

Use of High-Resolution Orthoimagery for Coastal Erosion Studies in Northwestern Alaska

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See also: instaar.colorado.edu/QGISL/ARCN/

Goals

- Present a “case study” for use of high-res. orthoimagery in environmental change research
- Provide an “end-user” perspective on challenges and opportunities

Coastal Erosion

- Rapid, observable change to the environment
- Multiple impacts on a variety of habitats
- Fragile coast is a sensitive indicator of “stressors”:
 - ✓ direct human disturbance
 - ✓ climate change:
 - sea level rise
 - increased permafrost melting
 - change in frequency and intensity of storms
 - longer ice-free season



Thermokarst Degradation and Bluff Erosion, E. of Anigaaq

1952

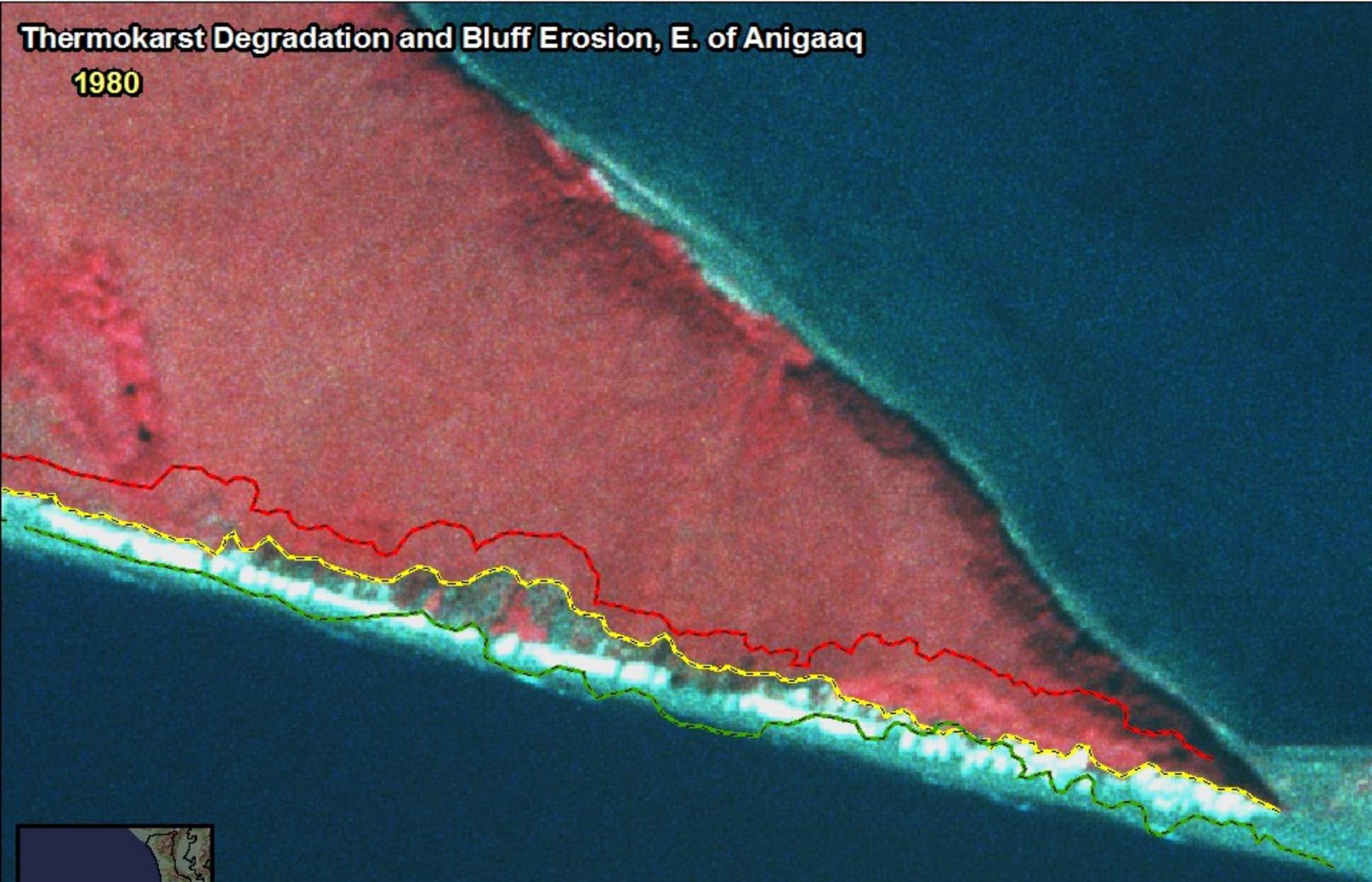


0 60 meters

A scale bar is located at the bottom left of the image. It consists of a horizontal line with a vertical tick at the left end labeled '0' and another vertical tick at the right end labeled '60 meters'. The bar is used to provide a sense of scale for the photograph.

Thermokarst Degradation and Bluff Erosion, E. of Anigaaq

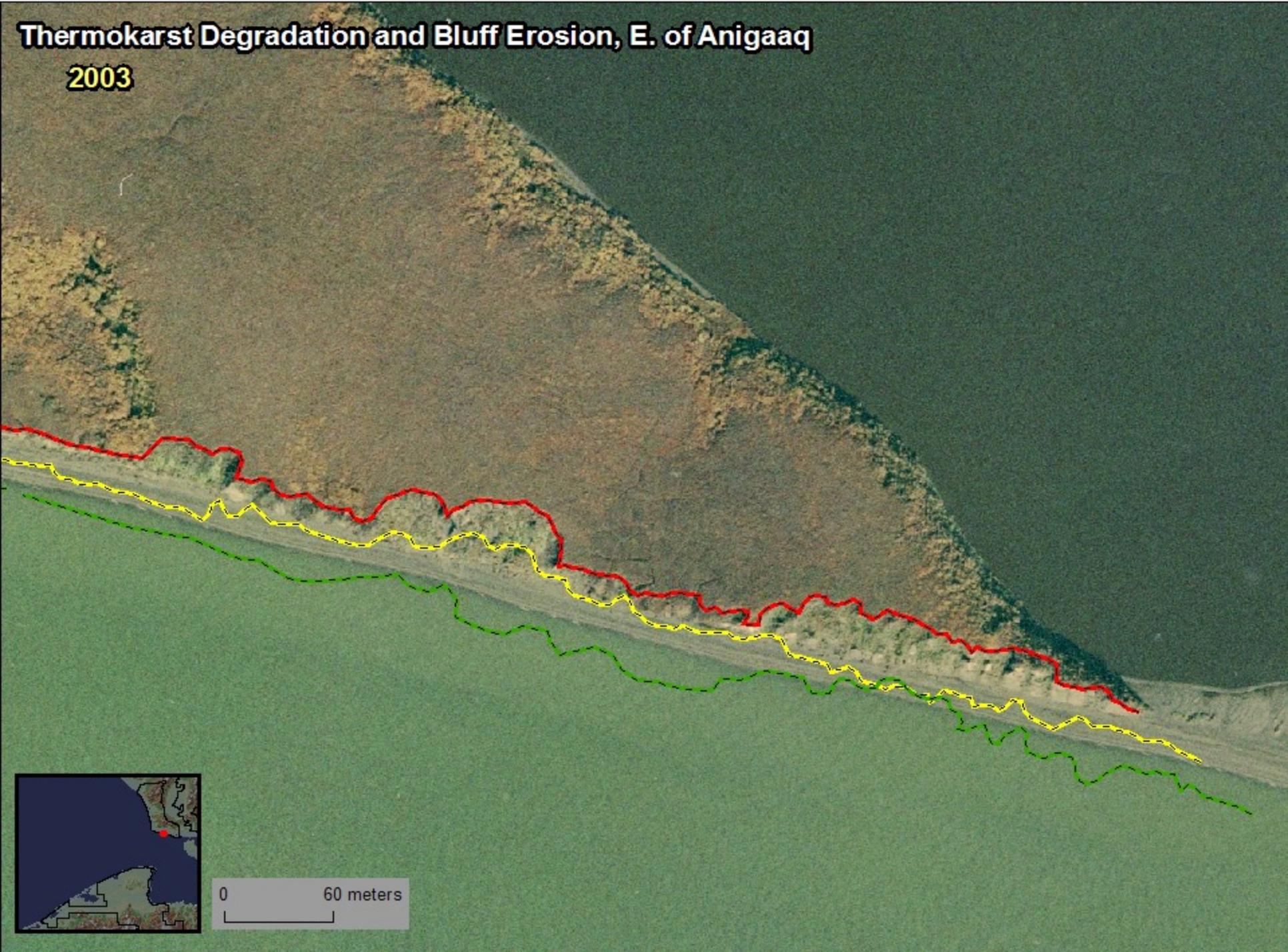
1980



0 60 meters

Thermokarst Degradation and Bluff Erosion, E. of Anigaaq

2003



0 60 meters

Flooding of Kiligmak Inlet

1952



0 150 meters

A horizontal scale bar is located at the bottom center of the image. It is marked with '0' at the left end and '150 meters' at the right end, with a vertical tick mark at the 150-meter point.

Flooding of Kiligmak Inlet

1980



0 150 meters



Flooding of Kiligmak Inlet

2003



0 150 meters

Talk Overview

- Field measurements
- Orthoimagery
- GIS results

Study Area

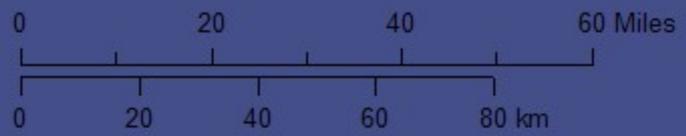
Chukchi Sea

Cape
Krusenstern
N. M.

Kivalina

Noatak

Kotzebue



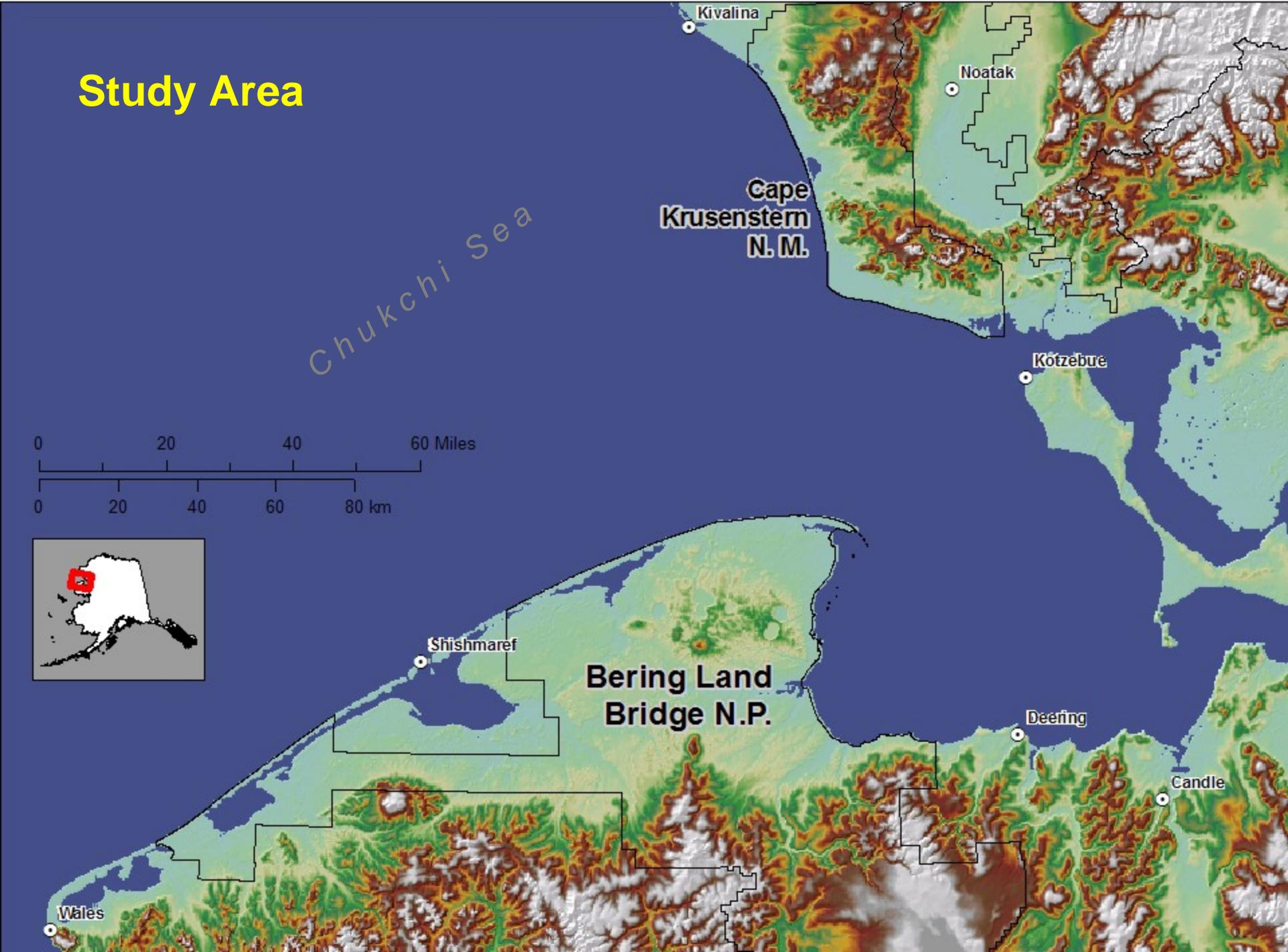
Shishmaref

Bering Land
Bridge N.P.

Deering

Candle

Wales



Lawsuit



Village sues energy firms for climate change

KIVALINA: 23 companies blamed for emissions tied to coastal erosion threat.

By ELIZABETH BLUEMINK
ebluemink@adn.com | ebluemink@adn.com
Published: February 27th, 2008 04:02 AM
Last Modified: February 27th, 2008 08:54 AM

The eroding village of Kivalina in the Northwest Arctic is suing Exxon Mobil and 23 other energy companies for damage related to global warming.



RON ENGSTROM / Anchorage Daily News

[Click to enlarge](#)

The suit was filed Tuesday in the U.S. District Court in San Francisco on behalf of the Native village's federally recognized tribe and its city government, according to lawyers for the village.

Kivalina, located on a shrinking barrier island in the Chukchi Sea, says the energy companies should pay to move the village to safer ground.

"We need to relocate now before we lose lives," said Janet Mitchell, city administrator for Kivalina, in a news release announcing the lawsuit.

Related Documents

- [PDF: Kivalina complaint](#)

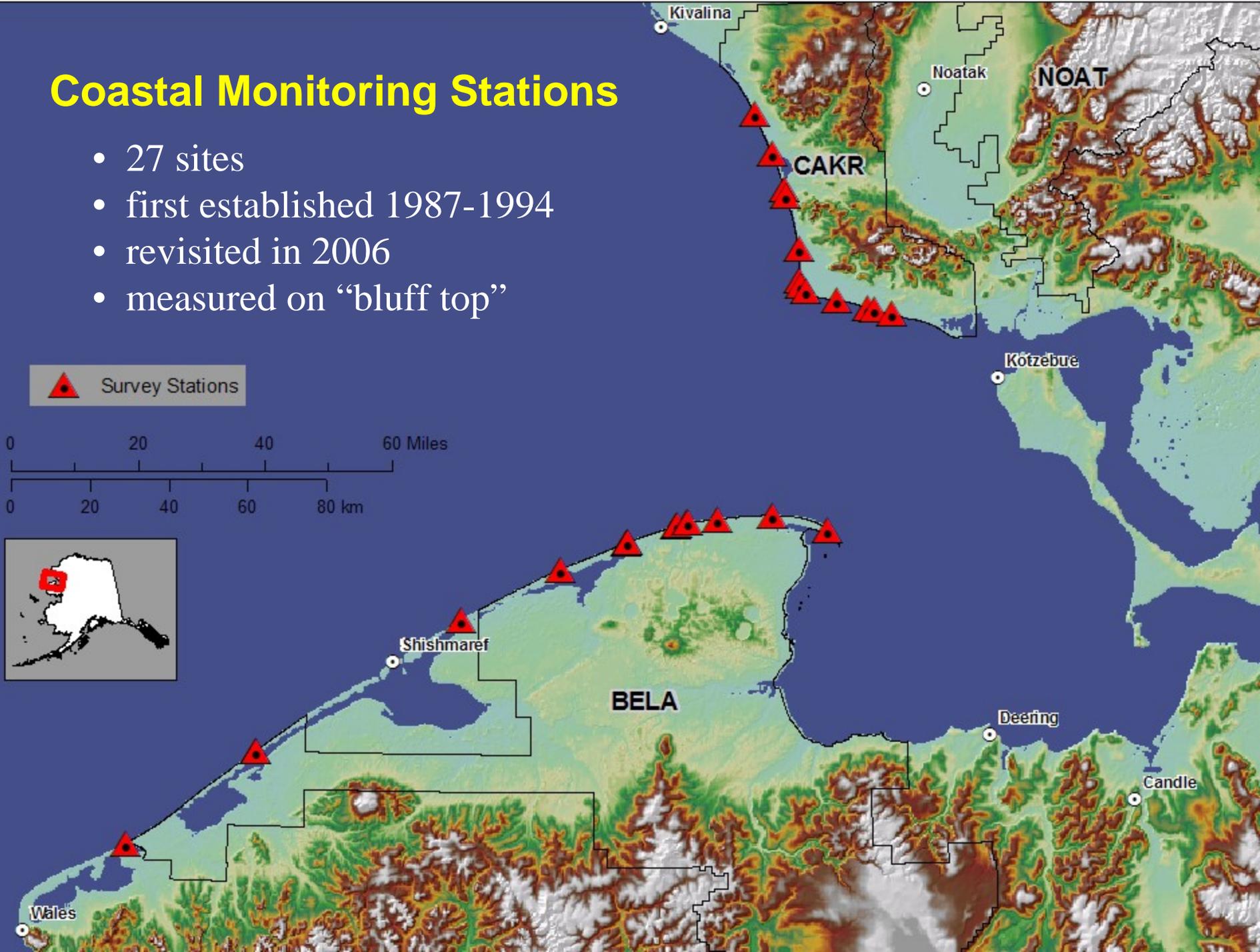
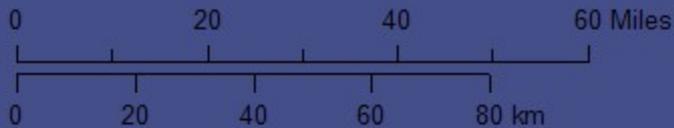
More Global Warming stories >>

- [Village sues energy firms for climate change](#)
- [State begins planning to rescue villages from sea](#)
- [Polar ice pack loss may break 2007 record](#)
- [Pollution runoff is eroding Alaska coast](#)
- [Conservationists to sue over polar bear status](#)

Coastal Monitoring Stations

- 27 sites
- first established 1987-1994
- revisited in 2006
- measured on “bluff top”

 Survey Stations

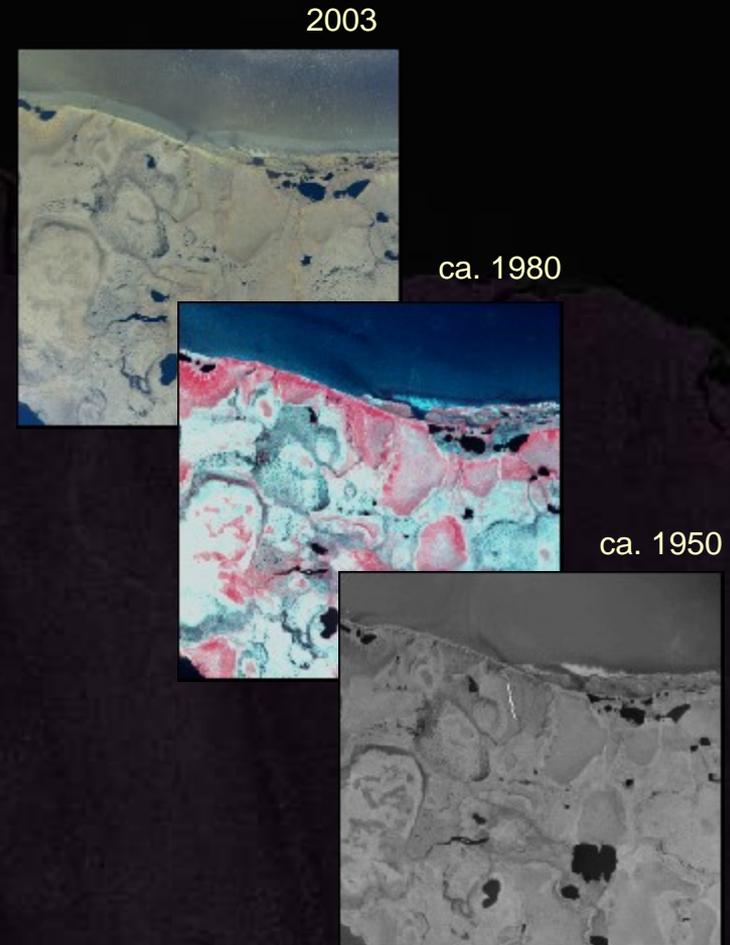


Field Methods



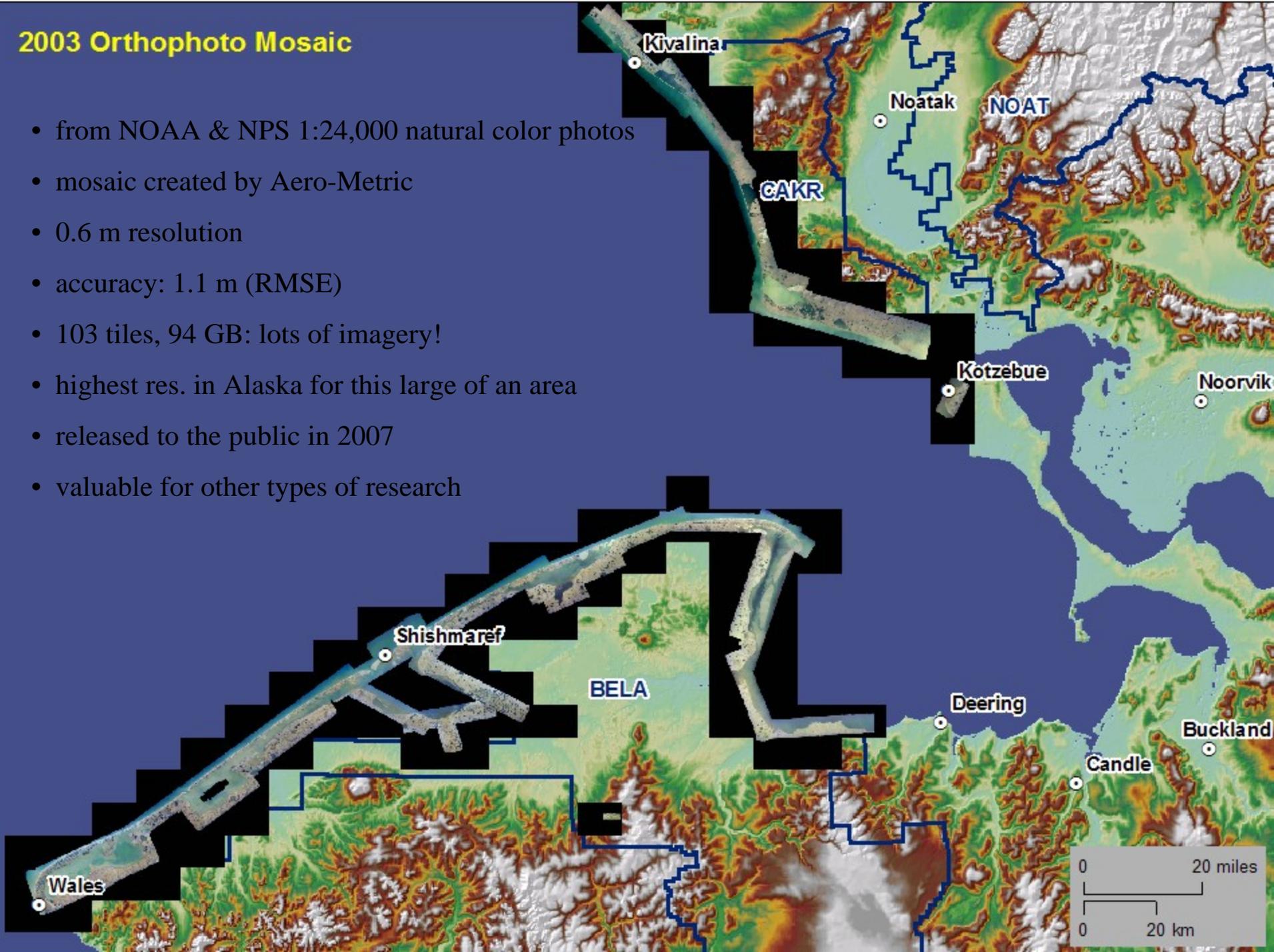
Remote Sensing & GIS Approach

- High-resolution base imagery
 - 2003 orthophoto mosaic
- Historic aerial photographs
 - orthorectified photos for ca. 1980
 - orthorectified photos for ca. 1950
- Comparison of different “time slices” allows us to detect and measure change



2003 Orthophoto Mosaic

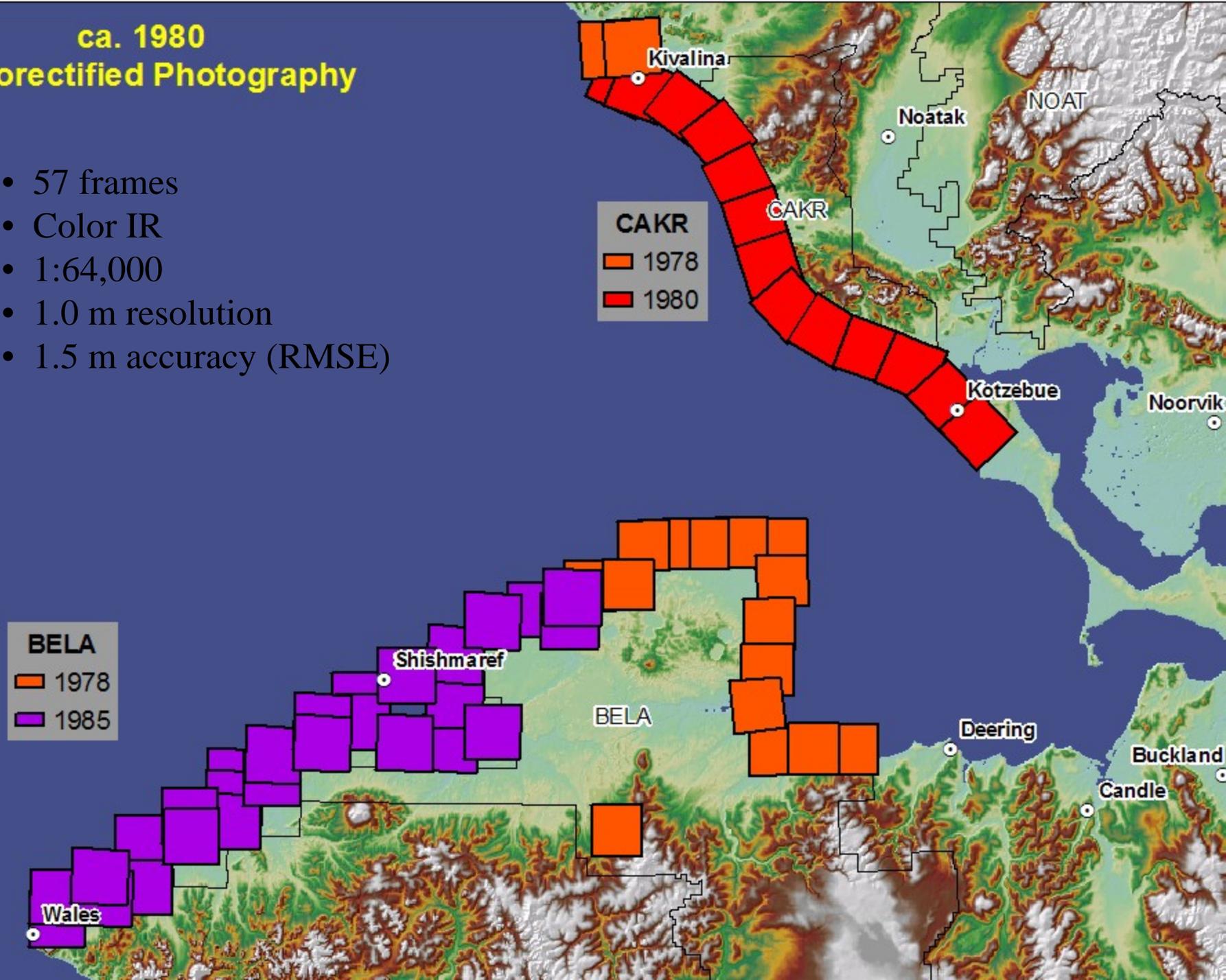
- from NOAA & NPS 1:24,000 natural color photos
- mosaic created by Aero-Metric
- 0.6 m resolution
- accuracy: 1.1 m (RMSE)
- 103 tiles, 94 GB: lots of imagery!
- highest res. in Alaska for this large of an area
- released to the public in 2007
- valuable for other types of research



ca. 1980

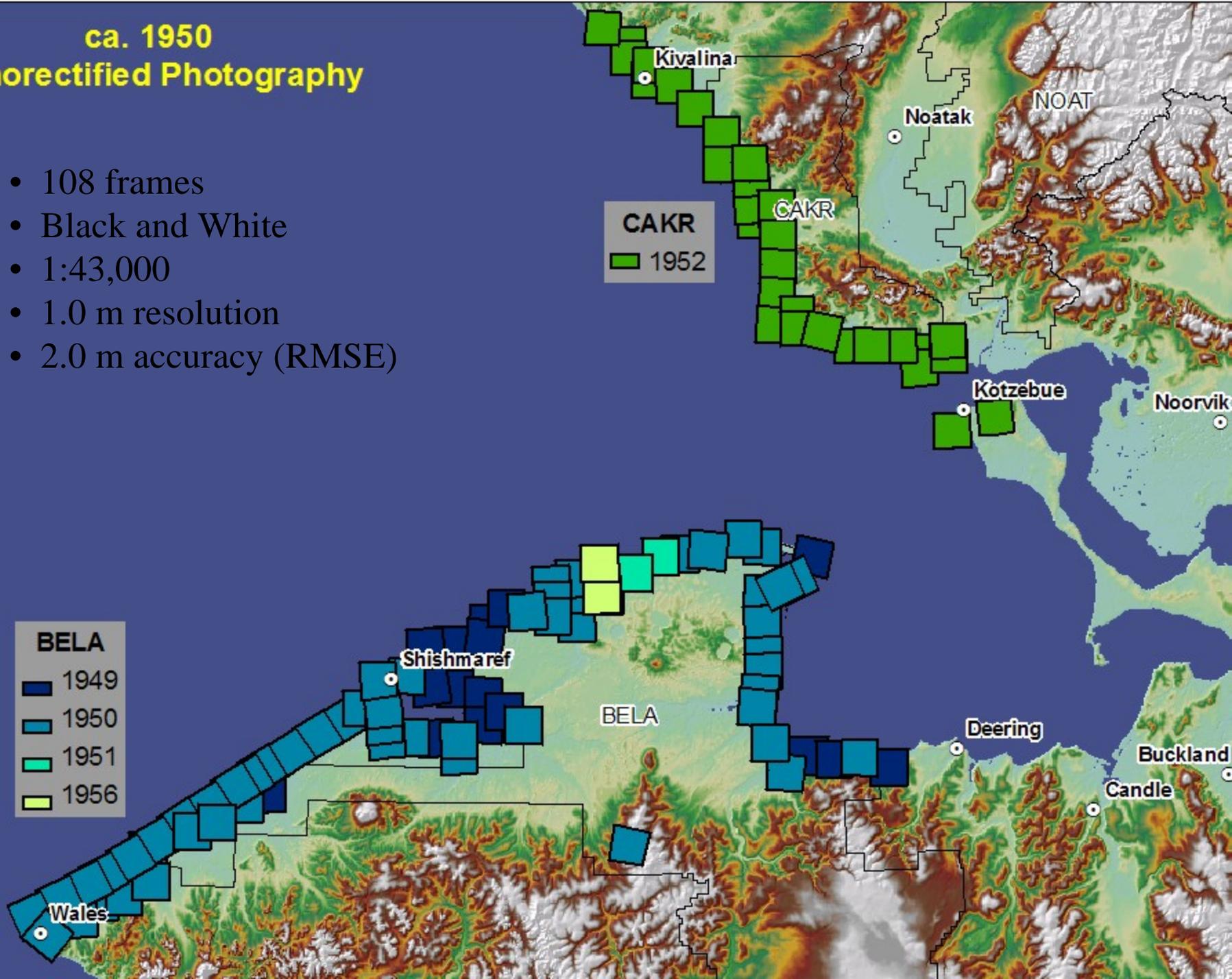
Orthorectified Photography

- 57 frames
- Color IR
- 1:64,000
- 1.0 m resolution
- 1.5 m accuracy (RMSE)



ca. 1950
Orthorectified Photography

- 108 frames
- Black and White
- 1:43,000
- 1.0 m resolution
- 2.0 m accuracy (RMSE)



Broader Use of the Imagery

Beyond analysis of coastal change, the imagery is of interest to land managers, scientists, and others for observation and study of natural features and ecosystems.

- cultural resources and archeological sites
- ecosystem components such as coastal zones, wetlands, geology, soils, permafrost, lake and stream hydrology, and vegetation assemblages
- marine, terrestrial, and freshwater habitats for a variety of animals

Available to the Public:

- readme file
- 2003 orthophoto mosaic (103 tiles)
 - image files (.tif, .tfw, .rrd)
 - sid files (.sid, .sdw)
 - metadata files (.html, .txt, .xml)
- ca. 1980 orthorectified photos (57 frames)
 - image files (.tif, .rrd) *Note: georeferencing info. embedded in .tif*
 - metadata files (.html, .txt, .xml)
- ca. 1950 orthorectified photos (108 frames)
 - image files (.tif, .rrd) *Note: georeferencing info. embedded in .tif*
 - metadata files (.html, .txt, .xml)
- accessory layers
 - 2003 image extent showing NPS vs. NOAA source areas
 - index shapefiles *Note: attributed with details*
 - 2003 tiles
 - ca. 1980 frames
 - ca. 1950 frames

Available to the Public, cont'd:

The three datasets are available on external hard drive.

Contact:

Arctic Network Data Manager
National Park Service
Arctic Network Inventory and Monitoring Program
4175 Geist Road
Fairbanks, AK 99709-3420
907-455-0600
Scott_Miller@nps.gov

Also available through <http://AlaskaMapped.org>.

Previously Released for Barrow

- GCP database
- 2002 Intermap IFSAR
 - ORRI
 - DSM/DTM
- 2002 Quickbird scenes
- Orthorectified aerial photography
- Accessory layers

Shoreline Reference Feature (SRF):

“bluff top” (wave-cut scarp)



Mainland bluff



Barrier island or spit

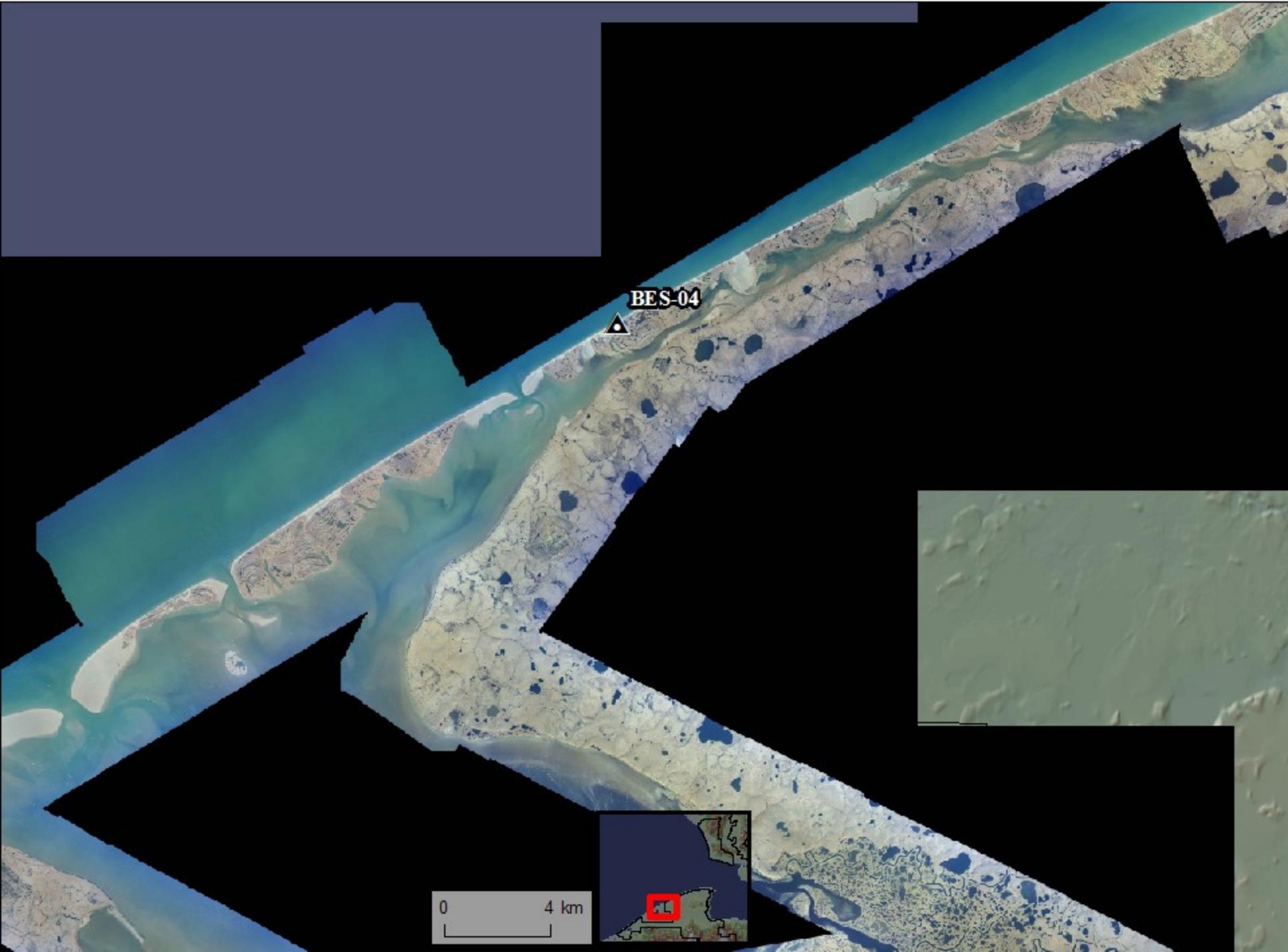


Beach ridge complex





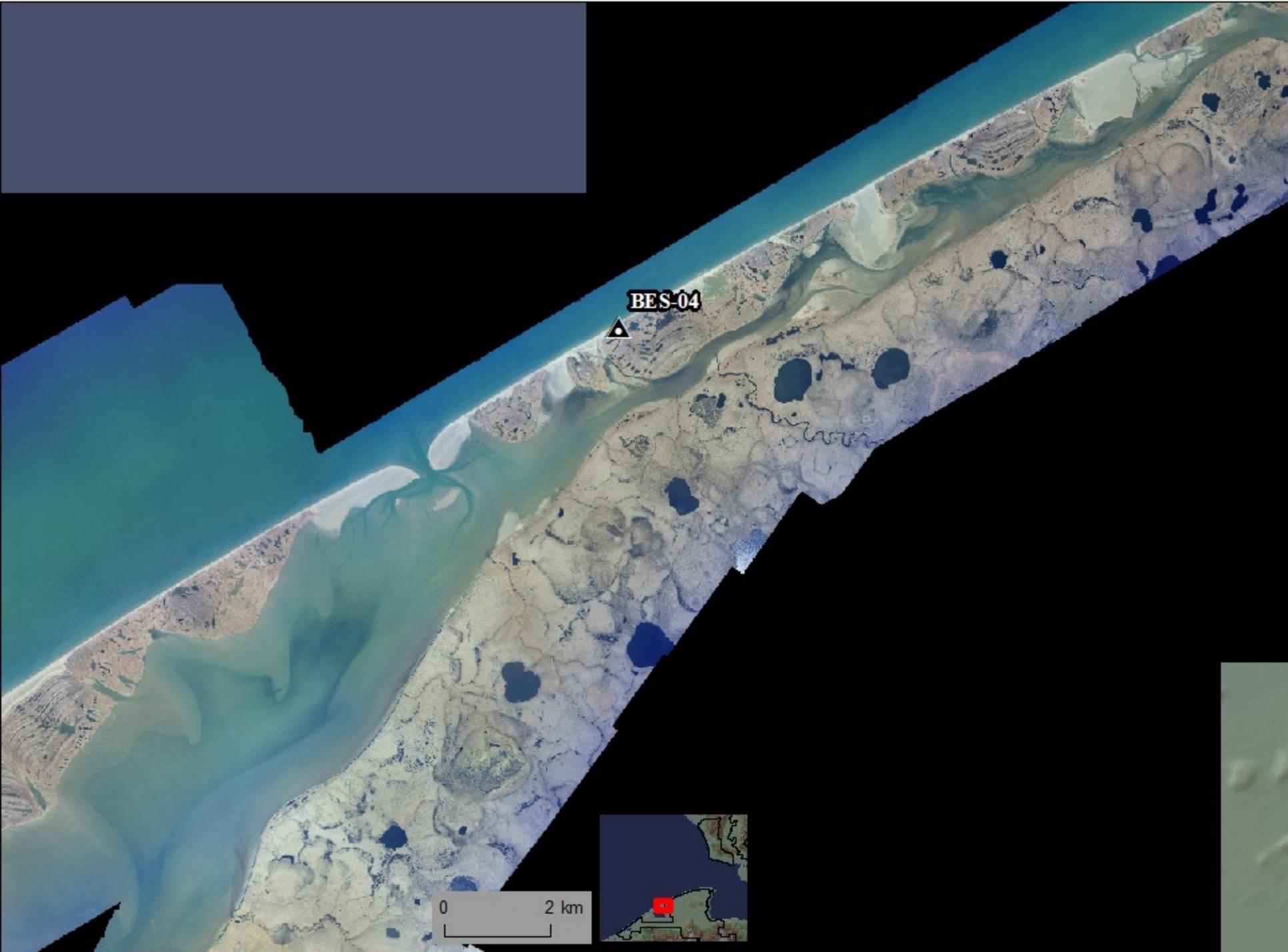




BES-04

0 4 km

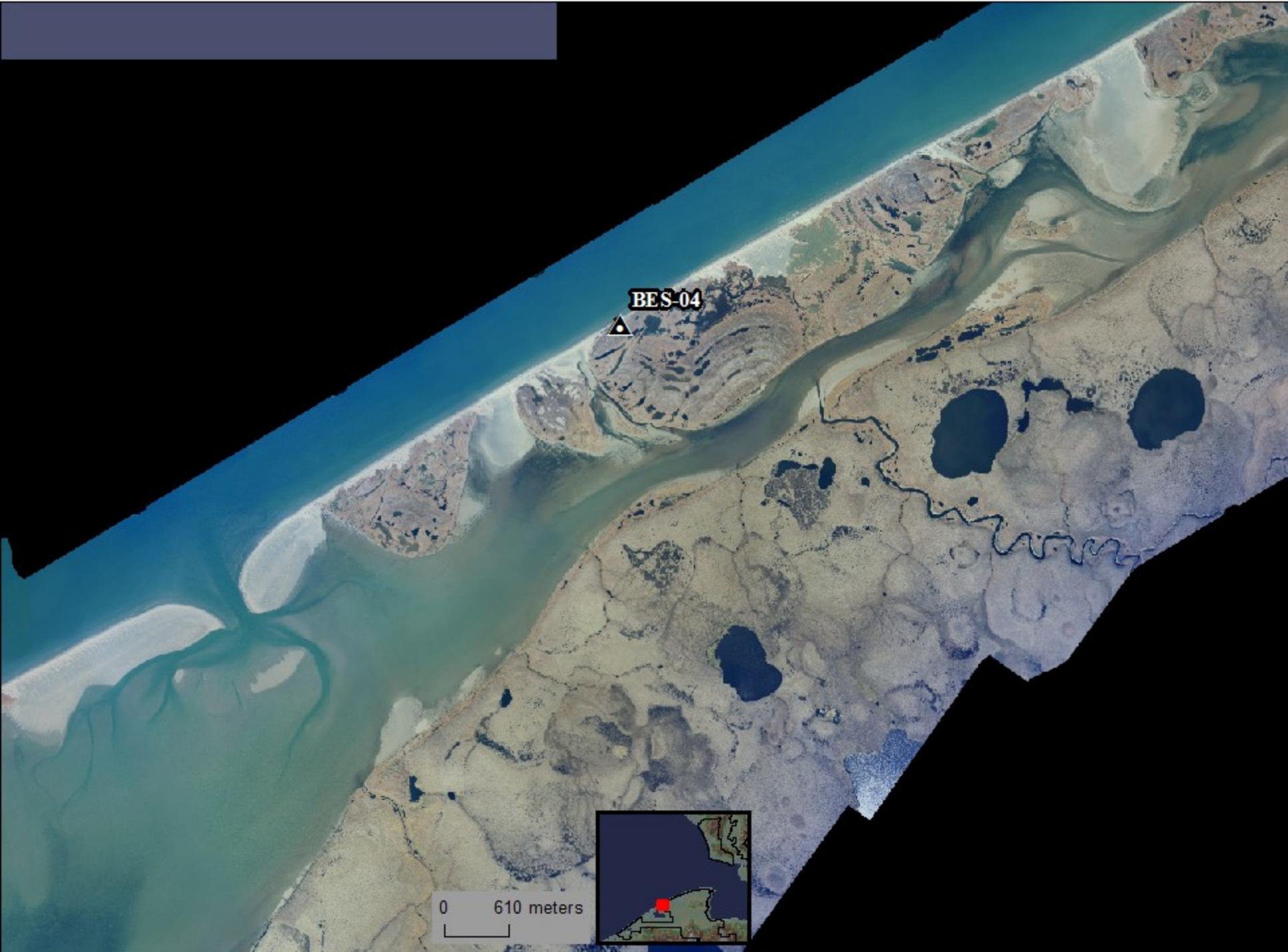




BES-04

0 2 km



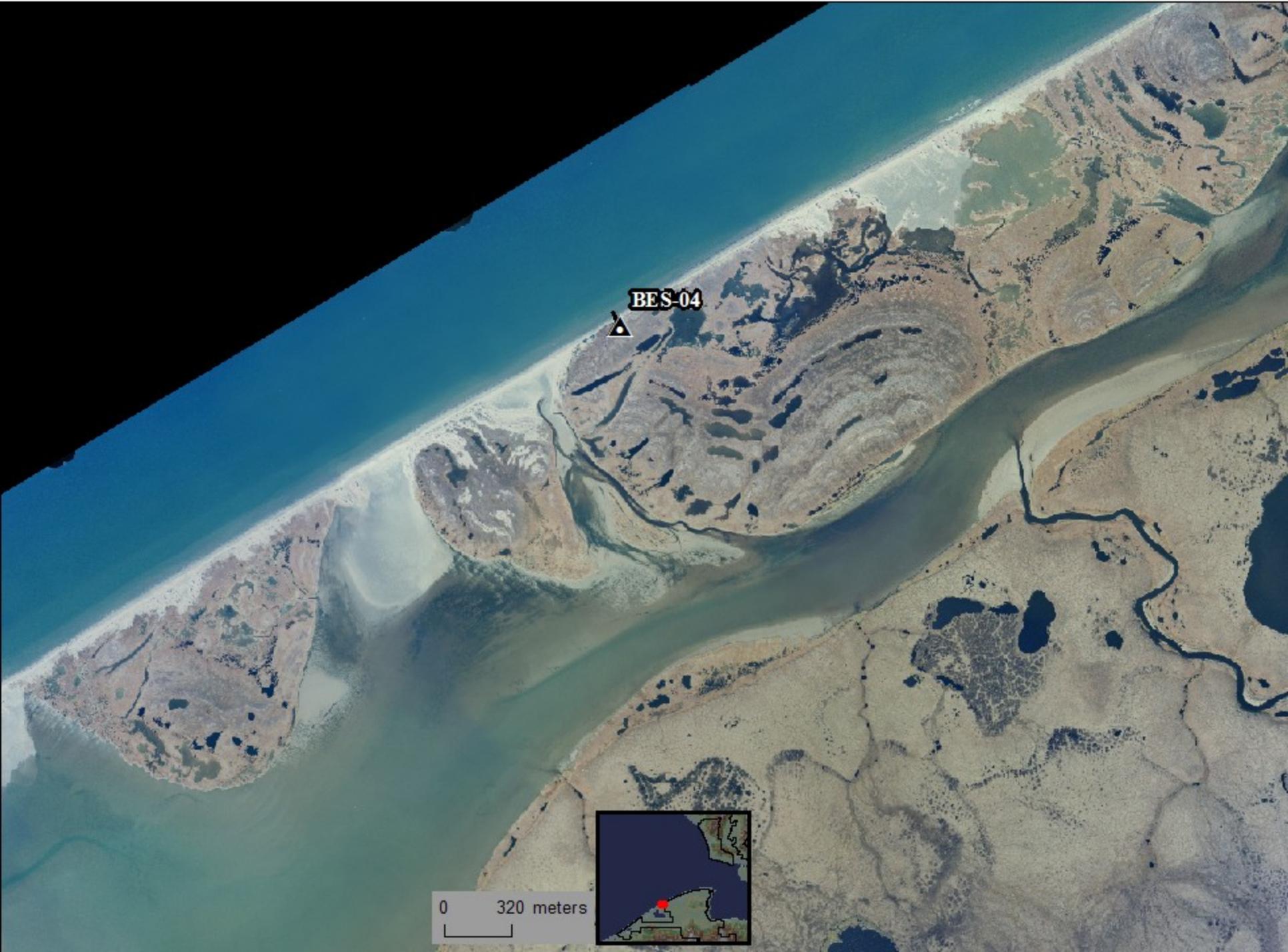


BES-04



0 610 meters

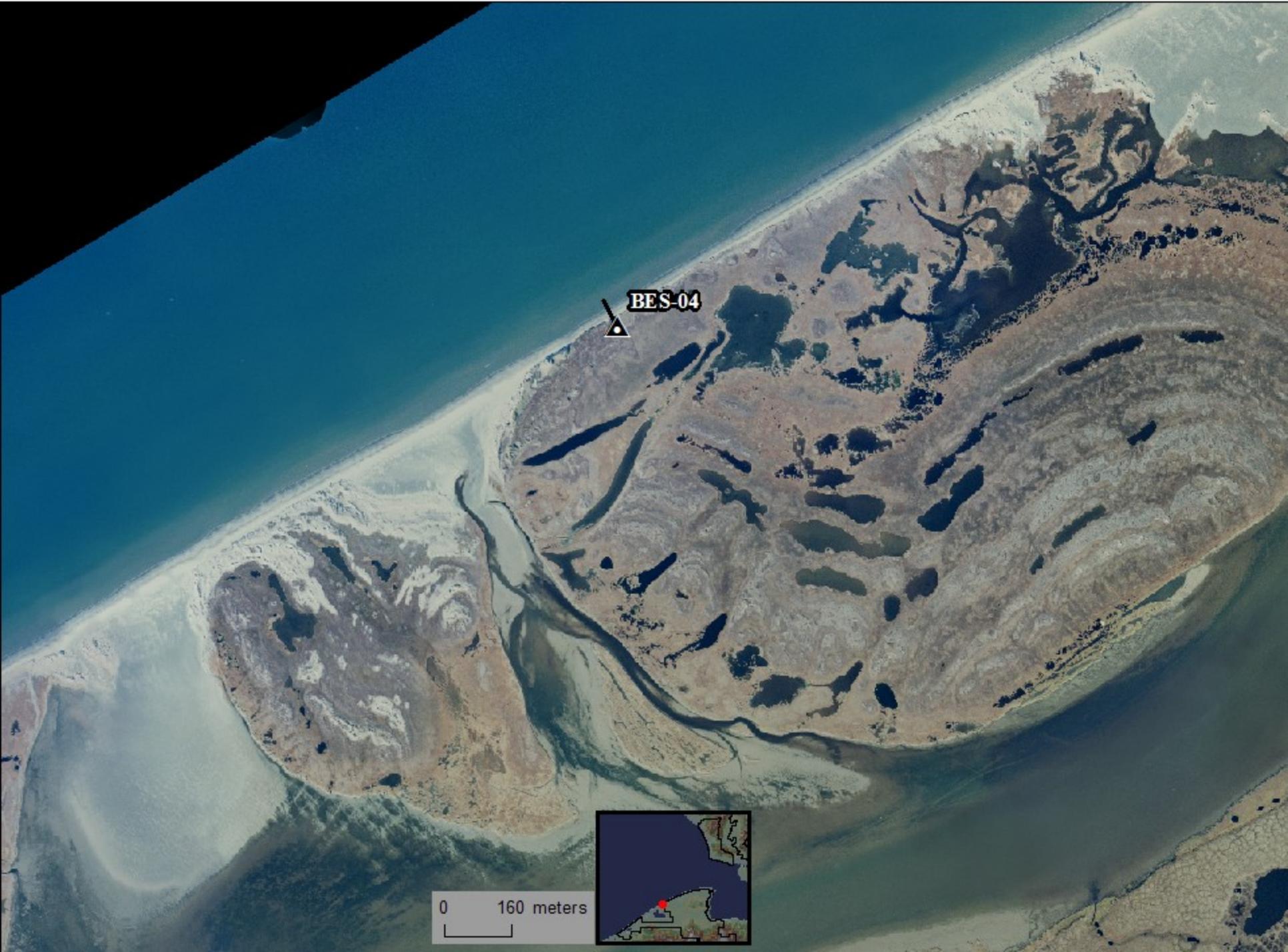




BES-04

0 320 meters





BES-04



0 160 meters





BES-04

0 80 meters

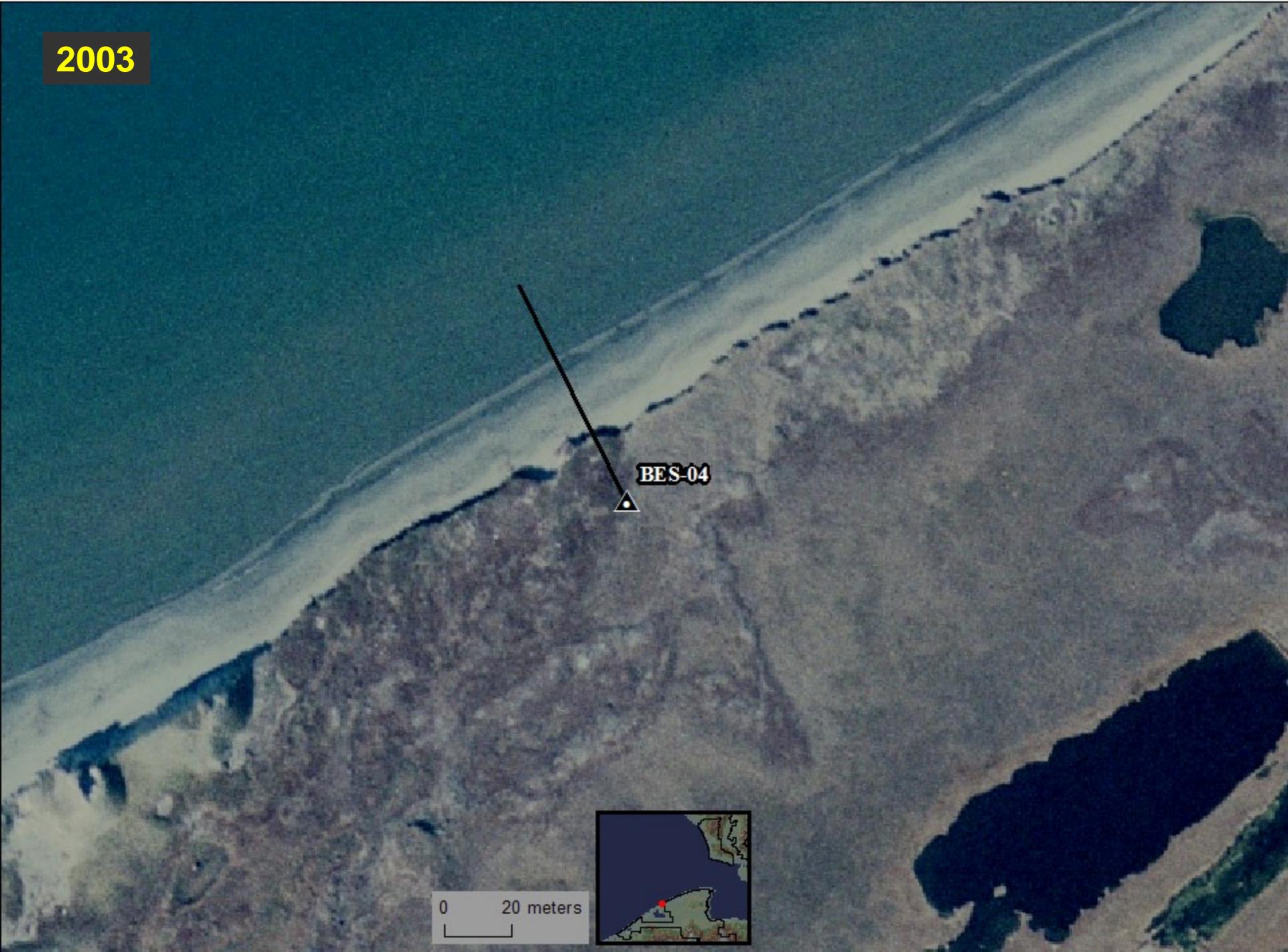


BES-04

0 40 meters



2003



BES-04

0 20 meters



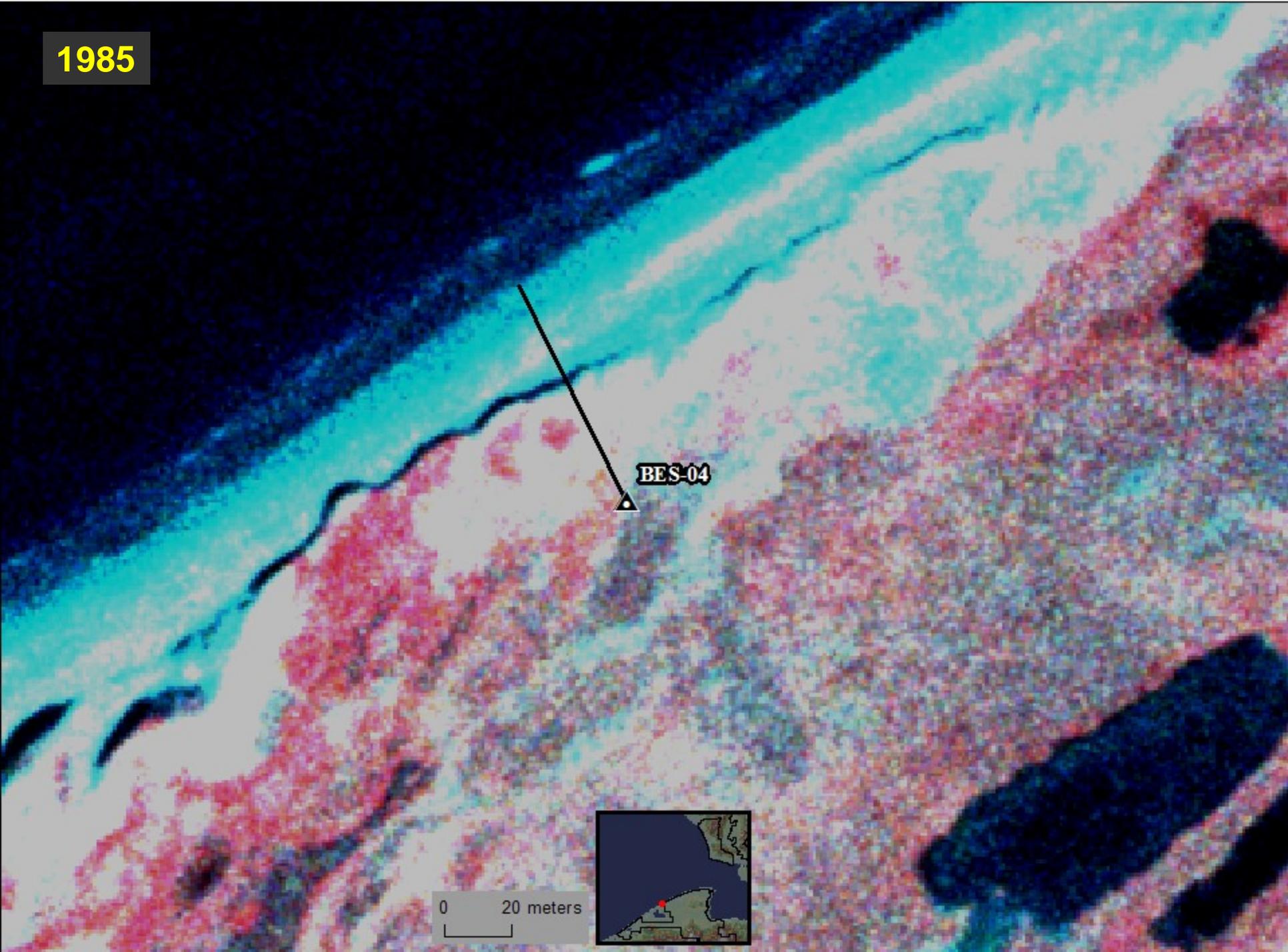
1949

BES-04

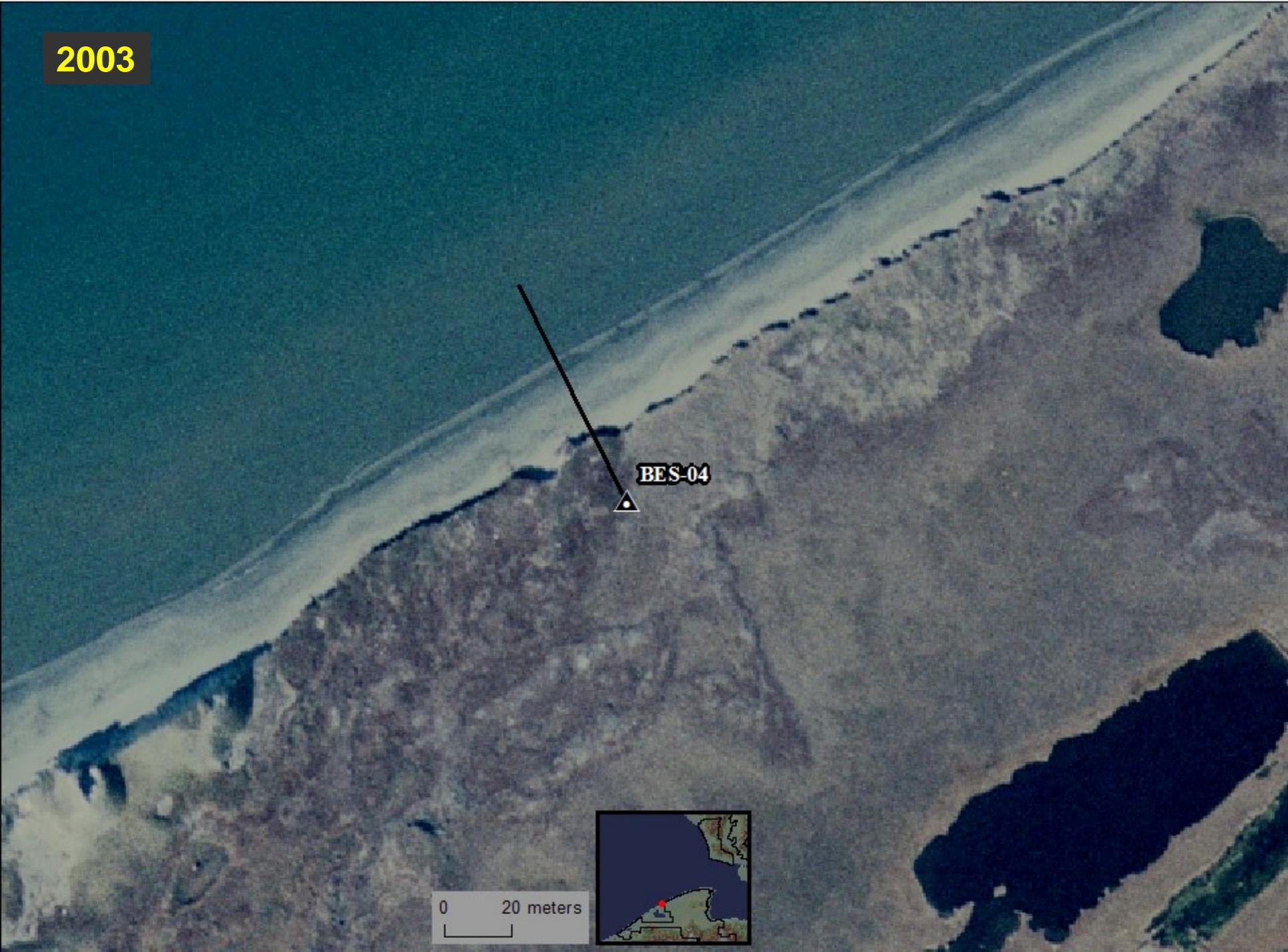
0 20 meters



1985



2003



BES-04

0 20 meters



1949

BES-04

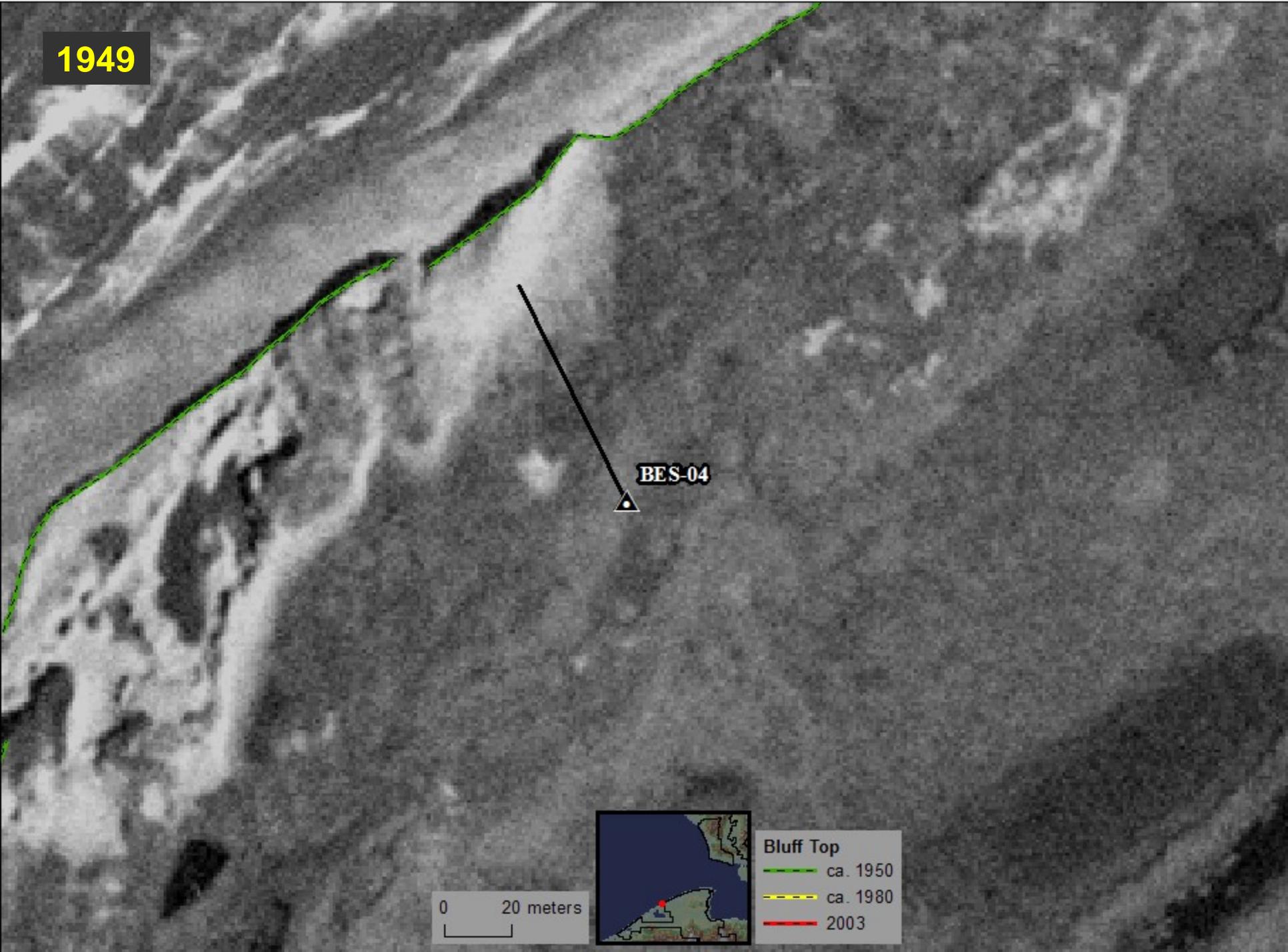
0 20 meters

Bluff Top

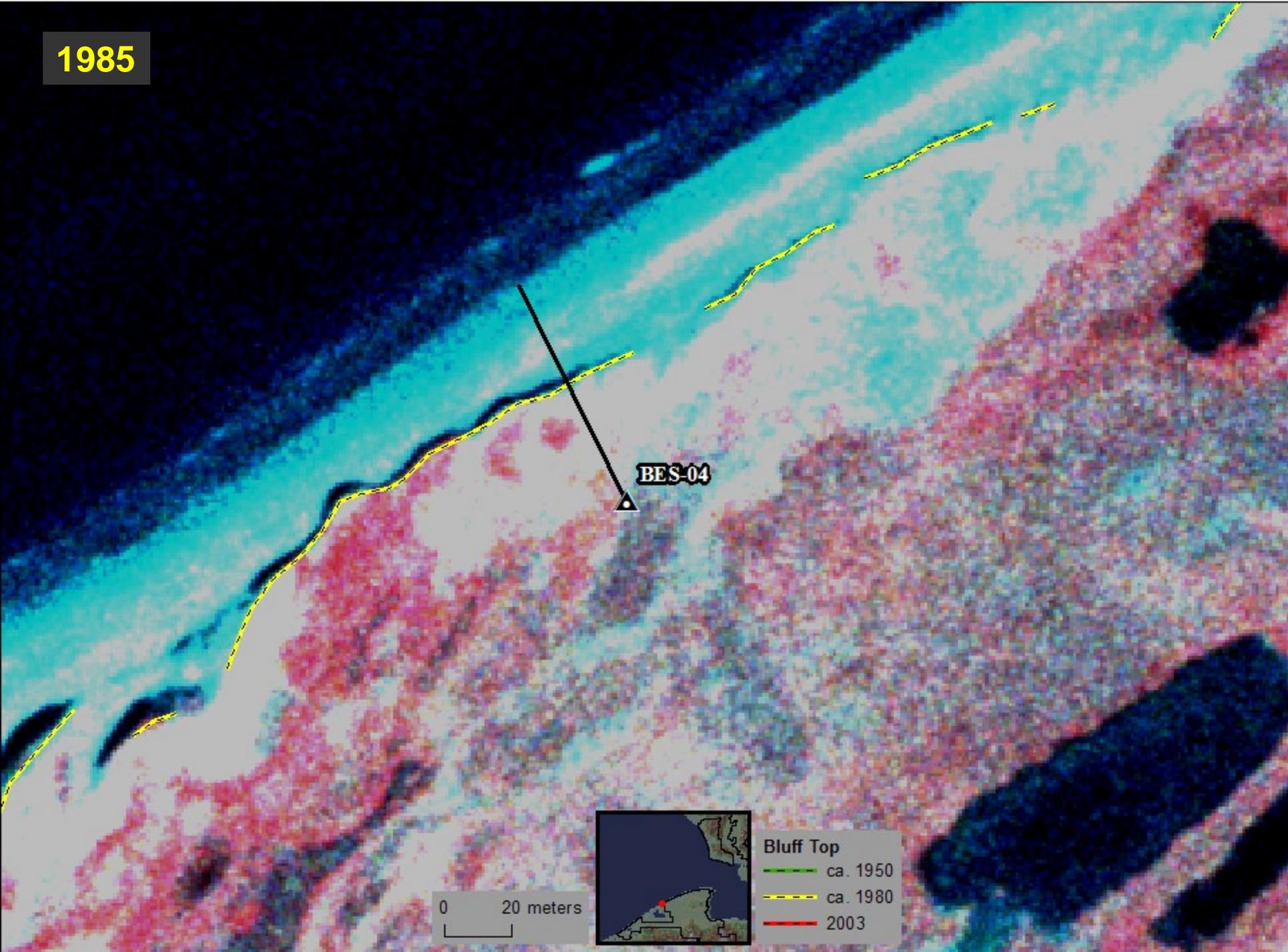
ca. 1950

ca. 1980

2003



1985



BES-04

0 20 meters



Bluff Top
— ca. 1950
- - ca. 1980
— 2003

2003



BES-04

0 20 meters

Bluff Top

ca. 1950

ca. 1980

2003



DSAS

The Digital Shoreline Analysis System (DSAS) version 3.0, an ArcGIS® Extension for Calculating Historic Shoreline Change

by E. Robert Thieler¹, Emily A. Himmelstoss¹, Jessica L. Zichichi^{2*}, and Tara L. Miller³

¹Coastal and Marine Geology Program, U.S. Geological Survey, Woods Hole, MA 02543

²Perot Systems - Science and Technology Solutions Group, Pembroke, MA 02349

* present address: GeoNet Systems www.geonetsystems.com

³Coastal and Marine Geology Program, U.S. Geological Survey, St. Petersburg, FL 33701

U.S. Geological Survey Open-file Report 2005-1304

2005

If you use the DSAS extension, please cite the following publication:

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.

The current version is 3.2

The following files are available for download:

[Readme_dsasv3_2.txt](#) (6 kb) - README file with installation instructions, known issues, and version history

[DSAS_v3_2.zip](#) (2210 kb) - the DSAS extension, compressed zip file

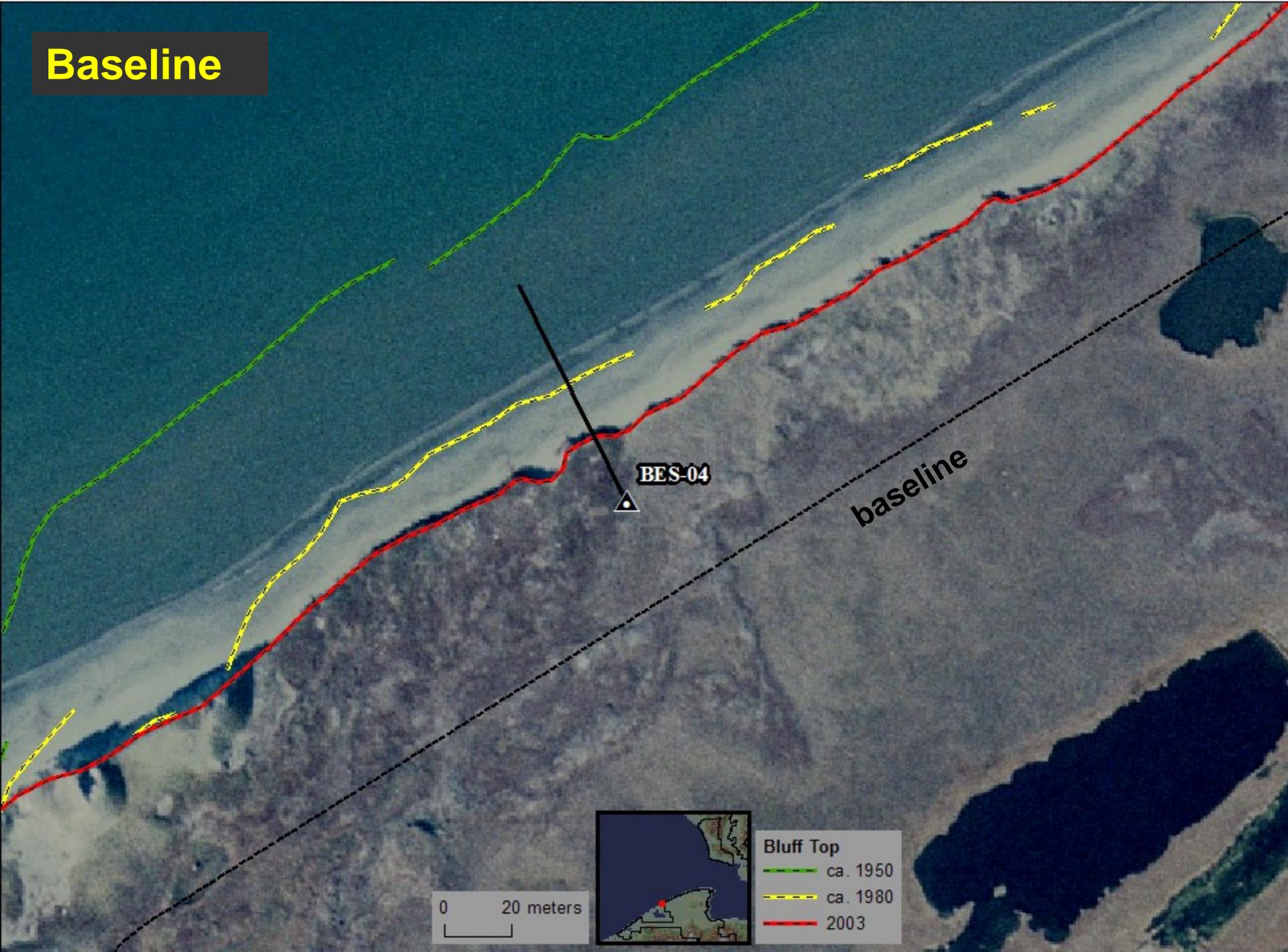
[DSASv3_2.pdf](#) (362 kb) - Adobe PDF user guide and tutorial.

[DSAS_sample_data.zip](#) (2544 kb) - Sample ArcGIS geodatabase, compressed zip file.

For more information, contact:
E. Robert Thieler
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tel: 508-457-2350

The Digital Shoreline Analysis System (DSAS) version 3.2 is a software extension to ESRI ArcGIS® v.9+ that enables a user to calculate shoreline rate-of-change statistics from multiple historic shoreline positions. A user-friendly interface of simple buttons and menu guides the user through the major steps of shoreline change analysis. Components of the extension and user-guide include: 1) instruction on the proper way to define a reference baseline for measurements; 2) automated and manual generation of measurement transects with user-specified parameters; and 3) output of calculated rates of shoreline change and other statistical information. DSAS computes shoreline rate-of-change using four different methods: 1) simple linear regression; 2) weighted least squares regression; 3) endpoint rate; and 4) jackknife iterative regression

Baseline



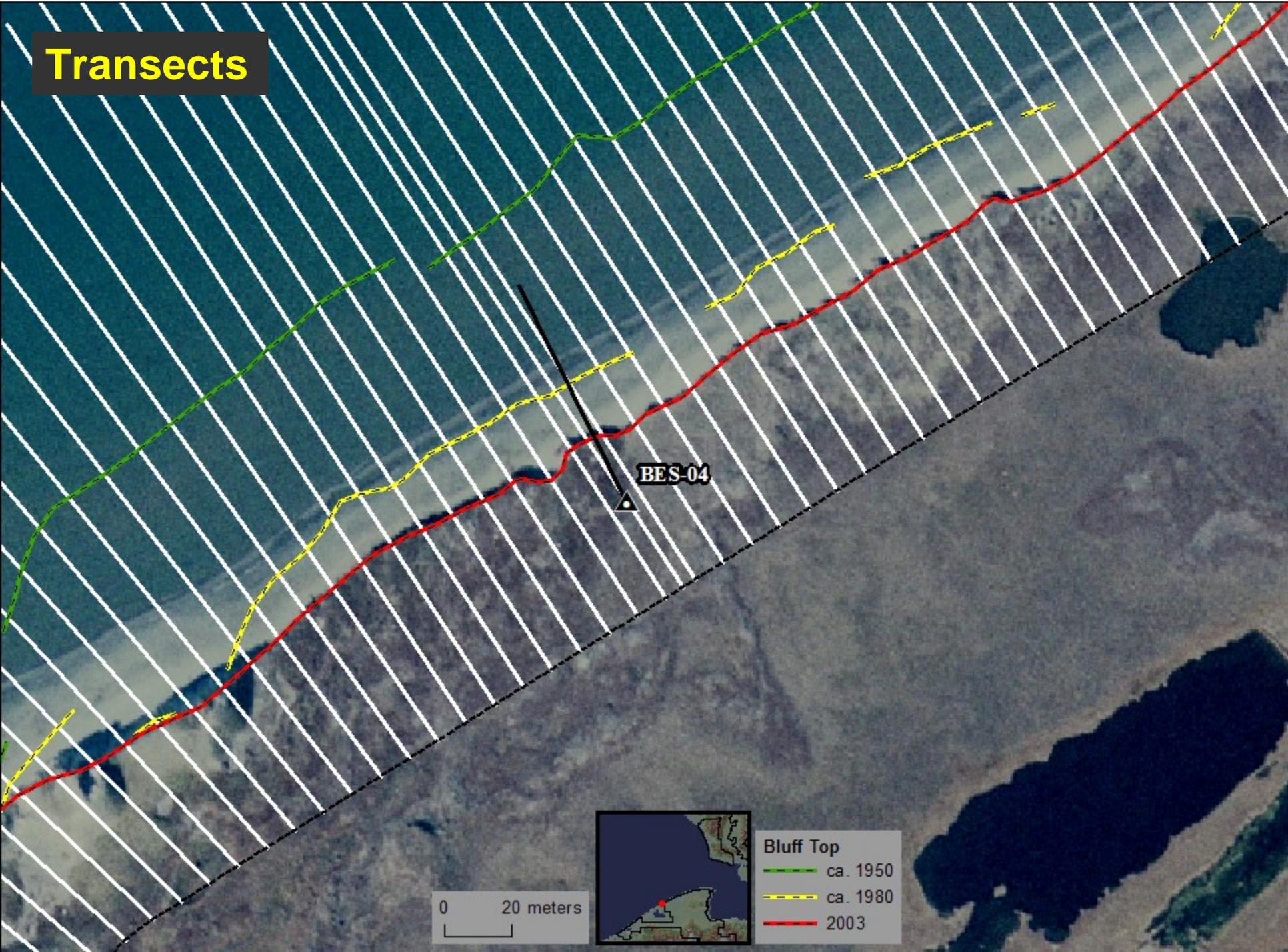
BES-04

baseline

0 20 meters

Bluff Top
ca. 1950
ca. 1980
2003

Transects



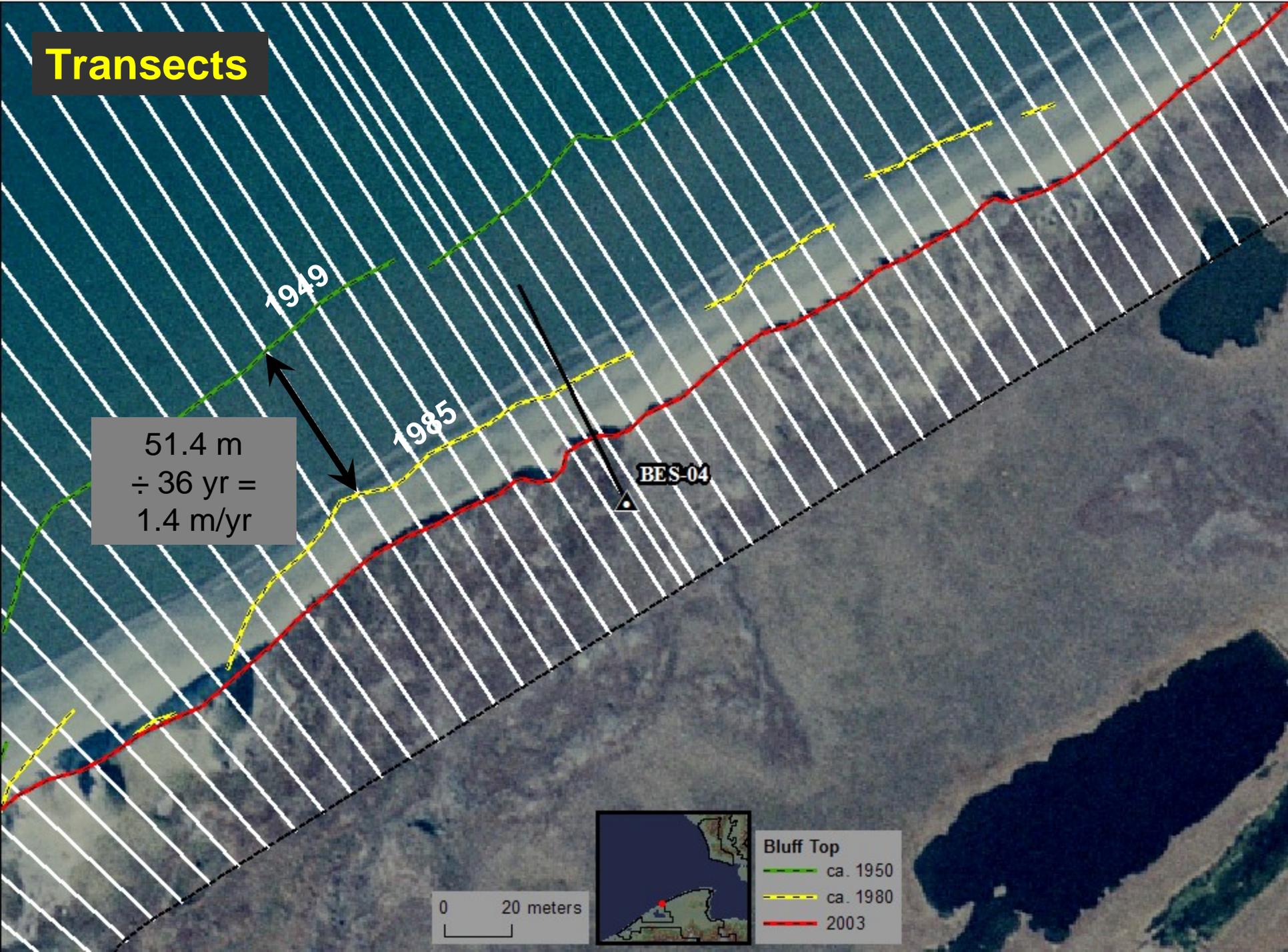
BES-04

0 20 meters

Bluff Top

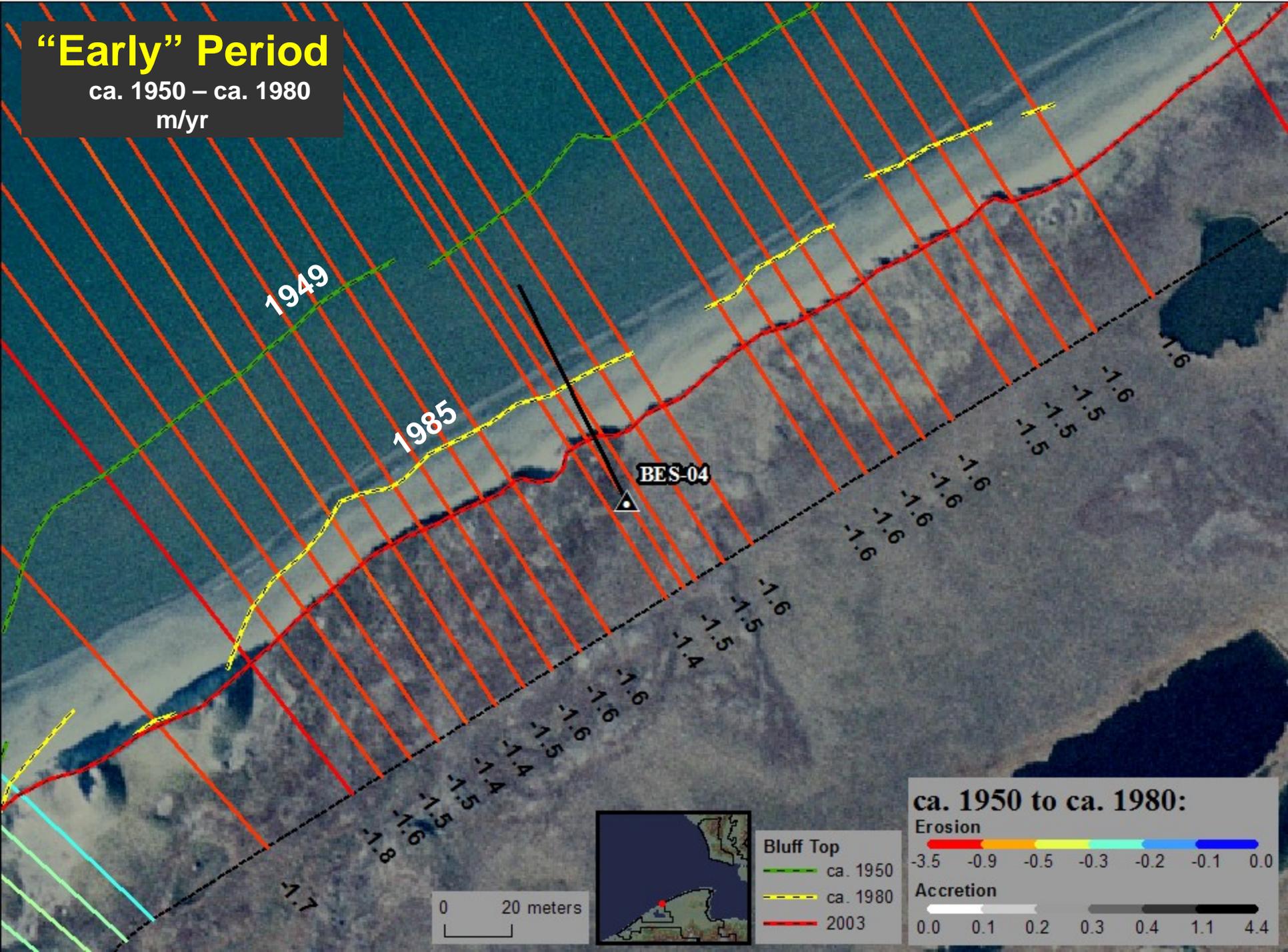
- ca. 1950
- ca. 1980
- 2003

Transects



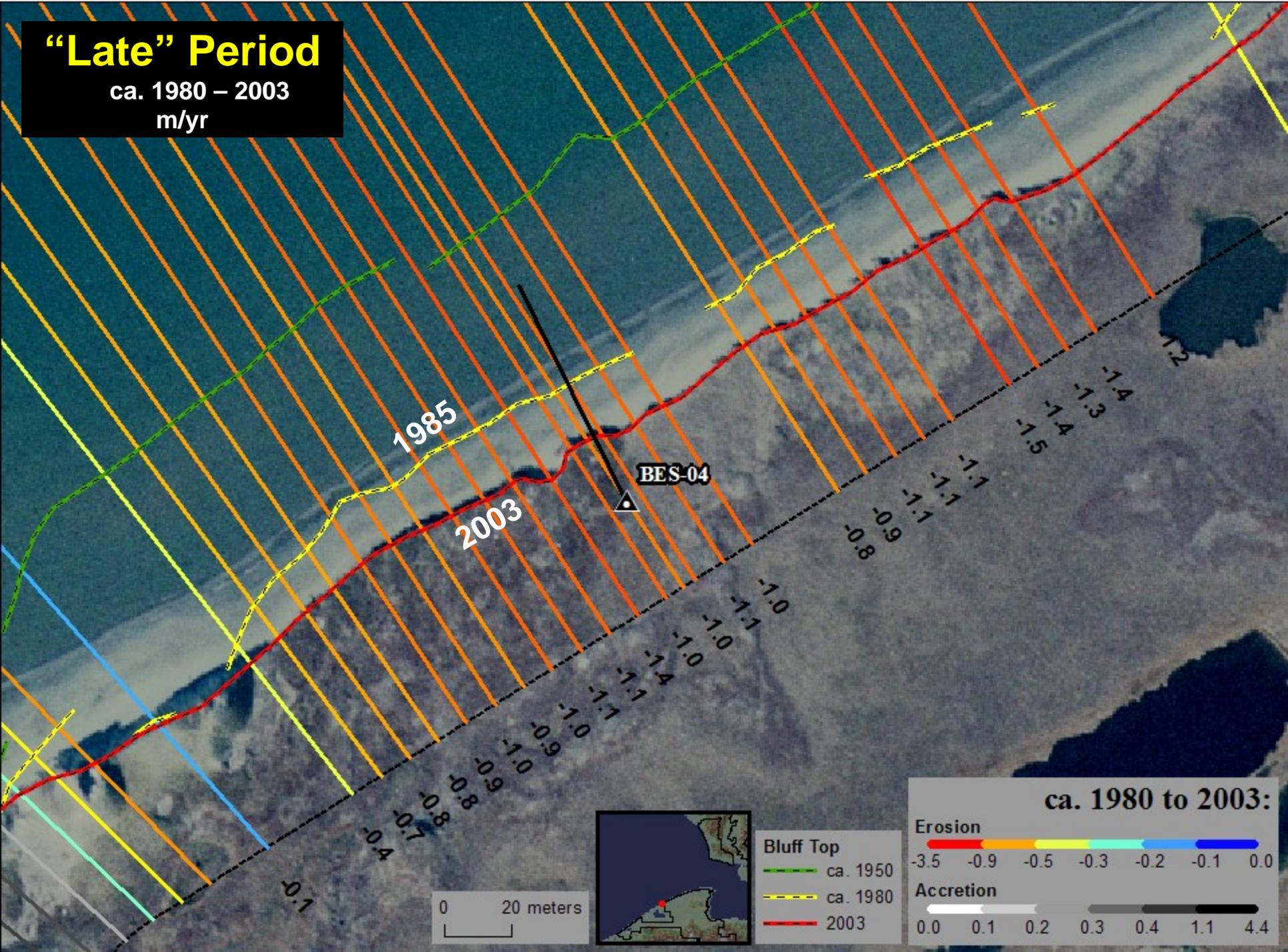
“Early” Period

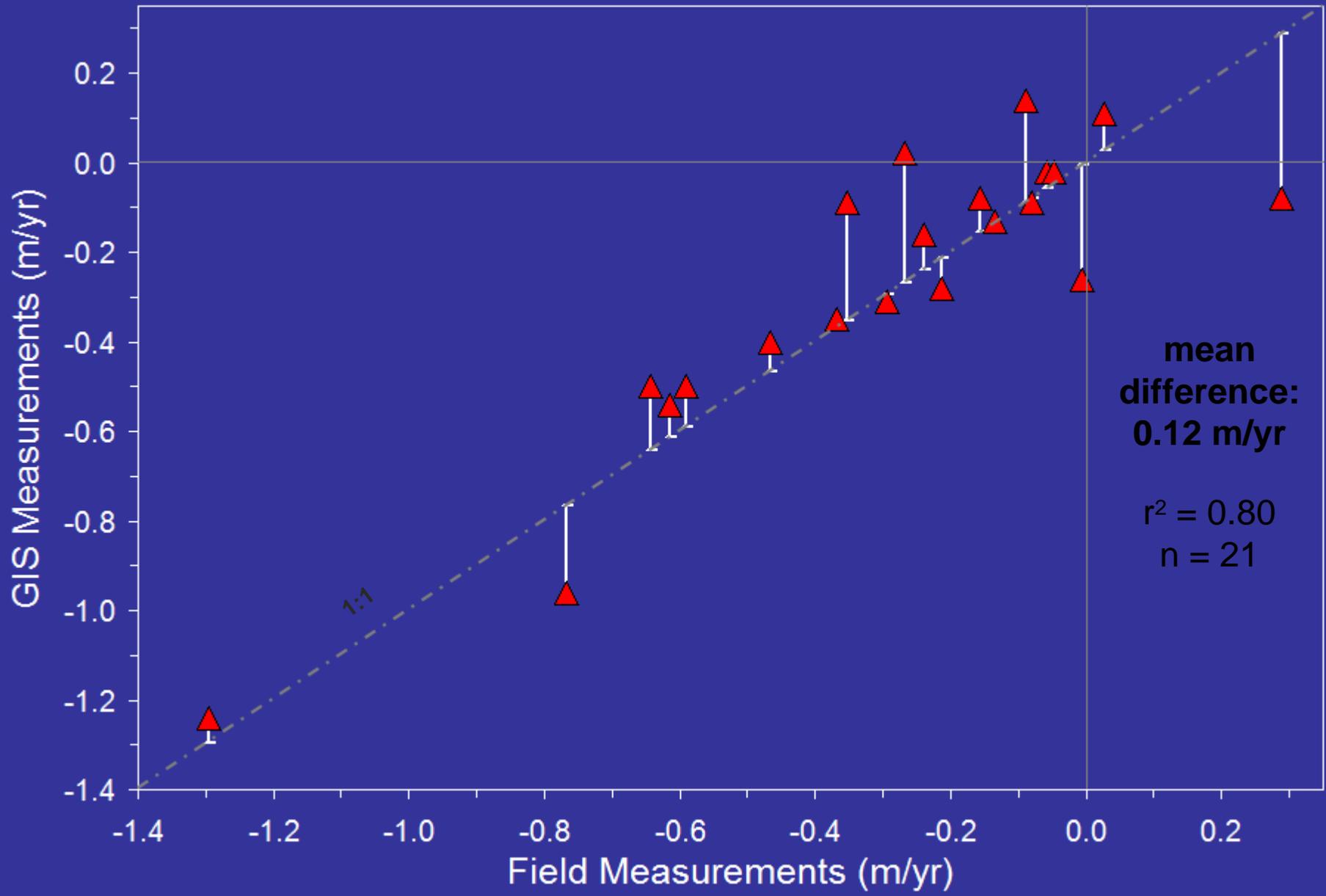
ca. 1950 – ca. 1980
m/yr



"Late" Period

ca. 1980 – 2003
m/yr





GIS Errors

Shoreline Position (m)

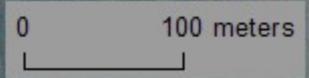
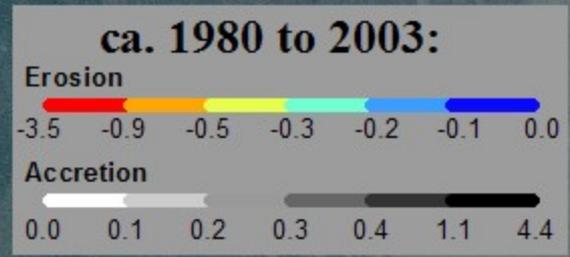
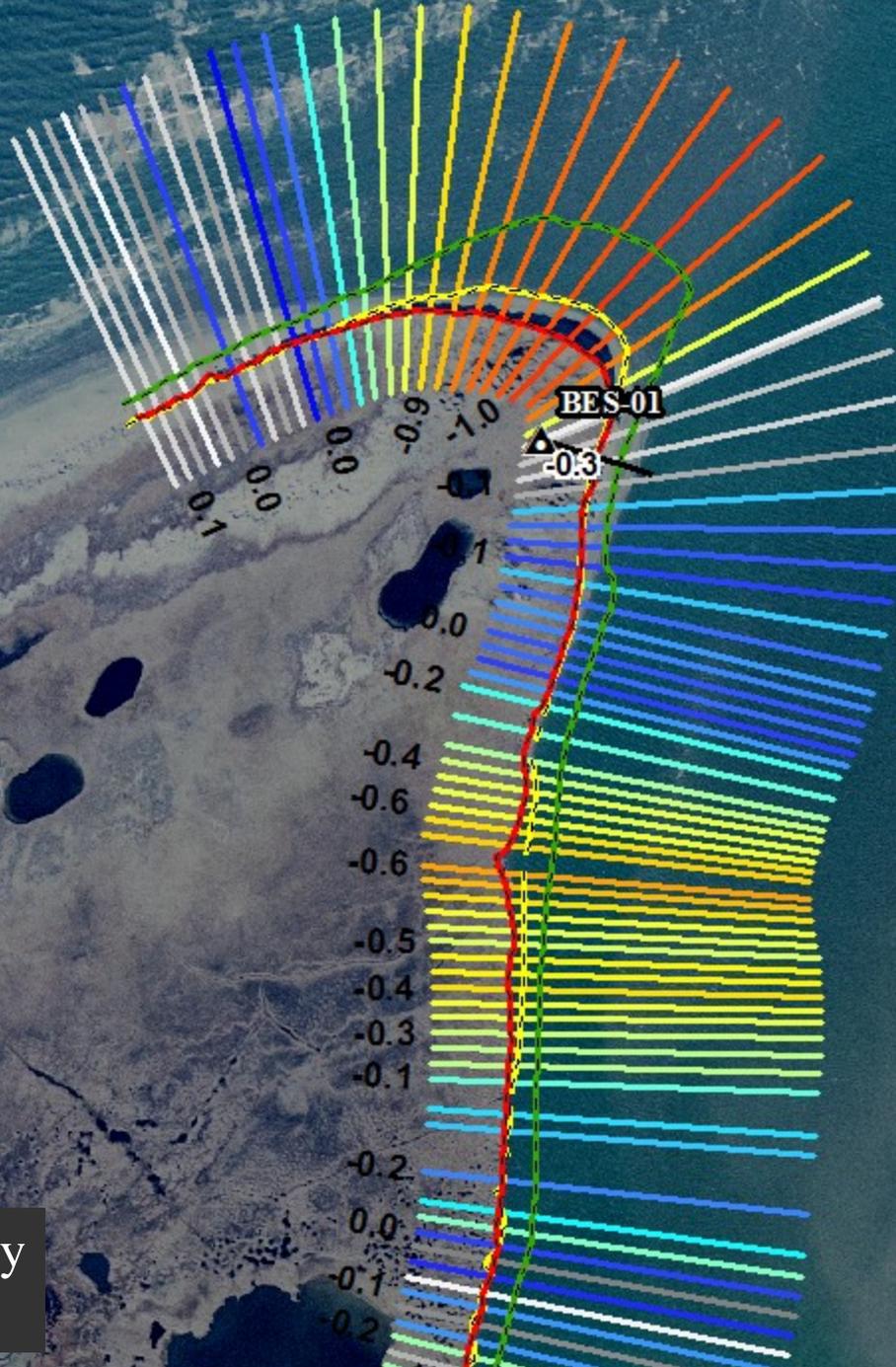
	ca. 1950	ca. 1980	2003
Orthorectification	2	1.5	NA
Digitizing	3	4	3
Total (SRSS)	3.6	4.3	3.0

Coastal Change

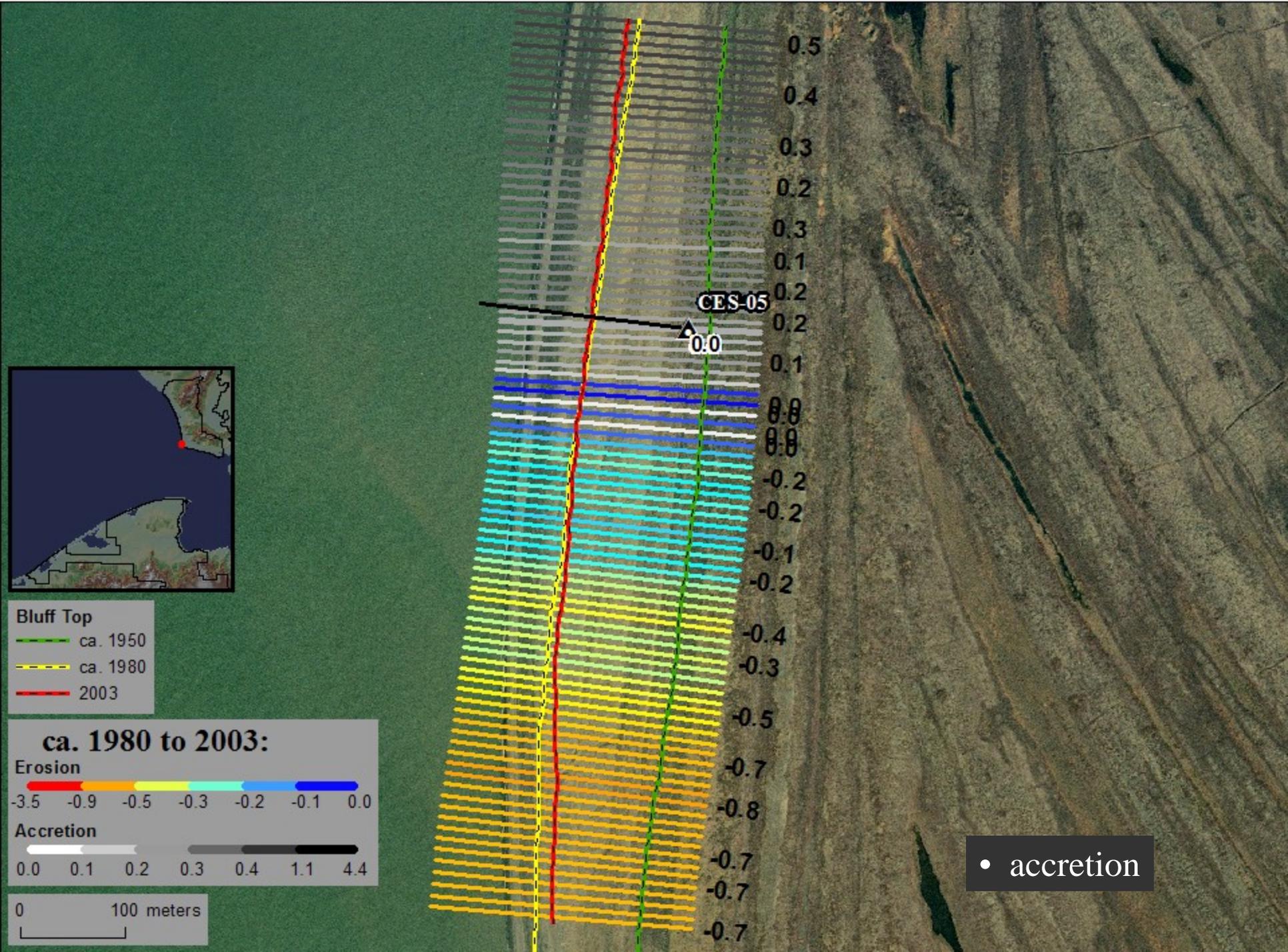
	“Early”	“Late”	“Long Term”
	ca. 1950 – ca. 1980	ca. 1980 - 2003	ca. 1950 - 2003
Position (m)	5.6	5.2	4.7
Rate (m/yr)	± 0.20	± 0.23	± 0.09

Field Test (mean difference)

Rate (m/yr)		± 0.12	
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- spatial variability
- “early” erosion



0.5
0.4
0.3
0.2
0.3
0.1
0.2
0.2
0.1
0.0
0.0
0.0
-0.2
-0.2
-0.1
-0.2
-0.4
-0.3
-0.5
-0.7
-0.8
-0.7
-0.7
-0.7

CES-05
▲
0.0



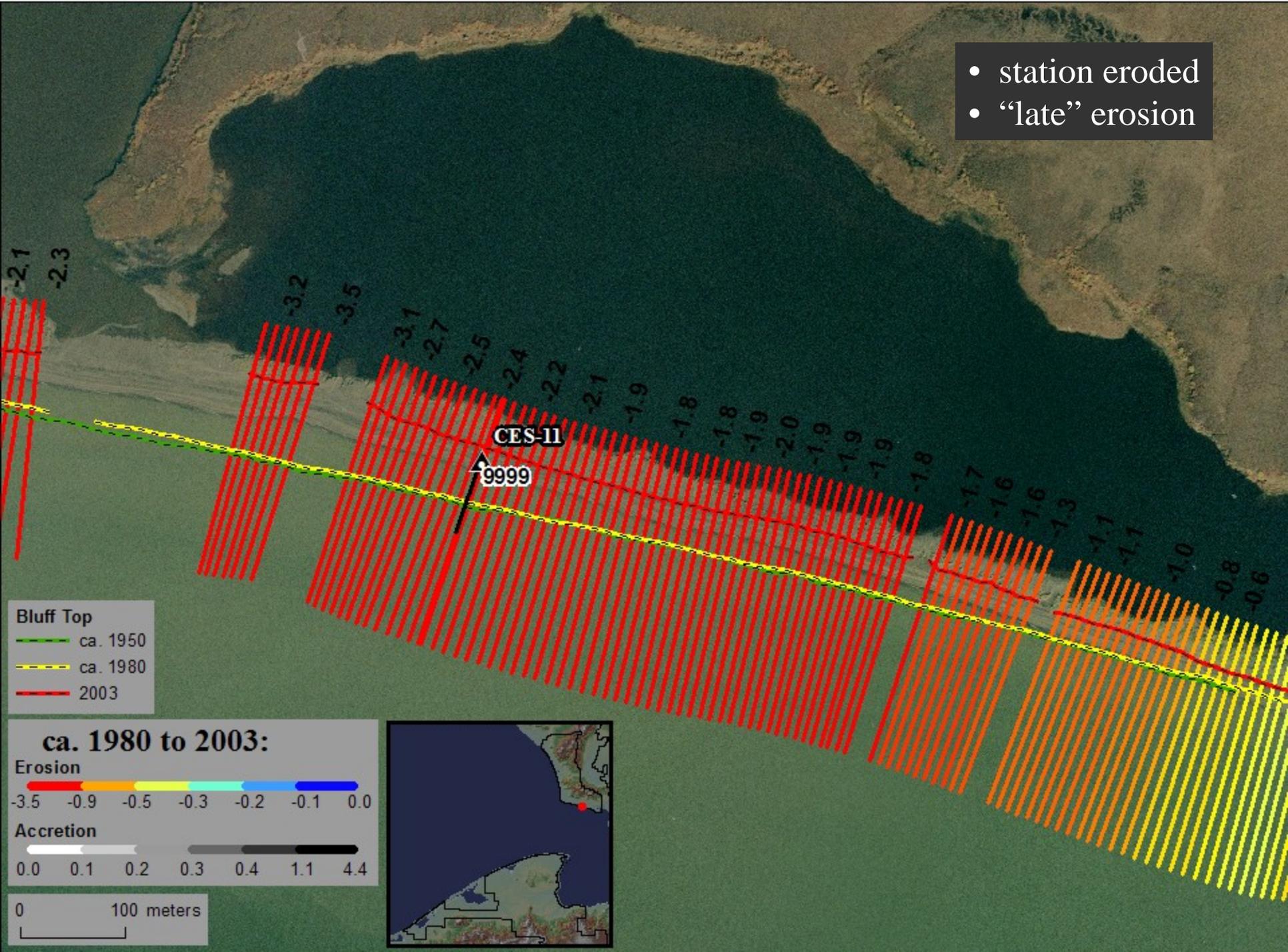
Bluff Top
— ca. 1950
- - ca. 1980
— 2003

ca. 1980 to 2003:
Erosion
-3.5 -0.9 -0.5 -0.3 -0.2 -0.1 0.0
Accretion
0.0 0.1 0.2 0.3 0.4 1.1 4.4

0 100 meters

• accretion

- station eroded
- “late” erosion



Bluff Top
 — ca. 1950
 — ca. 1980
 — 2003

ca. 1980 to 2003:
Erosion
 -3.5 -0.9 -0.5 -0.3 -0.2 -0.1 0.0
Accretion
 0.0 0.1 0.2 0.3 0.4 1.1 4.4

0 100 meters



“Early” Period

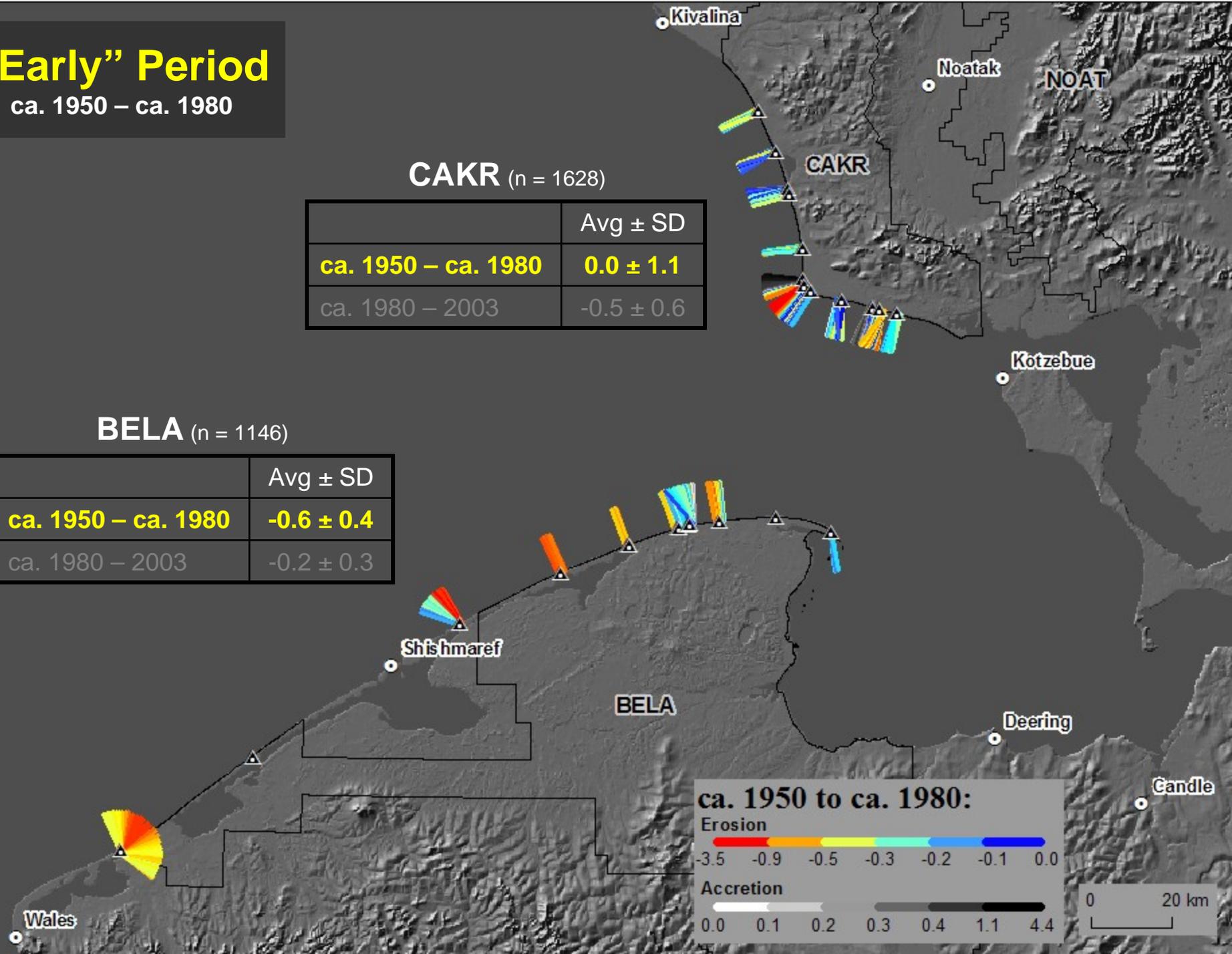
ca. 1950 – ca. 1980

CAKR (n = 1628)

	Avg ± SD
ca. 1950 – ca. 1980	0.0 ± 1.1
ca. 1980 – 2003	-0.5 ± 0.6

BELA (n = 1146)

	Avg ± SD
ca. 1950 – ca. 1980	-0.6 ± 0.4
ca. 1980 – 2003	-0.2 ± 0.3



“Late” Period

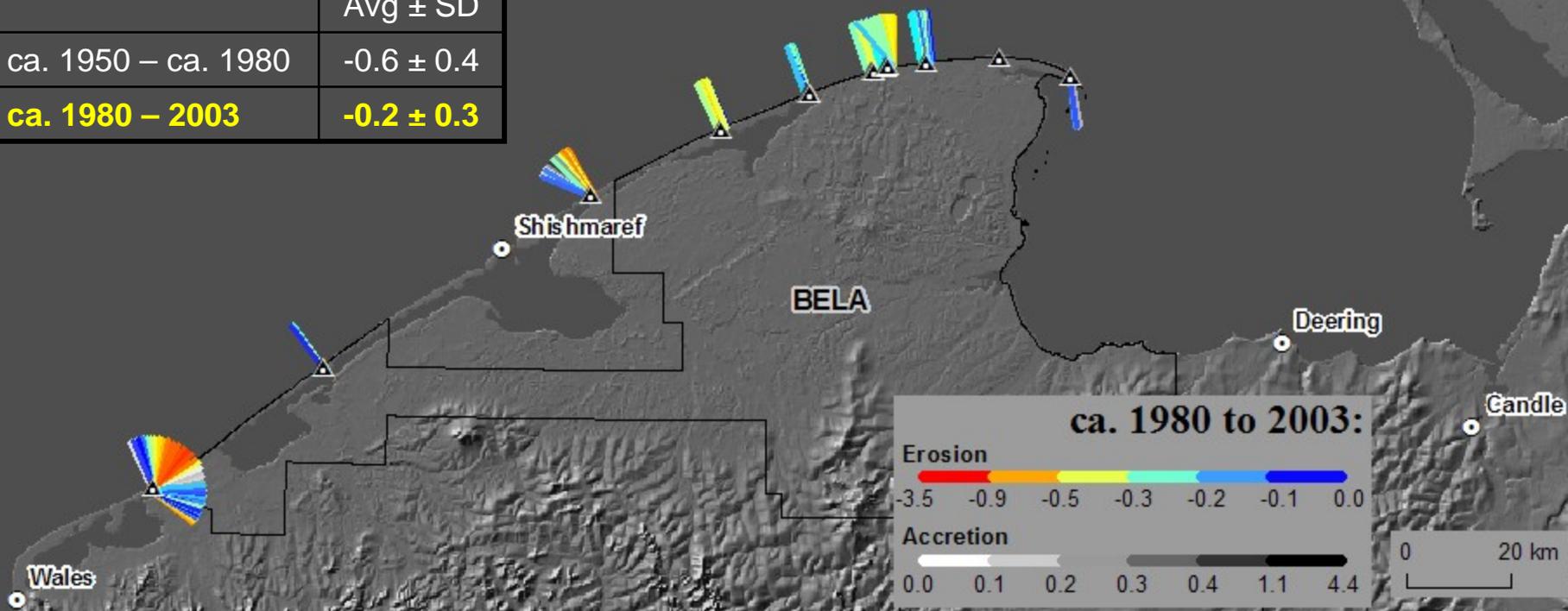
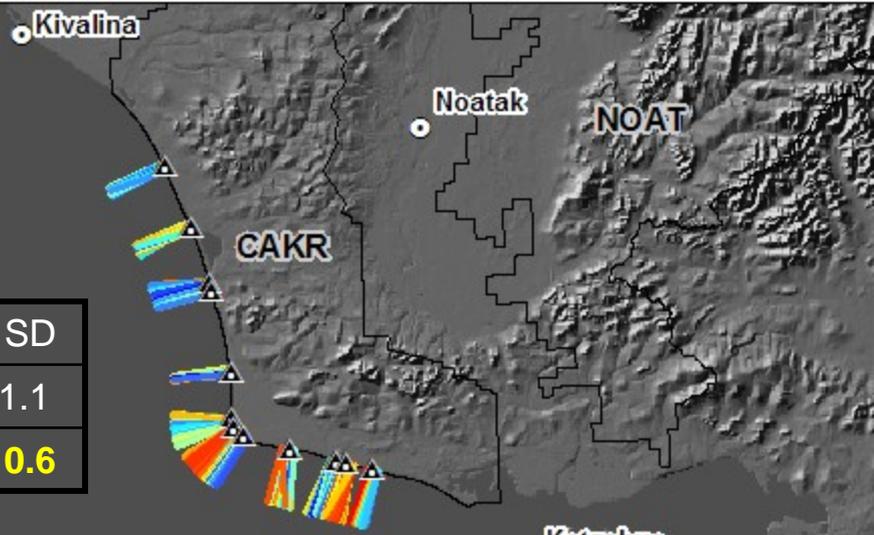
ca. 1980 – 2003

CAKR (n = 1628)

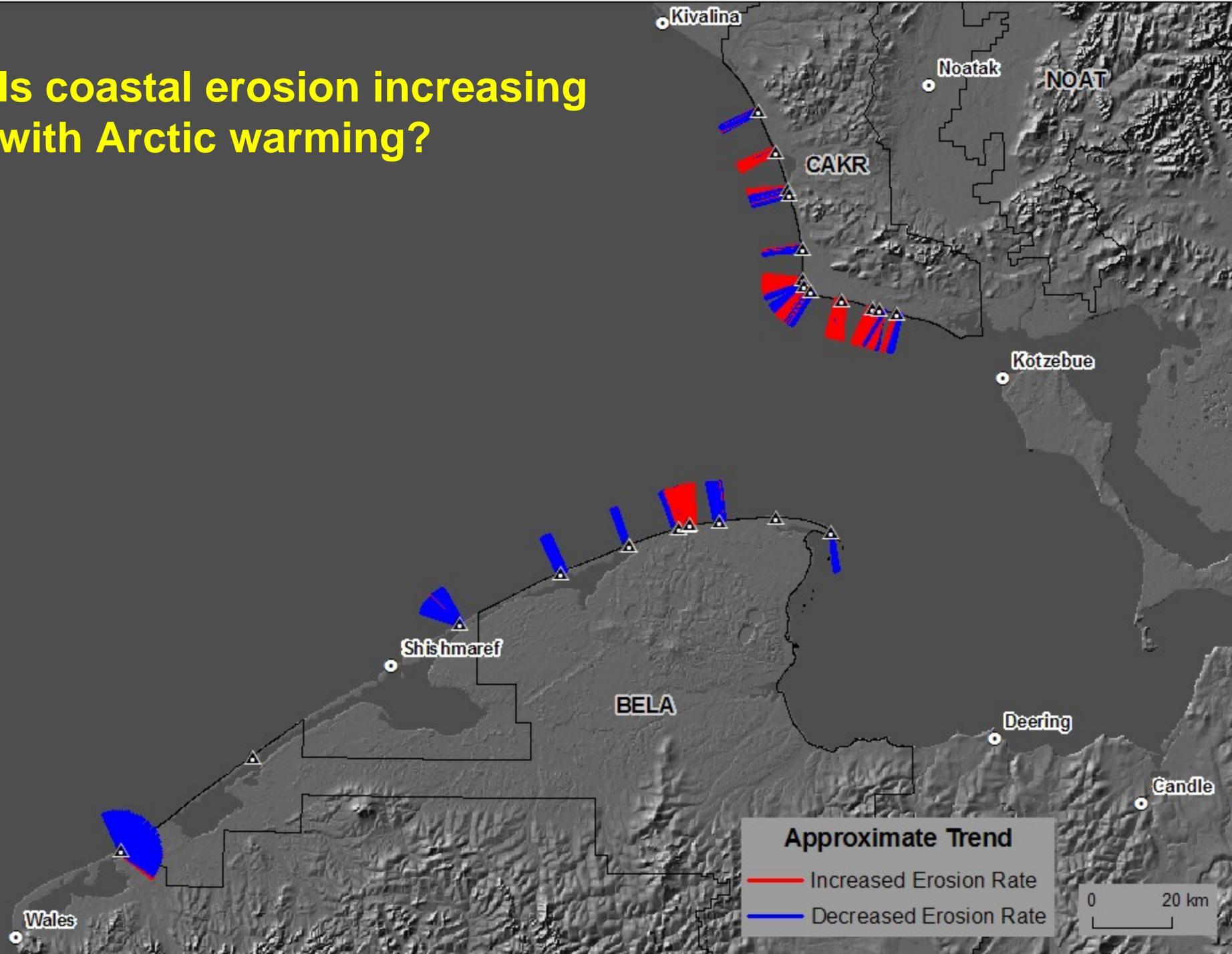
	Avg ± SD
ca. 1950 – ca. 1980	0.0 ± 1.1
ca. 1980 – 2003	-0.5 ± 0.6

BELA (n = 1146)

	Avg ± SD
ca. 1950 – ca. 1980	-0.6 ± 0.4
ca. 1980 – 2003	-0.2 ± 0.3



Is coastal erosion increasing with Arctic warming?



Research Conclusions

- GIS:
 - acceptably low errors
 - comprehensive spatial analysis

- Most coastlines are eroding

- Is global warming responsible?:
 - storm climatology important
 - high spatial and temporal resolution needed

Perspectives for NDOP

High-res. orthoimagery and DEM's are extremely valuable for environmental research

In academia, some challenges:

- data usually underfunded
- data sharing undervalued
- few? researchers appreciate the challenges and opportunities

Distribution is a challenge

- AlaskaMapped.org: fantastic new resource
- also distribute through the National Map?

Alaska is the “neglected child”

- imagery and DEM's usually poor quality
- expensive and time-consuming to create piecemeal
- lower 48 for comparison
- kudos to NDOP and NDEP!

Thank you!

Any questions or concerns:

William.Manley@colorado.edu

303-735-1300