Arctic Marine Research: A Practitioner's Perspective

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The Arctic is “HOT.”
U.S. invests approximately $400M→$1B per year in Arctic research through at least 15 agencies
 MANY AREAS OF FOCUS - ONE IS EXTENSION OF “CONTINENTAL SHELF” THROUGH CONVENTION ON THE LAW OF SEA
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.
To establish an extended continental shelf a coastal state must demonstrate that region is “natural prolongation” of continental landmass (creative ambiguity) - limits are then determined by:

- 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

Arctic
2003 2004 2007

Atlantic
2004 2005
2008 2012 2015

Marianas
2006

Bering Sea
2003

Gulf of Alaska
2005

Mendocino
2009 2014

Necker Ridge
2011

Kingman Reef - Palmyra Atoll
2010, 2014

Gulf of Mexico
2007

> 2,665,000 km²
Arctic is unique as an ocean basin in that >52% is made up of shelf (geologic)
Potential for Oil and Gas in the Arctic

USGS (2009) 13% of world’s undiscovered oil, 30% undiscovered gas, 20% undiscovered natural gas liquids

HYDRATE LIKELIHOOD AREAS IN THE ARCTIC

LEGEND

500 m
2500 m
200 M Limits
Extrapolated from recognized hydrate zones
Analogous to other hydrate-rich abyssal areas
Areas of high gas production and entrapment

Adapted from Max and Lowrie, 1990
Five nations having potential extended shelves

From Ron MacNab
2002 UNH Desktop Study

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-Mendelev Ridge as well as the Canadian shelf.
How do we map in this?
MBES 2003 - 2009 - Seabeam 2112 2x2 deg 12 kHz
Now - Kongsberg EM122 - 1x1 deg 12 kHz MBES
Hi-Res Subbottom - Knudsen 350B Chirp Sonar
Dredging
But none would have been able to easily collect useful data 15-20 years ago.
Minimum Ice Extent

Average Monthly Arctic Sea Ice Extent
September 1979 - 2012

Year

Extent (million square kilometers)
3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

2003
typical ice conditions
2003
8/10 “cheesy” ice
Redefinition of the 2500 m contour
Healy 03-02

~3000 km of multibeam sonar bathymetry

1-11 Sept 03

8/10 ice
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
Central Chukchi Plateau pockmarks

200-m diameter
20-m deep

VE = 10x
looking SW
Central Chukchi Plateau

-380 m

3 to 5 m deep

-470 m

Ice grooves

Niessen et al, 2013

Jakobsson et al, 2016

Evidence for an ice shelf covering the central Arctic Ocean during the penultimate glaciation

Niessen et al, 2013

\( \lambda = \sim 2 \text{ km} \)

\( H = \sim 10 \text{ m} \)
HEALY 2004 - Plan
Minimum Ice Extent

Average Monthly Arctic Sea Ice Extent
September 1979 - 2012

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

Average Monthly Arctic Sea Ice Extent
September 1979 - 2012

Year

Extent (million square kilometers)


2007
August 2007 – Russians Plant Flag on Seafloor at North Pole
mapping the 2500-m isobath & foot of the slope
Healy 03-02, 04-05, 07-03

2007 results

perspective view looking SW
2008 DREDGING IN THE ICE
Volcaniclastic sedimentary rock – hyaloclastite. Vesiculatlon in glass and grading of pumice implies deposited soon after shallow water volcanic eruption.

Metasediments - slate and coarse sandstones representing proximal continental arc sources – at least 420 Ma (zircon ages).

Also 112 Ma flood basalts.
LSSL
SEISMIC
DATA
15,481 km

From David Mosher
New Seamount: Savaqatigiit Seamount
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
LSSL Monitor Records

- Chukchi
- Lomonosov
- Alpha/ Mendeleev
- Makarov Basin
HEALY-1102
15 Aug – 28 Sept 2011

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

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Average sea ice state… 9/10
Average speed in ice….. 3.5 knts
Hyperbolic Echoes on Alpha/Mendeleev Ridge
Minimum Ice Extent

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Year


Extent (million square kilometers)

3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

2012
An ultrahigh-latitude submarine channel: Northern Chukchi Rise

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HEALY 1202 DREDGE SITES

Metasediment/carbonates

Fossil corals
Primona redaeformis?
43.5 BP

Foliated calcareous sandstones and phyllites

Metasediment/greenschisht facies

volcanoclastic altered basalt
Typical Sept Ice Margin
Long/Lat: -132 08.2 W, 80 01.7 N
2008 (9-13-2008)
Long/Lat: -156.072055 W, 80.293353 N
2007 (9-6-2007)
Average Monthly Arctic Sea Ice Extent
September 1979 - 2012

Year

Extent (million square kilometers)


2012
HEALY 1202 – Aug-Sept 2012
AND 2013??

Average Monthly Arctic Sea Ice Extent
August 1979 - 2013

6th LOWEST ICE EXTENT OF MEASUREMENT RECORD 2013
MINIMUM ICE EXTENT THROUGH 2016

Average Monthly Arctic Sea Ice Extent

Year

Extent (million square kilometers)

US ECS Arctic Mapping

operations: 227 days
transits: 52 days
average speed (in ice): 4 kts
average sea-ice state: 8-9/10
Area mapped: 442,000 km²
ALL BATHYMETRIC DATA MADE AVAILABLE WITHIN A FEW MONTHS OF COLLECTION
CHALLENGES

ACCESS!

ACCESS!
ACCESS!

PHYSICAL - PLATFORMS
<table>
<thead>
<tr>
<th>Schedule</th>
<th>Dates</th>
<th>Location</th>
<th>Project</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEALY 1101</td>
<td>25 Jun/29 Jul</td>
<td>Dutch/Kodiak</td>
<td>Ecosystems &amp; Chemistry</td>
<td>NASA</td>
</tr>
<tr>
<td>HEALY 1102</td>
<td>11 Aug/28 Sep</td>
<td>Barrow/Barrow</td>
<td>Law of Sea ECS</td>
<td>NOAA</td>
</tr>
<tr>
<td>HEALY 1103</td>
<td>05 Oct/27 Oct</td>
<td>Nome/Dutch</td>
<td>W. Arctic Currents</td>
<td>NSF</td>
</tr>
</tbody>
</table>
COORDINATION WITH THE LOCAL COMMUNITY and LOCAL LOGISTICS - PARTICULARLY FOR NON-NSF PIs
PERMITTING: ENVIRONMENTAL COMPLIANCE

CATEGORICAL EXCLUSION - no significant impact

ENVIRONMENTAL IMPACT STATEMENT - open for public comment and other federal agencies

INCIDENTAL HARASSMENT AUTHORITY (IHA) mitigation procedures - Marine Mammal/Protected Species Observers
PERMITTING: AUTHORIZATIONS

US requests to conduct marine scientific research in Russian EEZ

Perestroika and Glasnost  

Putin Era

Approved

Denied


John Farrell, USAID
Data from US Dept. of State
The Swedish-Russian-US-Arctic Ocean Investigation of Climate-Cryosphere-Carbon Interactions

2014
C3 = Carbon-Cryosphere-Climate

SEA ICE, PERMAFROST, CARBON CYCLE, GASHYDRATES IN SEDIMENTS, RELEASE OF CH₄ FROM SHELF AND SLOPE, GLACIAL HISTORY, OCEAN CIRCULATION, CLOUD FORMATION
Oden in Barrow, Alaska

5 July, start
3 Oct, end

20 Aug, rotation

Sea ice extent 23 sept.

Barrow, Alaska

Wrangel I.

New Siberian I.

Greenland

Sea ice extent 23 sept.

SWERUS 2014

Tromsö-Barrow-Tromsö on 90 days

Tromsö, Norway

Greenland

New Siberian I.

SWERUS 2014

Tromsö-Barrow-Tromsö on 90 days
TASKS:
• Acoustically map the distribution of gas seeps
• Acoustically determine the flux (rate) of methane release?
EK-80 on ODEN
Wide-Band Transceiver
Gas escape from slope
Acoustic Determination of Bubble Size → Estimation of Flux from Target Strength
GREAT STEP FORWARD: Coordination between NSF and Swedish Polar Secretariat

Petermann 2015 Expedition with Icebreaker Oden
Sediment coring
Piston/gravity/multi
Seismic profiling
GI gun, 210 cu, 48 chan/300 m
Land surveying
sea level change, ecology, boulder dating
Oceanography
Mammal obs
Ice Shelf Drilling
CAN THIS SORT OF ARRANGEMENT BE EXTENDED TO OTHER ICEBREAKERS - OTHER NATIONS?
~11 % OF THE ARCTIC OCEAN HAS BEEN MAPPED WITH MULTIBEAM

THERE IS STILL MUCH MUCH MORE TO MAP, TO LEARN & TO DISCOVER!!!