

*Such a Big Ocean but
our Footprints are so
Small
(Sonar Footprints)*

*Larry Mayer
Center for Coastal and Ocean Mapping
University of New Hampshire*



It's easy to image the earth



Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat

Google earth



But what about the $\frac{3}{4}$ of the Earth that's BLUE?



How inappropriate to call this planet
Earth when clearly it is *Ocean* -
Arthur C. Clark

data © NOAA, U.S. Navy, NGA, GEBCO
Image Landsat

Google earth



~ 600,000,000,000,000 photos

~ 10 Billion years

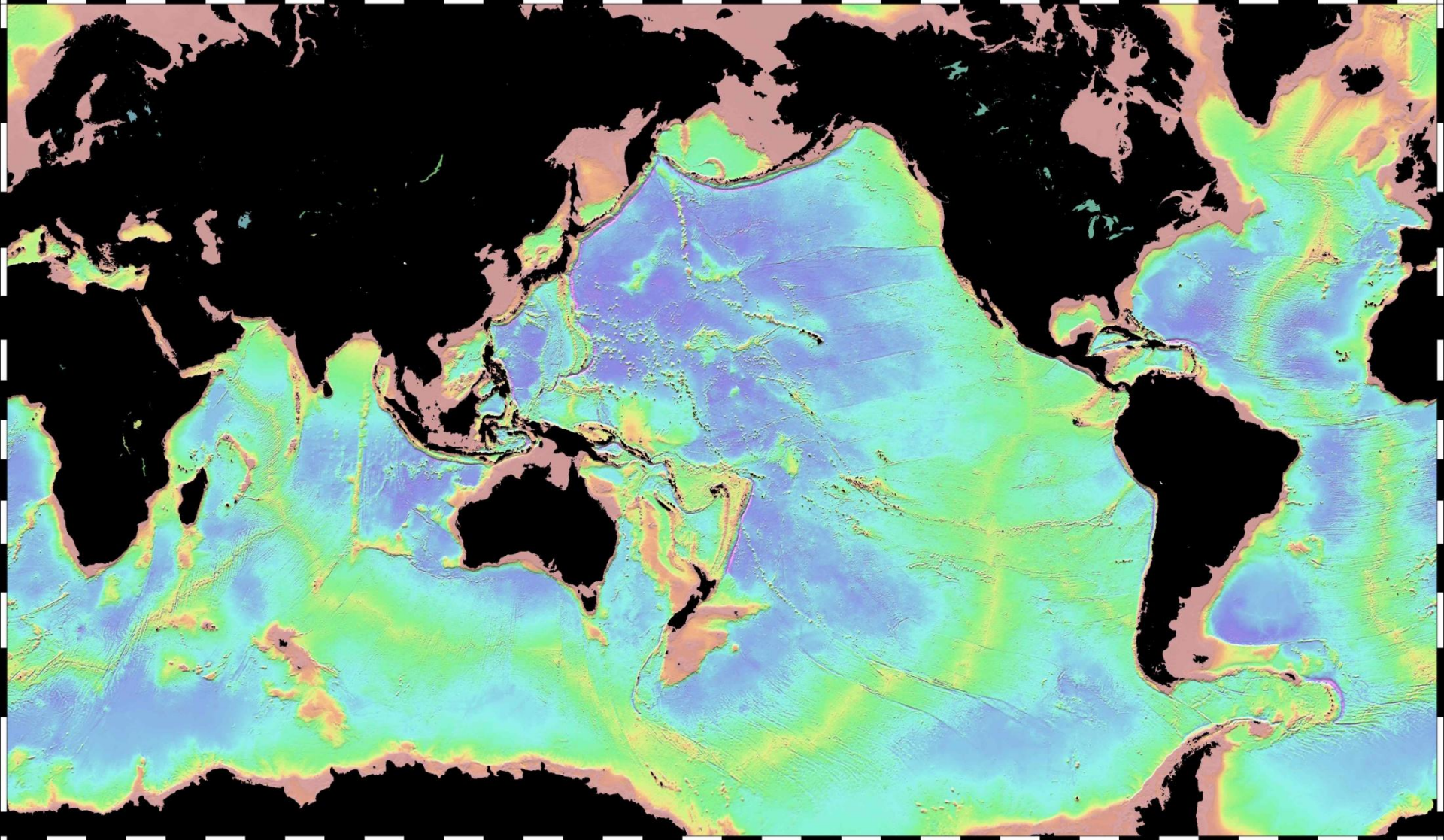


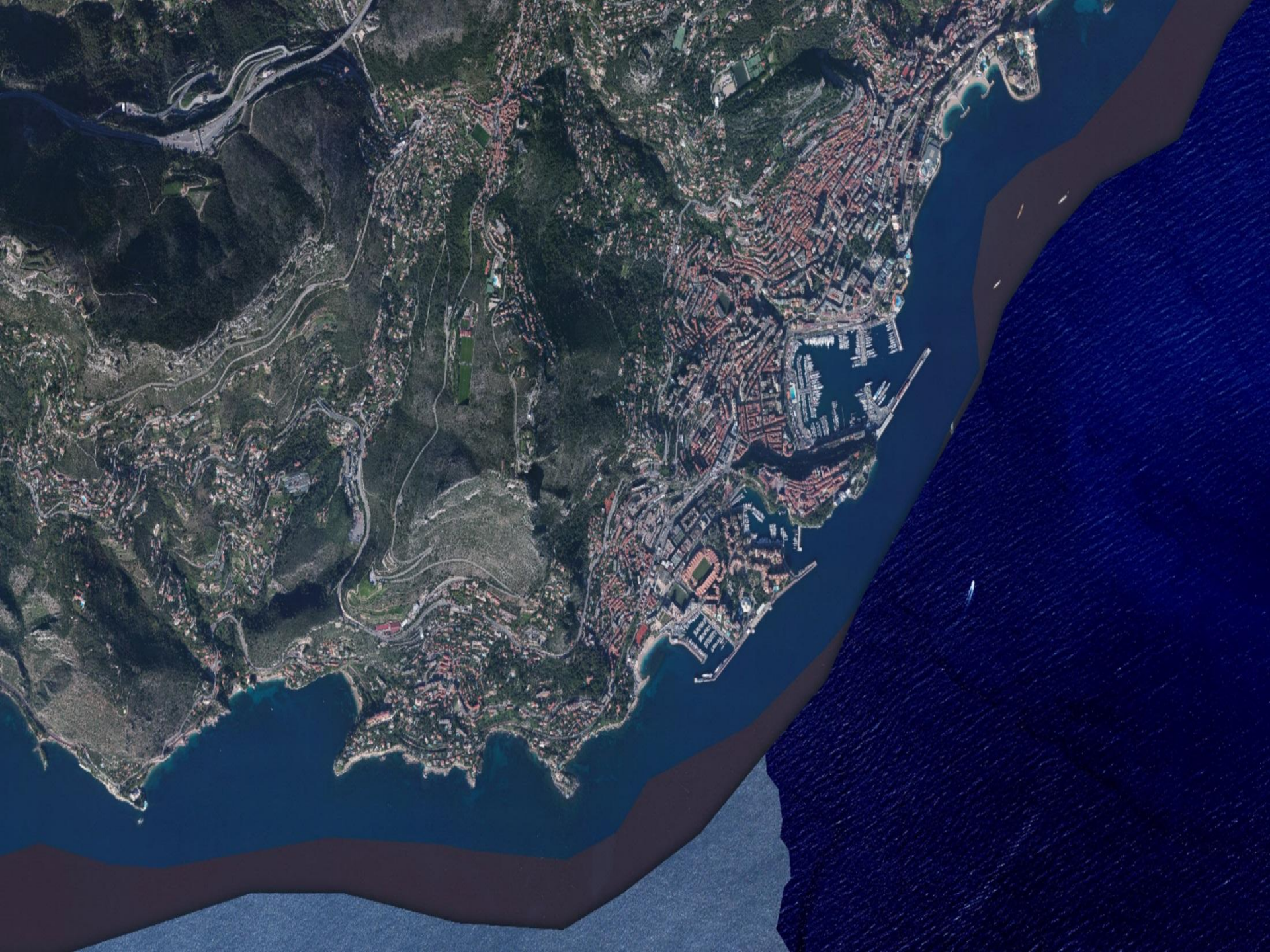
Bathymetry Predicted from Satellite Altimetry



Satellite Predicted Bathymetry

(Sandwell and Smith)







2km DTM

Direct Mapping

Lead Line:

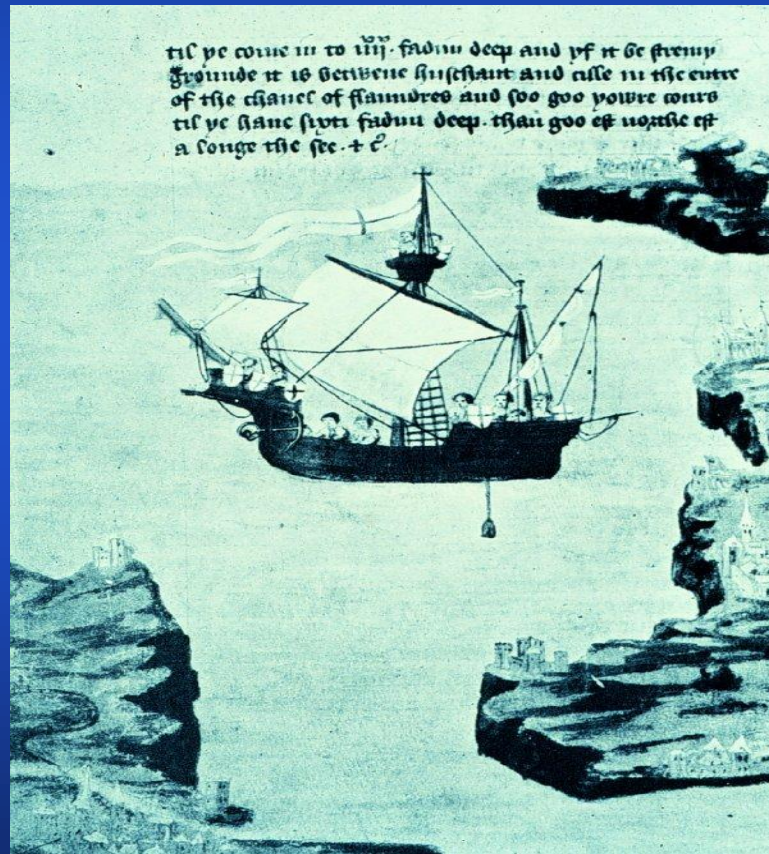


© Alfred Molon www.molon.de

2000 BC

Direct Mapping

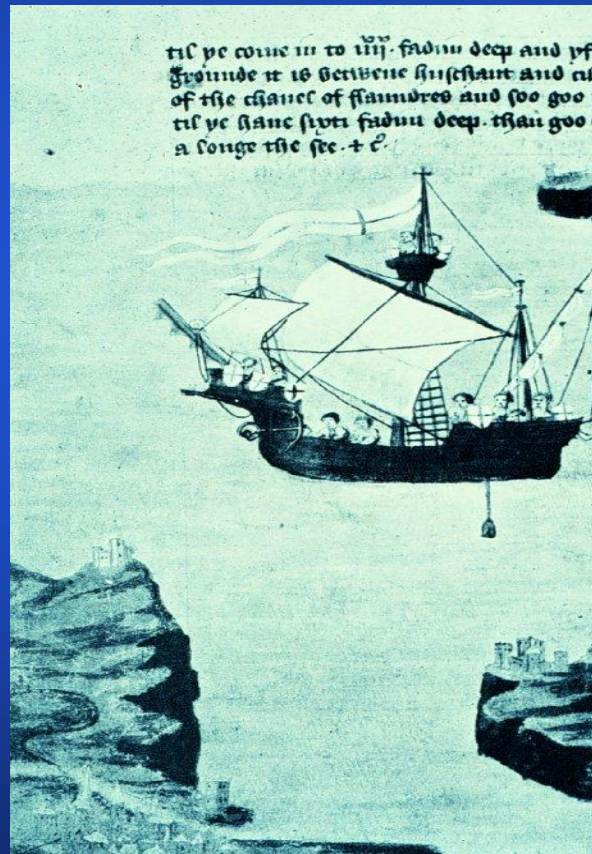
Lead Line:



1450

Direct Mapping

Lead Line:

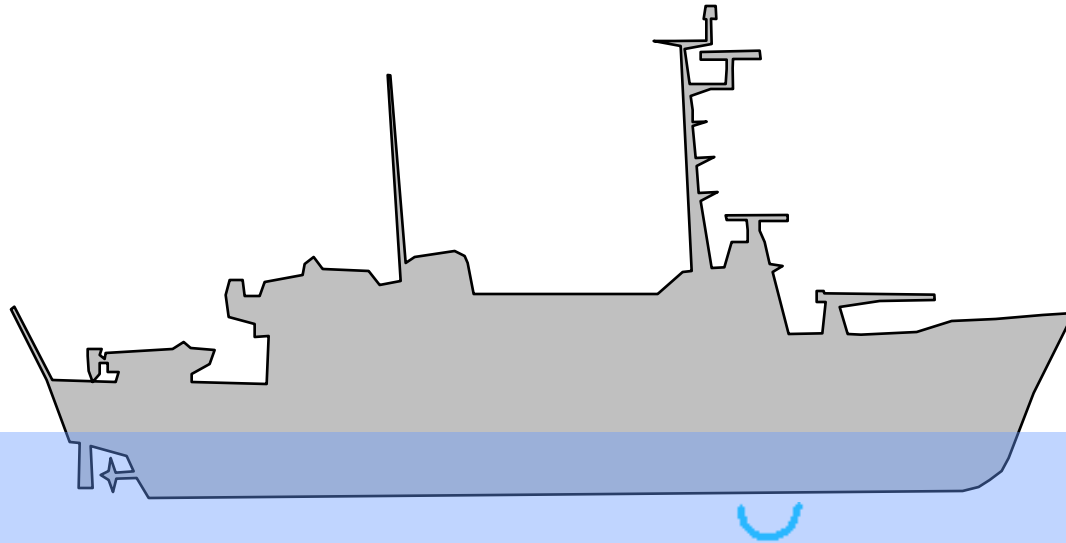


1450

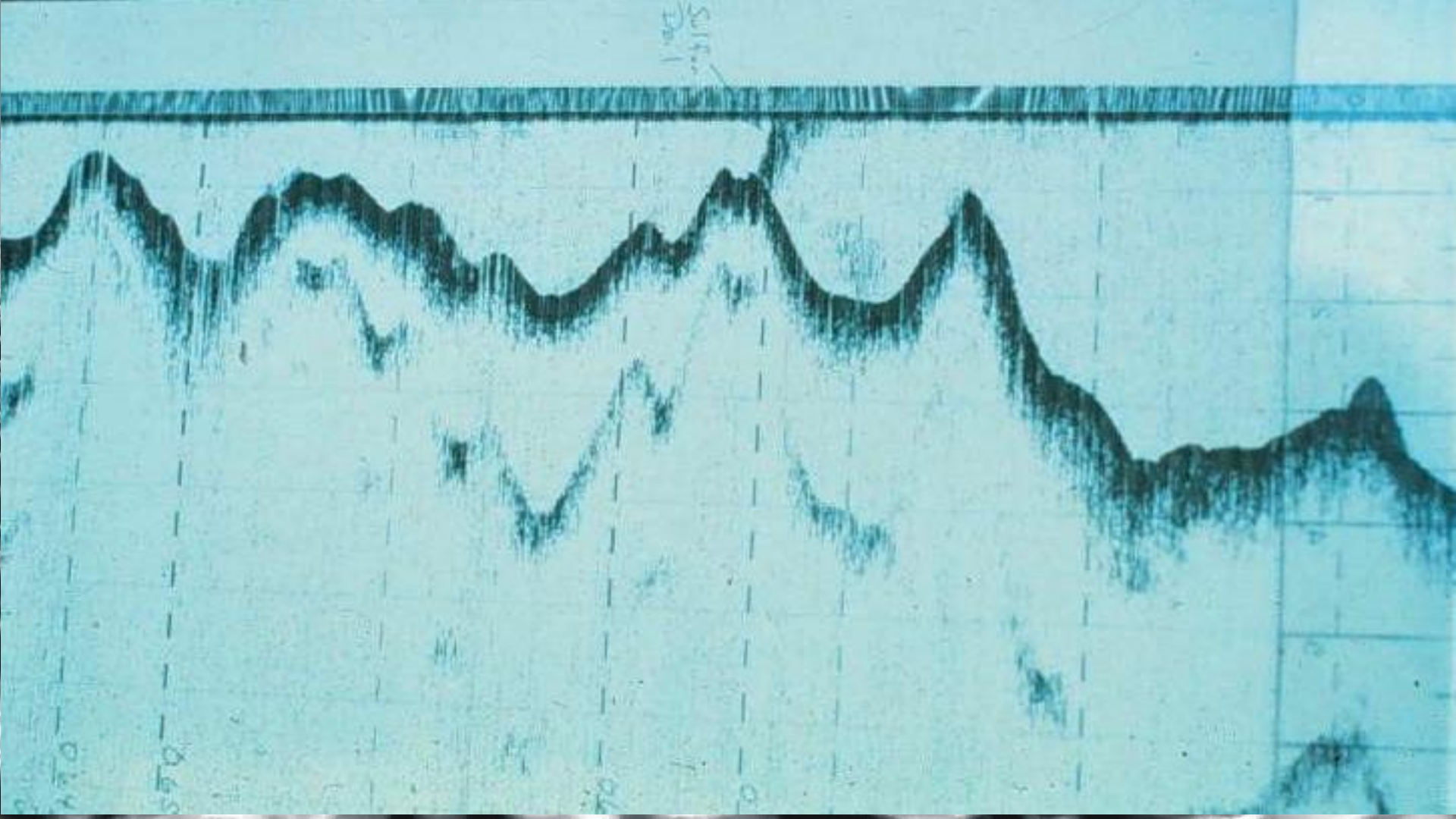


1940

Single Beam Echo Sounder

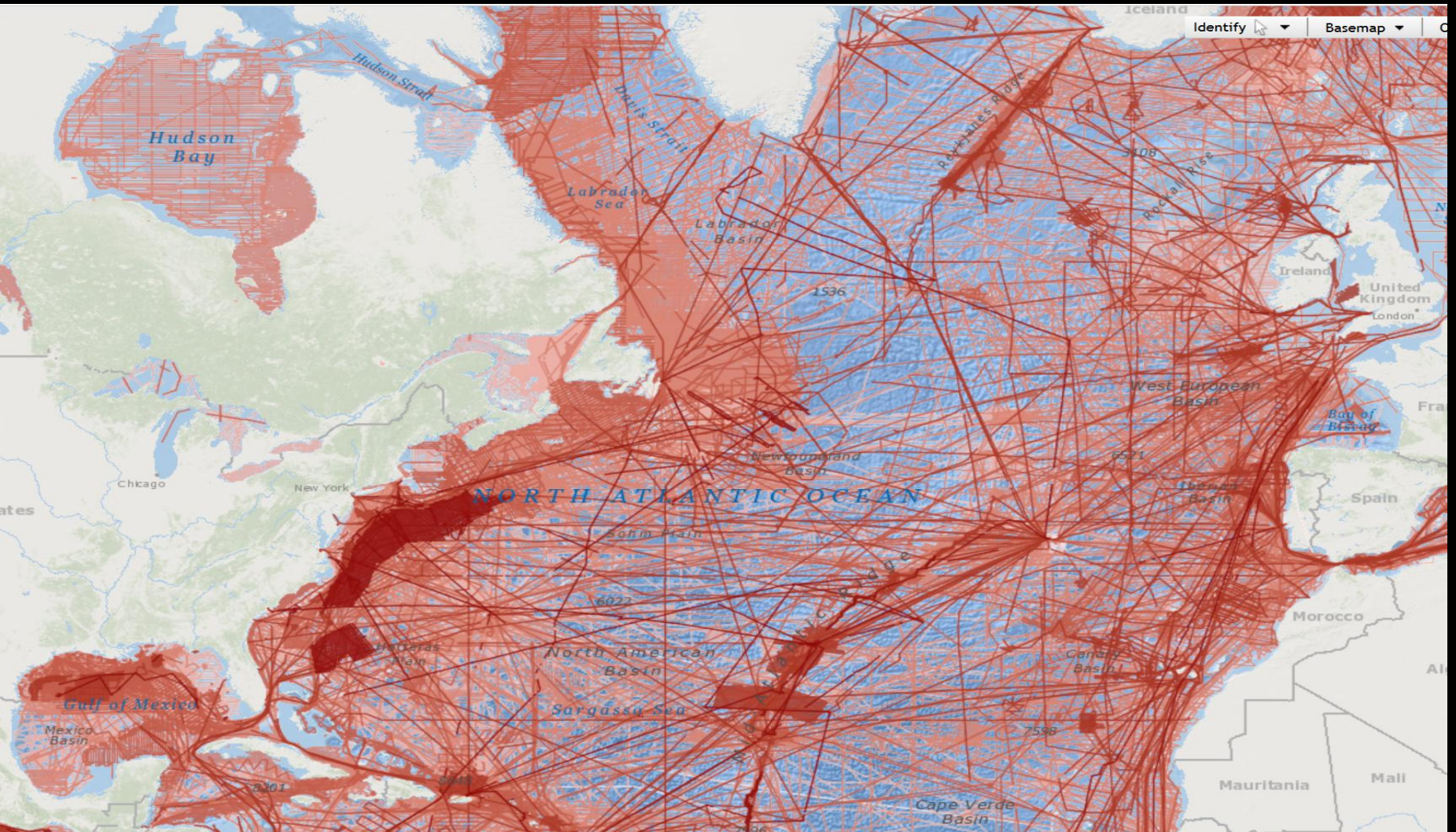


Single Beam Echo Sounder

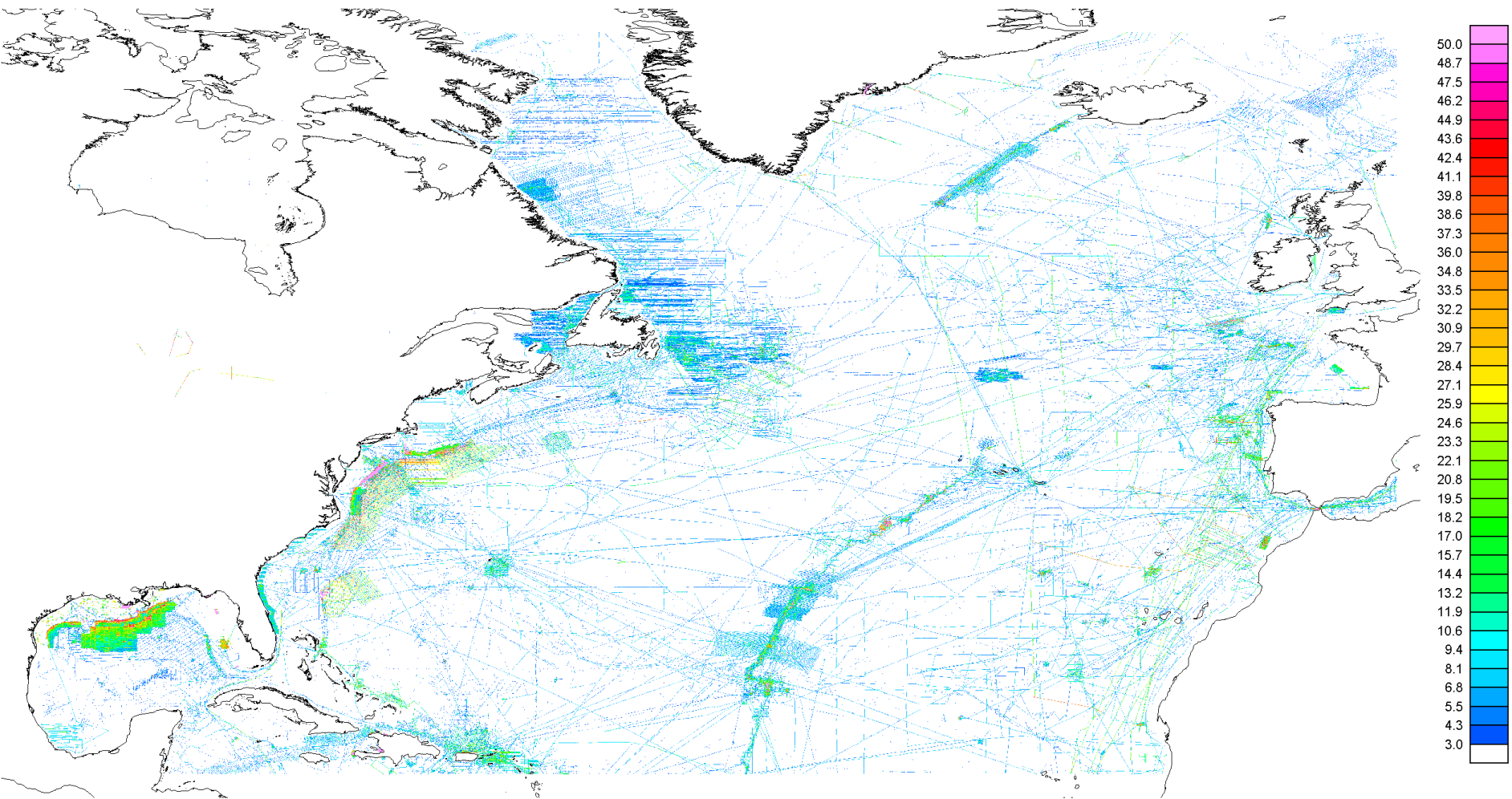




Singlebeam Sonar Shiptracks



Singlebeam Soundings per 2/km



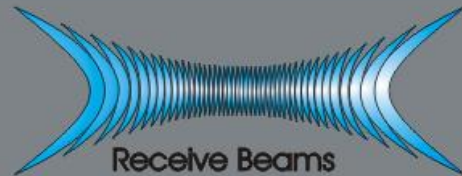
From Jenn Jencks and Brian Meyer NCEI



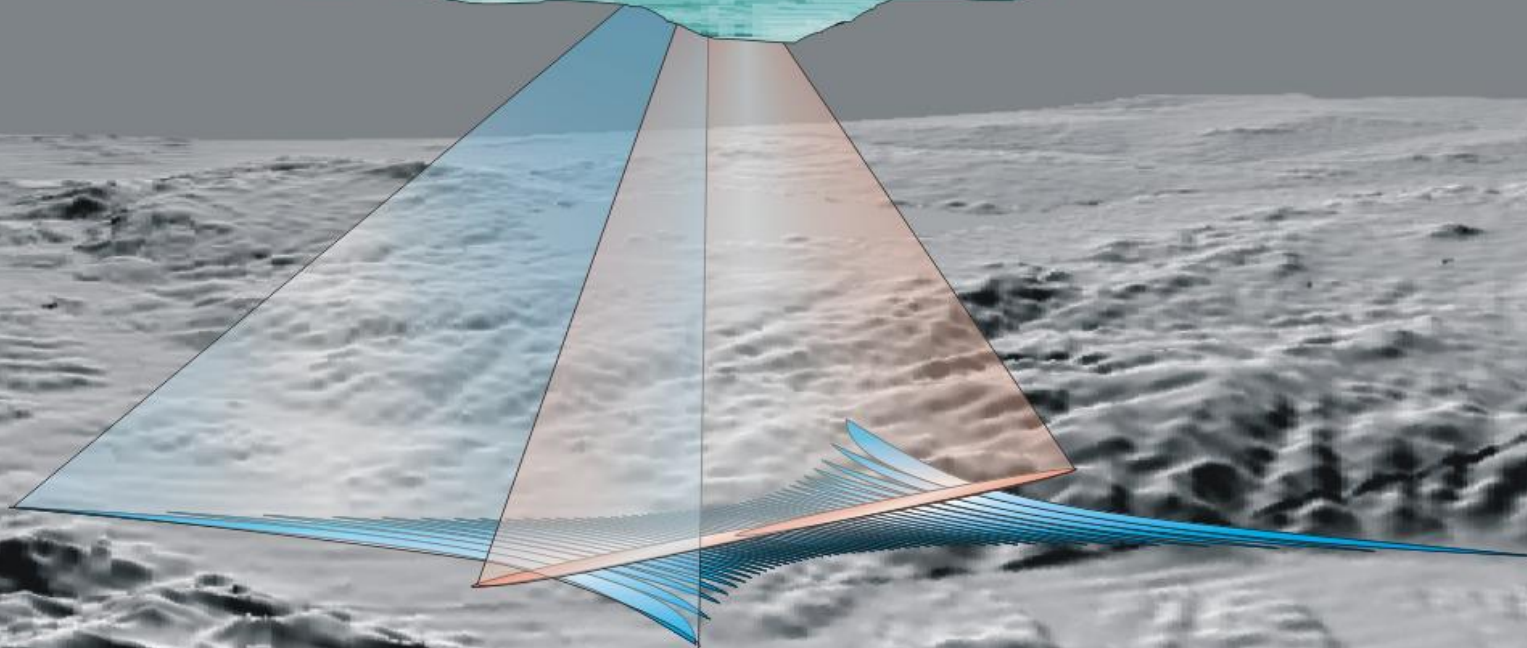
Transmit Beam



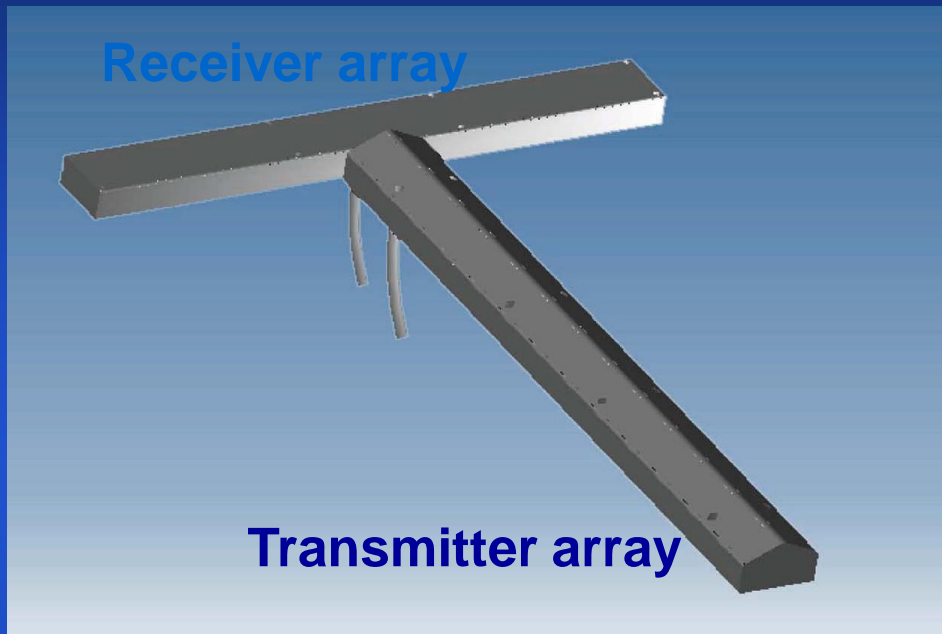
Intersection of transmit and receive beams



Receive Beams



Multibeam Sonar: Mills Cross or Mills T Array



Multibeam Sonar



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

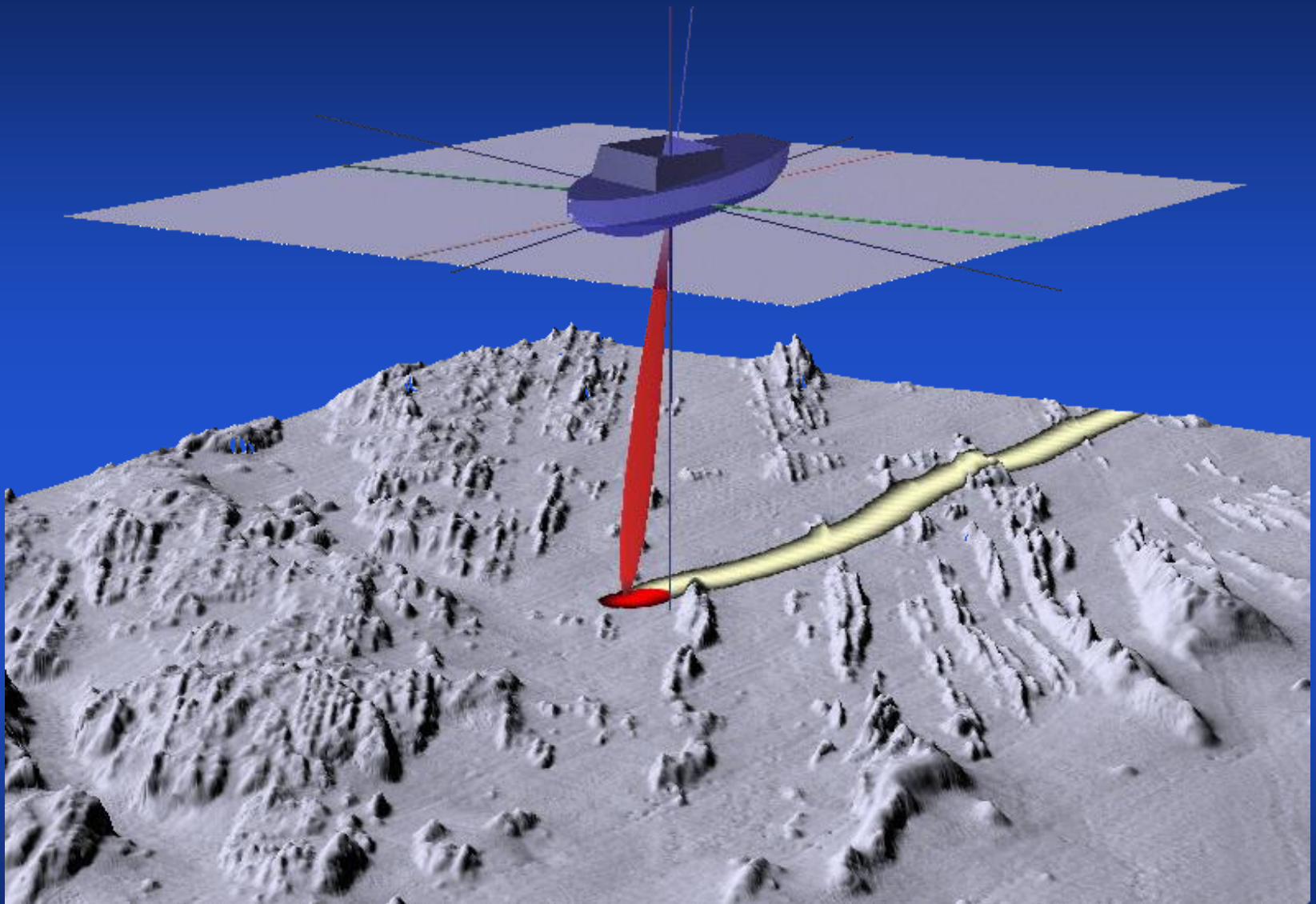


Image derived from theoretical sonar model interacting with artificial seabed DTM using "*SynSwath*"

John Hughes Clarke - UNB

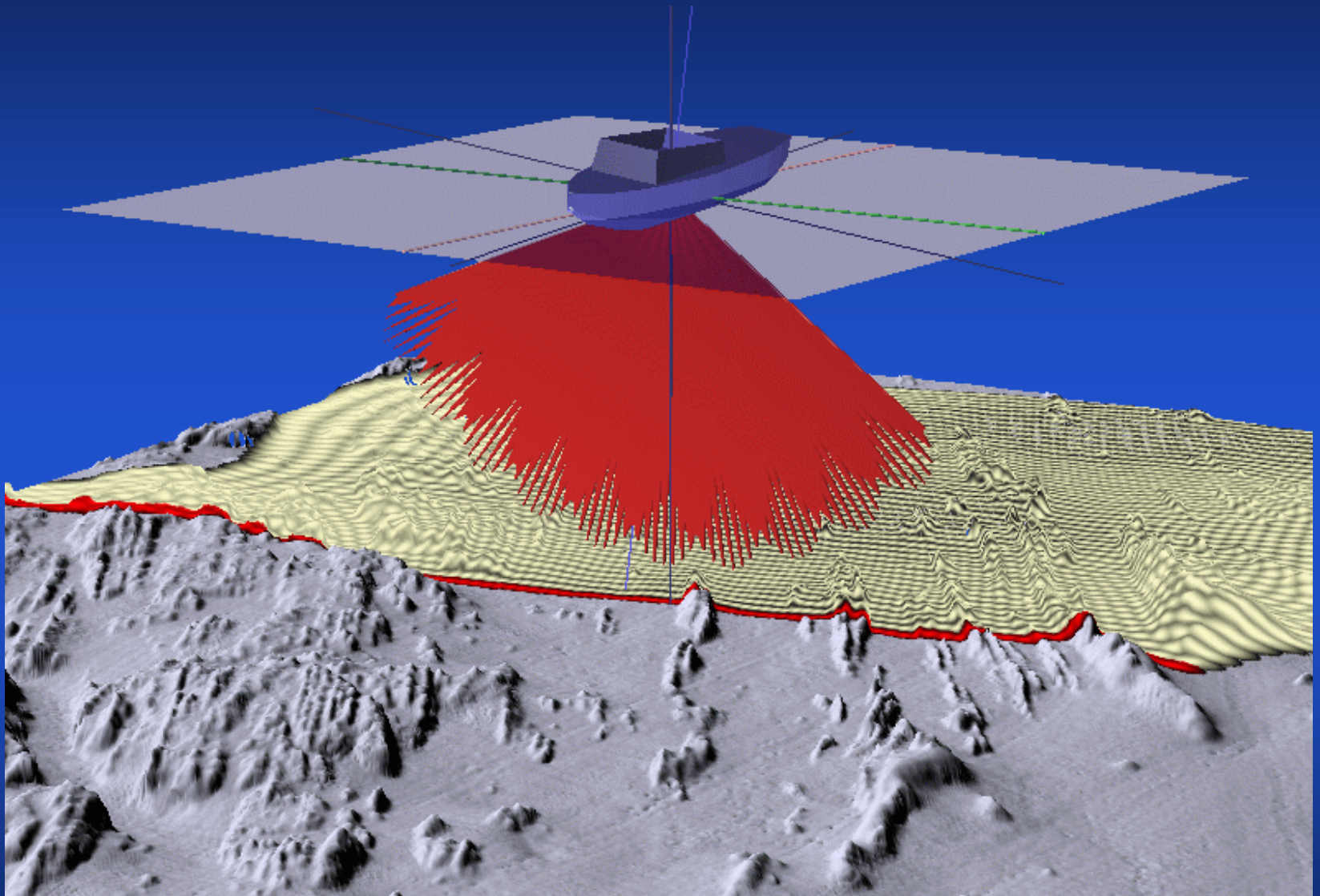
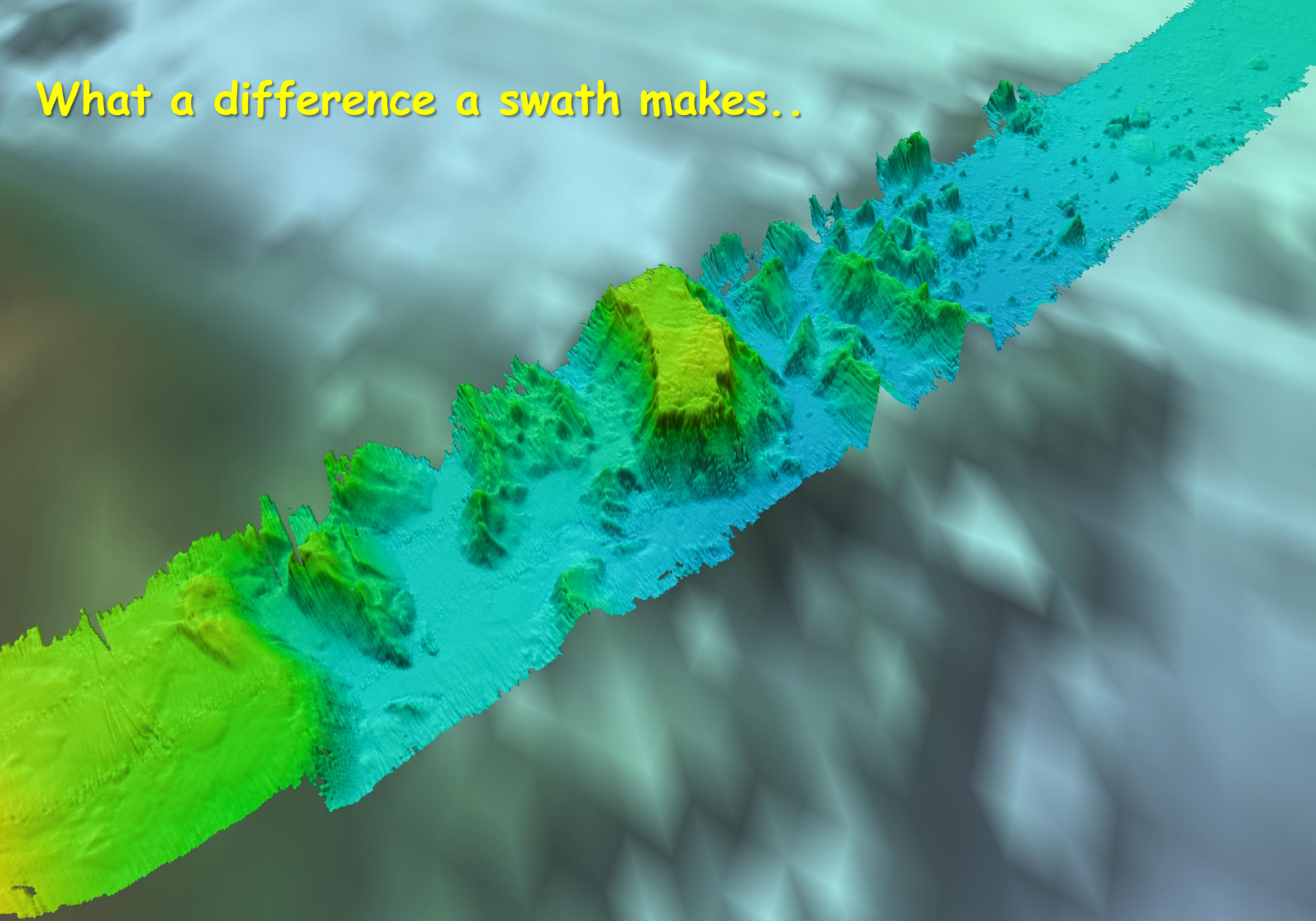


Image derived from theoretical sonar model interacting with artificial seabed DTM using "*SynSwath*"



What a difference a swath makes..





G E O R G I A

MONTEREY
SAN FRANCISCO

Grand Canyon

Pt. Arguello
Pt. Conception

Santa Cruz I.
San Miguel I.
Santa Rosa I.

LOS ANGELES

San Nicolas I.
Santa Catalina I.
South Cienega

SAN DIEGO

MEN

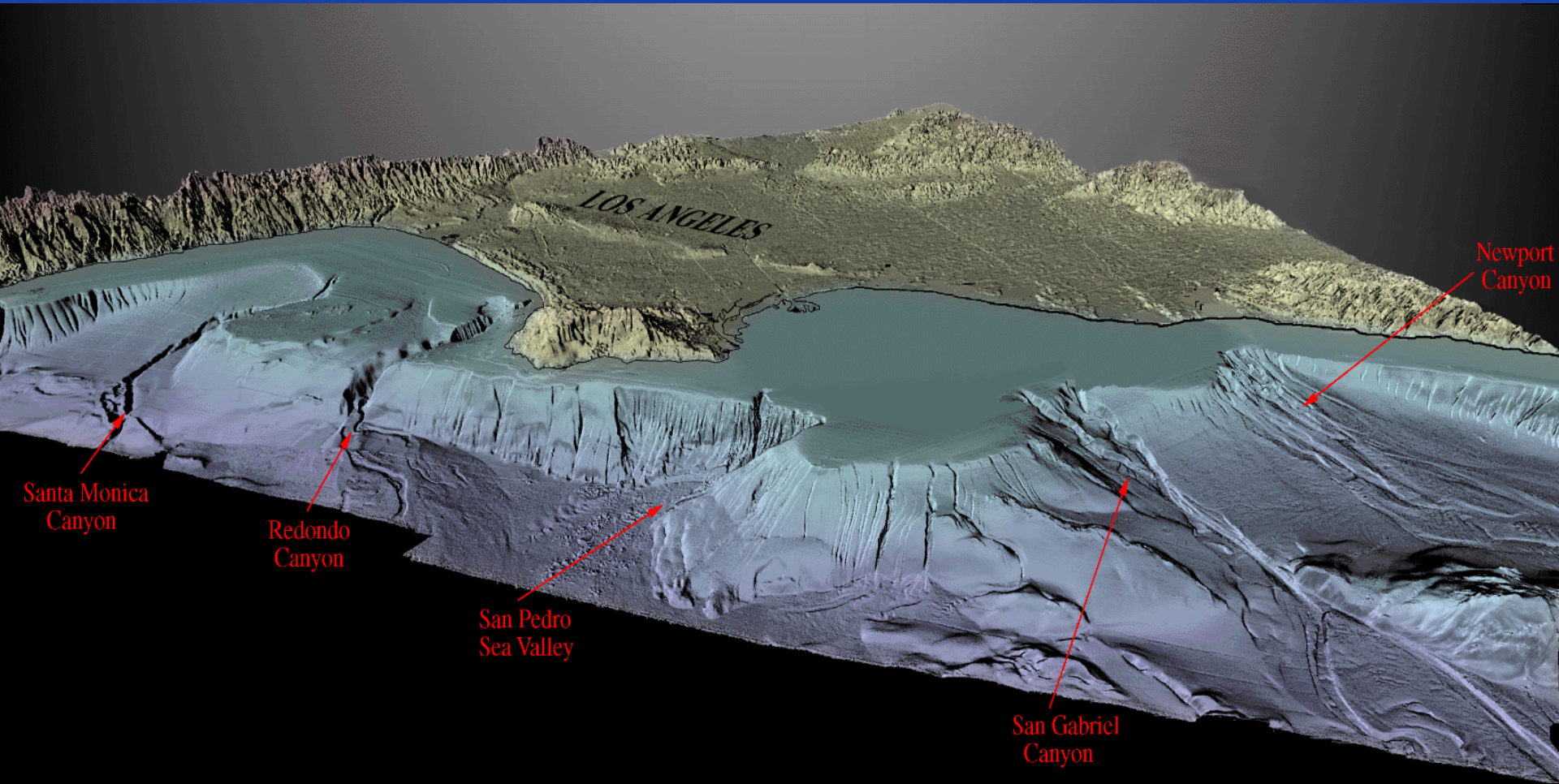
Cape Coronet
Cape San Quintin

DELAN BASIN
Angel de la Cruz

Guadalupe I.

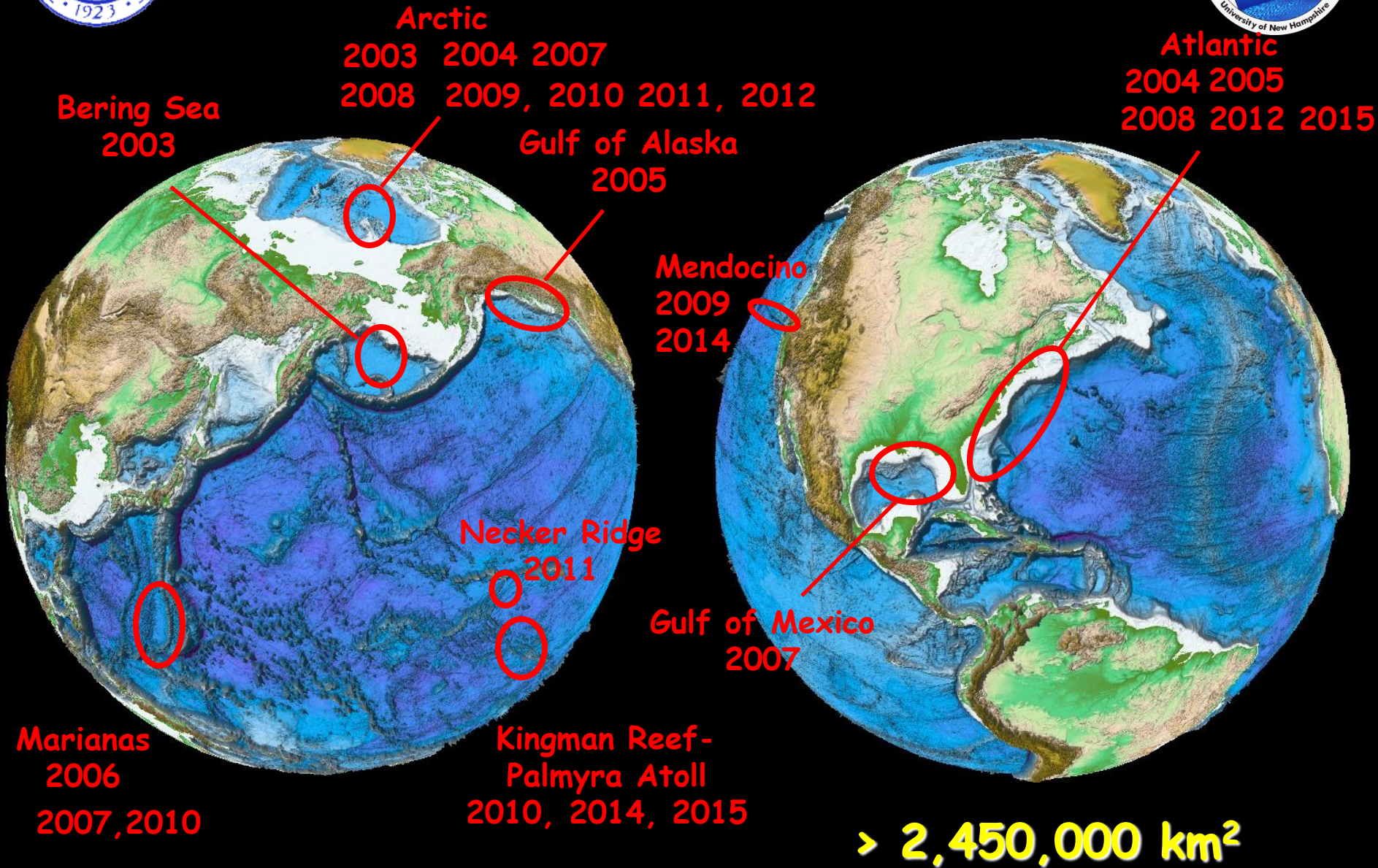
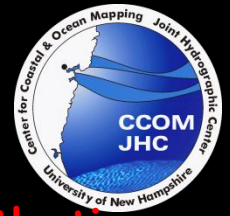
Sebastian Vizcaino Bay
Pt. Eugenia
Abreojos

A new perspective → new insights
and many new applications

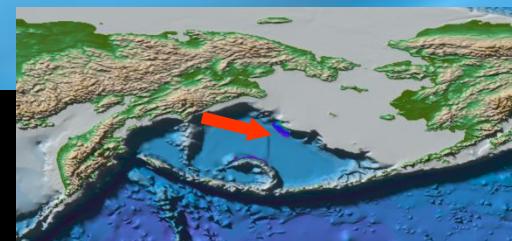
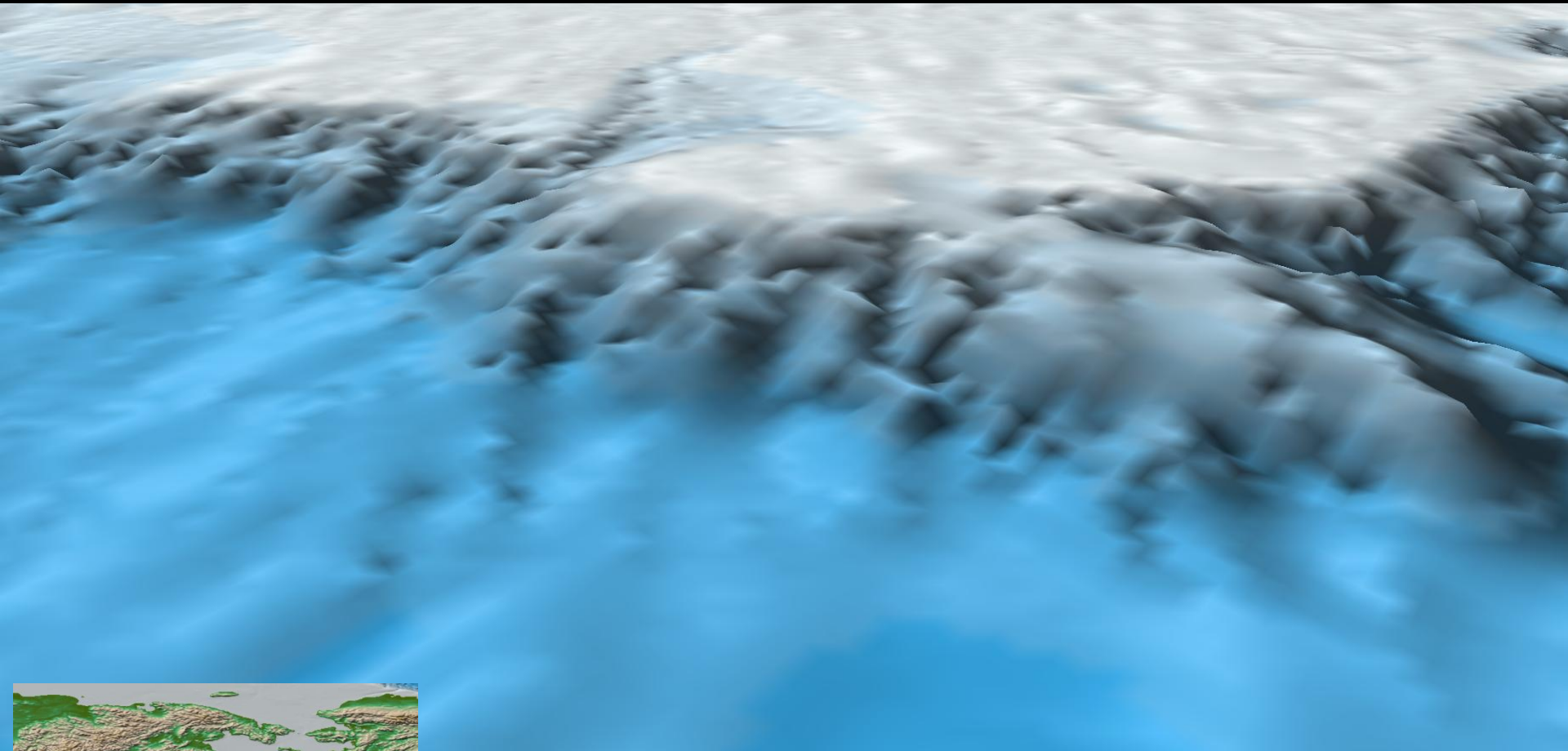




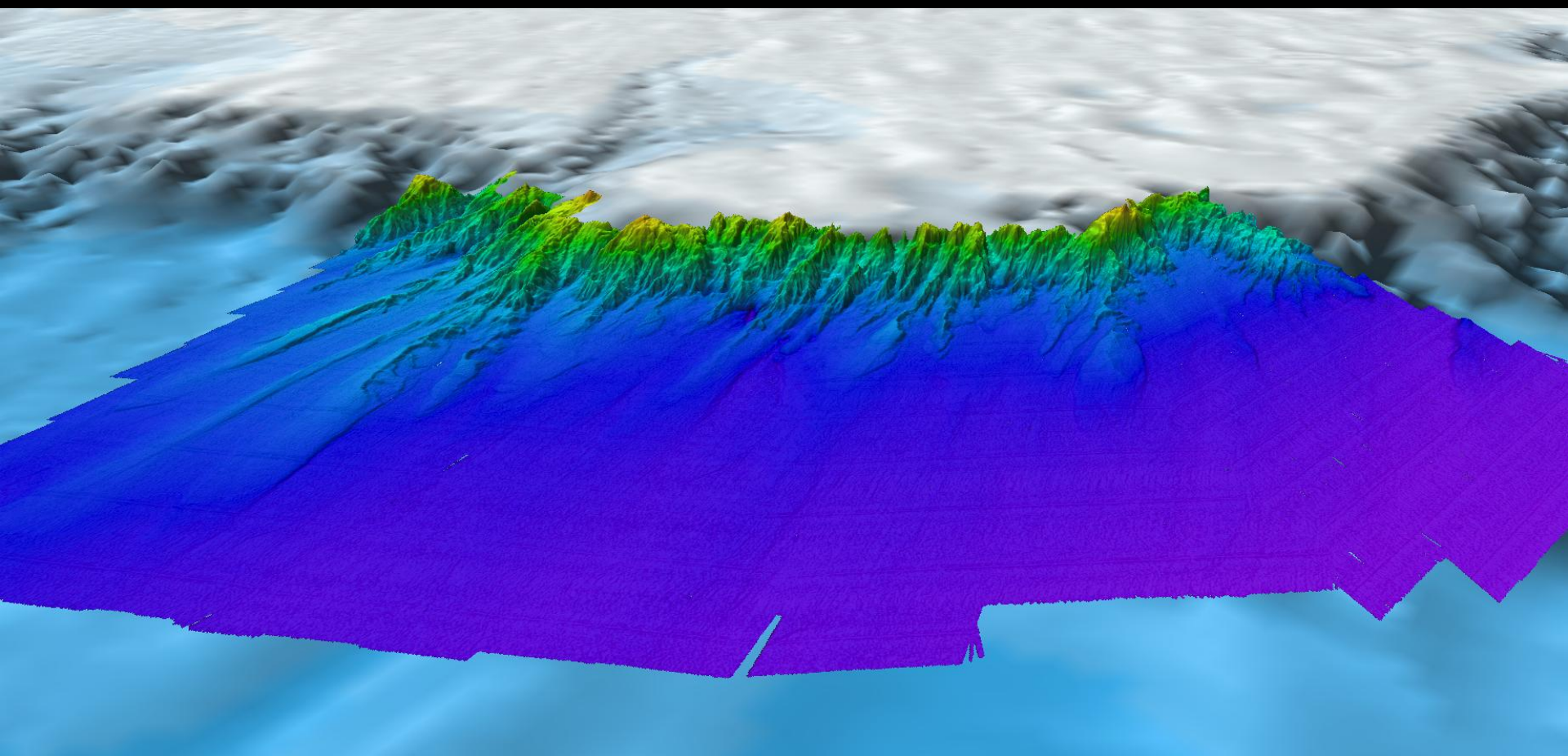
UNH CCOM-JHC U.S. Law-of-the-Sea Bathymetric Mapping to Date



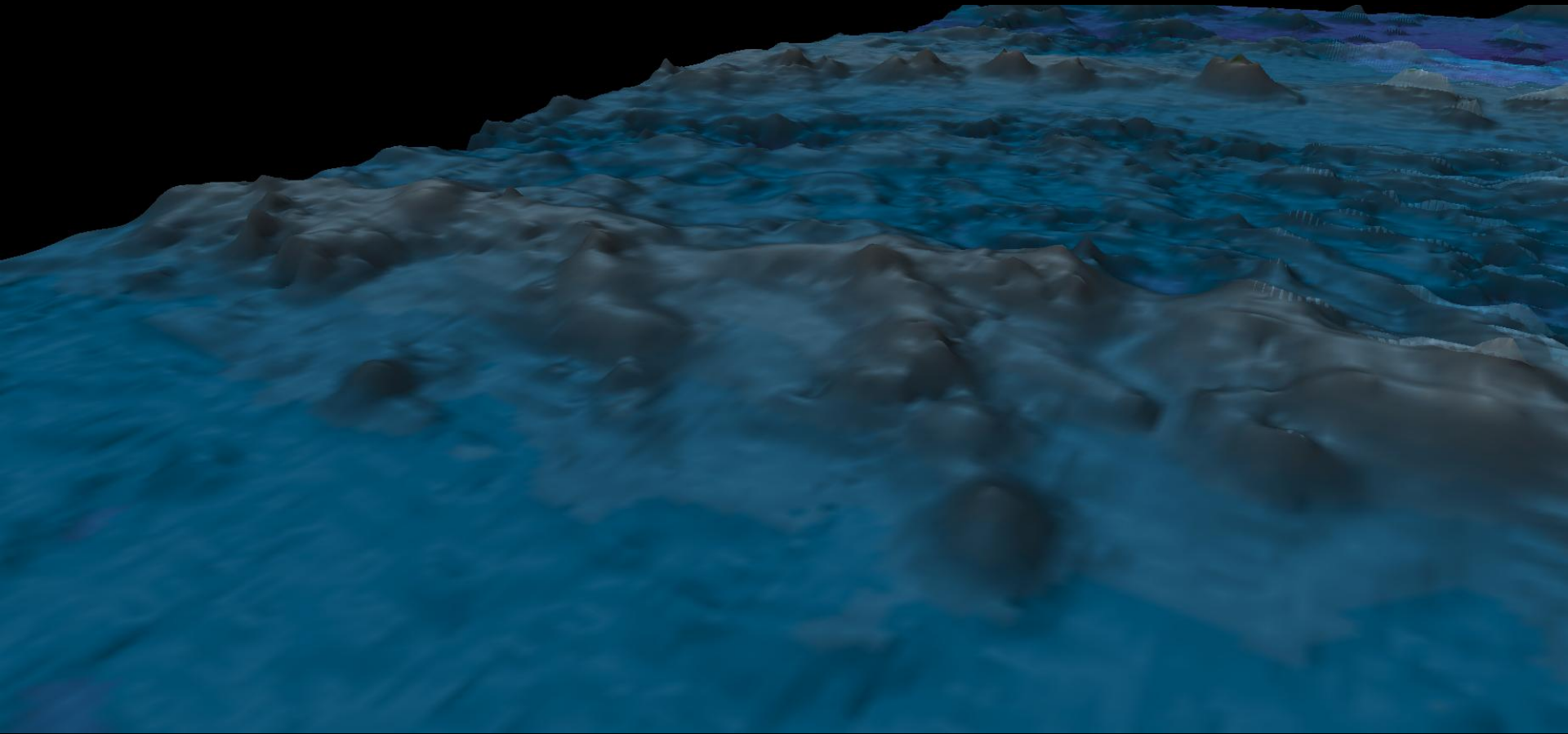
Beringian Margin



Beringian Margin

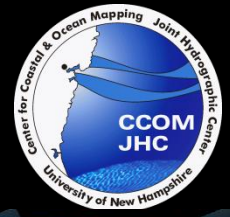


Marianas

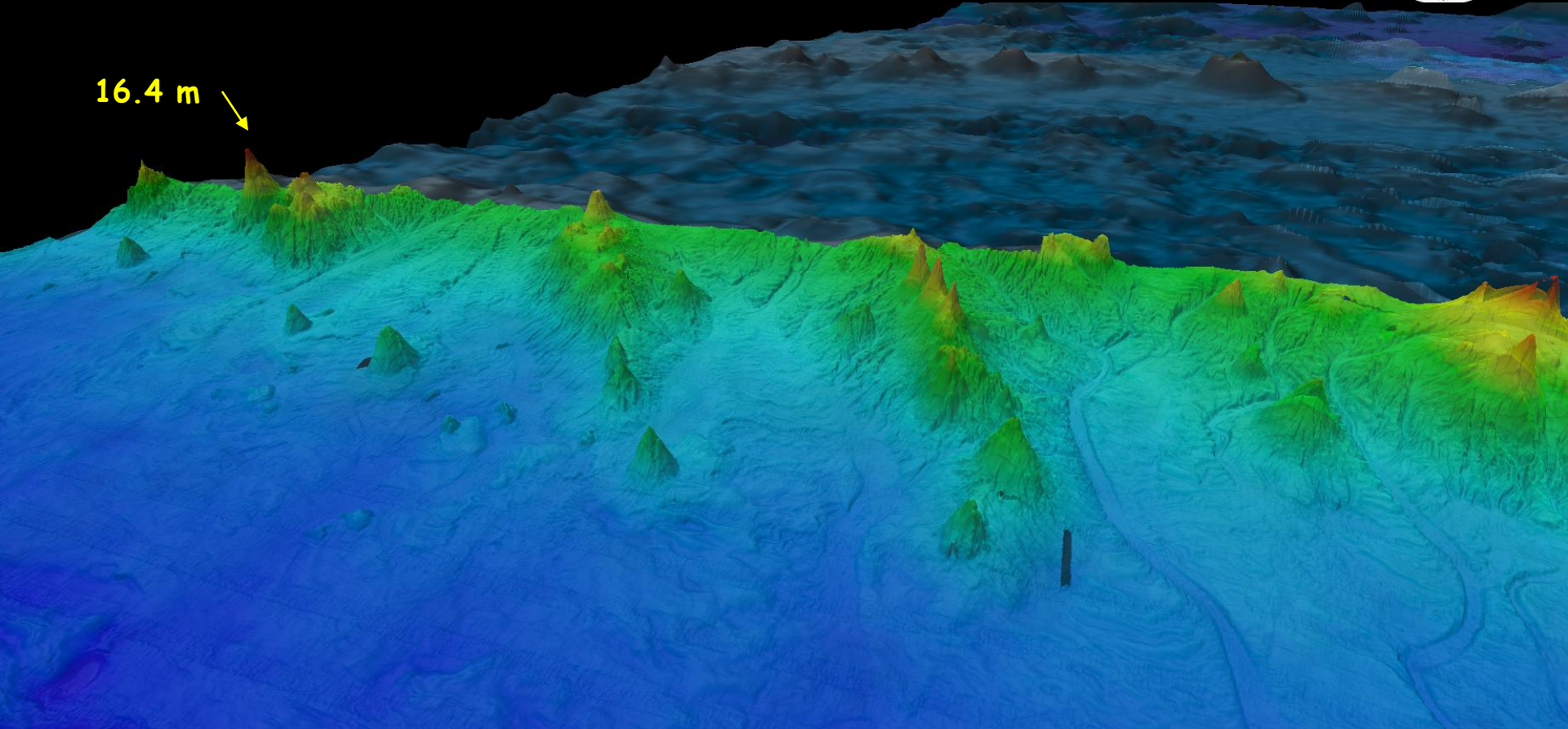




Marianas



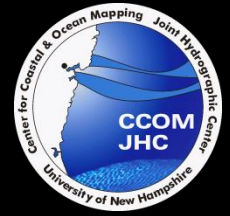
16.4 m



10 seamounts < 500 m

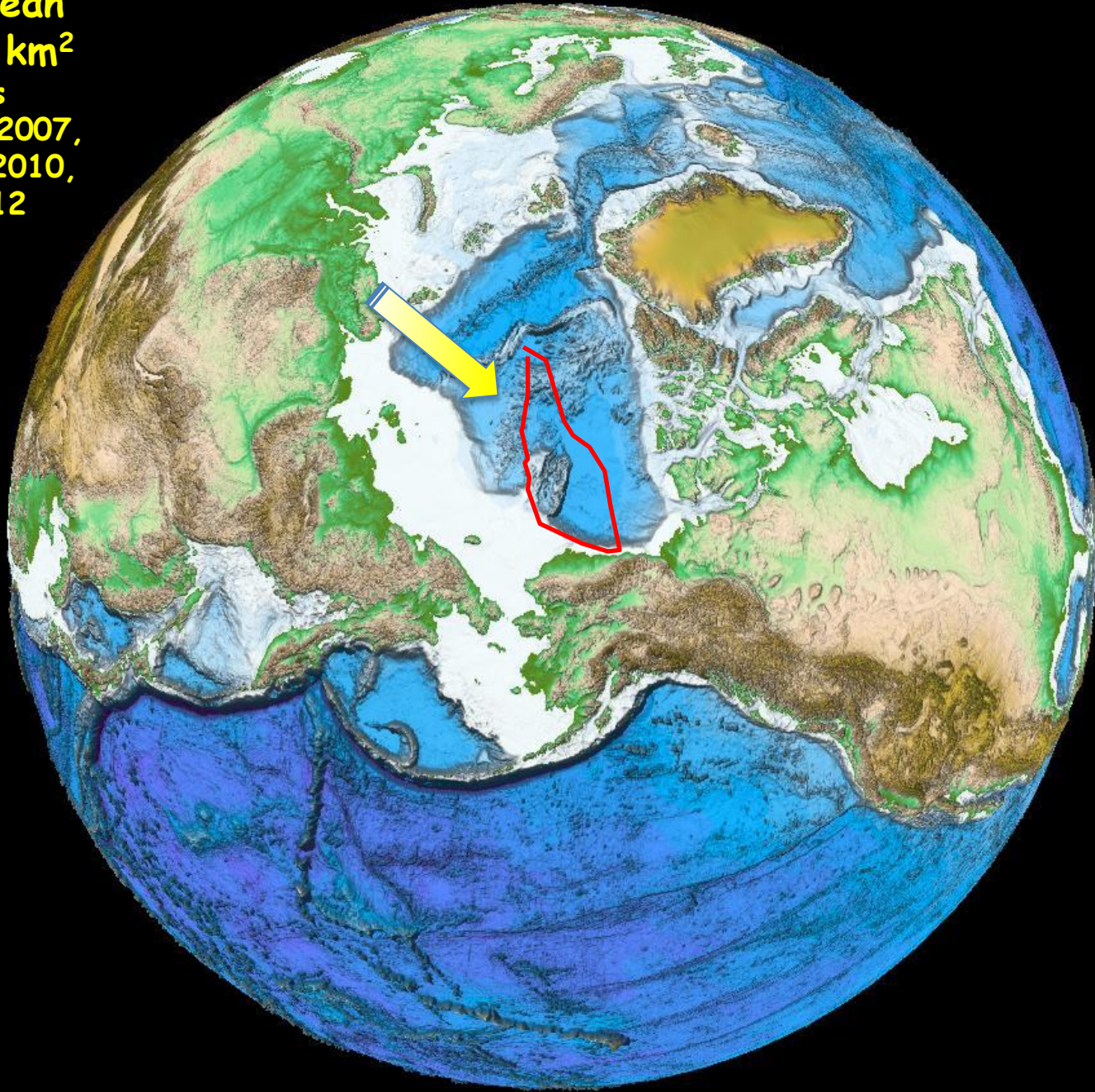


USS San Francisco (SSN 711) - in drydock after hitting uncharted seamount



<http://www.freerepublic.com/focus/f-news/1330034/posts?page=515>

Arctic Ocean
~420,000 km²
9 cruises
2003, 2004, 2007,
2008, 2009, 2010,
2011, 2012



Four Canadian - U.S. Joint Cruises in Arctic



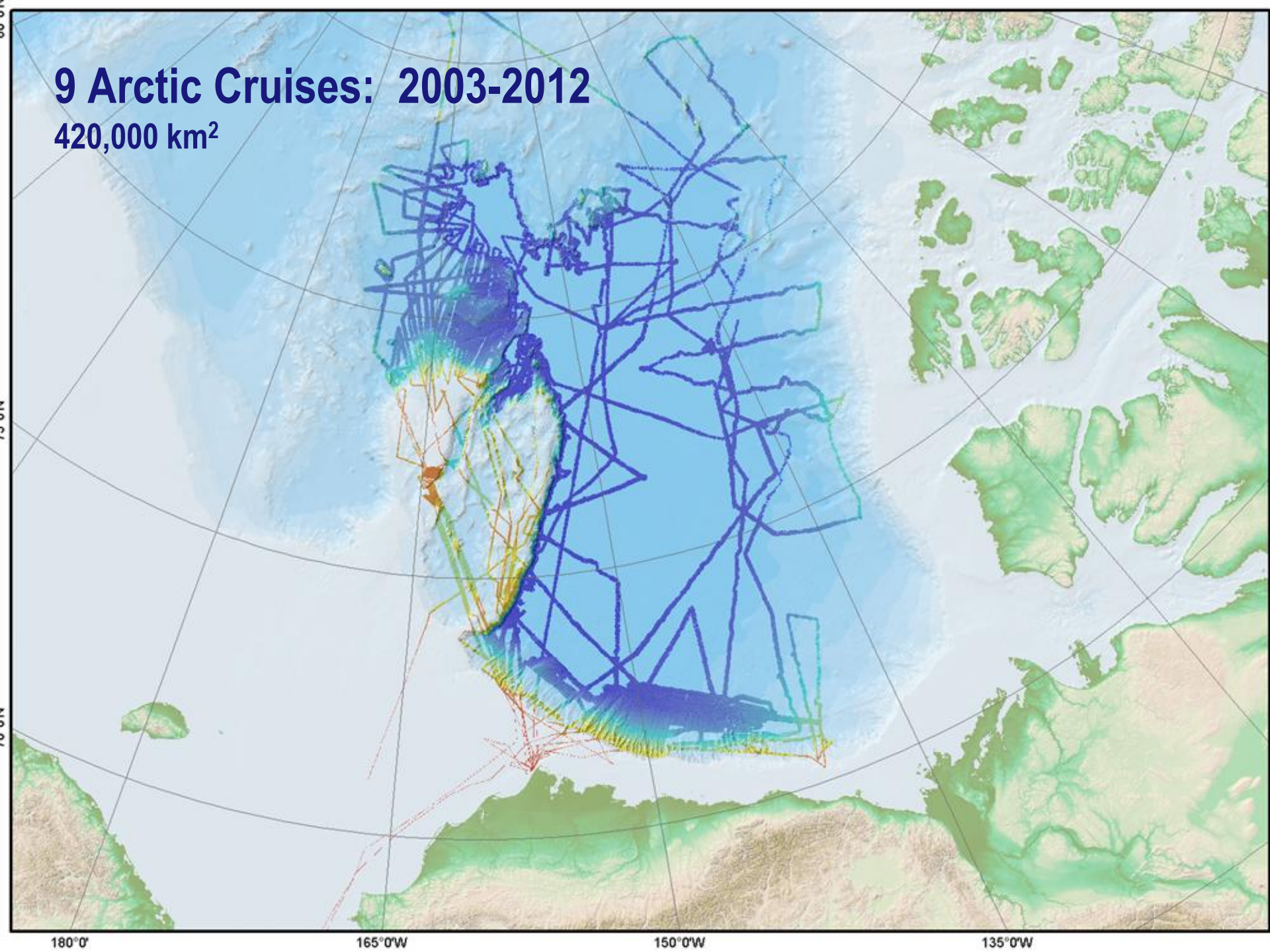
CCGS Louis S. St-Laurent



USCGC Healy

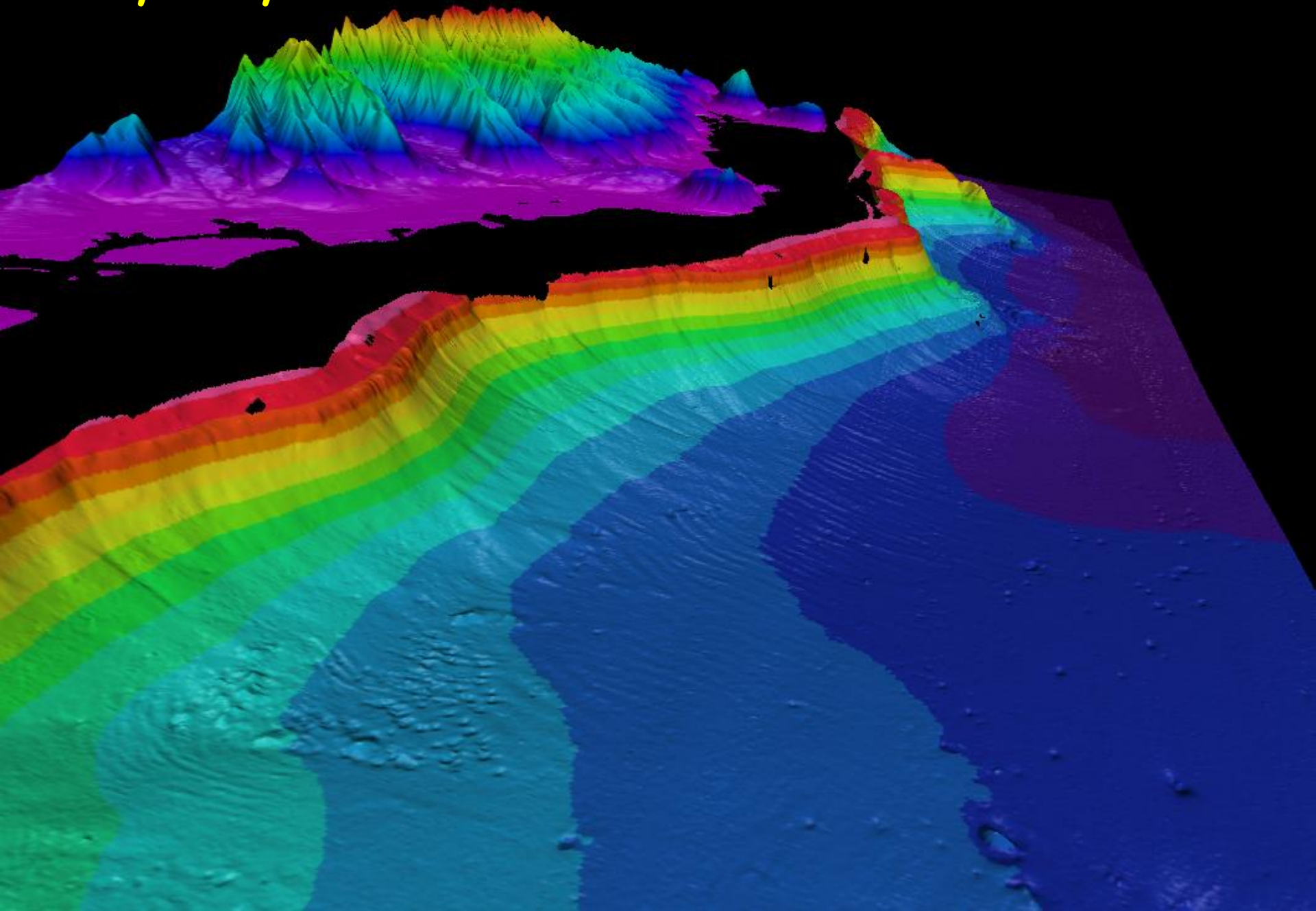
9 Arctic Cruises: 2003-2012

420,000 km²



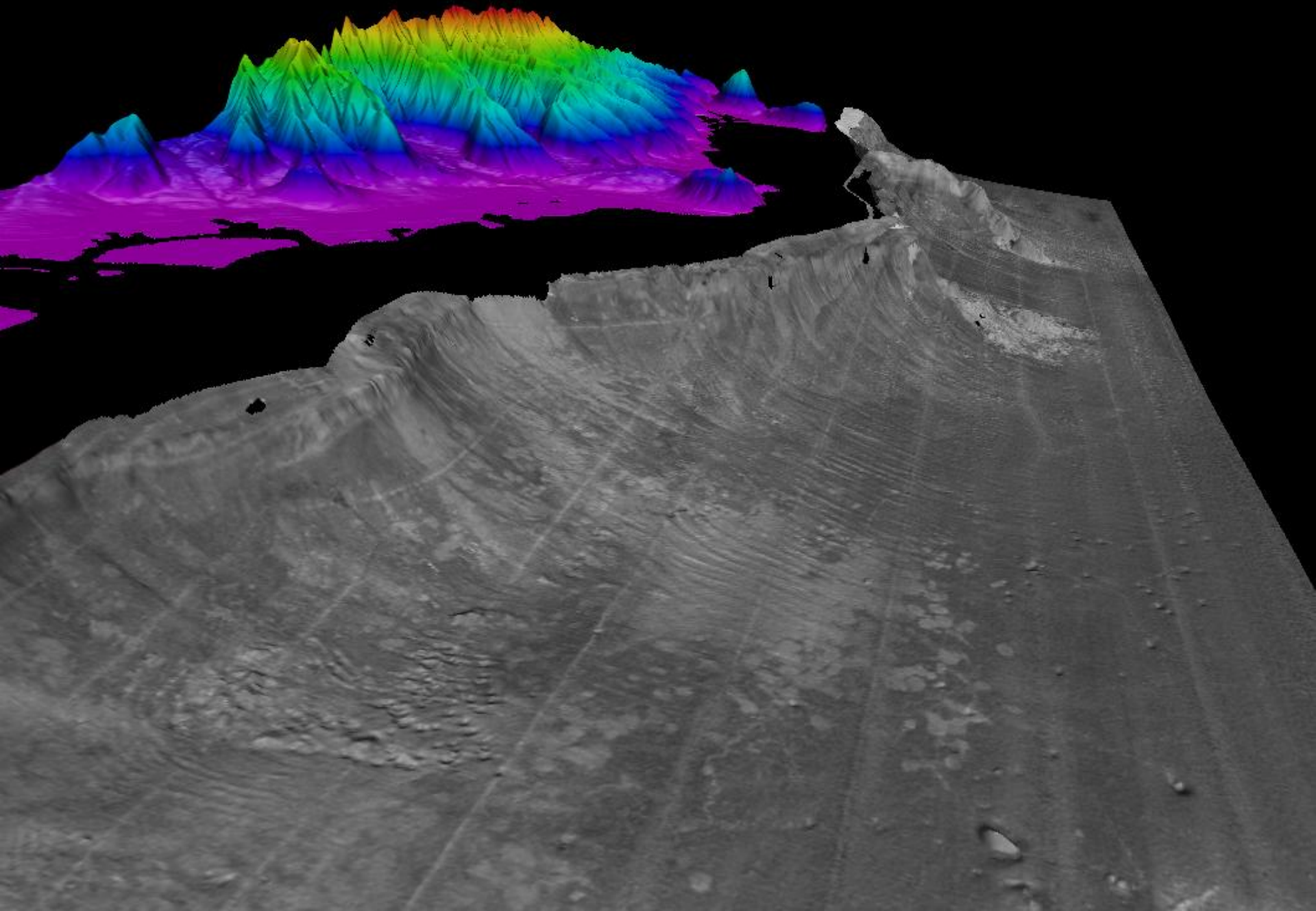
Bathymetry

From Where?

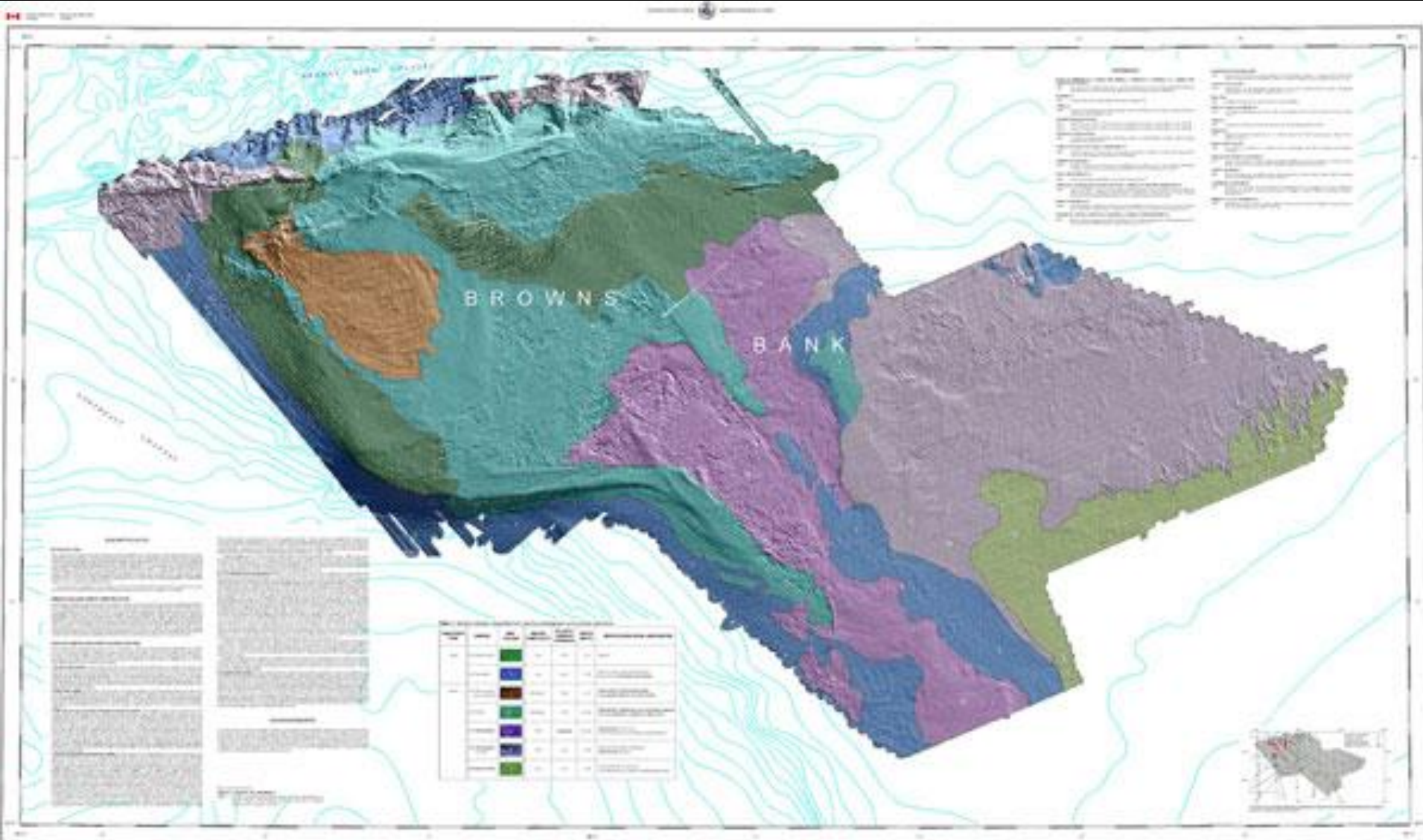


Seafloor Backscatter

To What?

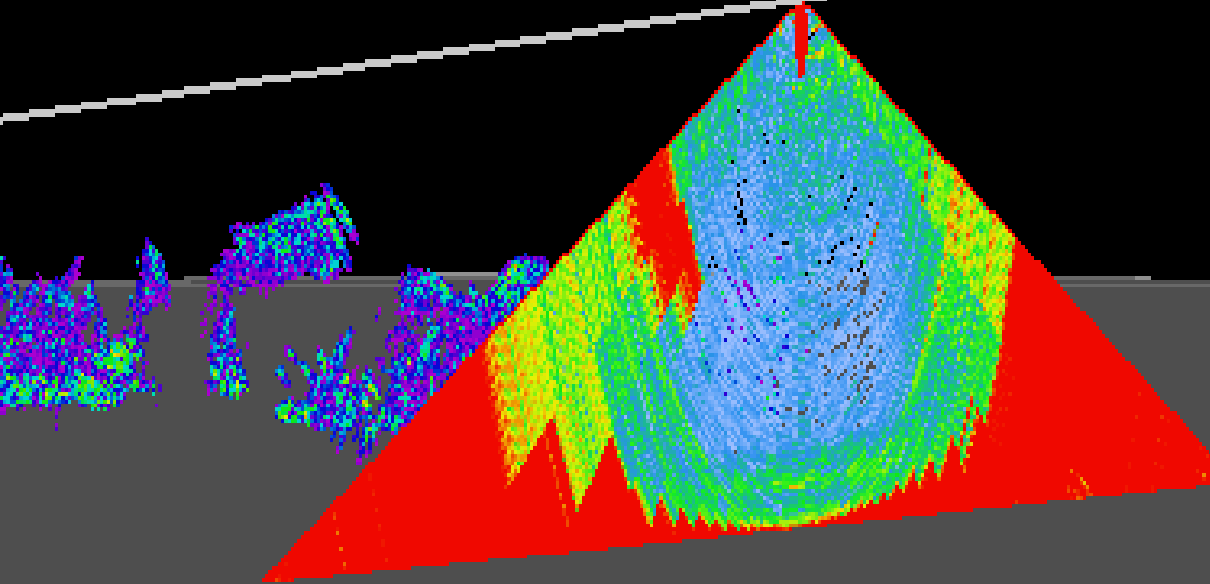


Seafloor Backscatter -- Habitat Mapping...



From Geological Survey of Canada

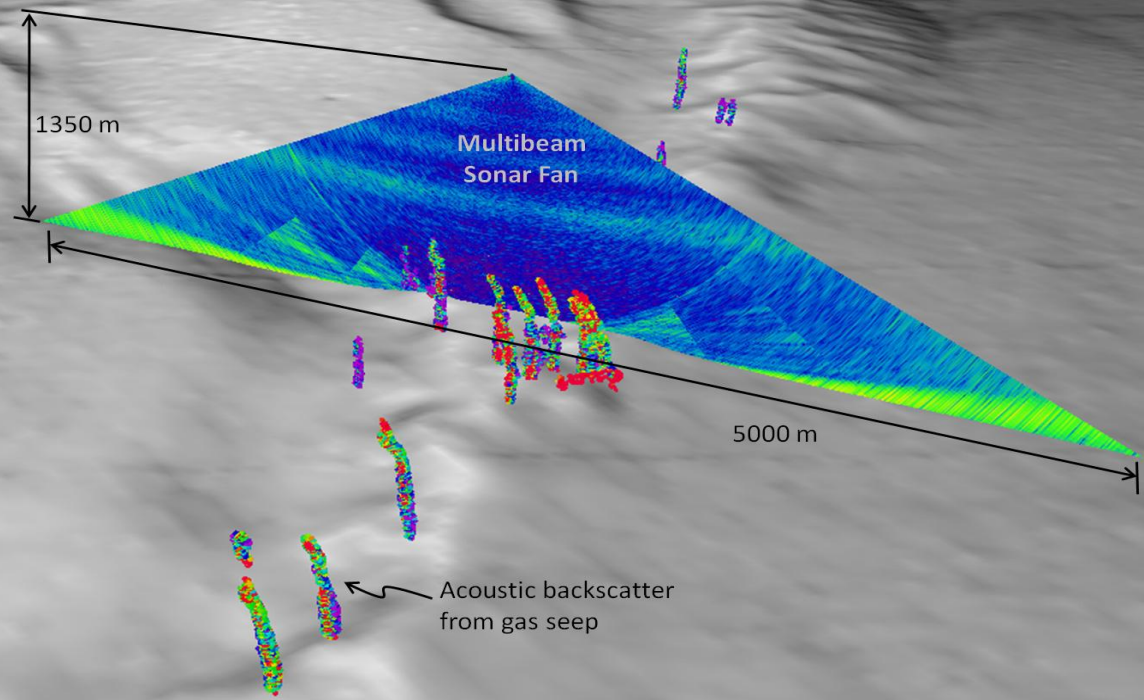
WATER COLUMN MAPPING



Pollock

Water Column Mapping:

Global Methane Fluxes

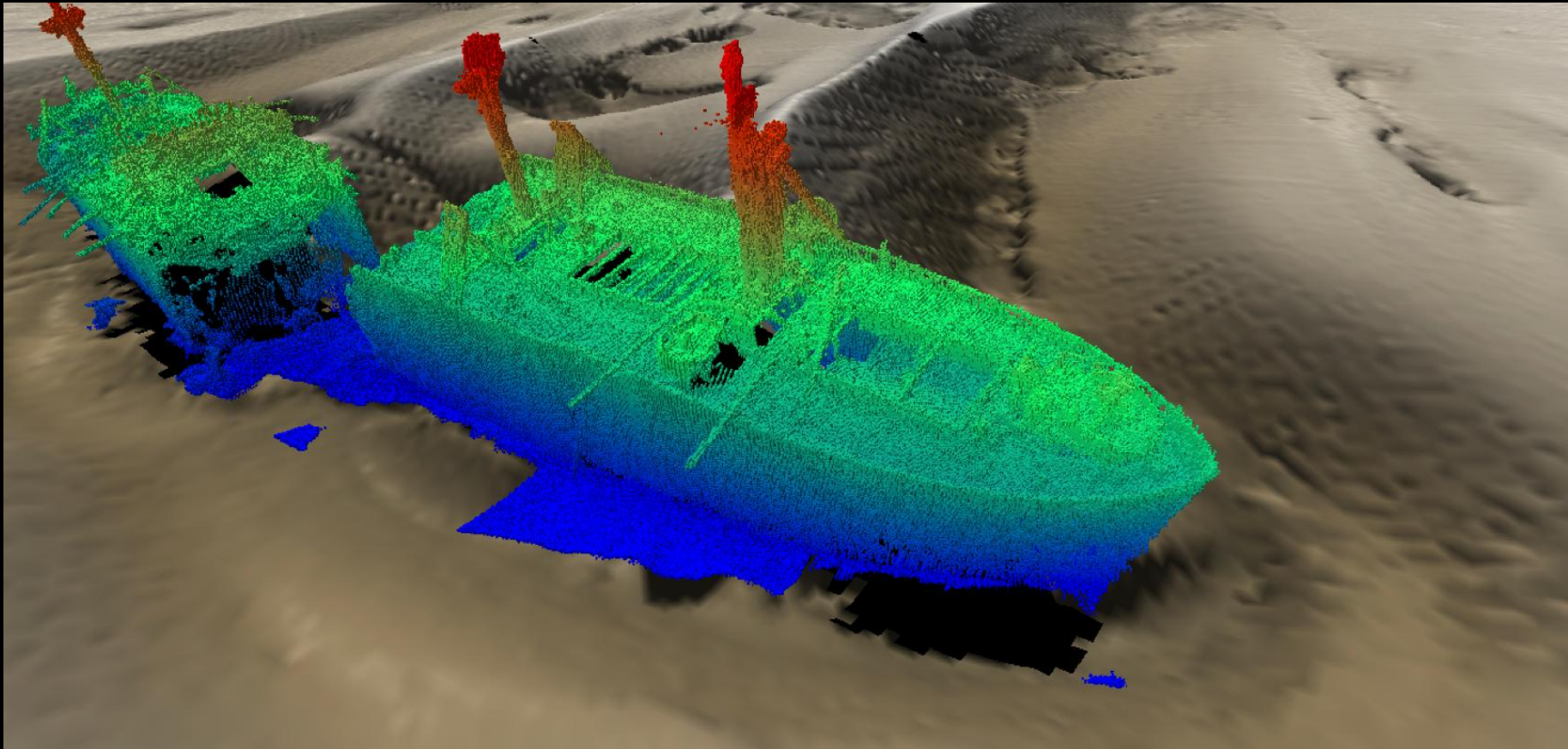


Gas Seeps

Tom Weber

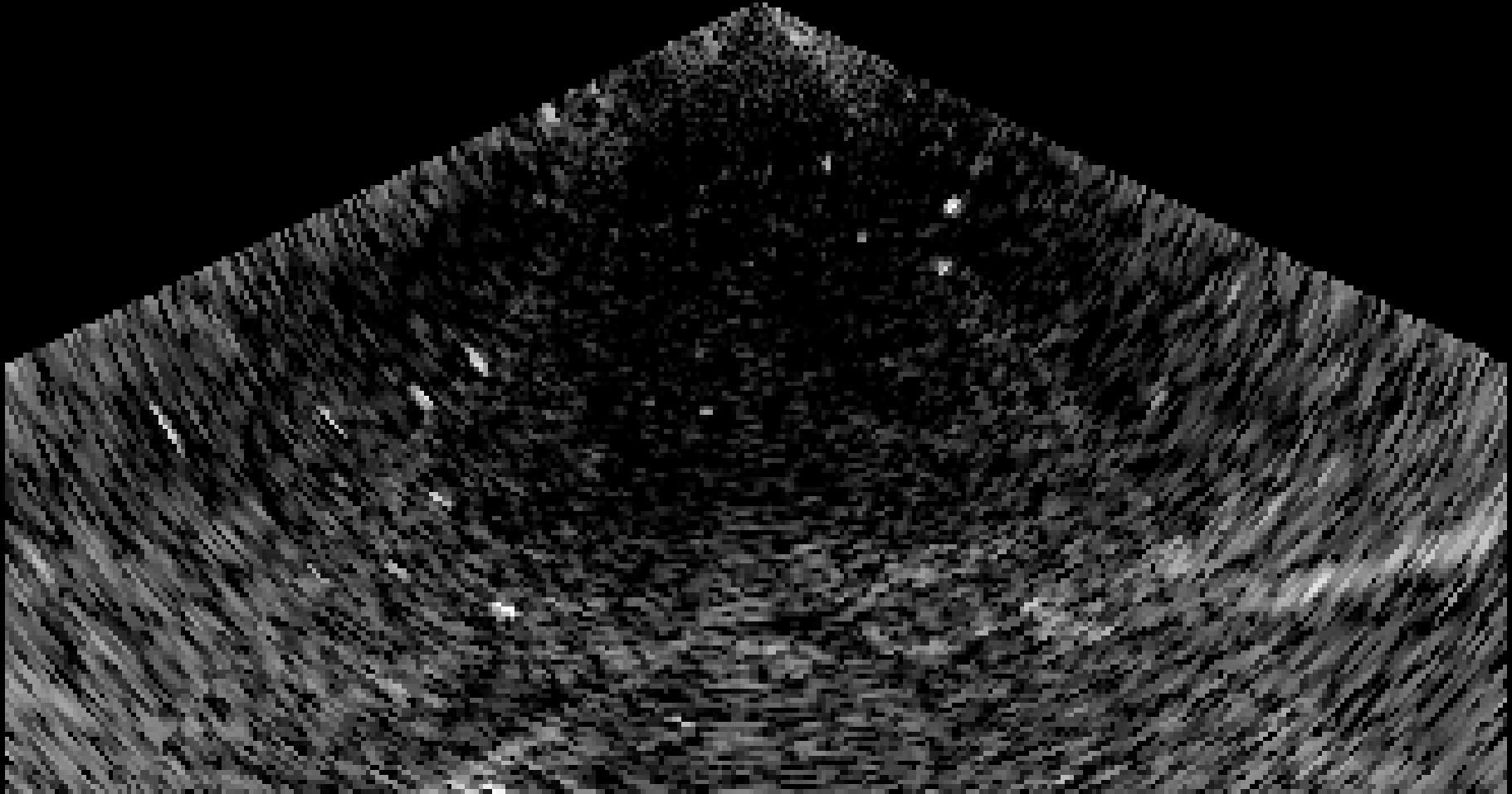


MID-WATER MAPPING FOR WRECK IDENTIFICATION



Duncan Mallace and the Port of London

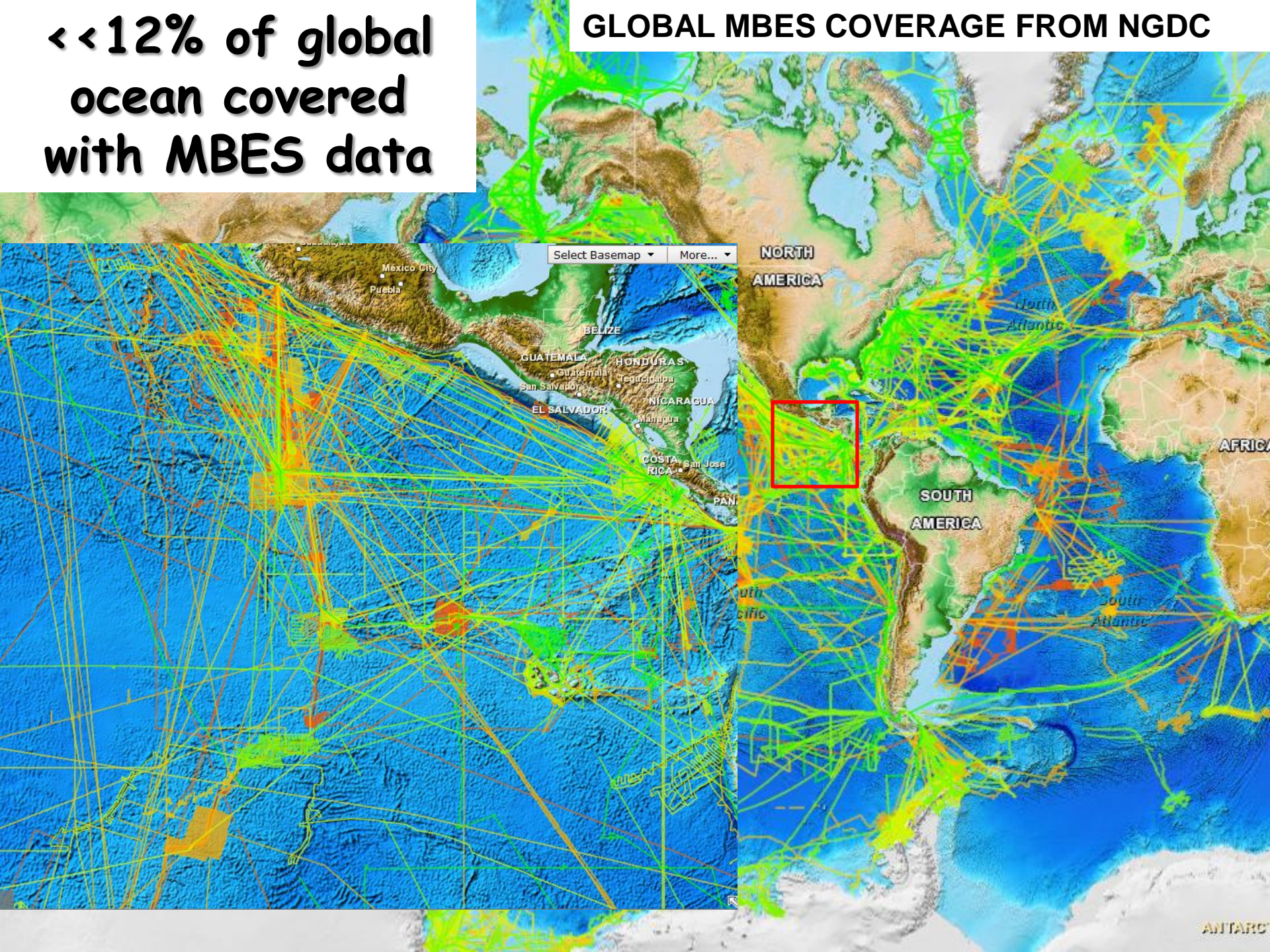
PHYSICAL OCEANOGRAPHY - internal waves, pycnoclines...



(Rob Hare, John Hughes Clarke and
Jonathan Beaudoin)

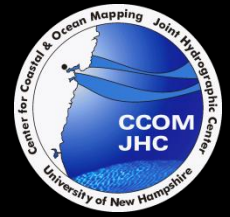
<<12% of global
ocean covered
with MBES data

GLOBAL MBES COVERAGE FROM NGDC





We've been at this for 40 years and still only about 12% of deep ocean has been mapped with MBES - **Why?**

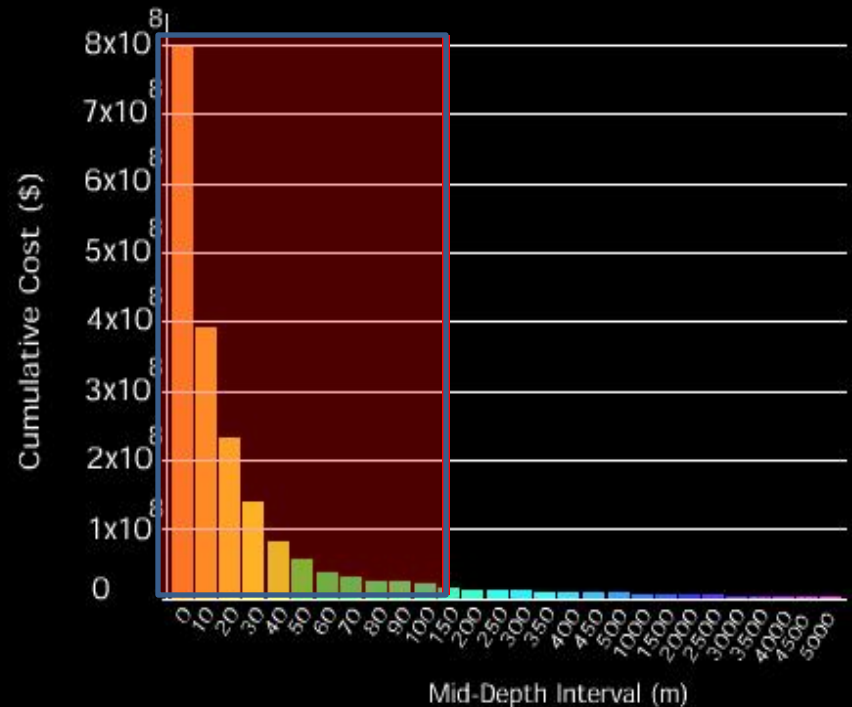
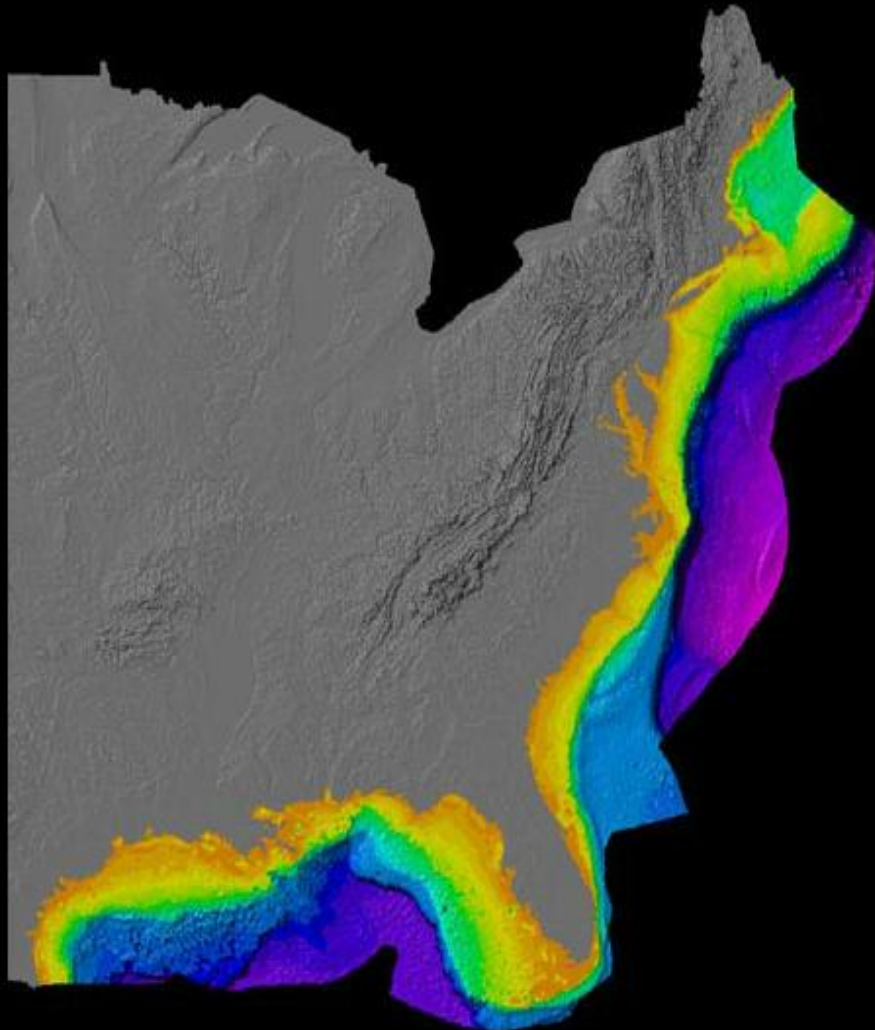


- Physics - tradeoffs between propagation, resolution and system size
- Belief that deep ocean is boring and uninteresting
- **Cost** - systems are not cheap - shiptime even more costly

**HOW MUCH WOULD IT COST TO
MAP THE ENTIRE WORLD OCEAN
WITH MULTIBEAM SONAR?**

IGNORE SHALLOW WATER

Cumulative Cost of Surveying Atlantic and Gulf EEZ with Multibeam vs Depth

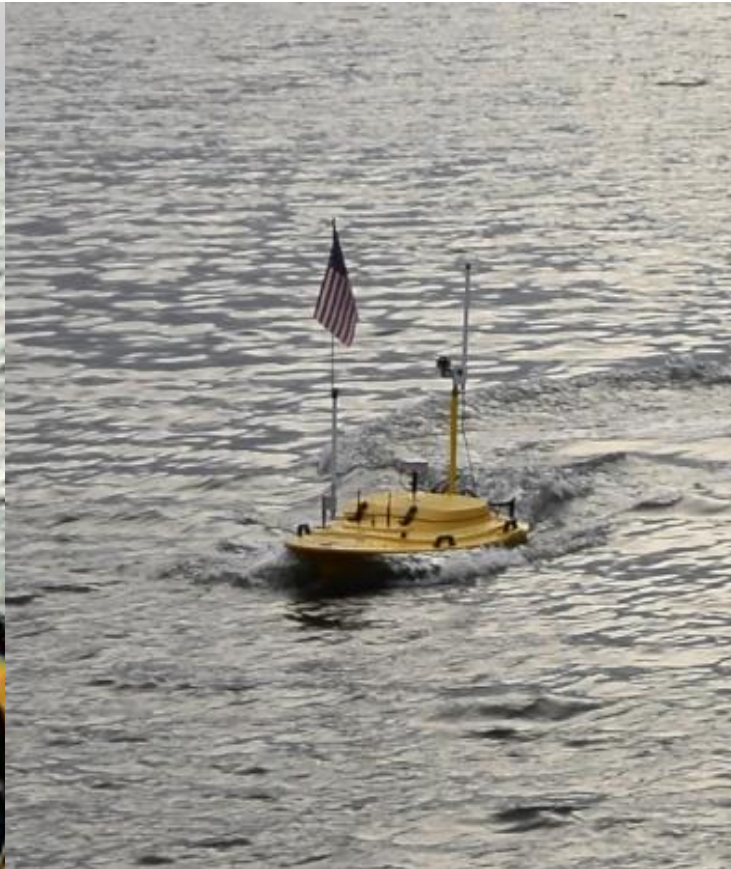


SHALLOW WATER MAPPING

Autonomous Surface Vessels



C-Worker
ASV Global

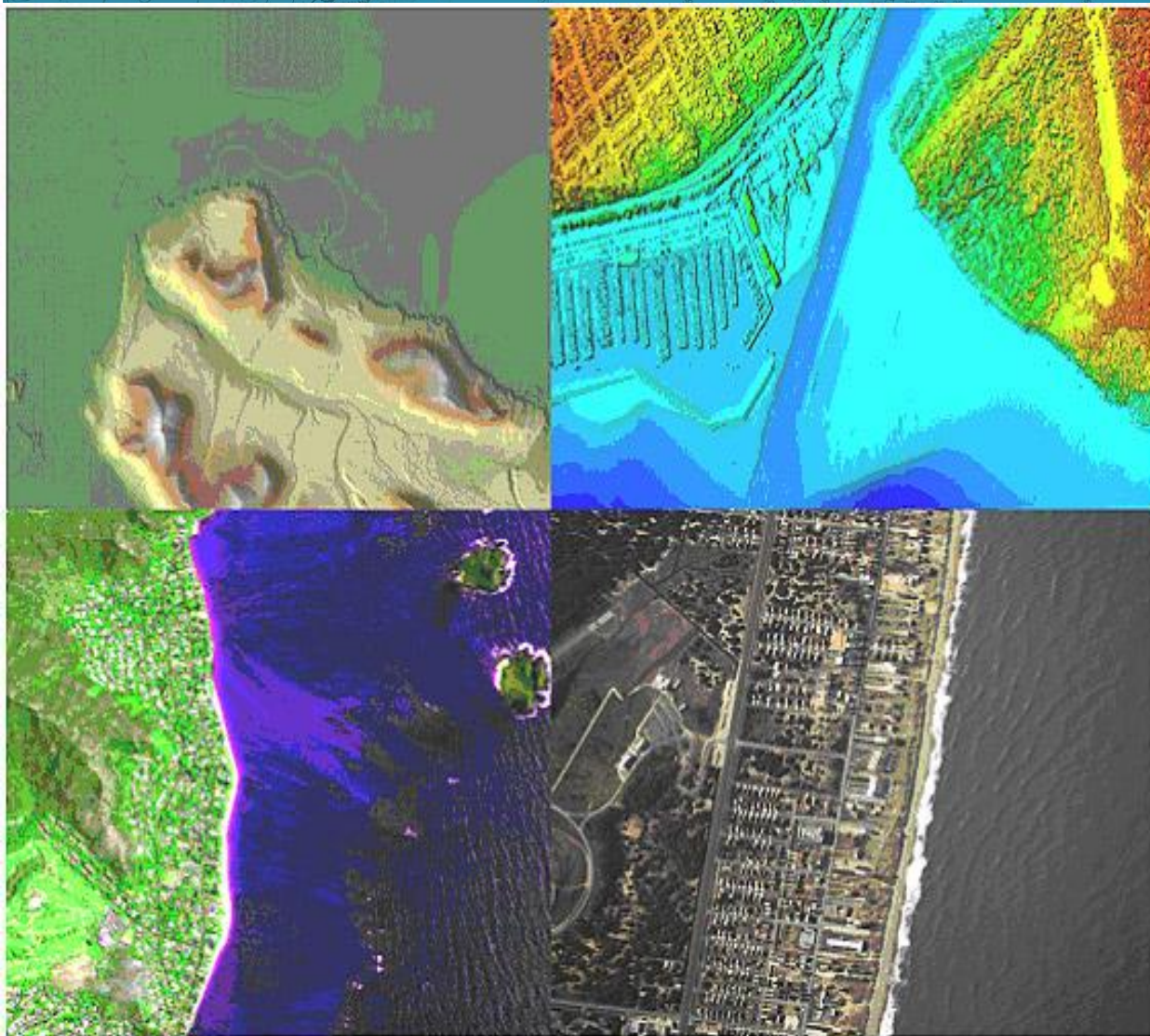
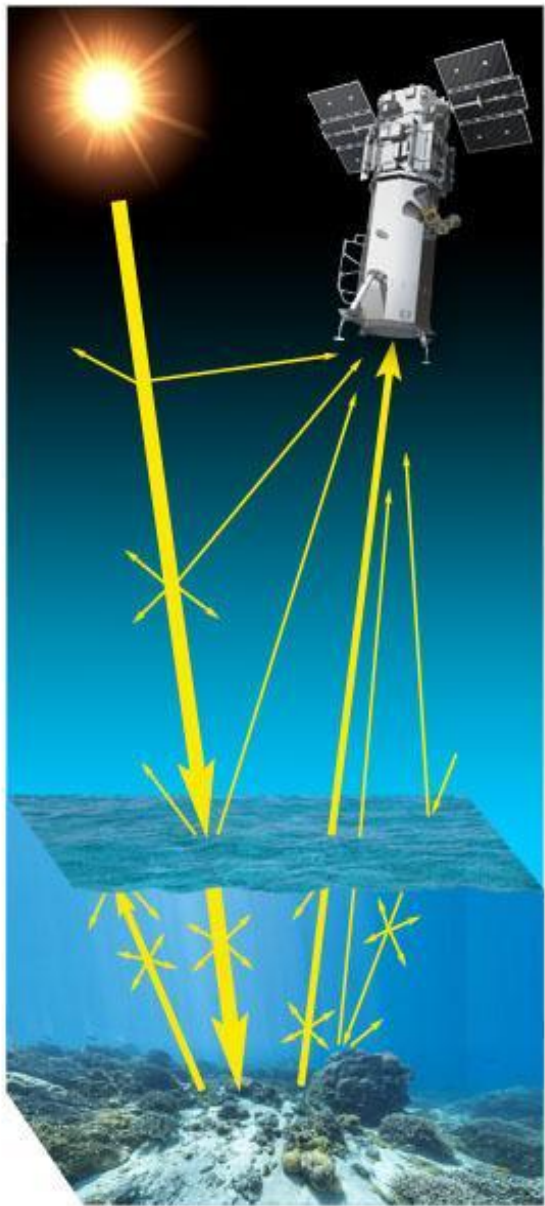


Teledyne Oceansciences
Z-Boat



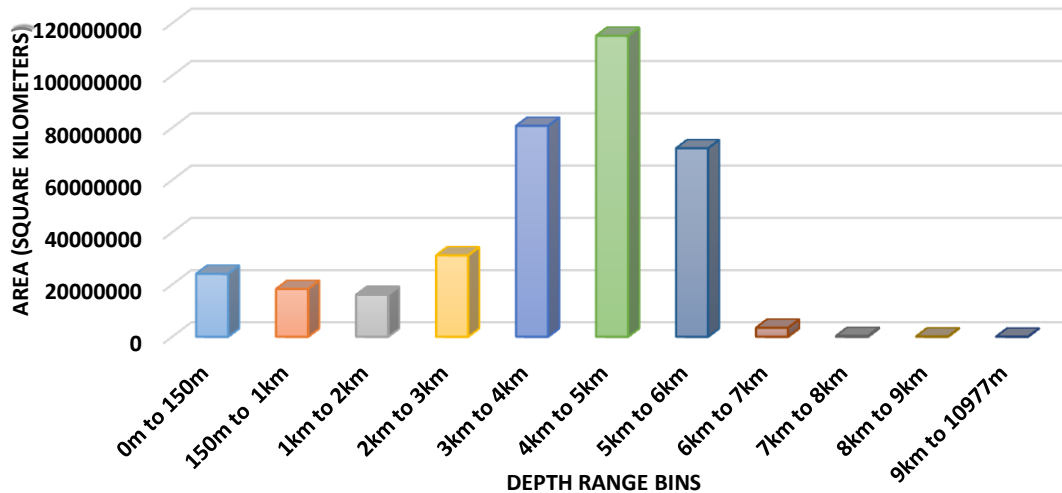
Hydronaulix
"EMILY" Boat

SHALLOW WATER MAPPING



MAPPING THE WORLD OCEAN WITH MBES (94%)

GEBCO 2014 Depth Distribution



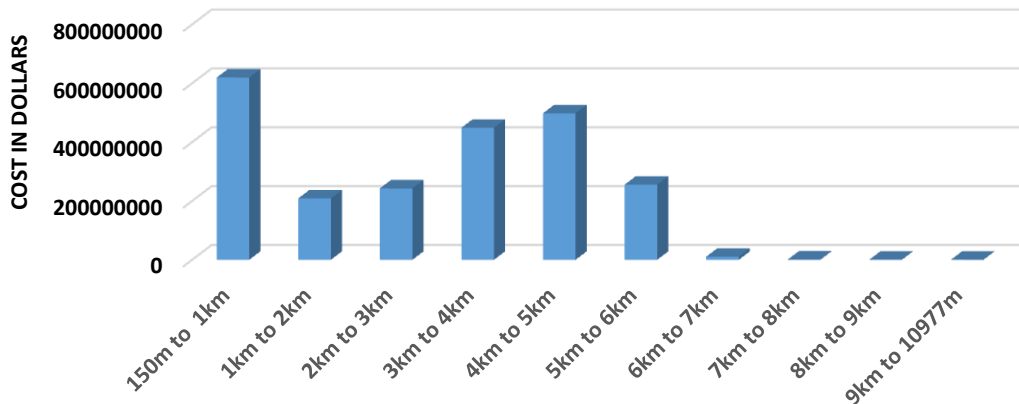
Assuming:

>150 m!

4x swath width
10 knots

Number of Days:
65,246

COST OF MAPPING WORLD OCEAN >150 m

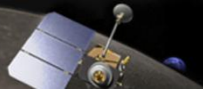


Ship Cost:

\$45,000/day

Total Cost:

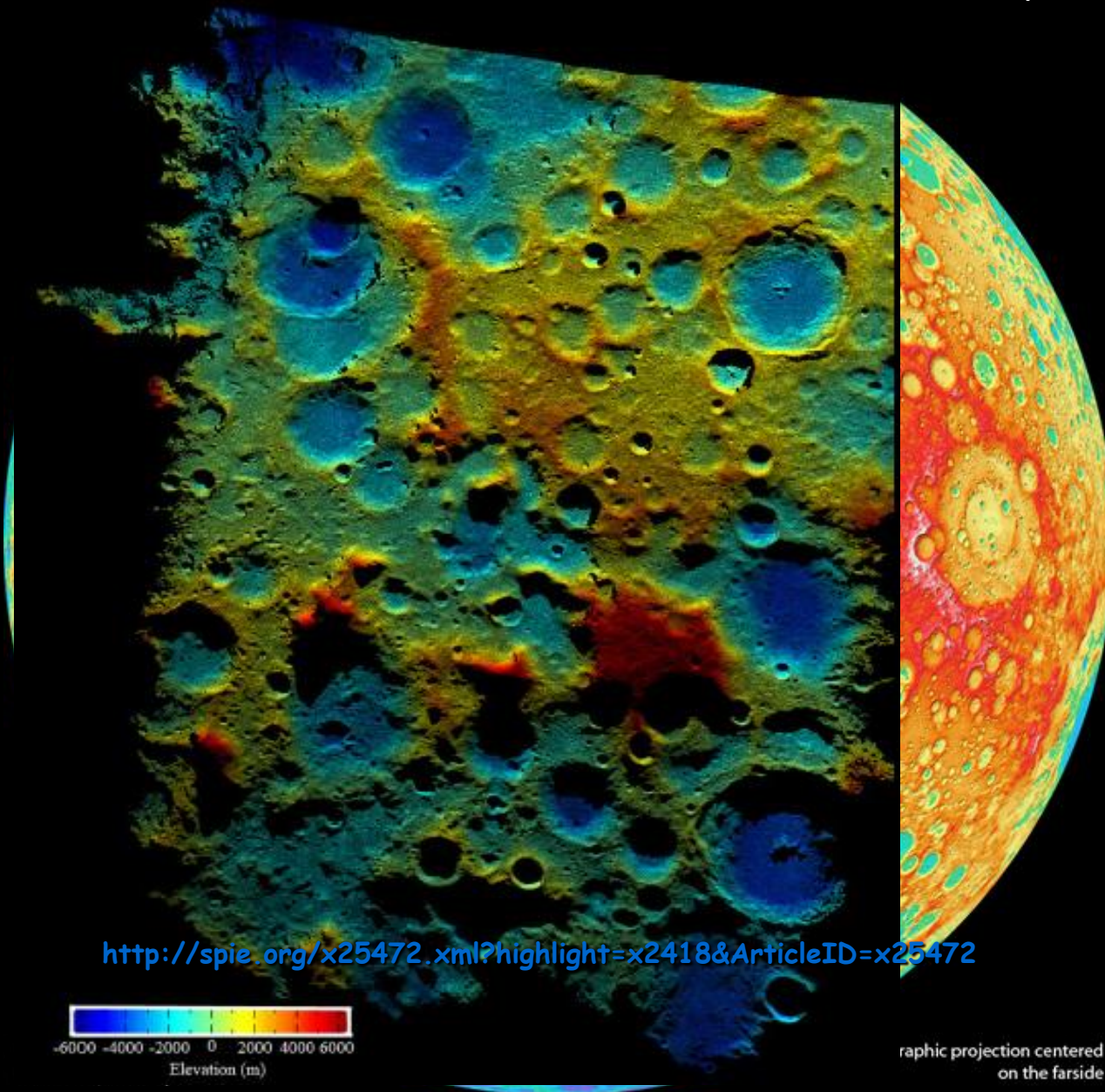
\$2.94 Billion



THE MOON

100m pixel resolution

~\$600M

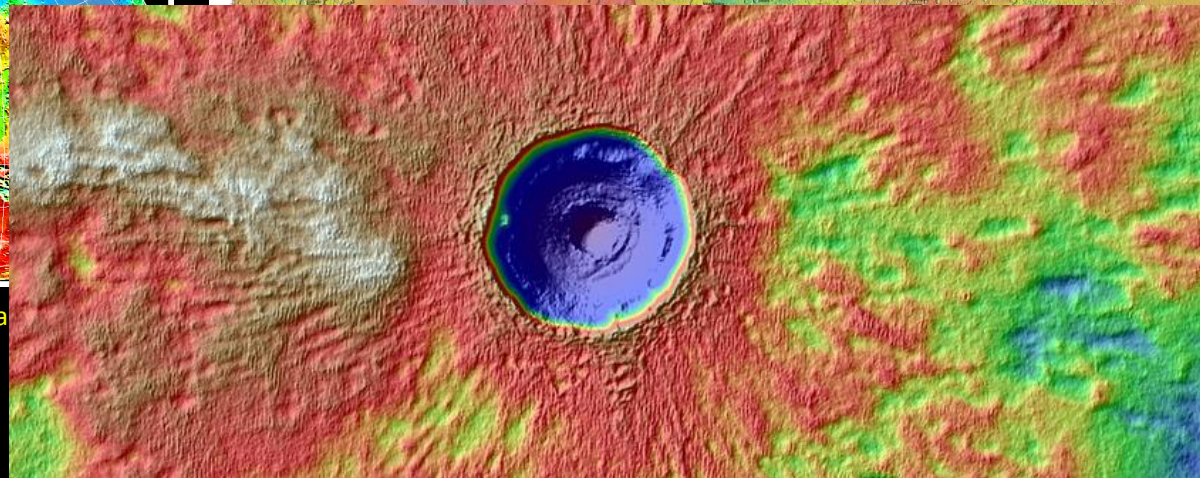
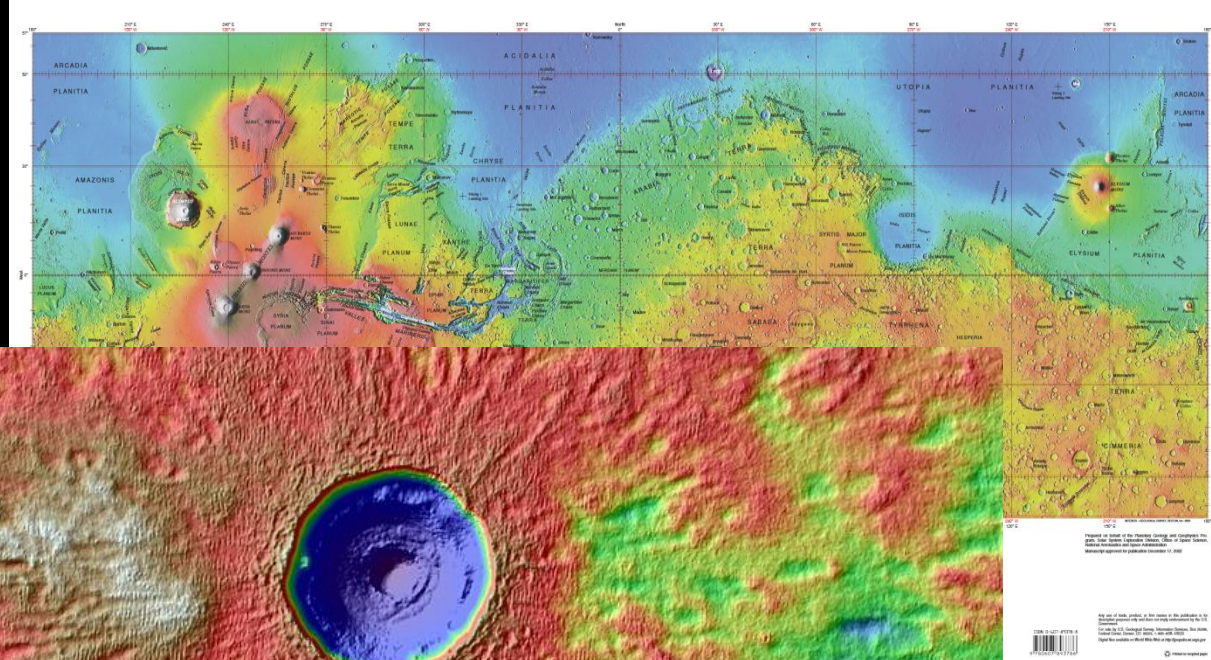
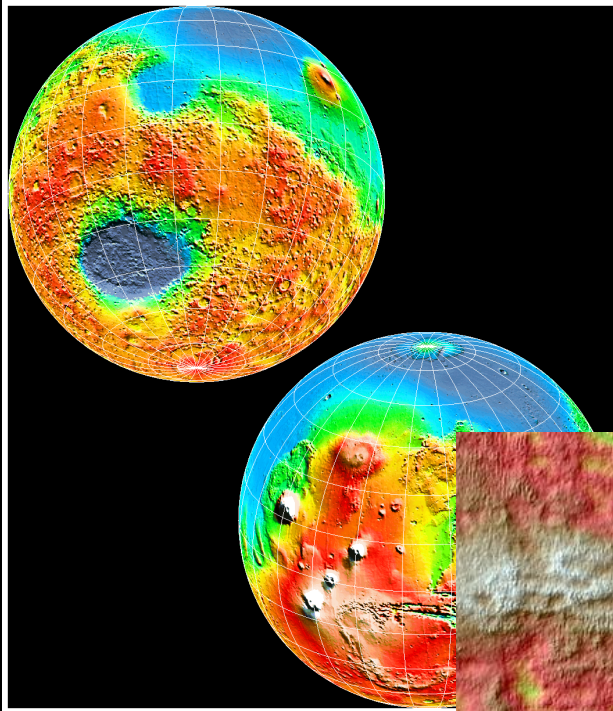


<http://spie.org/x25472.xml?highlight=x2418&ArticleID=x25472>



graphic projection centered on the farside

TOPOGRAPHY OF MARS



http://tharsis.gsfc.nasa.gov/global_pa

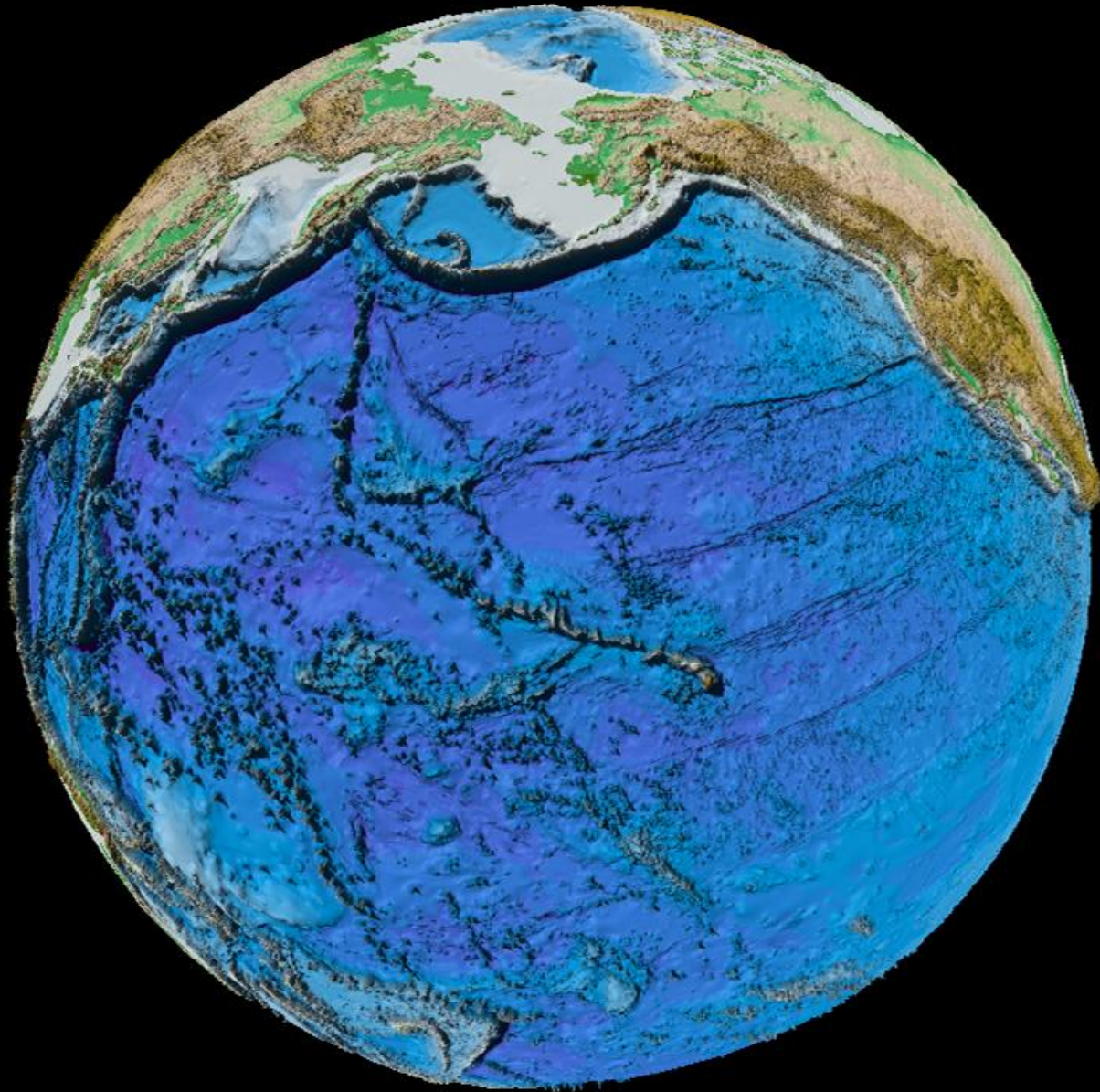
HIRISE Imagery NASA/JPL/UAriz/USGS

<http://www.uahirise.org/dtm>

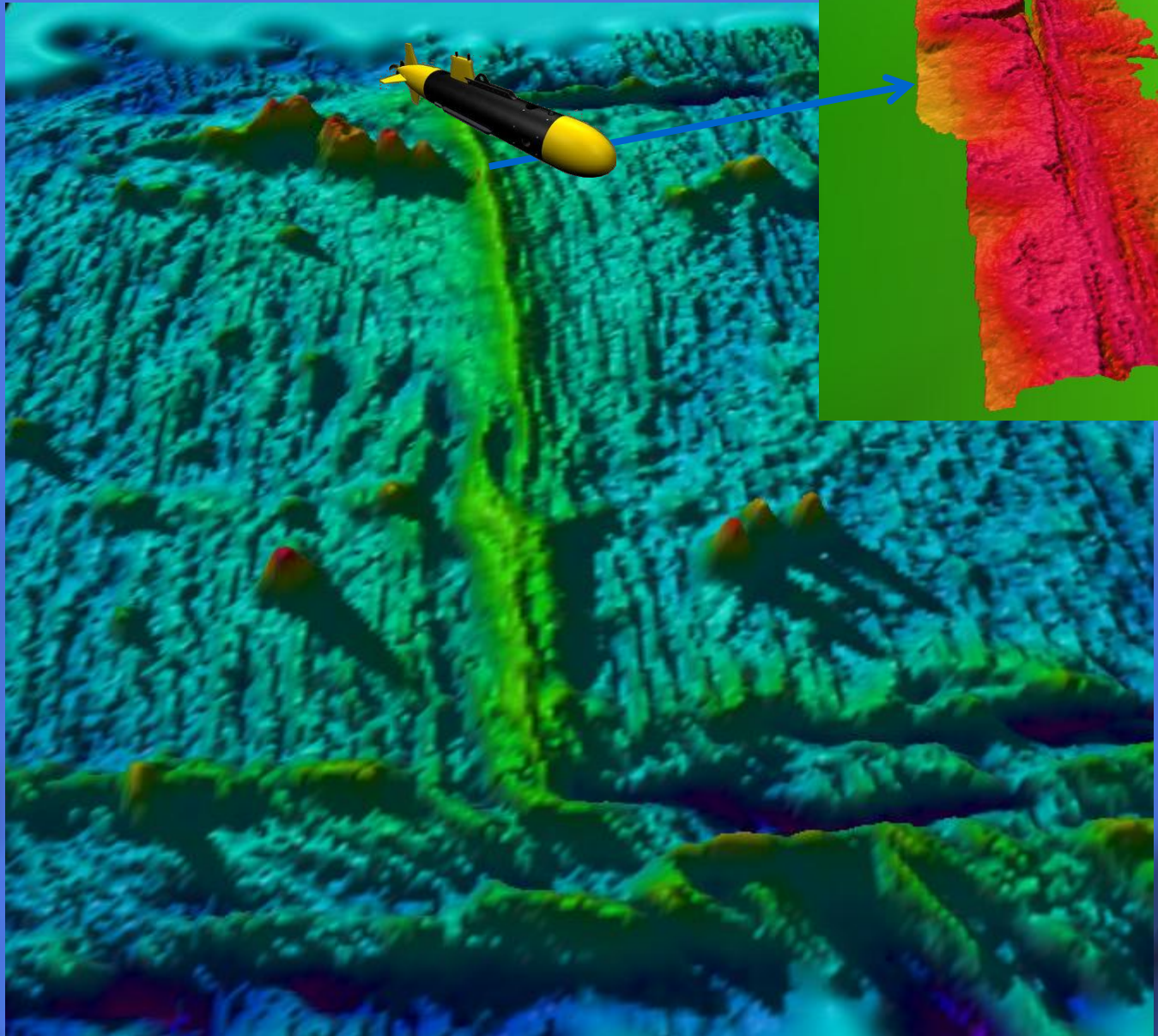
1 m DTMs

2-3 B\$

And
Earth?



And
Earth?

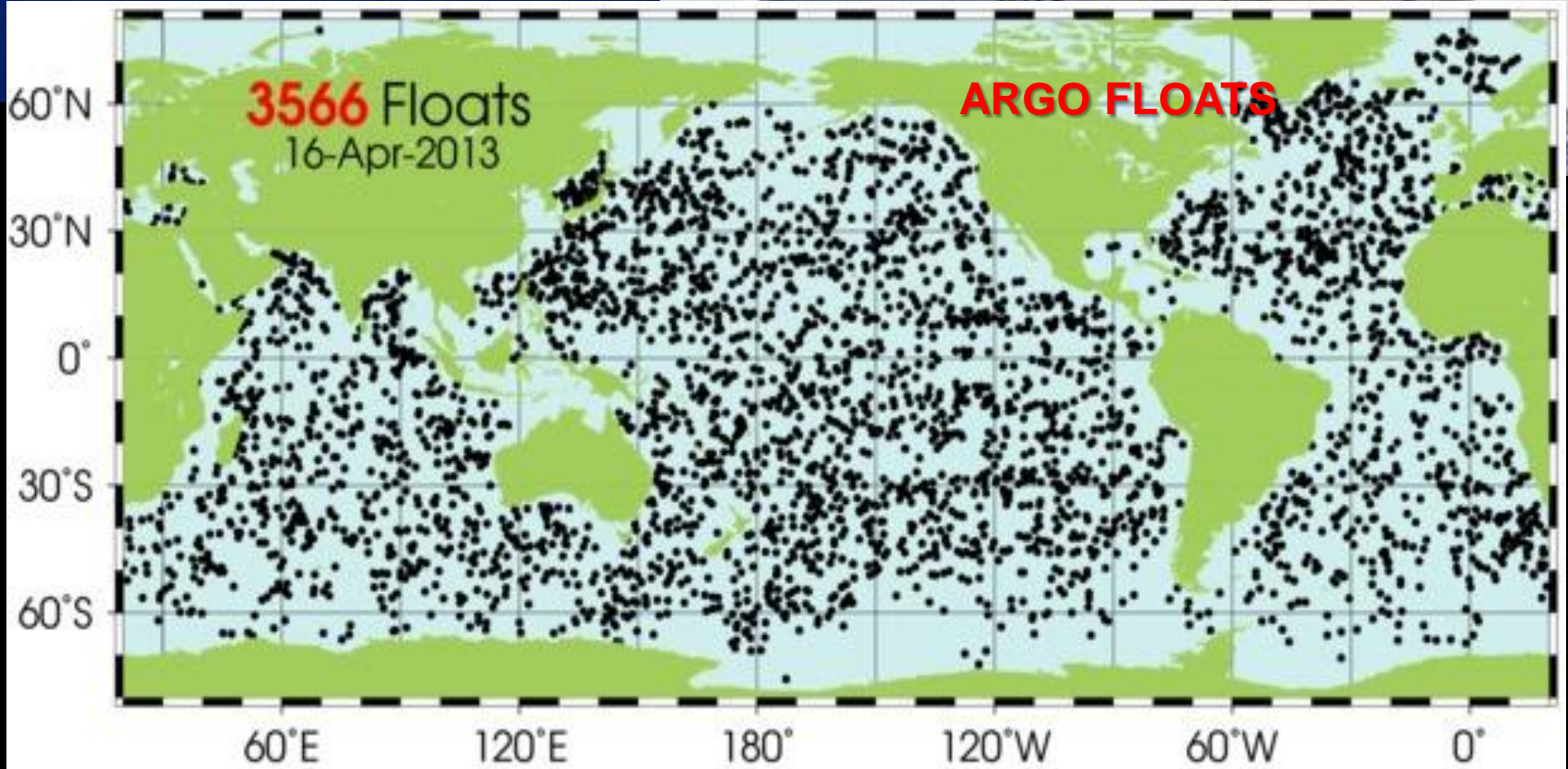


GLIDERS



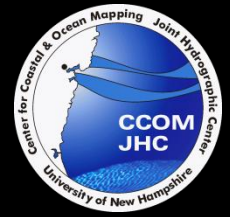
HOW?

**SURFACE
VESSELS**



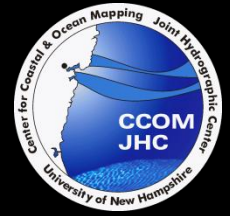


MULTIBEAM BARGE





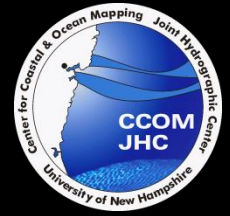
MULTIBEAM BARGE



**30 m x 15 m long array → 17 x 34 m resolution
in 4000 m water**



MULTIBEAM BARGE

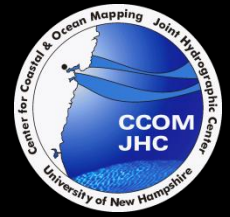


30 m x 15 m long array → 17 x 34 m resolution
in 4000 m water

remotely operated via telepresence



MULTIBEAM BARGE



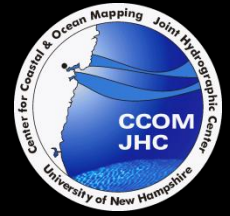
**30 m x 15 m long array → 17 x 34 m resolution
in 4000 m water**

remotely operated via telepresence

Other remote measurements (atmosphere, ocean, etc)

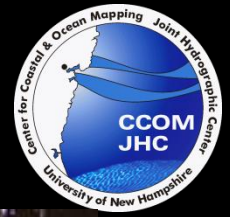


MULTIBEAM BARGE



30 m x 15 m long array → 17 x 34 m resolution
in 4000 m water

~1/3 the cost of a research vessel



XPRIZE
Making the Impossible **POSSIBLE**



THE BEGINNING



**There is so much more to map
and explore!**

