Mapping Canada's Arctic Seabed: Data Processing, Management and Distribution Strategies

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Arctic Change 2008
Quebec, Dec. 9-12, 2008
Antarctica, Nov. 2007, Explorer strikes submerged ice, sinks 20 hours later

August 1996, Hanseatic runs aground

Antarctica, Dec. 2008, Ushuaia runs aground in poorly charted waters
Global Warming
Charting the Canadian Arctic Archipelago
CCGS Amundsen
Mapping Instrumentation

Acoustic Instrumentation

- Kongsberg EM300 30 kHz multibeam echosounder
- Knudsen 3.5 kHz sub-bottom profiler

December 11, 2008
Arctic Change 2008
**CSL Heron**  
Mapping Instrumentation

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**Coda Octopus**  
F-180 IMU

**C&C Technologies**  
C-NAV GcGPS

**ODIM Brooke**  
Ocean MVP 30

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**Acoustic Instrumentation**

- Kongsberg EM3002 300 kHz multibeam echosounder
- Knudsen 3.5 kHz sub-bottom profiler
- Knudsen 200 kHz sidescan and single beam echosounder
Western Canadian Arctic Archipelago

Coverage Achieved
2003-2008
CCGS Amundsen
USCGC Healy
R/V Marai
CSL Heron

ArcticNet seabed mapping: “multiple traverses through the NW Passage...will provide an unprecedented opportunity to map bathymetry and seabed geology”
Challenges of Transit Style ArcticNet Mapping

1. Tides
2. Refraction
3. Visualization of multibeam/subbottom
4. Timely distribution to multiple ArcticNet researchers

Sources of systematic sounding error
1. Tides

Tide Type for CHS Tide Stations

- Red: Semi-diurnal
- Blue: Semi-diurnal w/ diurnal inequalities
- Purple: Mixed
- Orange: Diurnal

Locations:
- Alert
- Broughton Island
- Tuktoyaktuk
- Holman
- Churchill
- Broughton Island
- Tuktoyaktuk
- Holman
- Churchill
WebTide

- 2D finite-element barotropic ocean circulation models
- Models can predict tidal currents and sea surface elevation
- Created and maintained by Ocean Physics Group at Bedford Institute of Oceanography (BIO), Darmouth, NS
WebTide Model Coverage

- Three models required for Amundsen transits
- 80+ days of transit/yr
- Model selection needs to be automated
Coverage Polygons

- Coverage polygon for each model guides selection process
- Polygons designed to:
  - (1) extend beyond model coverage, safely encompassing near shore areas not covered by model
  - (2) abut polygons from neighbouring models, explicitly defining boundary between adjacent model meshes
- Encoding of decisions in polygon map format removes repeatability issues & fully documents post-processing procedure
2. Refraction

Mapping water depth with multibeam sonar

Depth errors due to refraction if sound speed profile ignored

- Refraction

- Sound speed

- Depth

- Assumed ray path

- Refracted ray path

- Depth errors due to refraction if sound speed profile ignored

- 740 m
- 785 m
- 18 m
- -6 m
ArcticNet CTD sampling sites (2004-2007)

- Sparsely sampled in 2007
- Never sampled!

Health Cruise 2007

- 2004
- 2005
- 2006
- 2007
Filling the Gaps: Oceanographic Climatologies

World Ocean Atlas 2001

- Sea surface salinity, August
  - 41 ppt
  - 5 ppt
- Sea surface temperature, August
  - 34°C
  - -3°C

GDEMv 3.0

Kliem & Greenberg (2003)
Can we get away with using “average” conditions instead of actual conditions?
The “Best” Climatology

- **WOA01 (125)**
- **GDEM (108)**
- **KLIEM (182)**
Northwest Passage

3 & 4 Visualization & Distribution
Multi-Year Coverage

<table>
<thead>
<tr>
<th>Year</th>
<th>Ship</th>
<th>Location</th>
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<tbody>
<tr>
<td>2002</td>
<td>Marai (Japan)</td>
<td></td>
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<tr>
<td>2003</td>
<td>Amundsen Healy (USA)</td>
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<tr>
<td>2004</td>
<td>Amundsen</td>
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<tr>
<td>2005</td>
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<td>2008</td>
<td>Amundsen Heron</td>
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</table>
A new field season of data can be quickly integrated into the basemaps using a highly automated process, available online within days of return.
Summary
How to drink from a fire hose

• UNB processing/delivery model allows for
  – Automated tidal reduction
  – Accelerated SVP post-processing
  – Automated updating of Basemaps website
  – Timely turnaround of transit data products from multiple mapping platforms delivered via lightweight web platform

December 11th, 2008

Arctic Change 2008
Conclusion

• No active Arctic deep water port (yet): future mapping will involve much transit from southern ports
• Amundsen demonstrates viability of *transit style mapping*
• There’s much ground to cover: future mapping platforms should log their transit data
• UNB processing/delivery model can
  – help process and deliver the “fire hose” of data…
  – …from several platforms…
  – …in a timely manner…
  – …such that vessels can plan their transits to *help fill the gaps*
Log your transit data…
we’ll happily take it!
Acknowledgements

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  – U.S. Geological Survey
  – Kongsberg Maritime
  – Royal (U.K.) Navy
  – Fugro Pelagros
  – Route Survey Office of the Canadian Navy
  – Rijkswaterstaat
Uncertainty Attribution

- UNB raytrace simulator used to estimate uncertainty associated with any given climatology
- Allows for attribution of uncertainty to soundings
Evaluation of Climatologies using UNB Raytrace Simulator

WOA01
Mean: -0.04 +/- 0.27% w.d.
Median: -0.05% w.d.

KLIEM
Mean: -0.03 +/- 0.31% w.d.
Median: 0.01% w.d.

GDEM
Mean: -0.07 +/- 0.29% w.d.
Median: -0.06% w.d.