Seafloor Mapping in the High Arctic:
The Challenges and the Joys

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A geospatial context for our studies of Arctic change

Nansen 1907
1893-1896
8 soundings
Fletcher's Ice Island (T-3)
1962 - 1974
LOREX - 1979

Hydro-Hole

Echo sounder

Positioning
Airborne Measurements and Point Soundings

Gravity Measurement

Magnetometer

Depth Sounding
CHS & GEBCO
(1967, 1968, 1979)
Data from Nuclear Submarines

SCICEX (1993-1997)

http://www.ldeo.columbia.edu/res/pi/SCICEX/

COMPOSITE SCICEX TRACKS

Sidescan Swath Bathymetric Sonar Pod (SSBS)

High Resolution Sub Bottom Profiler Pod (HRSBP)

http://www.oceandata.com/images/11hrsbp.jpg
The Drivers

Climate Change

UNCLOS

Article 76

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.
UNCLOS Article 76

The Process

- All coastal states are entitled to a 200 nm EEZ
- A coastal state is entitled to sovereign rights over the resources of the seabed and subsoil of "submerged extensions of the continental margin" beyond their 200 nm Exclusive Economic Zone (EEZ) if....
- Demonstrate a “natural prolongation” of the coastal state’s territorial landmass
  typically broad continental shelf and/or thick sedimentary wedge
Once the natural prolongation is established the extended continental shelf beyond the 200 nm EEZ is determined by a set of formulae and limit lines defined from the:

- depth and shape of the seafloor (FOS and 2500m contour)
- the thickness of the underlying sediments (1% line)
- distances from the territorial sea baselines (350 nm line)

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

Mayer et al. 2002 U.S. Law-of-the-Sea Desktop Study

- Arctic
  - 2003
  - 2004
  - 2007
  - 2008

- Bering Sea
  - 2003

- Gulf of Alaska
  - 2005

- Marianas
  - 2006
  - 2007

- Kingman Reef
  - Palmyra Atoll
  - soon

- Atlantic
  - 2004
  - 2005
  - 2008
  - soon

- Gulf of Mexico
  - 2007

Mayer et al. 2002 U.S. Law-of-the-Sea Desktop Study
Arctic is unique as an ocean basin in that >52% is made up of shelf (geologic)
Semi-enclosed basin with five nations having potential extended shelves

From Ron McNab
Session T12

Law and Politics of Canadian Jurisdiction on the Arctic Ocean Seabed

From Durham University
Single Beam Echo Sounder
Multibeam Echo Sounder
A new perspective → new insights
Arctic - Chukchi Plateau mapping
USCGC Healy

Seabeam 2112 - 12 kHz, 121-2° receive beams
bathymetry & acoustic backscatter
Knudsen 320BR 3.5-kHz chirp profiler

UNH: bathymetry, backscatter & 3.5-kHz processing at sea
operations…………………….. 65 days
transits………………………… 24 days
average speed (in ice)..........4 kts
average sea-ice state..........9/10
tracklines…………………~24,300 km
Area mapped…………..~135,000 km²
Healy 03-02
~3000 km of multibeam sonar bathymetry
1-11 Sept 03
8/10 ice
typical ice conditions
2003
8/10 “cheesy” ice
Redefinition of the 2500 m contour
3100 m high, summit at 900 m water depth
45 km long x 15 km wide
Healy Seamount Survey
Radarsat ice coverage for 10 October 2004. Image processed at either ASF, Qinetic or CDPF. © CSA2004
How do we map in this?
HEALY 04-05 TRACK
6-26 Oct. 2004
6700 line km

“Ratchet Surveying”
“Pirouette Surveying”
Barrow margin
looking SE, ve=10x

mapped 2500-m isobath

ridges
<300 m high,
~100 km long

erosion

2500 m
HEALY 07-03
Depart Barrow:
17 Aug. 07
Return Barrow
15 Sept. 07
mapping the 2500-m isobath & foot of the slope
perspective view looking SW

2007 results

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

Where we thought FOS was

Where we now think it is
Where we thought Foot of Slope was

Where we now believe it is
$\lambda \approx 2 \text{ km}$

$H \approx 10 \text{ m}$

3 to 5 m deep

central Chukchi Plateau

ice grooves

380 m

-470 m

$\lambda \approx 2 \text{ km}$

$H \approx 10 \text{ m}$
Pt Barrow
Arctic surveys

pockmarks

Barrow margin

Pt Barrow

0 500 km
central Chukchi Plateau pockmarks

VE = 10x
looking SW

200-m diameter
20-m deep
Multibeam mapping

USCGC Healy

CCGS Amundsen

I/B Oden

R/V Polarstern

Chukchi Borderland

Mackenzie

Alpha-Mendeleev

Lomonosov Ridge

Gakkel Ridge

Morris Jesup Rise

Yermak Plateau

Eurasian Shelf Seas

Canadian Archipelago

Multibeam mapping

R/V Polarstern

I/B Oden

USCGC Healy

CCGS Amundsen

R/V Polarstern

I/B Oden

CCGS Amundsen

USCGC Healy

Gakkel Ridge

Mackenzie

Alpha-Mendeleev

Lomonosov Ridge

Eurasian Shelf Seas

Canadian Archipelago

Multibeam mapping
Glacial Sole Marks

From S. Blasco

Image Generated by
Jason Bartlett, CHS

Amundsen Gulf
Gary Knolls Mud Volcanoes

Beaufort Sea

From S. Blasco

Canada
Shelf Slump

Beaufort Shelf

More at session T34 - Seafloor Mapping of the Arctic Ocean - Room 207

From S. Blasco

Natural Resources Canada
Ressources naturelles Canada

Canada
~6 % OF THE ARCTIC OCEAN HAS BEEN MAPPED WITH MULTIBEAM
THERE IS MUCH MUCH MORE TO DISCOVER!!!
www.ccom.unh.edu
Bathymetric Compilation

IBCAO (2002)
Resources of extended U.S. continental shelf estimated to be worth 1.3 TRILLION $