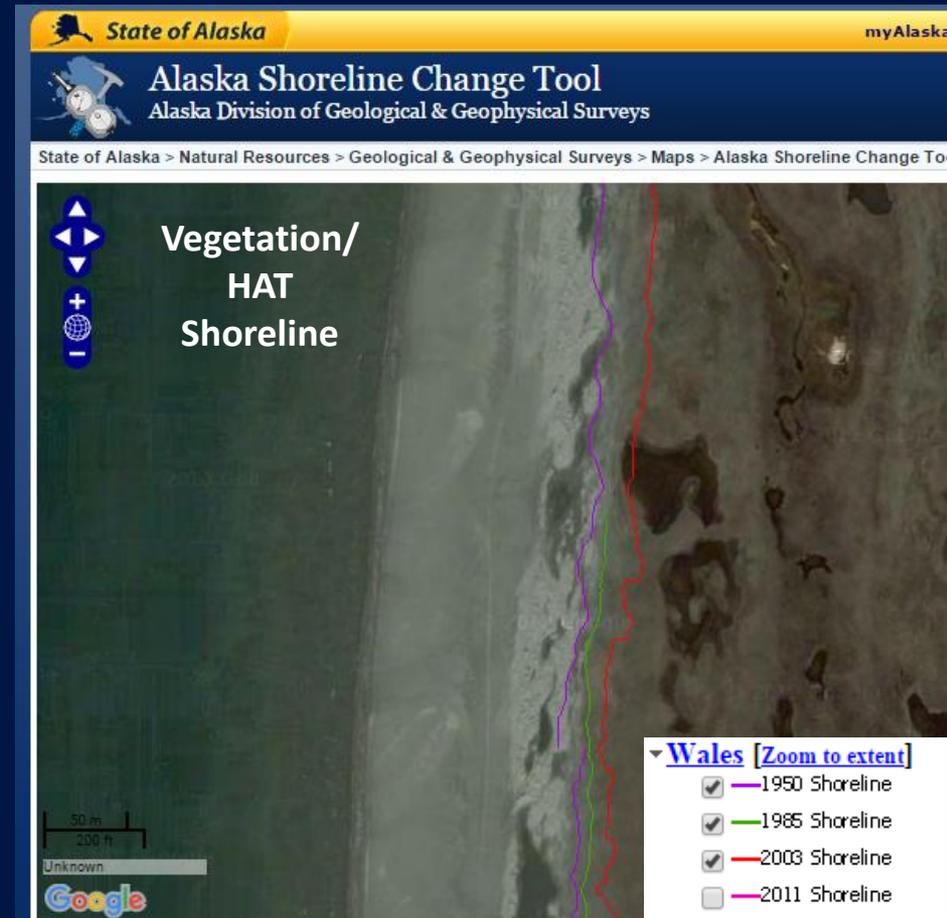
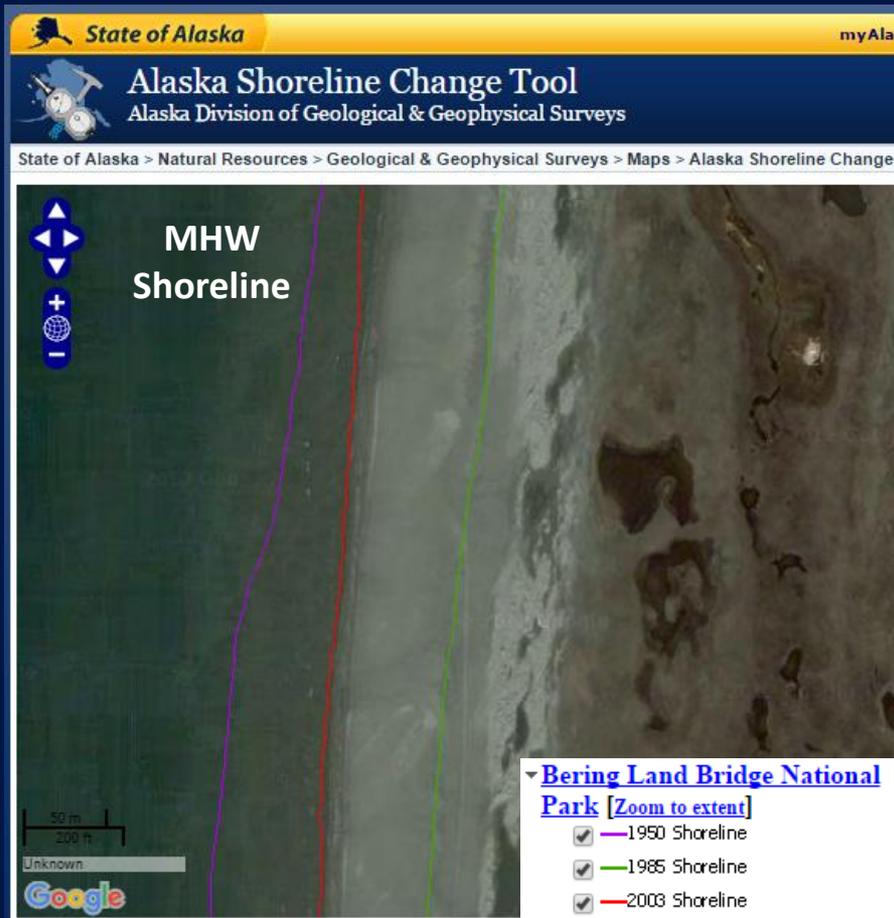
December 2007



# EXAMPLES OF SHORELINE CHANGE



*For the same location, two separate shorelines have been identified.  
The data result in very different rates of shoreline change.*

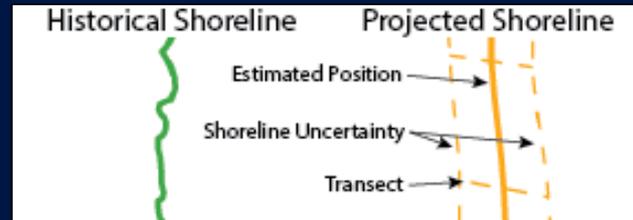


North of Wales

# PROJECTED SHORELINE POSITIONS



The new **Alaska Shoreline Change Tool** is an online tool that uses historical shorelines to determine a *long-term rate of change*, then *project* out from the most recent measured shoreline.



<http://maps.dggs.alaska.gov/shoreline>

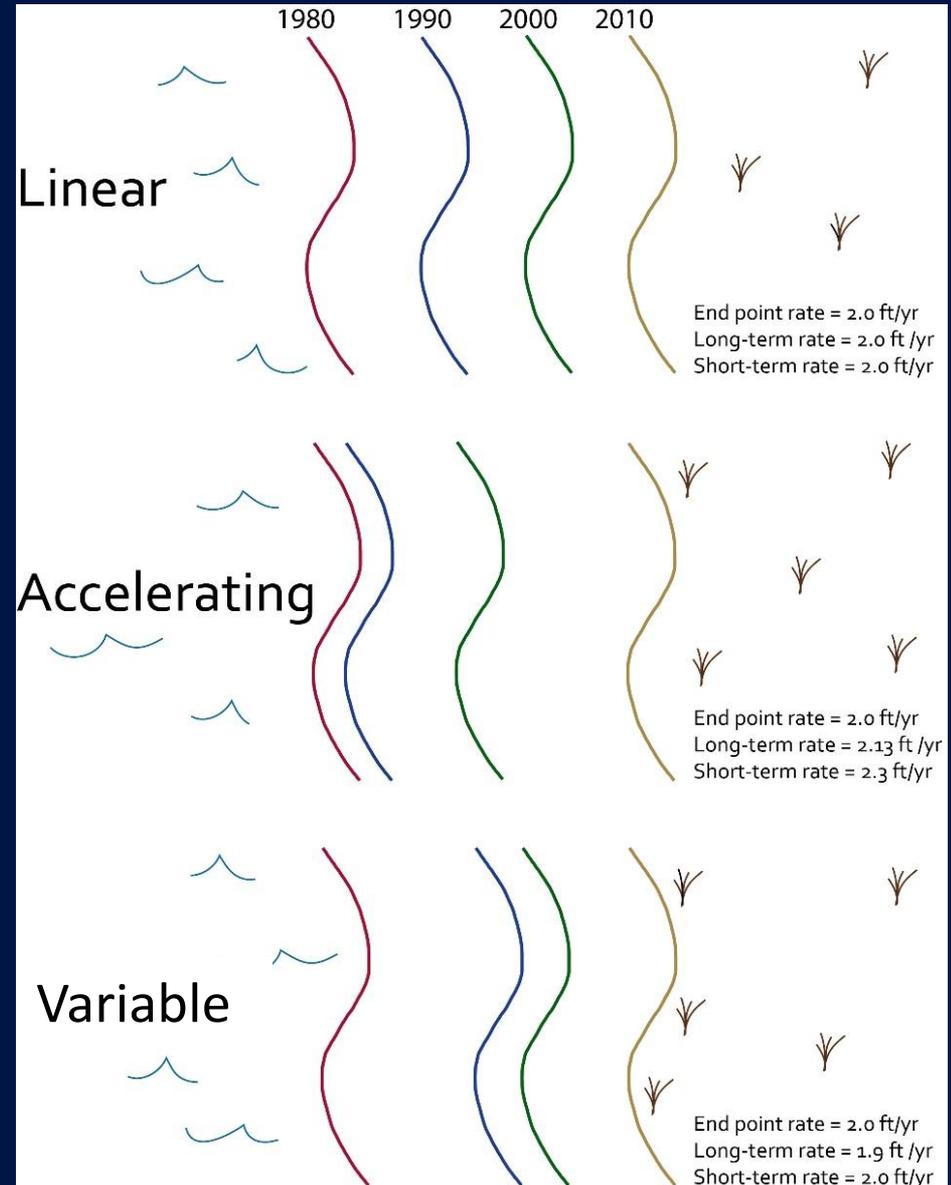
# PROJECTED SHORELINE POSITIONS

*Annualized rates of shoreline change can be projected into the future to determine potential locations of shoreline positions.*

For Example:  
 The long-term erosion rate is **2 ft/yr** so if we want to project the shoreline position to year 2030,

$$\begin{aligned} & \text{linear erosion} \\ & = (2030 \text{ yr} - 2010 \text{ yr}) * 2 \text{ ft/yr} \end{aligned}$$

we would expect **40 ft** of erosion between 2010 and 2030



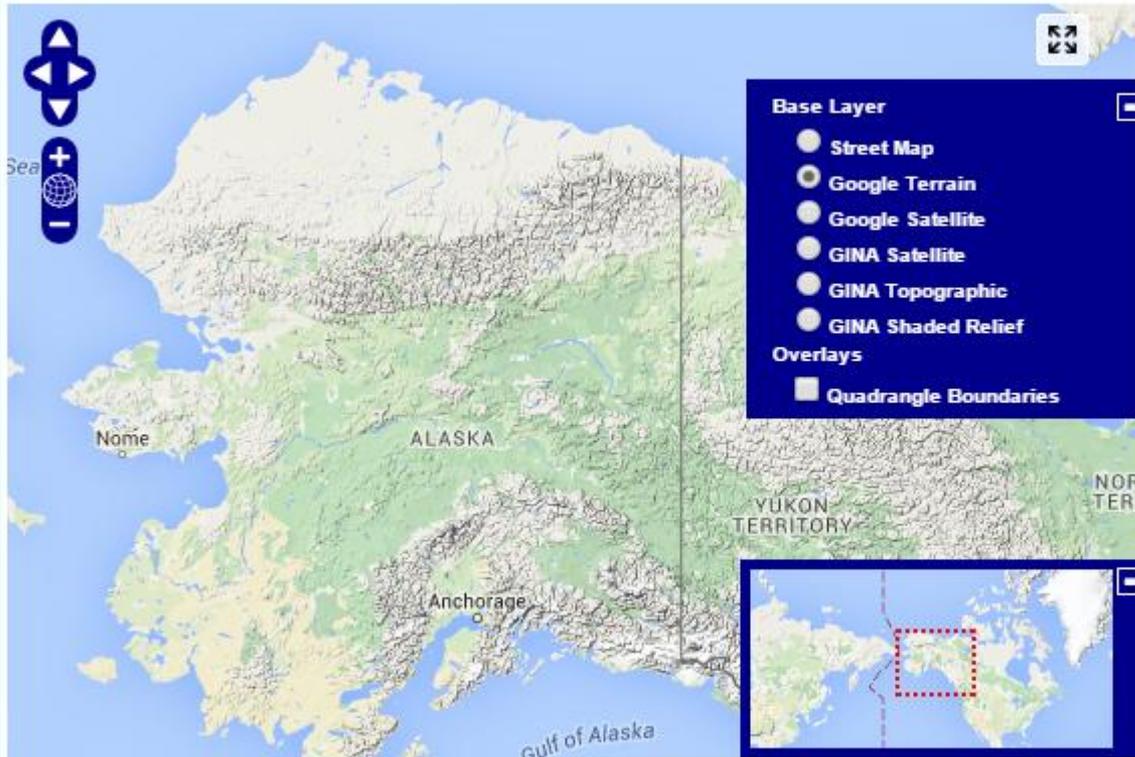
# Alaska Shoreline Change Tool



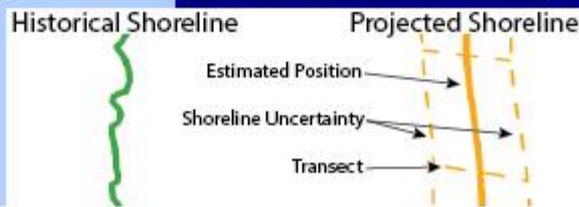
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## Alaska Shoreline Change Tool Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > Alaska Shoreline Change Tool



- ▶ [Port Heiden](#) [Zoom to extent]
- ▶ [Unalakleet](#) [Zoom to extent]
- ▶ [Wales](#) [Zoom to extent]
- ▶ [Kivalina](#) [Zoom to extent]
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- ▶ [Bering Land Bridge National Park](#) [Zoom to extent]
- ▶ [Cape Krusenstern National Monument](#) [Zoom to extent]



200 km  
100 mi  
Unknown



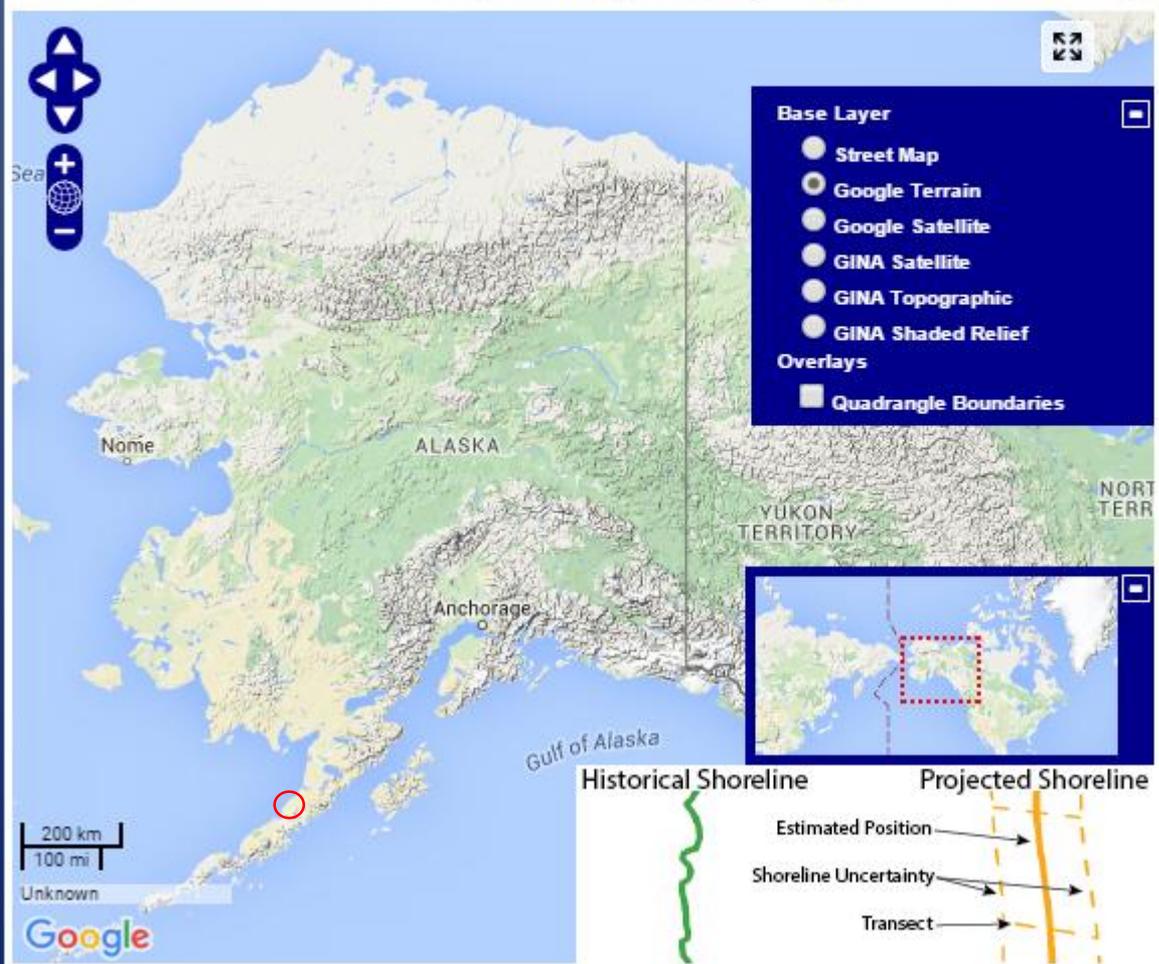
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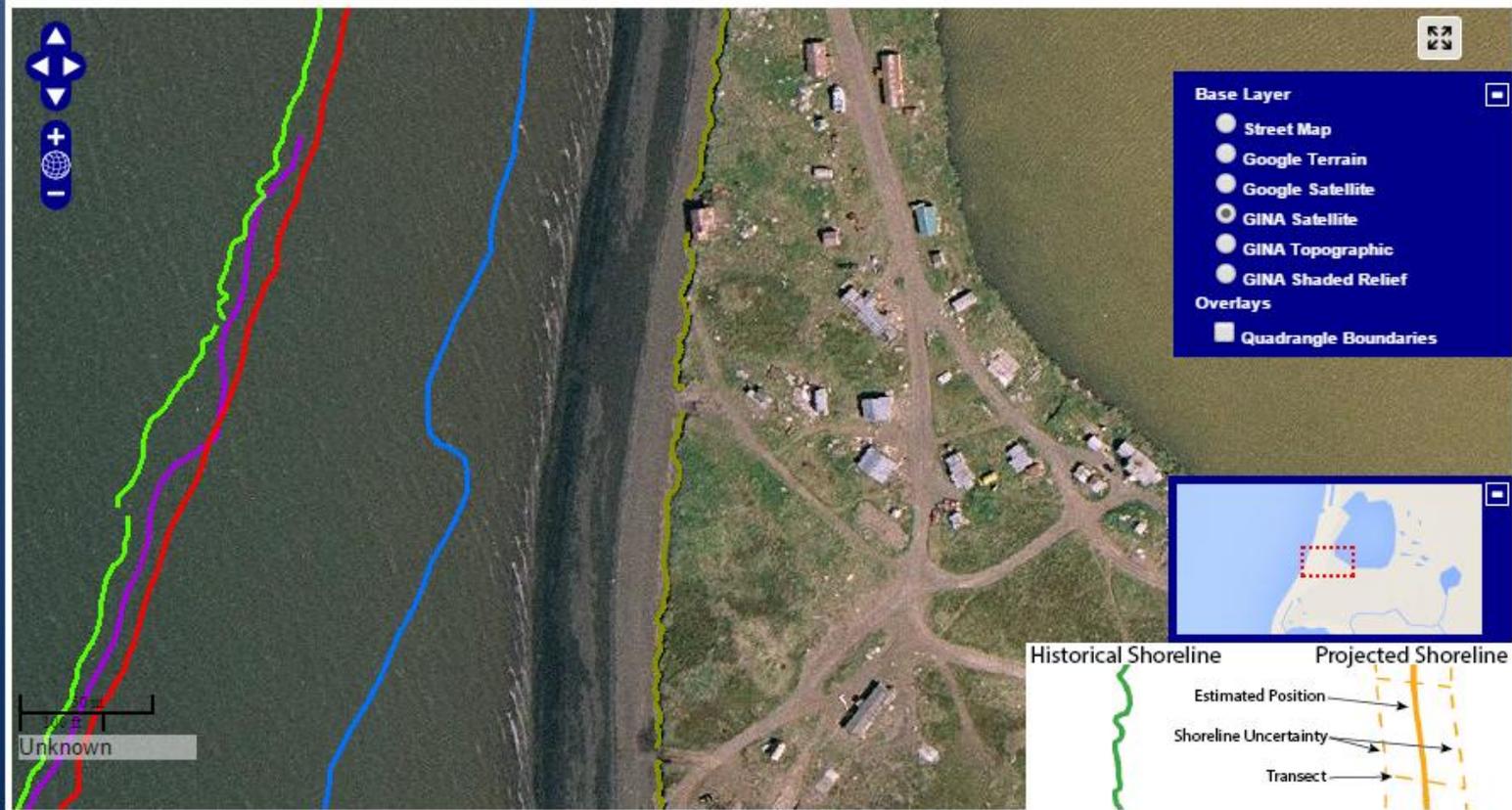
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# Alaska Shoreline Change Tool



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### Port Heiden [\[Zoom to extent\]](#)

- 1957 Shoreline
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- 1983 Shoreline
- 2002 Shoreline
- 2009 Shoreline
- 2011 Shoreline
- 2013 Measured Shoreline
- 2013 Implied Shoreline
- 2020 Projected Shoreline
- 2020 Uncertainty
- 2025 Projected Shoreline
- 2025 Uncertainty
- 2035 Projected Shoreline
- 2035 Uncertainty

### Unalakleet [\[Zoom to extent\]](#)

### Wales [\[Zoom to extent\]](#)

### Kivalina [\[Zoom to extent\]](#)

### Central Beaufort [\[Zoom to extent\]](#)

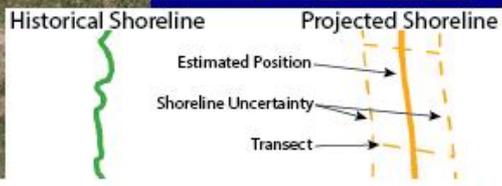
### East Beaufort [\[Zoom to extent\]](#)

### East Chukchi [\[Zoom to extent\]](#)

### West Beaufort [\[Zoom to extent\]](#)

### Bering Land Bridge National Park [\[Zoom to extent\]](#)

### Cape Krusenstern National Monument [\[Zoom to extent\]](#)



# Alaska Shoreline Change Tool



State of Alaska

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## Alaska Shoreline Change Tool Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > Alaska Shoreline Change Tool

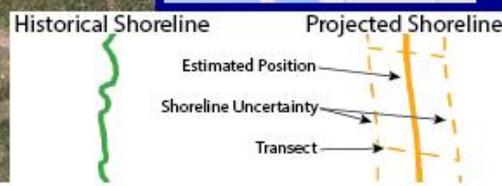


**Base Layer**

- Street Map
- Google Terrain
- Google Satellite
- GINA Satellite
- GINA Topographic
- GINA Shaded Relief

**Overlays**

- Quadrangle Boundaries



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# Alaska Shoreline Change Tool

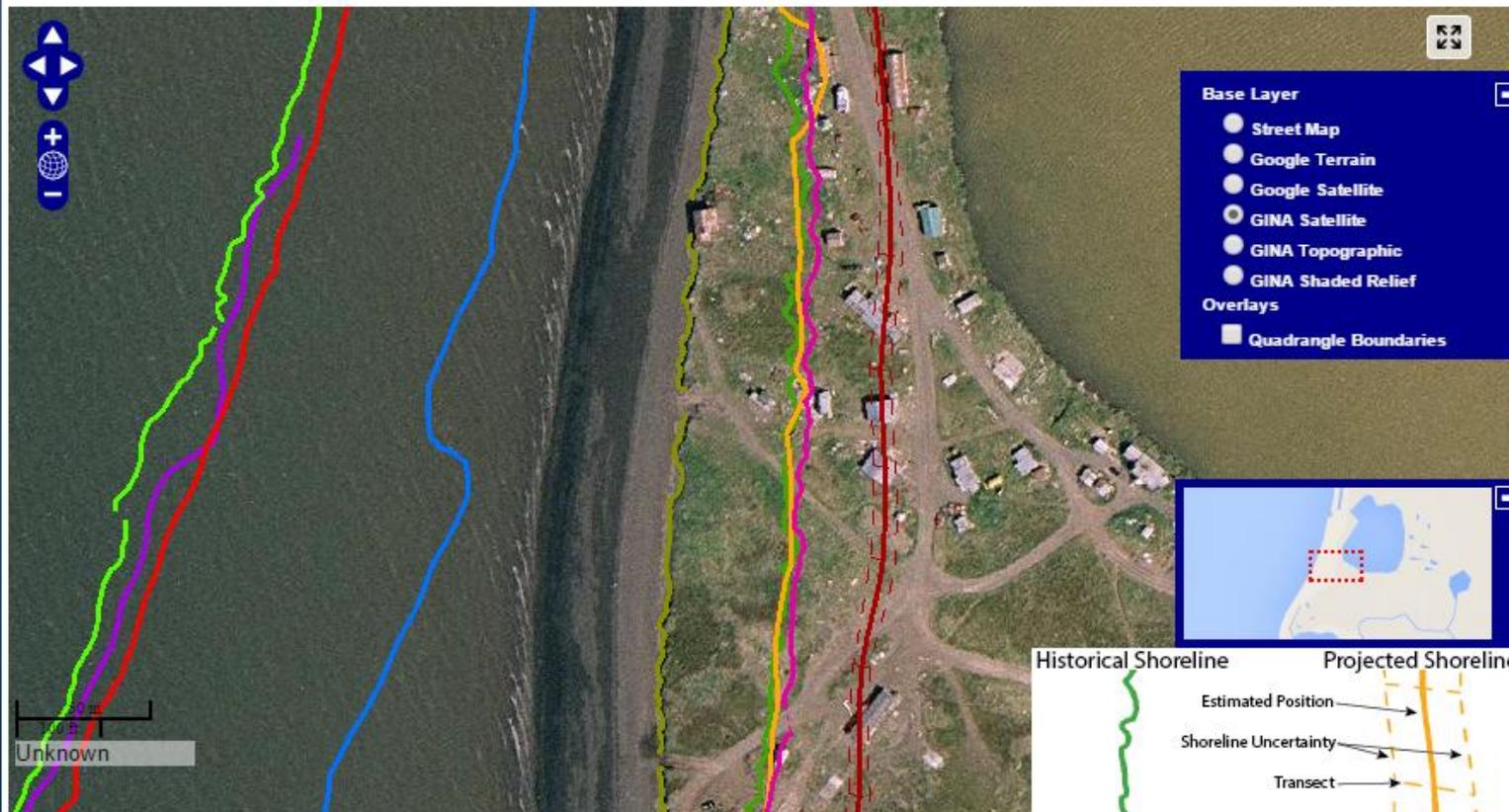


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## Alaska Shoreline Change Tool Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > Alaska Shoreline Change Tool



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### Cape Krusenstern National Monument [Zoom to extent]

Historical Shoreline      Projected Shoreline

Estimated Position

Shoreline Uncertainty

Transect

Projected Shoreline

Estimated Position

Shoreline Uncertainty

Transect

Projected Shoreline

Estimated Position

Shoreline Uncertainty

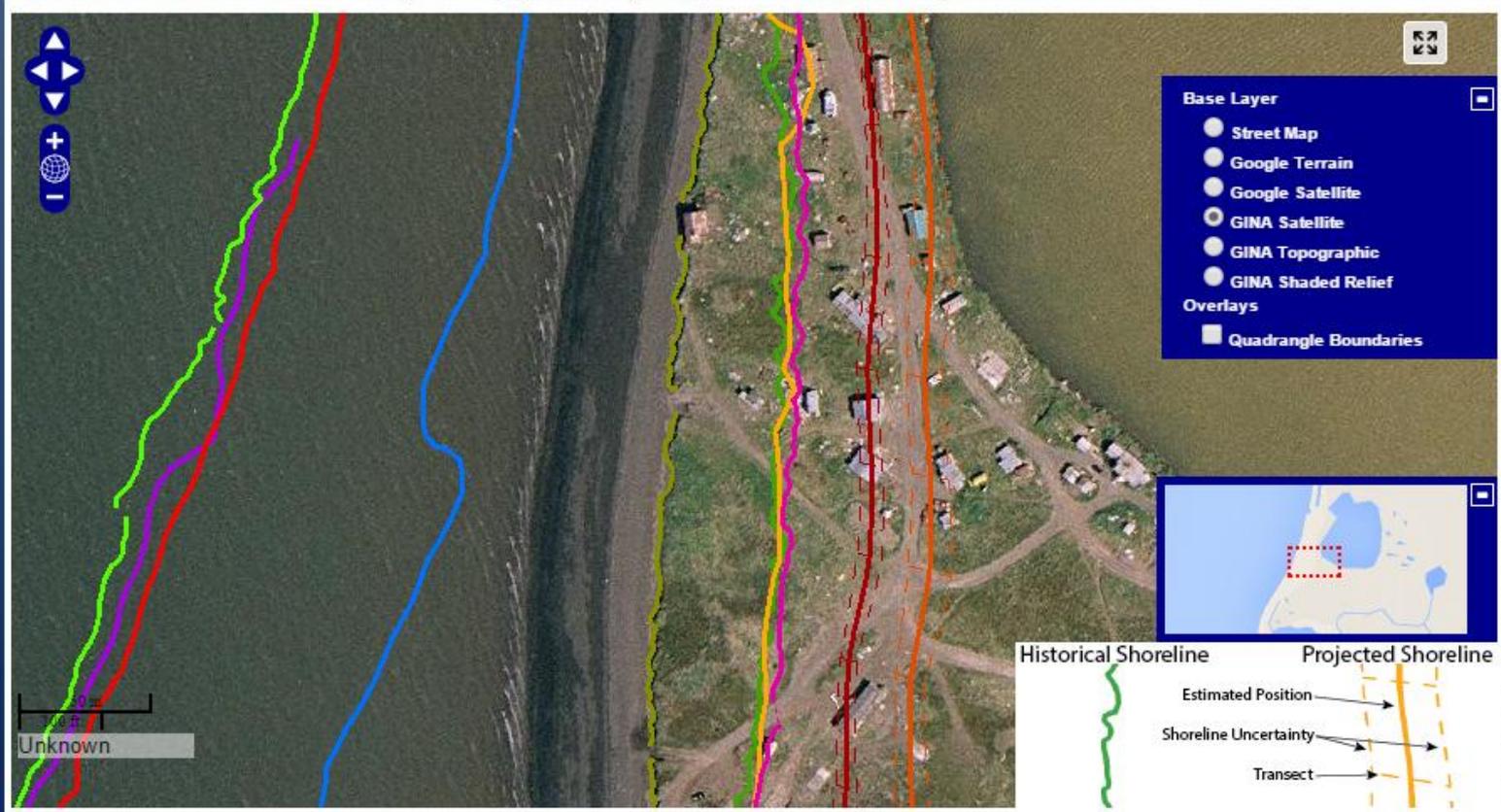
Transect

# Alaska Shoreline Change Tool



## Alaska Shoreline Change Tool Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > Alaska Shoreline Change Tool



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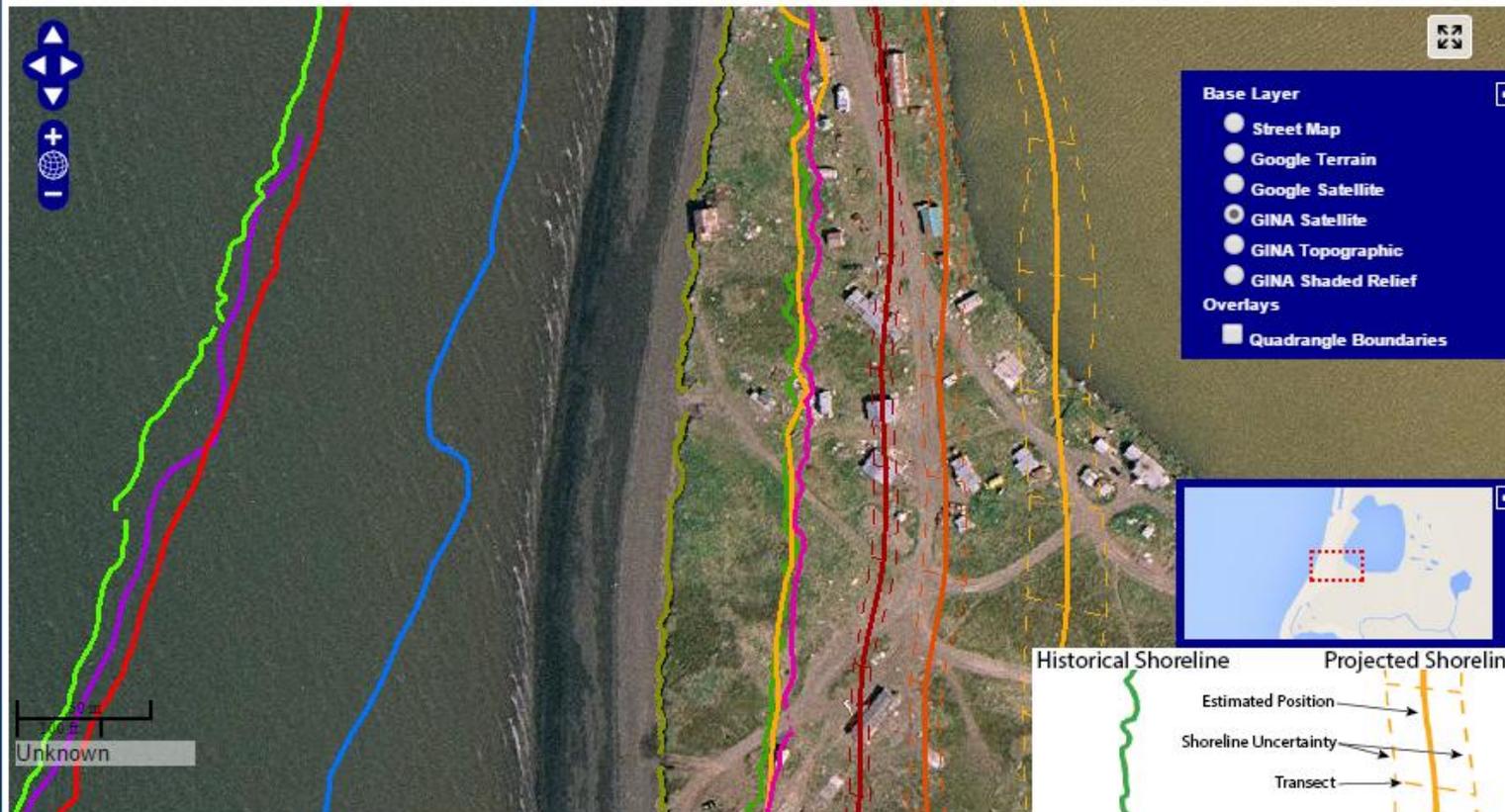


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# APPLICATIONS AND LIMITATIONS OF PROJECTED SHORELINE POSITIONS



1. How long is the record of historical shoreline positions used in the calculation?
2. What type of shoreline indicator is used?
3. How accurate are the historical shoreline positions used in the analysis?
4. What type of calculation is used to project rates of change?



# QUESTIONS?



# CONTACT INFO



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*Phone: 907-750-6155*



*Nicole Kinsman  
NOAA*

*[nicole.kinsman@noaa.gov](mailto:nicole.kinsman@noaa.gov)*

*Cell: 202-306-5736*



# REFERENCES



Gould, A.I., Kinsman, N.E.M., and Hendricks, M.D., 2015, Guide to projected shoreline positions in the Alaska shoreline change tool, in DGGs Staff, Alaska shoreline change tool: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 158, 11 p. doi:[10.14509/29503](https://doi.org/10.14509/29503)

Himmelstoss, E.A. 2009. "DSAS 4.0 Installation Instructions and User Guide" in: Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan. 2009 Digital Shoreline Analysis System (DSAS) version 4.0 — An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278. \*updated for version 4.3.

Kinsman, N.E.M., and Gould, A.I., 2014, Contemporary shoreline retreat rates at Meshik in Port Heiden, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2014-4, 21 p. doi:[10.14509/27321](https://doi.org/10.14509/27321)

Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan, 2009, Digital Shoreline Analysis System (DSAS) version 4.0— An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278.

Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Miller, T.L., Digital Shoreline Analysis System (DSAS) version 3.0; An ArcGIS® extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2005-1304.

## Online Links:

<http://maps.dggs.alaska.gov/shoreline>

<http://portal.aoots.org/>



Coastal Impact  
Assistance Program