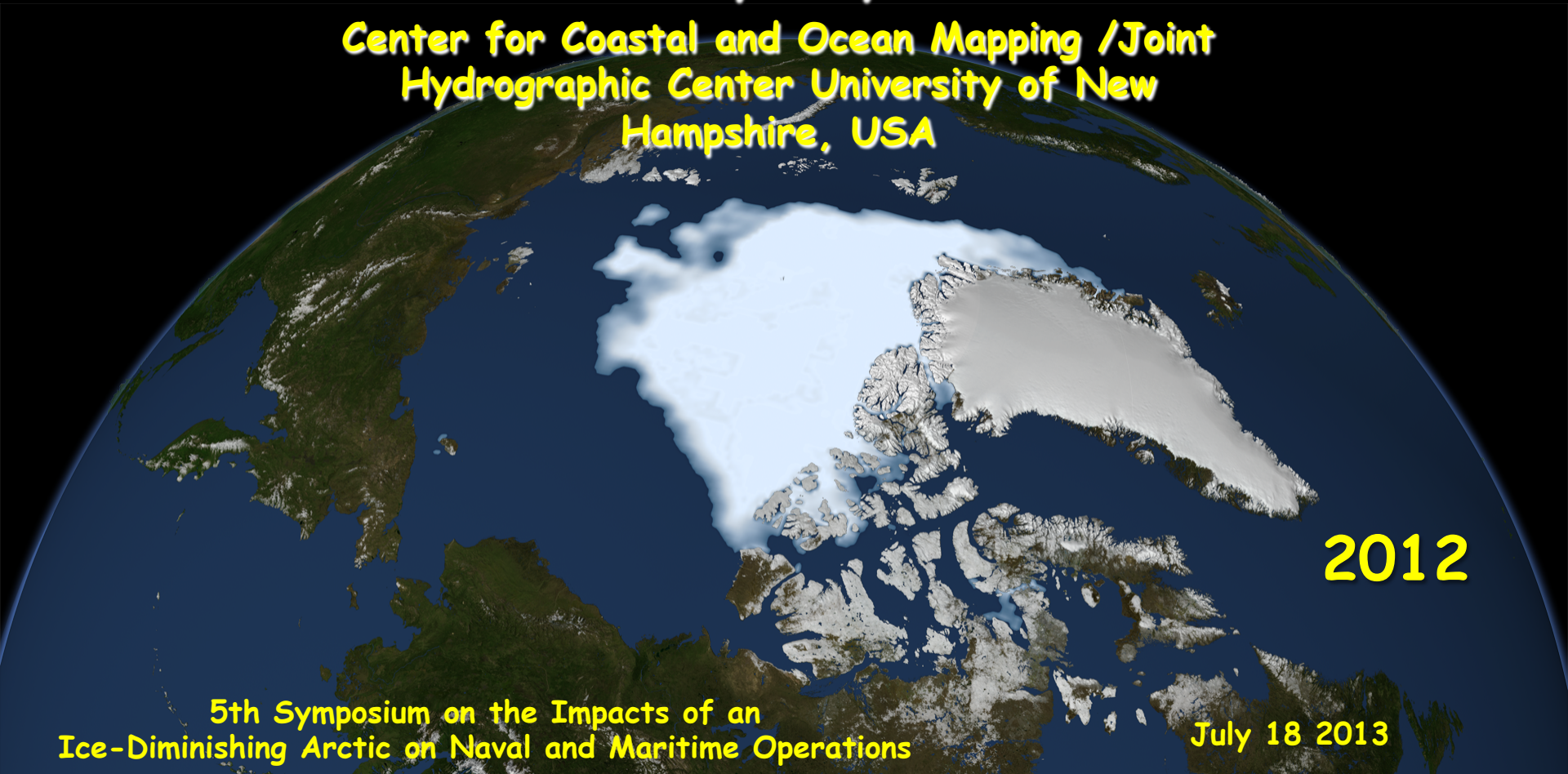
Mapping the Extended Continental Shelf in a Changing Arctic

Larry Mayer

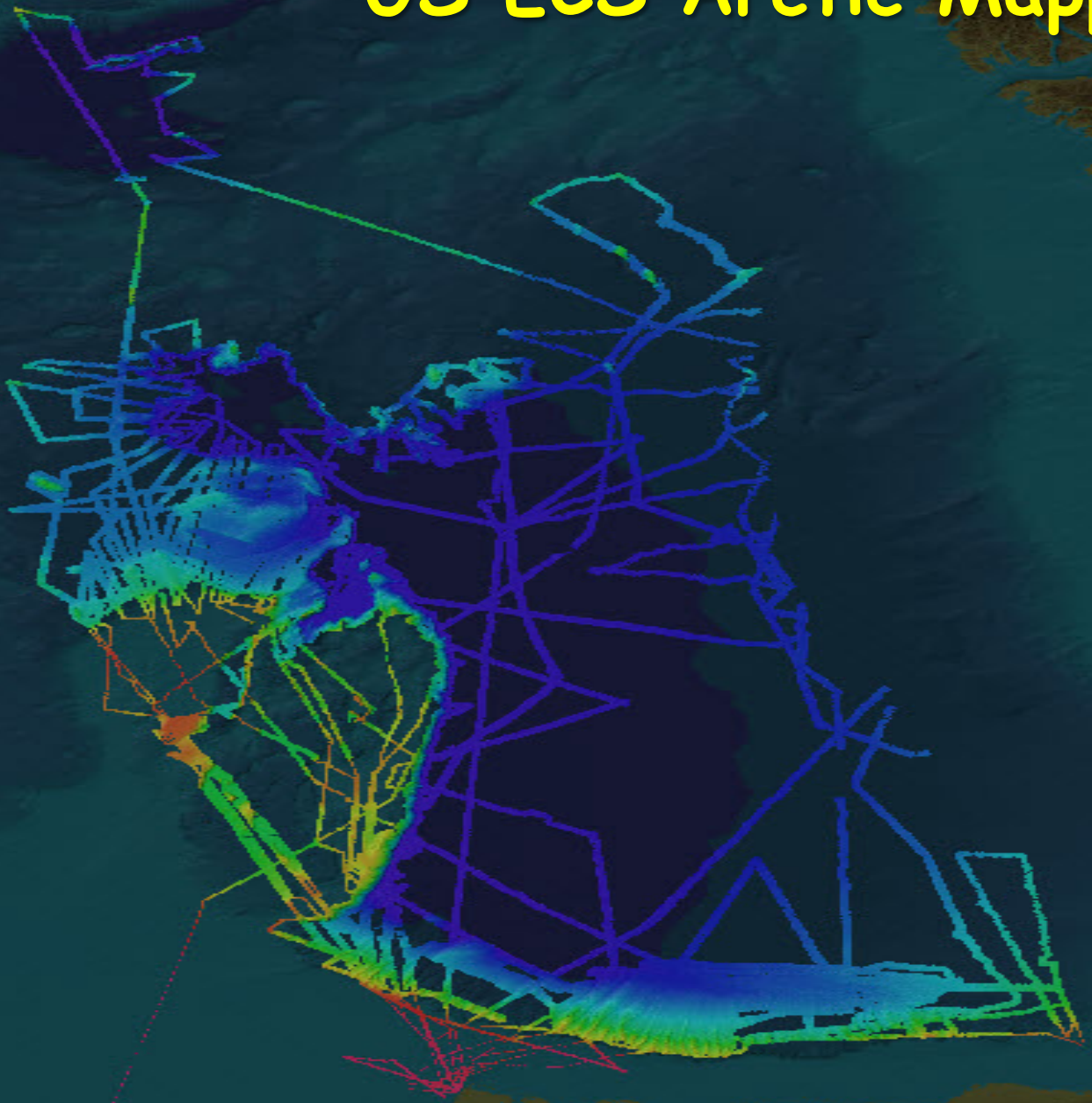
Center for Coastal and Ocean Mapping /Joint Hydrographic Center University of New Hampshire, USA



5th Symposium on the Impacts of an Ice-Diminishing Arctic on Naval and Maritime Operations

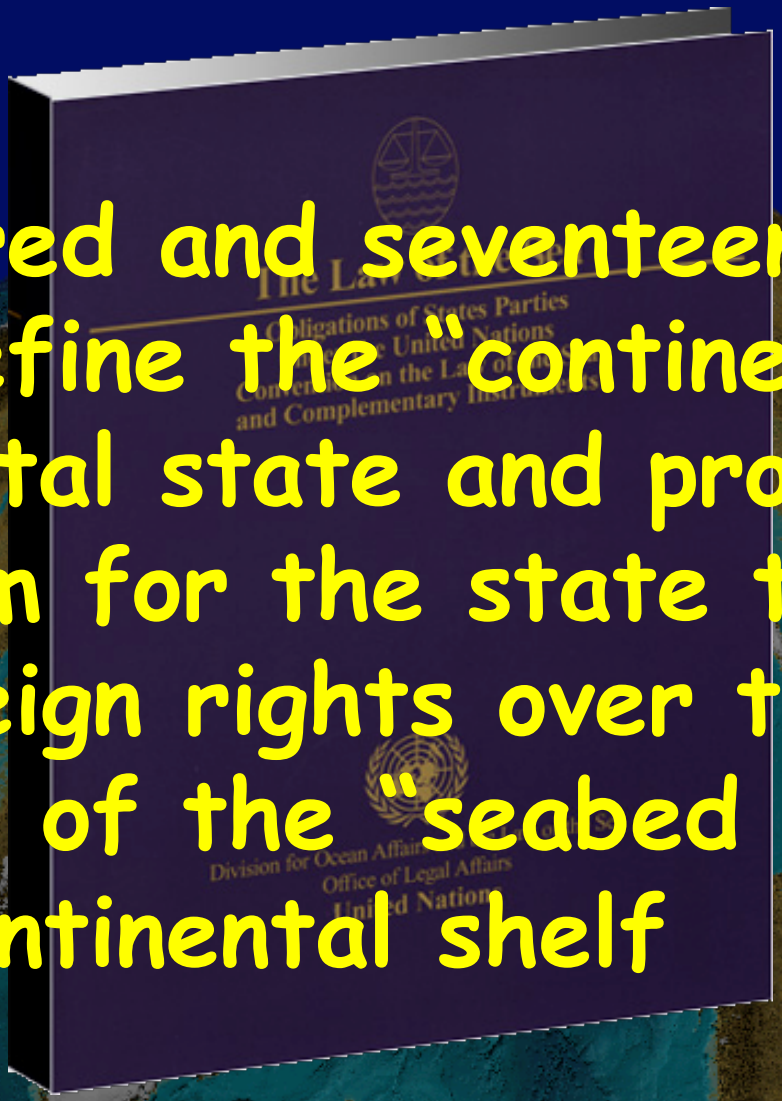
July 18 2013

US ECS Arctic Mapping



2003,2004,
2007,2008,
2009,2010,
2011, 2012

ARTICLE 76 of UNCLOS



Six hundred and seventeen words that redefine the "continental shelf" of a coastal state and provide a mechanism for the state to extend its sovereign rights over the resources of the "seabed and subsoil" of the continental shelf

Data Required

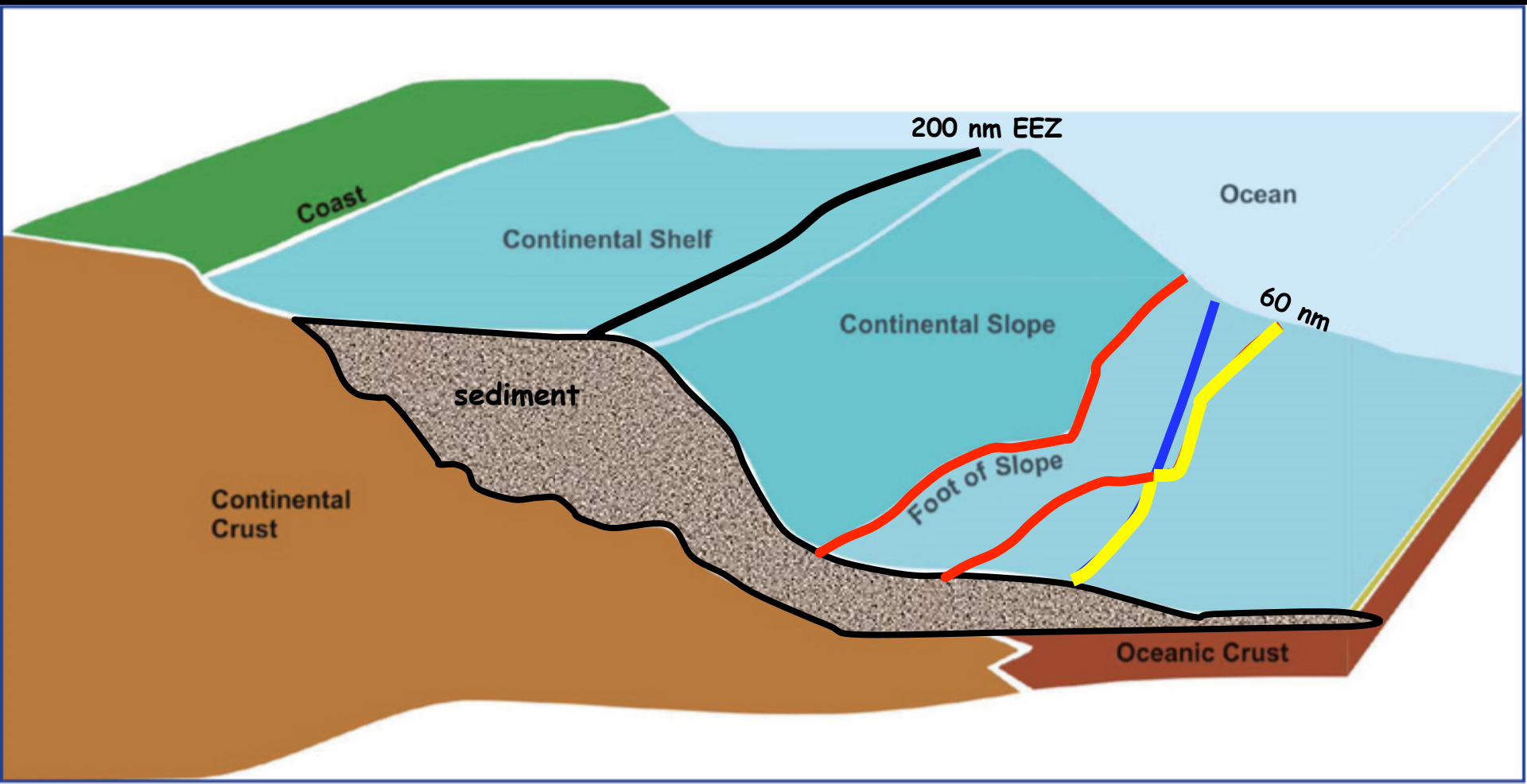
- To establish an extended continental shelf a coastal state must demonstrate that the region is a "natural prolongation" of continental landmass – limits of which are determined by:
  - depth and shape of the seafloor (FOS and 2500m contour)
  - the thickness of the underlying sediments (1% line)
  - distances from territorial sea baselines (350 nm line)

Need to map the seafloor

Formulae Lines:

Foot of Slope + 60 nmi - bathy

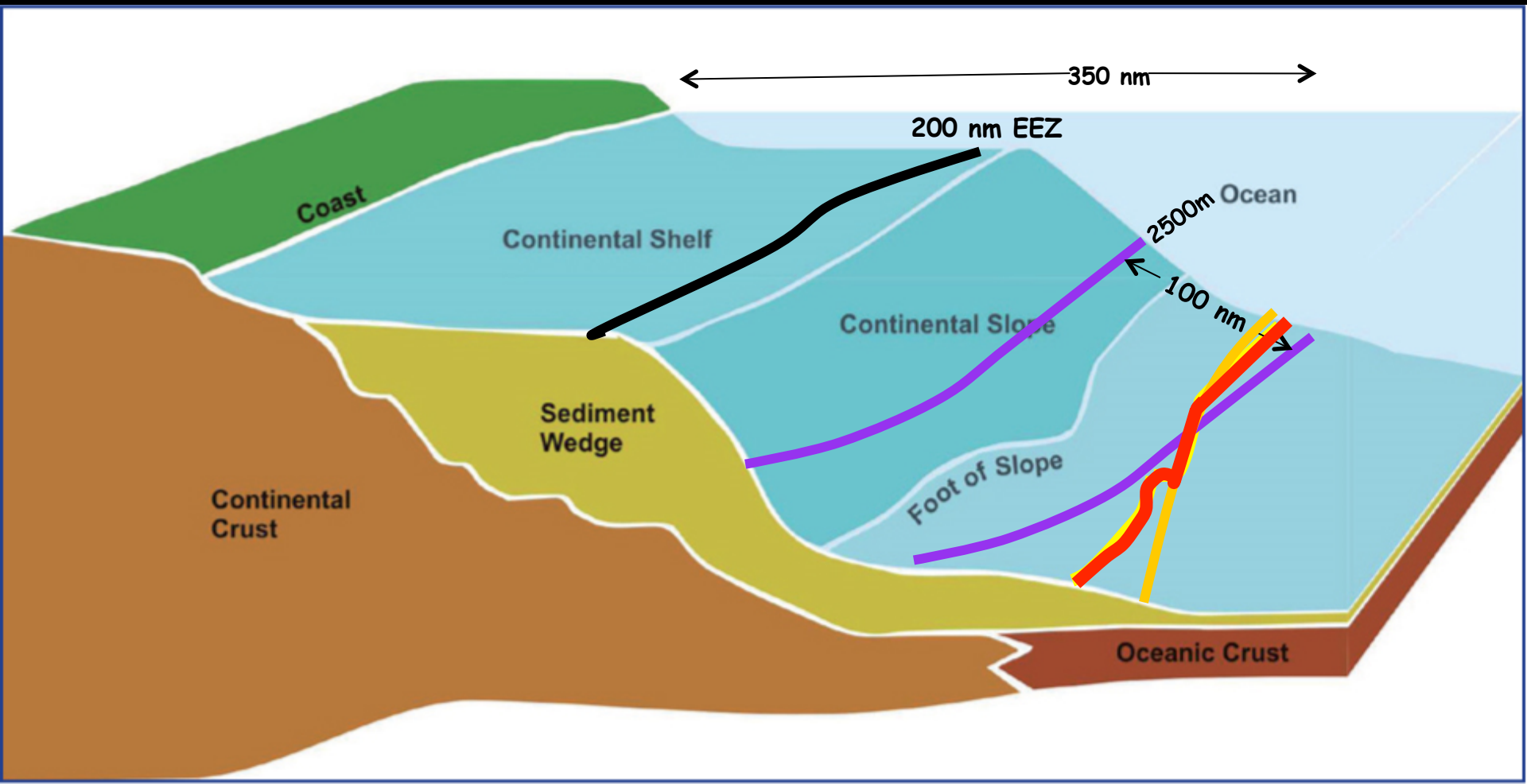
Gardiner line - **sediment thickness less than 1% of distance back to FOS** - seismic and bathy



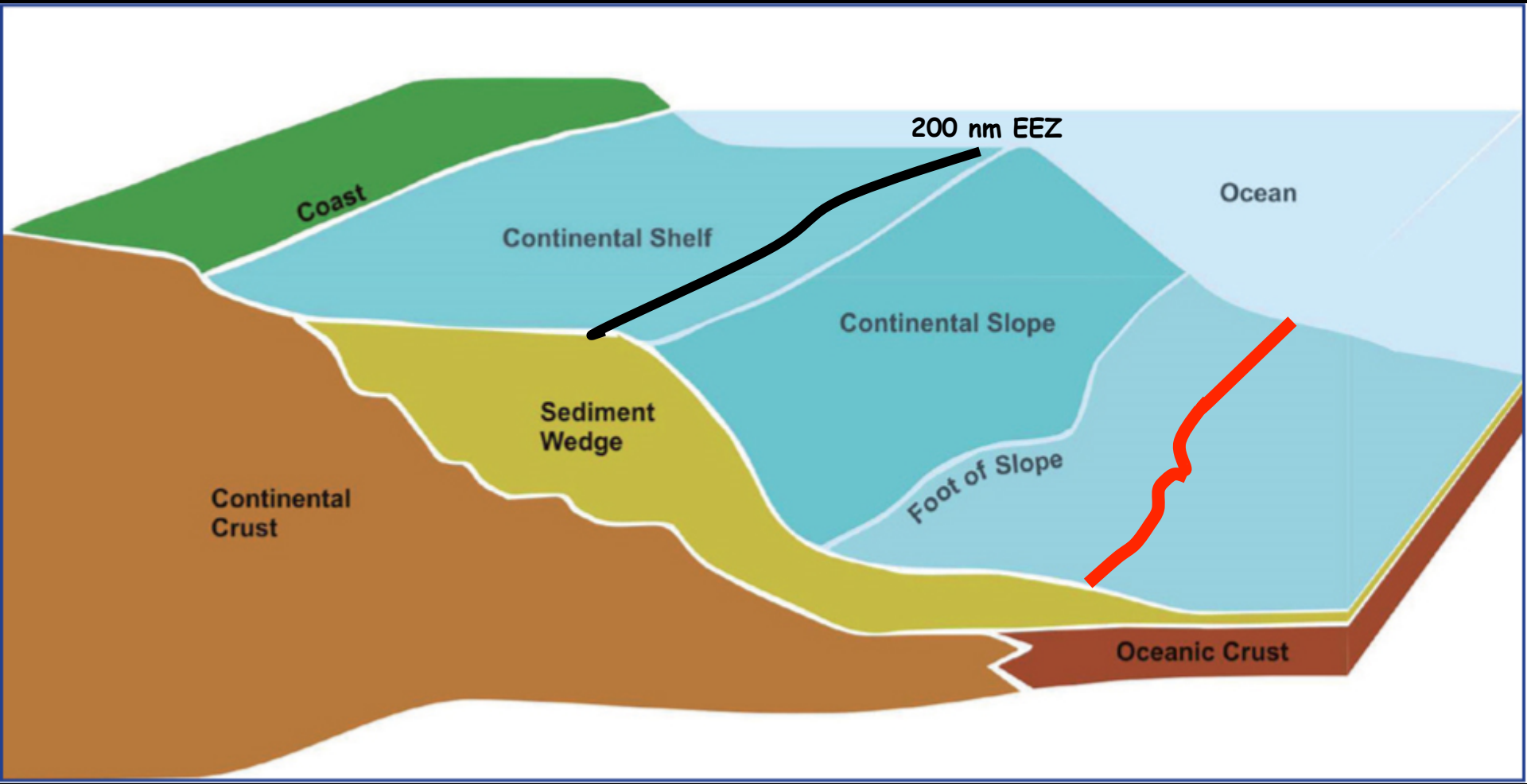
Limit Lines:

2500 m contour+100 nmi - bathy

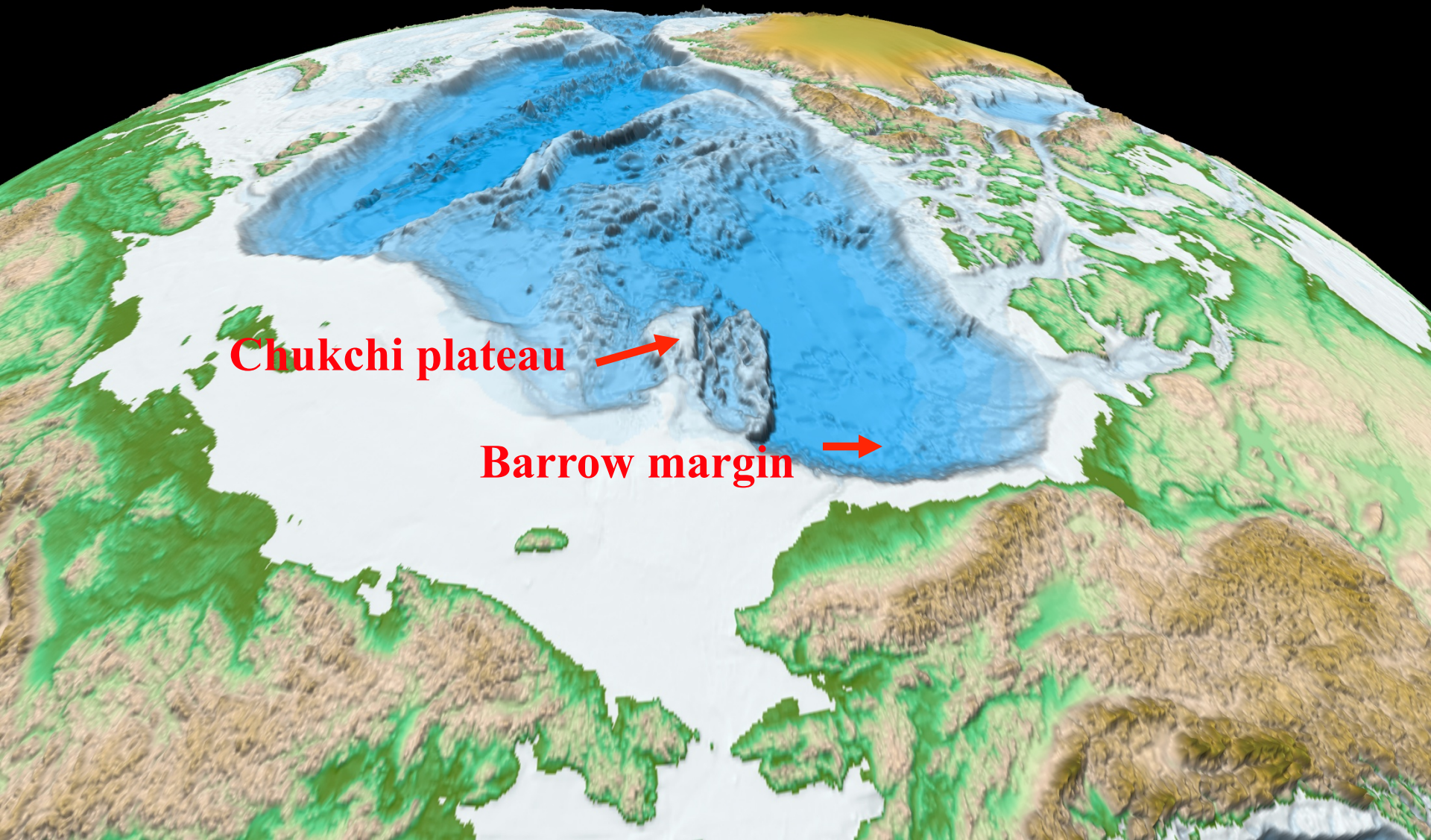
350 nmi from baseline - distance

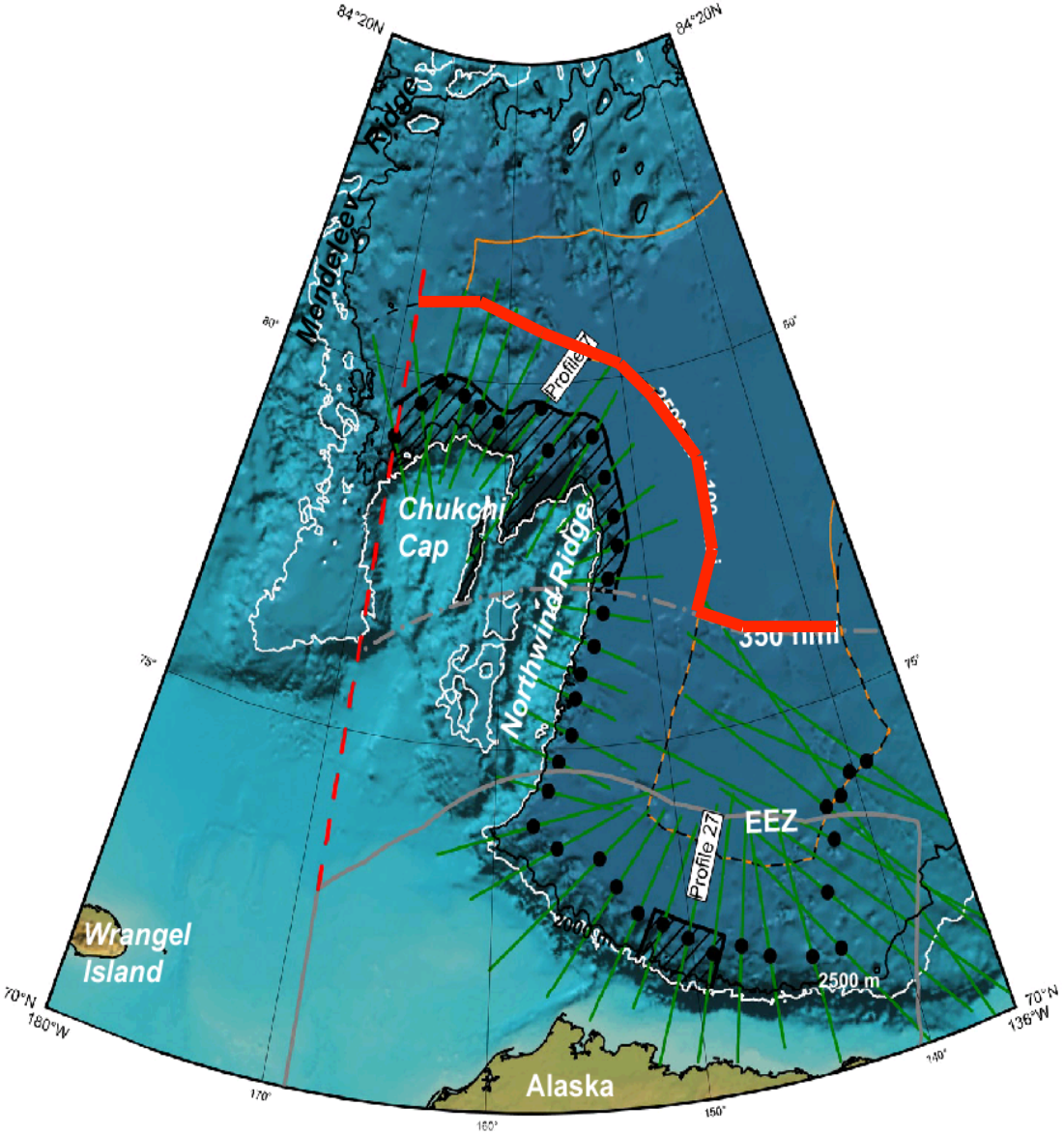


EXTENDED CONTINENTAL SHELF



US ECS MAPPING in the Arctic





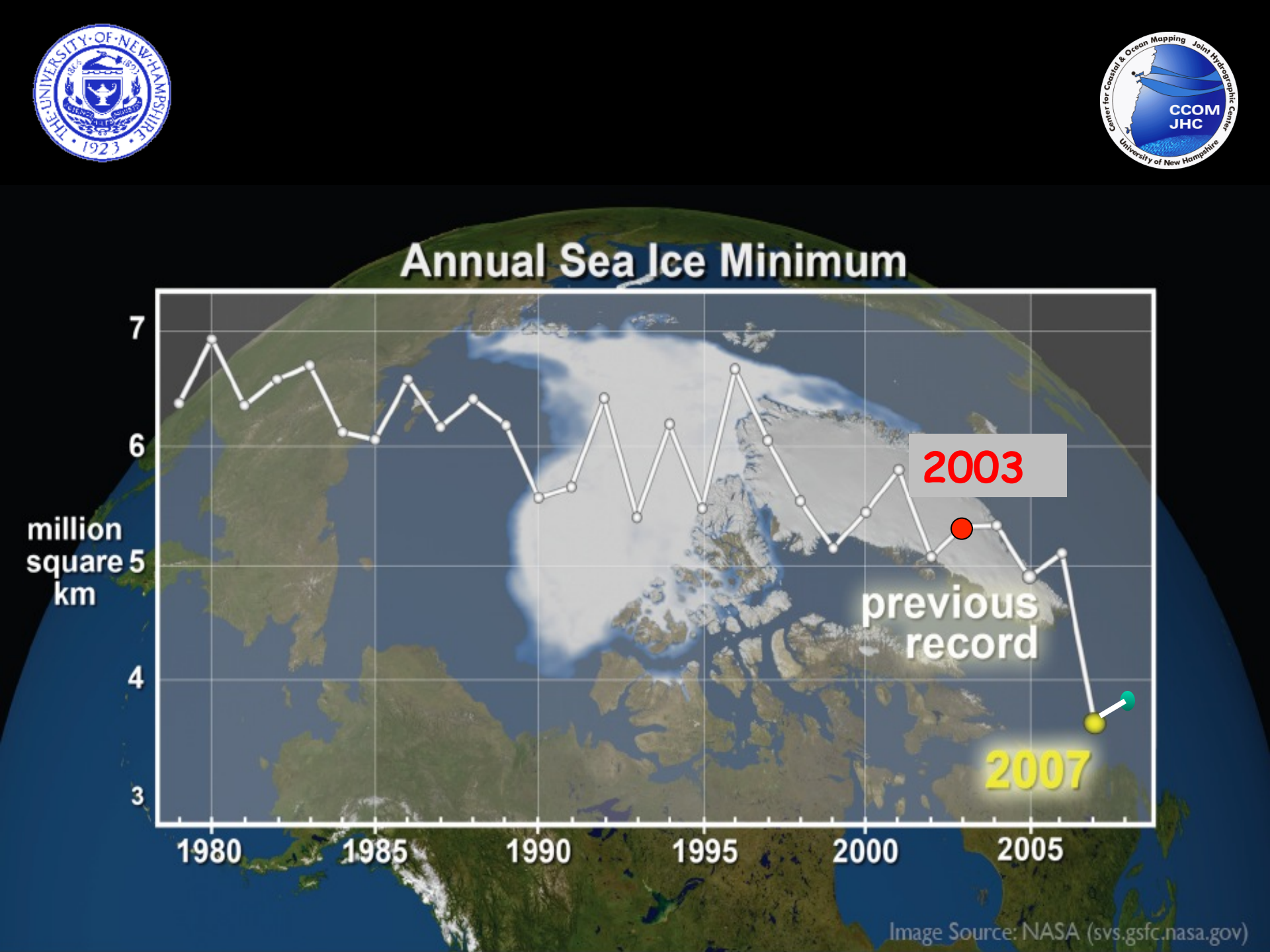
5.10B. Bathymetry from IBCAO in detailed area ARC, drawn bathymetric profiles, and possible locations of the FOS. Labeled profile is shown in figure 5.11. Note that the orange line, which represents the 2500 m + 100 nm, makes use of the 2500 m contour of the Alpha-Mendeleev Ridge as well as the Canadian shelf.

How do we map in this?

USCGC *Healy*

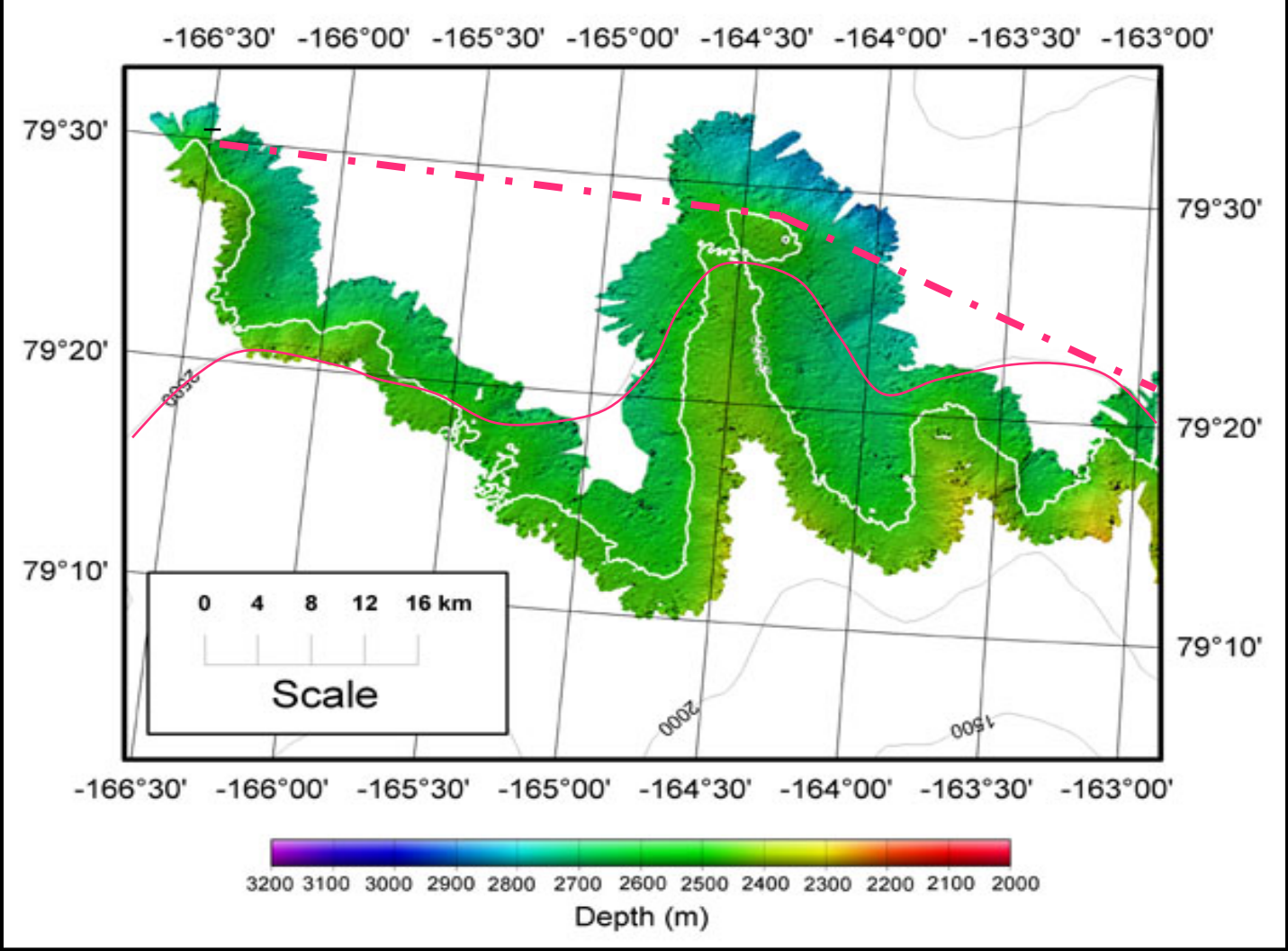
Length, Overall =128 meters
Beam = 25 m
Propulsion = Diesel/Electric
Displacement = 16,000 LT
Shaft HP = 30,000 HP
Props = 2 fixed pitch
Cruising Speed = 12 knots.
Max Speed – 17 knts
Fuel Cap = 4.62 M liters
Icebreaking = 1.4 m continuous, 2.44 m backing and ramming
Accommodations = 19 Officer, 12 CPO, 54 enlisted, 35 (+15) scientists

2001-2009 – Seabeam 2112 2x2 deg 12 kHz MBES
Now – Kongsberg EM122 – 1x1 deg 12 kHz MBES

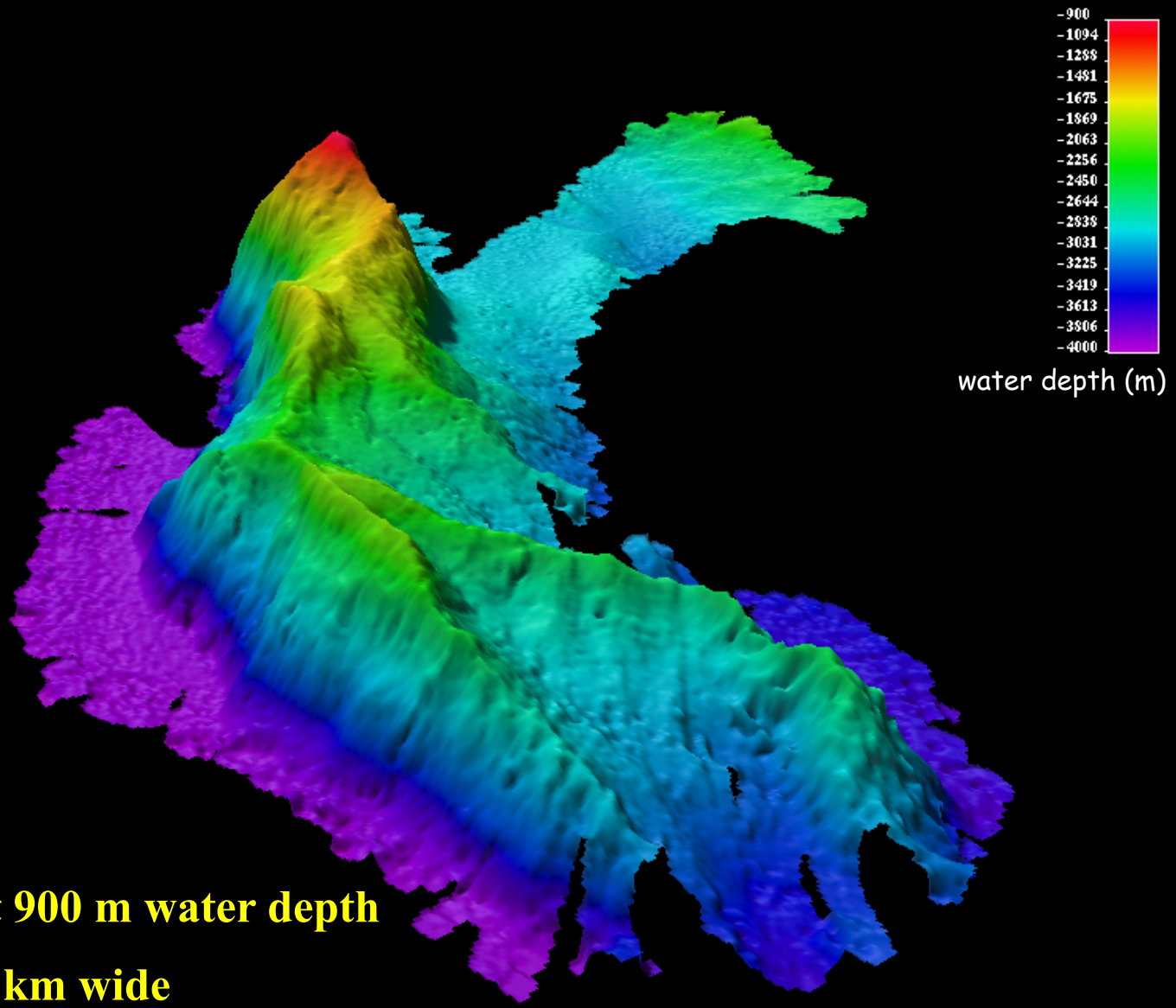

Annual Sea Ice Minimum
7
6
5
4
3
million square km
1980
1985
1990
1995
2000
2005
2003
previous record
2007
Image Source: NASA (svs.gsfc.nasa.gov)


typical ice conditions
2003
8/10 “cheesy” ice

Redefinition of the 2500 m contour



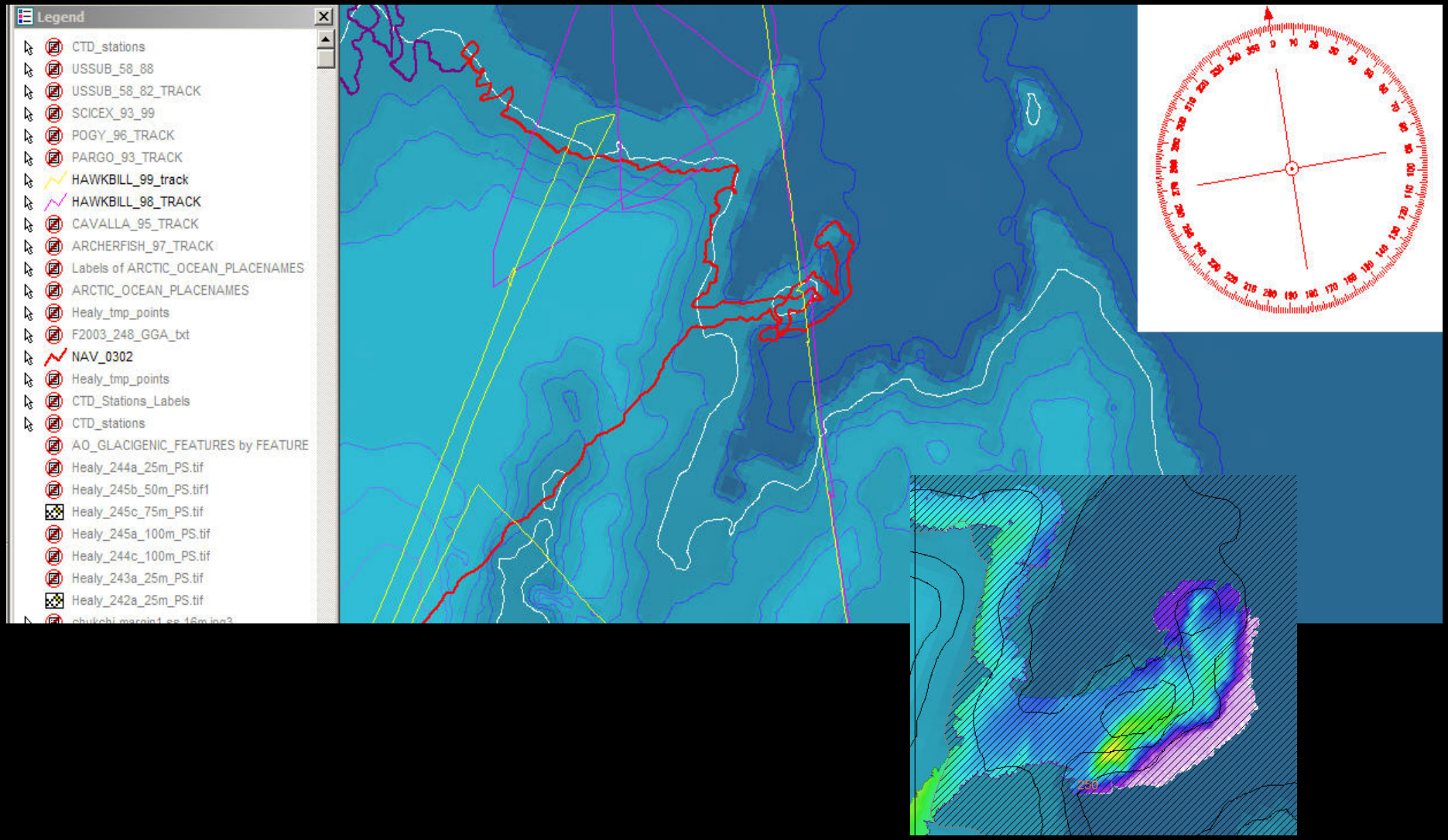
Healy Seamount
looking S, ve=6x



3100 m high, summit at 900 m water depth

45 km long x 15 km wide

Healy Seamount Survey

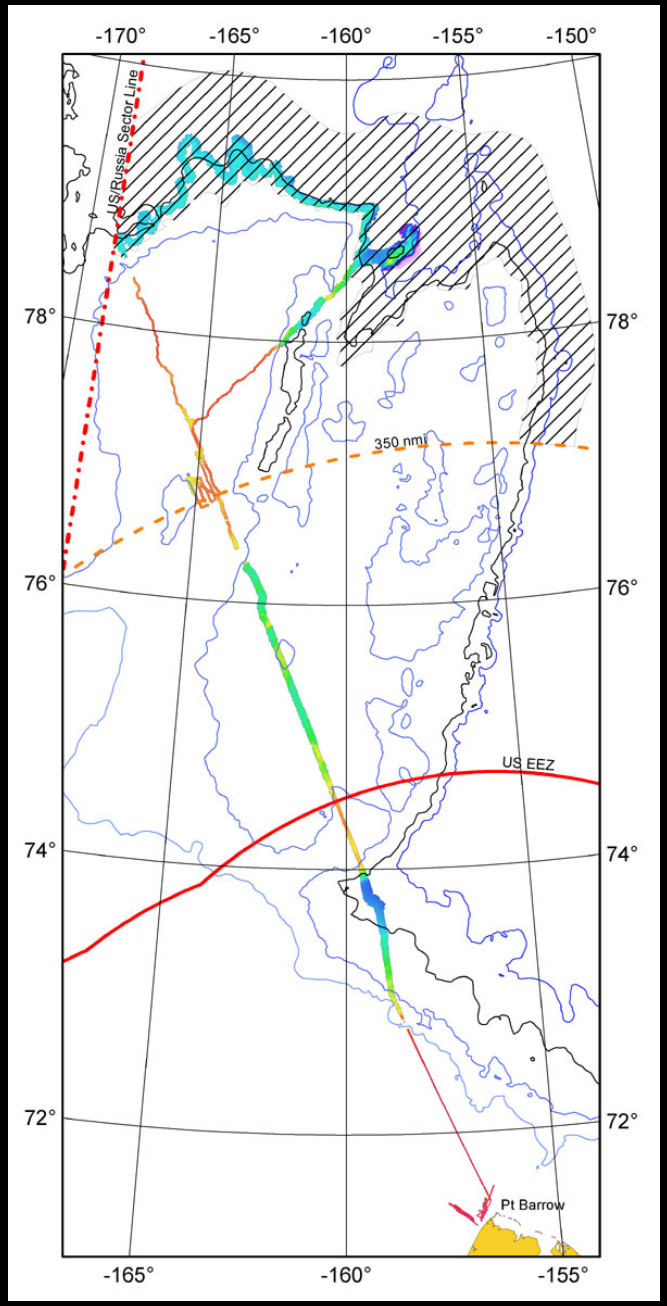


Healy 03-02

~3000 km of multibeam sonar bathymetry

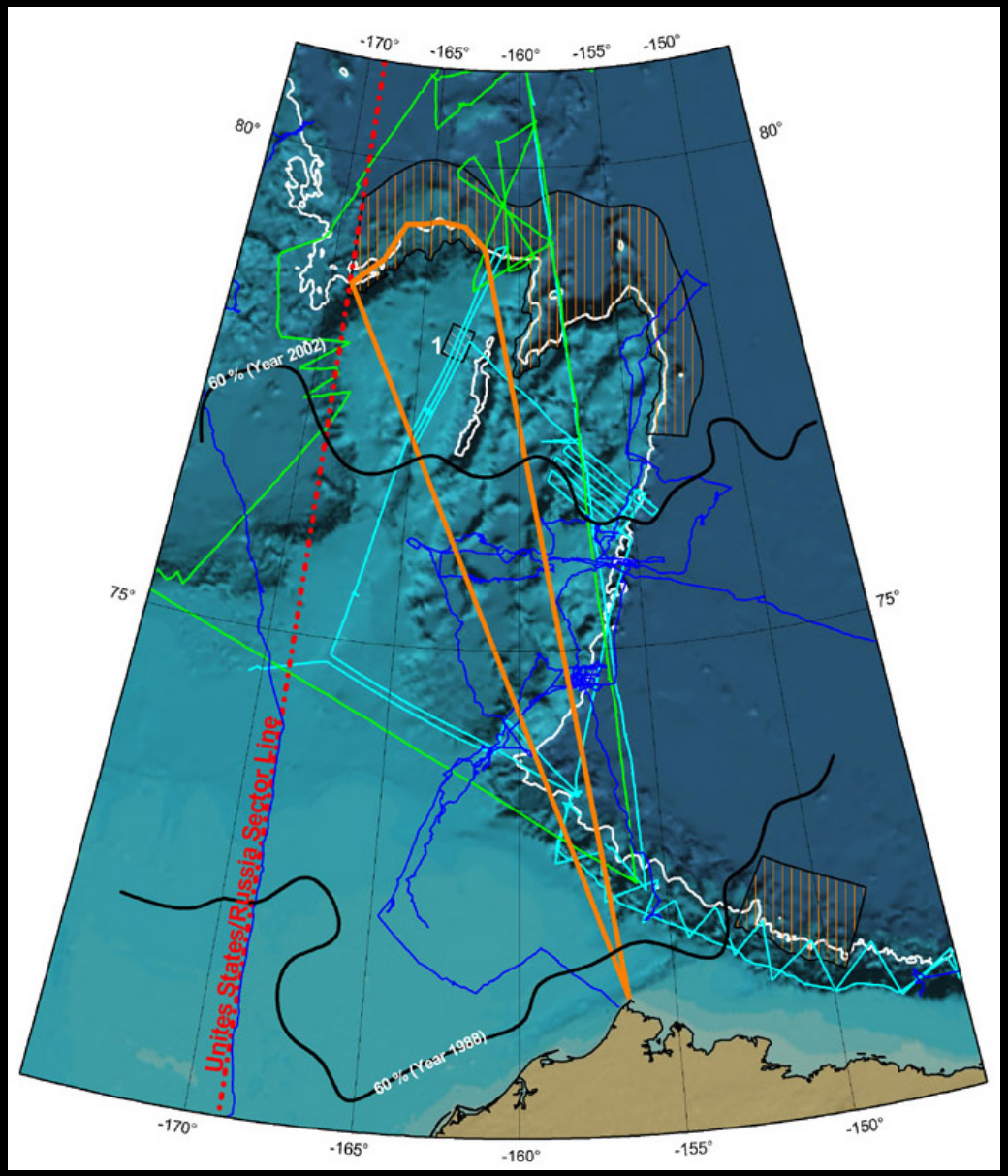
1-11 Sept 03

8/10 ice

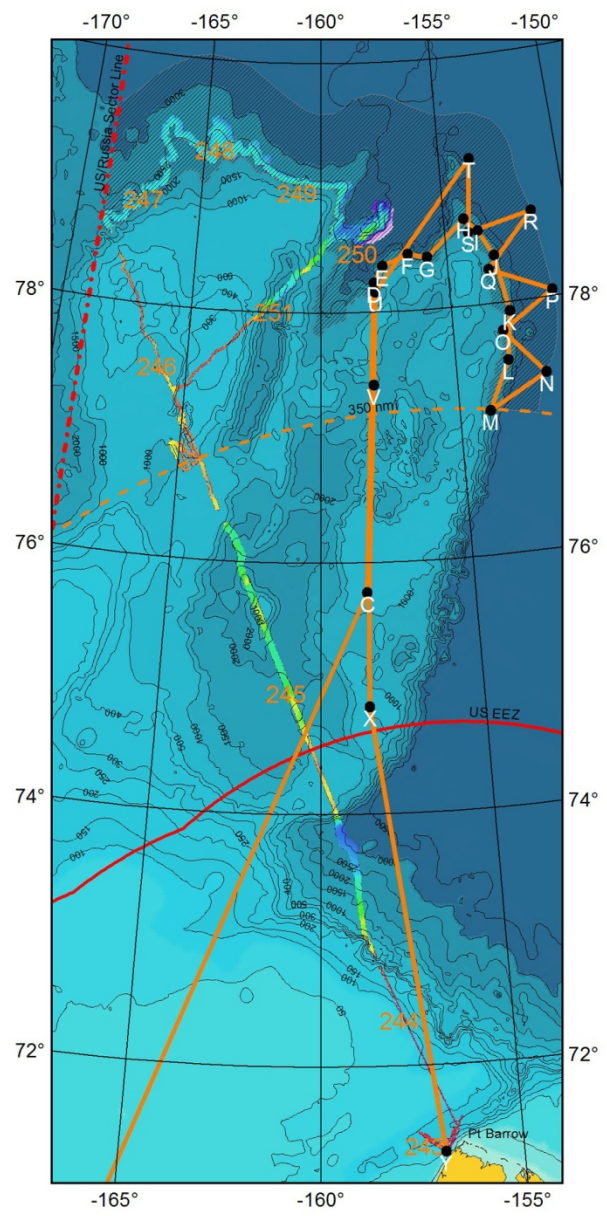


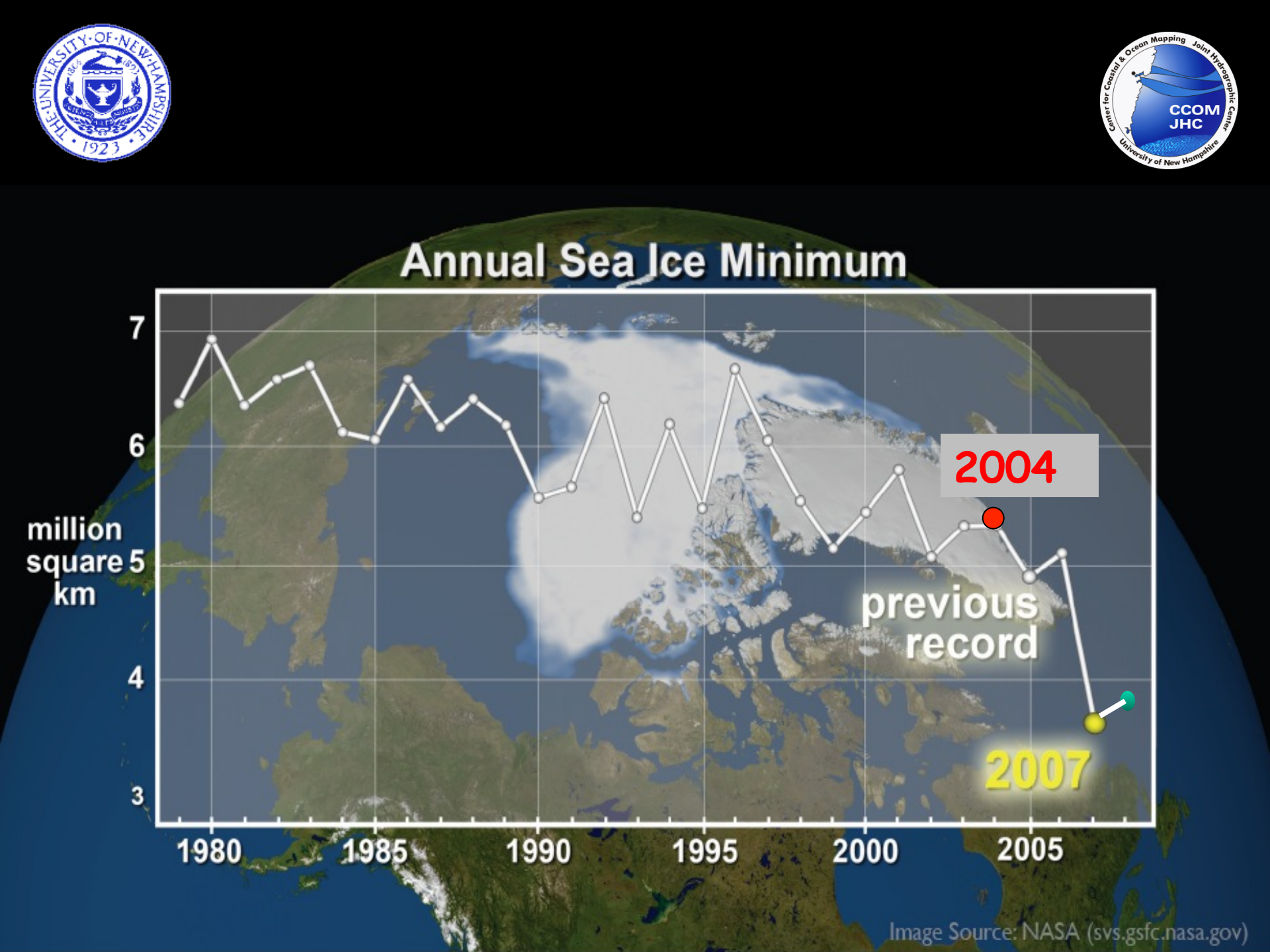
HEALY 03-02 Sept 2003

Healy 03-02
~3000 km of
multibeam
sonar
bathymetry
1-11 Sept 03
8/10 ice

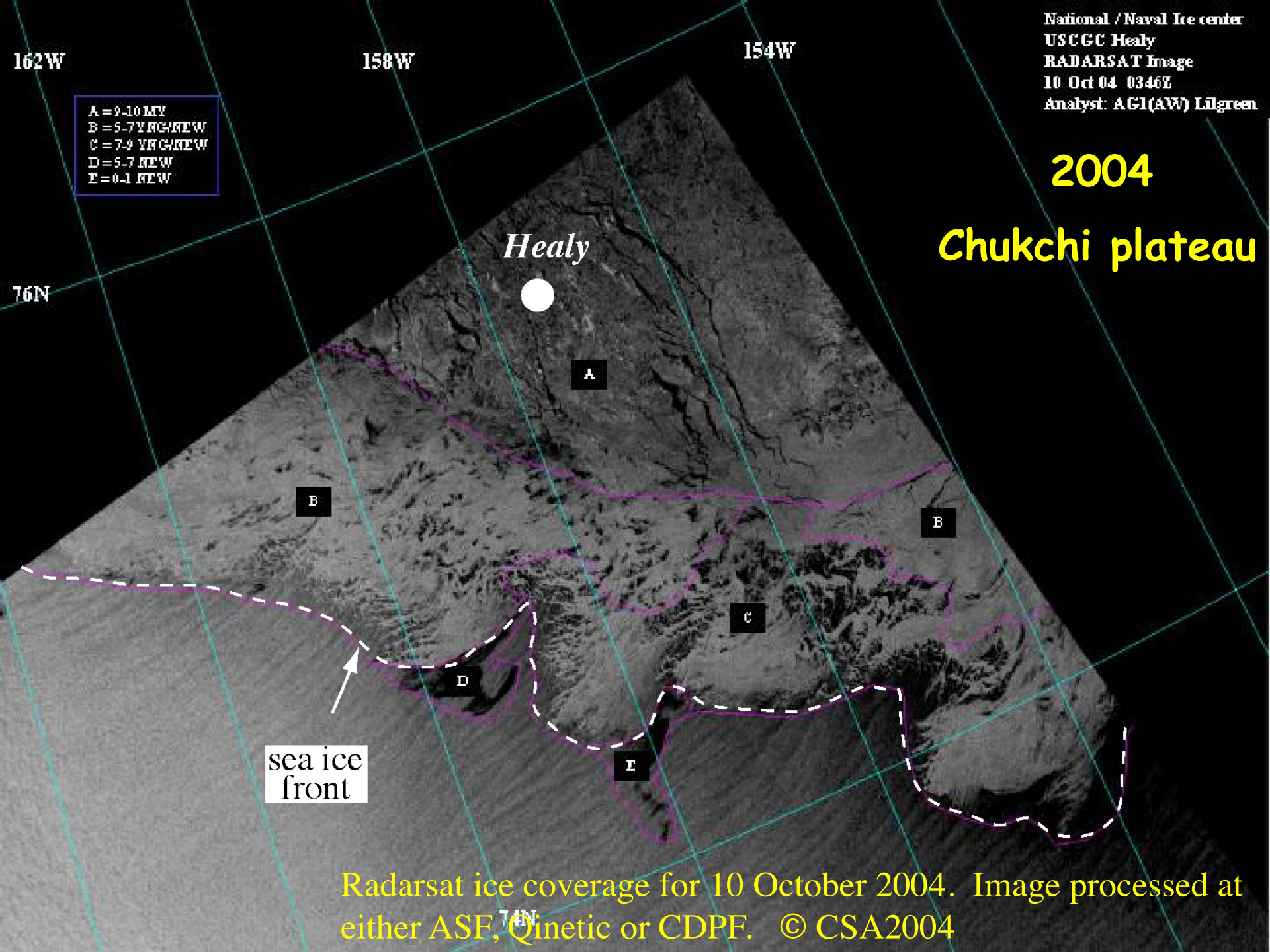


HEALY 2004 - Plan




Annual Sea Ice Minimum
7
6
5
4
3
million square km
1980
1985
1990
1995
2000
2005
2004
previous record
2007
Image Source: NASA (svs.gsfc.nasa.gov)


2004



2004 Chukchi plateau

Radarsat ice coverage for 10 October 2004. Image processed at either ASF, Qinetic or CDPF. © CSA2004

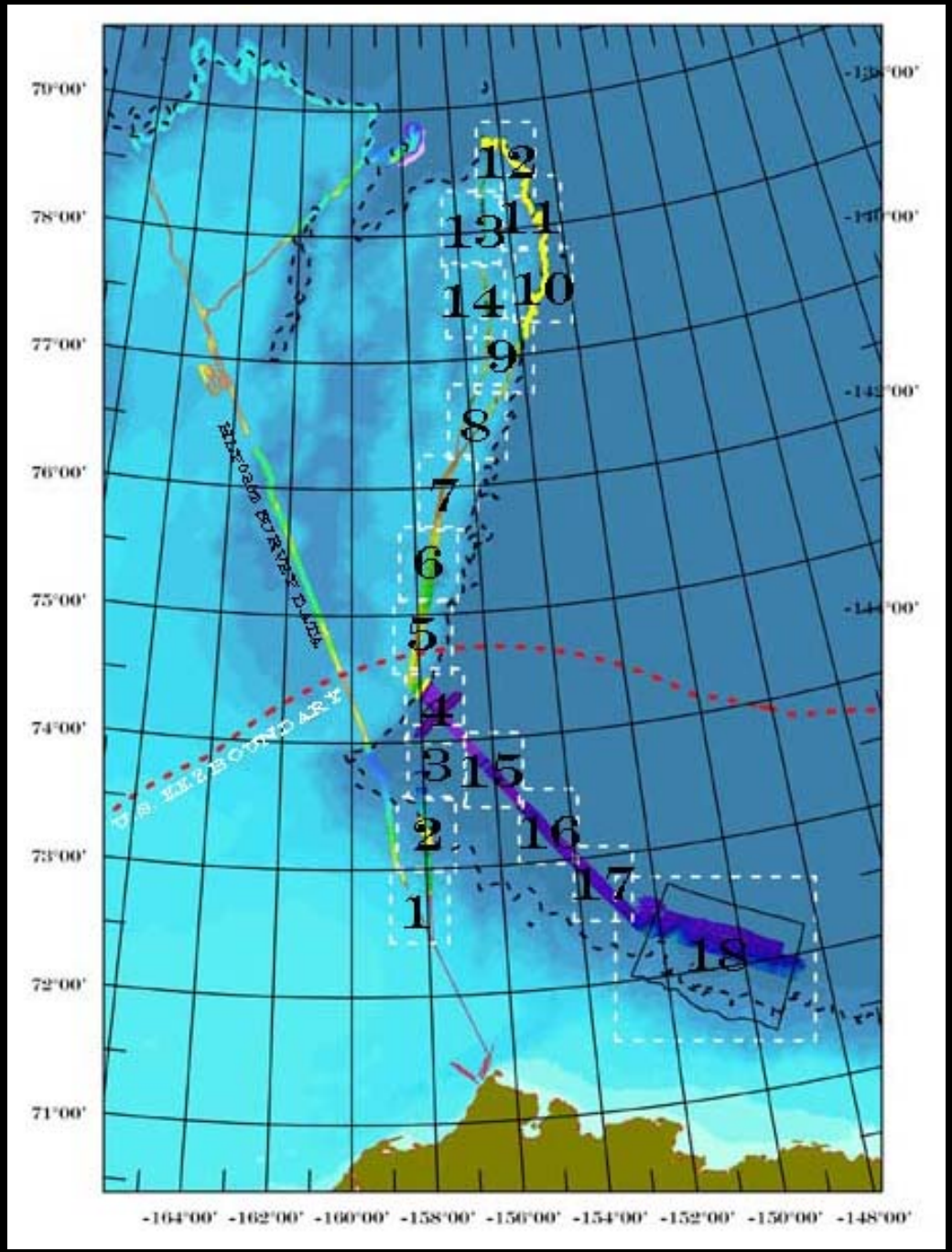
HEALY
04-05
TRACK

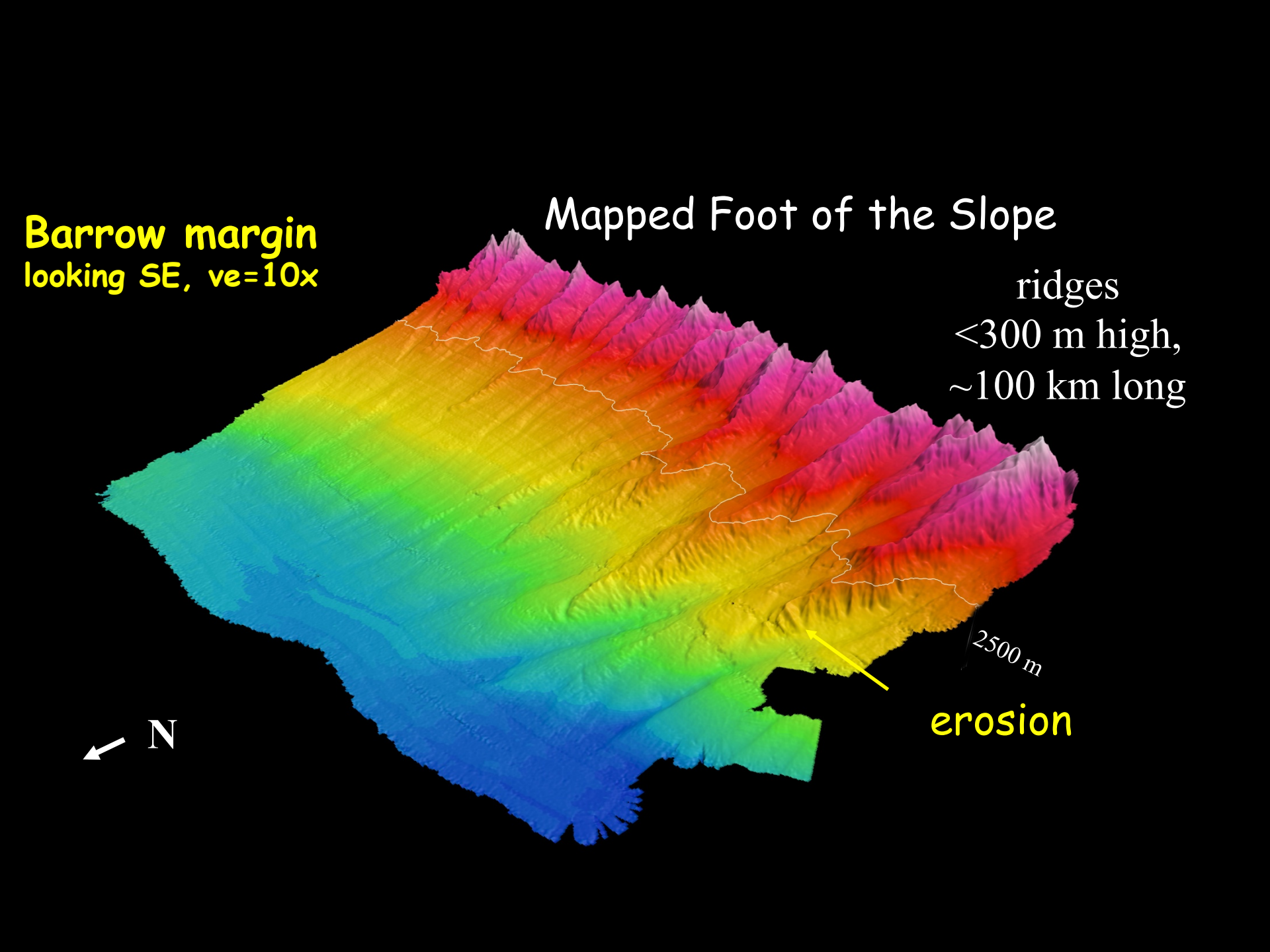
6-26 Oct.
2004

6700 line km

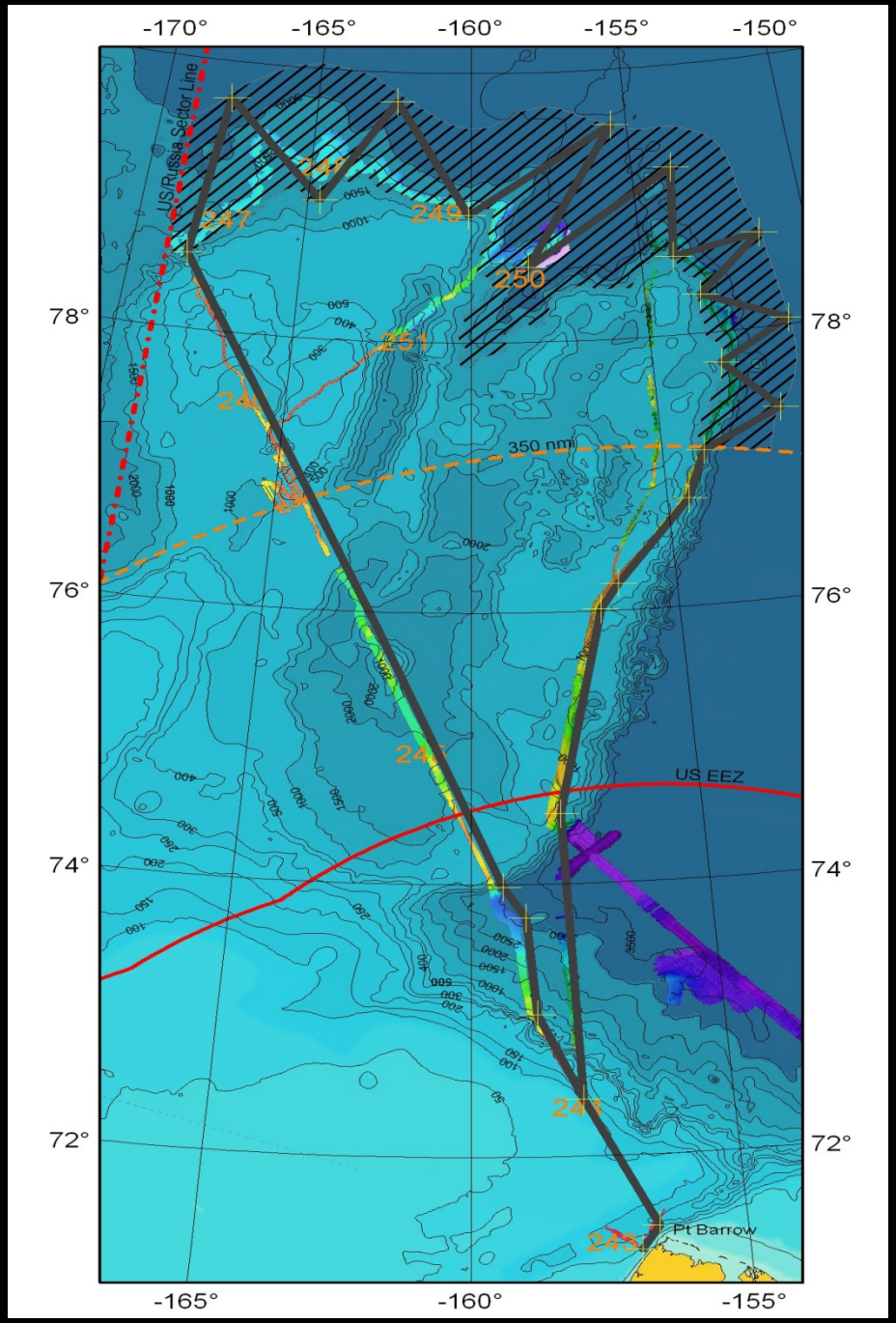
"Ratchet Surveying"

"Pirouette Surveying"



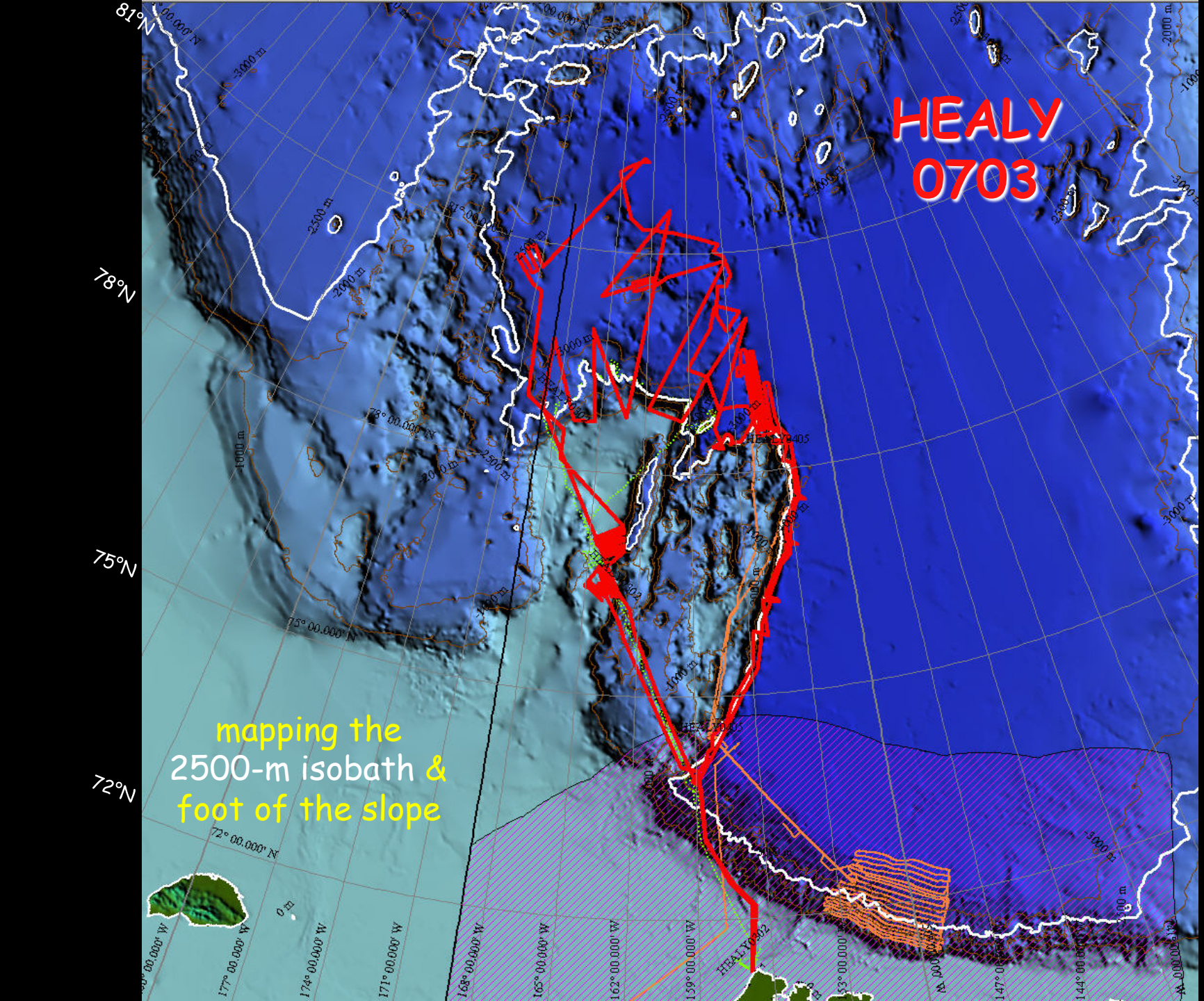

Barrow margin
looking SE, ve=10x
Mapped Foot of the Slope
ridges
<300 m high,
~100 km long
2500 m
erosion
N

HEALY 07-03
Depart Barrow:
17 Aug. 07
Return Barrow
15 Sept. 07

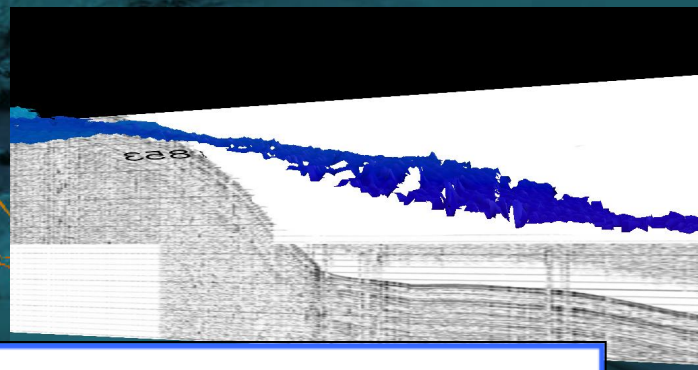


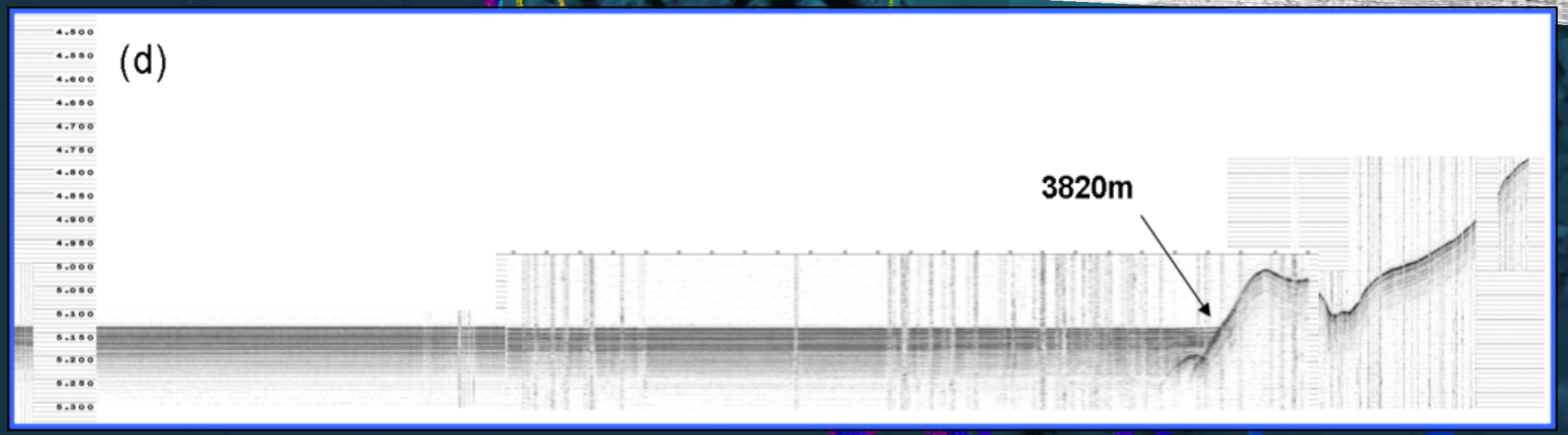

Annual Sea Ice Minimum
7
6
5
4
3
million square km
1980
1985
1990
1995
2000
2005
2007
previous record
2007
Image Source: NASA (svs.gsfc.nasa.gov)

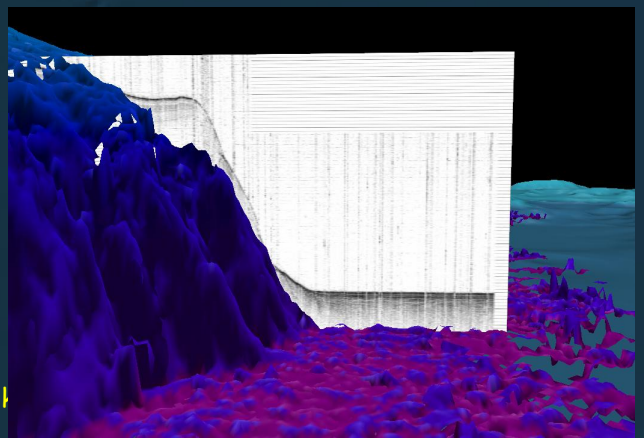

MARINE CRANE


HEALY
0703
mapping the
2500-m isobath &
foot of the slope
81°N
78°N
75°N
72°N

Healy 03-02, 04-05, 07-03







Where we now think it is

perspective view look

HEALY 0805 - SHIPTRACK AND DREDGE SITES

5,000 m

2,500 m

0 m

-2,500 m

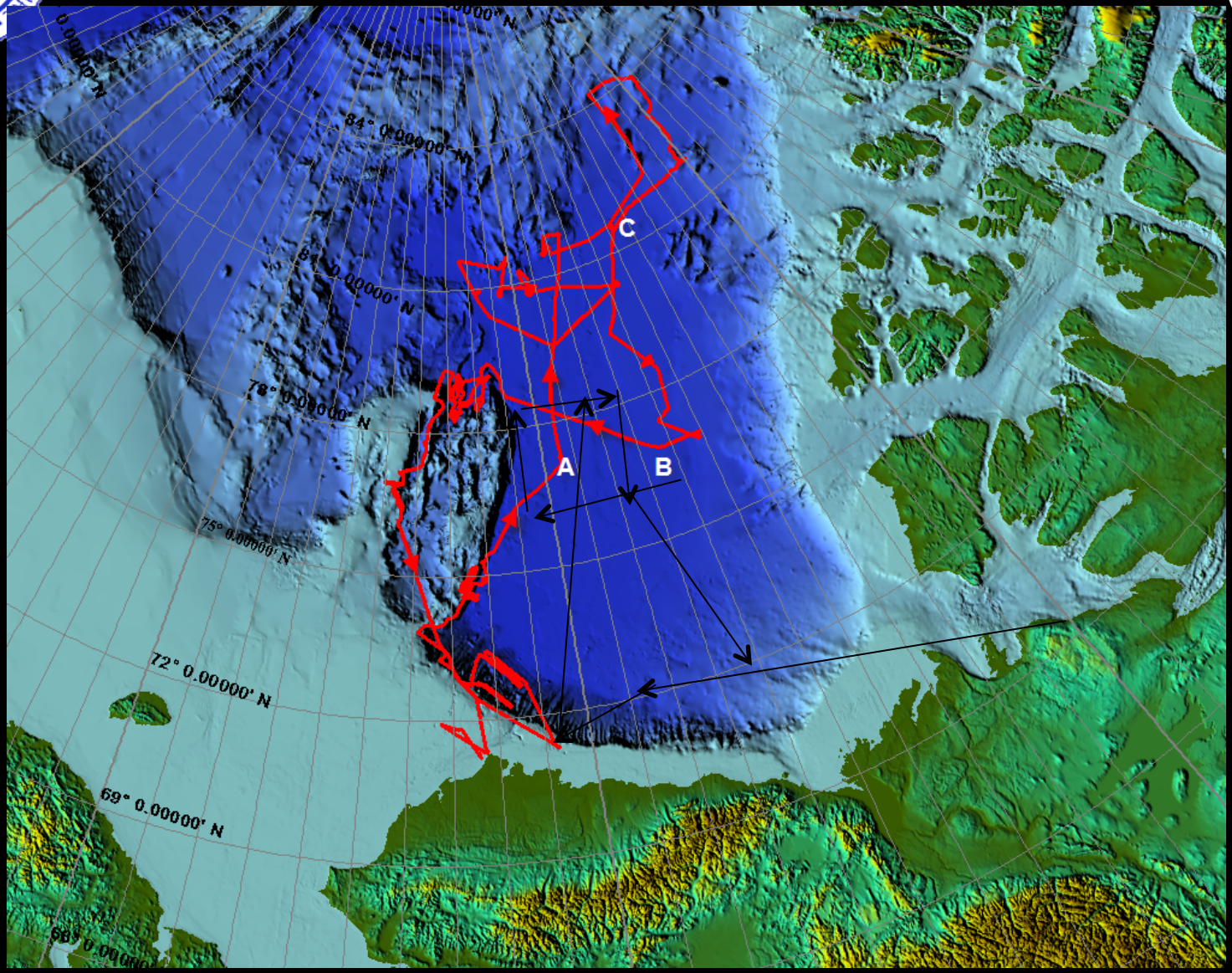
-5,000 m

-5,567 m

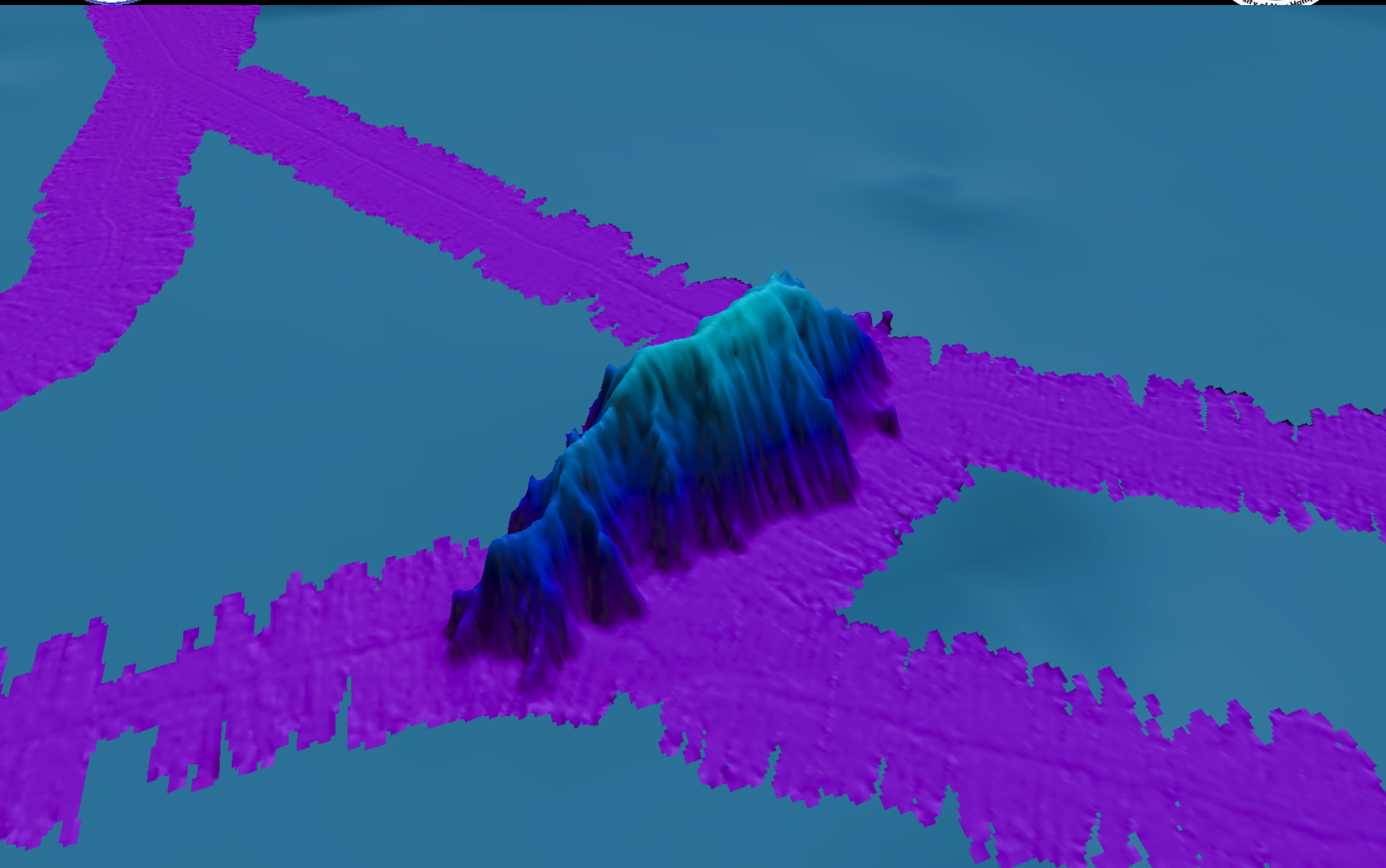
0 km 125 km 250 km 375 km 500 km

HEALY 0905 – JOINT CANADIAN/U.S. PROGRAM – FOCUS ON SEISMIC

HEALY 0905


84° 0.00000' N
81° 0.00000' N
78° 0.00000' N
75° 0.00000' N
72° 0.00000' N
69° 0.00000' N
A
B
C

New Seamount: Savaqatigiit Seamount

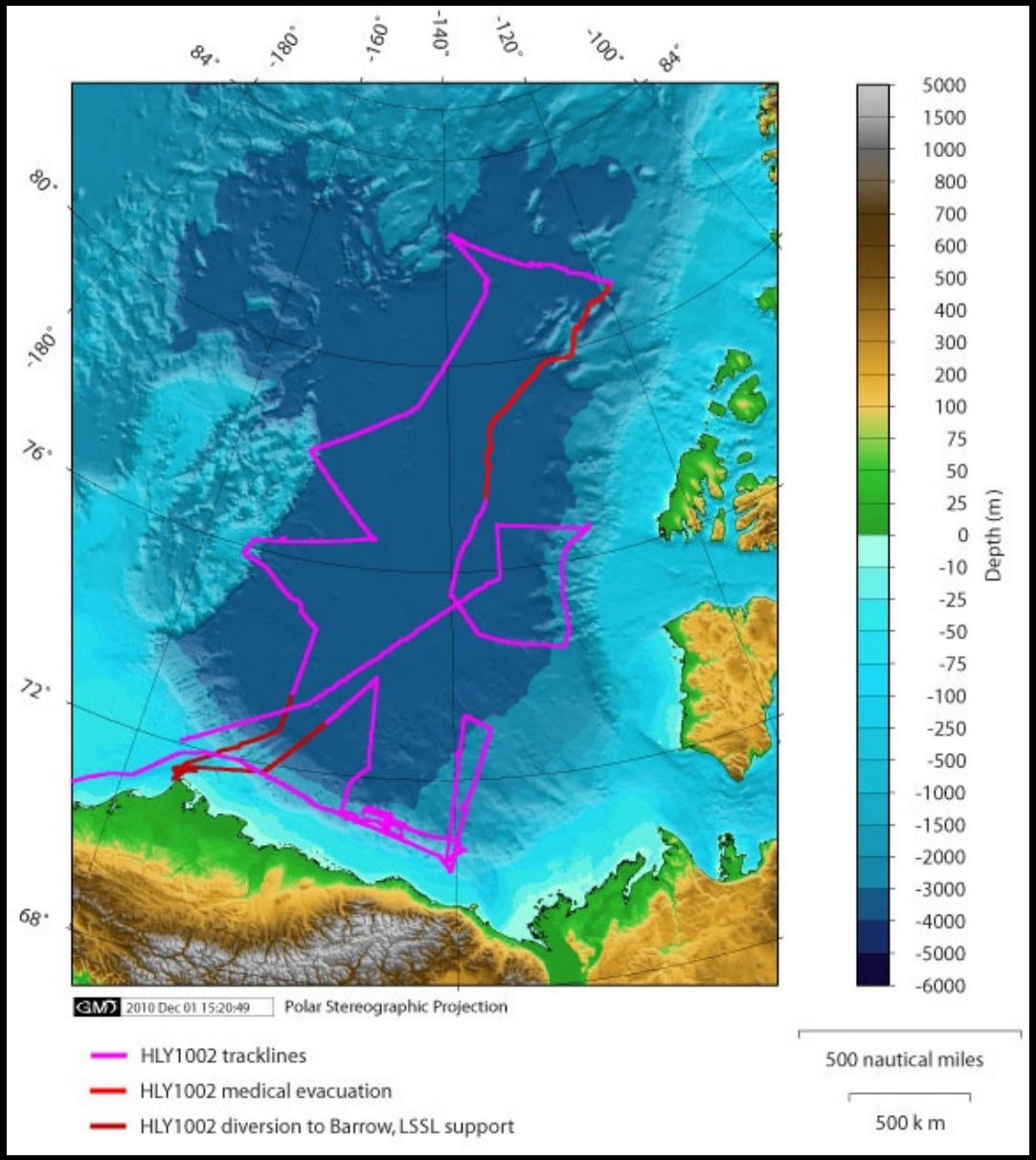


HEALY 1002 – Again – Joint with LSSL - seismic

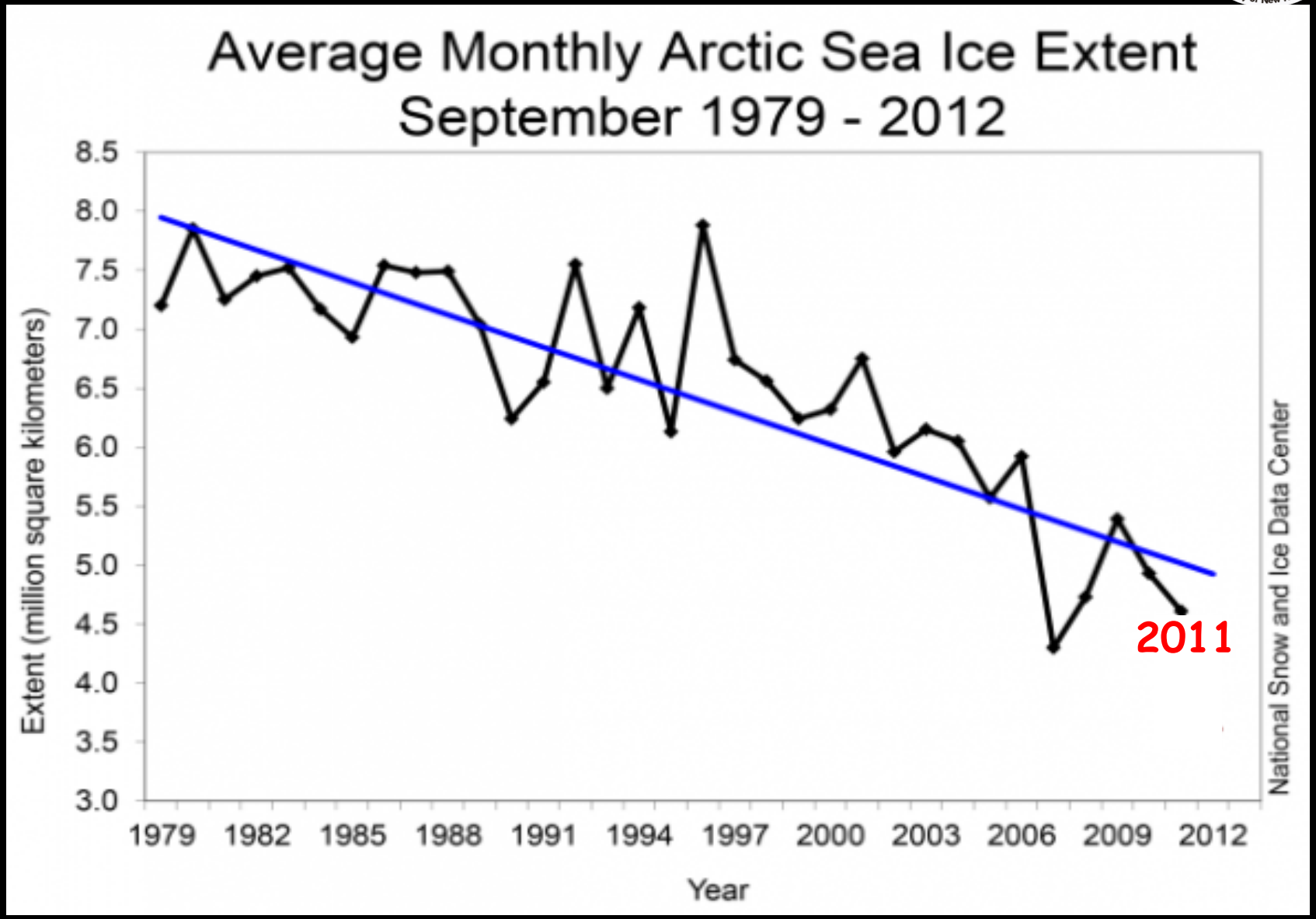
CCGS Louis S. St-Laurent

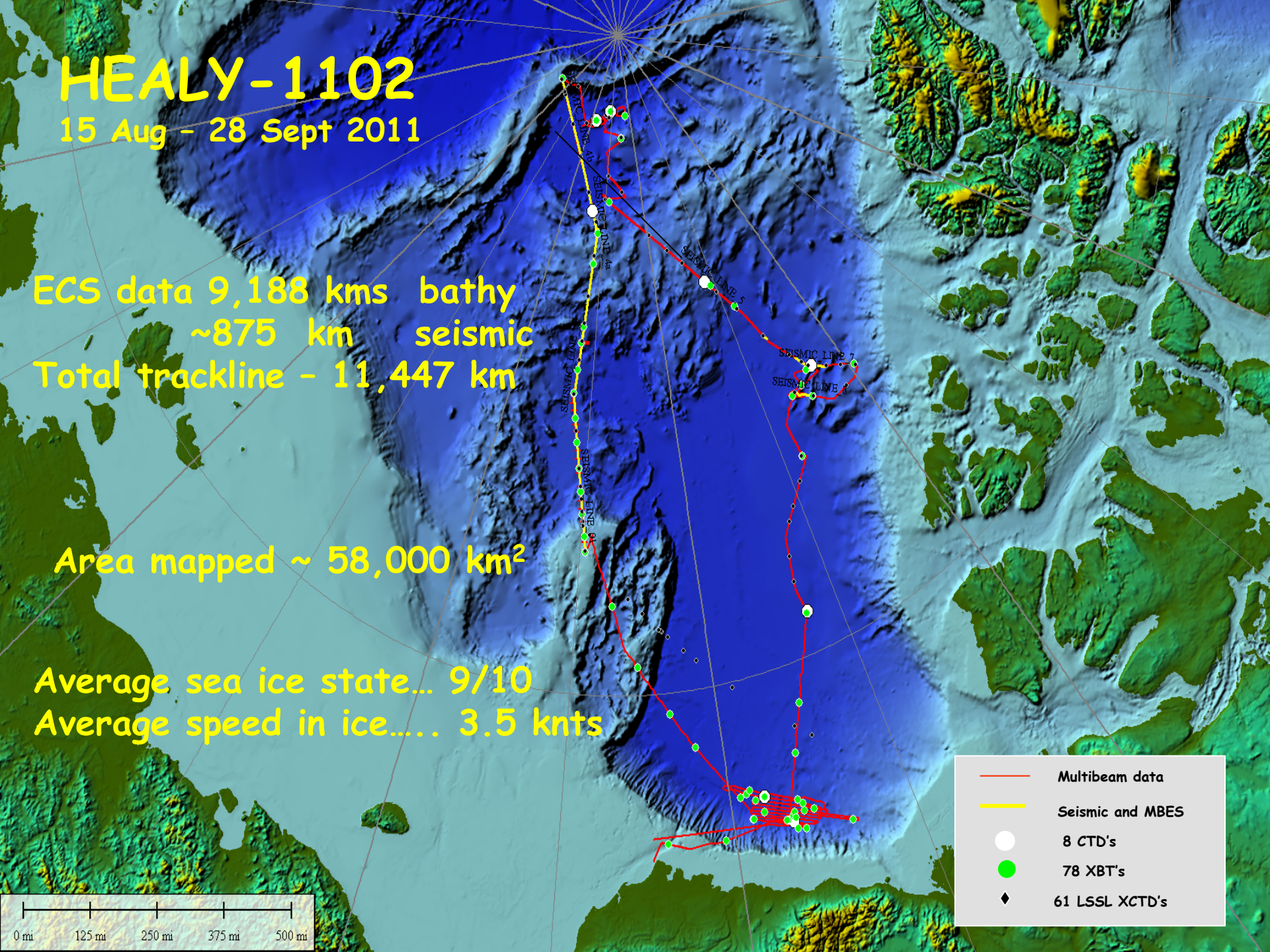
USCGC Healy

HEALY 1002


84°
-180°
-160°
-140°
-120°
-100°
84°
80°
-180°
76°
72°
68°
5000
1500
1000
800
700
600
500
400
300
200
100
75
50
25
0
-10
-25
-50
-75
-100
-250
-500
-1000
-1500
-2000
-3000
-4000
-5000
-6000
Depth (m)
2010 Dec 01 15:20:49
Polar Stereographic Projection
HLY1002 tracklines
HLY1002 medical evacuation
HLY1002 diversion to Barrow, LSSL support
500 nautical miles
500 k m

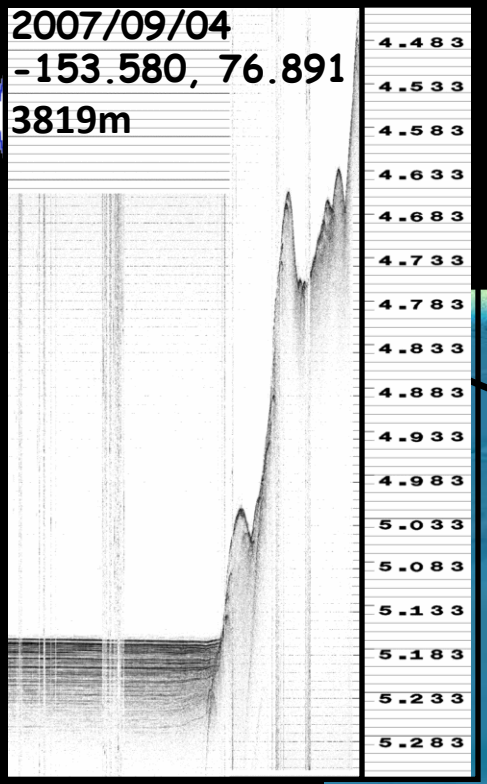
Minimum Ice Extent

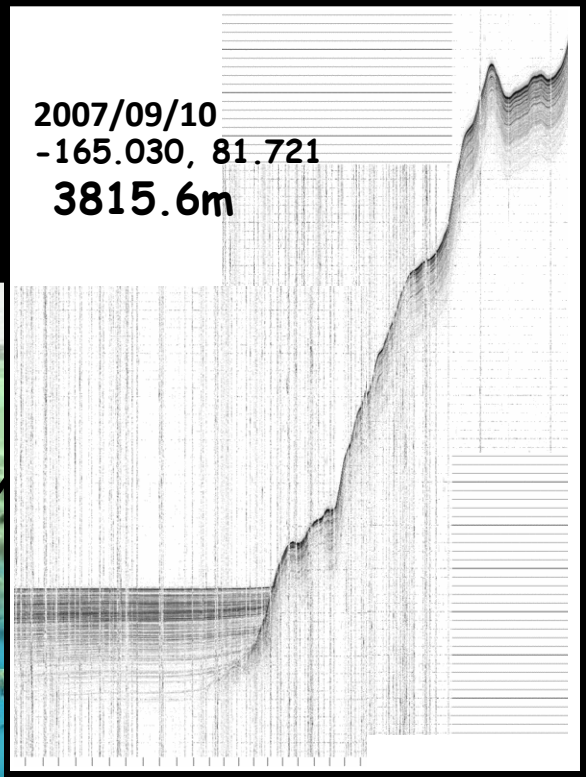


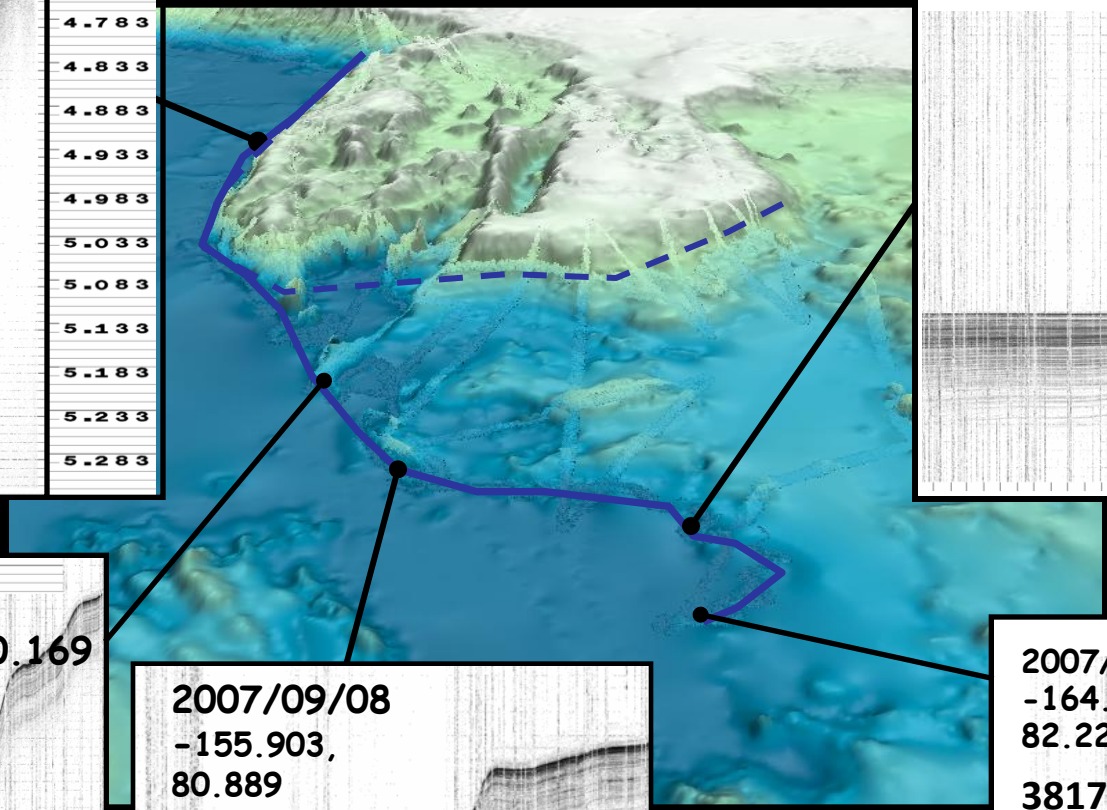

HEALY-1102
15 Aug – 28 Sept 2011
ECS data 9,188 kms bathy
~875 km seismic
Total trackline – 11,447 km
Area mapped ~ 58,000 km²
Average sea ice state… 9/10
Average speed in ice….. 3.5 knts
SEISMIC LINE 4a
SEISMIC LINE 5
SEISMIC LINE 7
SEISMIC LINE 8
SEISMIC LINE 8b
Multibeam data
Seismic and MBES
8 CTD's
78 XBT's
61 LSSL XCTD's
0 mi
125 mi
250 mi
375 mi
500 mi

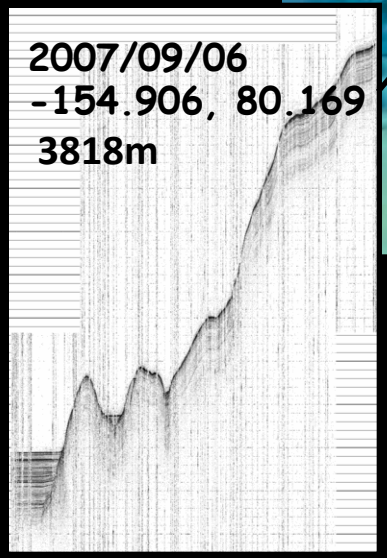

HEALY

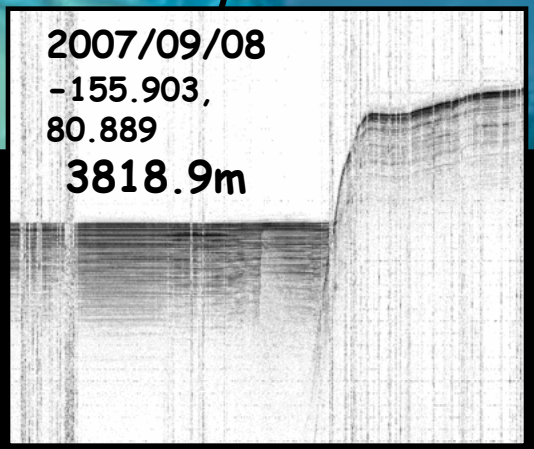
The "Foot of the Slope"

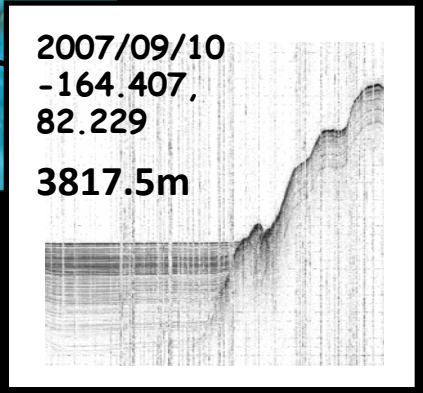




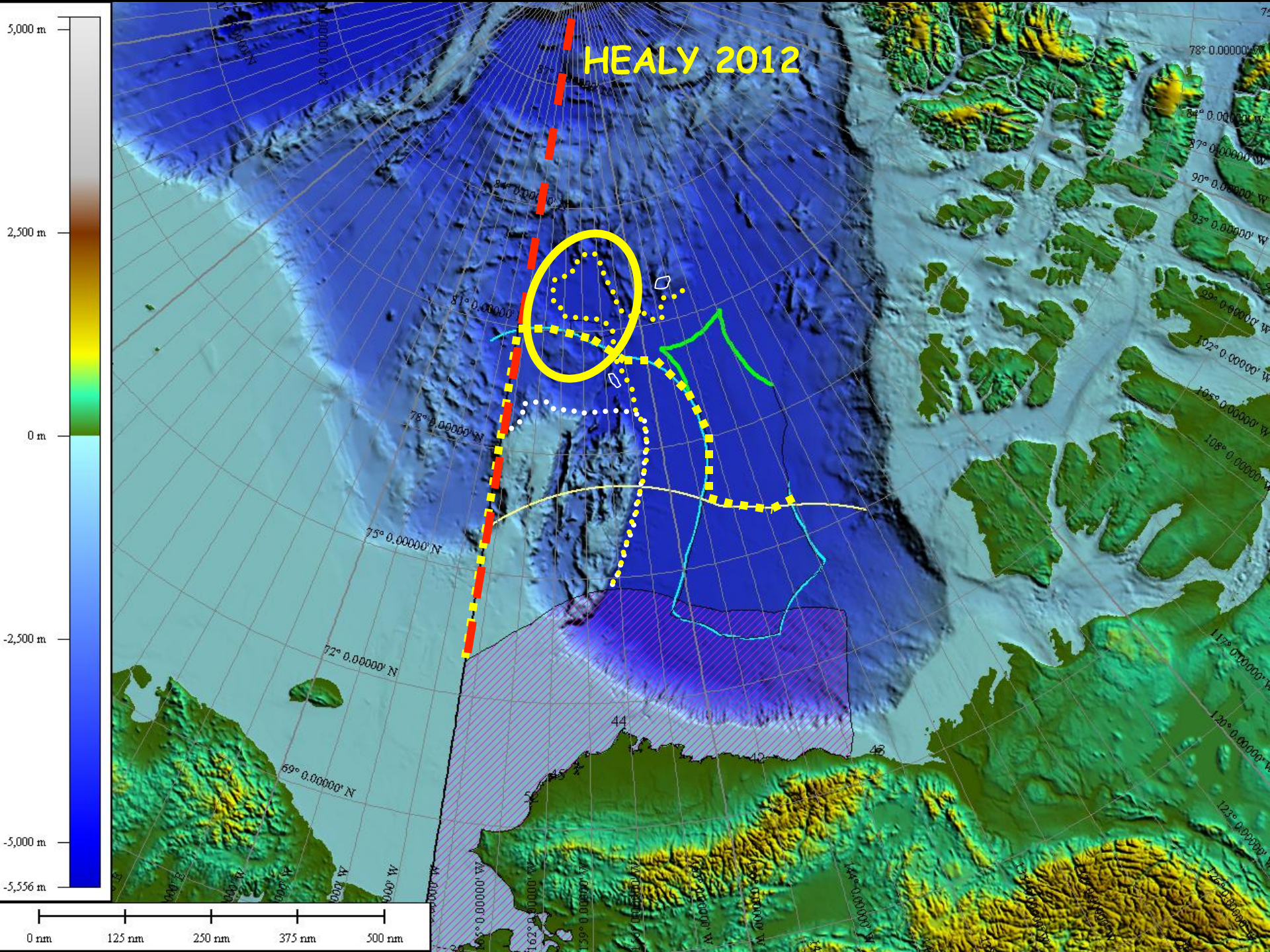


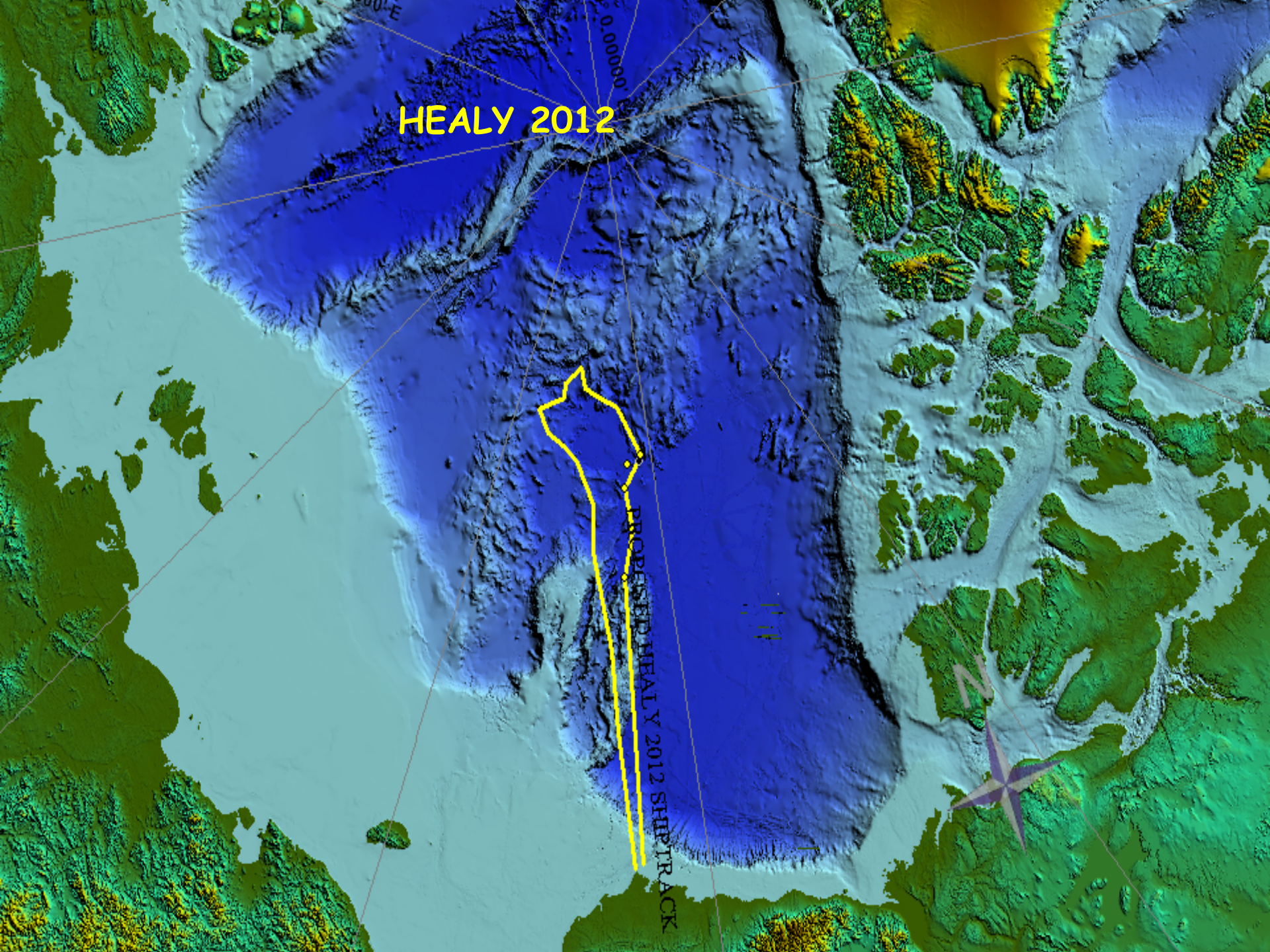




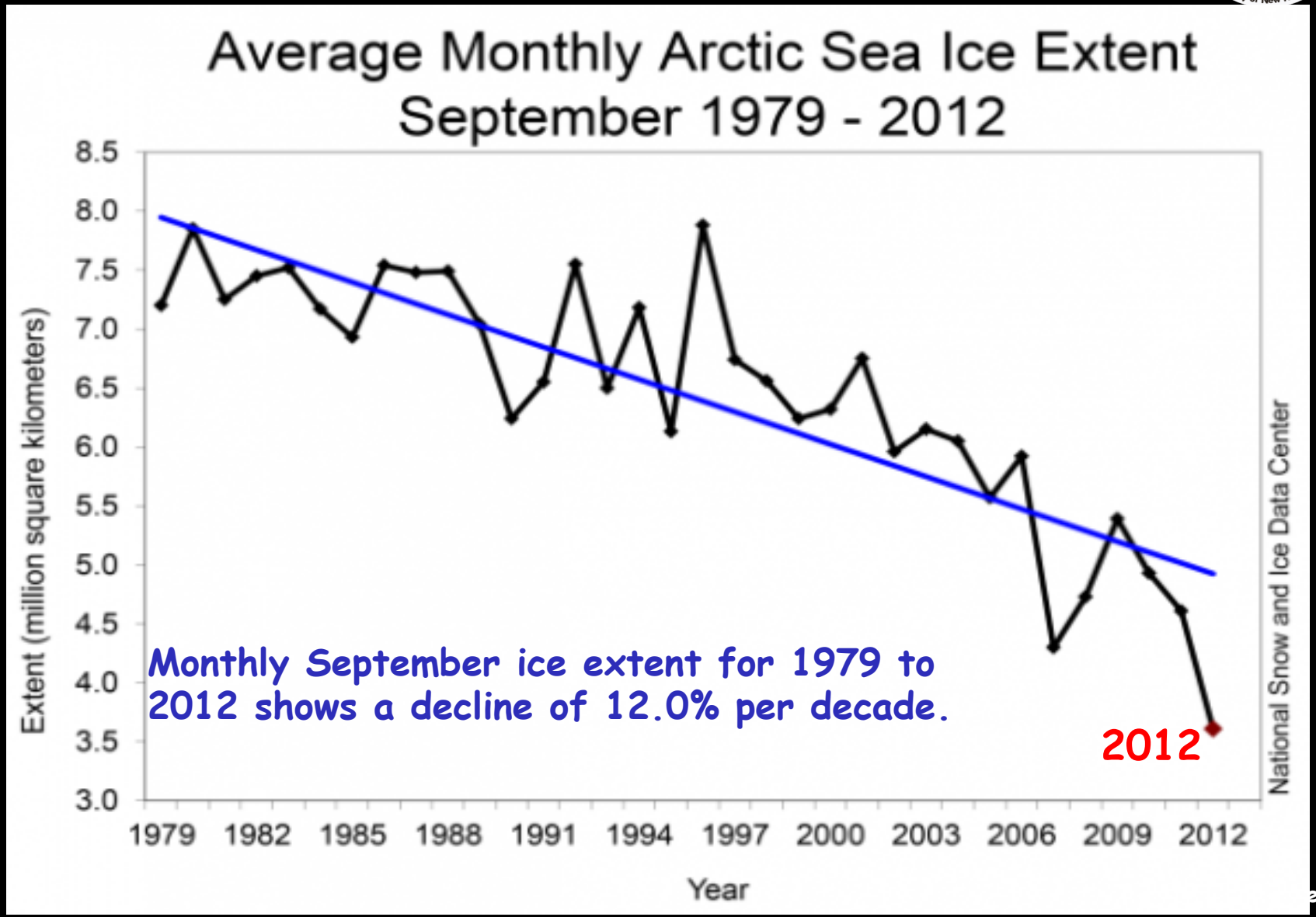


(From Brumley, 2009)


HEALY 2012
5,000 m
2,500 m
0 m
-2,500 m
-5,000 m
-5,556 m
0 nm
125 nm
250 nm
375 nm
500 nm


HEALY 2012
PROPOSED HEALY 2012 SHIPTRACK

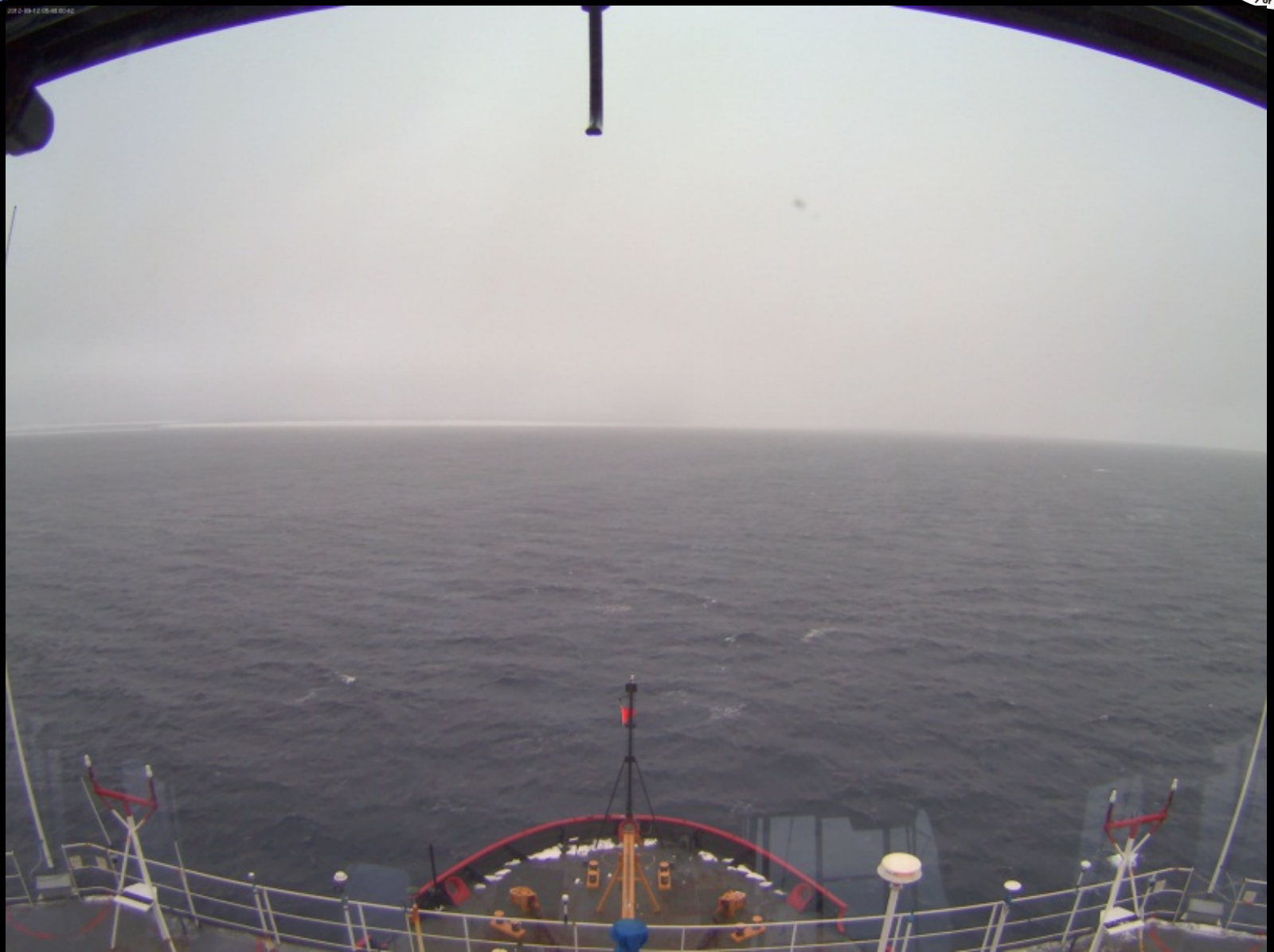
Minimum Ice Extent

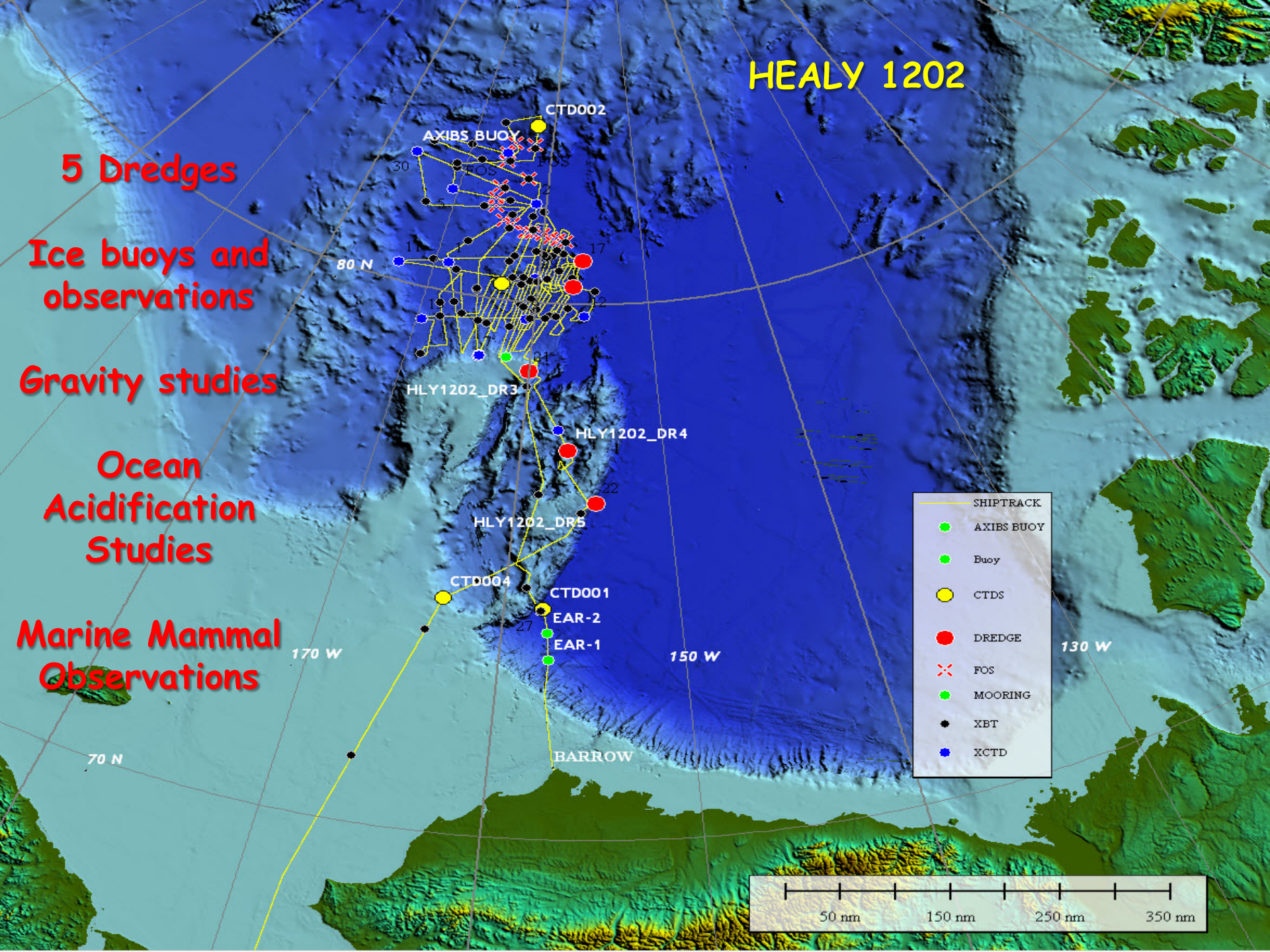


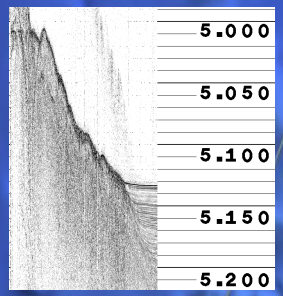
Long/Lat.: -156.072055 W, 80.293353 N

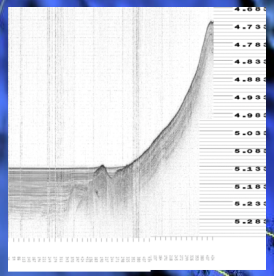
2007 (9-6-2007)

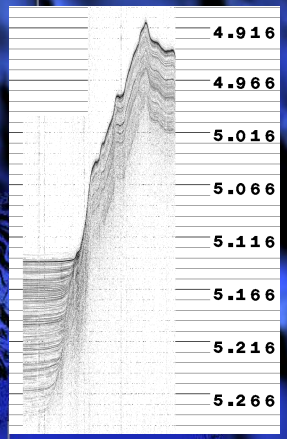
Long/Lat.: -156.072055 W, 80.293353 N
2012 (9-12-2012)

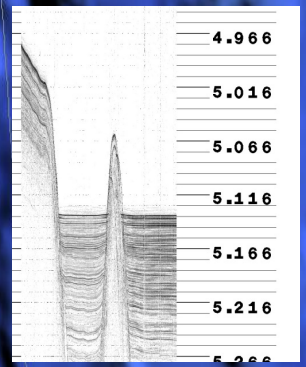


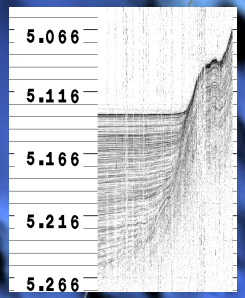

HEALY 1202
5 Dredges
Ice buoys and observations
Gravity studies
Ocean Acidification Studies
Marine Mammal Observations
CTD002
AXIBS BUOY
HLY1202_DR3
HLY1202_DR4
HLY1202_DR5
CTD004
CTD001
EAR-2
EAR-1
BARROW
80 N
70 N
170 W
150 W
130 W
SHIPTRACK
AXIBS BUOY
Buoy
CTDS
DREDGE
FOS
MOORING
XBT
XCTD
50 nm
150 nm
250 nm
350 nm

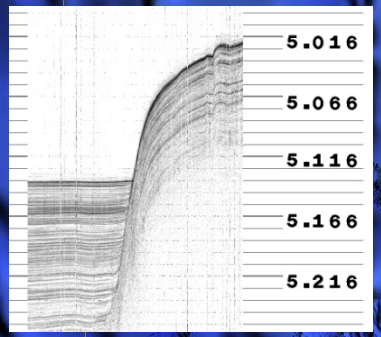

5.000
5.050
5.100
5.150
5.200




4.916
4.966
5.016
5.066
5.116
5.166
5.216
5.266


4.966
5.016
5.066
5.116
5.166
5.216


5.066
5.116
5.166
5.216
5.266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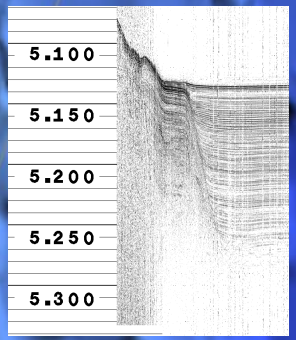
5.066
5.116
5.166
5.216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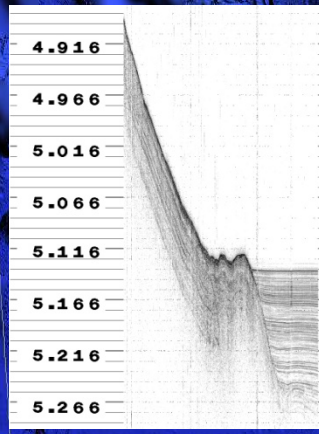
5.150
5.200
5.250
5.300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5.016
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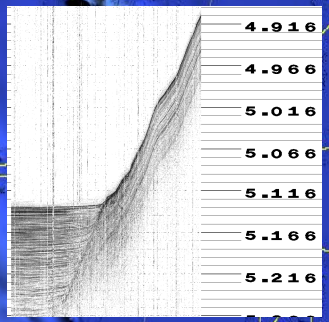
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4.966
5.016
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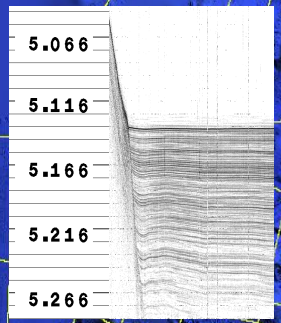
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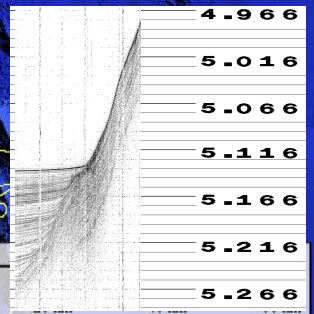
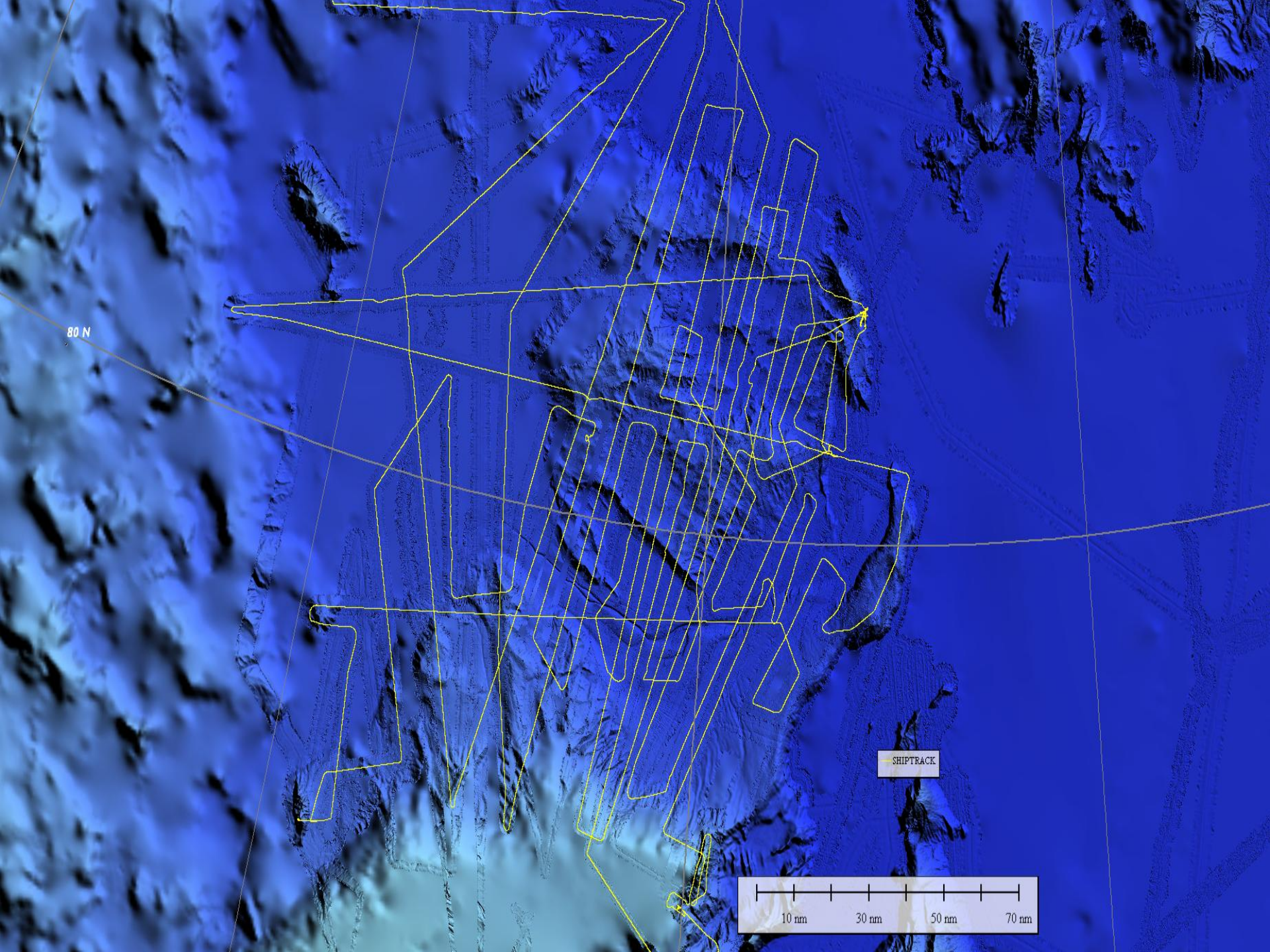
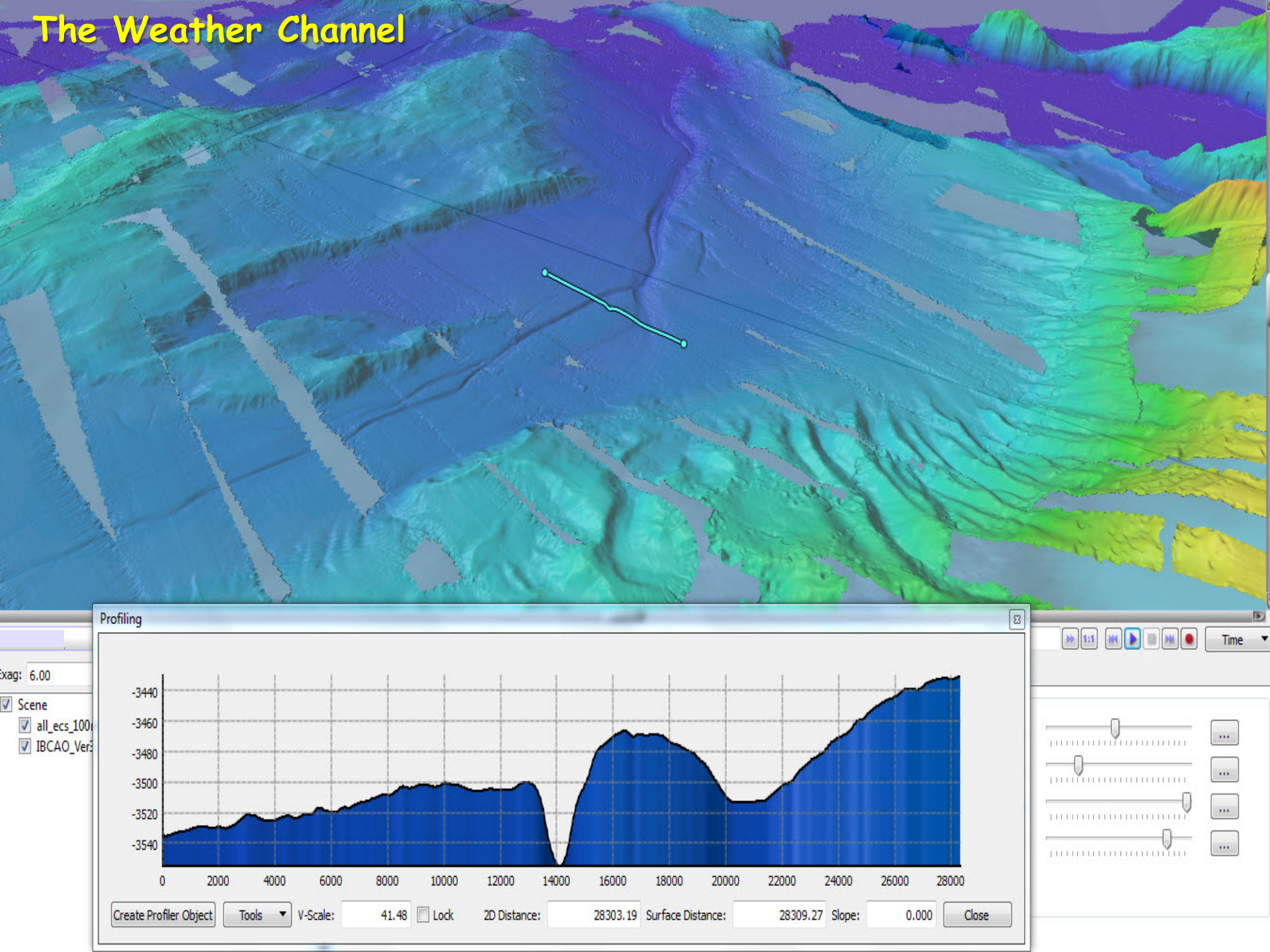

4.966
5.016
5.066
5.116
5.166
5.216
5.266

0 nm

80 N


80 N
SHIPTRACK
10 nm
30 nm
50 nm
70 nm


The Weather Channel
Profiling
-3440
-3460
-3480
-3500
-3520
-3540
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
26000
28000
Create Profiler Object
Tools
V-Scale:
41.48
Lock
2D Distance:
28303.19
Surface Distance:
28309.27
Slope:
0.000
Close
Exag:
6.00
Scene
Time

HEALY 1202 DREDGE SITES

80 N

HLY1202_DR1

HLY1202_DR2

HLY1202_DR3

HLY1202_DR4

HLY1202_

volcanoclastic?

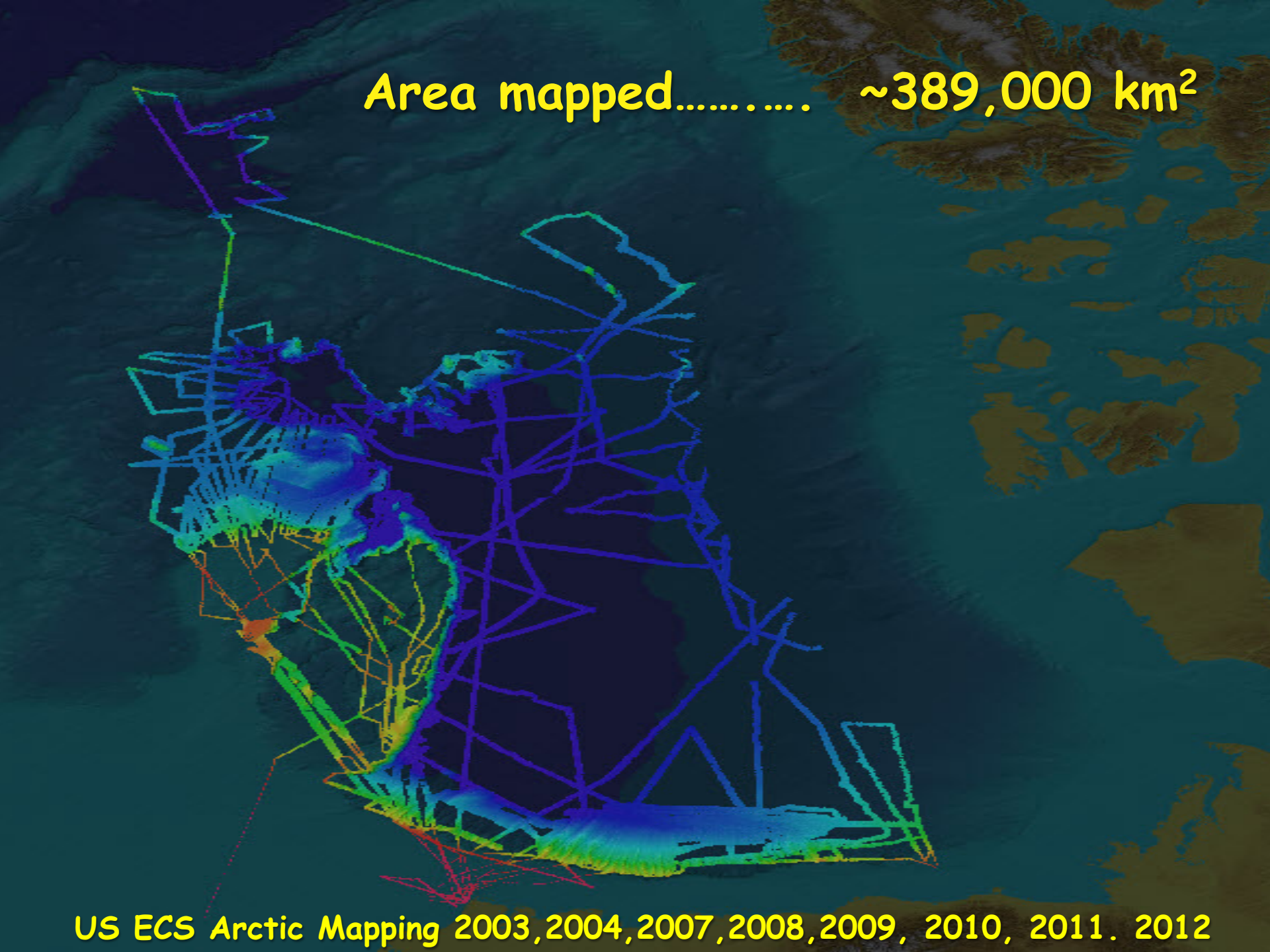
coral

altered basalt

metasediment

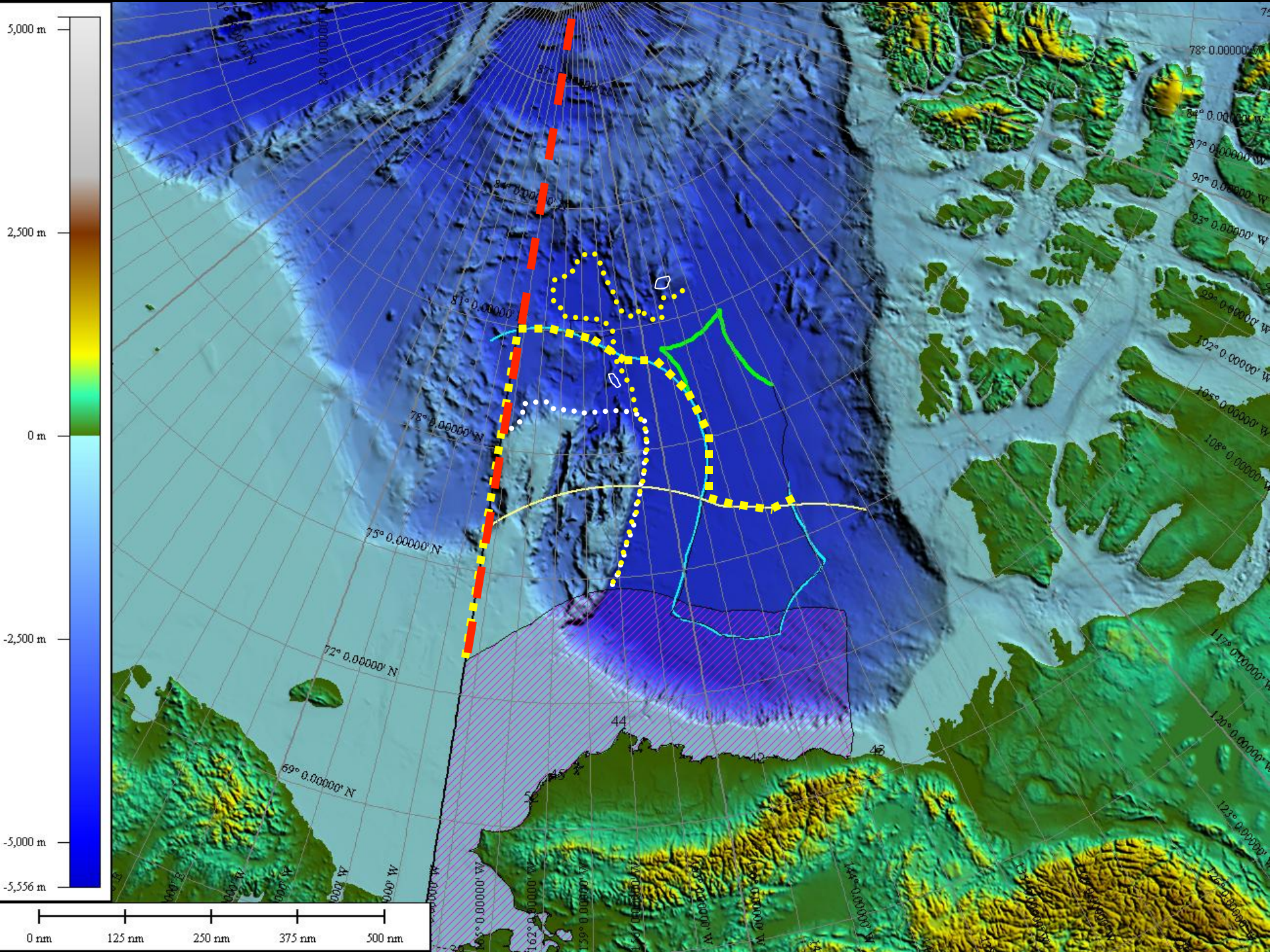
schisht

schisht

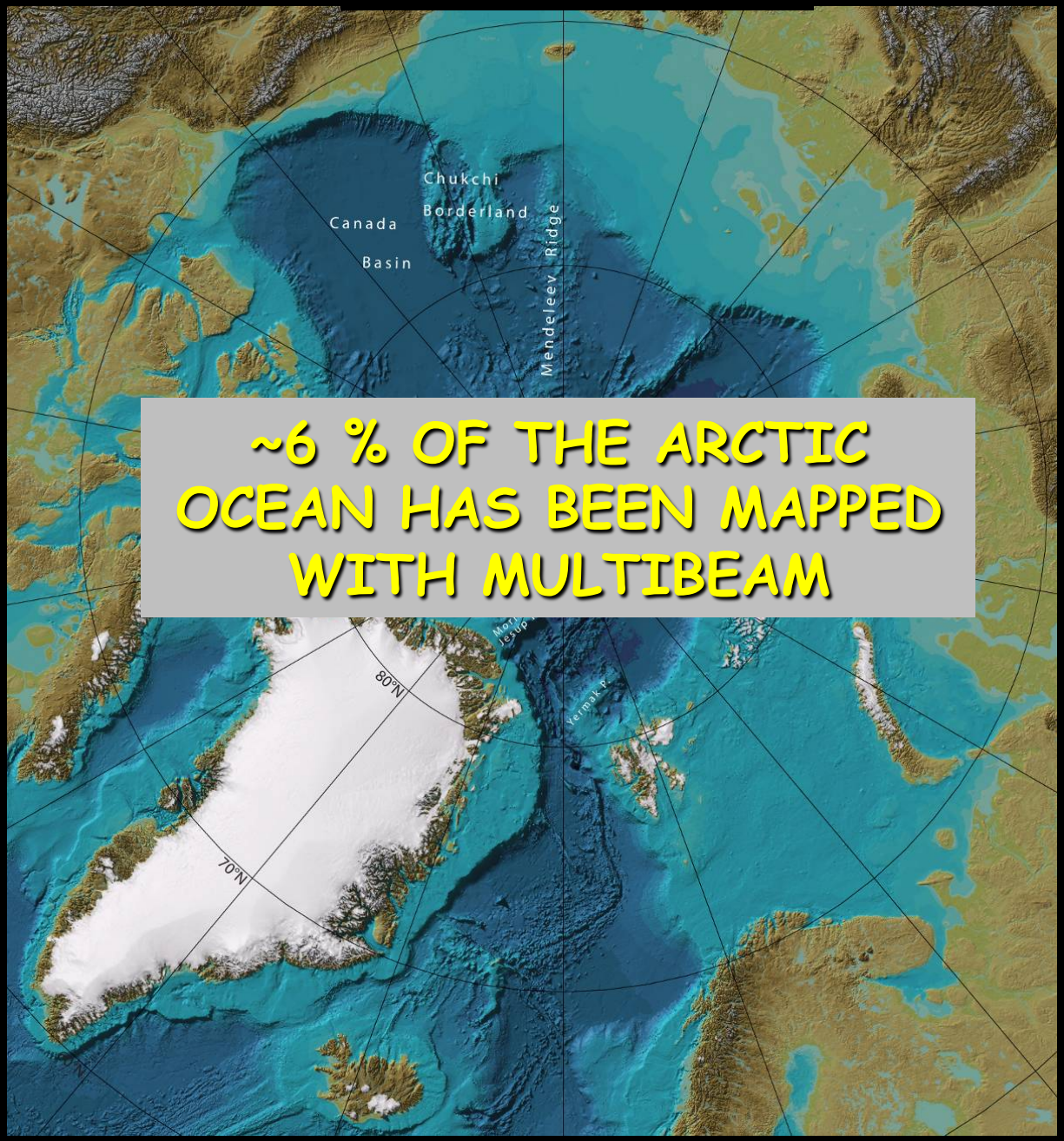

Area mapped…….…. ~389,000 km²
US ECS Arctic Mapping 2003,2004,2007,2008,2009, 2010, 2011. 2012

www.ccom.unh.edu

ALSO available through NGDC and LDEO GeoMapApp

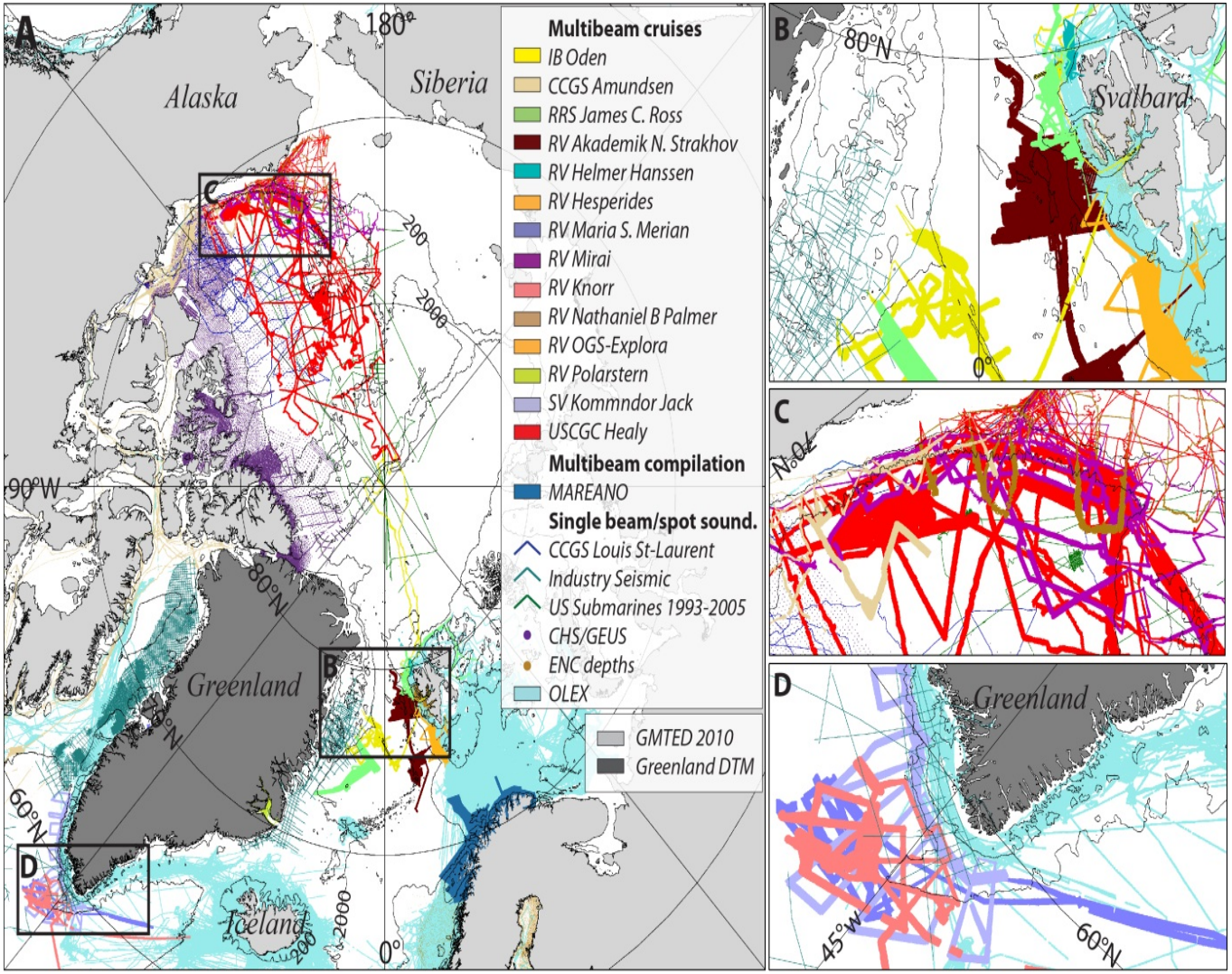

5,000 m
2,500 m
0 m
-2,500 m
-5,000 m
-5,556 m
0 nm
125 nm
250 nm
375 nm
500 nm
81° 0.00000' N
78° 0.00000' N
75° 0.00000' N
72° 0.00000' N
69° 0.00000' N
78° 0.00000' W
84° 0.00000' W
87° 0.00000' W
90° 0.00000' W
93° 0.00000' W
99° 0.00000' W
102° 0.00000' W
105° 0.00000' W
108° 0.00000' W
117° 0.00000' W
120° 0.00000' W
123° 0.00000' W
44
42
48

IBCAO 2008

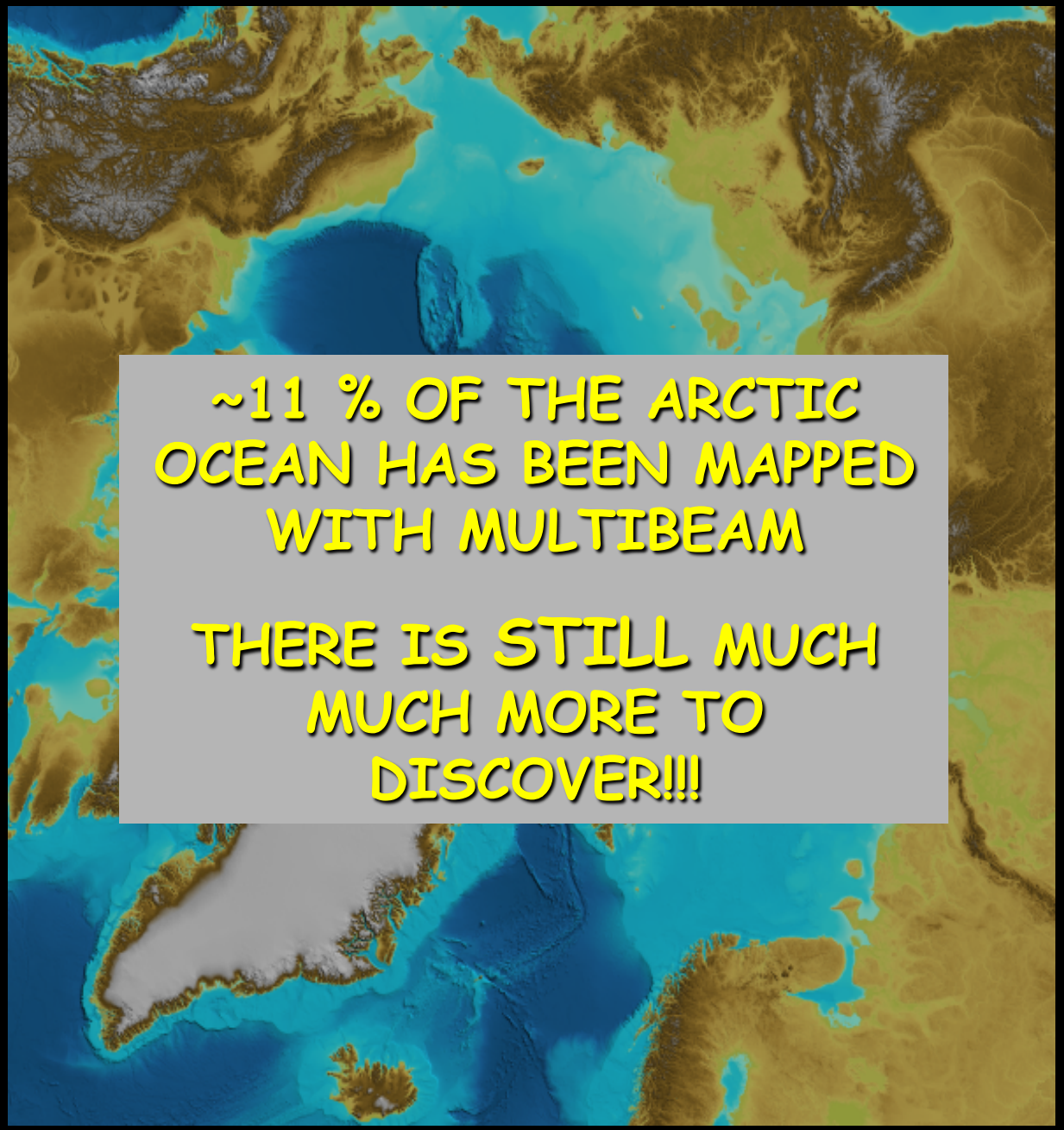


~6 % OF THE ARCTIC OCEAN HAS BEEN MAPPED WITH MULTIBEAM

SINCE IBCAO 2008



IBCAO VER 3.0

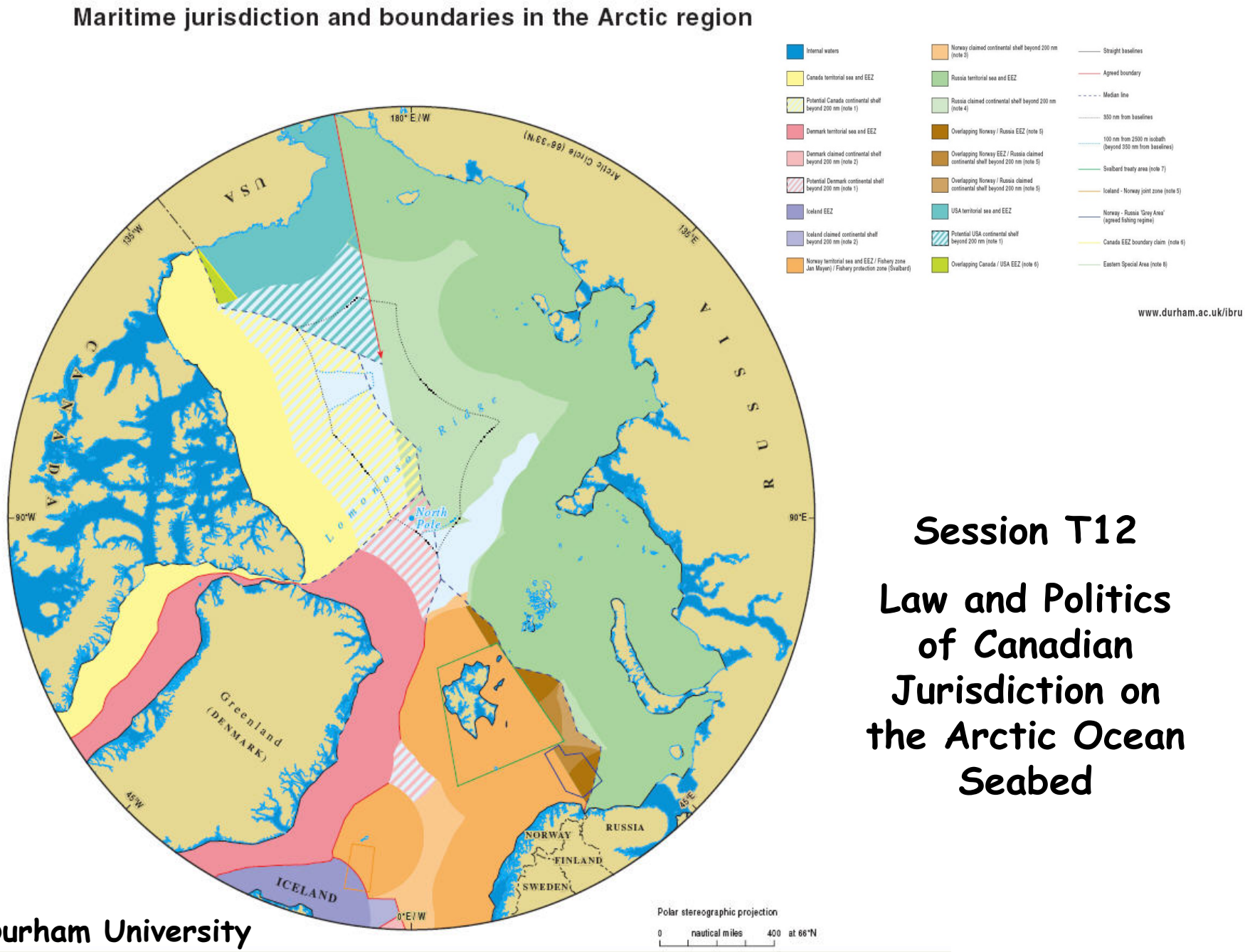


~11 % OF THE ARCTIC OCEAN HAS BEEN MAPPED WITH MULTIBEAM

THERE IS STILL MUCH MUCH MORE TO DISCOVER!!!

IBRU International Boundaries Research Unit

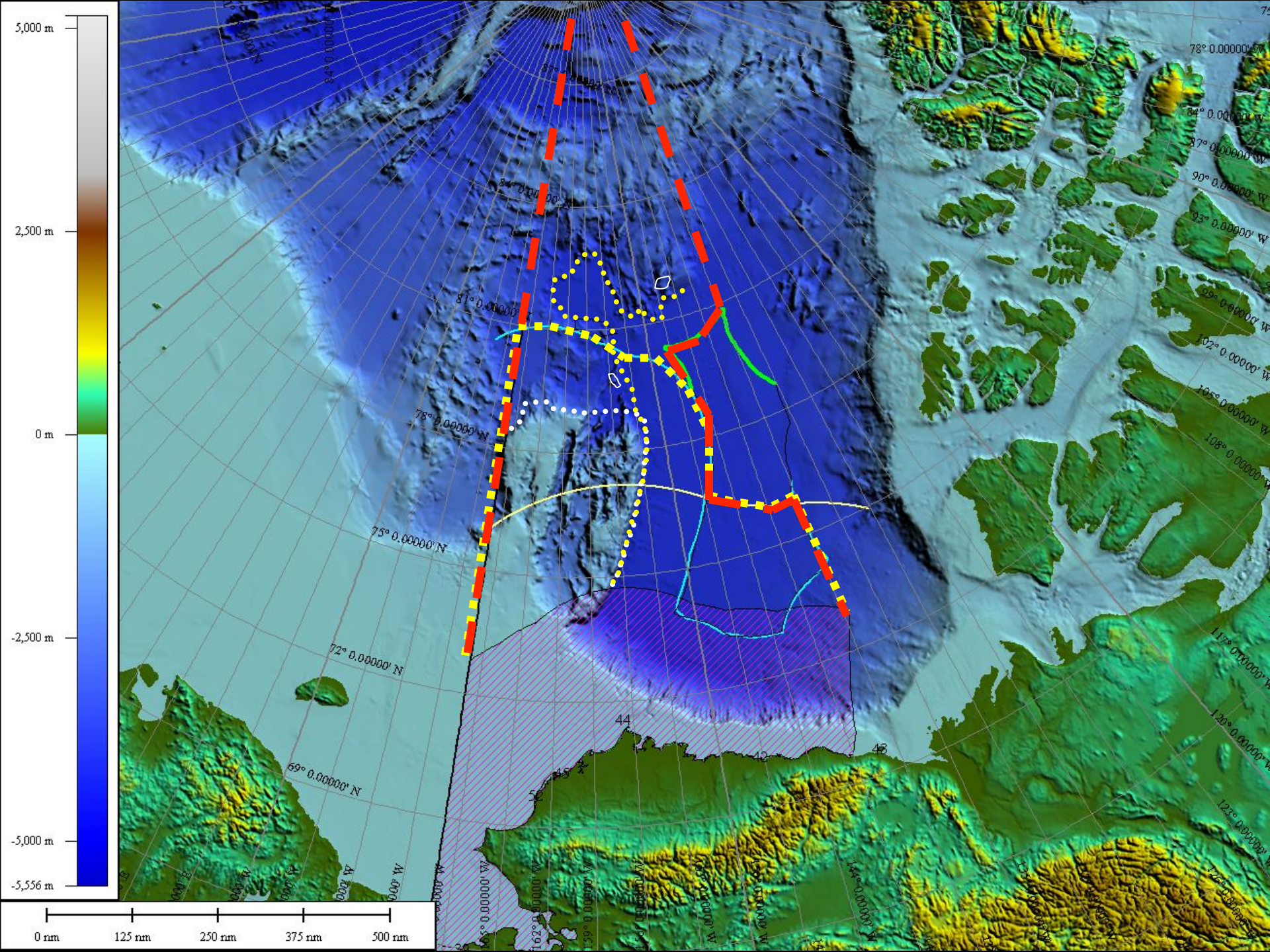
Durham University



Session T12

Law and Politics of Canadian Jurisdiction on the Arctic Ocean Seabed

From Durham University


5,000 m
2,500 m
0 m
-2,500 m
-5,000 m
-5,556 m
0 nm
125 nm
250 nm
375 nm
500 nm
75° 0.00000' N
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180° 0.00000' W
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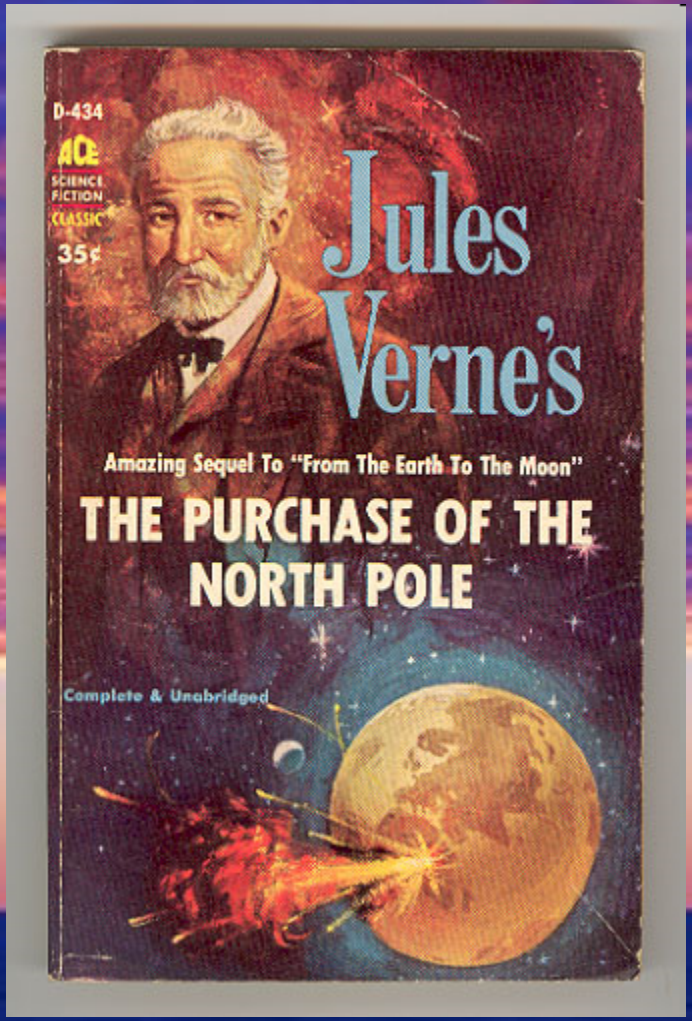
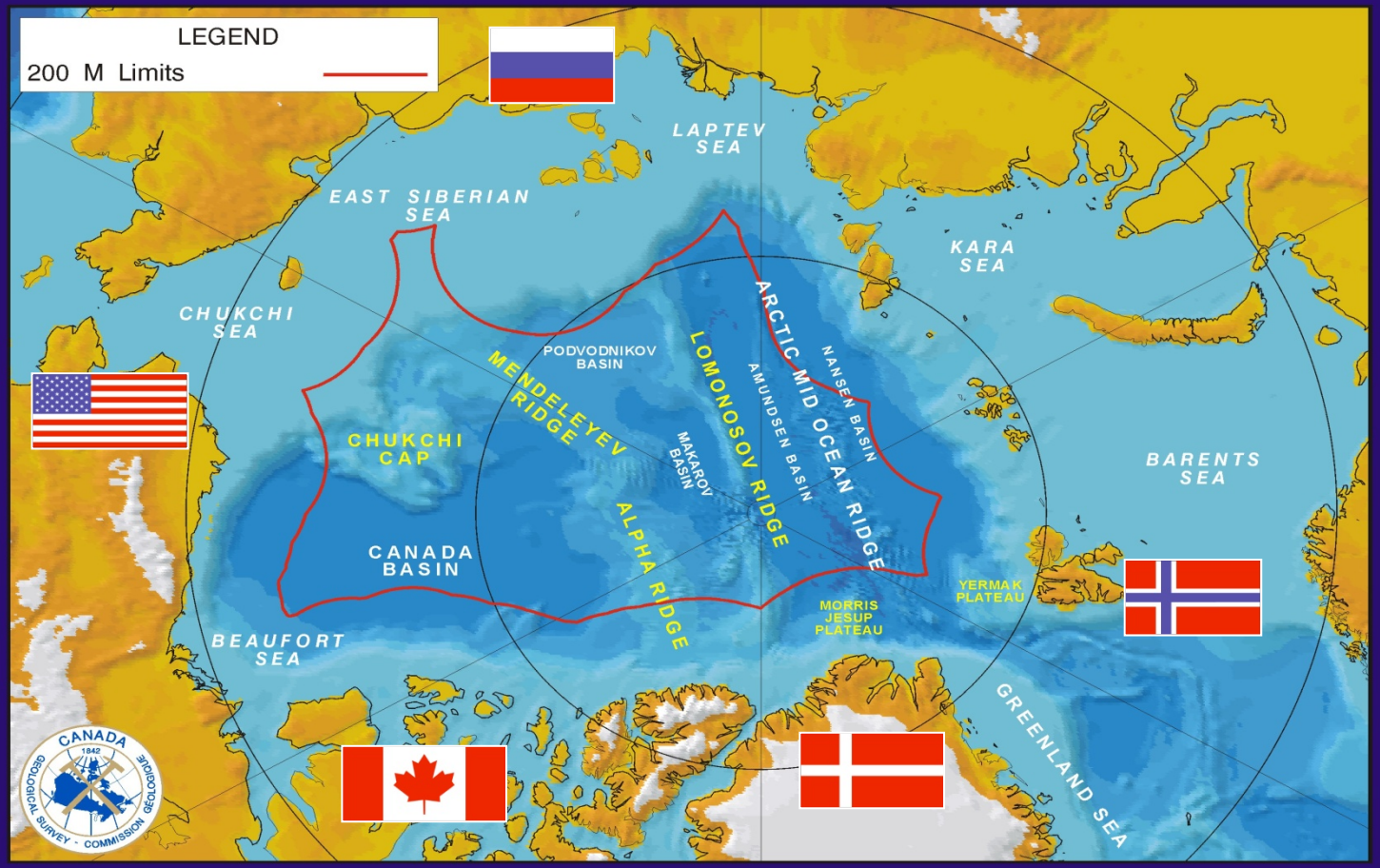


"THERE ARE FORTUNES TO BE MADE IN POLAR REAL ESTATE. JUST CHANGE THE CLIMATE OF BOTH POLES, WARM THEM UP, GIVE THEM MILD WINTERS AND PLEASANT SUMMERS, AND WATCH THEM BOOM! "

Five nations have potential extended shelves



From Ron MacNab