

# Recent Changes in Arctic Ice Cover From First-Hand Experience

Larry Mayer

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

2012



## **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**

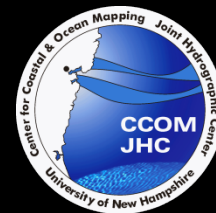
**Fuel Cap = 4.62 M liters**

**Icebreaking = 1.4 m continuous, 2.44 m  
backing and ramming**

**Accommodations = 19 Officer, 12 CPO,  
54 enlisted, 35 (+15) scientists**



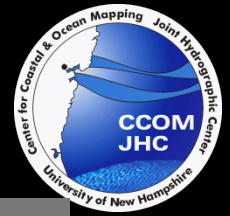
# SEA ICE: frozen seawater ~ -1.8° C



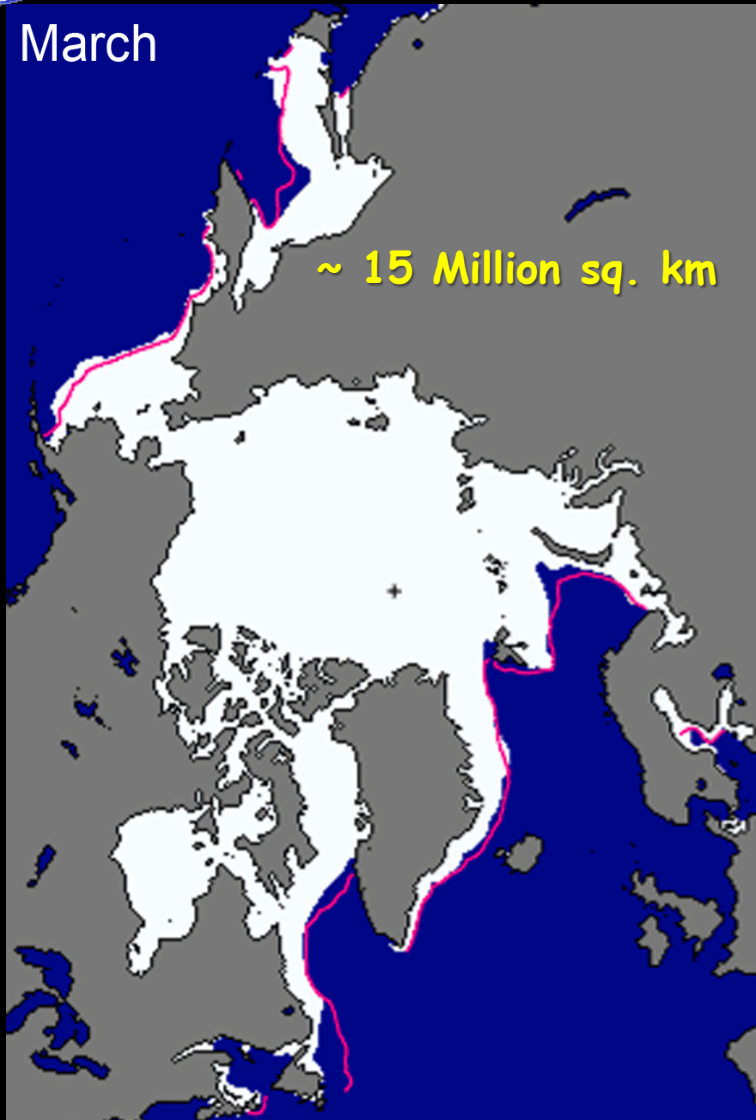
<http://nsidc.org/gallery/coppermine/displayimage.php?pos=-461>



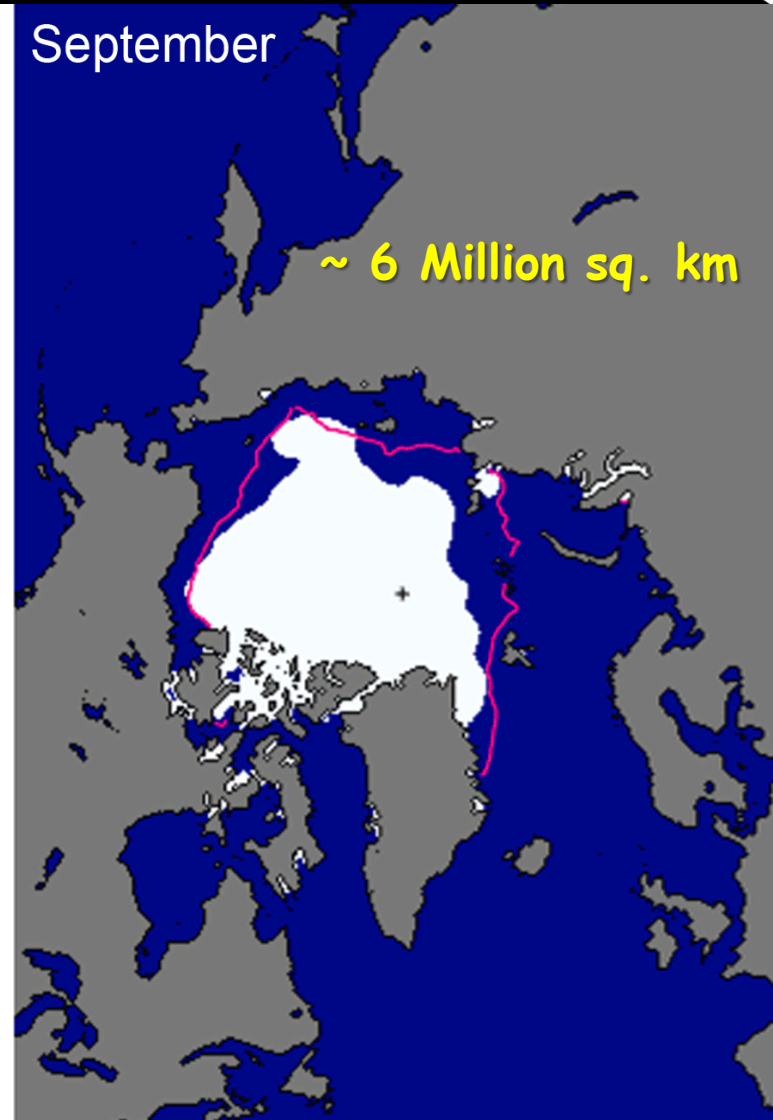
# Annual Cycle of Sea Ice Growth



March



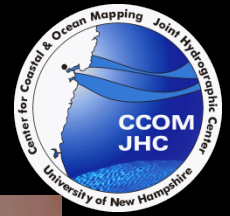
September



From NSIDC



# First Year Ice - 30 - 120 cm

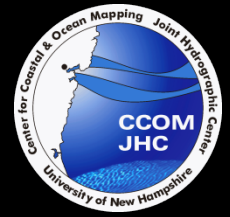


<http://www.utsa.edu/lrsg/antarctica/simba/pictures/album/index.html>

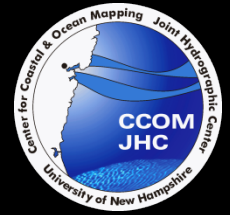


# Multi-year Ice - 2 - 4 m

Survived a melt season --

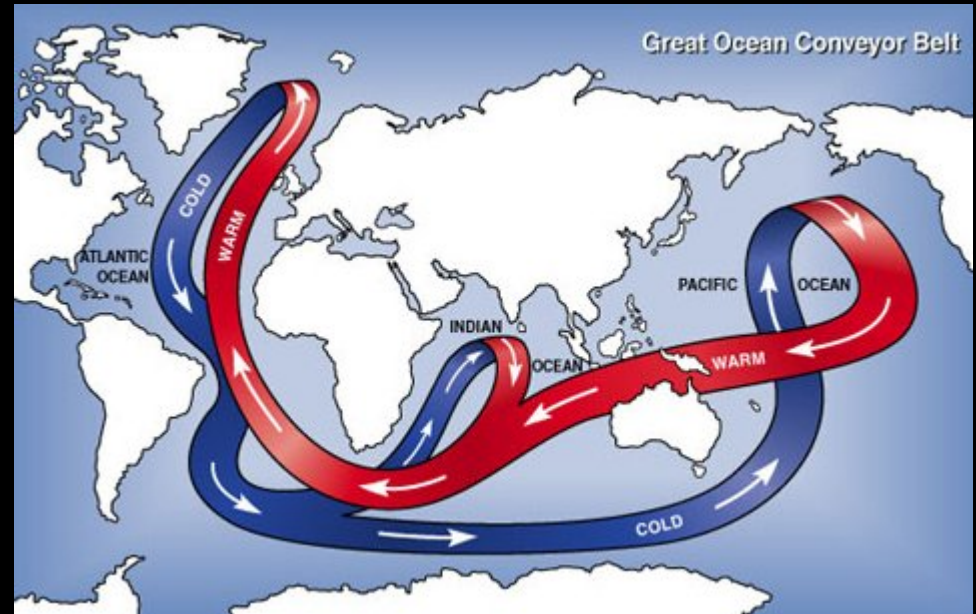
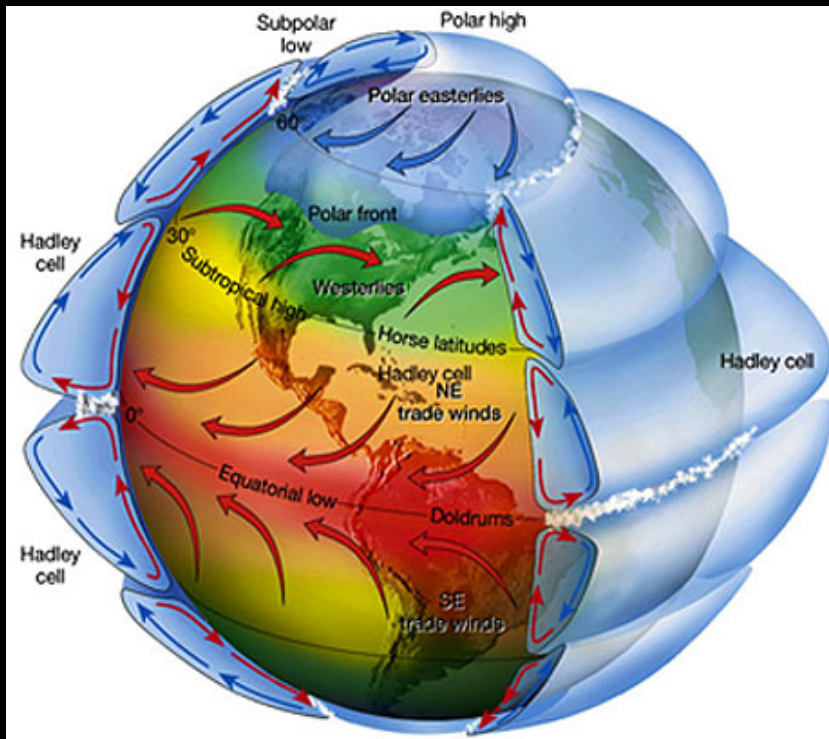


<http://continentalshelf.gov/missions/08arctic/sep17a.html>



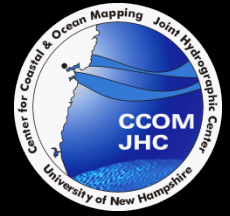
# Why do we care?

## GLOBAL CLIMATE - Atmospheric and Oceanic Circulation



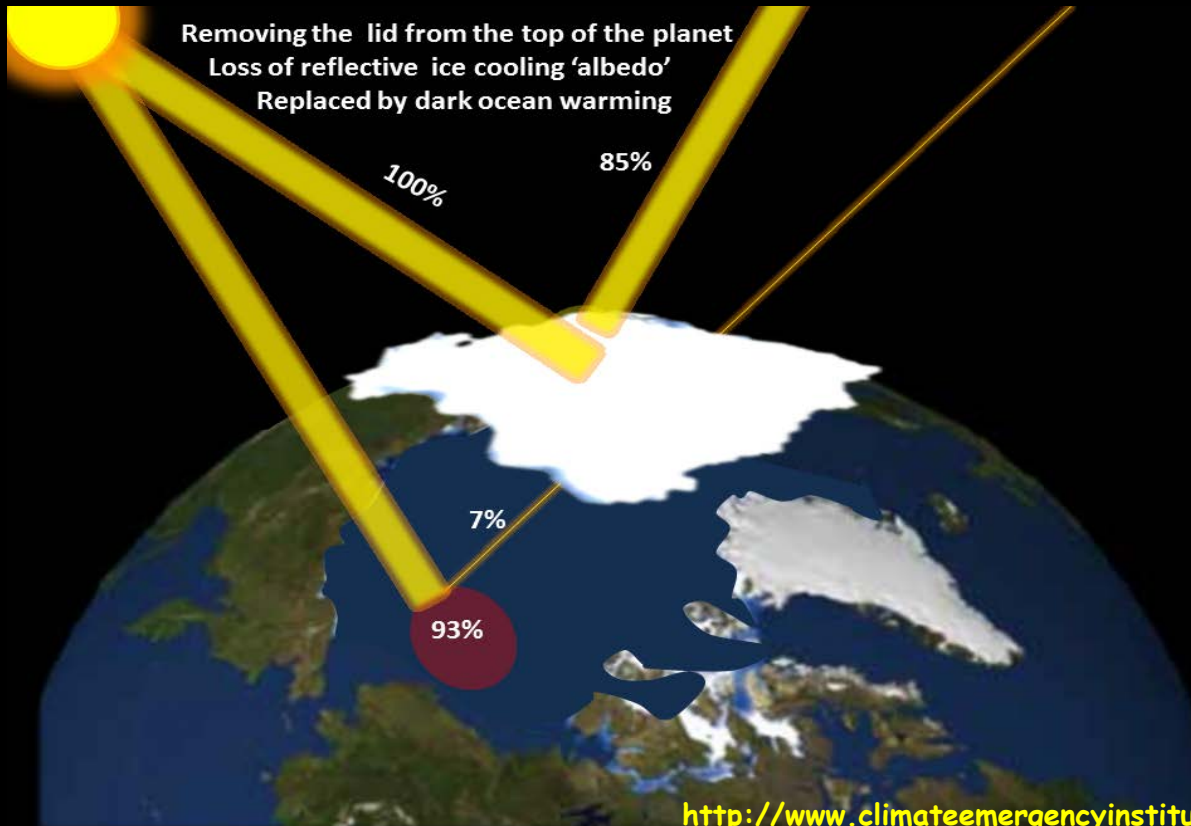
[http://science1.nasa.gov/media/medialibrary/2004/03/01/05mar\\_arctic\\_resources/currents1.jpg](http://science1.nasa.gov/media/medialibrary/2004/03/01/05mar_arctic_resources/currents1.jpg)

<http://serc.carleton.edu/earthlabs/climate/5.html>



# Changes in sea ice:

- Changes the extent of the "thermal blanket" on the ocean and production of saline water
- Changes the ALBEDO → positive feedback loop

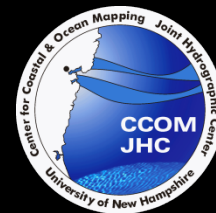




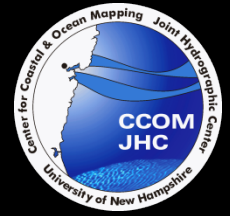


# COASTAL EROSION:

Sea ice dampens winds and waves -



<http://coastalcare.org/2010/08/erosion-doubles-along-alaskas-arctic-coast/>



## ECOSYSTEM AND HABITAT:

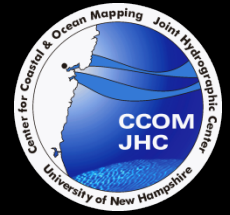
- Melting ice releases nutrients and causes changes in rate of photosynthesis

- Ice is important habitat for seals, polar bears and other critters



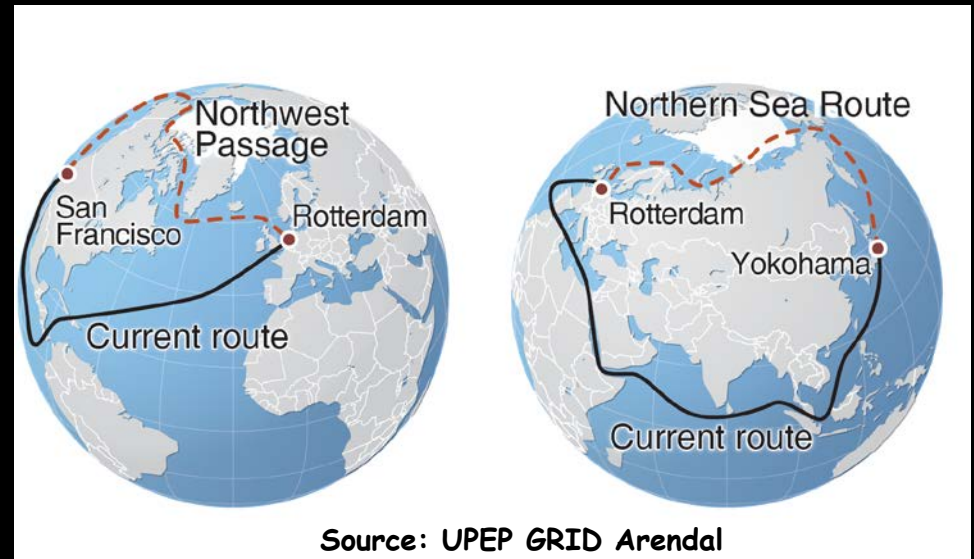


# ACCESS TO THE ARCTIC:



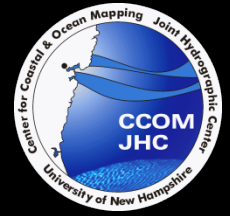
- Ice cover has greatly limited access to the Arctic Ocean
  - Mapping and research
  - Understanding processes
  - Access to resources (e.g. fisheries and oil and gas)

- Shipping routes 40% shorter

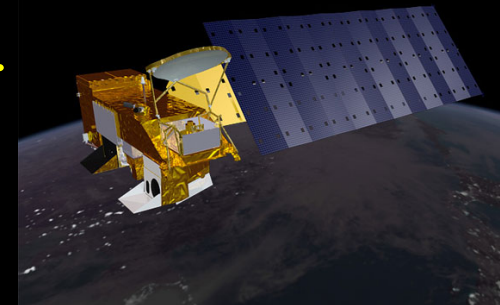




# How do we measure sea ice extent?



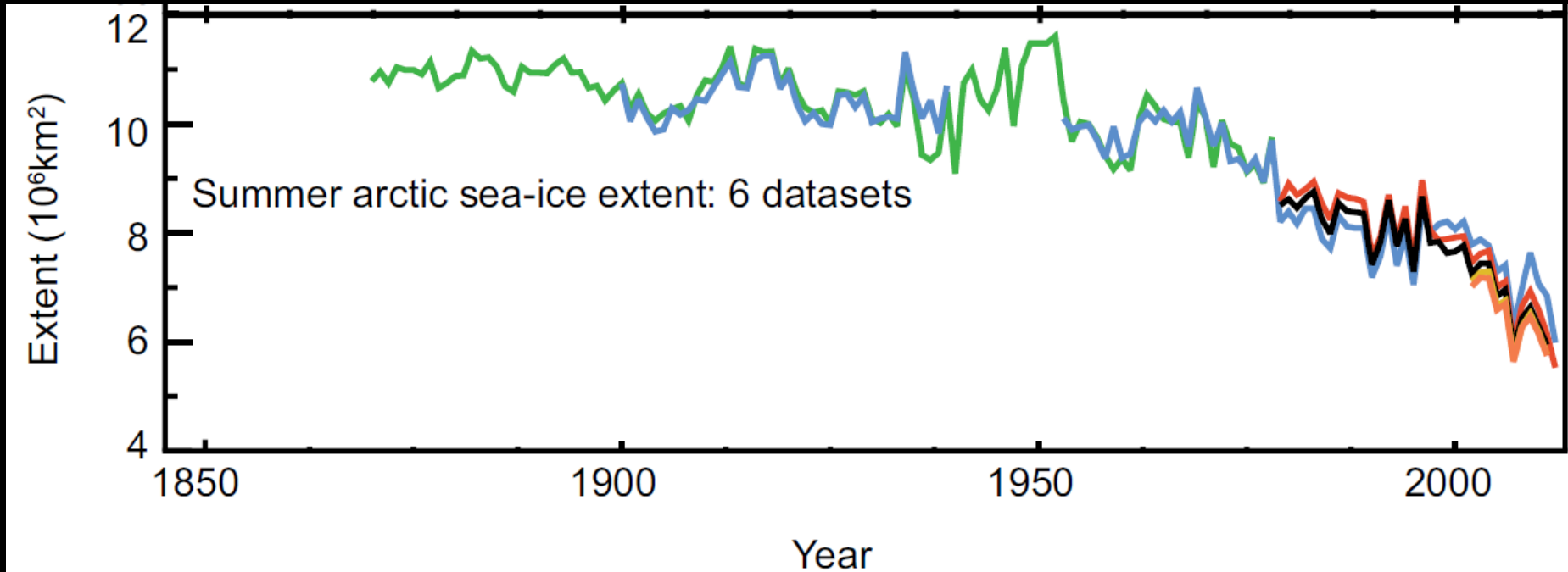
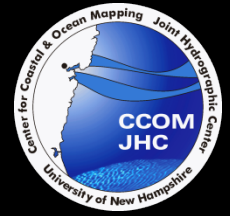
- Vikings kept records of ice along north coast of Iceland
- Shipping records from mid 1700's
- Russian ice-charts since 1933 with others contributing since 1950's
- **SATELLITES** since 1979 - microwave radiometers



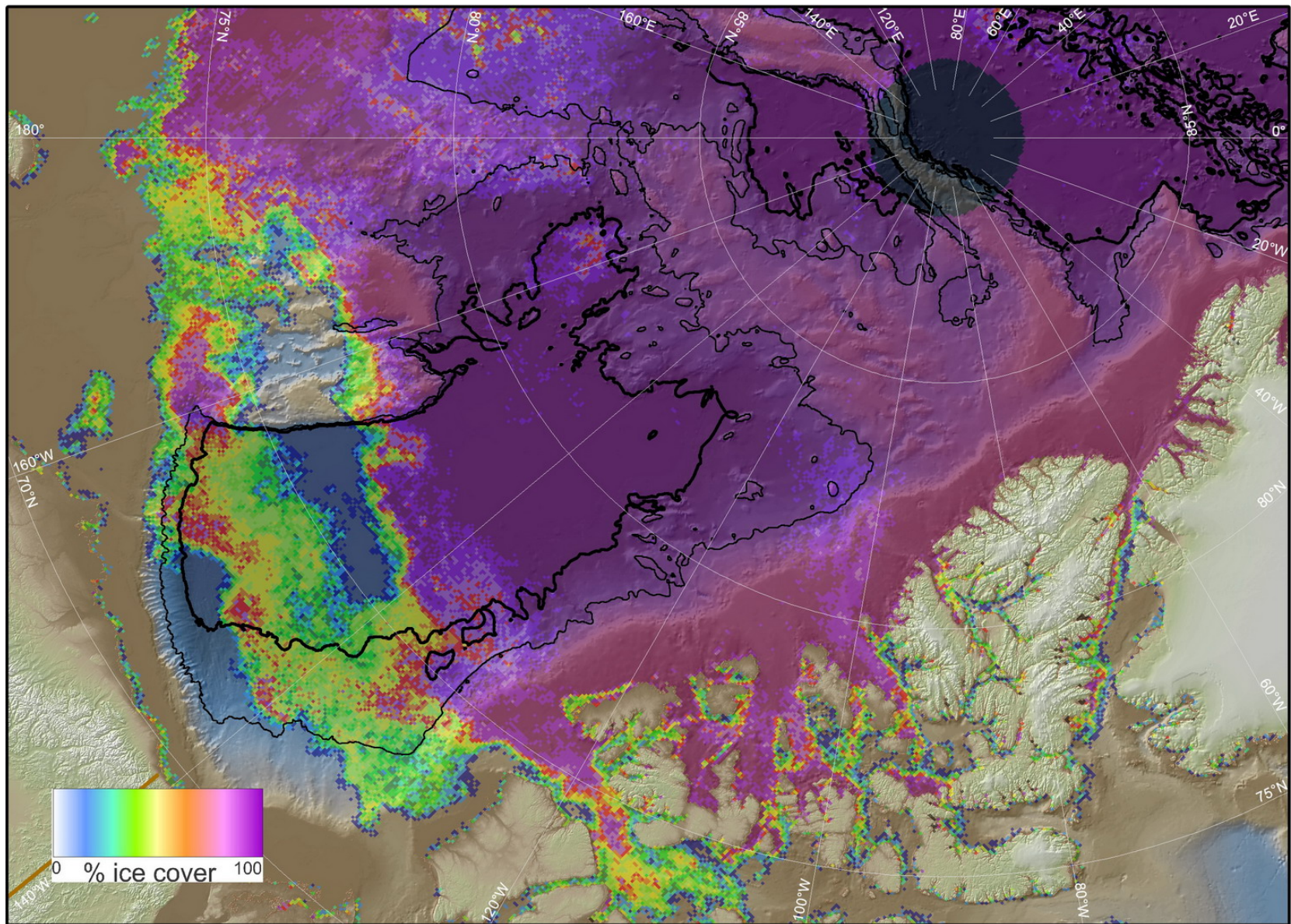
**NASA AMSR**



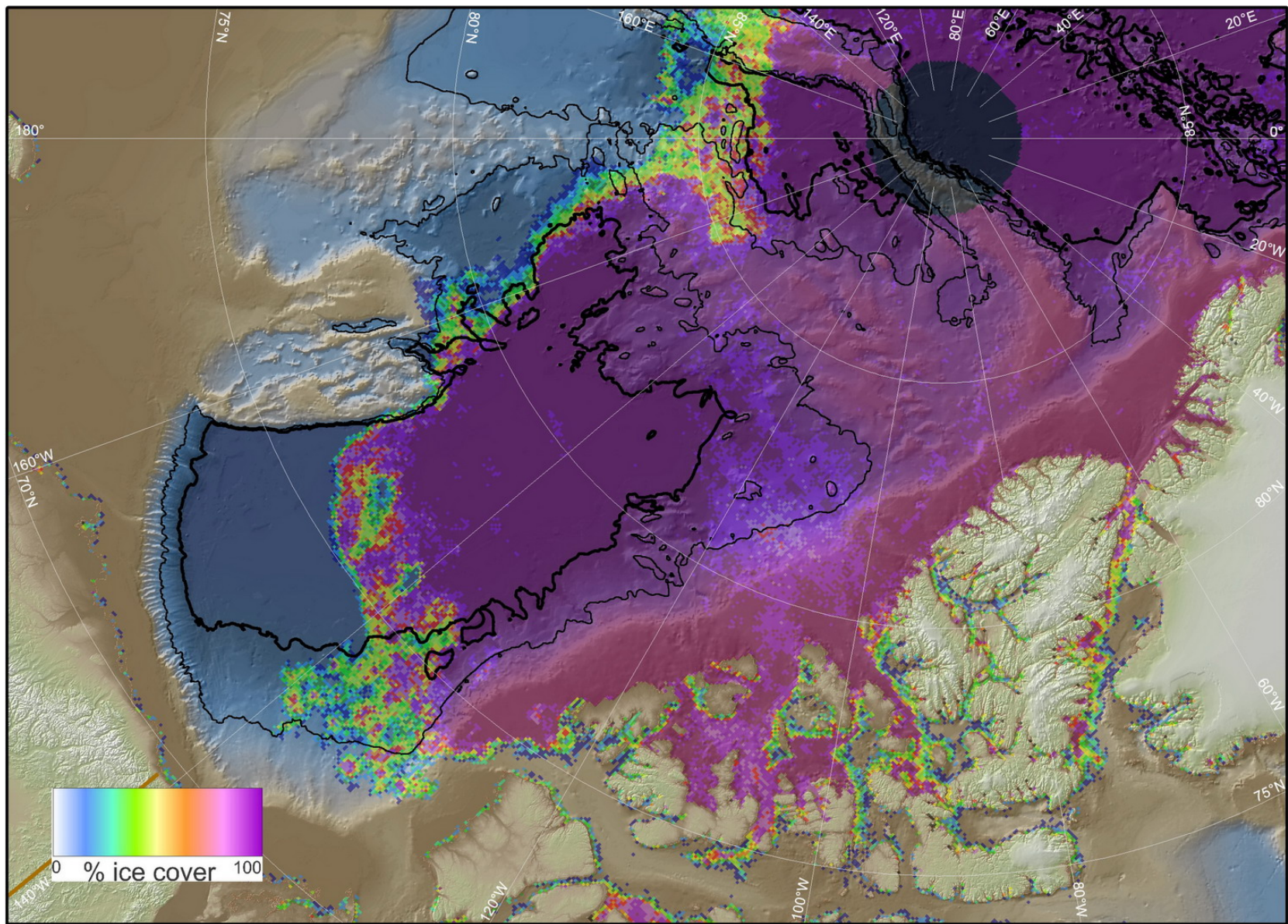
# Historic and Satellite Record of Summer Ice Extent



WORKING GROUP I CONTRIBUTION TO THE IPCC FIFTH ASSESSMENT REPORT  
CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS

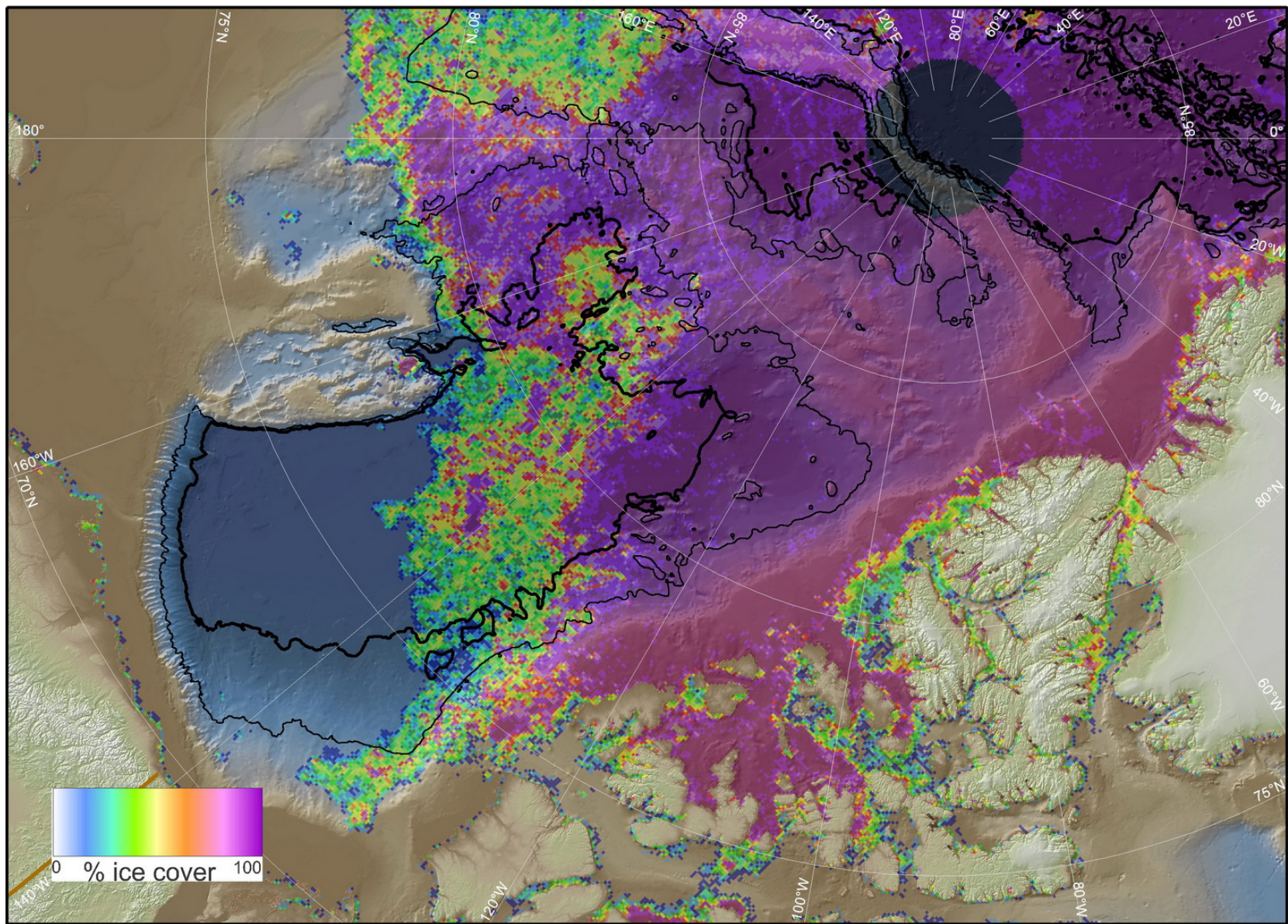


2006

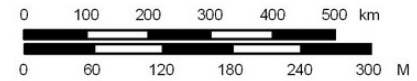


2007

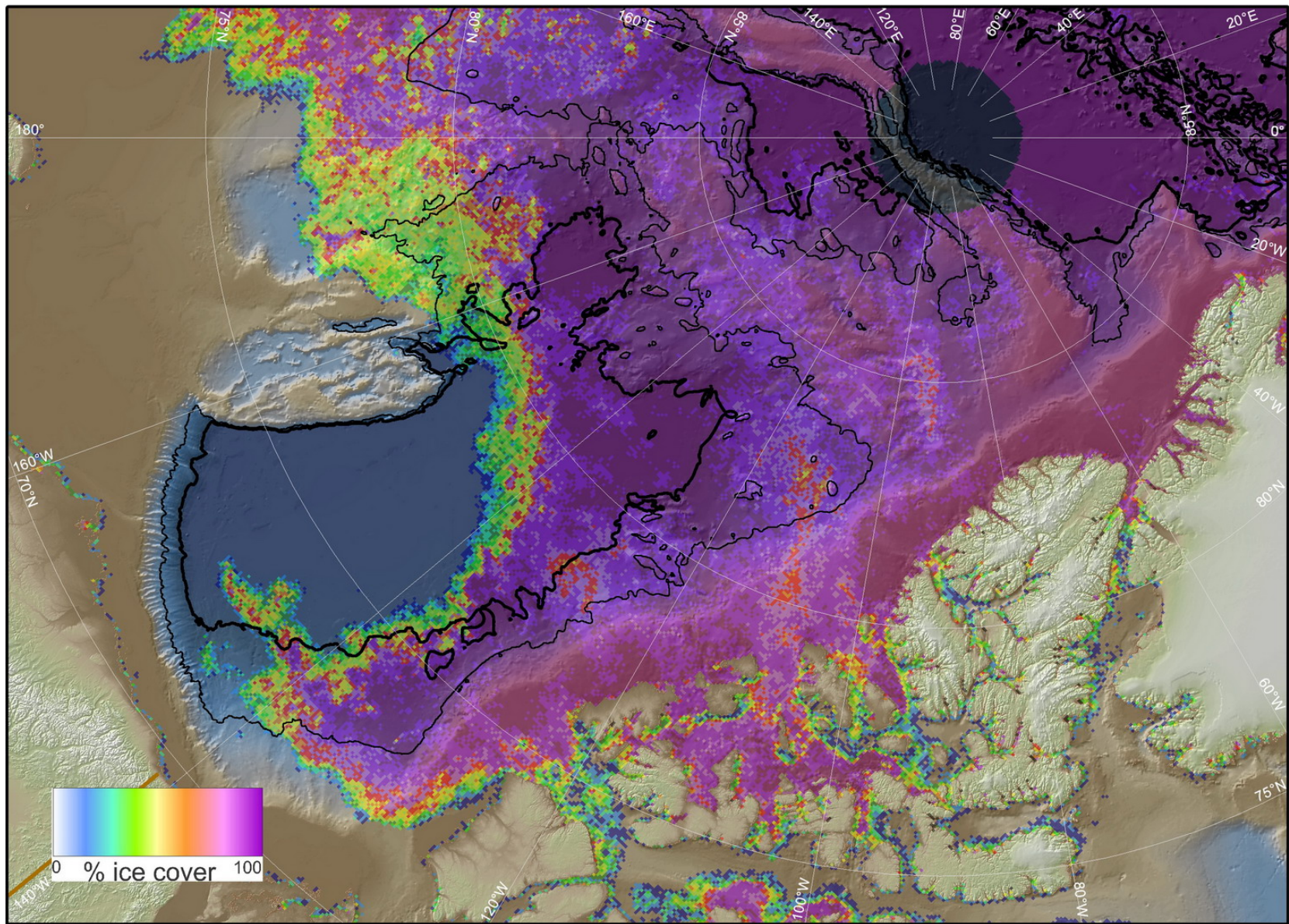




2008

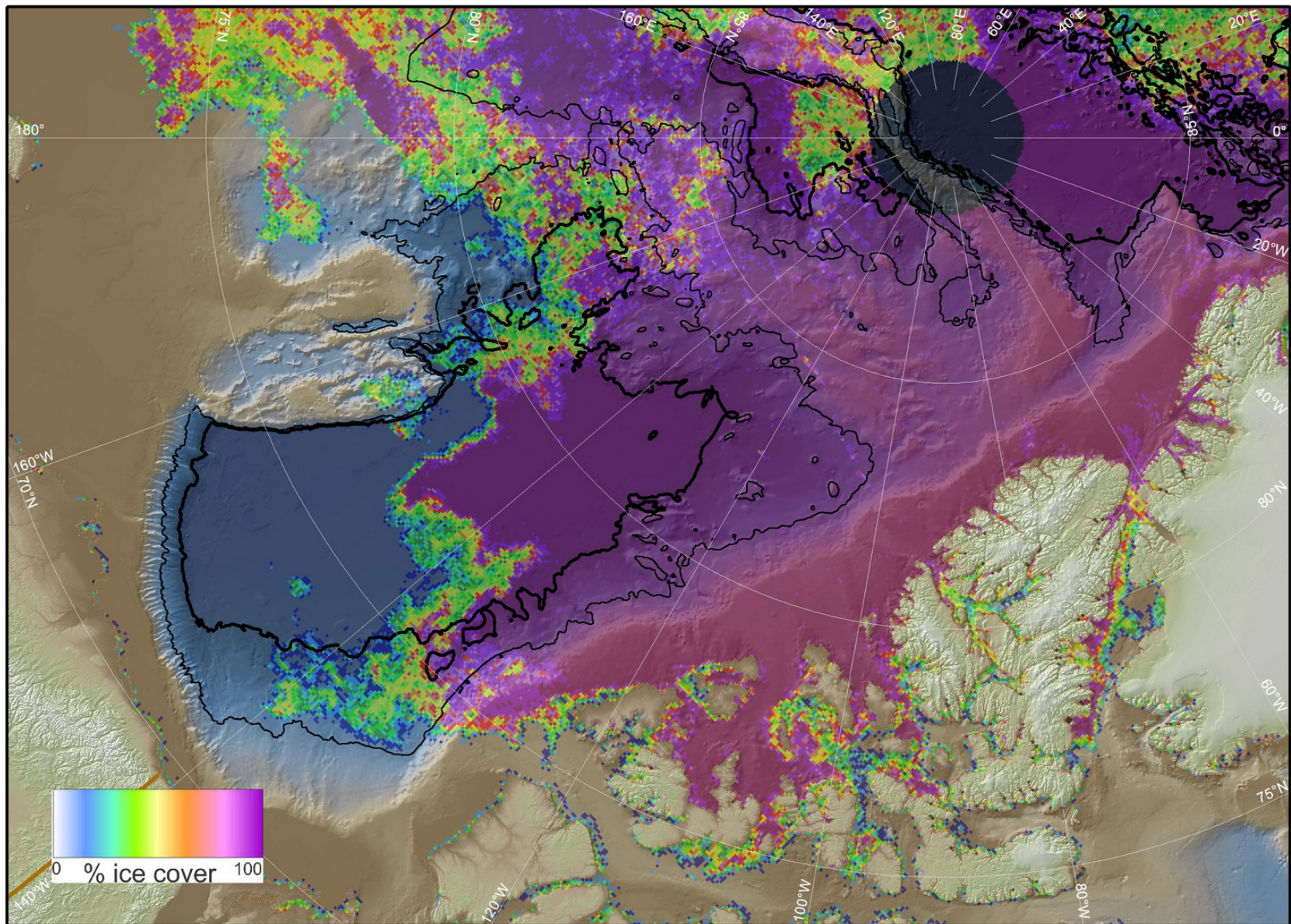




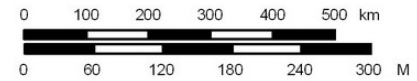


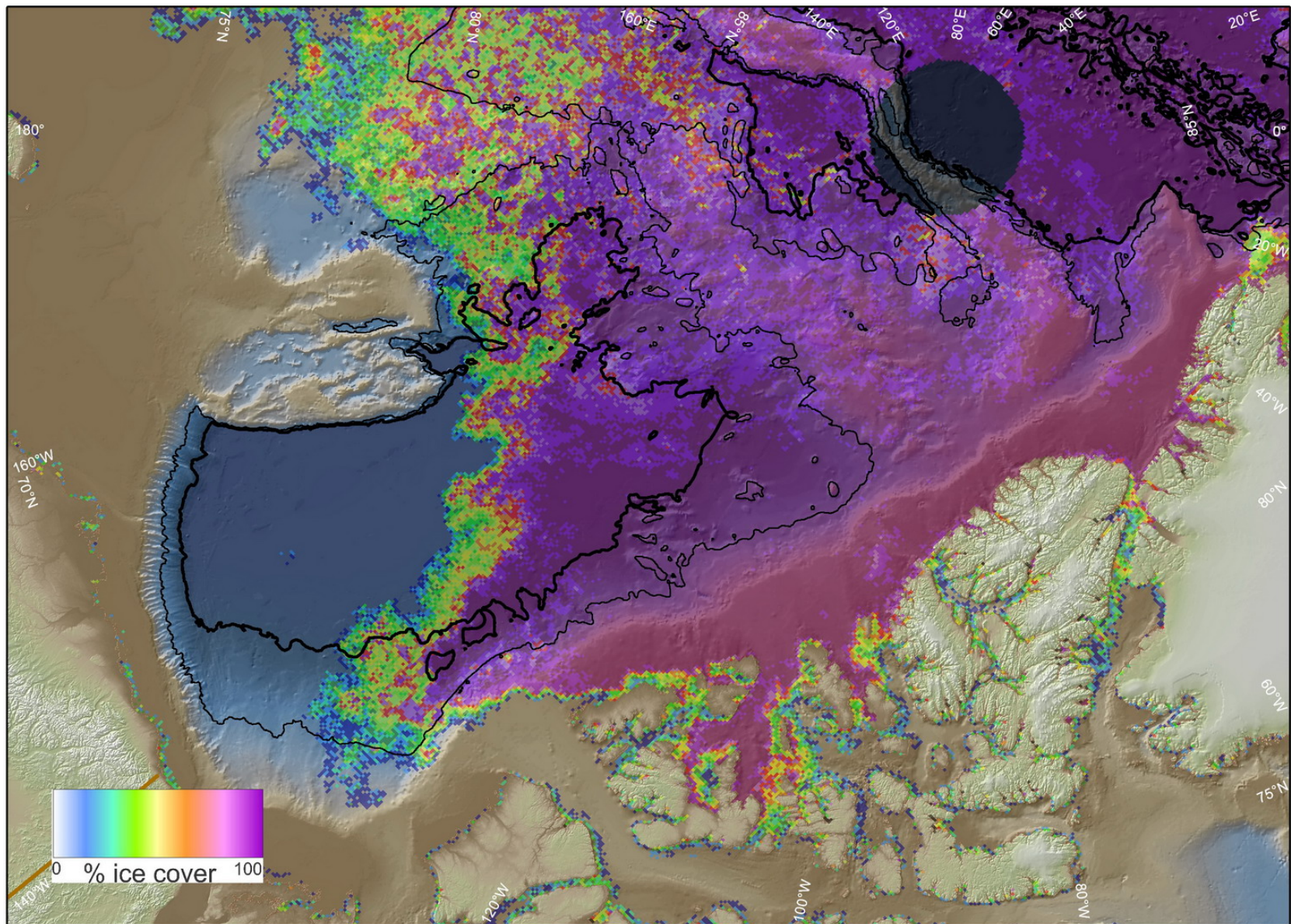
2009





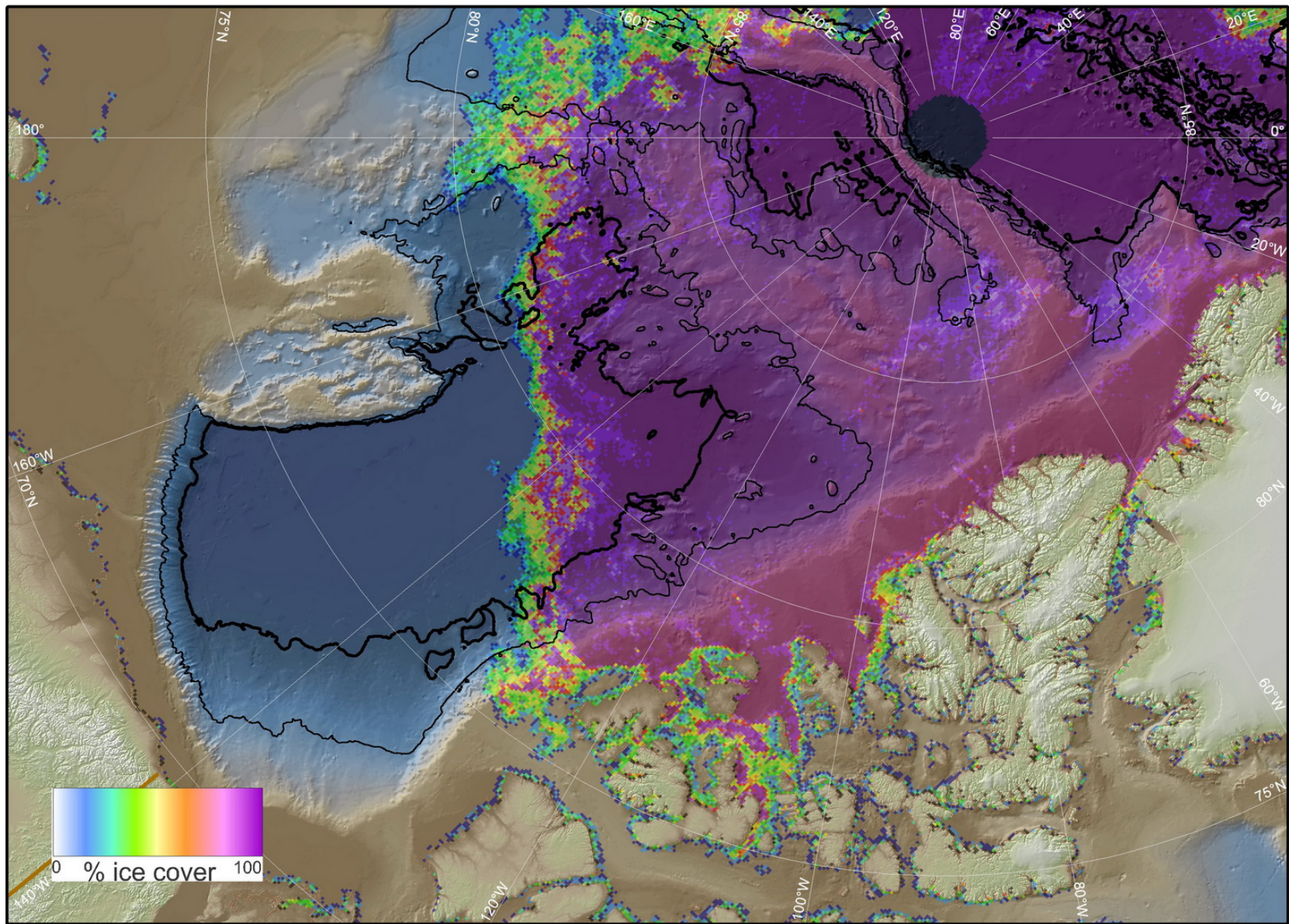
2010



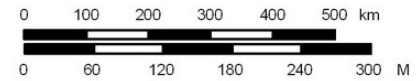


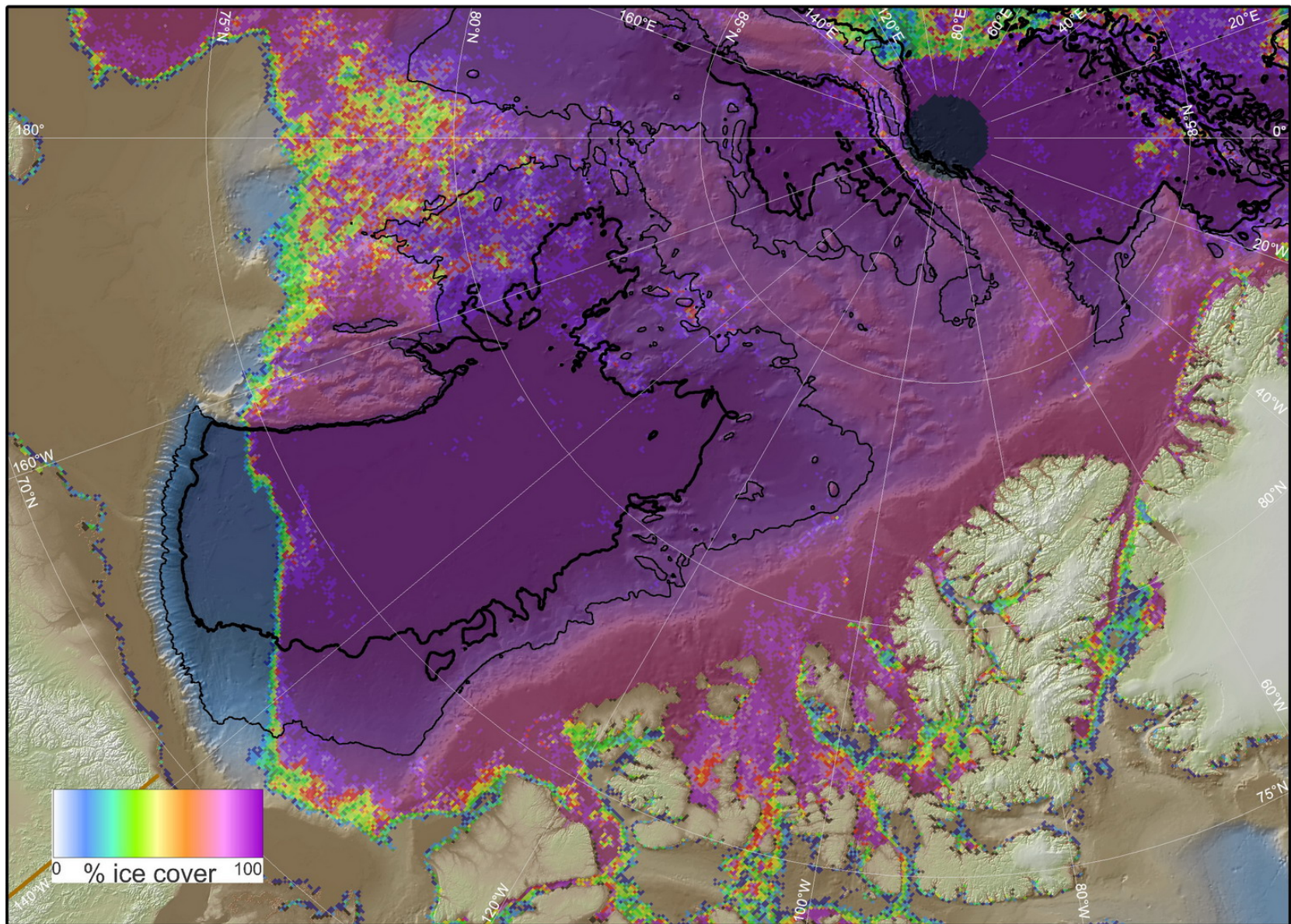
2011



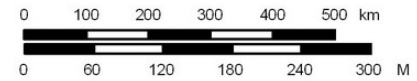


2012



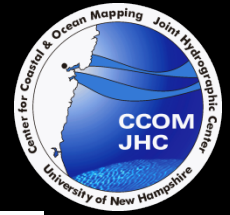


2013

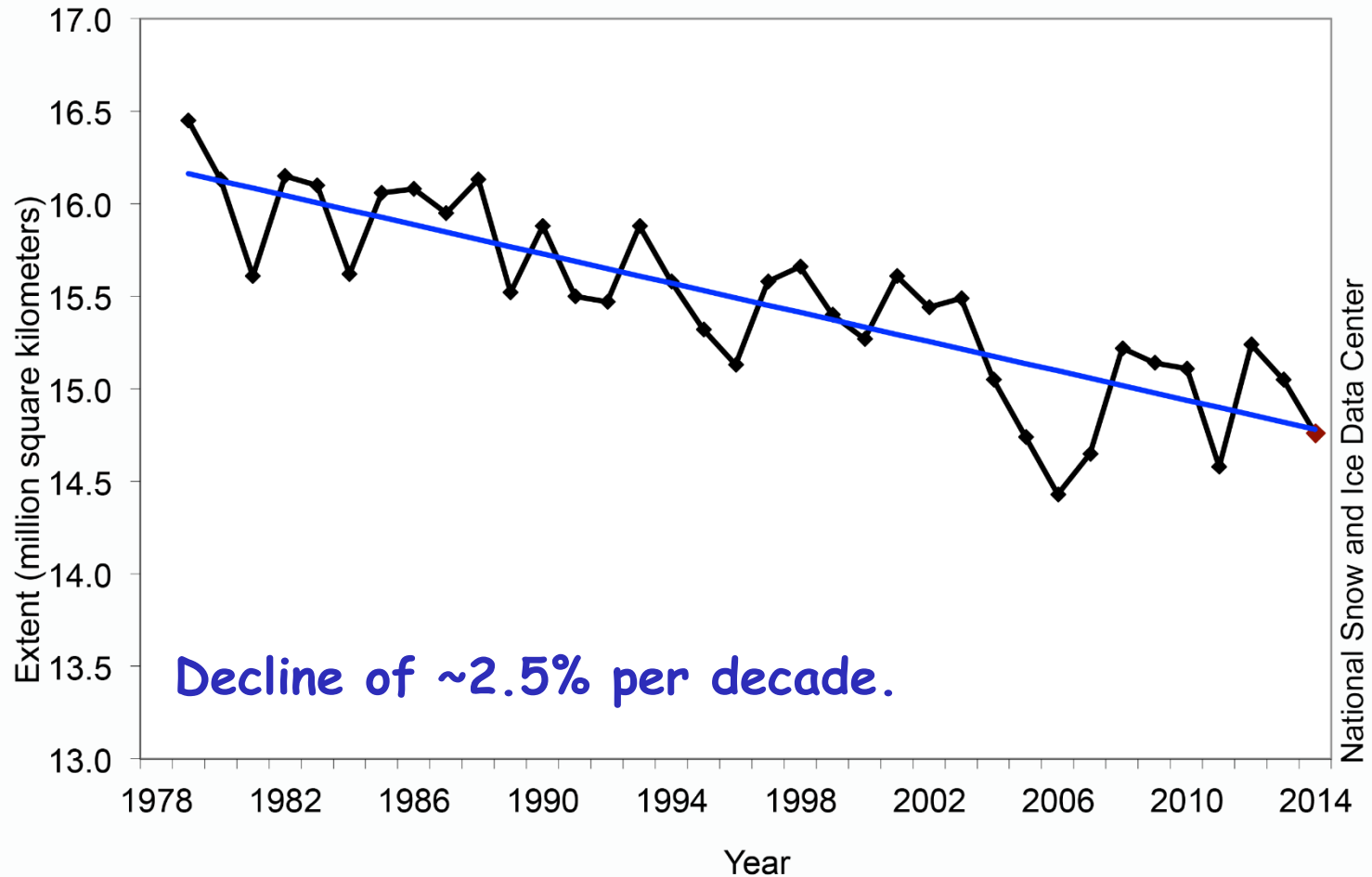




# Maximum Ice Extent - 1979-2014

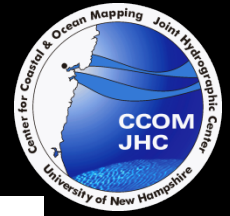


## Average Monthly Arctic Sea Ice Extent March 1979 - 2014

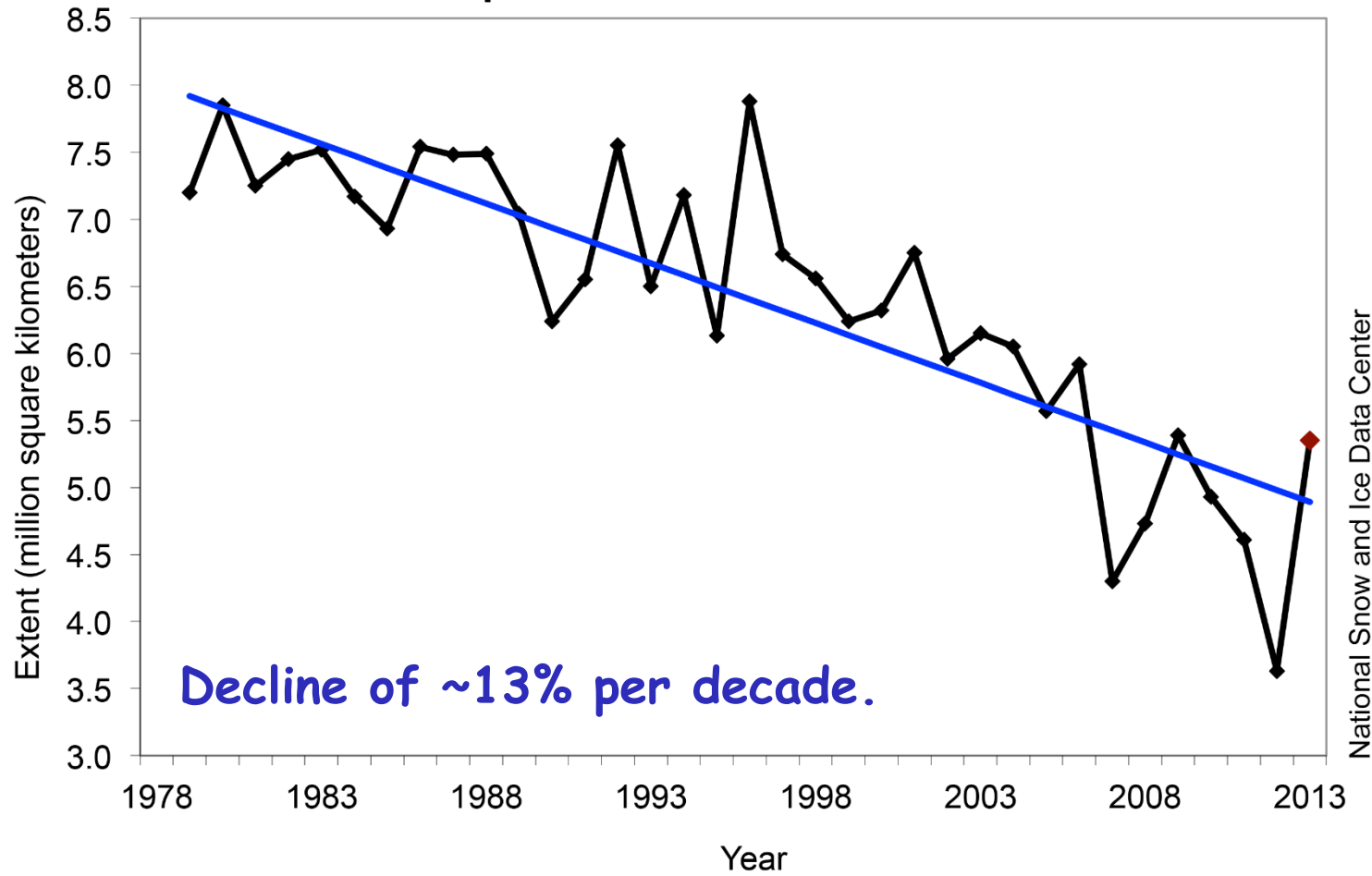




# Minimum Ice Extent - 1979-2014

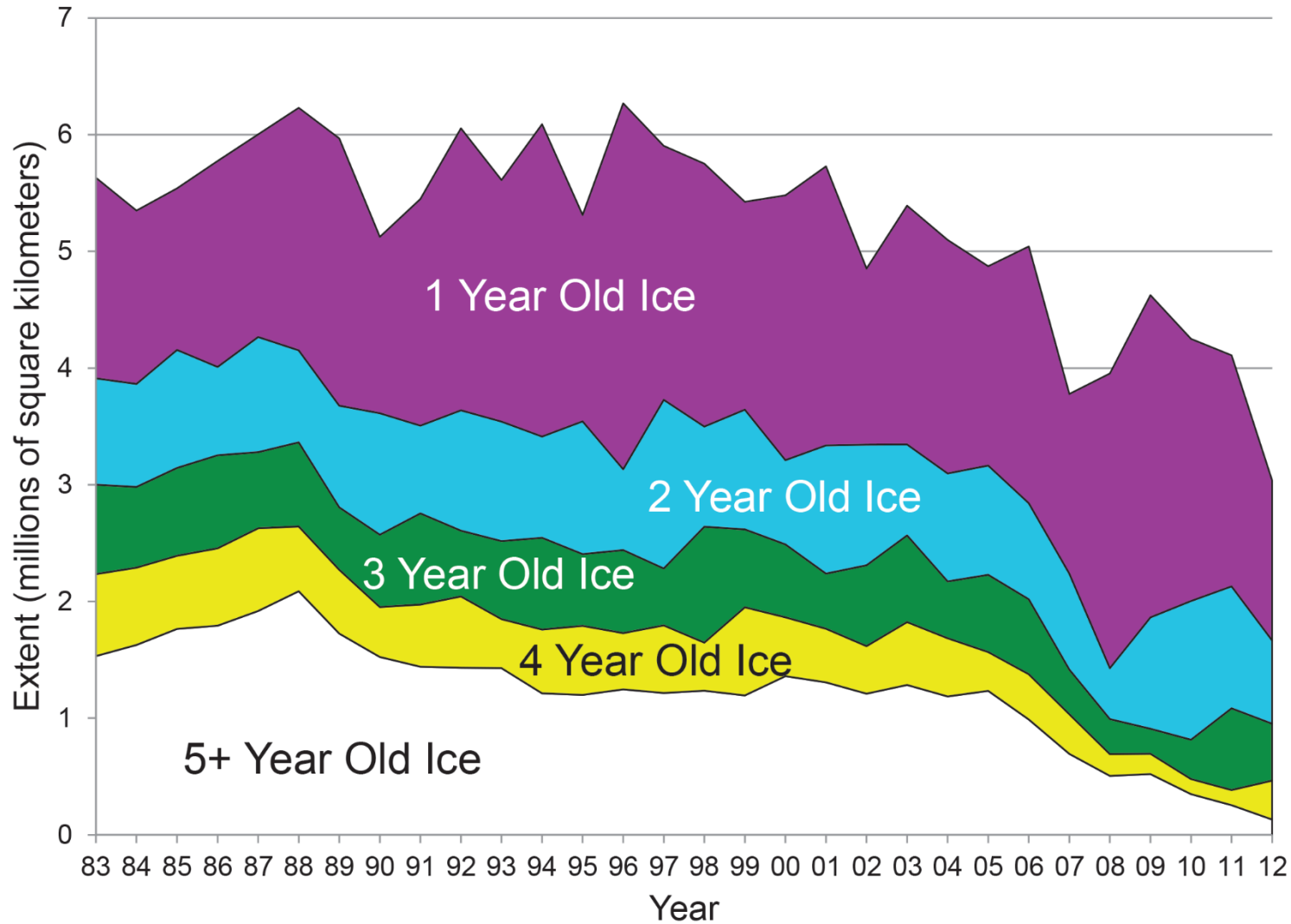
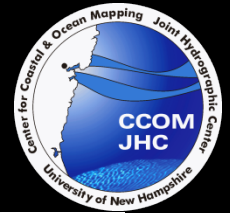


## Average Monthly Arctic Sea Ice Extent September 1979 - 2013





# Ice Thickness and Age of Ice 1983-2012

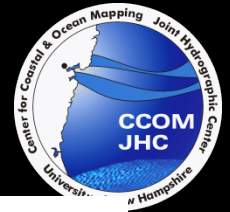


NSIDC courtesy M. Tschudi and J. Maslanik, University of Colorado Boulder

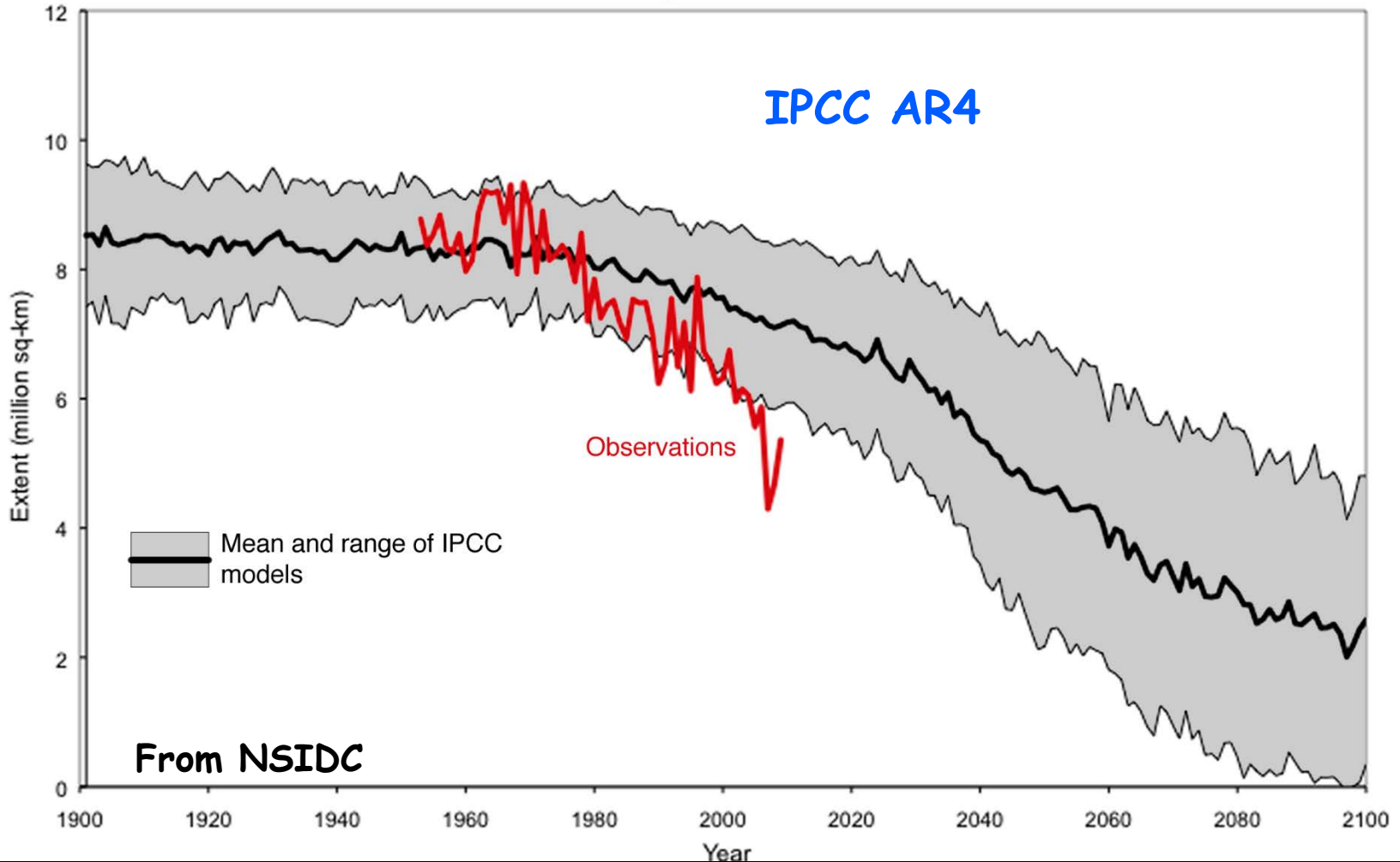




# MODELING FUTURE TREND

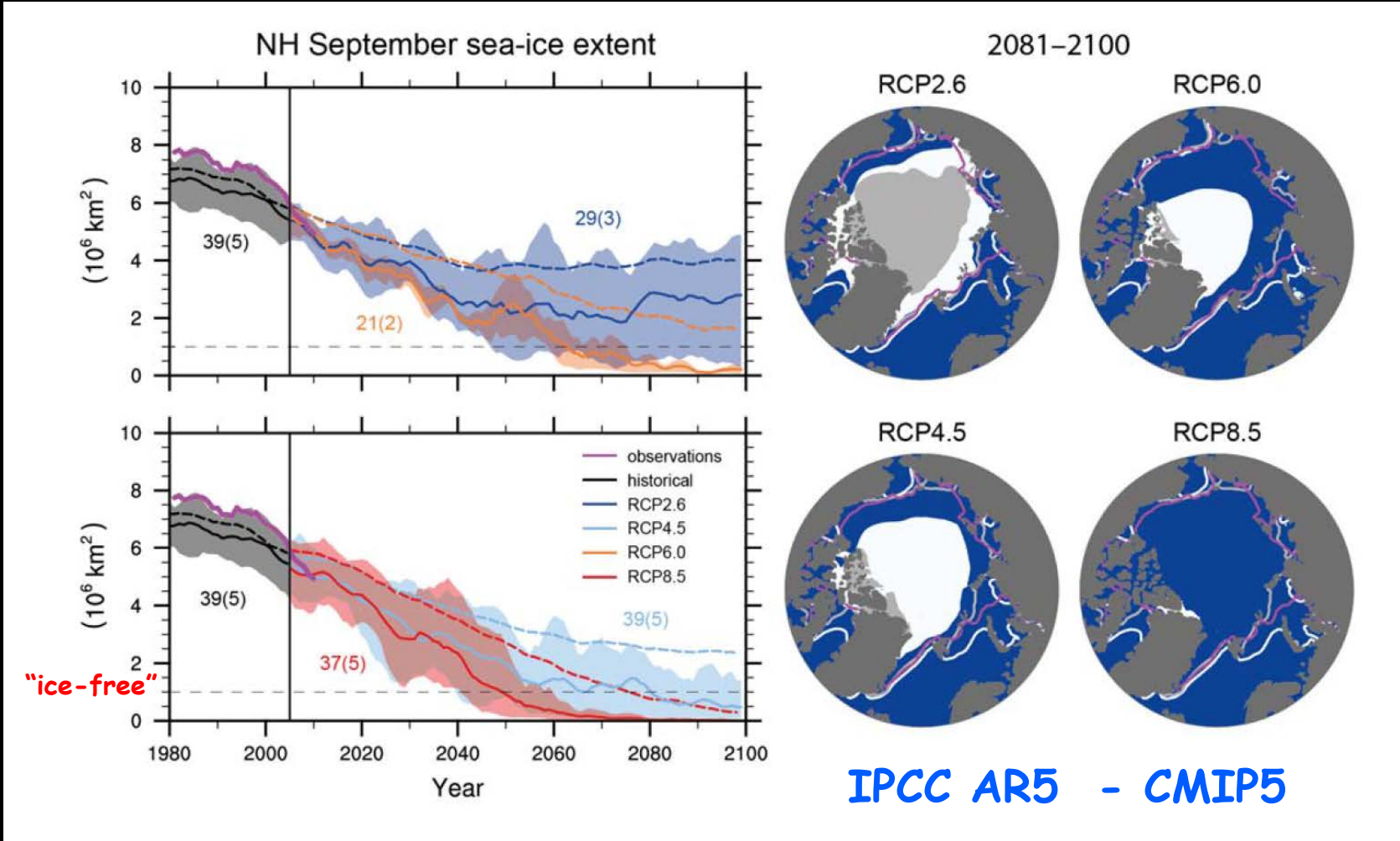
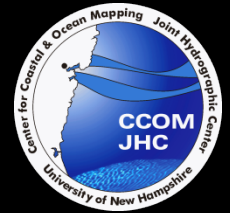


## Arctic September Ice Extent



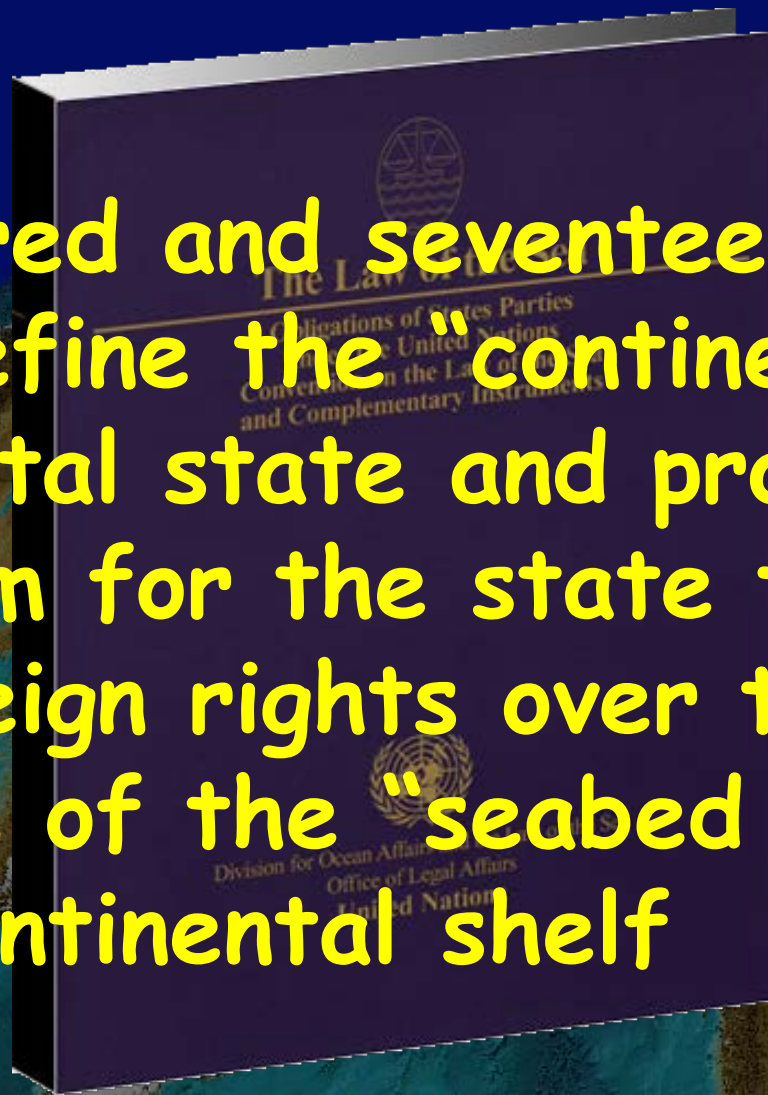


# MODELING FUTURE TREND



# 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

# Chukchi Region and Barrow Margin

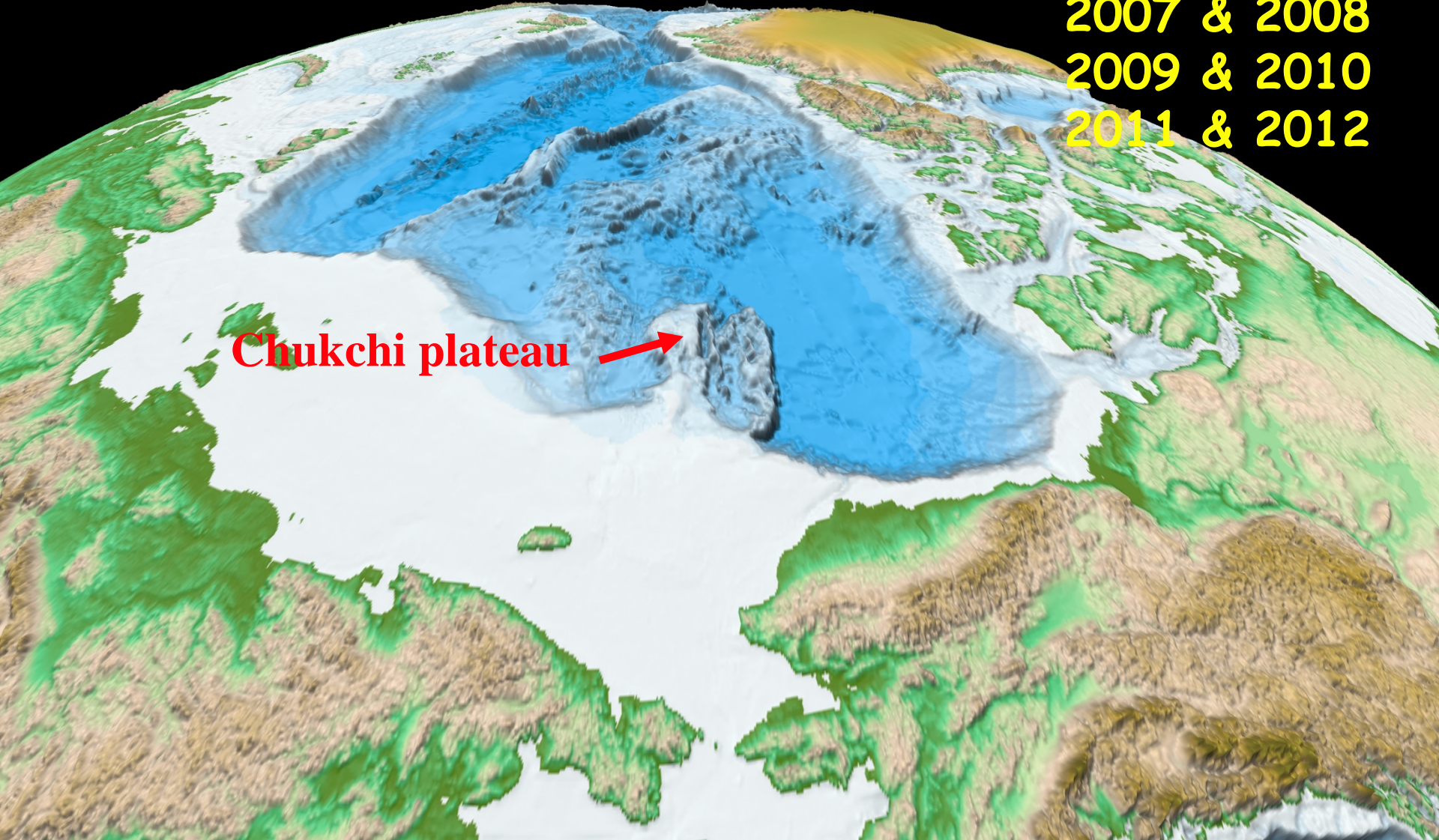
2003 & 2004

2007 & 2008

2009 & 2010

2011 & 2012

Chukchi plateau 



# History of Seafloor Mapping

Lead Line:

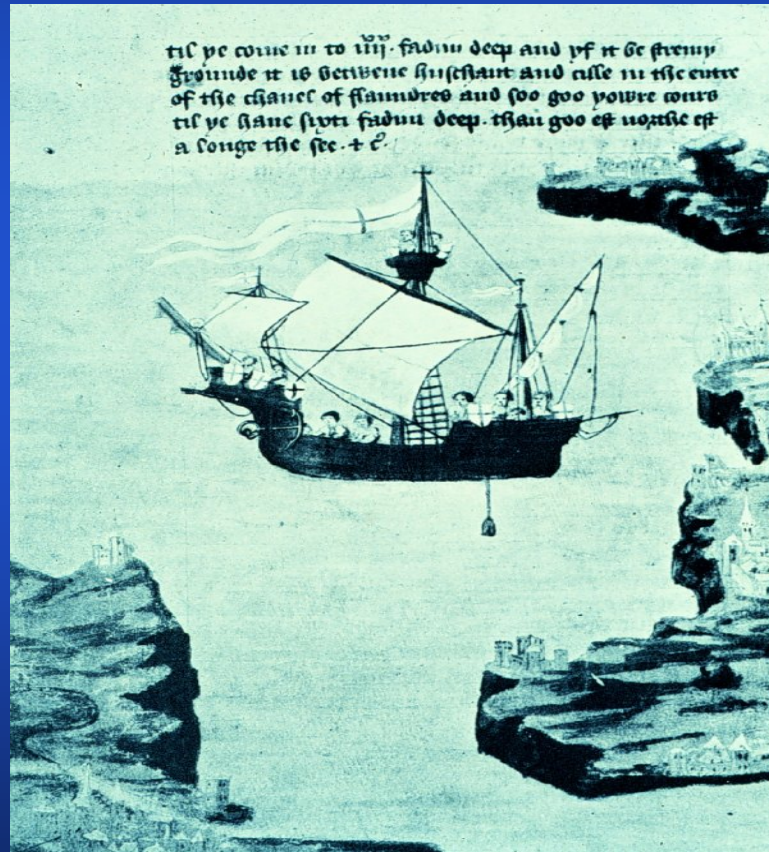


© Alfred Molon [www.molon.de](http://www.molon.de)

2000 BC

# History of Seafloor Mapping

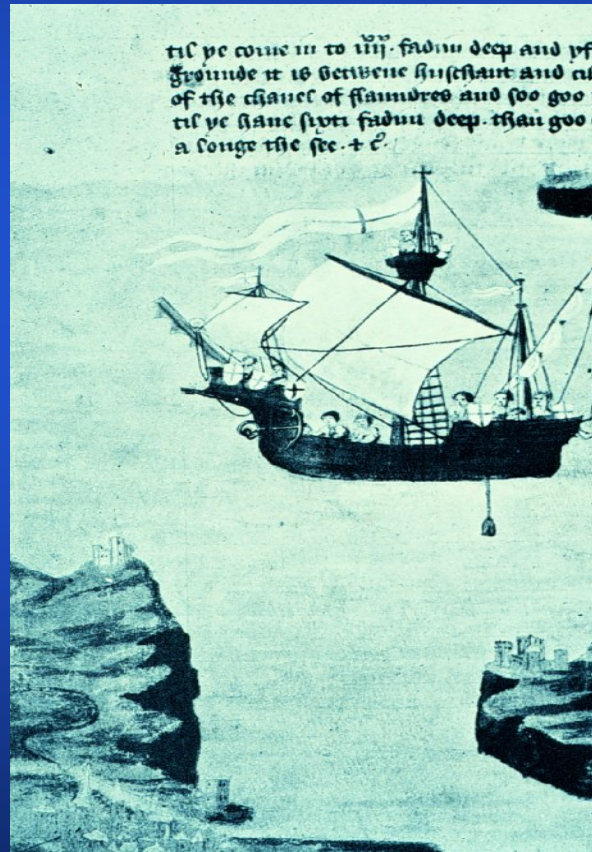
## Lead Line:



1450

# History of Seafloor Mapping

## Lead Line:



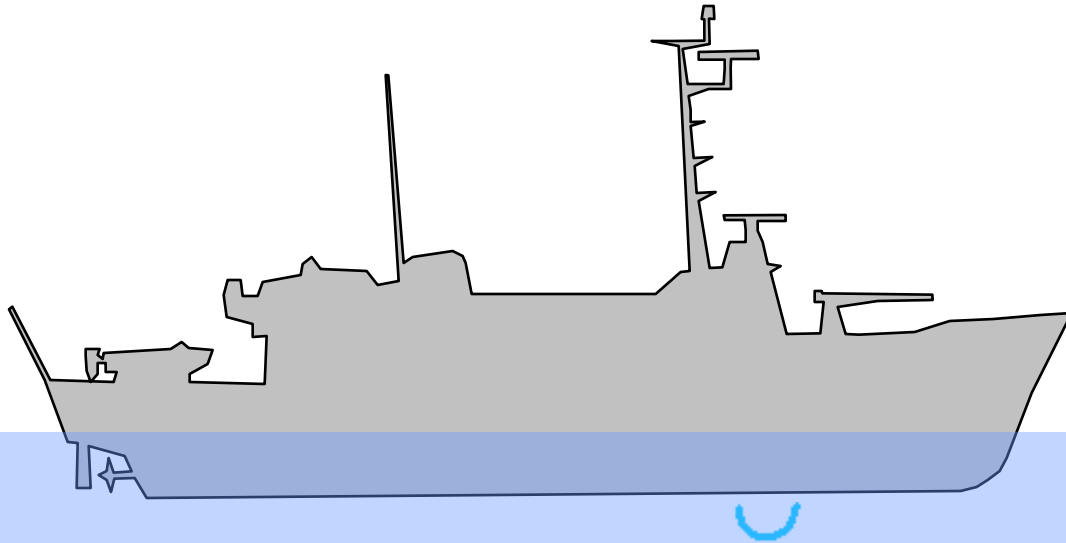
1450



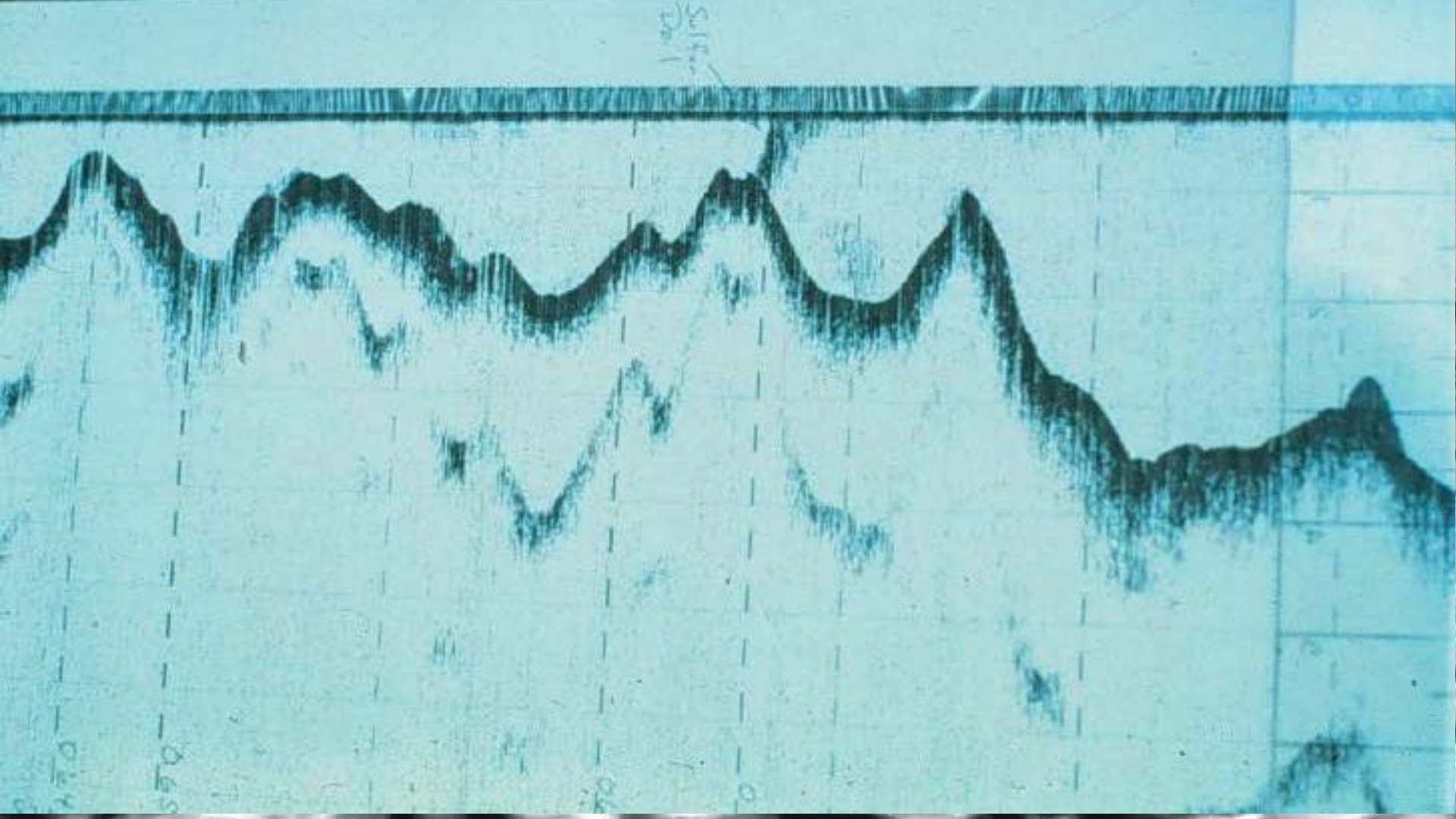
1940



# Single Beam Echo Sounder



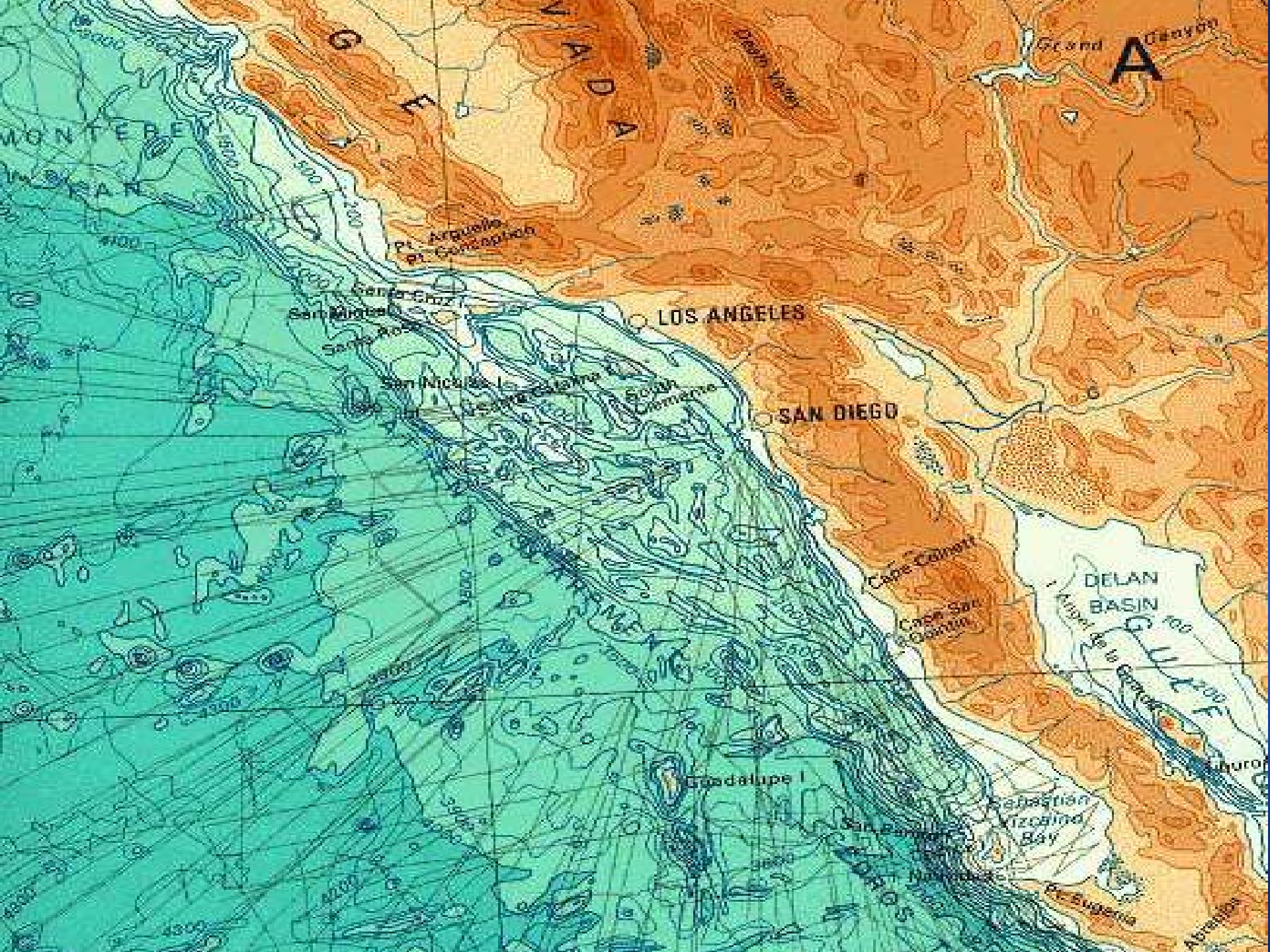
# Single Beam Echo Sounder



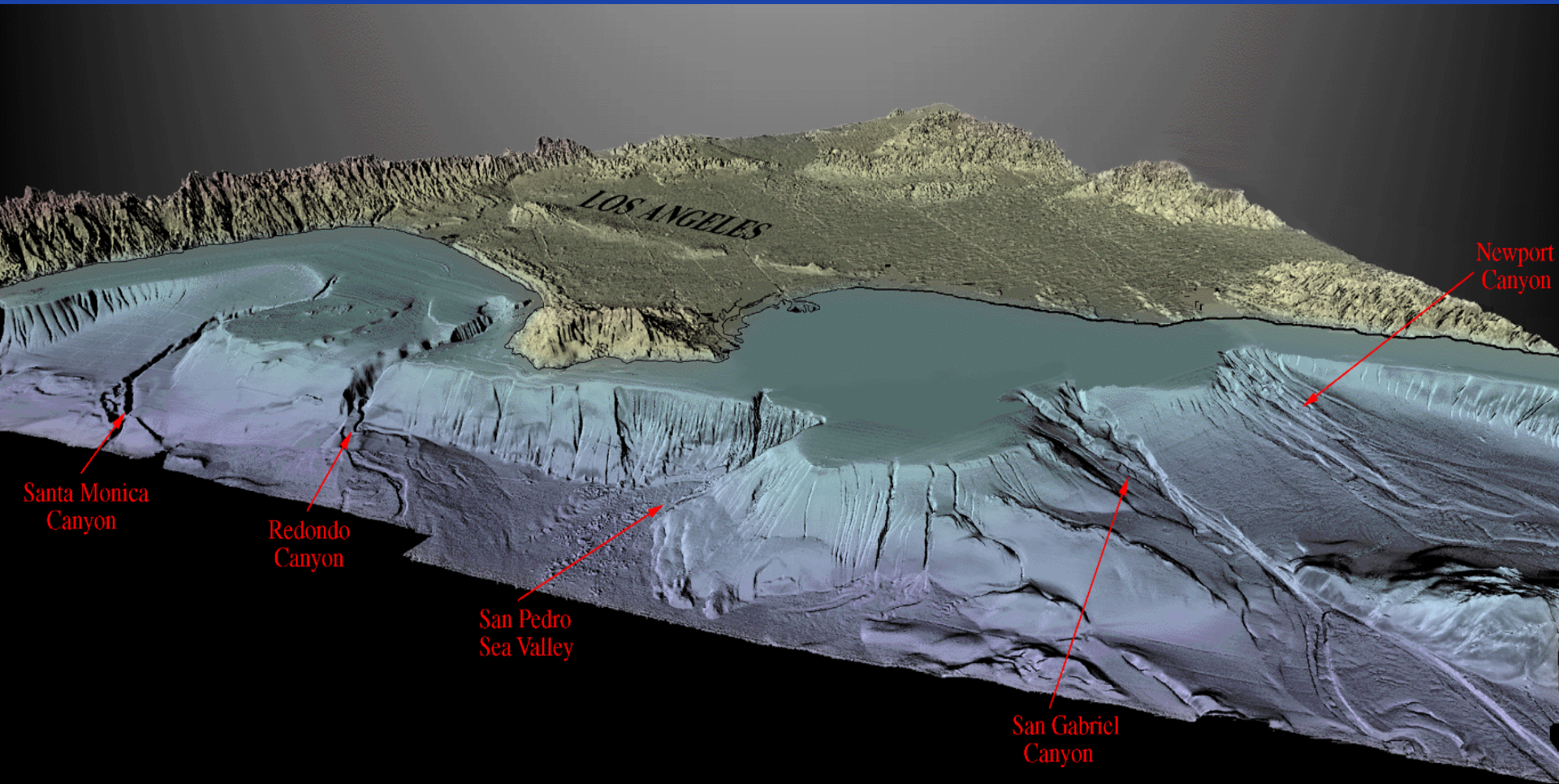
# *Multibeam Sonar*



Image from: <http://www.atlas-elektronik.de>



A new perspective → new insights  
and many new applications



To explore... to discover... to understand... to  
establish sovereign rights... WE MAP







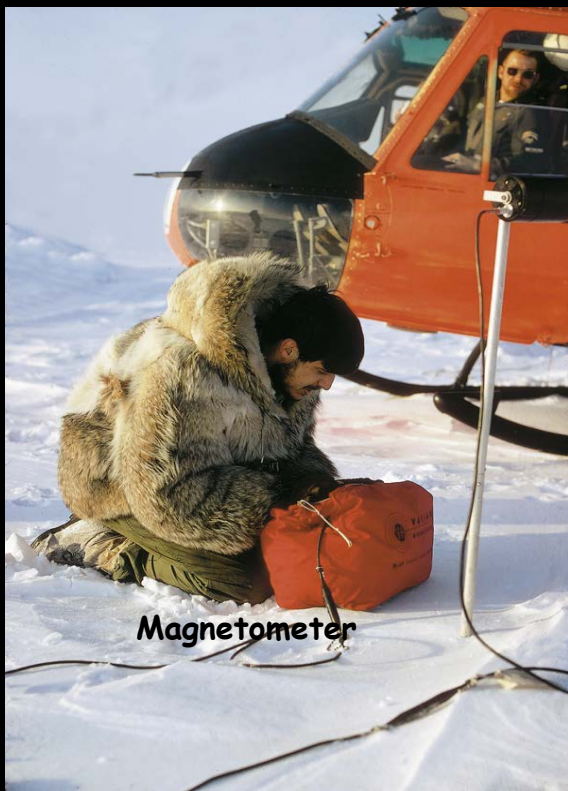
# Airborne Measurements and Point Soundings



From Geoterrex (tm) advertising flyer.



Gravity Measurement



Magnetometer



Depth Sounding







# Fletcher's Ice Island (T-3)

1962 - 1974

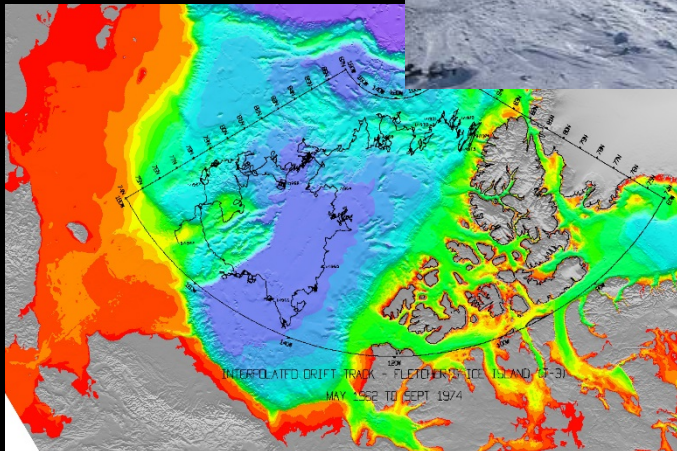
LOREX - 1979



Hydro-Hole



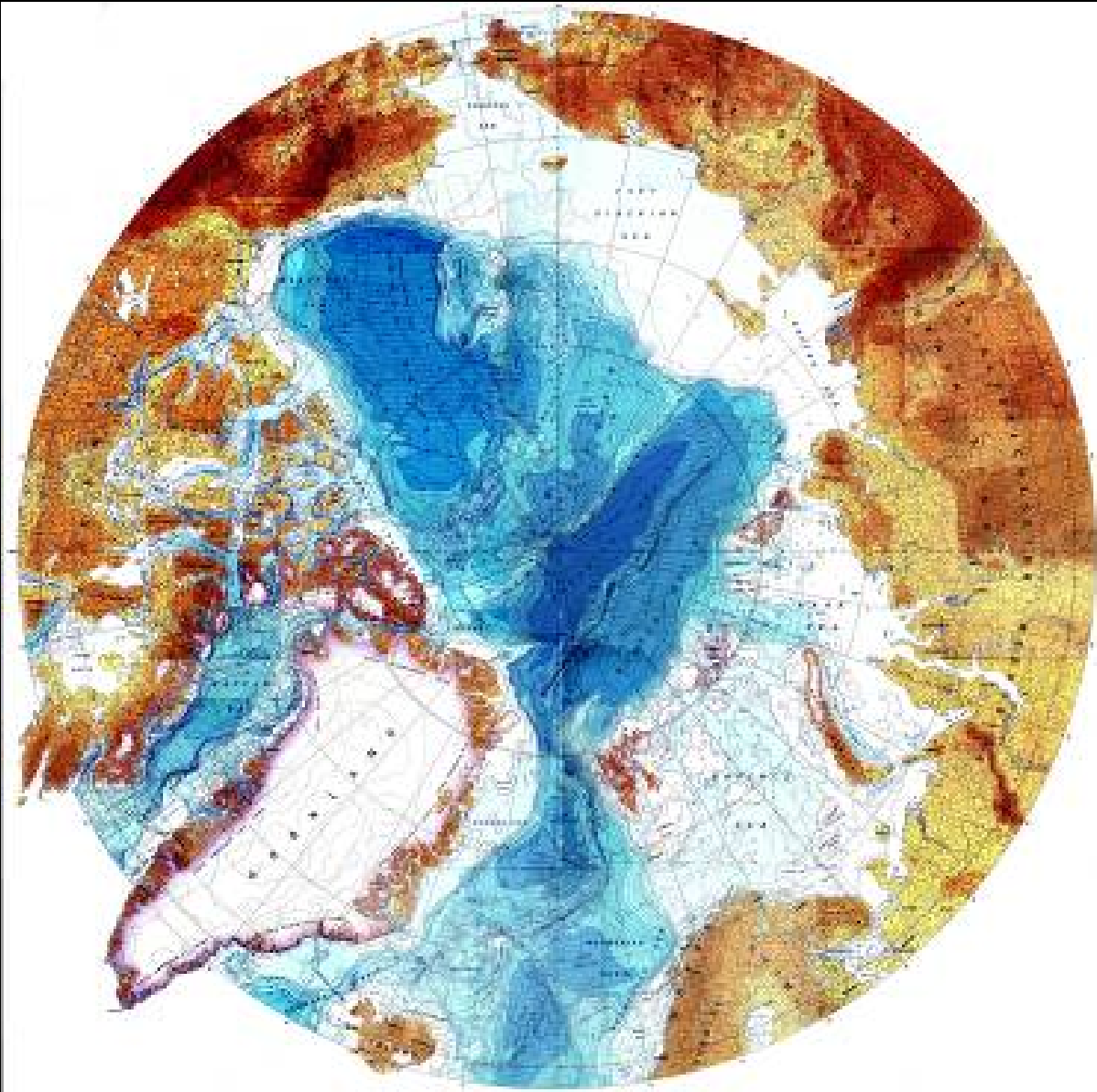
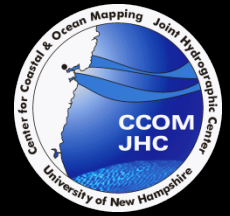
Echo sounder



Positioning

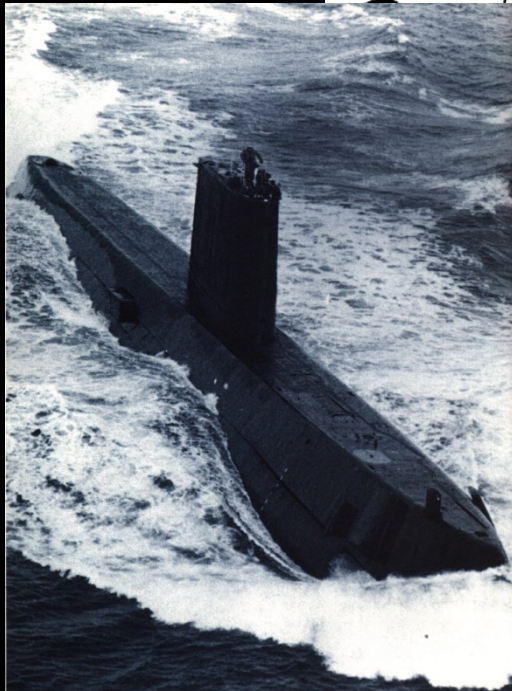
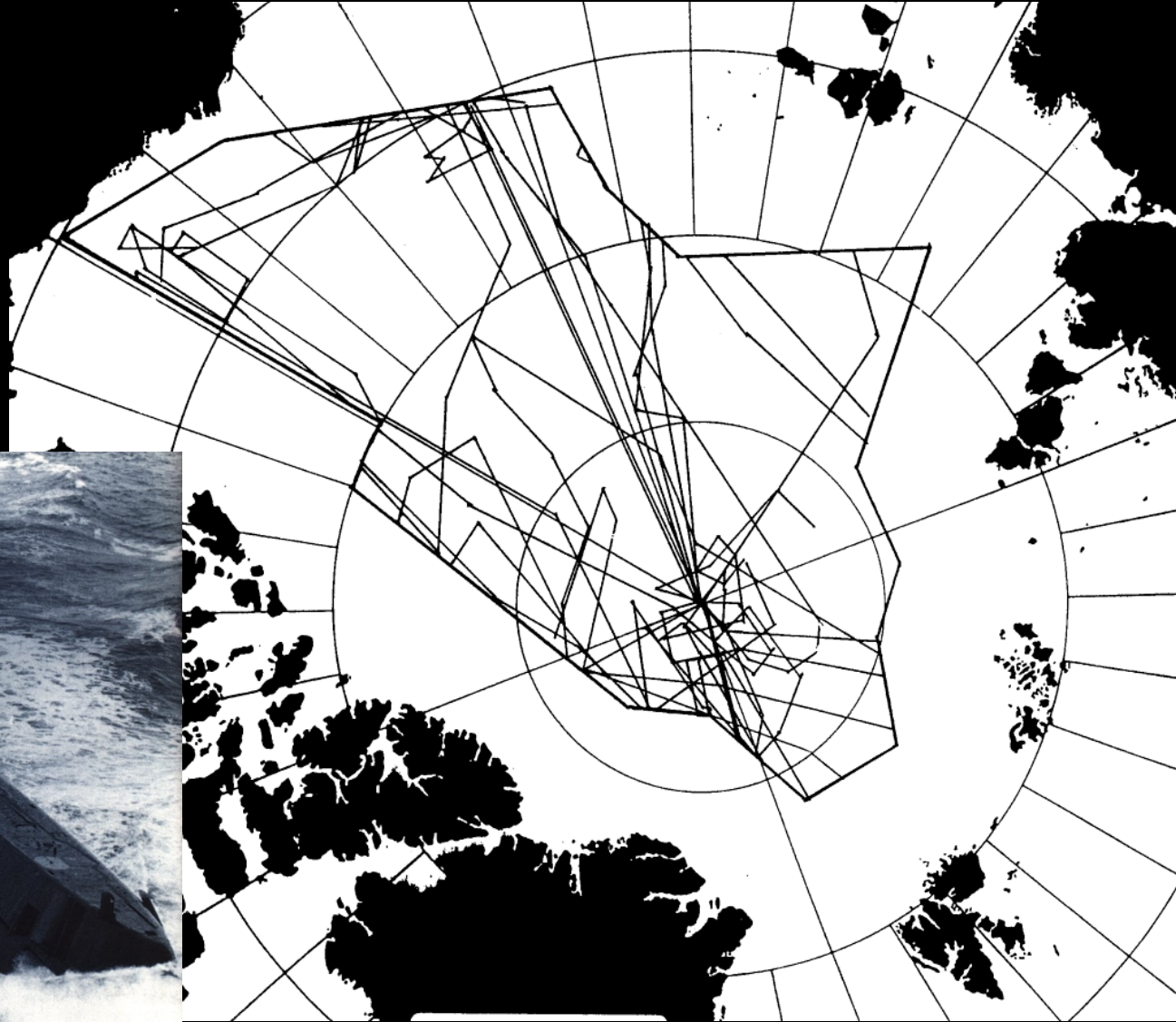


# CHS & GEBCO (1967, 1968, 1979)





# Data from Nuclear Submarines



**Sounding tracks of US Navy submarines from 1983 to 1988  
(from Bob Anderson via NGDC).**

# 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

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backing and ramming

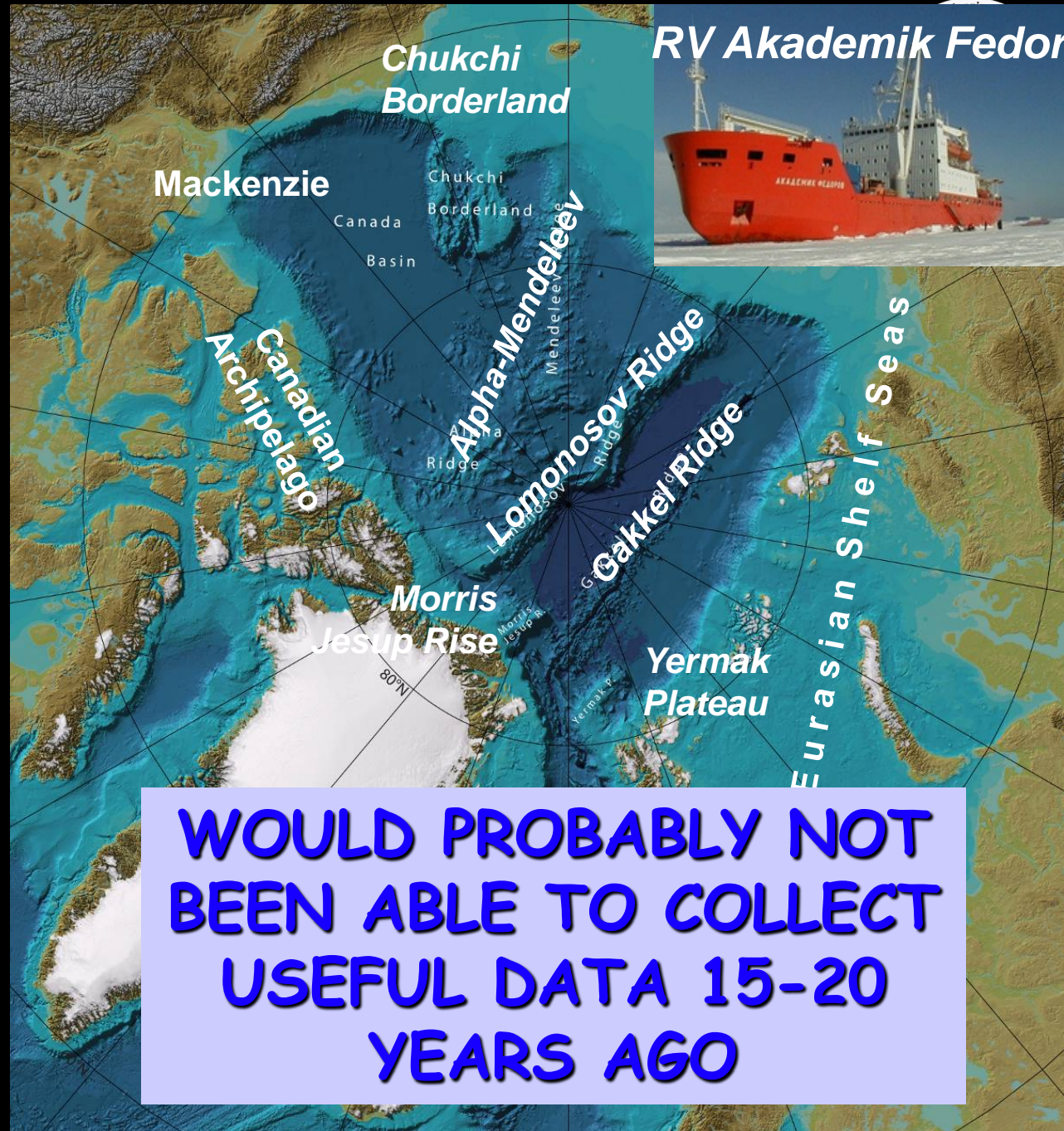
Accommodations = 19 Officer, 12 CPO,  
54 enlisted, 35 (+15) scientists

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

# Map beam mapping

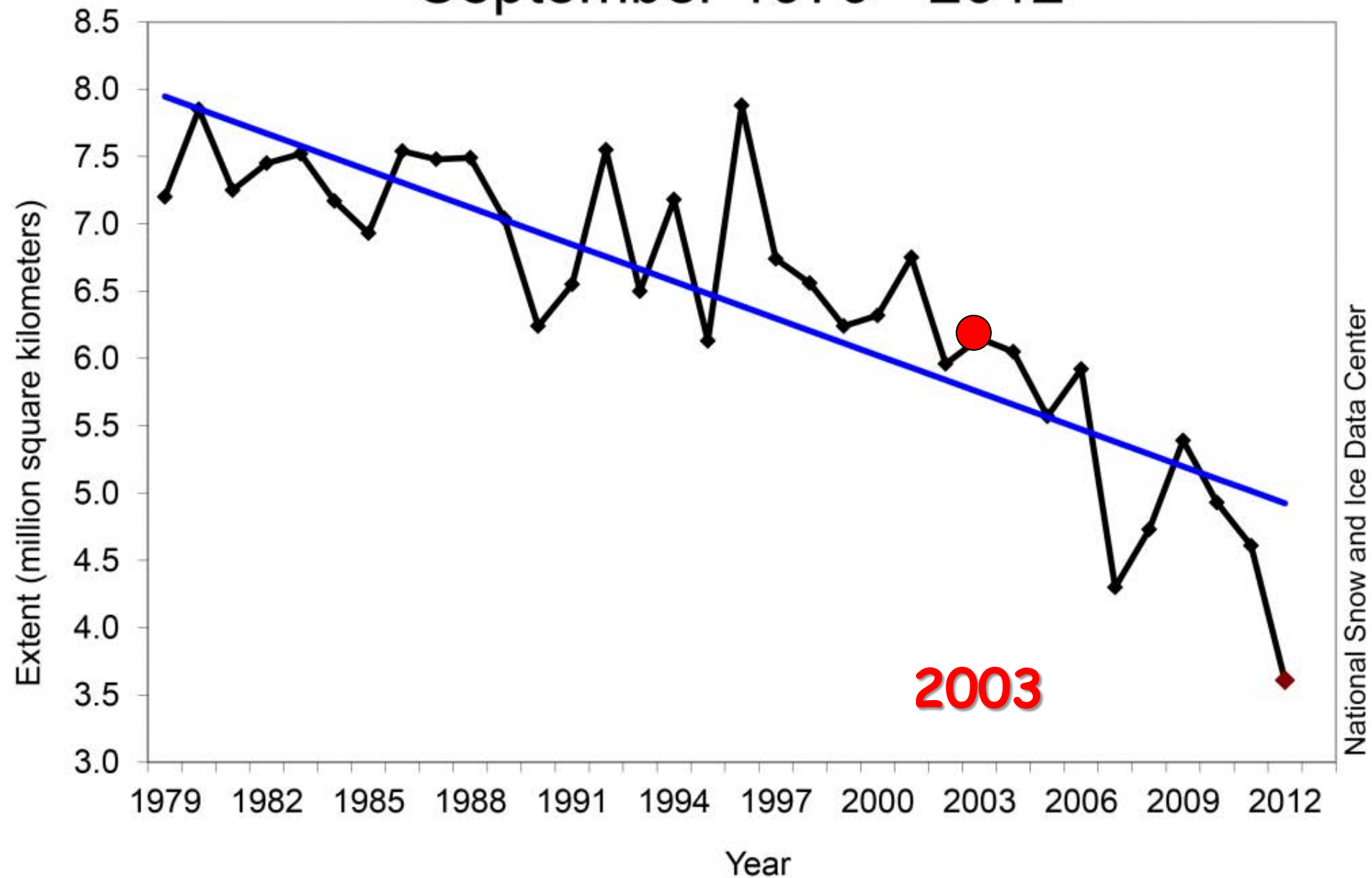


# RV Akademik Fedoro



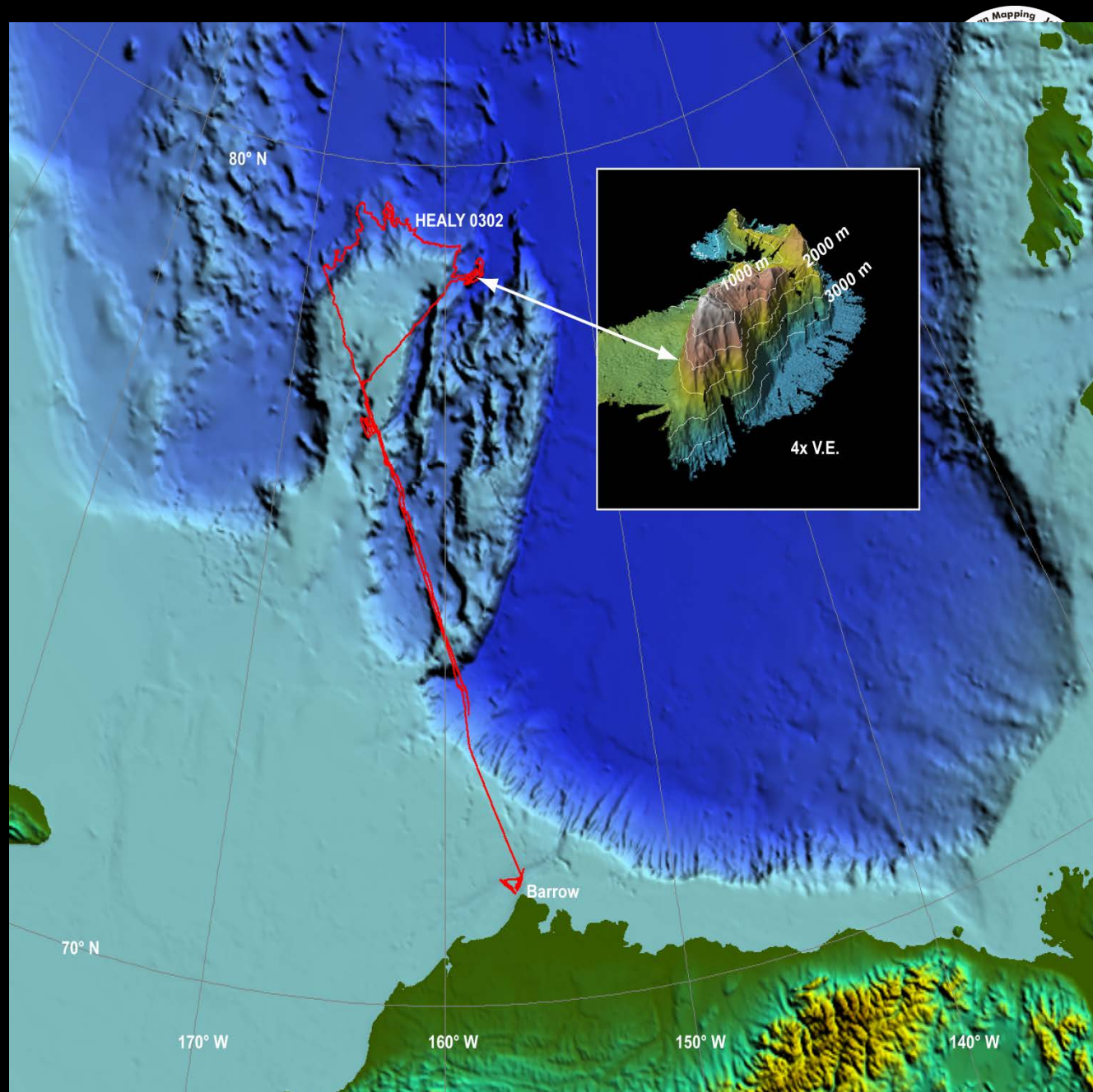
**WOULD PROBABLY NOT  
BEEN ABLE TO COLLECT  
USEFUL DATA 15-20  
YEARS AGO**

# Average Monthly Arctic Sea Ice Extent September 1979 - 2012





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



typical ice conditions  
2003  
8/10 "cheesy" first year ice







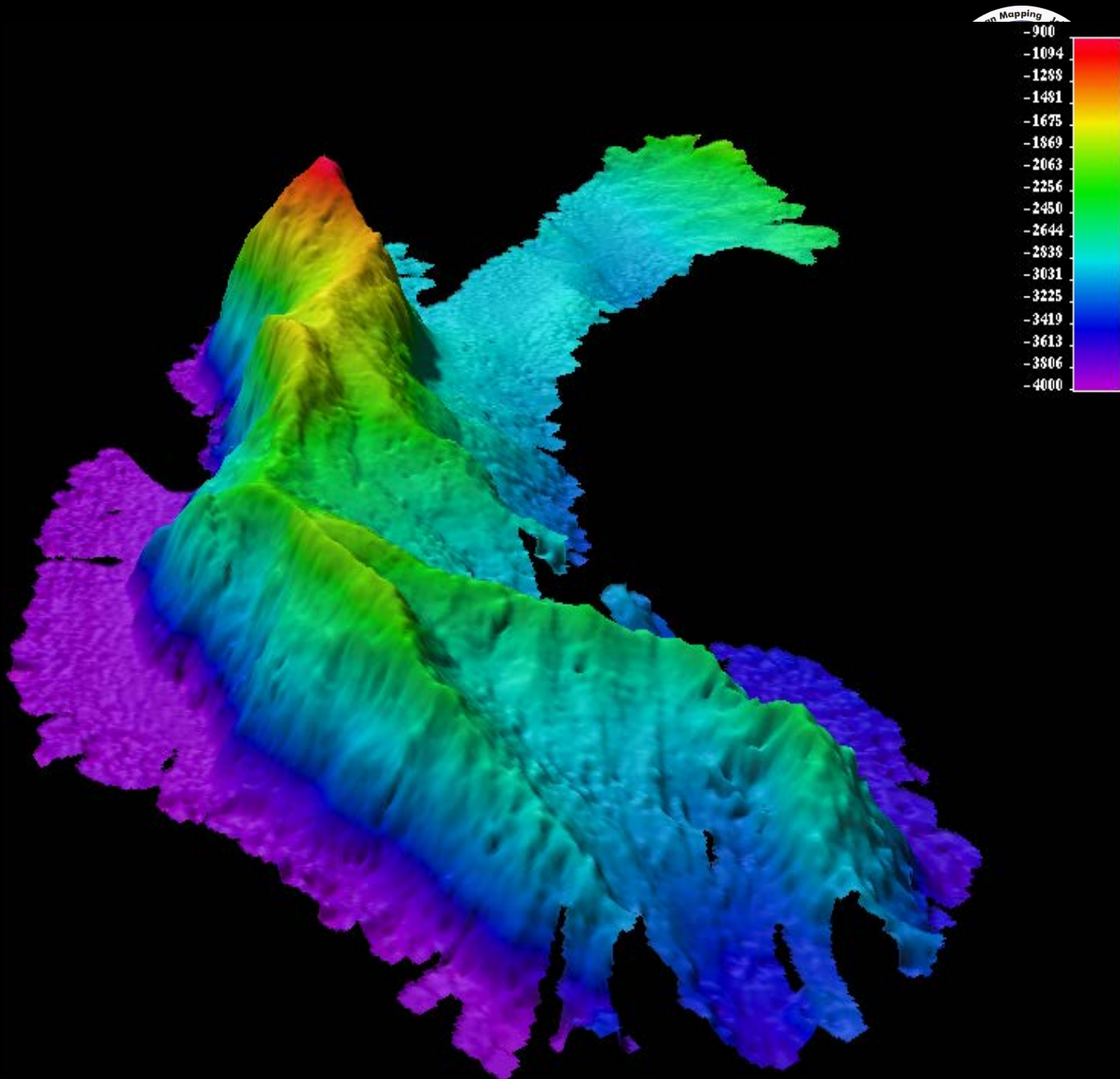
**Healy 03-02**

**~3000 km of  
multibeam  
sonar  
bathymetry**

**1-11 Sept 03**

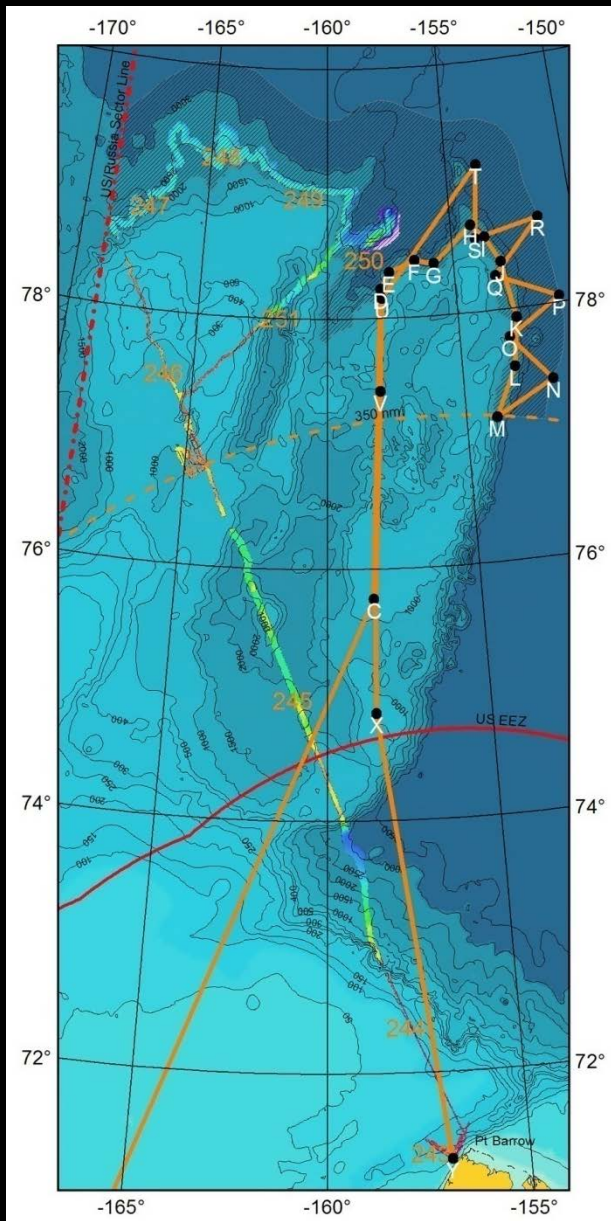
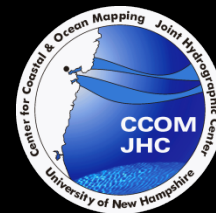
**8/10 ice**

**Discovery of  
3100 m high  
uncharted  
seamount!**

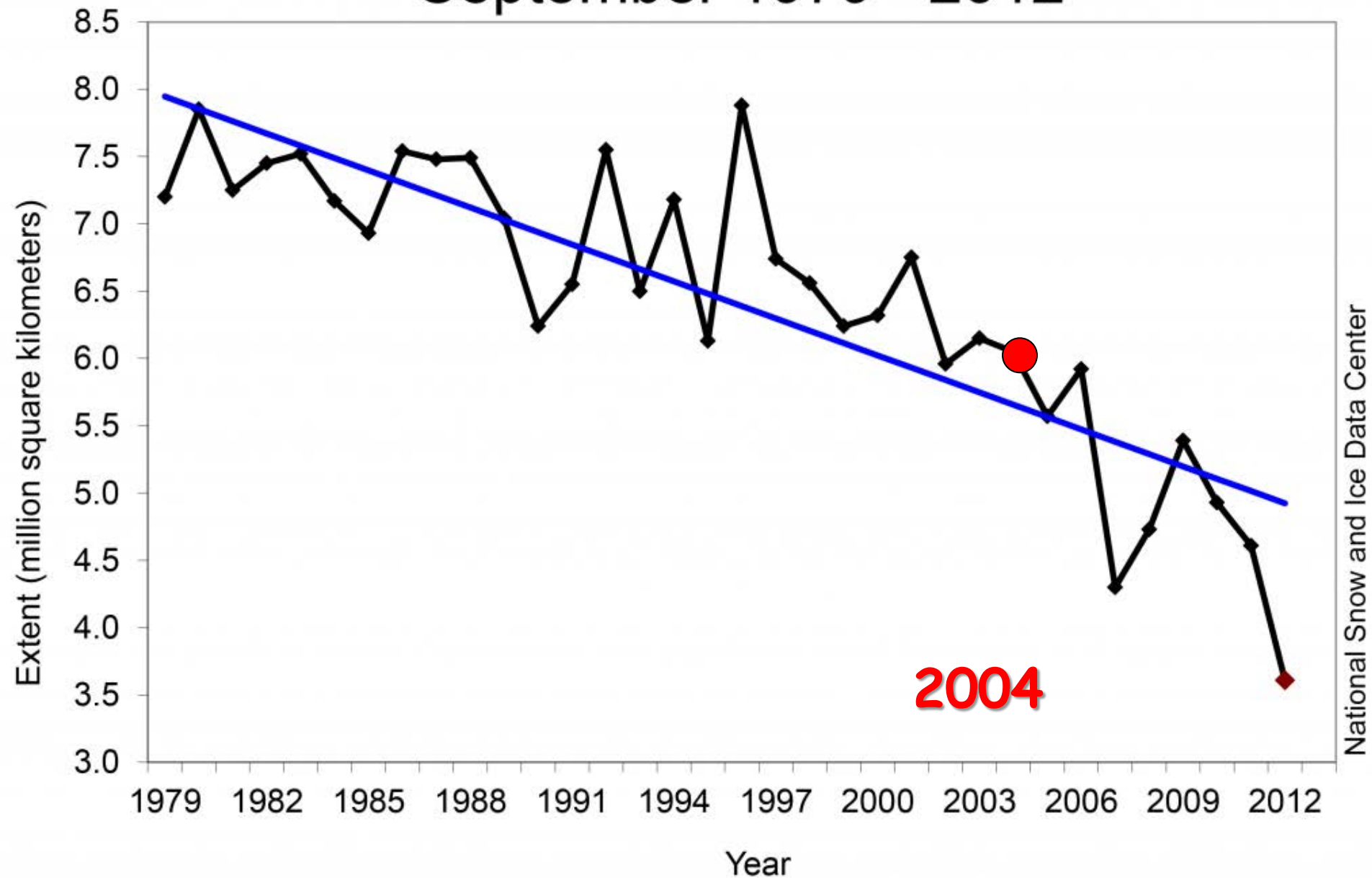




# HEALY 2004 - Plan



# Average Monthly Arctic Sea Ice Extent September 1979 - 2012



National / Naval Ice center  
USCGC Healy  
RADARSAT Image  
10 Oct 04 0346Z  
Analyst: AC1(AW) Lilgreen

**2004**

**Chukchi plateau**

162W

158W

154W

A = 9-10 MY  
B = 5-7 YRCHREW  
C = 7-9 YRCHREW  
D = 5-7 REW  
E = 0-1 REW

*Healy*



A

B

B

C

D

E

sea ice front



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



HEALY  
04-05  
TRACK

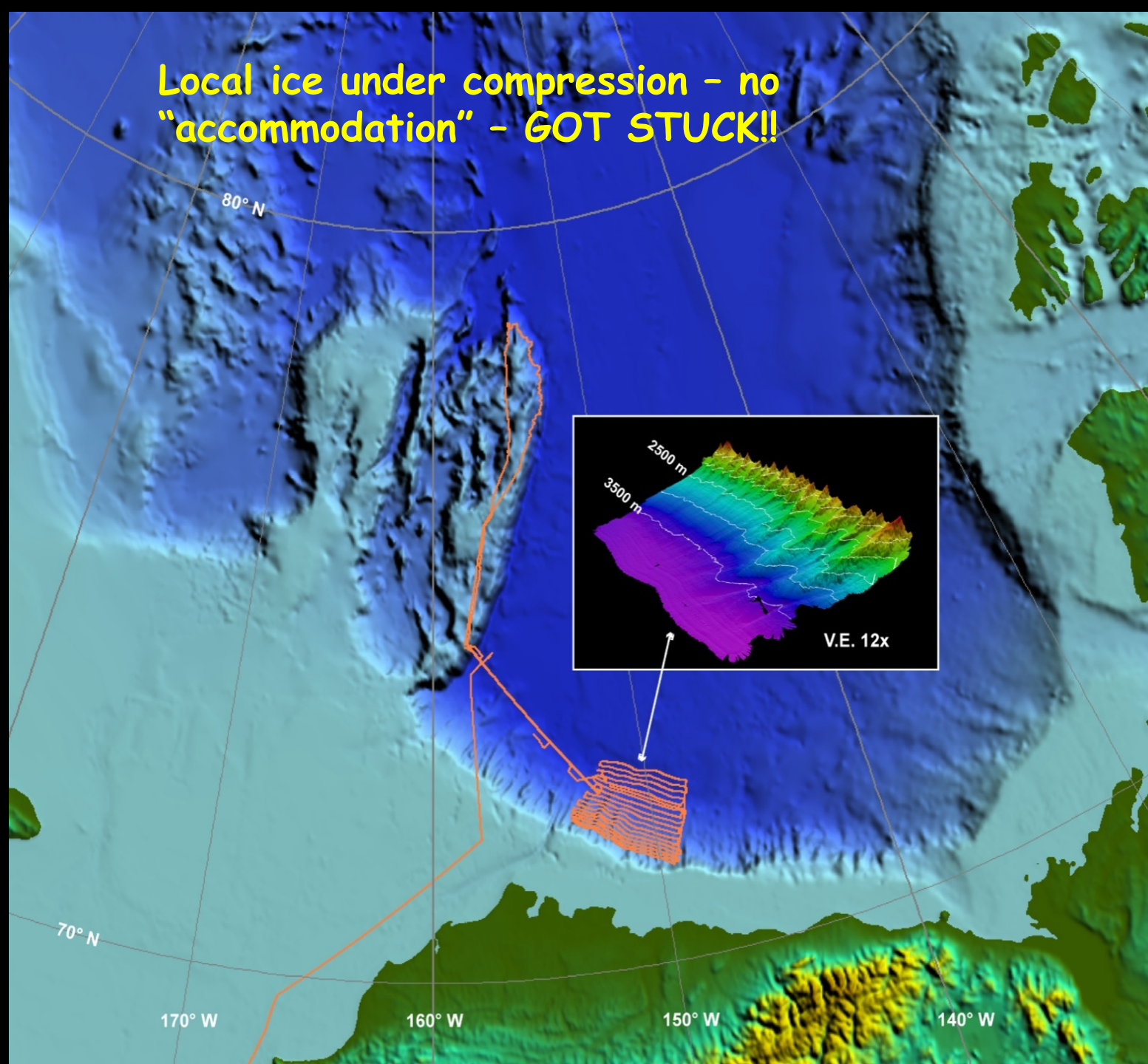
6-26 Oct.  
2004

6700 line  
km

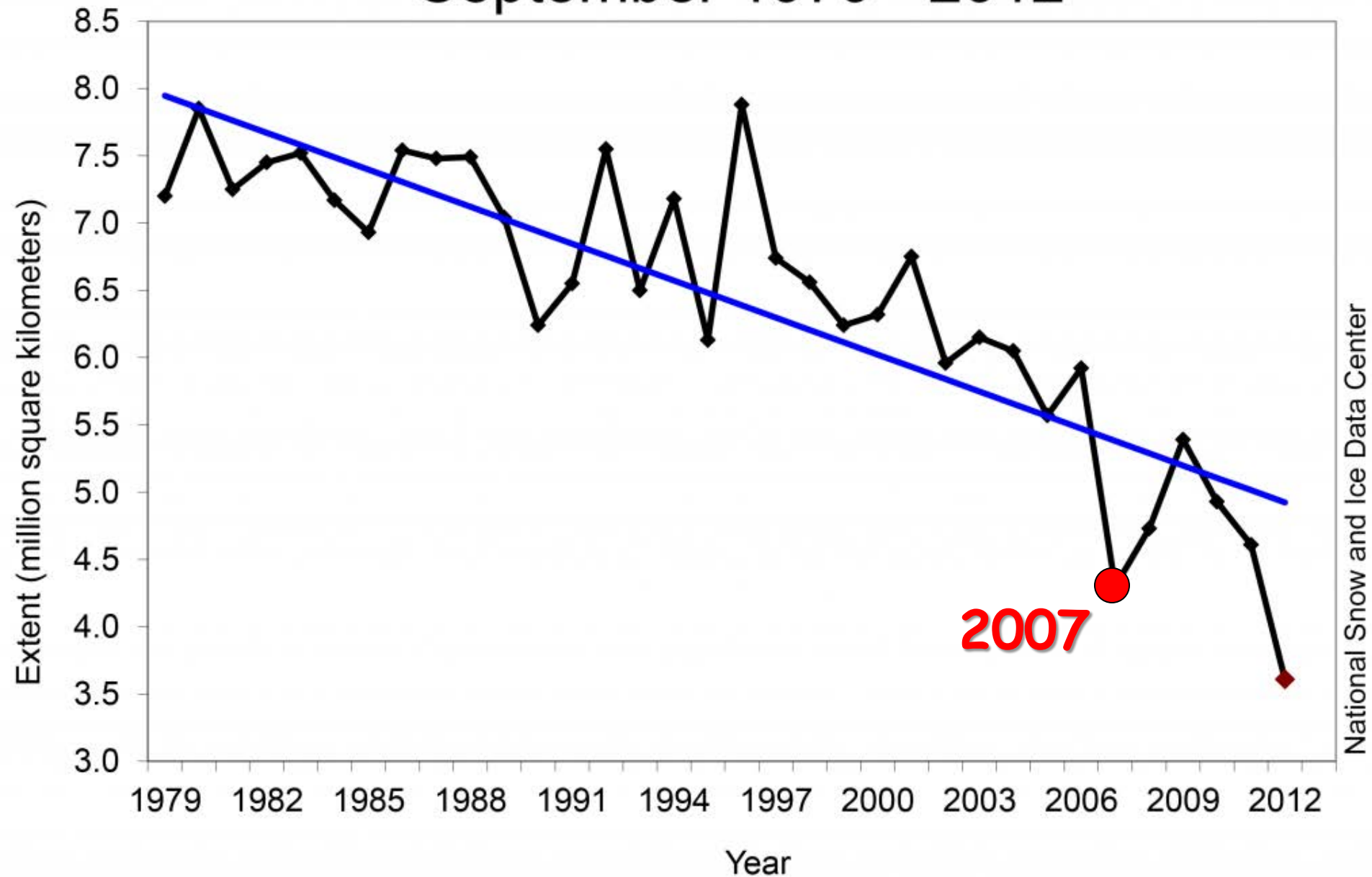
"Ratchet  
Surveying"

"Pirouette  
Surveying"

Local ice under compression - no  
"accommodation" - GOT STUCK!!



# Average Monthly Arctic Sea Ice Extent September 1979 - 2012





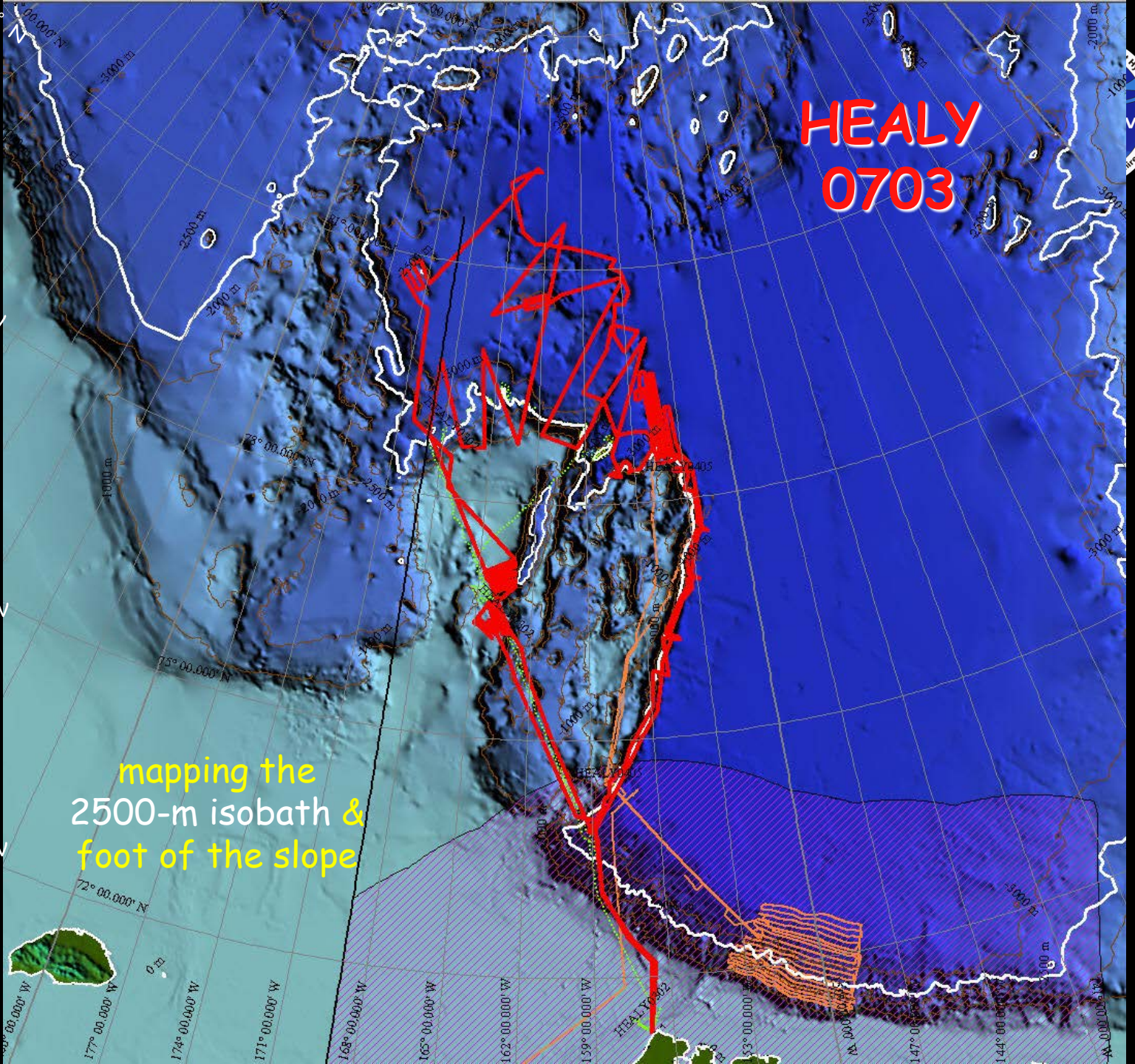




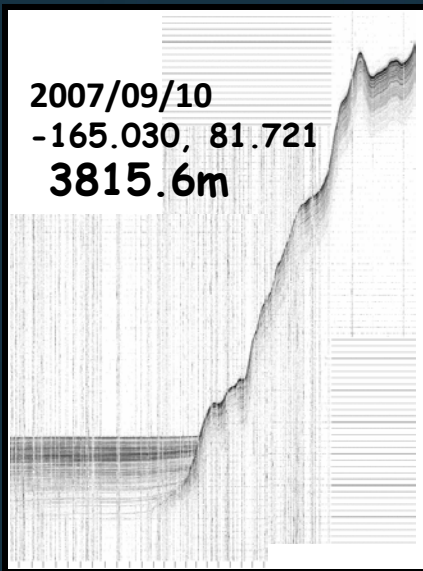


**HEALY  
0703**

mapping the  
2500-m isobath &  
foot of the slope



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



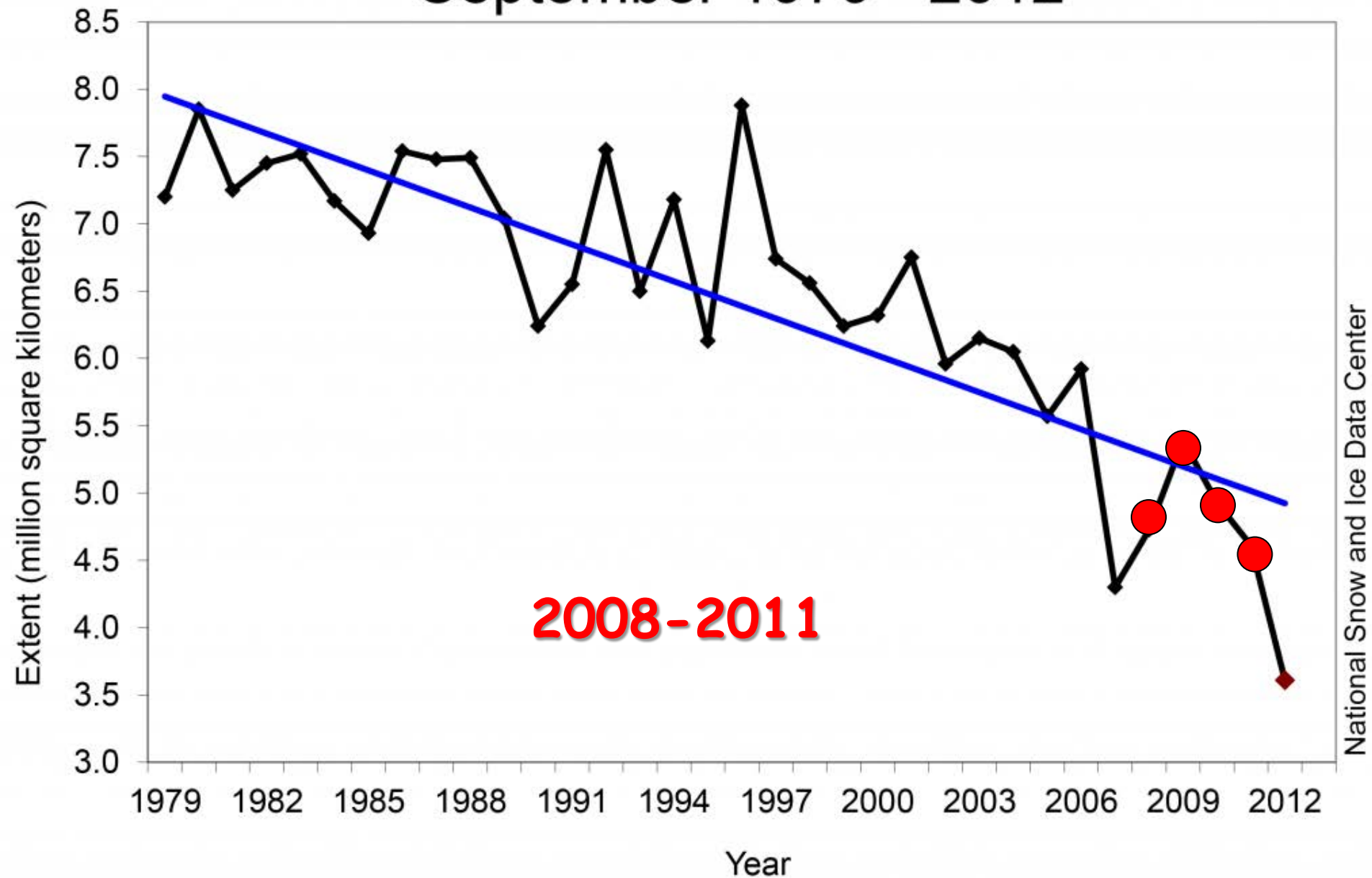
2007 results

Where we thought FOS was

Where we now think it is

perspective view looking SW

# Average Monthly Arctic Sea Ice Extent September 1979 - 2012



# JOINT PROGRAMS WITH CANADIAN ICEBREAKER *LOUIS S. St. LAURENT*



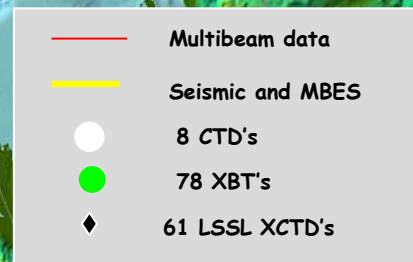
# HEALY-1102

15 Aug - 28 Sept 2011

ECS data 9,188 kms bathy  
~875 km seismic  
Total trackline - 11,447 km

Area mapped ~ 58,000 km<sup>2</sup>

Average sea ice state... 9/10  
Average speed in ice..... 3.5 knts





# LSSL AUV LAUNCH



20

U. S. COAST GUARD

SEP 3 2011



SEP 3 2011

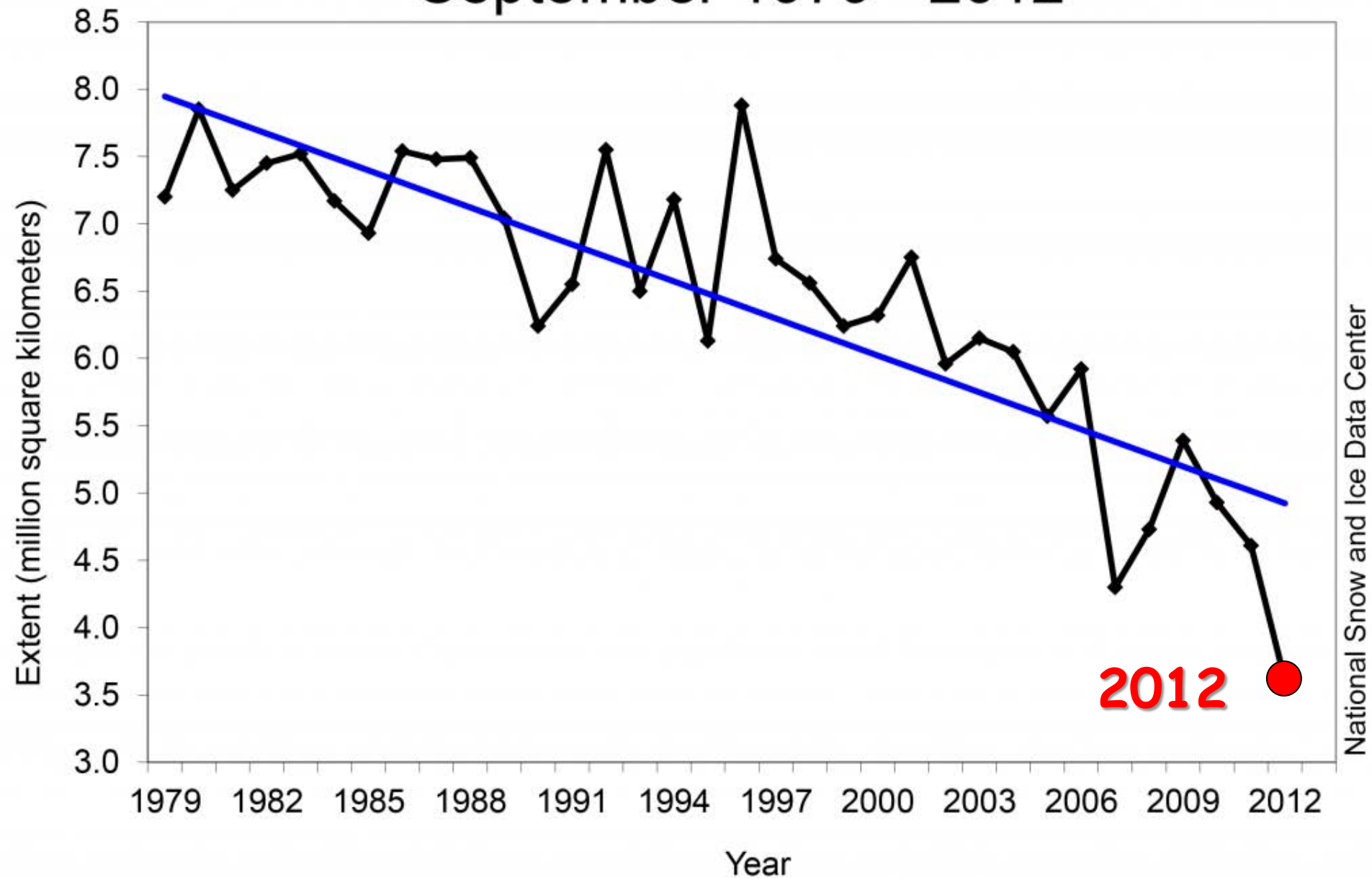




**SVP buoys**

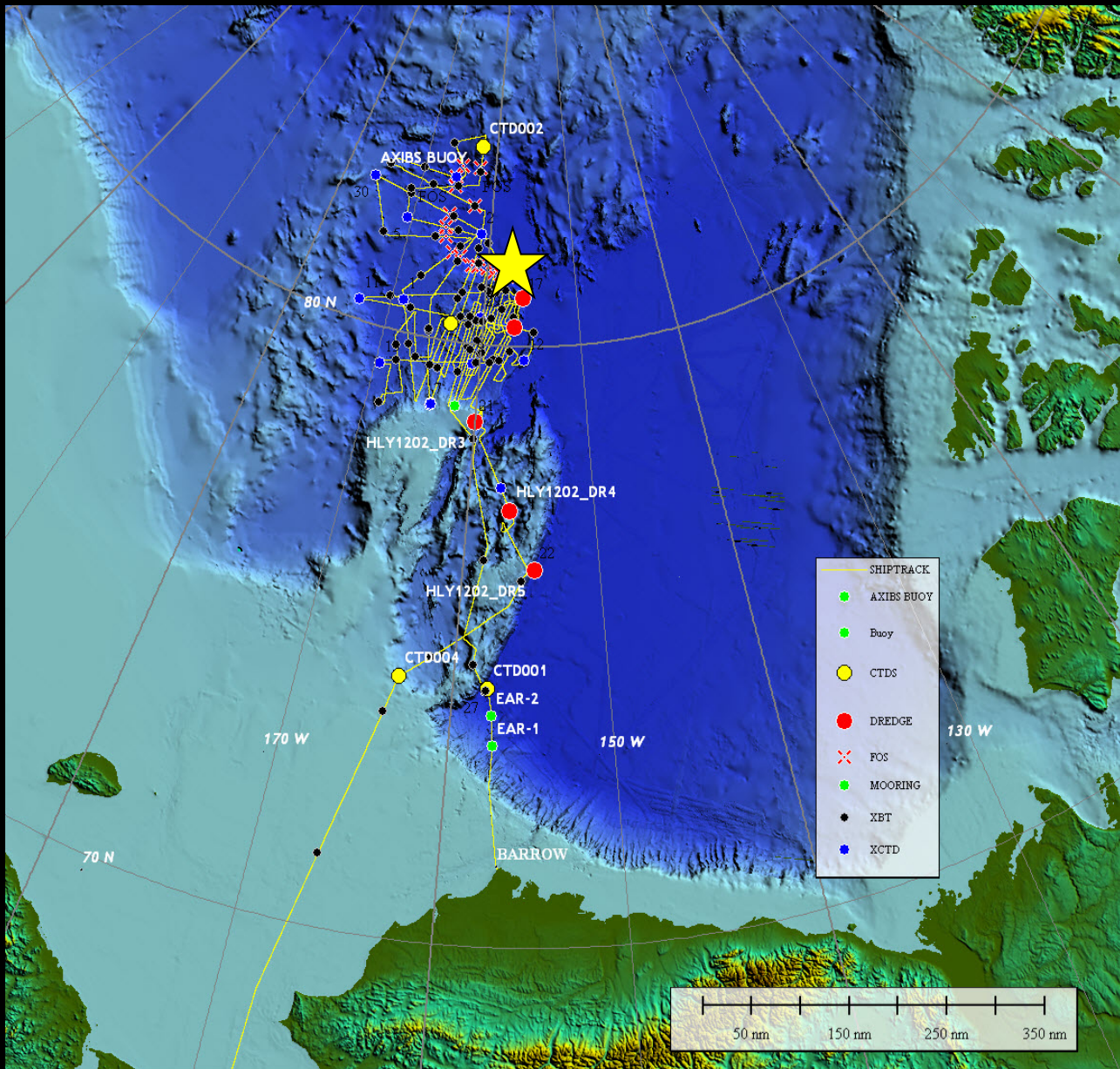
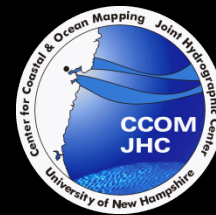
**3 Sept 2011**

# Average Monthly Arctic Sea Ice Extent September 1979 - 2012



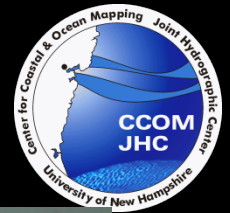


# HEALY 1202 - Aug- Sept 2012



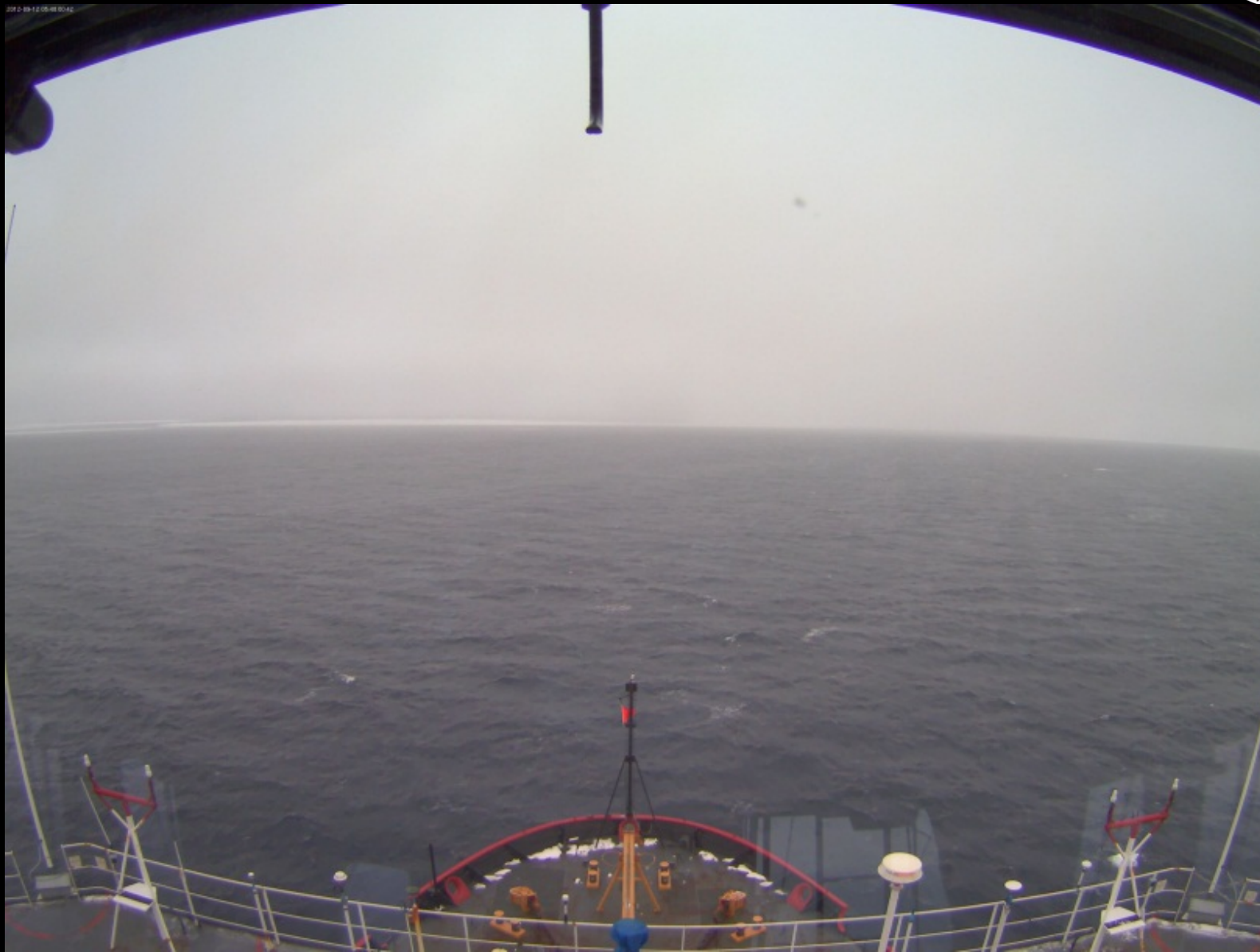
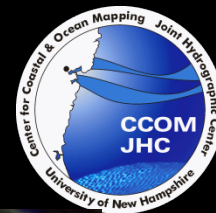


Long/Lat: -156.072055 W, 80.293353 N  
2007 (9-6-2007)



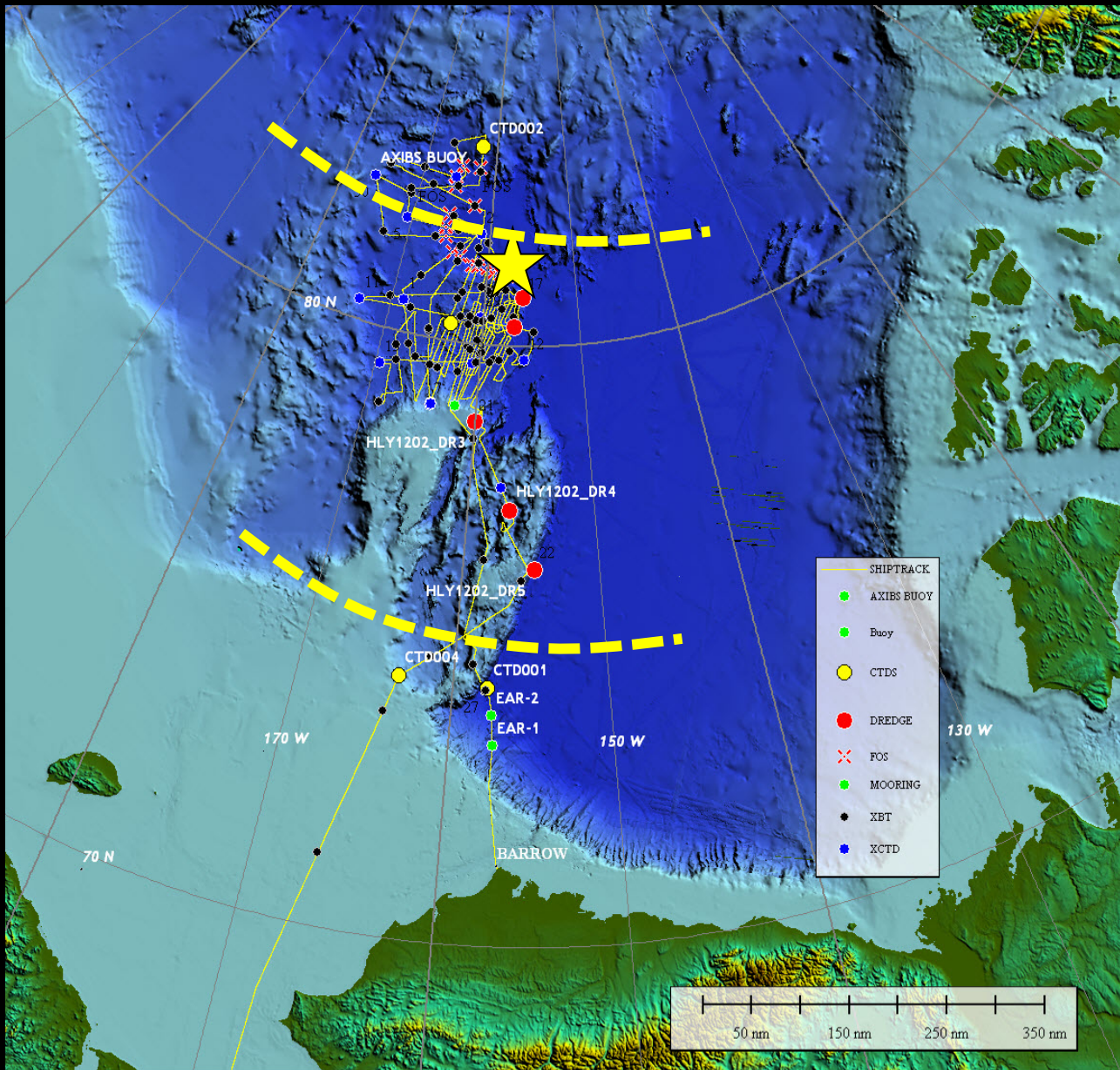
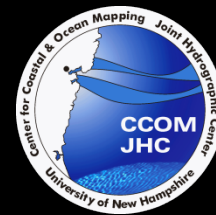


Long/Lat: -156.072055 W, 80.293353 N  
2012 (9-12-2012)

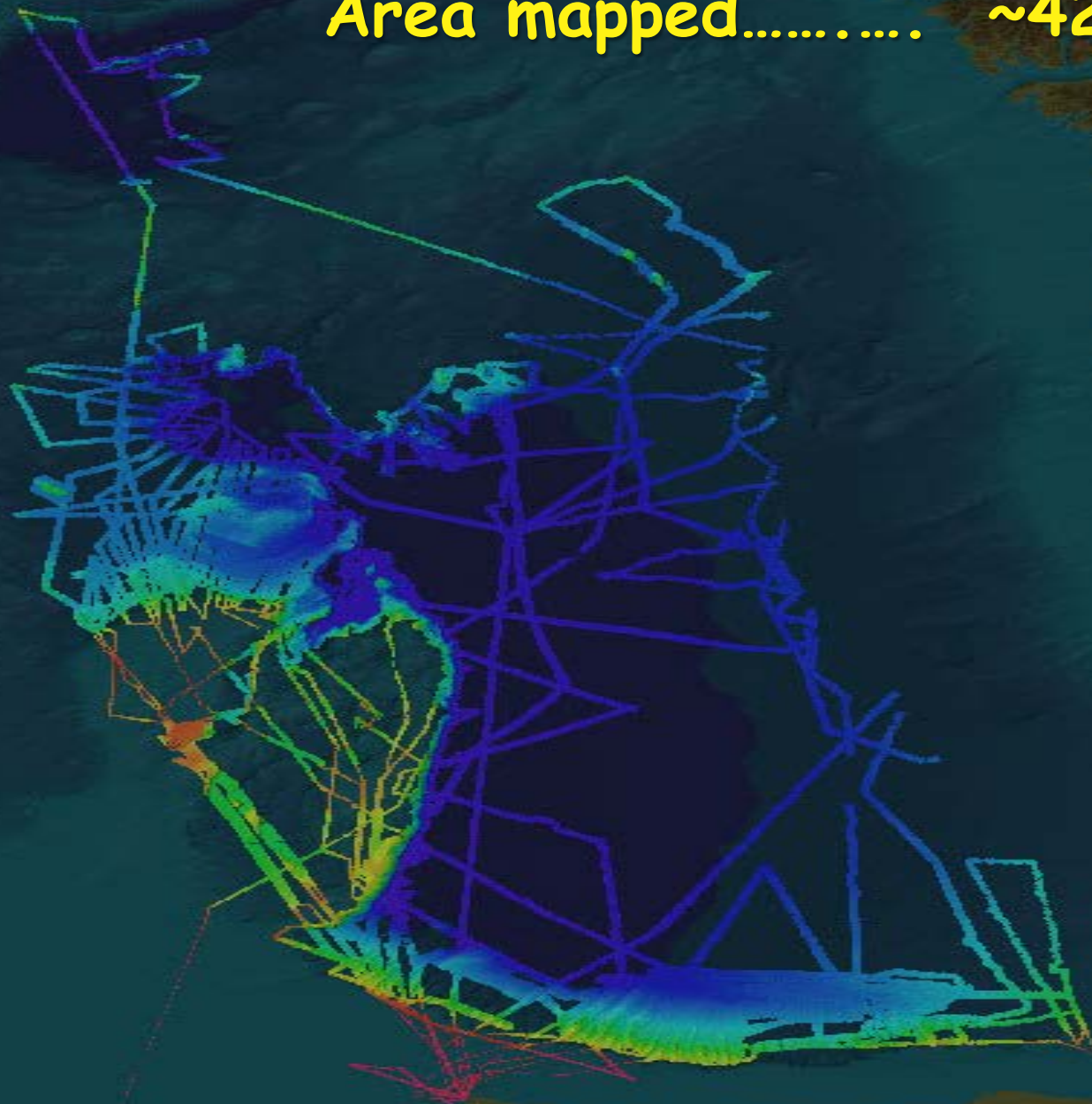




# HEALY 1202 - Aug- Sept 2012

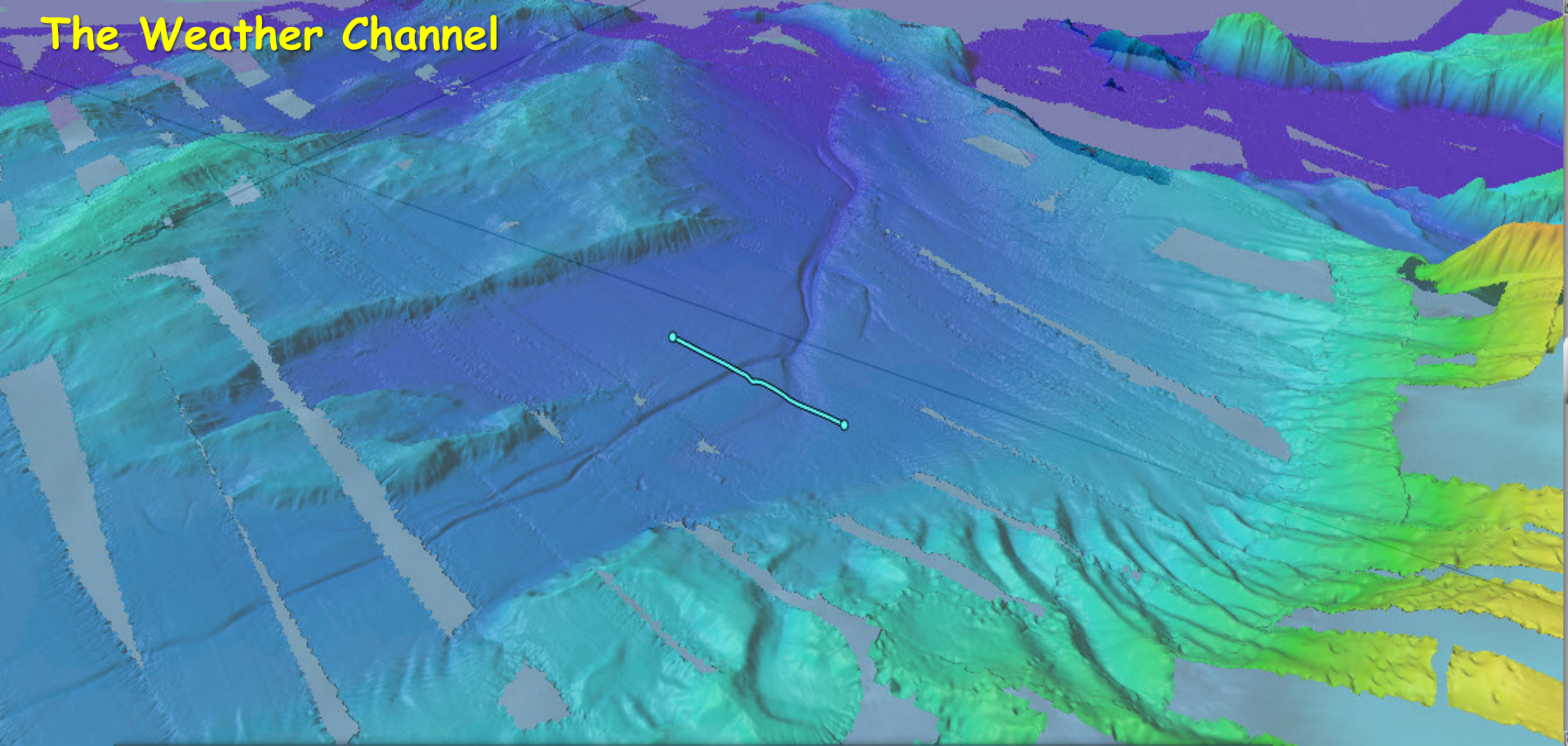


Area mapped..... ~420,000 km<sup>2</sup>

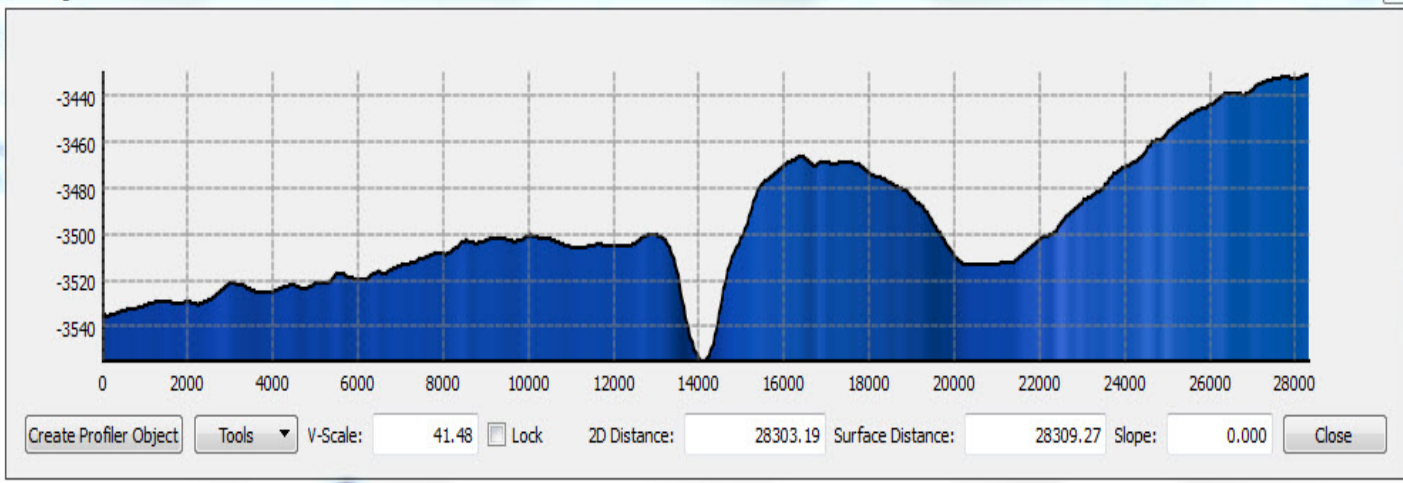


US ECS Arctic Mapping 2003, 2004, 2007, 2008, 2009, 2010, 2011. 2012

# The Weather Channel



Profiling



Timeline and control interface with various sliders and buttons. The timeline is labeled "Time" and includes playback controls (play, stop, back, forward) and a "Time" label. Below the timeline are four horizontal sliders with handles and three menu buttons (three dots).



PLANET EARTH

## Arctic sea ice up 60 percent in 2013

Amazon Videos | Feedback | Like <1.2m | Follow @MailOnline | DailyMail | Sunday, Apr 20th 2014 3PM 44°F 6PM 48°F 5-Day Forecast

# MailOnline

## And now it's Arctic ice cap

- 533,000 more square
- BBC reported in 2007 summer by 2013
- Publication of UN clin caused by humans pu

By DAVID ROSE

PUBLISHED: 18:37 EST, 7 September

# The New American

THAT FREEDOM SHALL NOT PERISH

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Wednesday, 18 December 2013 15:52

## Al Gore Forecasted "Ice-Free" Arctic by 2013; Ice Cover Expands 50%

Written by [Alex Newman](#)

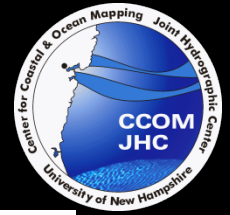
Tweet 239

Like 5,076 people like this.

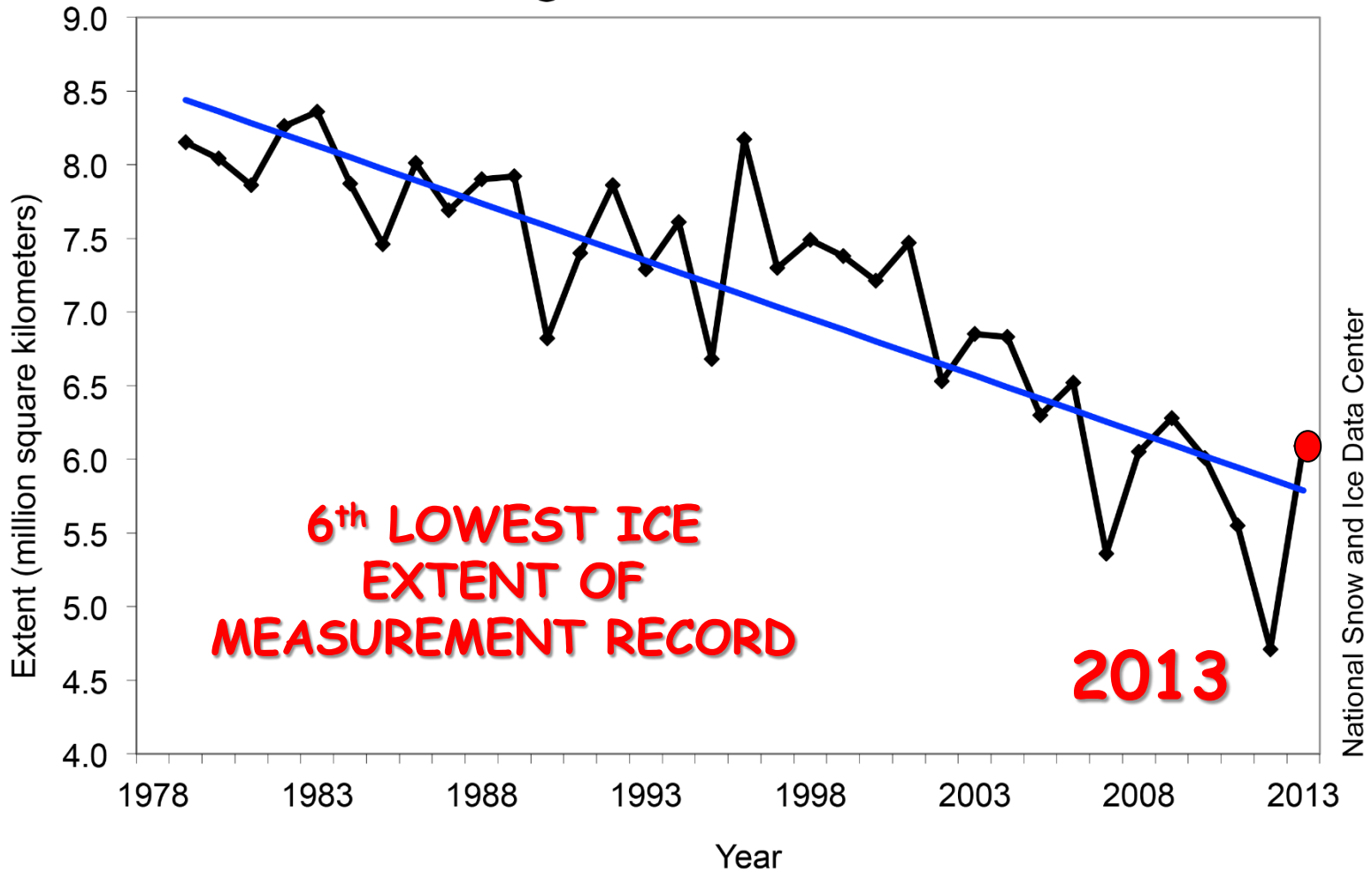
font size [Print](#) [E-mail](#)



# AND 2013??

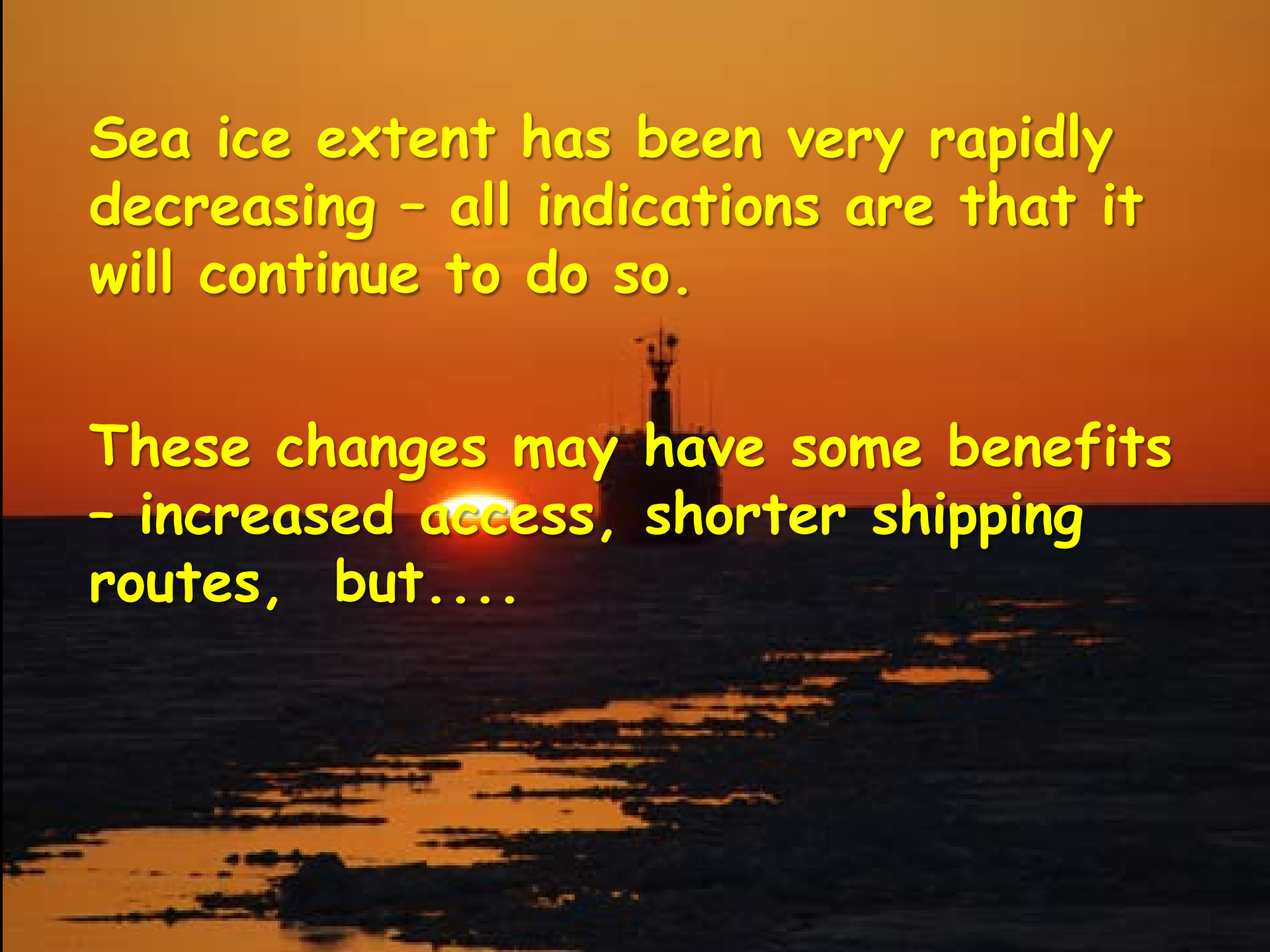


## Average Monthly Arctic Sea Ice Extent August 1979 - 2013



Sea ice extent has been very rapidly decreasing - all indications are that it will continue to do so.

These changes may have some benefits - increased access, shorter shipping routes, but....



A sunset over the ocean with a lighthouse silhouette. The sun is low on the horizon, casting a bright glow and reflecting on the water. The sky is a mix of orange and red. The lighthouse is a dark silhouette in the center of the frame.

Many negative impacts:

Destruction of critical habitat

Increased coastal erosion

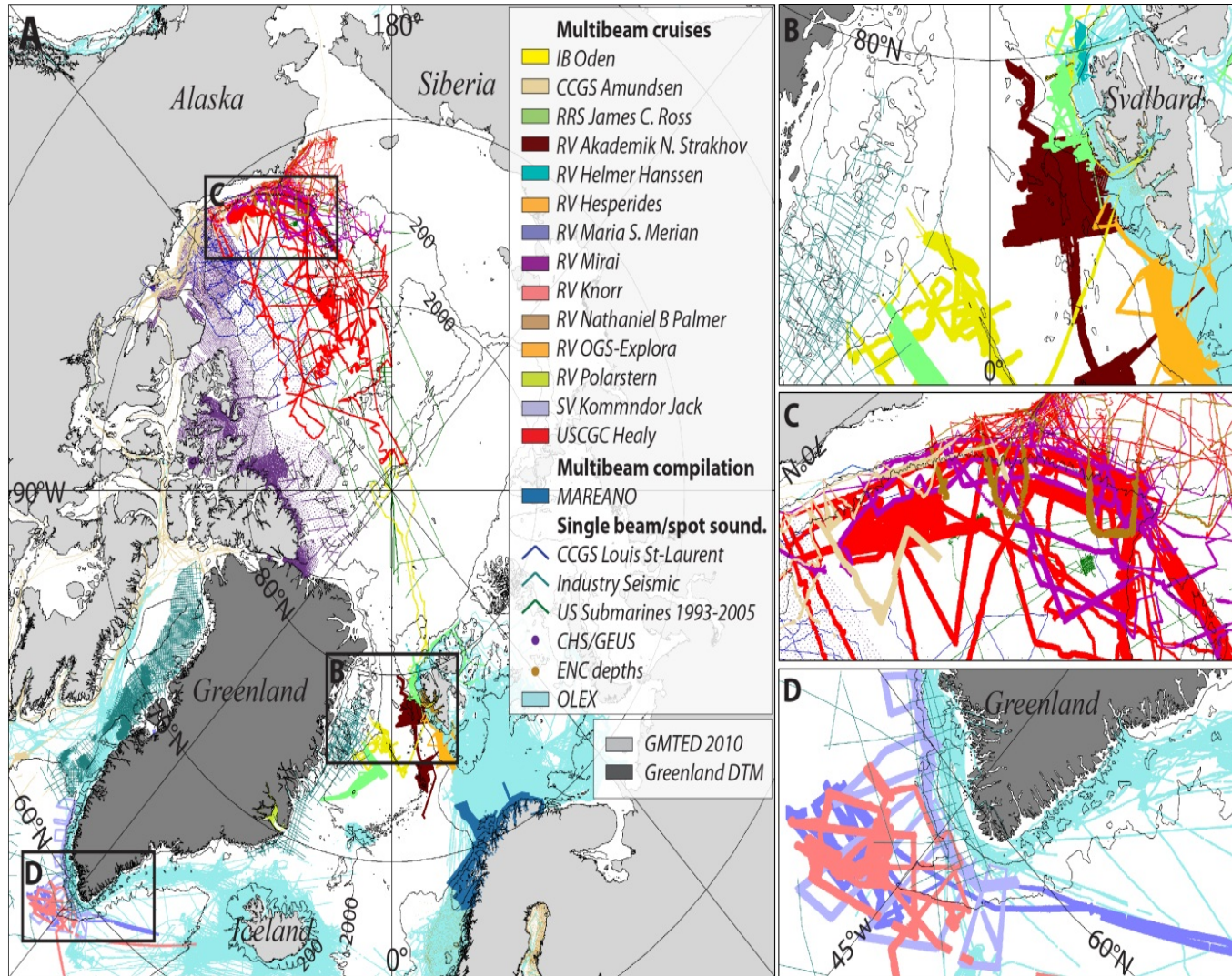
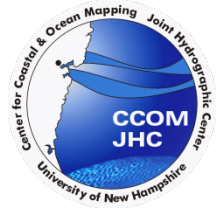
Complex and yet not well understood impacts on atmospheric and oceanic circulation and thus global climate --- tipping point??



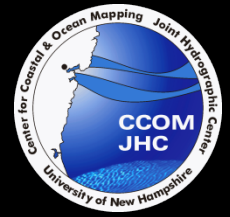




# SINCE IBCAO 2008



# IBCAO VER 3.0



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

**THERE IS STILL MUCH  
MUCH MORE TO  
DISCOVER!!!**

