The changing sea-ice cover of the Canadian Arctic

What’s going on?

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Outline

• Sea ice and ice services
• 100 year of change in Arctic sea ice
• Projected future of Arctic sea ice
• Impacts on Canadian Arctic Shipping
Sea ice - a very Canadian issue

- Canada claims the world’s:
  - longest coastline
  - greatest area of ice

- Annual variation in extent of ice is ≈ ½ the area of Canada (4M km²)

- Seasonal effects on:
  - weather and climate
  - marine ecosystems
  - safety and efficiency of marine transportation
Shipping in Canada’s Arctic -- Today

- Ship traffic is typically restricted to the very short open water season between July and September.
- Relatively low level of shipping – approx. 100 voyages / year.
- Most shipping occurs in coastal waterways within and adjacent to the arctic islands.
- Multi-year ice is a significant hazard throughout this season. Transits are rare, destination trips more common.
Why an Ice Service?

*Ice is a significant marine hazard*
Why an Ice Service?

Icebergs are a significant marine hazard

Reduta Oriona in drydock after striking an iceberg (July, 1996)
And more recently

ice and a hole about the size of a fist

Photo – Washington Post
North American Ice Service (NAIS)  
A Canada - US partnership

Mission: *be the authoritative source of marine ice information to meet the needs and obligations of the United States and Canadian governments.*

Vision: *create a harmonized suite of products and services for ice information to meet government needs for safety of navigation, security and informed decision making*
NAIS and the Canadian Ice Service

• Mandate/Mission
  • Warn maritime users of hazardous ice conditions in Canadian waters
  • Maintain a general historic knowledge of ice conditions and ice climatology

• Provides ice information in support of:
  • Ship routing
  • Icebreaking operations
  • Climate monitoring
  • Weather forecasting, etc.
From data to information

**Satellite Optical**
- NOAA AVHRR
- DMSP OLS

**Microwave**
- RADARSAT
- ENVISAT
- QUIKSCAT
- DMSP SSM/I

**Airborne**
- Visual Obs
- SLAR/SAR

**Surface**
- Buoys
- Ship Reports
- Shore Obs

**Models**
- Marine weather
- Ice

**Image Products**
- Analysed images

**Chart Products**
- Daily tactical ice analyses
- Weekly strategic ice analyses

**Climatological Products**
- Ice Atlases
- Normals / Extremes

**Text Products**
- Ice hazard warnings
- 30-day forecasts
- Seasonal Outlooks

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FICN11 CWIS 181450
ICEBERG BULLETIN FOR EAST COAST WATERS AND THE STRAIT OF BELLE ISLE
AND ITS APPROACHES ISSUED BY ENVIRONMENT CANADA FROM CANADIAN ICE
SERVICE IN OTTAWA AT 1500 UTC WEDNESDAY 18 OCTOBER 2000.
Arctic sea-ice is dynamic.
Arctic sea-ice is changing
Extent 1900-2005

- Significant decreases since 1950
- Decrease largest in summer
- Accelerating in recent years
Arctic sea-ice thickness is key but difficult to observe and sample.

Rothrock et al.: Thinning of the Arctic Sea-Ice Cover, 1999

Holloway and Sou: Has Arctic Sea Ice Rapidly Thinned? (2001)
Unusual sea-ice events 2005

- The 66 square-km Ayles ice shelf
- Broke away in August 2005
- Freed by high temperatures and winds.
- 3,000 years old
- 15 km long by 5 km wide
- 35 meters thick
- Detected by Laurie Weir NAIS in near real time

Copland, Mueller and Weir (2007)
Unusual sea-ice events 2006

MODIS
September 24, 2006

Lack of ice in Northwest Passage stuns researchers

Last Updated: Tuesday, October 31, 2006 | 9:52 AM CT
CBC News
Unusual sea-ice events 2007

Multi-year pack ice with leads

Rapid westward expansion of large leads

Mar 01

Feb 28

Feb 26

Lead 22-22 km

21-22 km

Ward Hunt Ice Shelf

Ward Hunt Island

Ellesmere Island
Unusual sea-ice events 2007

“Crushing ice imprisons sealing ships
Coast Guard pushing hard to aid 100 trapped vessels, including one of their own”

Supplies low for ice-bound N.L. sealers
Thursday, April 19, 2007
Summer 2007 from space

September 2001

September 2007
So what?
Summer 2007 was well outside any of the forecasts.
Observed Arctic Sea Ice Extent 1978-2006

Arctic Hemisphere - OK .... But what about in Canada's Arctic

National Snow and Ice Data Center, 2006
Western Arctic

10% Decrease over the period 1968-2006

Historical Total Accumulated Ice Coverage 0625 - 1015

Western Arctic / Arctique de l'Ouest

short name / nom en bref:
WARCTIC

source region / région source:
WA / AO

ice season (mmdd) / saison des glaces (mmdd):
0625-1015

averages based upon / les moyennes basées sur:
1971-2000

by / par:
CIS / SCG
Eastern Arctic

25% Decrease over the period 1968-2006

Historical Total Accumulated Ice Coverage 0625 – 1015

Eastern Arctic / Arctique de l’Est

short name / nom en bref: EARCTIC
source region / région source: EA / AE
ice season (mmdd) / saison des glaces (mmdd): 0625-1015
averages based upon / les moyennes basées sur: 1971-2000
by / par: CIS / SCG
East Coast

31% Decrease over the period 1969-2007

Historical Total Accumulated Ice Coverage 1126 - 0716

The bar chart shows the normalized ice coverage for the Eastern Coast (ECOST) from the seasons 1968/69 to 2006/07. The data indicates a 31% decrease over the period 1969-2007. The ice season (mmdd) is from 1126 to 0716. The averages are based upon the seasons 1970/71 to 1999/00. The chart is created by CIS/SCG.
NW Passage – record two low years in a row

- Extent of ice on Sept 3 since 1968 shows extreme year to year variability
- 2006 had least ice
- 2007 is almost as low
Northwest Passage Nearly Clear of Ice

- Only 2% of entire ocean surface along the NWP is covered by sea ice
- Normally, 14% of the surface would be ice-covered
Normal Ice Conditions – Sept 3

- Of the 2300 km length of the NWP, there was only about 20 km of ice to traverse.
- Normally, there would be 400 km of ice.
Hudson Bay and Approaches

50% decrease over the period 1971-2006

Historical Total Accumulated Ice Coverage 0625 – 1015

Season / Saison

Normalised Ice Coverage / Couverture des Glaces Normalisée

Years / Années:
- 1971
- 1972
- 1973
- 1974
- 1975
- 1976
- 1977
- 1978
- 1979
- 1980
- 1981
- 1982
- 1983
- 1984
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

Source Region / Région Source:
- HB / BH

Ice Season (mmdd) / Saison des Glaces (mmdd):
- 0625-1015

Averages Based Upon / Les Moyennes Basées Sur:
- 1971-2000

By / Par:
- CIS / SCG
Murmansk to Churchill – The Arctic Bridge
Implications for Canada

- Increased access to Hudson Bay and Port of Churchill
- Similar to Gulf of St Lawrence by mid-century

<10% Ice Cover in Shipping Route to Churchill

Increase from 13 to 20 weeks in 35 years
After what, and so what?

Now what?
Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% per decade, with larger decreases in summer of 7.4% per decade.

N. Hemisphere summer ice extent is 21% less than in 1978

Sea ice is projected to shrink in both the Arctic and Antarctic under all SRES scenarios. In some projections, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century.

IPCC 4th Assessment Summary Report 2007
GCM Projections for Northern Hemisphere

- Canadian model has ice-free summers by 2050
- Main ensemble of models delays this until next century
Future abrupt reductions in the summer Arctic sea ice

Marika M. Holland, Cecilia M. Bitz, and Bruno Tremblay

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, 2006

• Recent simulations show that abrupt retreat of sea ice is possible
• Near ice-free Septembers in 2040-2060 - system responds in a non-linear way
Climate models projections show that Northern Sea Route is expected to open first.
Then Transpolar Route will open reliably before North West Passage.

Arctic Sea Ice Summer Minimum
Year 2049
Implications for the Canadian Arctic and the Northwest Passage

• Last ice to melt will be in the Canadian Arctic
• Multi-year ice will linger longest in the Northwest Passage and high inter-annual variability will continue
• Northern Sea Route and Transpolar route will open first and be more reliable, attractive ocean transit route
The Arctic contains vast mineral deposits and 23 per cent of natural gas reserves.

Economic factors such as the price of oil and gas will drive Arctic Shipping Growth and not climate change.
Cruise ship traffic is increasing steadily in Canada’s Arctic
Conclusions

• There has been a significant decrease in the extent of sea ice in the Northern Hemisphere and in the Canadian Arctic since 1971 and particularly since 1990. This trend should continue.

• Hudson Bay will likely experience the most dramatic reductions. Ice regime in the future will approximate current Gulf of St Lawrence by mid-century – Port of Churchill will benefit.

• The Northern Sea Route and Trans-Polar routes will likely attract increasing transit shipping before the Northwest Passage.
Final Fearless Forecasts

- Extreme inter-annual variability in ice conditions, presence of multi year ice, and lack of infrastructure will still make the Northwest Passage less attractive to transit shipping.

- Shipping will increase in Canada’s Arctic in support of resource development, but will be mainly destination not transit trips.

- There will be increasing demands for ice and marine weather services in the north, that need to be supported by sound science.