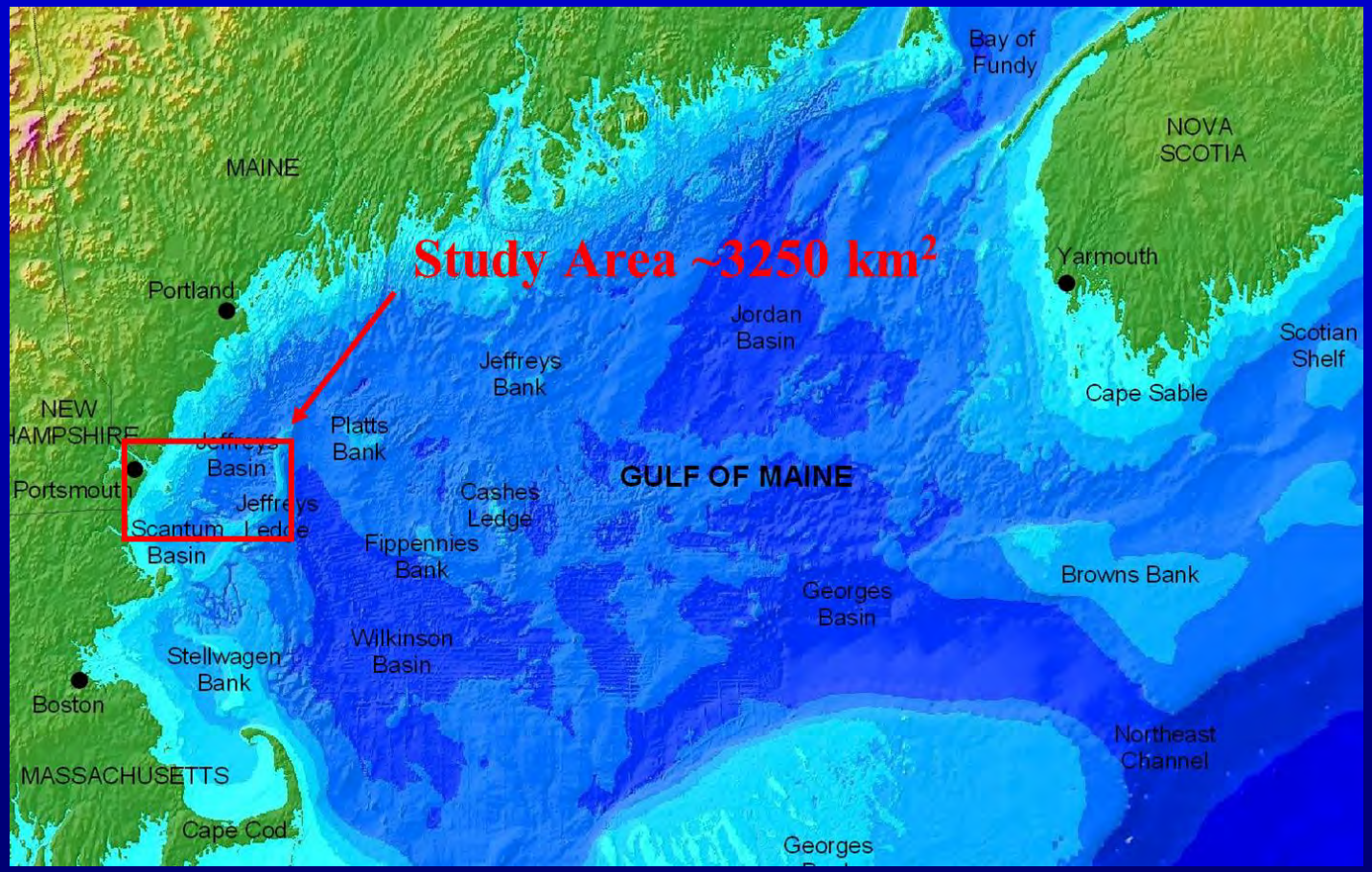
High Resolution Mapping of Morphologic Features and Seafloor Sediments of the New Hampshire and Vicinity Continental Shelf, Western Gulf of Maine



Larry Ward

Zachery McAvoy

Giuseppe Masetti

Rachel Morrison

University of New Hampshire

Center for Coastal and Ocean Mapping

BOEM Bureau of Ocean Energy Management

National Oceanic and Atmospheric Administration · NOAA · U.S. Department of Commerce

Center for Coastal & Ocean Mapping · Joint Hydrographic Center · CCOM JHC · University of New Hampshire

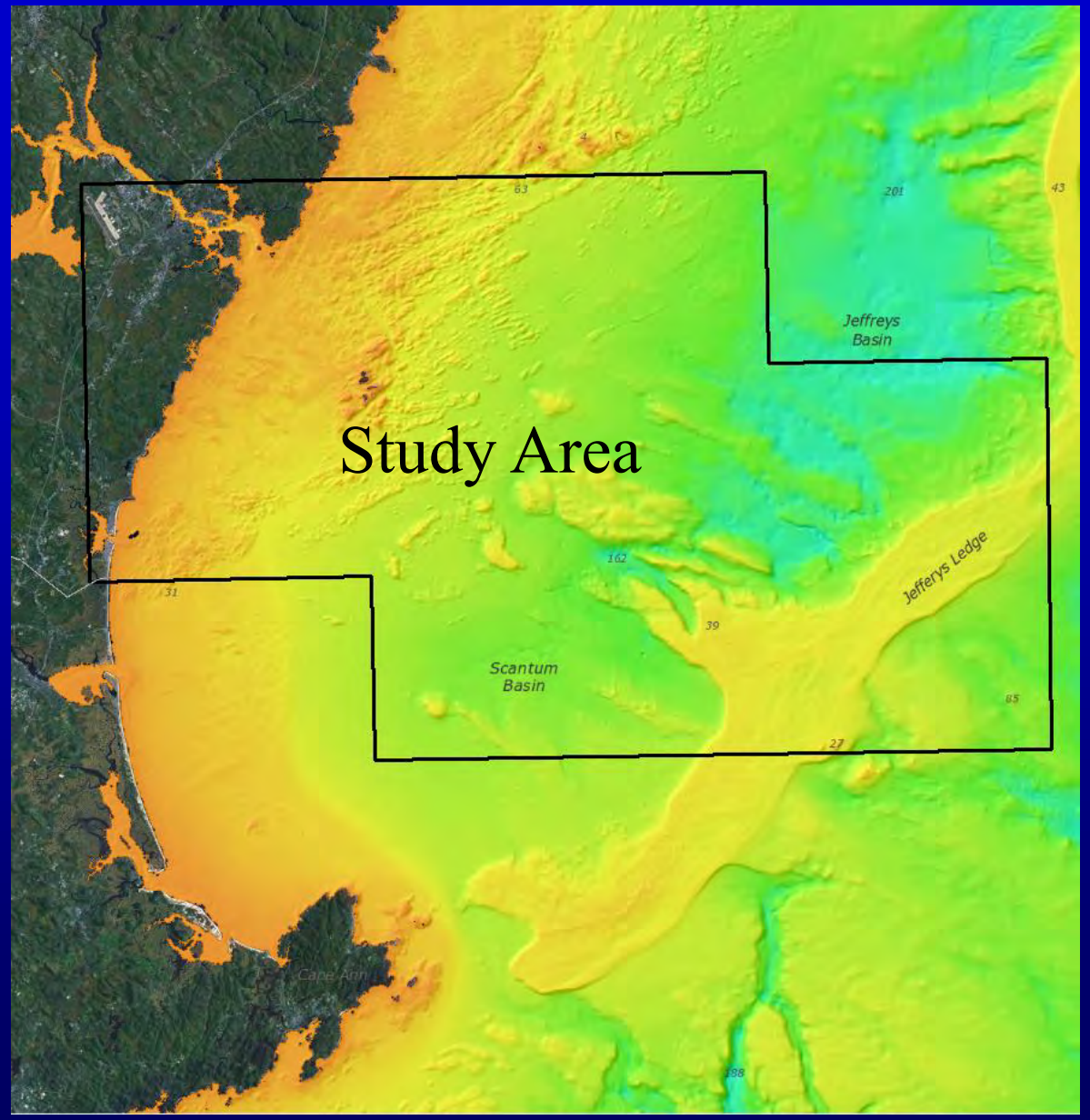
NH

Seal of the State of New Hampshire · 1776

New Hampshire Geological Survey · 1839 · 2001

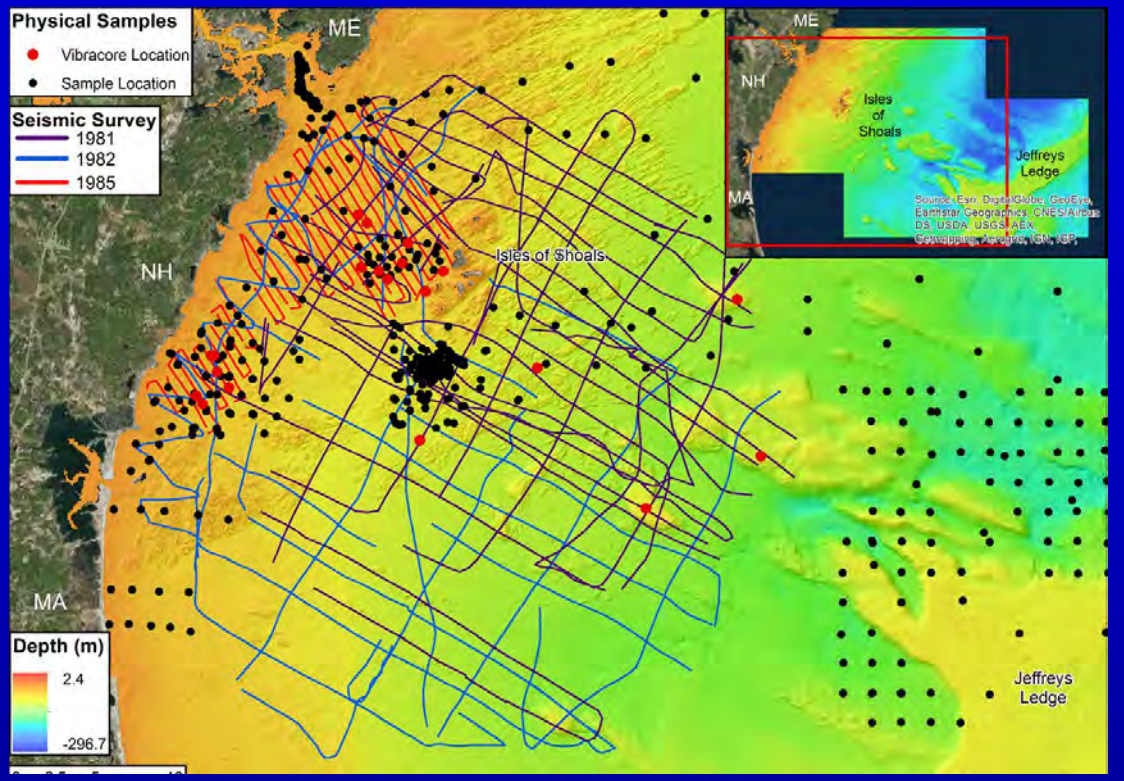
Integrated Research on the NH Shelf and Coast

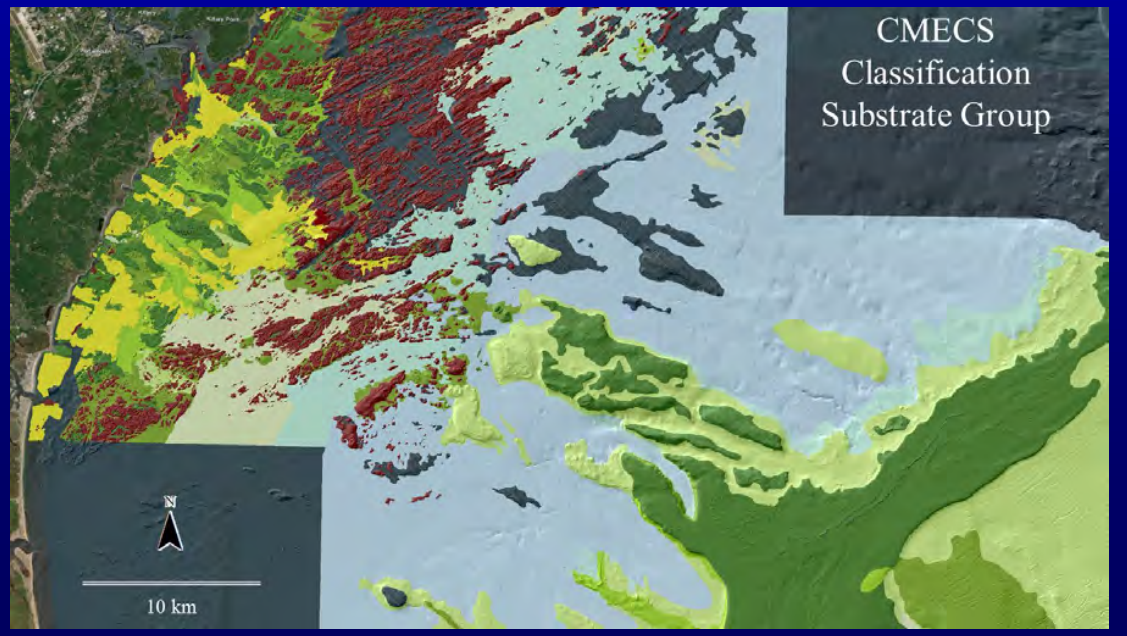
- Map the Surficial Geology of the NH Continental Shelf and Vicinity
  - Morphologic Features (Geoforms)
  - Surficial Sediments
- Assess Potential Sand/Gravel Resources
- Assess the Technical Characteristics of the New Hampshire Beaches
- Assess Sand Resource Needs for the New Hampshire Coast
  - Beach Nourishment
- Develop New Models and Techniques for Exploration of Sand and Gravel Deposits Using Acoustics and Ground Truth



Mapping the Surficial Geology of the NH Continental Shelf

- Over the Last Five Years Completed
  - High Resolution Surficial Geology Maps
  - Sand and Gravel Isopach Maps
- Based on an Extensive Database
  - WGOM Bathymetry and Backscatter Synthesis
  - Archived Sediment Database
    - 1400 Surface Sediment Analyses
    - 23 Vibracores (from the 80s)
    - ~1300 km of subbottom seismics (analog)
- Segmented in ArcGIS
  - Bathymetry and Backscatter
  - Bathymetric Derivatives
- Extremely Labor Intensive and Expensive

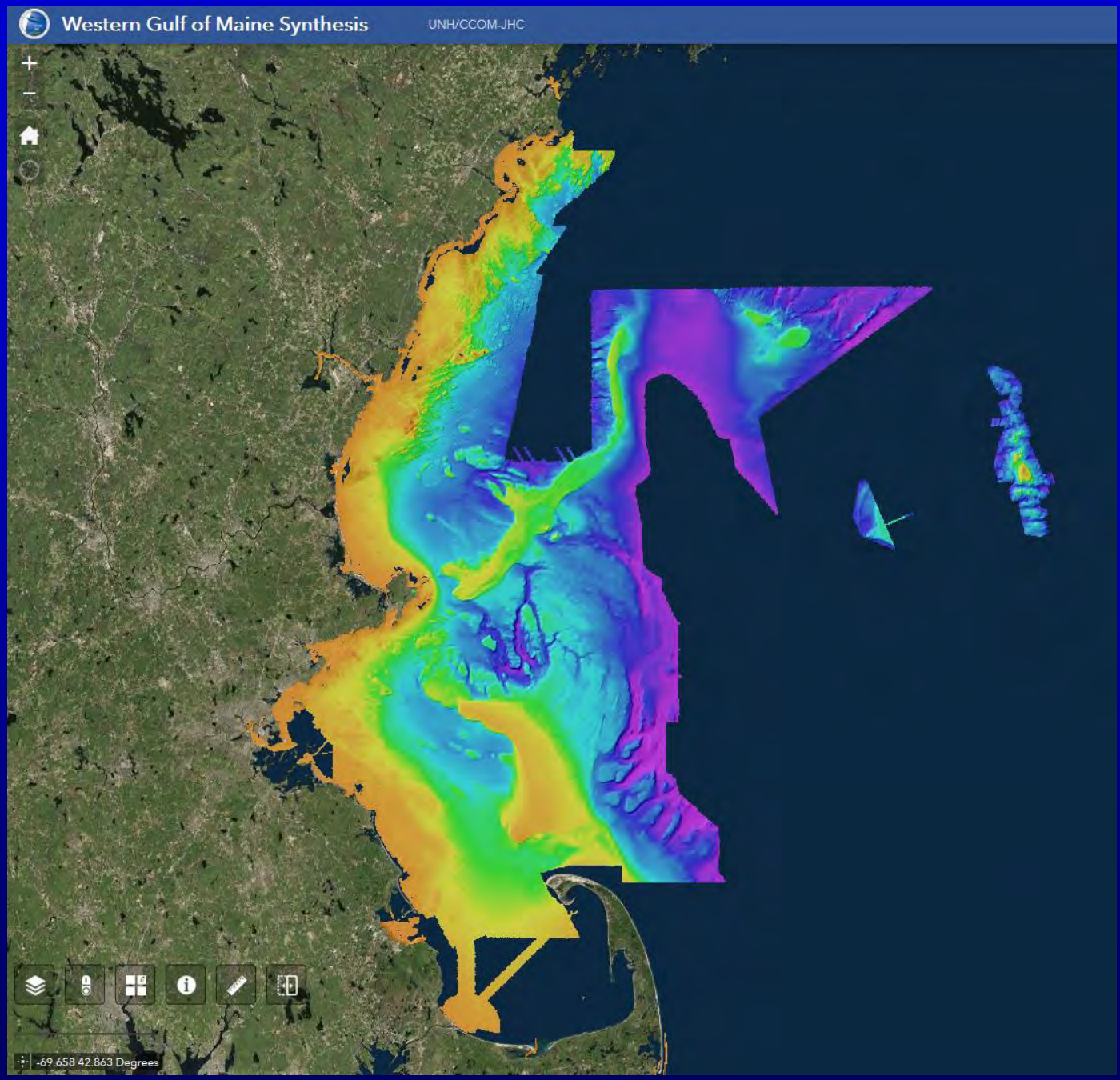




WGOM Bathymetry Synthesis - MBES @ 2m Grid

(UNH CCOM: Paul Johnson)

- Shows Bathymetry at Best Possible Gridding
- New Bathymetry Added as it Becomes Available
- Frequently Being Updated and Upgraded
- Available via CCOM/JHC Web Site

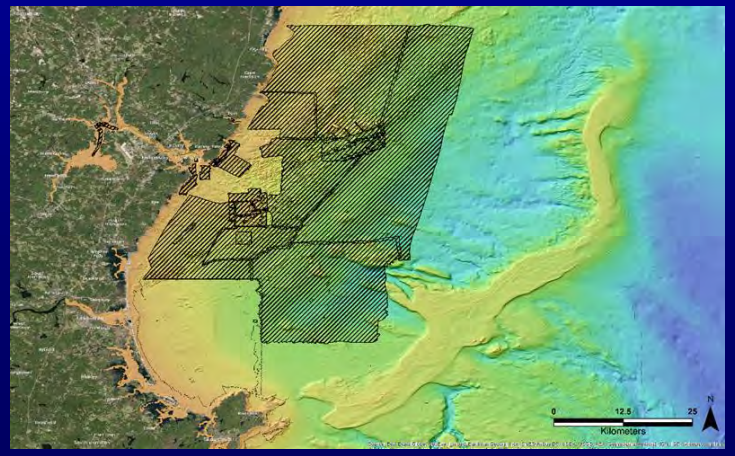


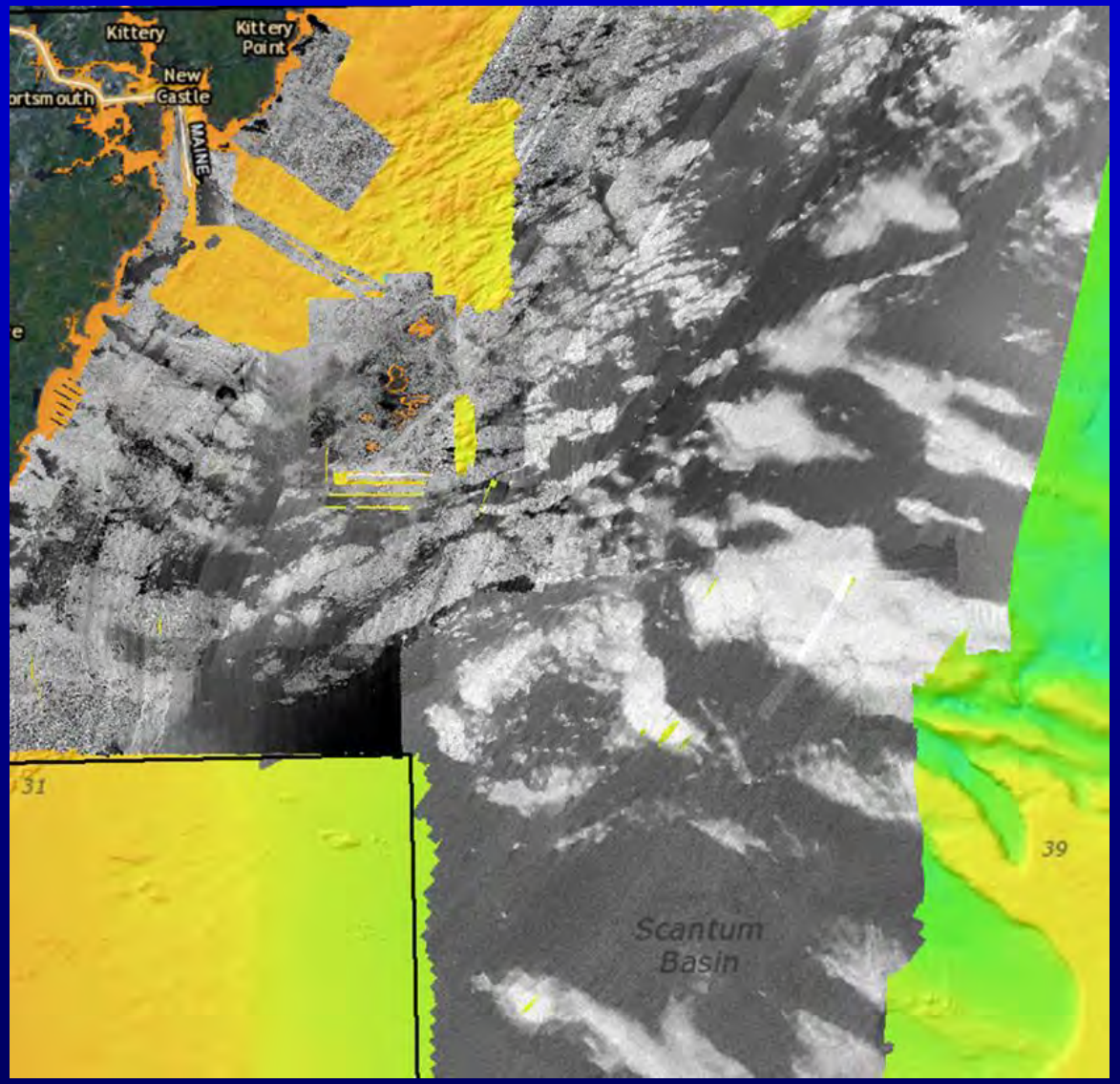
https://maps.ccom.unh.edu/portal/apps/webappviewer/index.html

WGOM Backscatter Synthesis

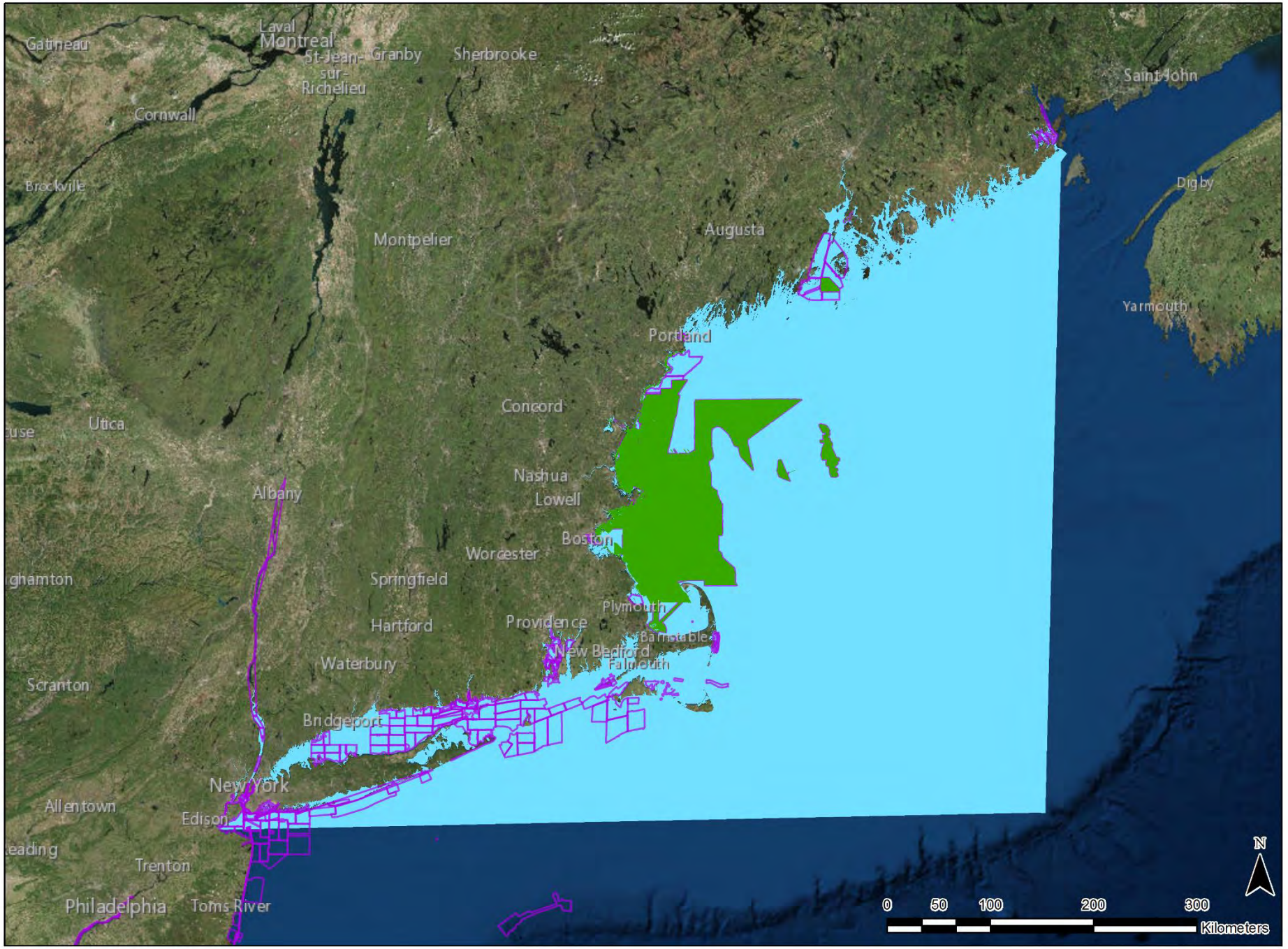
(UNH CCOM: Paul Johnson)

- Backscatter at 1.5 m Grid
- Based on 14 Surveys with Different Systems and Frequencies (300 and 400 kHz)
- Individual Surveys Re-Processed and Merged Into a Mosaic for General Mapping Purposes (Qualitative)





http://ccom.unh.edu/gis/maps/WGOM_4m/


Gatineau
Laval
Montreal
St-Jean-sur-Richelieu
Granby
Sherbrooke
Saint John
Cornwall
Brockville
Digby
Montpelier
Augusta
Yarmouth
Portland
Concord
Utica
Nashua
Lowell
Albany
Boston
Worcester
Springfield
Plymouth
Hartford
Providence
Barnstable
New Bedford
Falmouth
Waterbury
Scranton
Bridgeport
New York
Allentown
Edison
Trenton
Philadelphia
Toms River
N
0
50
100
200
300
Kilometers

Adopted CMECS for Surficial Sediment Maps

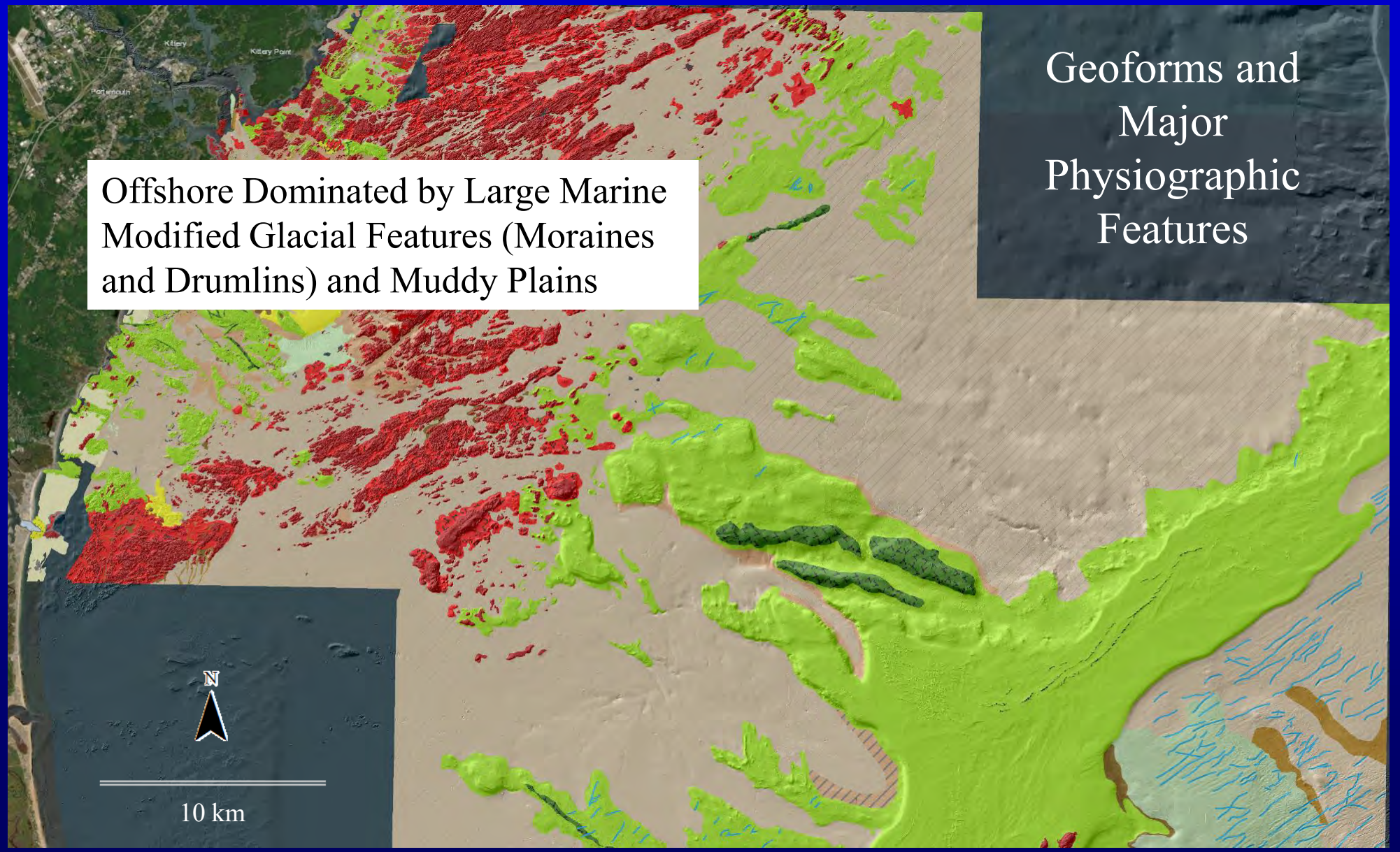
Substrate Origin	Substrate Class	Substrate Subclass	Substrate Group	Substrate Subgroup
Geologic Substrate	Rock Substrate	Bedrock		
	Unconsolidated Mineral Substrate	Coarse Unconsolidated Substrate	Gravel	Boulder
				Cobble
				Pebble
				Granule
			Gravel Mixes	Sandy Gravel
				Muddy Sandy Gravel
				Muddy Gravel
			Gravelly	Gravelly Sand
				Gravelly Muddy Sand
				Gravelly Mud
		Fine Unconsolidated Substrate	Slightly Gravelly	Slightly Gravelly Sand
				Slightly Gravelly Muddy Sand
				Slightly Gravelly Sandy Mud
				Slightly Gravelly Mud
			Sand	Very Coarse Sand
				Coarse Sand
				Medium Sand
				Fine Sand
				Very Fine Sand
			Muddy Sand	Silty Sand
				Silty-Clayey Sand
				Clayey Sand
			Sandy Mud	Sandy Silt
				Sandy Silt-Clay
				Sandy Clay
			Mud	Silt
				Silt-Clay
				Clay

Advantages:

Groups Sediment Sizes

Helpful When Incomplete Data Coverage

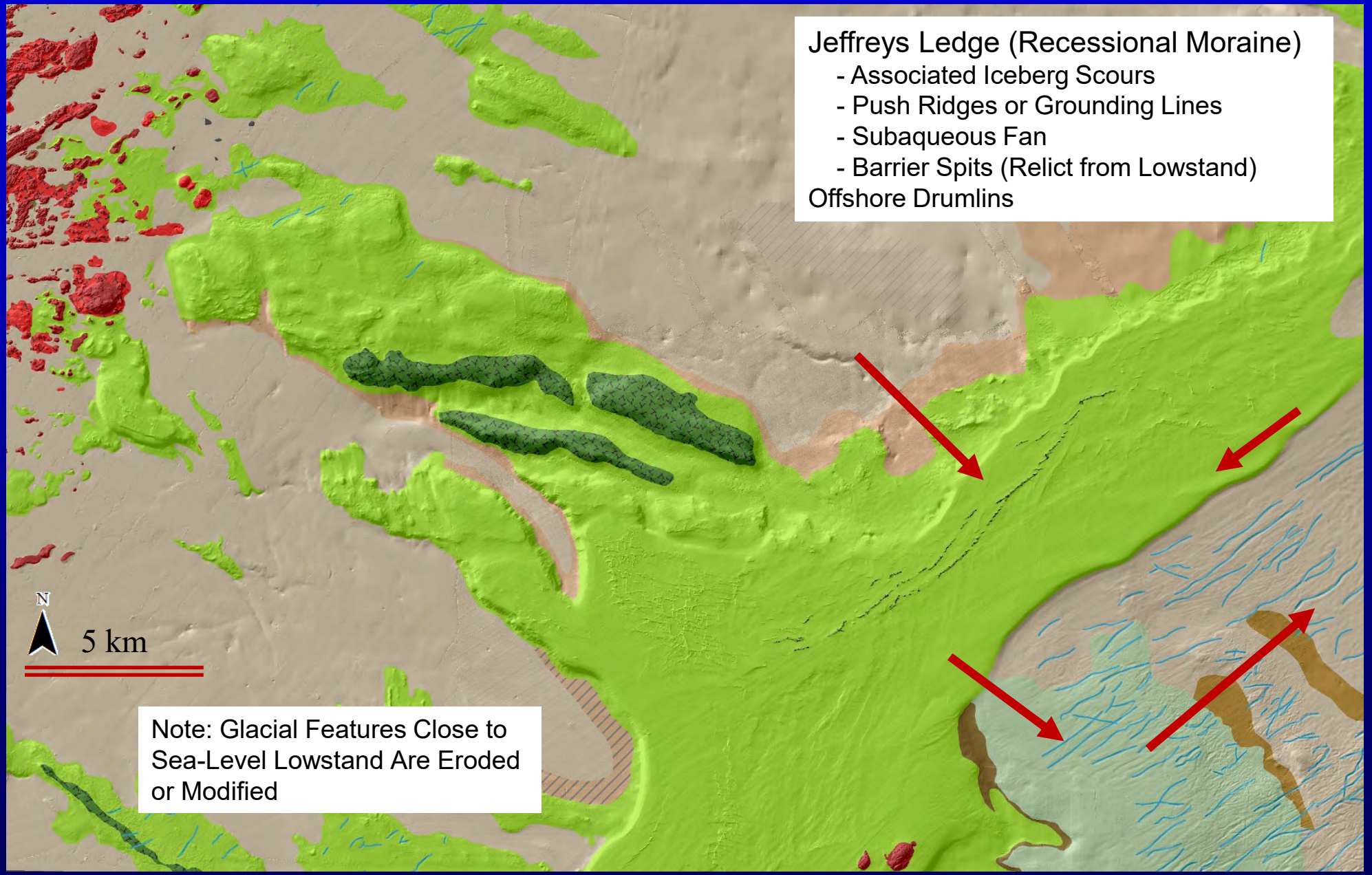
Physiographic Characteristics of the Outer NH Shelf



Legend

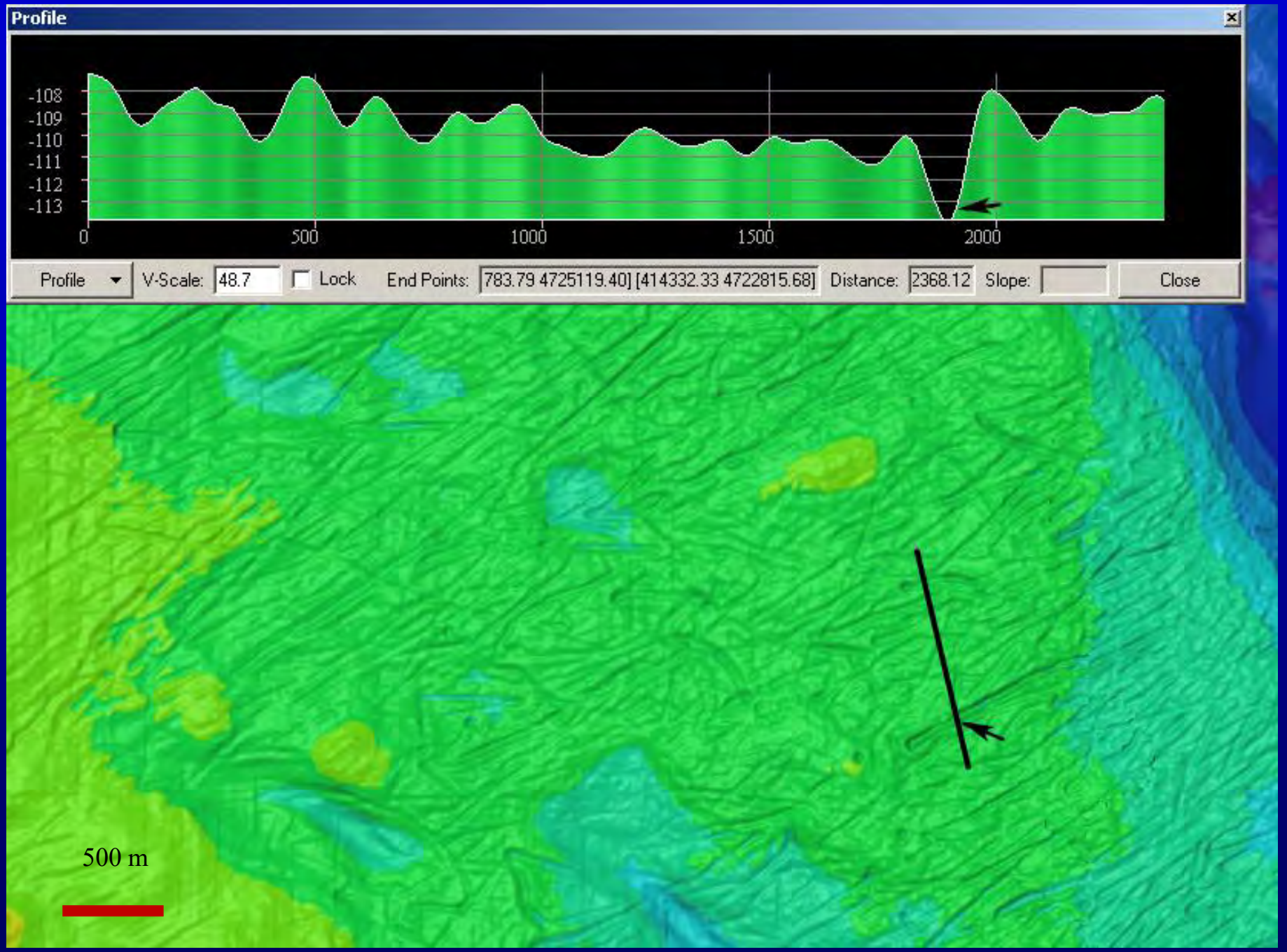
- Marine Modified Glacial Feature
- Moraine
- Ridge
- Iceberg Scours
- Bedrock Outcrop
- Bedrock Border
- Sediment Draped Bedrock
- Megaclast Field
- Subaqueous Fan
- Inlet
- Marine Formed Feature
- Ebb Tidal Delta
- Shoal
- Tombolo
- Nearshore Ramp
- Seafloor Plain
- Slope
- Bedforms
- Channel
- Depression
- Unverified

Physiographic Characteristics of the NH Shelf



Legend

- Marine Modified Glacial Feature
- Moraine
- Ridge
- Iceberg Scours
- Bedrock Outcrop
- Bedrock Border
- Sediment Draped Bedrock
- Megaclast Field
- Subaqueous Fan
- Inlet
- Marine Formed Feature
- Ebb Tidal Delta
- Shoal
- Tombolo
- Nearshore Ramp
- Seafloor Plain
- Slope
- Bedforms
- Channel
- Depression
- Unverified

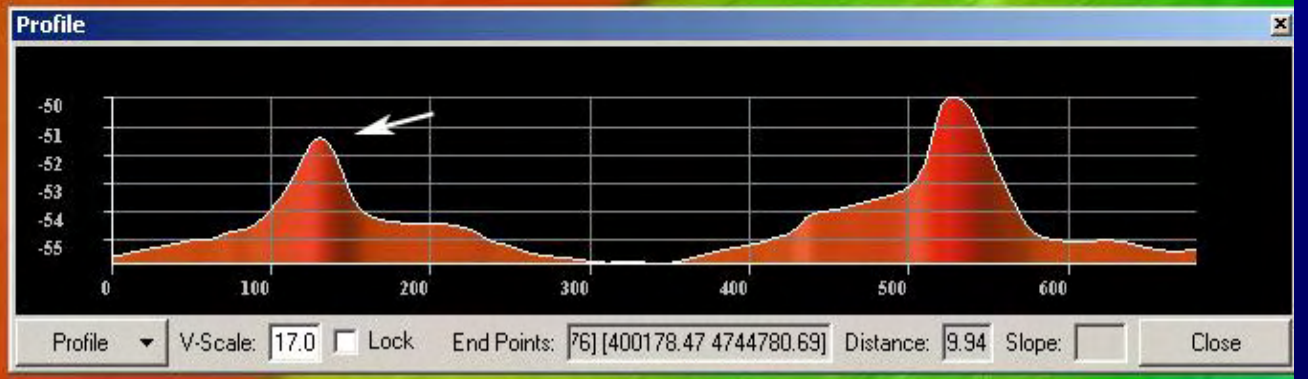


Jeffreys Ledge Iceberg Scours

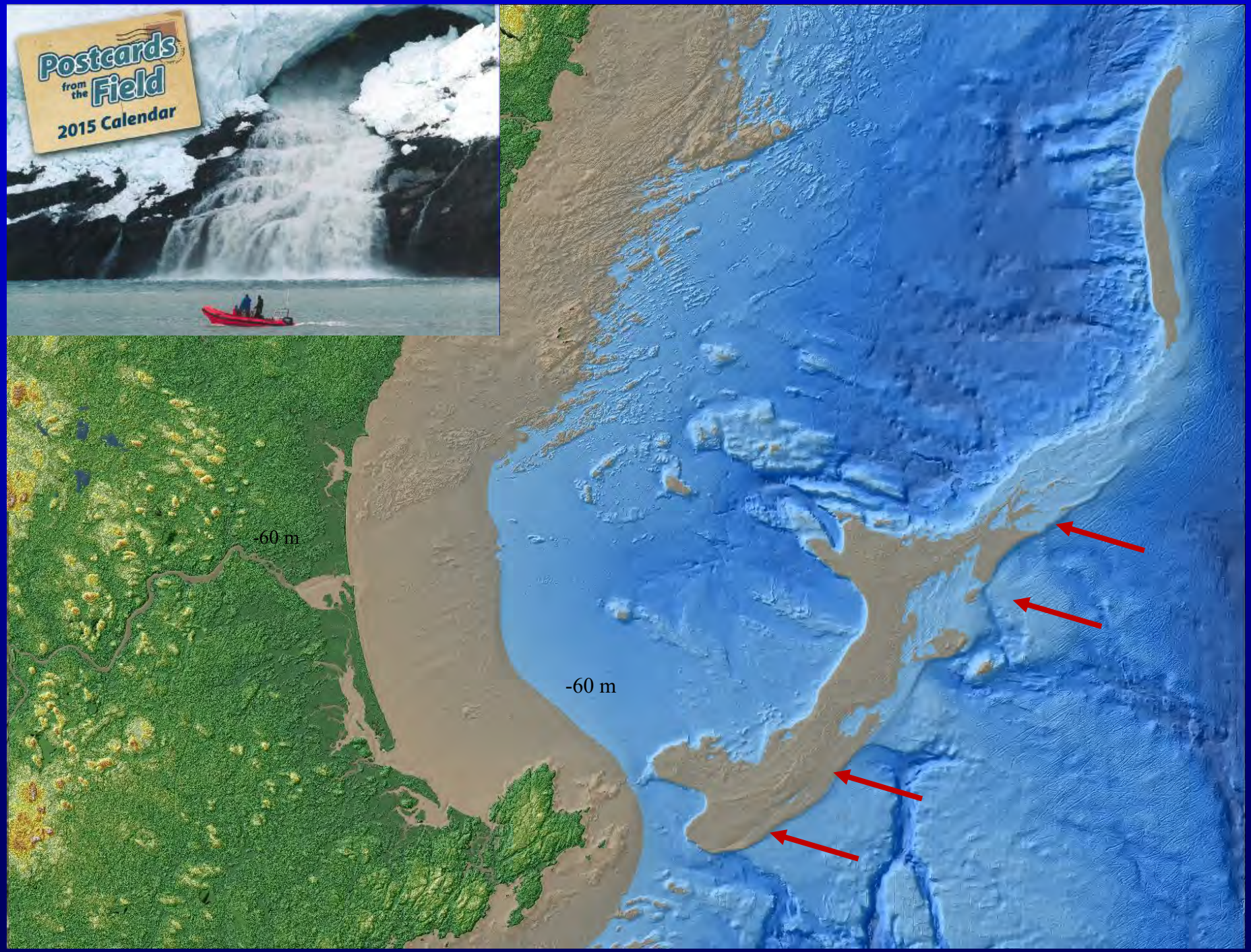
Oriented NE-SW
1 to 5 m deep
Kms in length

Jeffreys Ledge Push Ridges or Grounding Lines

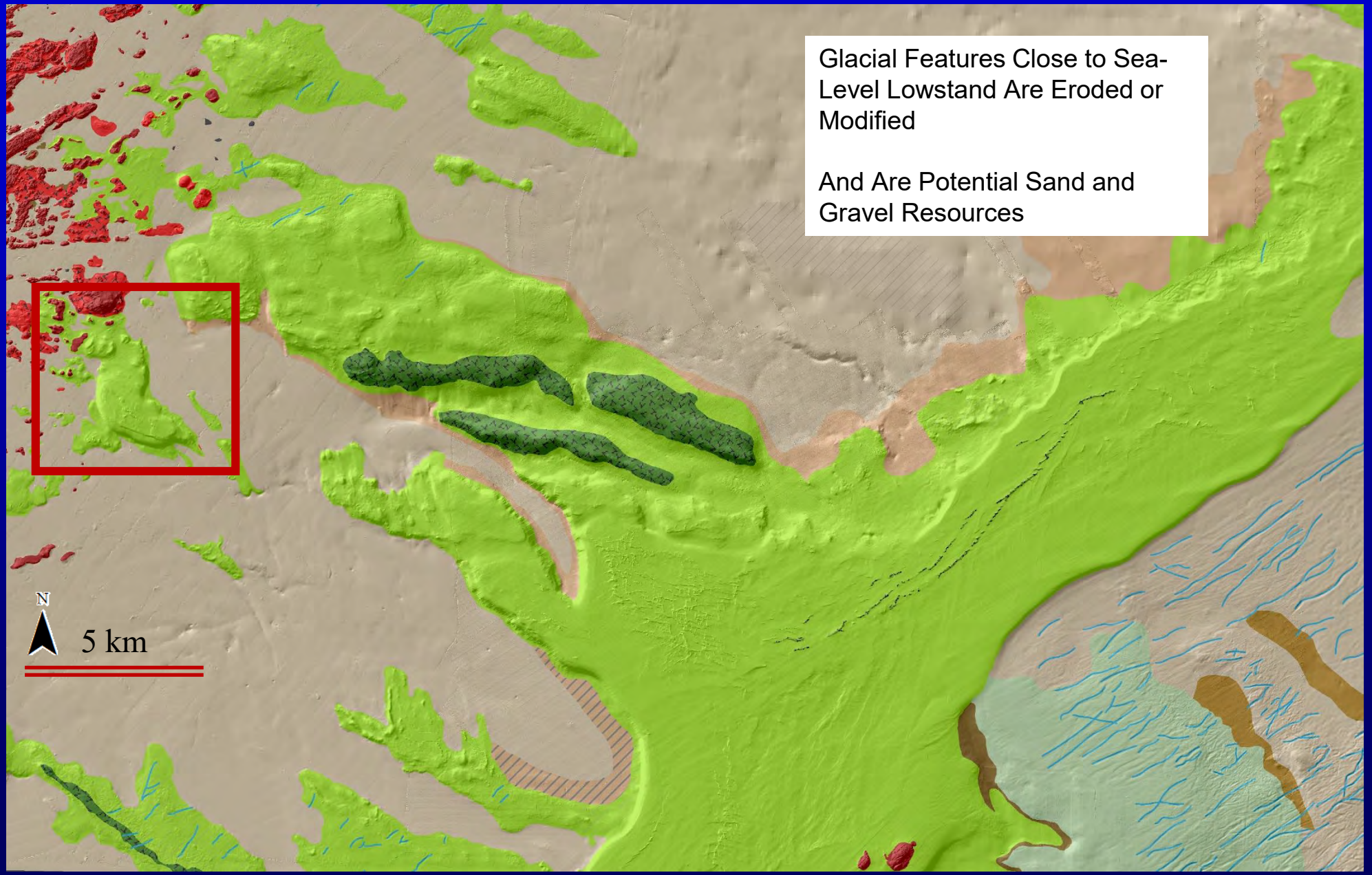
200 m



Approximate Position of Shoreline During Lowstand (-60 m)

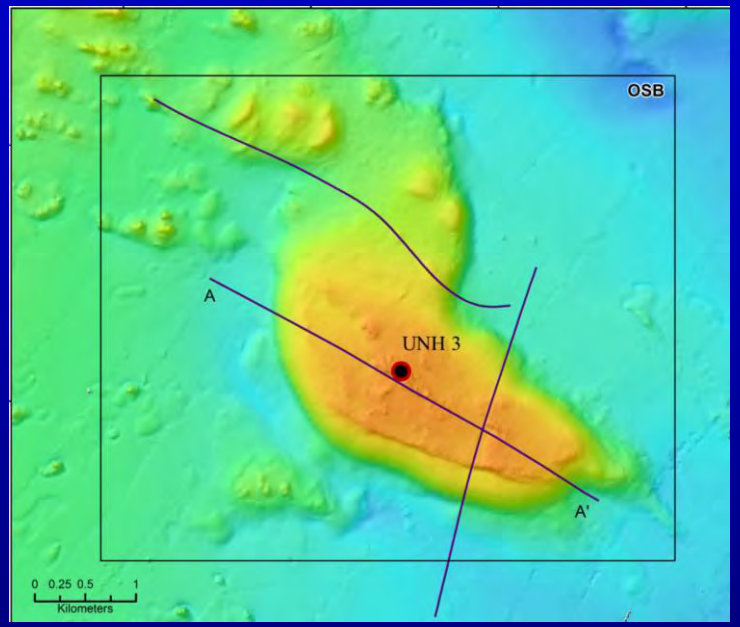


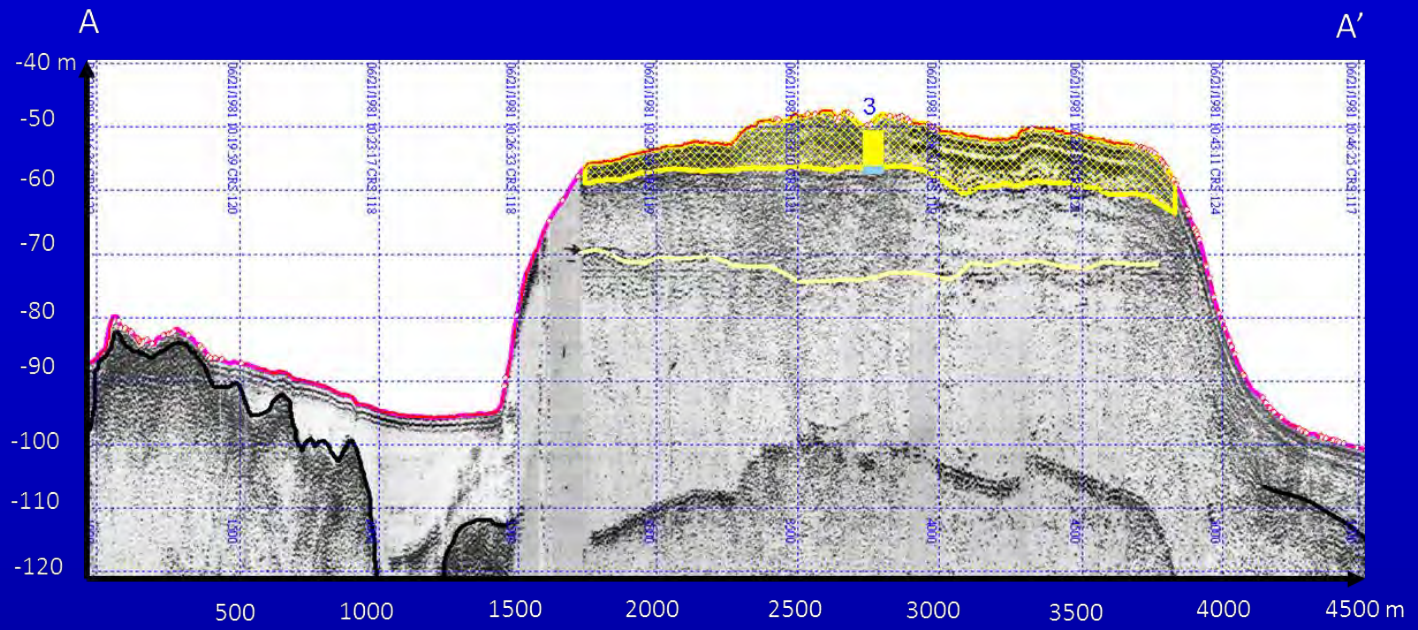
Physiographic Characteristics of the Outer NH Shelf

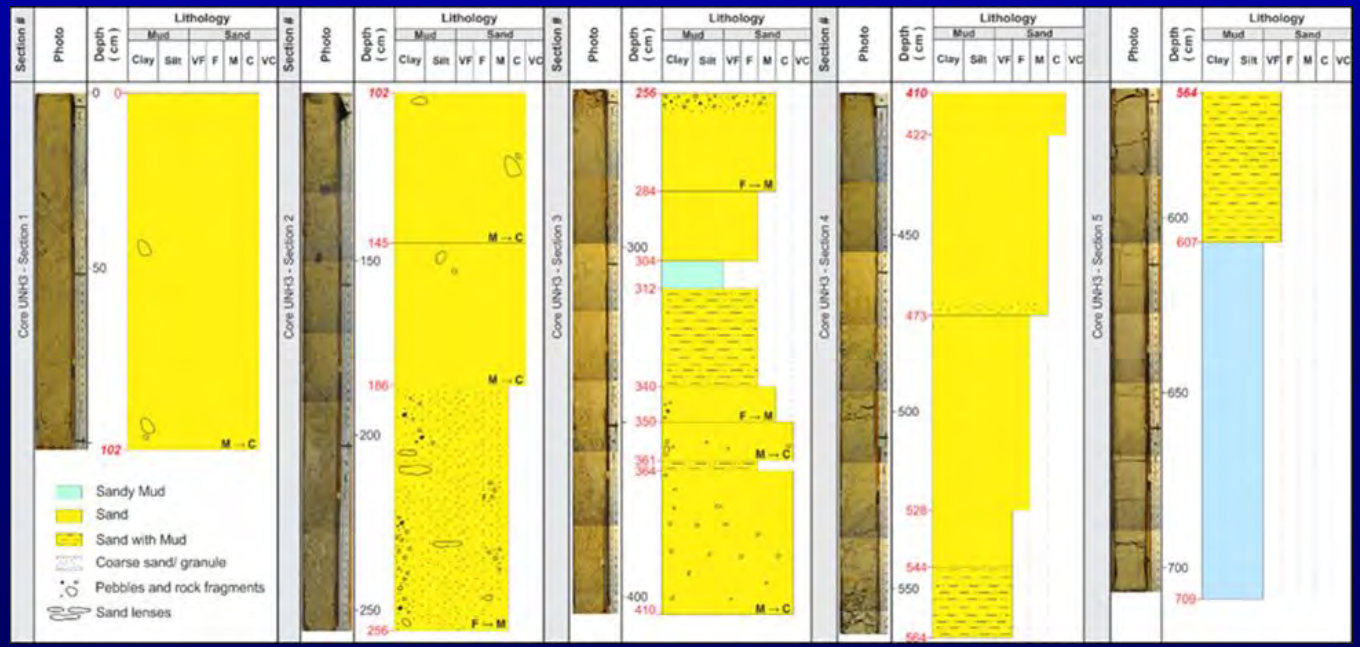


Legend

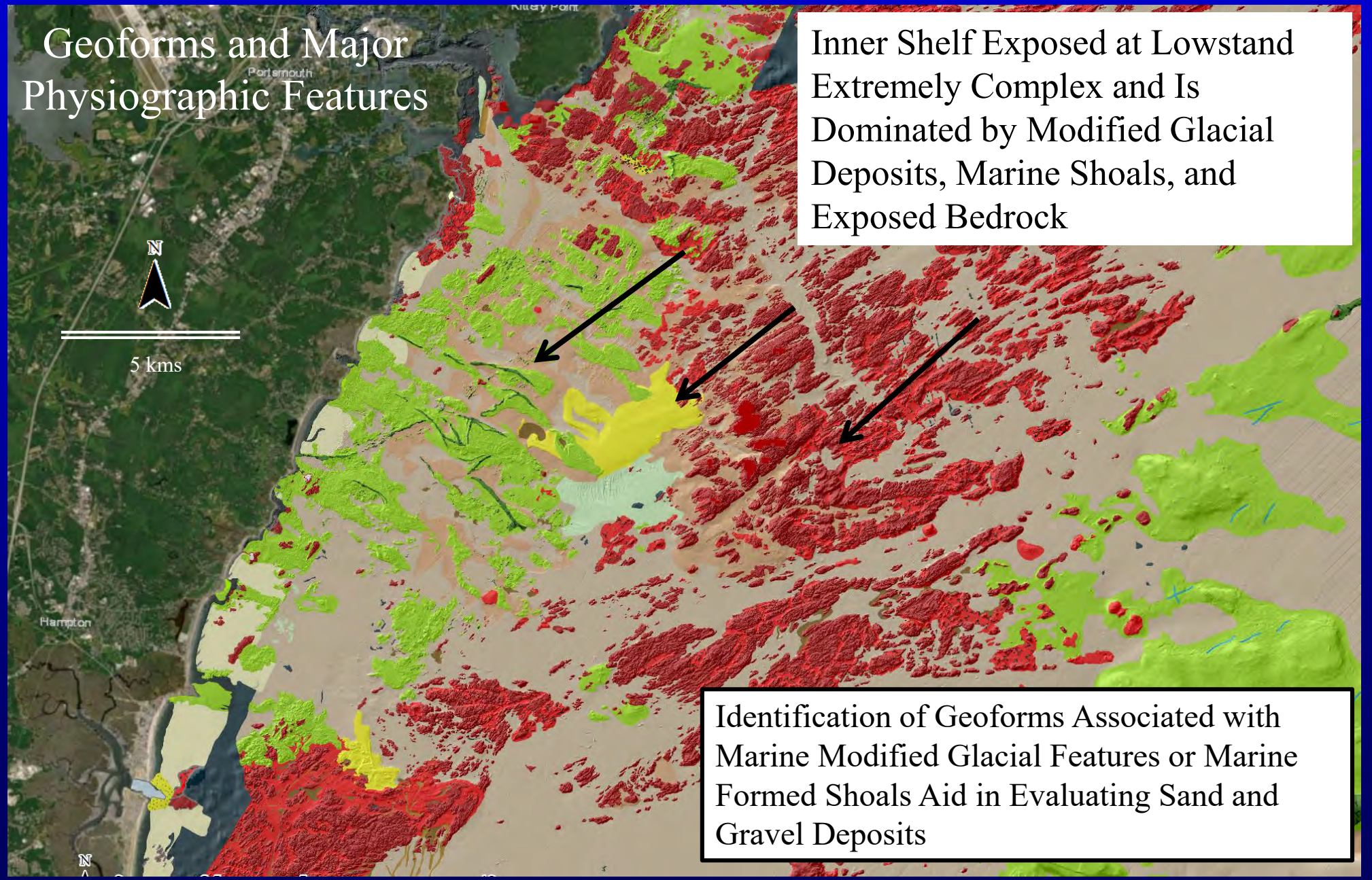
- Marine Modified Glacial Feature
- Moraine
- Ridge
- Iceberg Scours
- Bedrock Outcrop
- Bedrock Border
- Sediment Draped Bedrock
- Megaclast Field
- Subaqueous Fan
- Inlet
- Marine Formed Feature
- Ebb Tidal Delta
- Shoal
- Tombolo
- Nearshore Ramp
- Seafloor Plain
- Slope
- Bedforms
- Channel
- Depression
- Unverified


OSB
A
UNH 3
A'
0 0.25 0.5 1
Kilometers

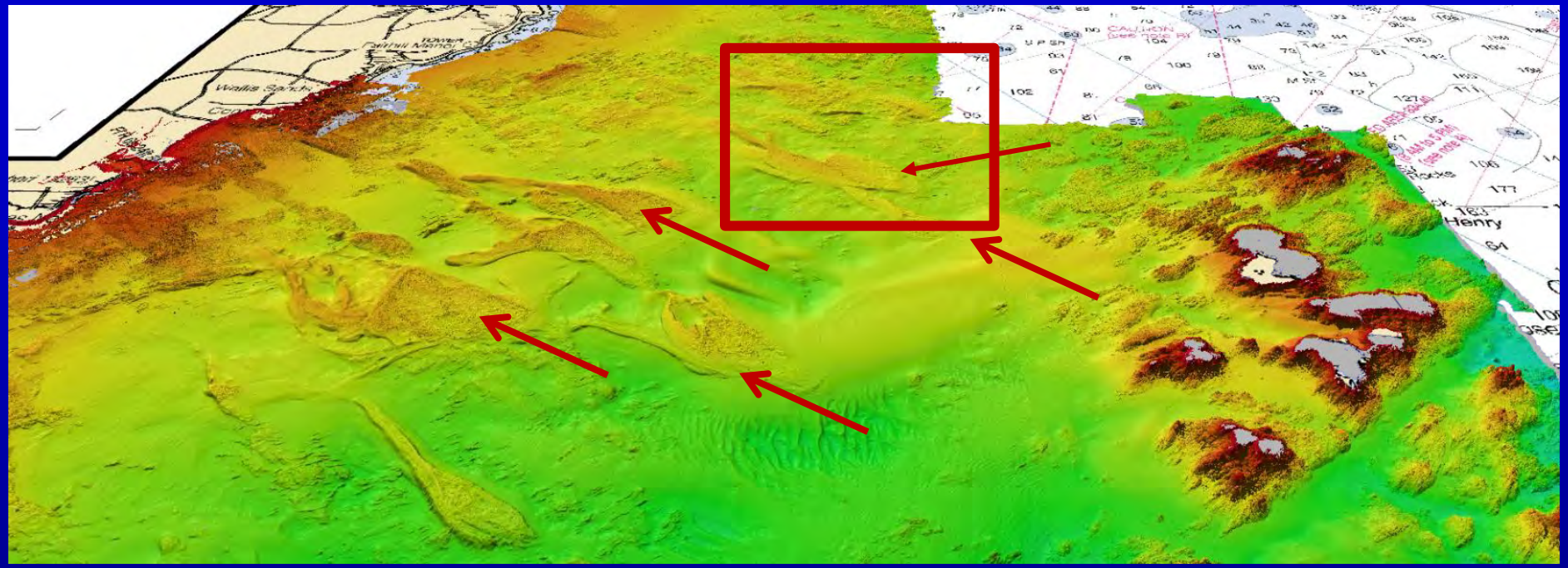

A
A'
-40 m
-50
-60
-70
-80
-90
-100
-110
-120
3
500
1000
1500
2000
2500
3000
3500
4000
4500 m

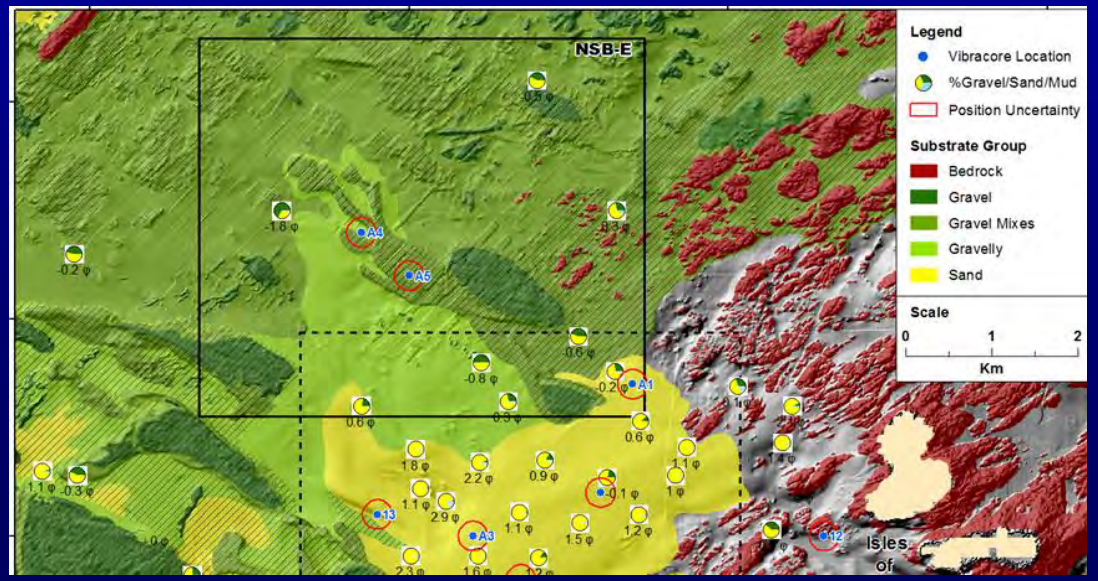

Section #
Photo
Depth (cm)
Lithology
Mud
Sand
Clay
Silt
VF
F
M
C
VC
Core UNH3 - Section 1
Core UNH3 - Section 2
Core UNH3 - Section 3
Core UNH3 - Section 4
Core UNH3 - Section 5
M → C
F → M
Sandy Mud
Sand
Sand with Mud
Coarse sand/ granule
Pebbles and rock fragments
Sand lenses

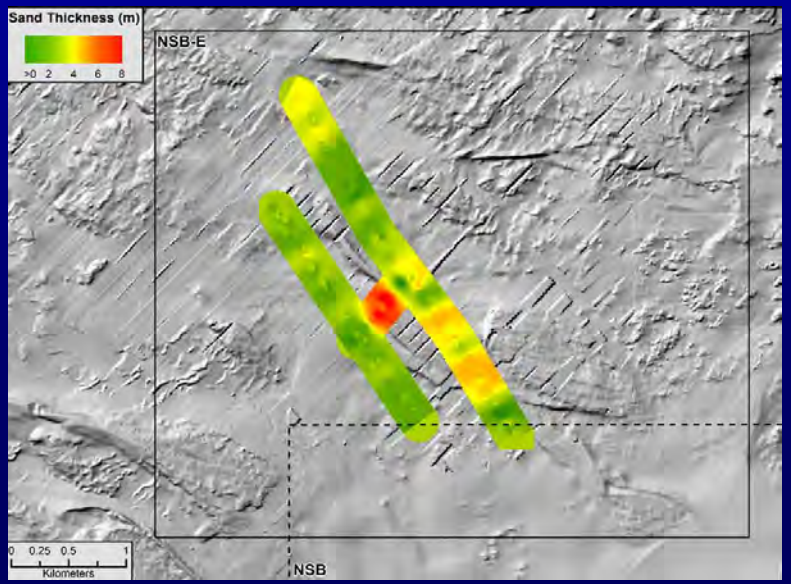
Physiographic Characteristics of the Inner NH Shelf

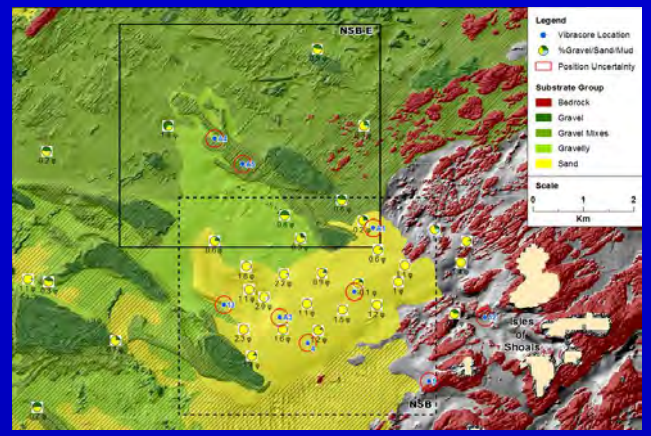


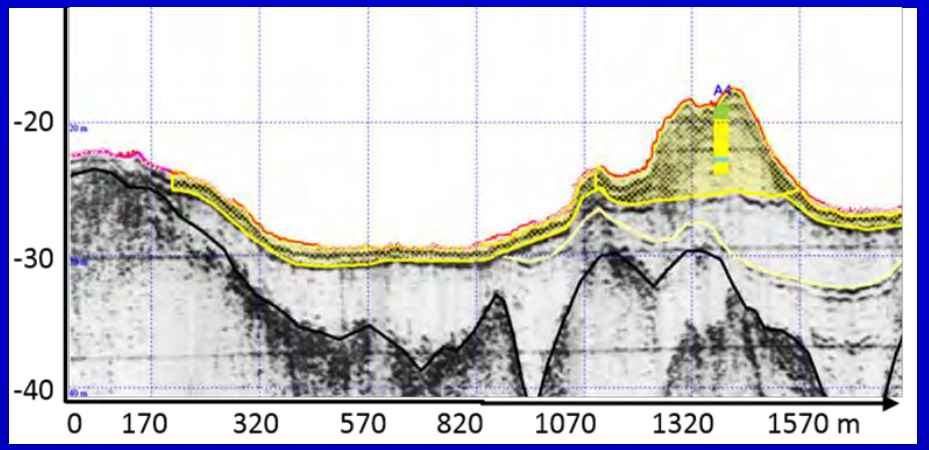
Examples of Modified Glacial Deposit and Associated Marine Shoals

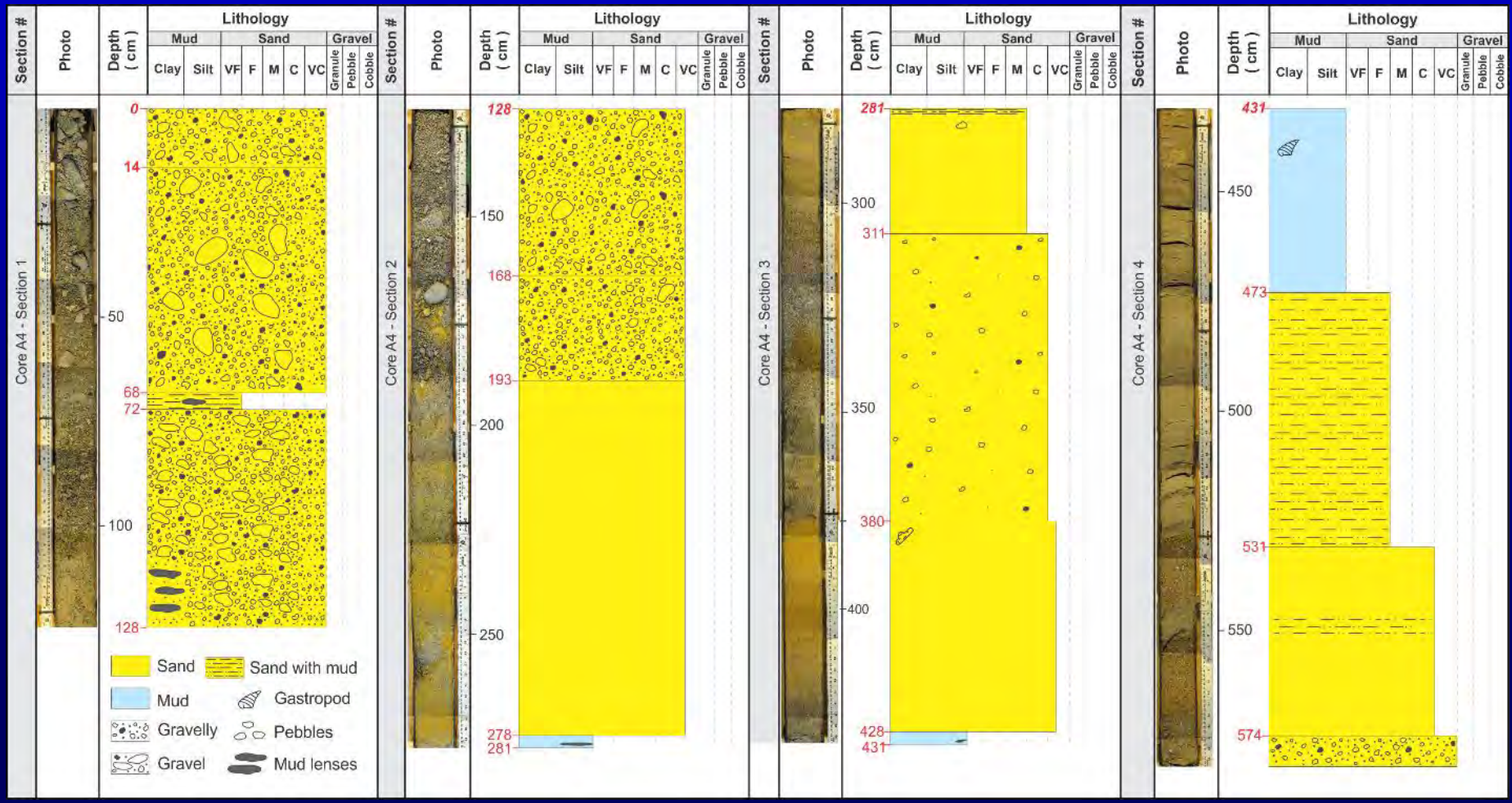




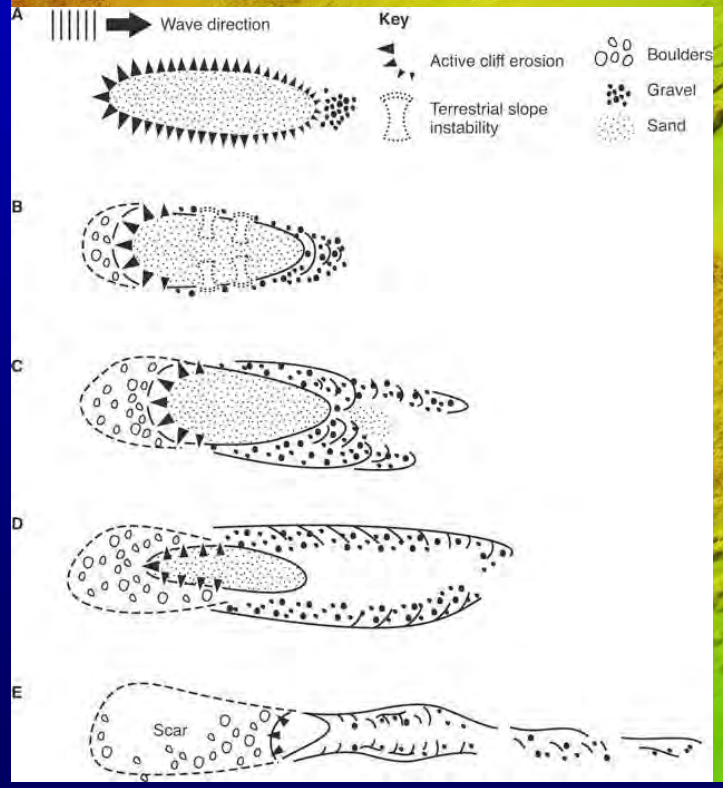



Legend
Vibracore Location
%Gravel/Sand/Mud
Position Uncertainty
Substrate Group
Bedrock
Gravel
Gravel Mixes
Gravelly
Sand
Scale
0 1 2
Km
NSB1E
Isles of Shoals
NSB1


-20
-30
-40
A4
0 170 320 570 820 1070 1320 1570 m


Section #
Photo
Depth (cm)
Lithology
Mud
Clay
Silt
Sand
VF
F
M
C
VC
Gravel
Granule
Pebble
Cobble
Core A4 - Section 1
Core A4 - Section 2
Core A4 - Section 3
Core A4 - Section 4
0
14
50
68
72
100
128
128
150
168
193
200
250
278
281
281
300
311
350
380
400
428
431
431
450
473
500
531
550
574
Sand
Sand with mud
Mud
Gastropod
Gravelly
Pebbles
Gravel
Mud lenses

Model for Development of Sand and Gravel Deposits
(With Positive Relief)

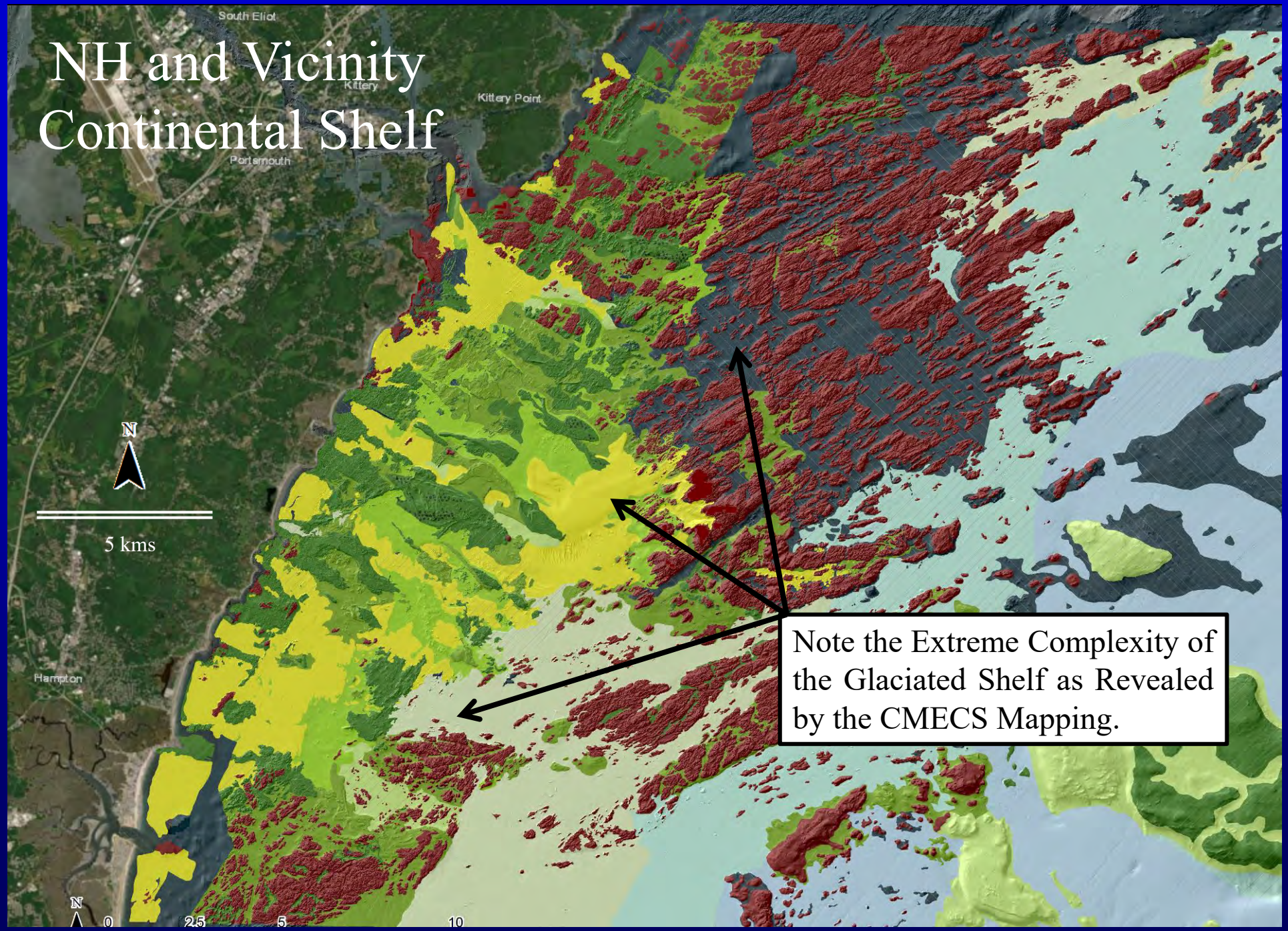


1. Drumlin, Esker or Glacial Feature Deposited During Glaciation

2. Glacial Feature Eroded By Wave Processes During Sea-level Fluctuations

3. Shoals Form From Material Eroded From Drumlin by Marine Processes (Waves and Tides)

Carter and Orford. 1988. Model for Erosion of Drumlin and Beach Ridge Formation (figure reproduced in Masselink, Hughes and Knight. 2011. Introduction to Coastal Processes and Geomorphology, 2nd edition. Hodder Education. Figure 11.6



CMECS Classification Substrate Group

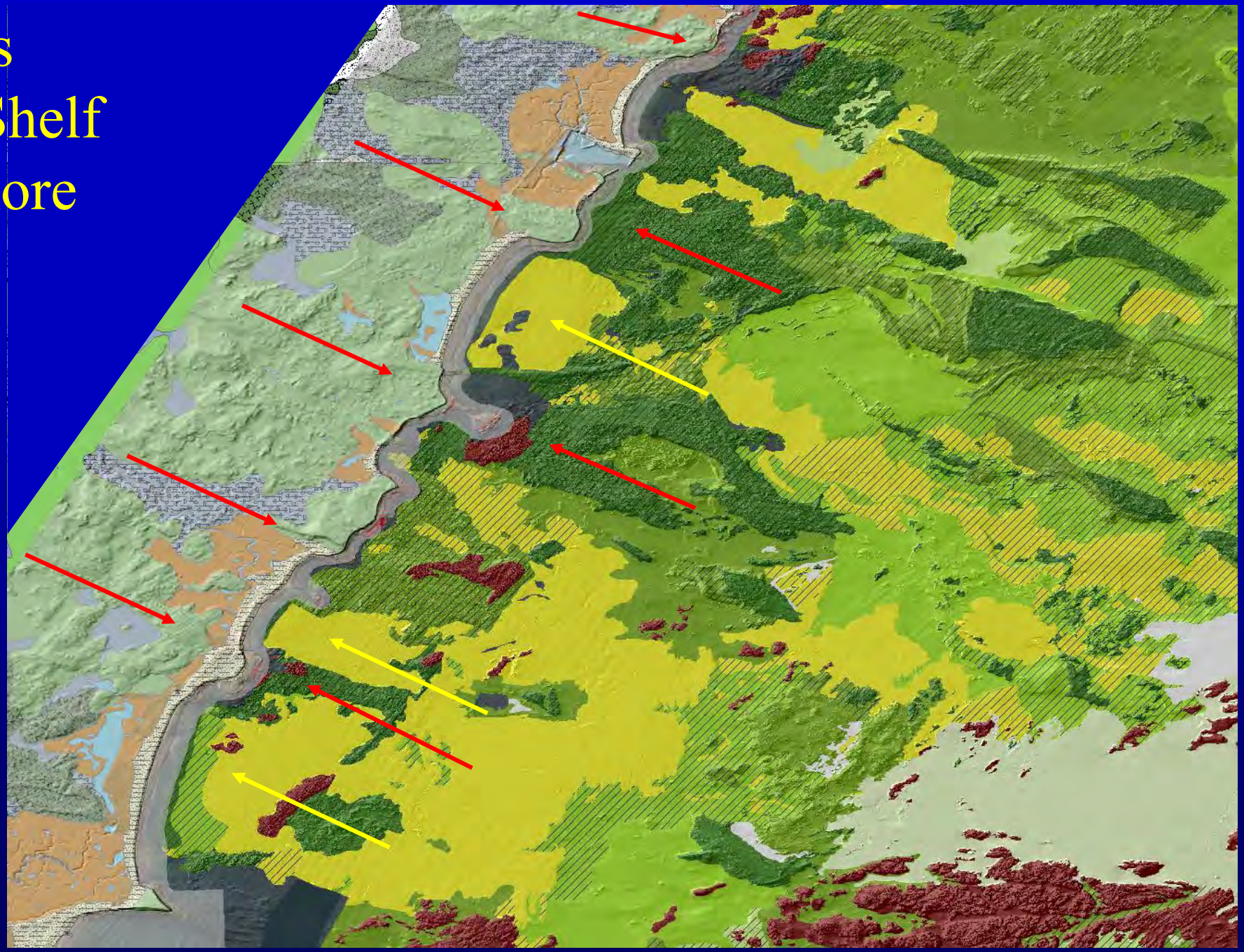
Legend

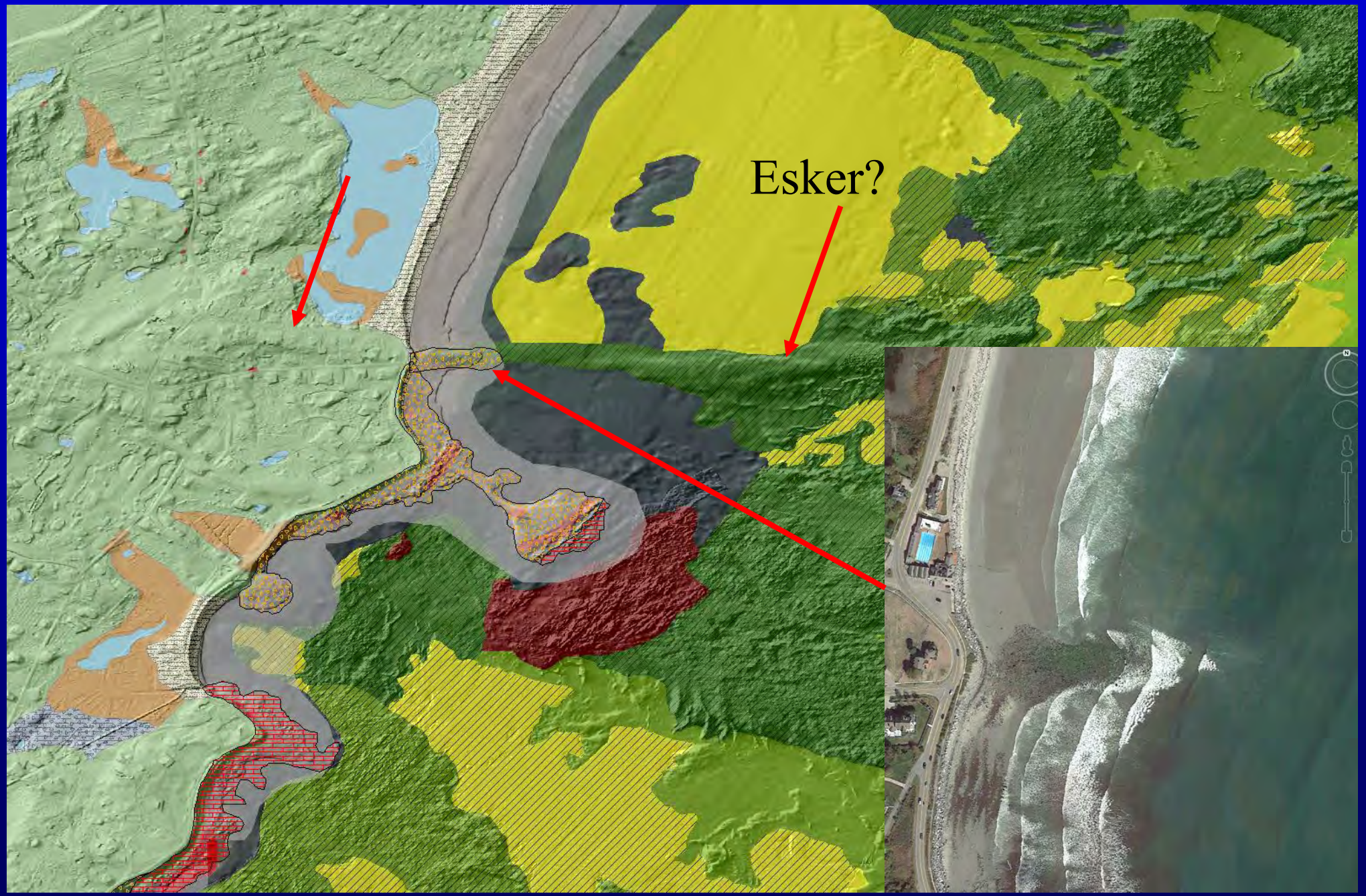
- Megaclast
- Gravel
- Gravel Mixes
- Gravelly
- Slightly Gravelly
- Sand
- muddy Sand
- sandy Mud
- Mud
- Unverified
- Unknown
- Bedrock Outcrop

Many of the Features Found on the Inner Shelf Can Be Traced Onshore

Nearshore Ramp (Sandy)

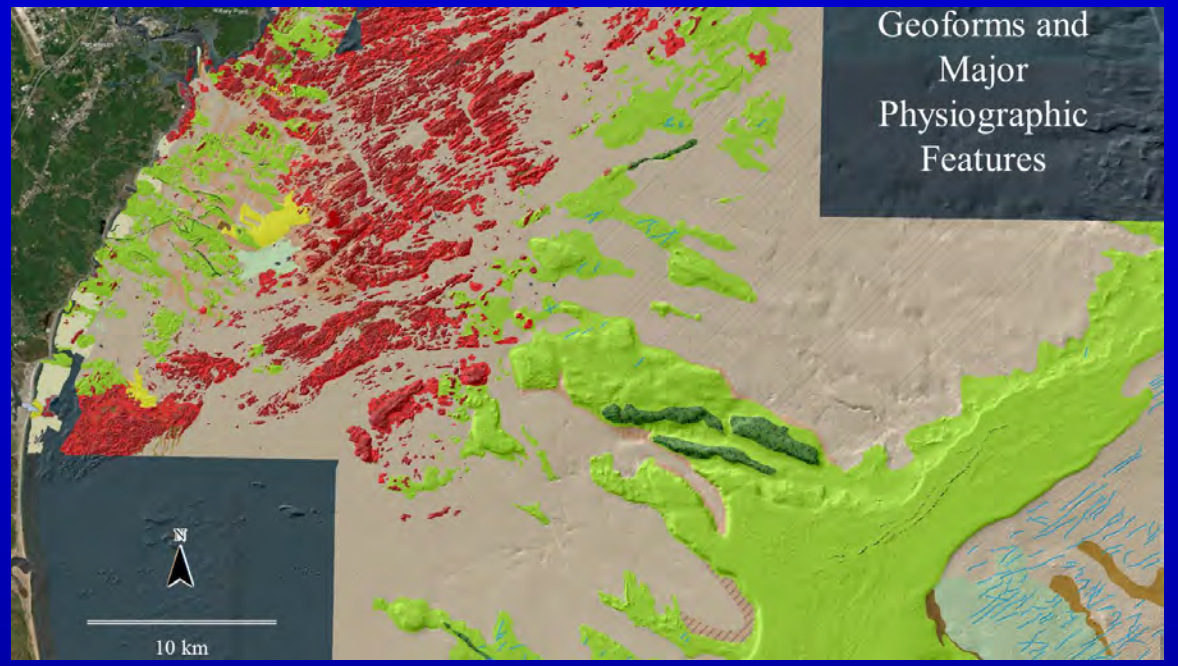
Modified Glacial Deposits

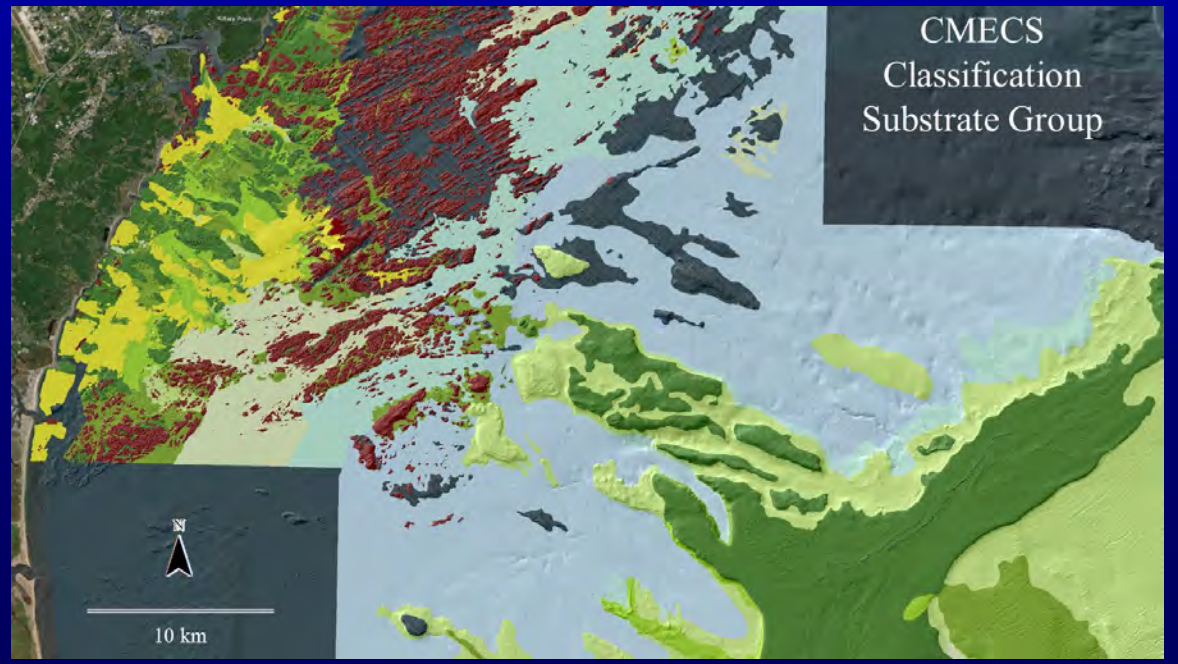



Esker?

Lessons Learned and the Way Forward

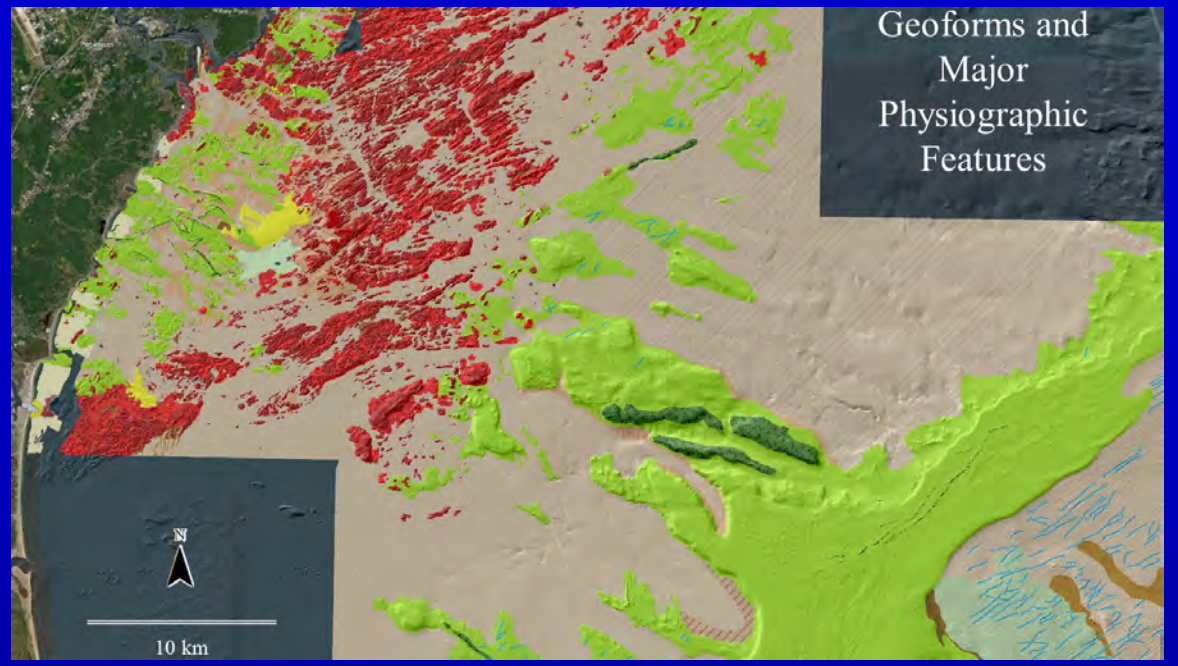
- Over the Last Five Years Completed
  - High Resolution Surficial Geology Maps
  - Sand and Gravel Isopach Maps
  - Provided Major Advance in Our Understanding of the NH Shelf
  - And Sand and Gravel Resources
- Extremely Labor Intensive and Expensive
- Most Work Done Via "Expert Opinion"
- Therefore, Need Different Approach to Map Complex Paraglacial Seafloor

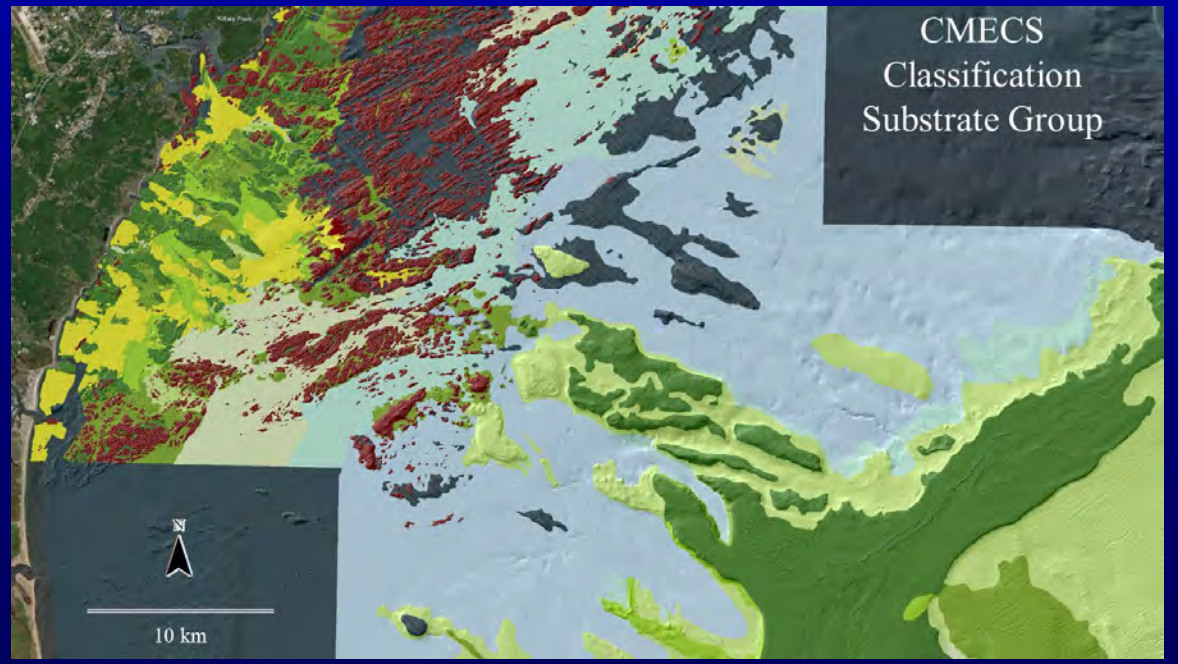




Lessons Learned and the Way Forward

- Need Remote Sensing and Automated Approaches
  - Tried Before Using ArcGIS and Geocoder
  - Problems With Complexity of Seafloor
- Need Better Way to Identify Landforms and Segment Seafloor
- Presently, Conducting an Evaluation of the Utility of a New Algorithm Developed at UNH CCOM: BRESS

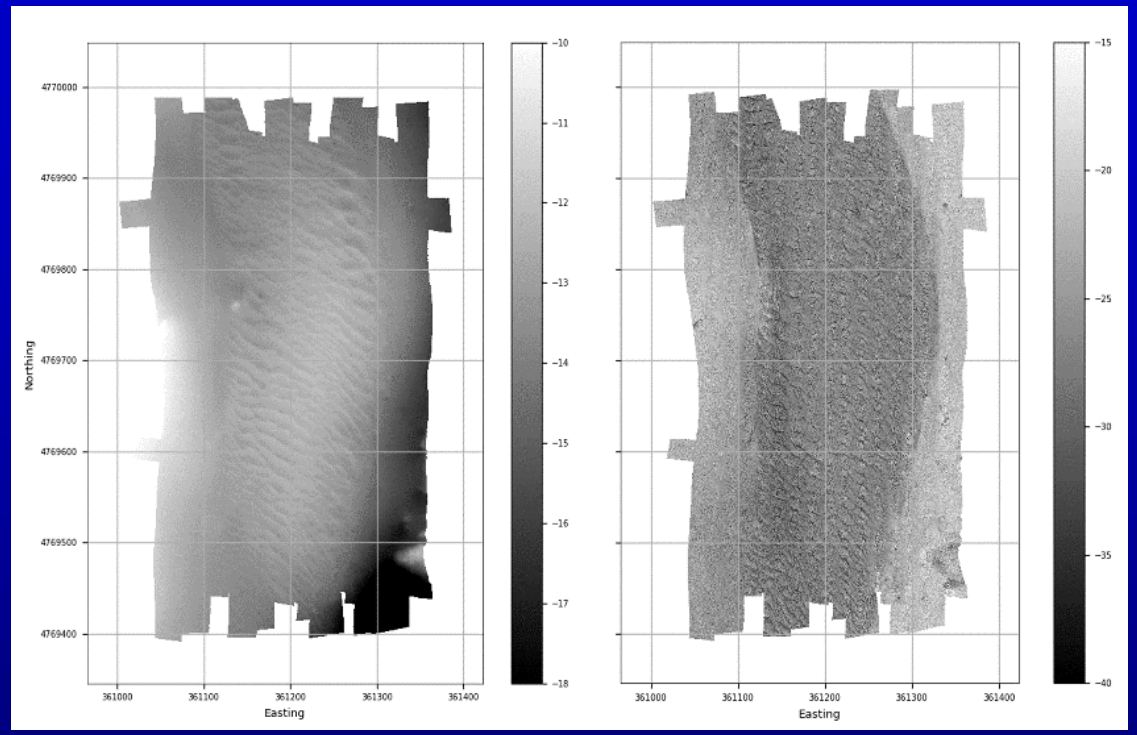




BRESS: Bathymetric and Reflectivity-Based Estimator of Seafloor Segments

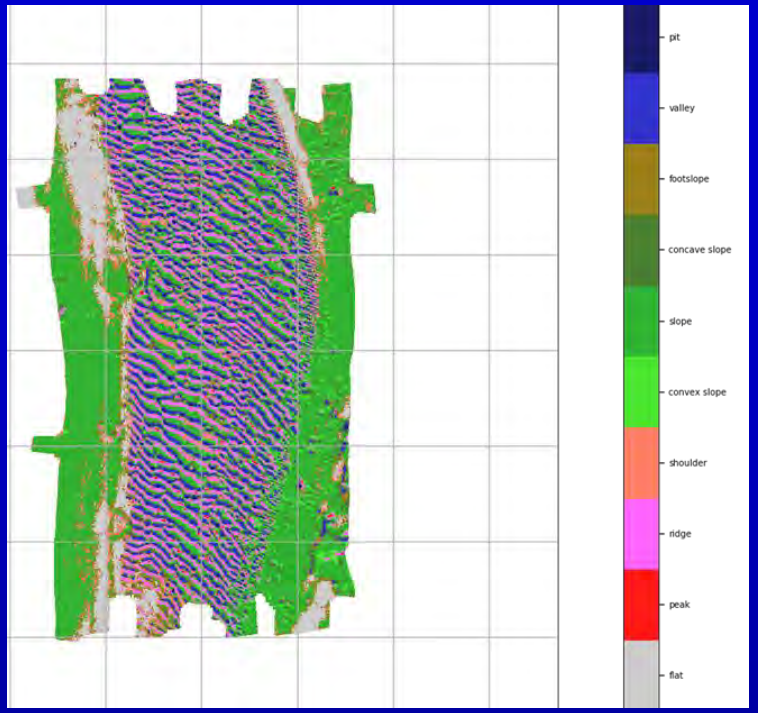
- Preliminary Segmentation from Co-Located DEMs and Backscatter Mosaics
- Based on Principles of:
  - Topographic Openness
  - Pattern Recognition
  - Texture Classification

Ref.: G. Masetti, Mayer, L. A., and Ward, L. G., "A Bathymetry- and Reflectivity-Based Approach for Seafloor Segmentation", Geosciences, vol. 8(1). MDPI, 2018.

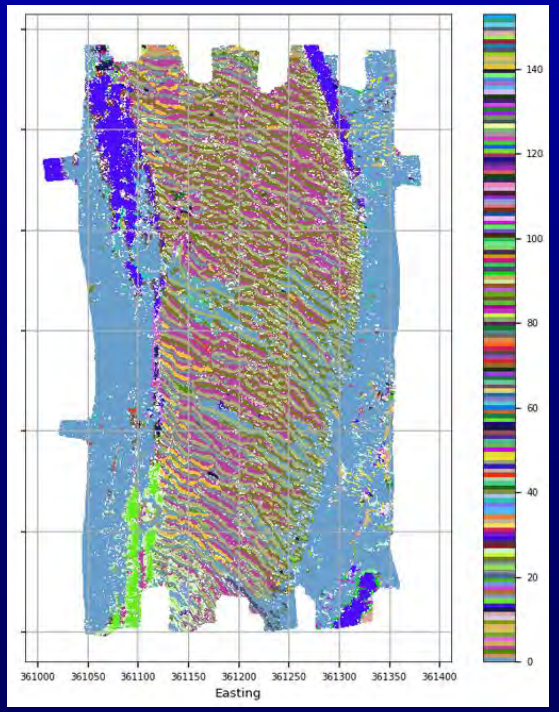


INPUTS: DEM and Backscatter Mosaic

Output: Landforms

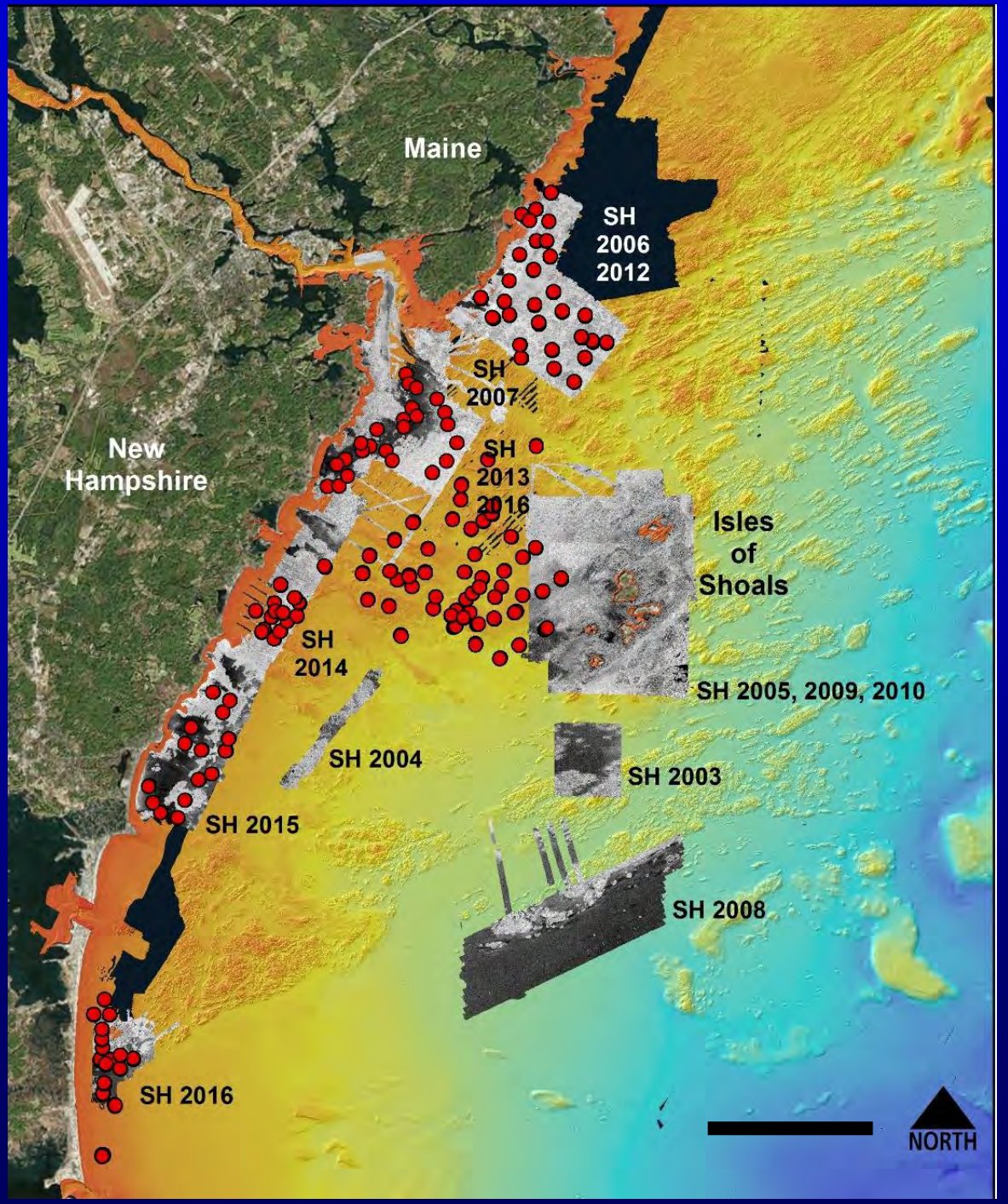


Output: Segments (Landforms With Similar Textures)



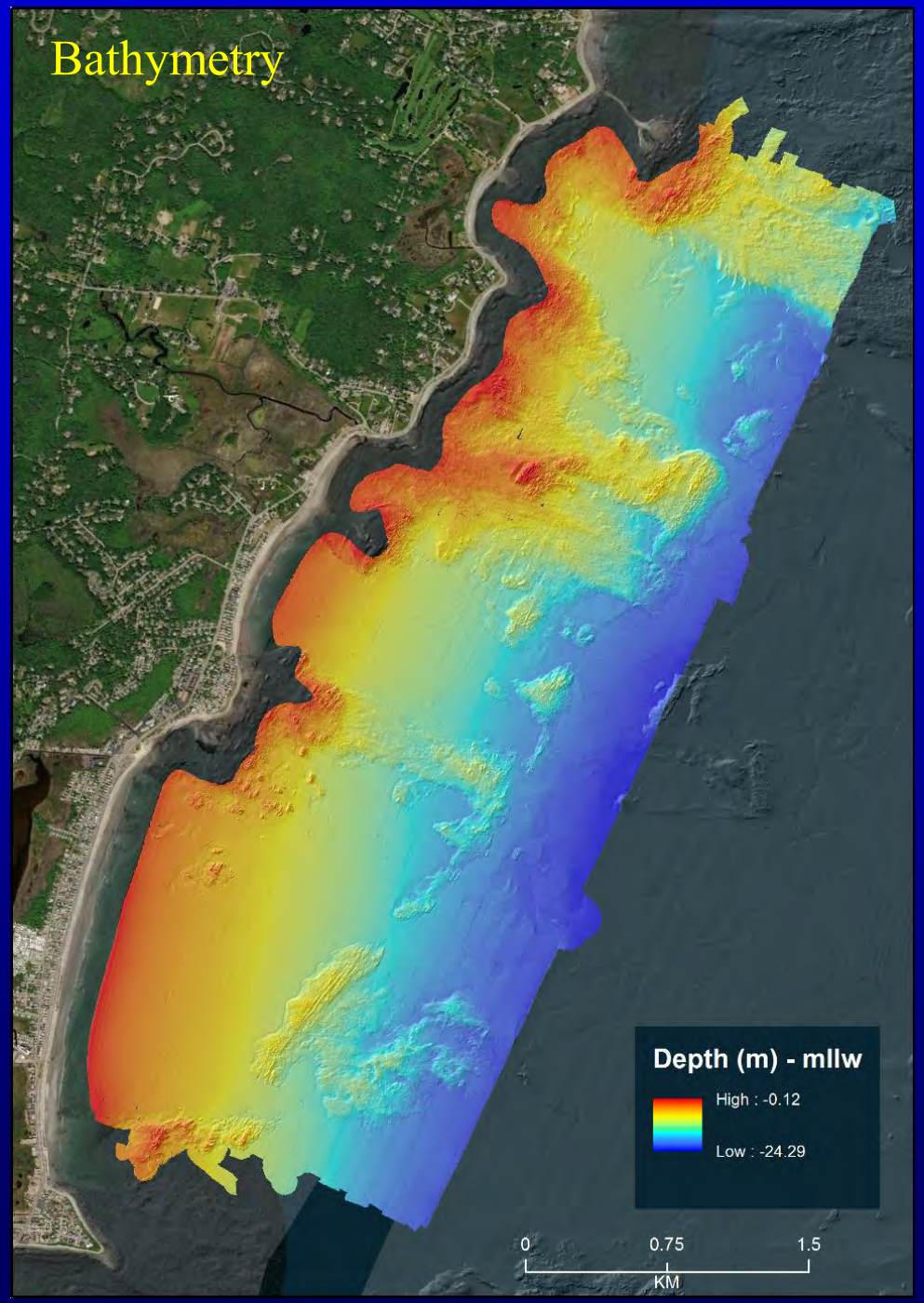
BRESS Evaluation

- Assessing the Potential of BRESS to Help Define and Map Geoforms, and
- Identify Areas With Similar Sediments Based on Morphology and Reflectivity
- Using High Resolution MBES Surveys Conducted by CCOM
- Over 10 Surveys Conducted in a Variety of Seafloor Settings
- Conducted Extensive Field Campaign to Serve as Ground Truth
  - 85 Stations with Video and Bottom Sediments
  - 66 Stations with Video (Too Coarse to Sample)



Input to BRESS

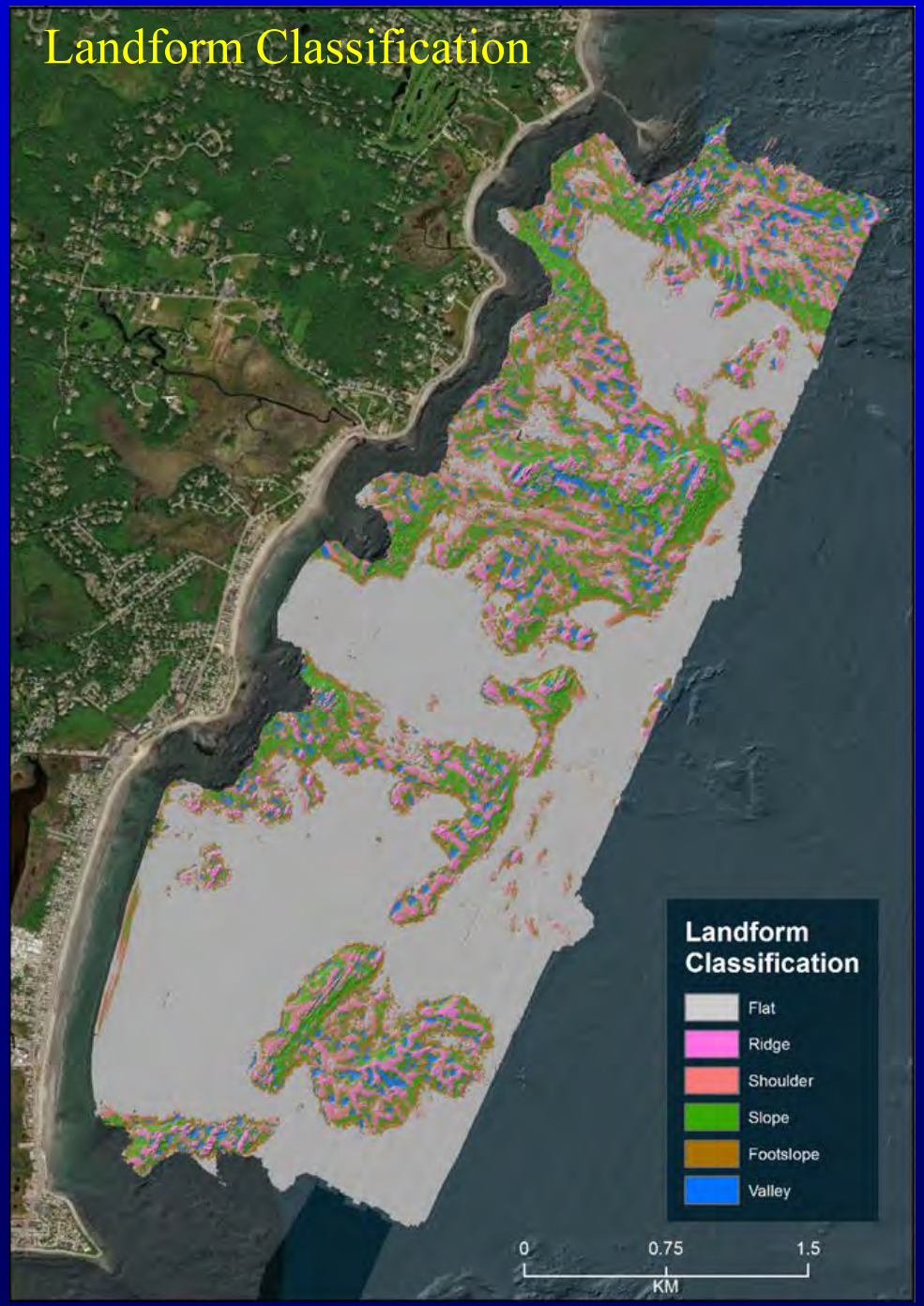
- CCOM Summer Hydro: 2015
- MBES System:EM2040
- 300 kHz
- Gridding: 1meter

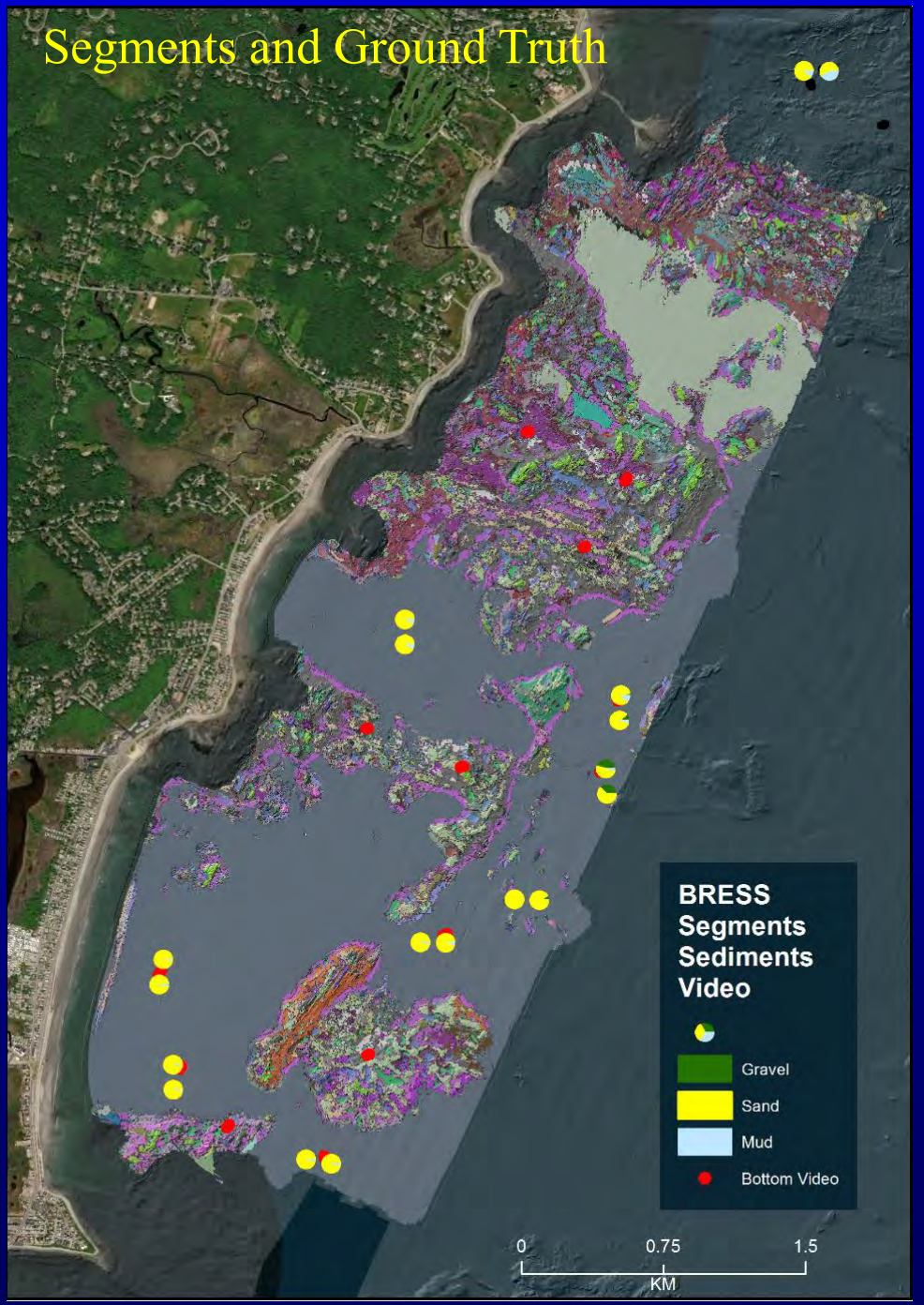


Initial Results

Geoforms Identified Relatively Well

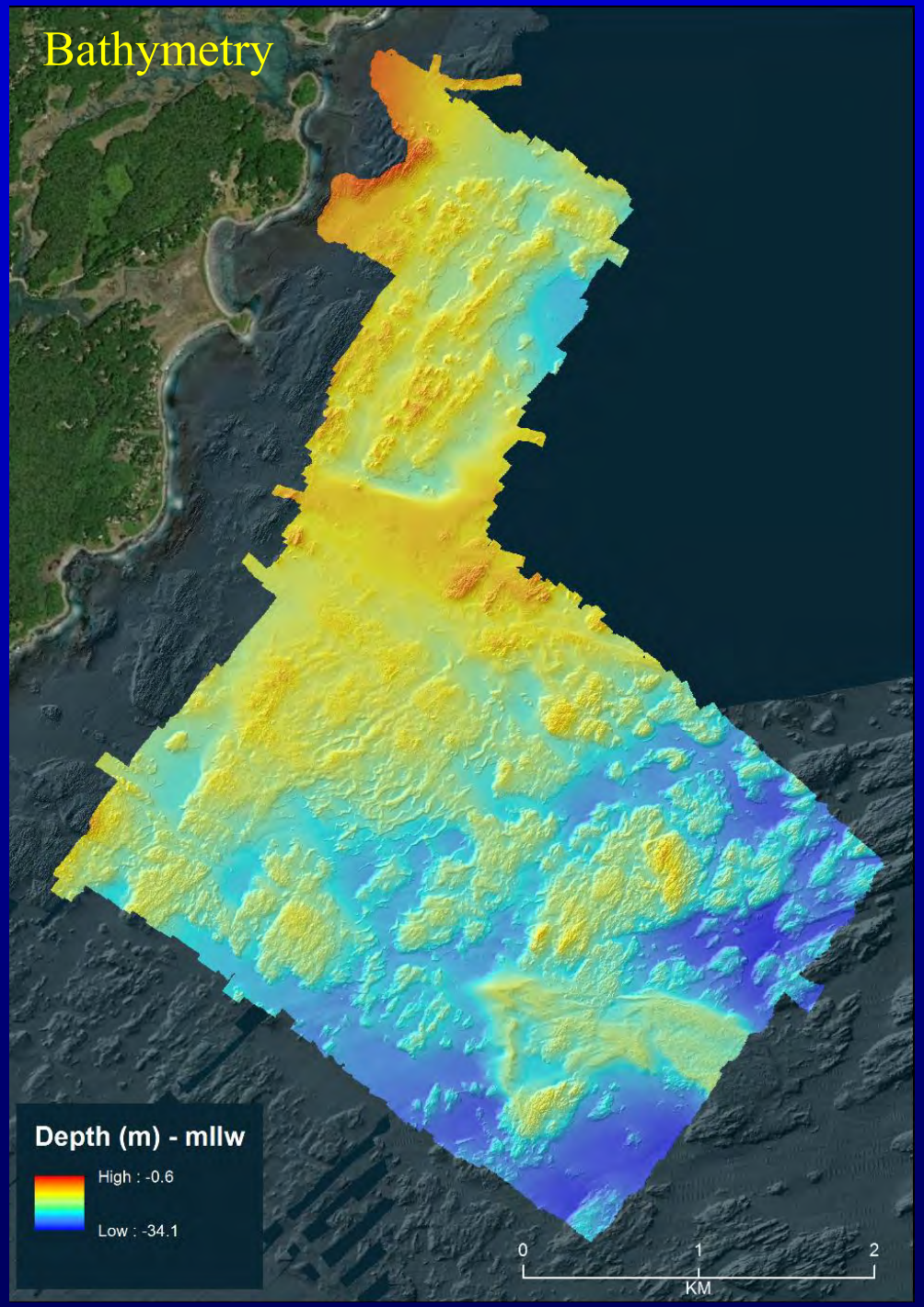
Joined Segments Agree with the Ground Truth Very Well





Input to BRESS

- CCOM Summer Hydro: 2012
- MBES System: EM2040
- 300 kHz
- Gridding: 1meter

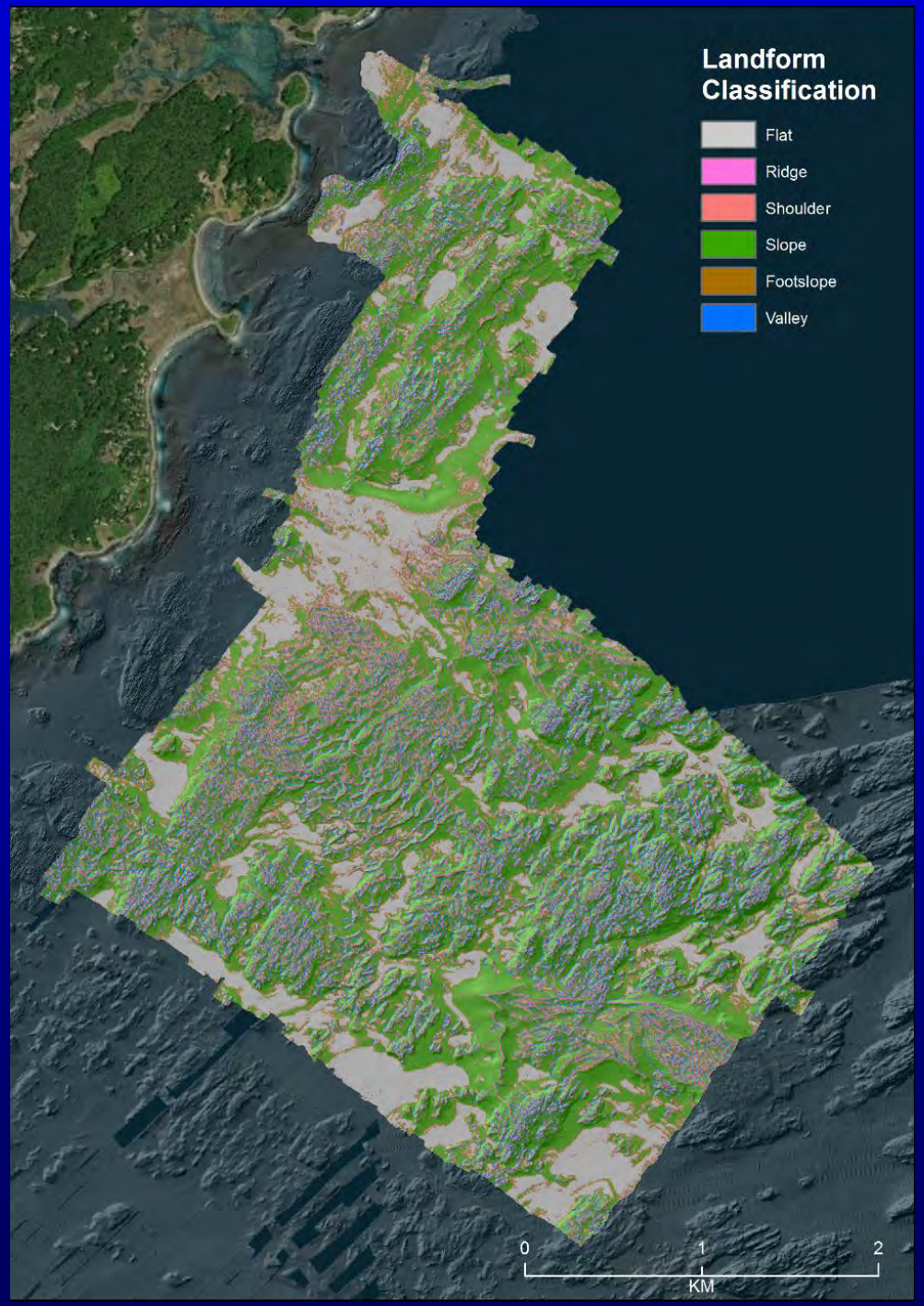


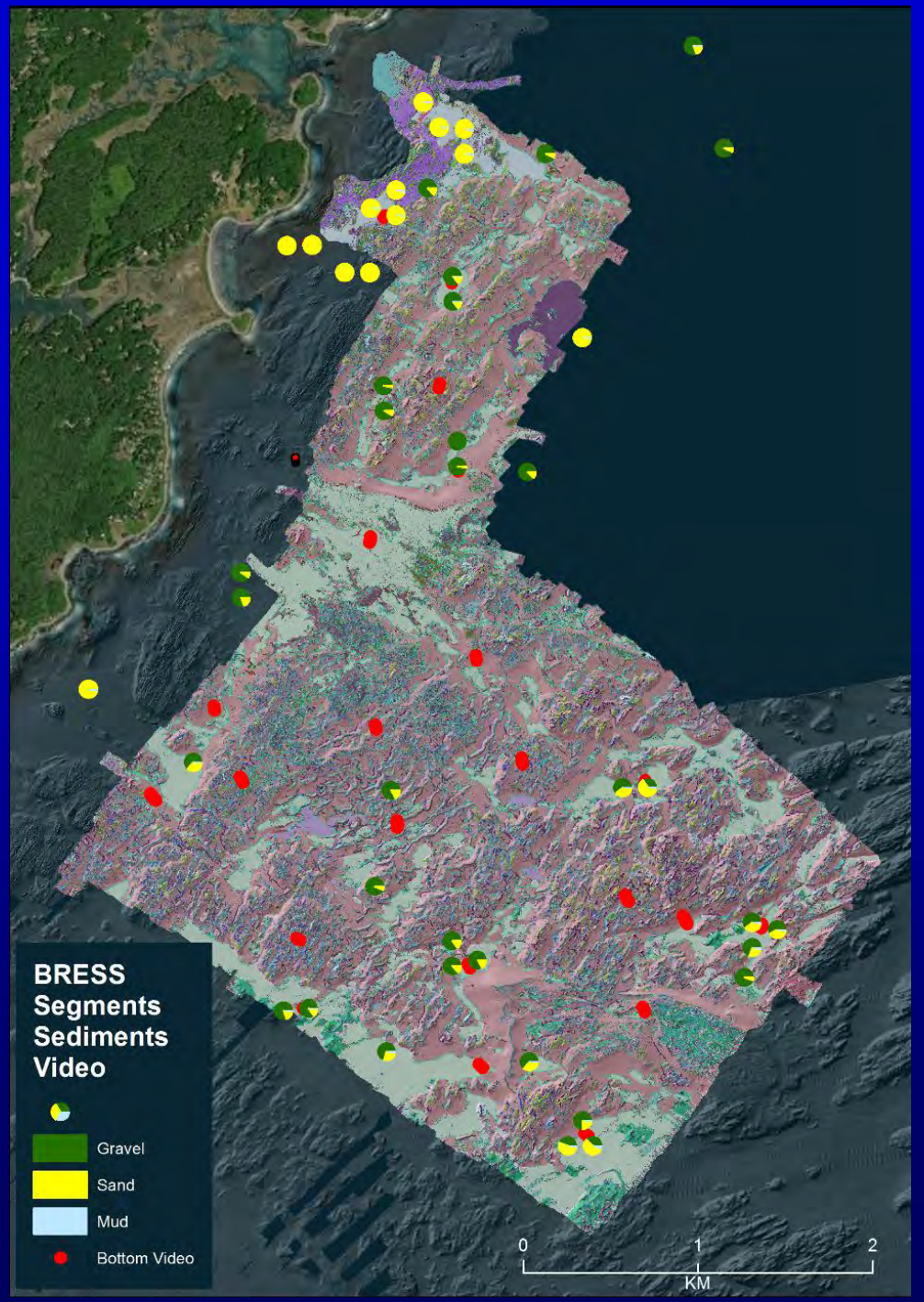
Initial Results

Geoforms Identified Relatively Well

But Impossible to Segment

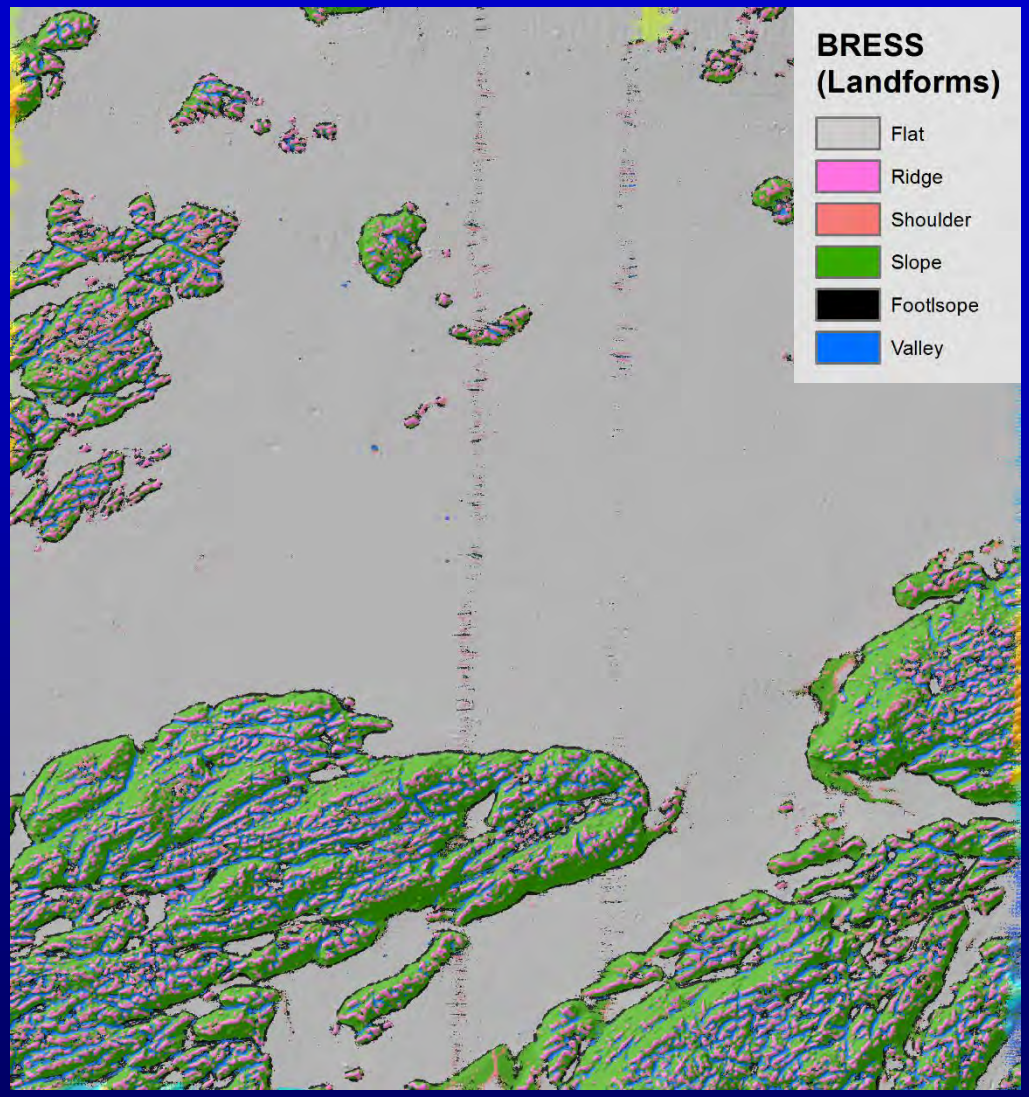
Poor Agreement Between Joined Segments and Ground Truth

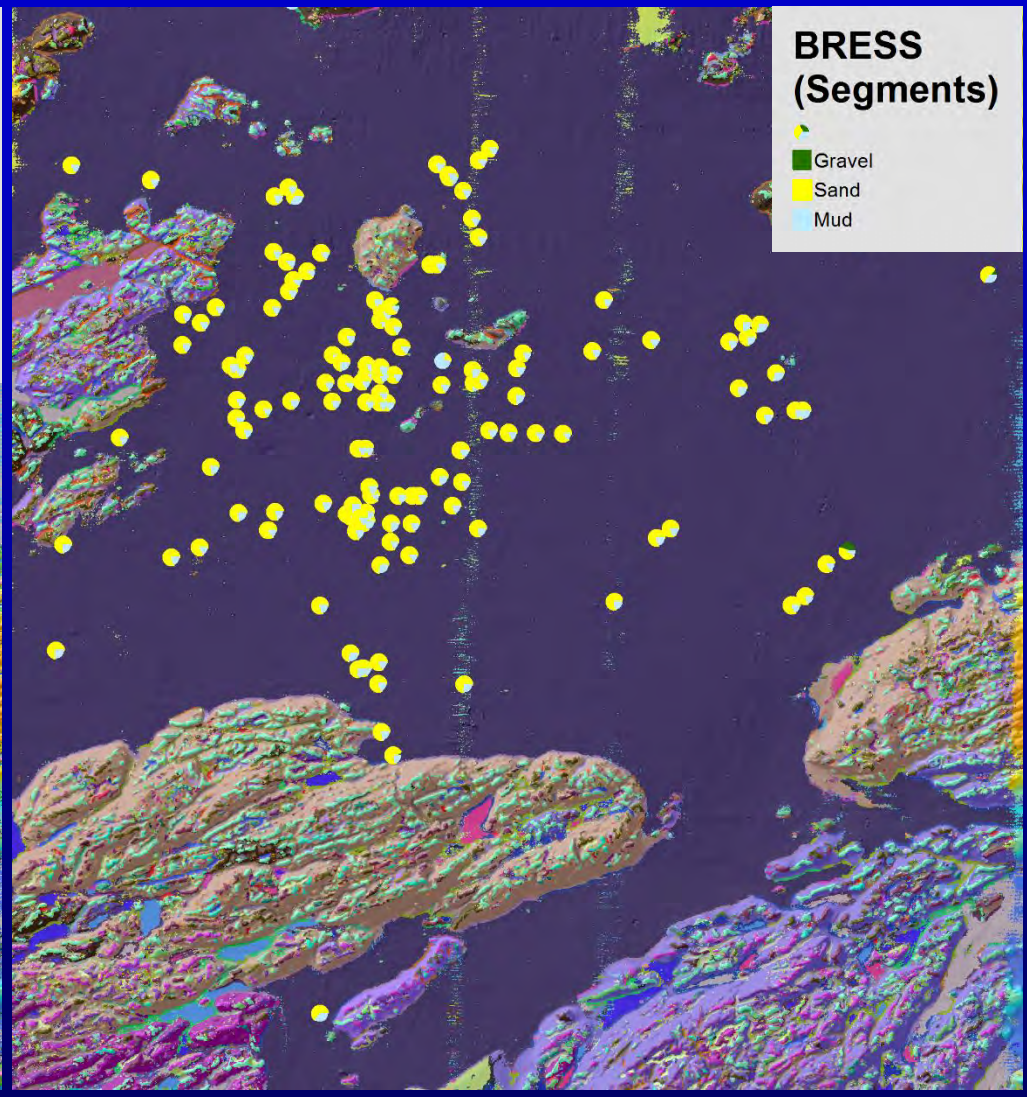




Input to BRESS

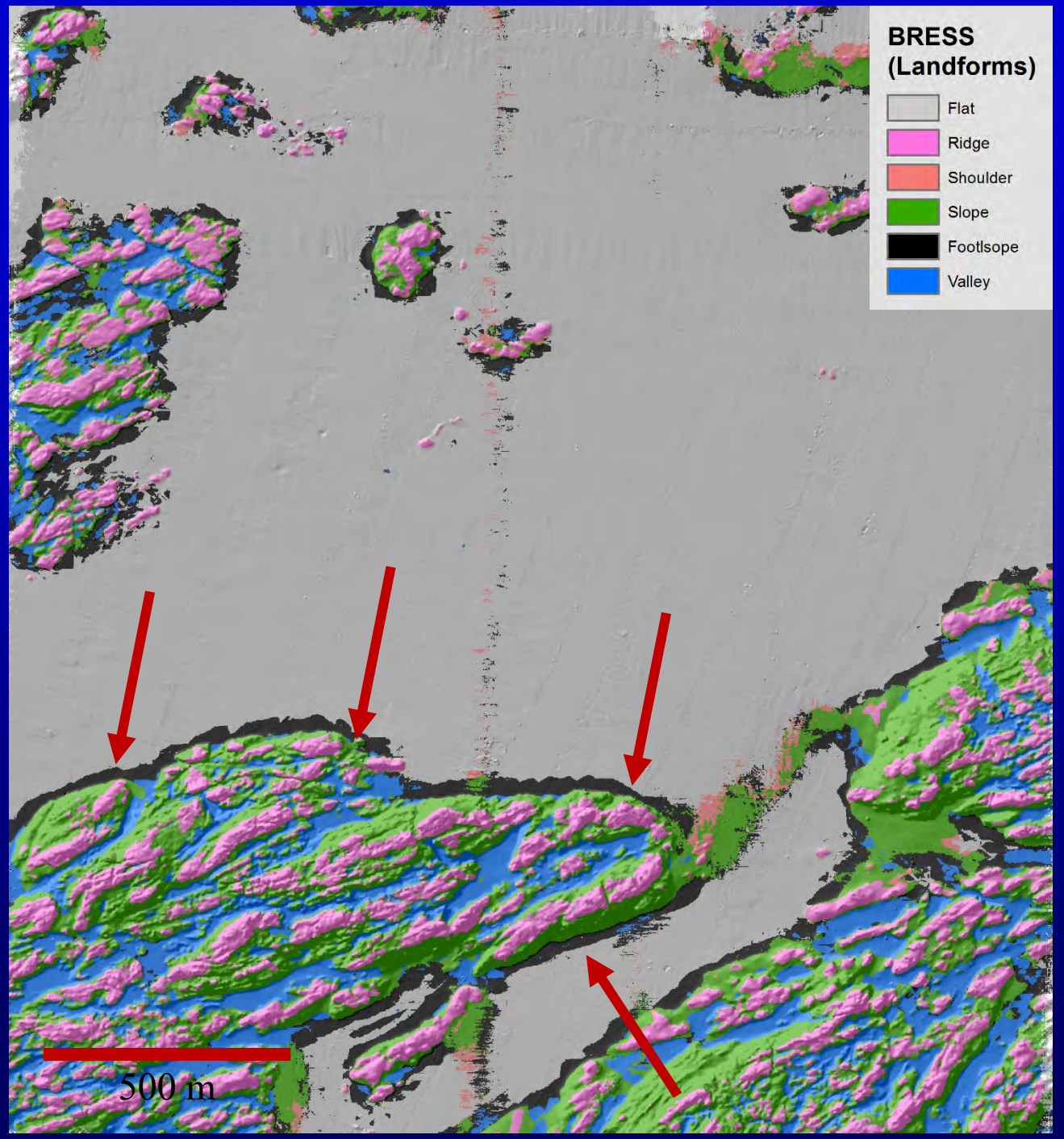
- CCOM Summer Hydro: 2003
- MBES System: EM3000
- 300 kHz
- Gridding: 1meter





Results of Initial BRESS Assessment

- Promising Results on Less Complex Seafloors
- Poor Results on Very Complex Seafloors
- Landform Analysis May Provide Automated Approach for Segmenting Geoforms (e.g., Bedrock Outcrops)
- By Merging Similar Landforms (e.g., Footslopes – See Arrors)



What's Next

- Improve Our Ability to Identify Geoforms and Surficial Sediments Using Acoustics
  - Bathymetry, Backscatter and Derivatives to Identify Form and Surficial Sediments
  - Continue Assessment of BRESS to Segment Seafloor
  - Assess ARA Analysis Using Theme Base
  - Along With Ground Truth

- Develop Conceptual Models of Features Likely to Contains Sand and Gravel (Marine Modified Glacial Deposits)

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