

Sea Ice Information

Charts, Data Products, and Forecasts

Florence Fetterer
National Snow and Ice Data Center
CIRES, University of Colorado, Boulder
nsidc.org/noaa

**Arctic Council's Working Group on the Protection of the Arctic Marine Environment (PAME)
Arctic Shipping Best Practice Information Forum 16-18 November 2021**



National Snow and Ice Data Center
Advancing knowledge of Earth's frozen regions



Acknowledgements

- Caryn Panowicz, Operations Technical Director, U.S. National Ice Center
- International Ice Charting Working Group (IICWG) Task Team 8-2: Maritime Training Center Engagement, led by Keld Qvistgaard, Danish Meteorological Institute
- John Falkingham, IICWG Secretariat
- Dr. Scott Weese, Environment and Climate Change Canada
- Dr. Rick Allard, Naval Research Laboratory
- Dr. Mitch Butchnell, NOAA Geophysical Fluid Dynamics Laboratory

Outline

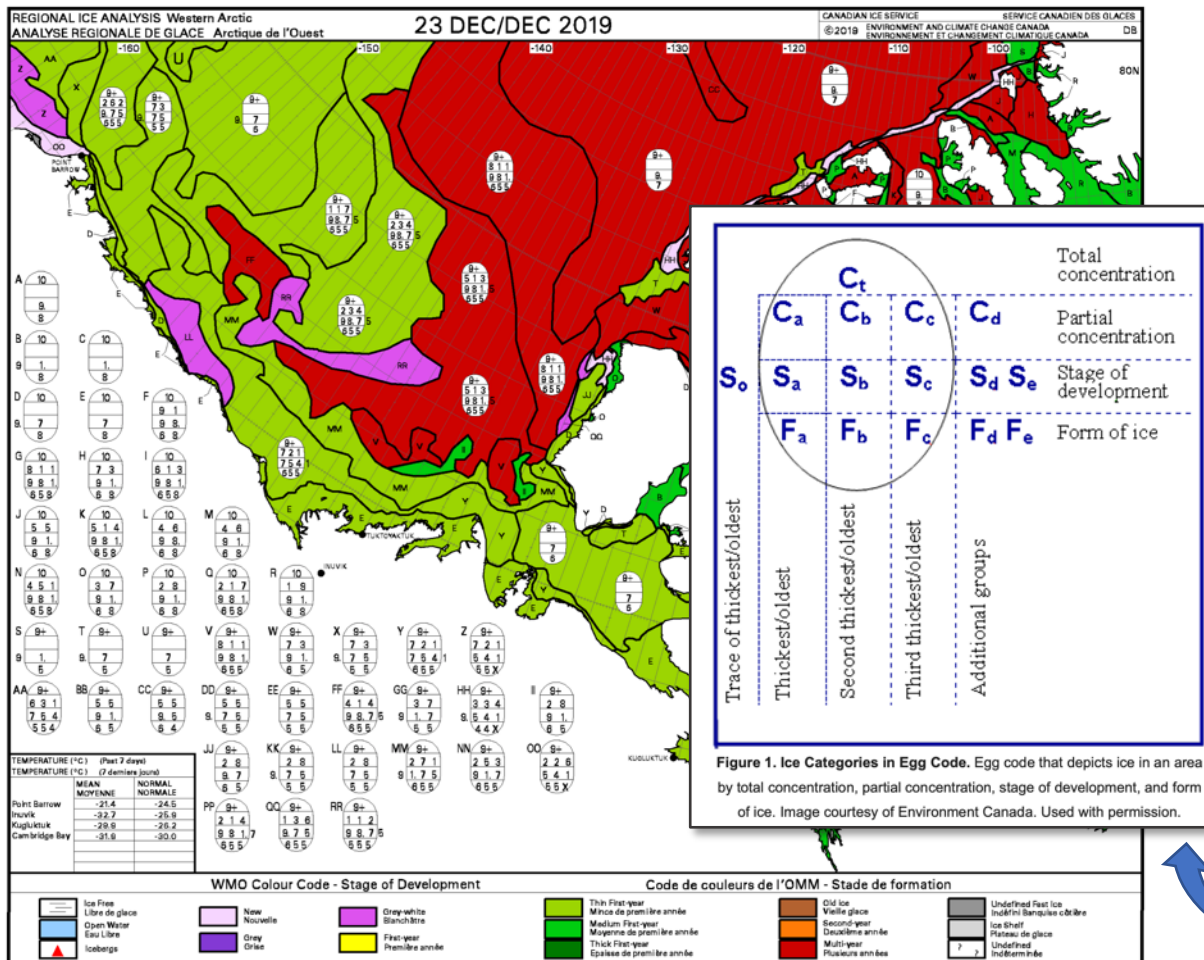
- Overview of sea ice information you can use with the Polar Code (e.g. with the POLARIS method)
- The International Ice Charting Working Group (IICWG) web site and the Polar View web portal: Great sources for ice information to support maritime operations
- The IICWG Task Team on Maritime Training Centre Engagement
- Archives of ice data originating from operational ice services, suitable for research into past conditions
- On forecasting ice conditions

NOAA@NSIDC provides archived iceberg and ice chart data and derived products. We are not an operational service provider.

Those needing short term forecasts for voyage planning should contact their respective national ice service as well as the ice service for waters they will be sailing in.

The Polar Code and sea ice charts

- The Code has levels of requirements according to the profile of the vessel and temperature and the expected ice conditions that the vessel will operate in.
- It uses ship categories or classes to apply requirements based on anticipated hazards.
 - Category A: a ship designed for operation in polar waters in at least **medium first-year ice**, which may include old ice inclusions.
 - Category B: a ship designed for operation in polar waters in at least **thin first-year ice**, which may include old ice inclusions.
- “... ships operate in ice conditions where there can be a range and combination of ice types (thickness, strength) and concentrations – termed an ice regime – with associated ranges of risk, the Polar Code requires a methodology to be used to assess the operational capabilities of the ship in ice”
- The most widely used methodology is called **POLARIS** (Polar Operational Limit Assessment Risk Indexing System).
- **POLARIS** assigns a risk index that depends on the ship’s ice class and the ice conditions. Input to POLARIS: actual ice conditions, as described by sea ice charts that use **WMO descriptors for total concentration and partial concentration by type within polygons or mapped areas**.



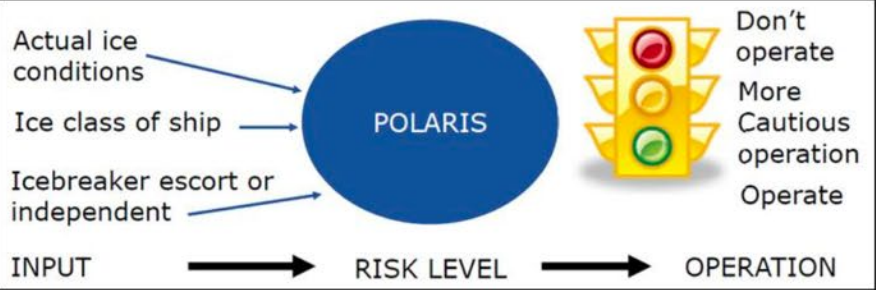
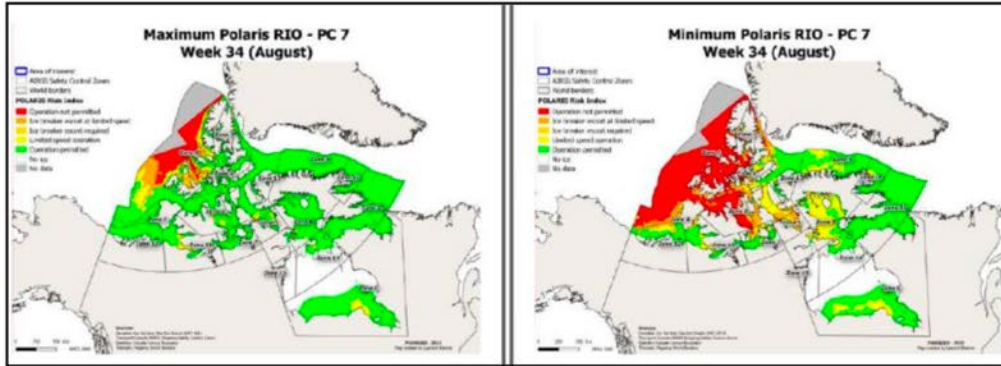
A Canadian Ice Service chart of the Beaufort Sea, with inset providing the key to the WMO “egg code”.



8.B Resources for decision making in ice-covered waters

Polar Operational Limit Assessment Risk Indexing System (POLARIS) (IMO)

☐ Combines SIGRID3 codes and vessel ice class capability in ice



RIO = Risk Index Outcome
 = Sum of (Partial Ice concentrations x Risk Values)
 $RIO = (C_1 \times RIV_1) + (C_2 \times RIV_2) + (C_3 \times RIV_3) + (C_4 \times RIV_4)$
 $C_1 \dots C_4$ - concentrations of ice types within ice regime (maximum of four from Egg Code)



RIO_{SHIP}	Ice classes PC1-PC7
$RIO \geq 0$	Normal operation
$-10 \leq RIO < 0$	Elevated operational risk*
$RIO < -10$	Operation subject to special consideration**

Increasing ice thickness (severity) →

	RISK INDEX VALUES (RIVs) for each Ice Type											
	ICE FREE	NEW ICE	GREY ICE	GREY WHITE ICE	THIN FIRST YEAR 1ST STAGE	THIN FIRST YEAR 2ND STAGE	MEDIUM FIRST YEAR	MEDIUM FIRST YEAR 2ND STAGE	THICK FIRST YEAR	SECOND YEAR	MULTI YEAR	HEAVY MULTI YEAR
PC 1	3	3	3	3	2	2	2	2	2	2	1	1
PC 2	3	3	3	3	2	2	2	2	2	1	1	0
PC 3	3	3	3	3	2	2	2	2	2	1	0	-1
PC 4	3	3	3	3	2	2	2	2	1	0	-1	-2
PC 5	3	3	3	3	2	2	2	1	0	-1	-2	-2
PC 6	3	2	2	2	2	1	1	0	-1	-2	-3	-3
PC 7	3	2	2	2	1	1	1	0	-2	-3	-3	-3
IAS	3	2	2	2	2	1	0	0	-3	-4	-4	-4
IA	3	2	2	2	1	0	-1	-2	-4	-5	-5	-5
IB	3	2	2	1	0	-1	-2	-3	-4	-5	-6	-6
IC	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8
No Ice Class	3	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-8

↑ Increasing ice class

Increased Risk

The International Ice Charting Working Group

“Through collaboration and cooperation in data sharing, standards, training, product development, research activities, and the delivery of information services, the IICWG aims to enhance the safety of maritime operations in ice-covered waters.”

- 17 participating agencies
- See <https://nsidc.org/noaa/iicwg/> for all IICWG business
- See the Ice Logistics Portal <https://www.bsis-ice.de/IcePortal/> for current ice charts from the world's ice services





International Ice Charting Working Group

[Overview](#)[Meetings](#)[Task Teams](#)[IICWG Business](#)[Participating Agencies](#)[Charter, Terms of Reference, Vision & Strategic Goals](#)[Related Links](#)

IICWG Overview

The International Ice Charting Working Group (IICWG), formed in October 1999, is a working group of the world's national ice services to promote coordination of operational sea ice and iceberg information services to better meet the needs of their national and international maritime clients. Through collaboration and cooperation in data sharing, standards, training, product development, research activities, and the delivery of information services, the IICWG aims to enhance the safety of maritime operations in ice-covered waters. For more on the history and purpose of the IICWG, see [The IICWG - An Historical Perspective After 13 Years](#). For a comprehensive description of sea ice information services worldwide, see [WMO's Sea Ice Information Services in the World](#).



The IICWG is governed by a [Charter](#) and [Terms of Reference](#) and has adopted a [Vision and Strategic Goals](#).

The current co-chairs of the IICWG are:

- Marianne Thyrring, Director-General, Danish Meteorological Institute
- Russ White, Director-General, Prediction Services, Environment and Climate Change Canada

Current Ice Information

- The latest ice charts can be found on the [Ice Logistics Portal](#).
- Emergency situations involving floating ice: [International Ice Service Emergency Contact List](#) (PDF 116 KB, Nov 2020).
- General inquiries about floating ice: [Regional Contact List](#) (PDF 86 KB, Aug 2021).



International Ice Charting Working Group

Overview

Meetings

Task Teams

IICWG Business

Participating Agencies

Charter, Terms of Reference, Vision & Strategic Goals

Related Links

IICWG Overview

The International Ice Charting Working Group (IICWG), formed in October 2000, is a working group of the world's national ice services to promote coordinated operational sea ice and iceberg information services to better meet the needs of their national and international maritime clients. Through collaborative cooperation in data sharing, standards, training, product development activities, and the delivery of information services, the IICWG aims to ensure the safety of maritime operations in ice-covered waters. For more on the purpose of the IICWG, see [The IICWG - An Historical Perspective After 20 Years](#). For a comprehensive description of sea ice information services worldwide, see [WMO's Sea Ice Information Services in the World](#).


The IICWG is governed by a [Charter](#) and [Terms of Reference](#) and has a [governance structure](#).

The current co-chairs of the IICWG are:

- Marianne Thyrring, Director-General, Danish Meteorological Institute
- Russ White, Director-General, Prediction Services, Environment and Climate Change Canada

Current Ice Information


- The latest ice charts can be found on the [Ice Logistics Portal](#).
- Emergency situations involving floating ice: [International Ice Service](#) (Nov 2020).
- General inquiries about floating ice: [Regional Contact List](#) (PDF 86 KB, AUG 2021).



Home [S411 charts](#)

World regions: [Southern](#) | [Northern 90W](#) | [Northern 90E](#) | [MetAreas](#) | [Position](#)

NORTHERN HEMISPHERE (90W)



Click on a region or choose from the list to view the data products in the area:

- [Arctic Basin](#)
- [East Siberian Sea](#)
- [Laptev Sea](#)

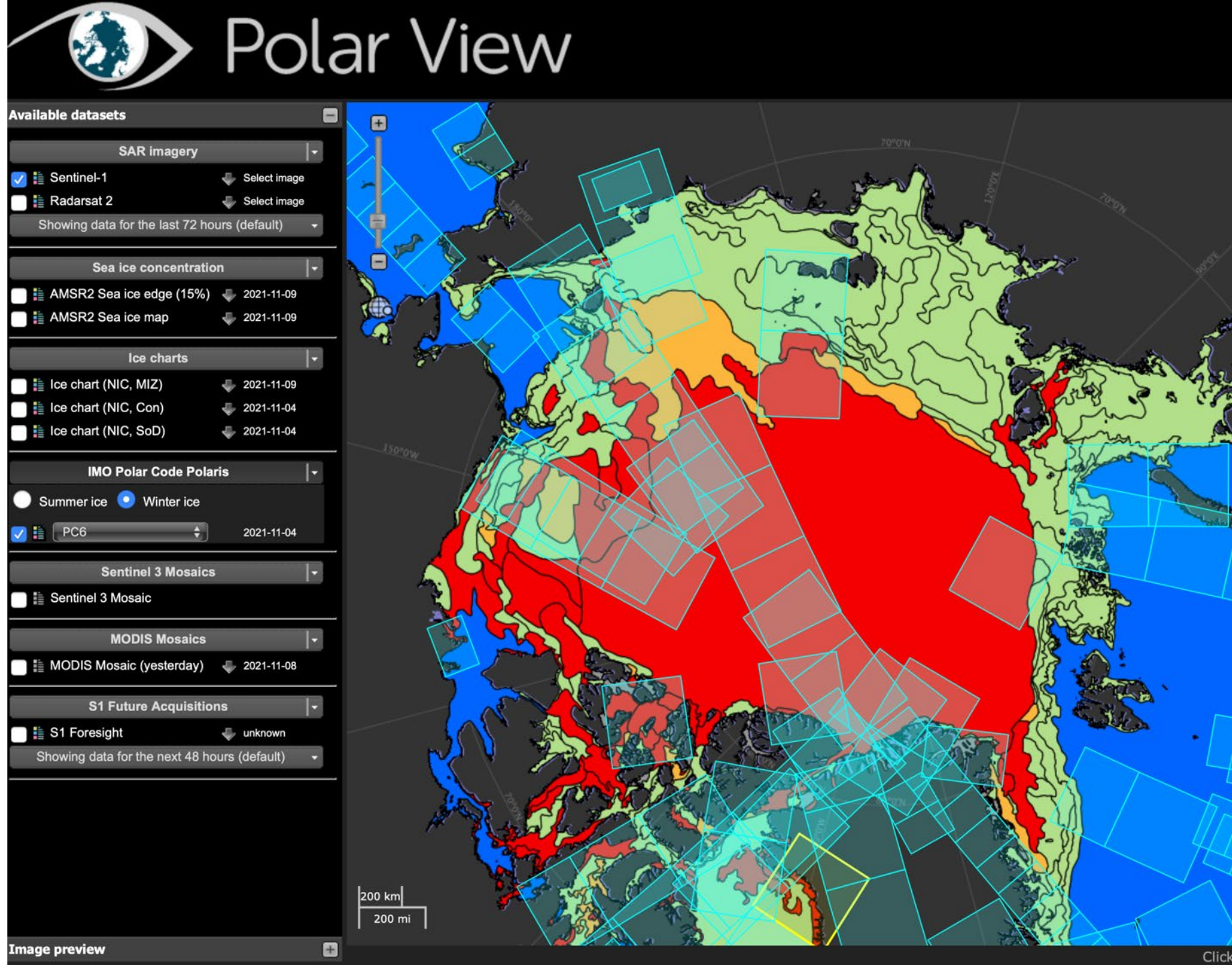
Participating Agencies

Organizational Structure of Ice Services (PDF)

	Argentine Naval Hydrographic Office
	Australian Bureau of Meteorology
	British Antarctic Survey
	Canadian Ice Service
	Danish Meteorological Institute
	Finnish Meteorological Institute
	Federal Maritime Administration
	Icelandic Meteorological Office

Polar View aims to be the site for authoritative ice information to support maritime operations.

The Ice Logistics Portal will be incorporated into the Polar View portal.



IICWG Task Team on Maritime Training Centre Engagement

- Led by Keld Qvistgaard of the Danish Meteorological Institute
- Compiled resources for understanding, observing, and reporting ice
- Compiled resources for decision making in ice-covered waters
- Material will be posted on the IICWG website





8.A Resources for understanding, observing and reporting ice

MANICE

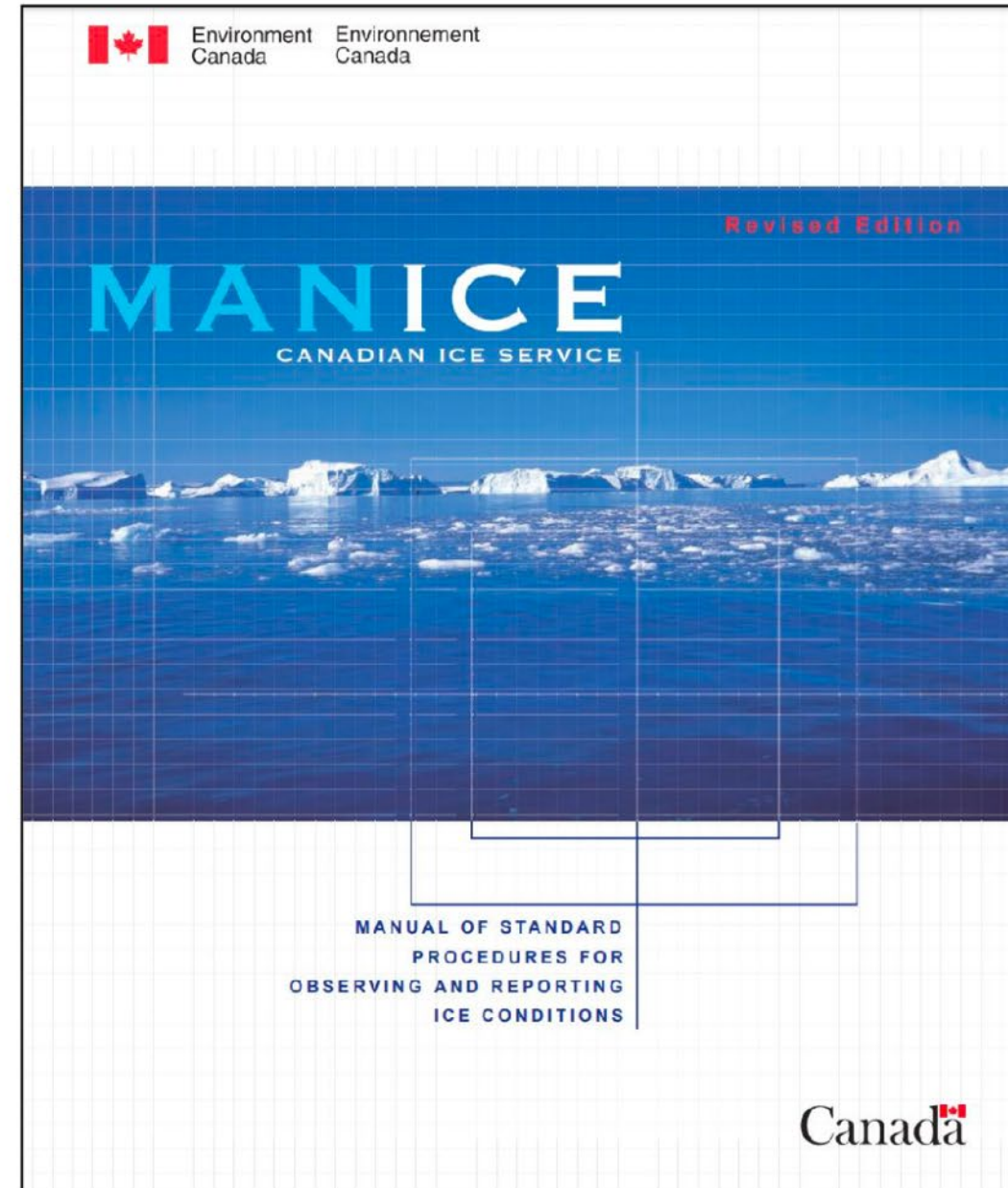
(One of 15 resources for understanding and reporting ice)

Selected contents:

- General ice terminology
- Ice observations and observed ice charts
- Iceberg messages
- Ice Analysis charts

Comments:

- Reference for all products issued by the Canadian Ice Service
- Contains all pertinent definitions related to ice
- Last updated in 2016
- Issued by the Canadian Government (Environment and Climate Change Canada)
- Available online





8.B Resources for decision making in ice-covered waters

Nautical Institute Literature
(<https://www.nautinst.org/>)

*(One of 19 resources
for decision making)*

<https://www.nautinst.org/resource-library/technical-library/ice.html>
<https://www.nautinst.org/resource-library/publications.html>

Selected contents:

- Guidance for operations in ice-covered waters
- Navigation in Ice
- Search and Rescue in Polar Waters
- Training and Certification

Comments for Polar Ship Operations and Handling Ships in First Year Ice:

- provides overview of operational considerations in planning and executing voyages in ice covered waters
- One focuses on waters affected only by first year ice, the other on Polar waters

Comments for Polar Ship Operations contains:

- step by step planning tree for strategic and tactical planning
- Ice transit Decision Process

Membership for Maritime Professionals

The Nautical Institute

The global body for maritime professionals. The Nautical Institute is a non-governmental organisation with consultative status at the International Maritime Organization (IMO)

Navigating The Future





8.B Resources for decision making in ice-covered waters

THE ARCTIC SHIPPING BEST PRACTICE INFORMATION FORUM

www.arcticshippingforum.is

Selected contents:

- About Protection of the Arctic Marine Environment
- Operating guidelines
- Comprehensive online document library
- Comprehensive information portal grouped and referenced to individual chapters in the IMO Polar Code:

Part IA: Safety Measures

Part IB: Guidance to Part IA

Part IIA: Pollution prevention Measures

Part IIB: Guidance to Part IIA

Comments:

- Some may find the amount of information a bit overwhelming
- Is the information up to date?

PAME
Protection of the Arctic Marine Environment

Log in

Search ...

HOME PAME PROJECTS

WELCOME
To the Web-Portal of the Arctic Shipping Best Practice Information Forum

POLAR CODE CHAPTERS
EXPLANATION AND SUBMISSIONS

Part IA: Safety Measures

- Chapter 1: General
- Chapter 2: Polar Water Operation Manual
- Chapter 3: Ship structure
- Chapter 4: Subdivision and stability
- Chapter 5: Watertight and weathertight integrity
- Chapter 6: Machinery installations
- Chapter 7: Fire safety/Protection
- Chapter 8: Life saving appliances and arrangements
- Chapter 9: Safety of navigation
- Chapter 10: Communication
- Chapter 11: Voyage planning
- Chapter 12: Manning and training

Part IIA: Pollution Prevention Measures

- Chapter 1: Prevention of Pollution by Oil
- Chapter 2: Control of pollution by noxious liquid substances in bulk
- Chapter 4: Prevention of pollution by sewage from ships
- Chapter 5: Prevention of pollution by garbage from ships

Part IB
Additional Guidance Regarding the Provisions of the Introduction and Part I-A

Part IIB
Additional Guidance Regarding the Provisions of the Introduction and Part I-A

Sea ice information from operational services; data archived and served by NOAA@NSIDC

- **SIGRID-3 ice chart data from CIS and from USNIC**
 - SIGRID-3 is a vector format for encoding “egg code” information about concentration and ice stage of development in polygon attributes
 - CIS files are online
 - USNIC SIGRID3 files are being archived but are not yet available online. Please contact me if you need them.

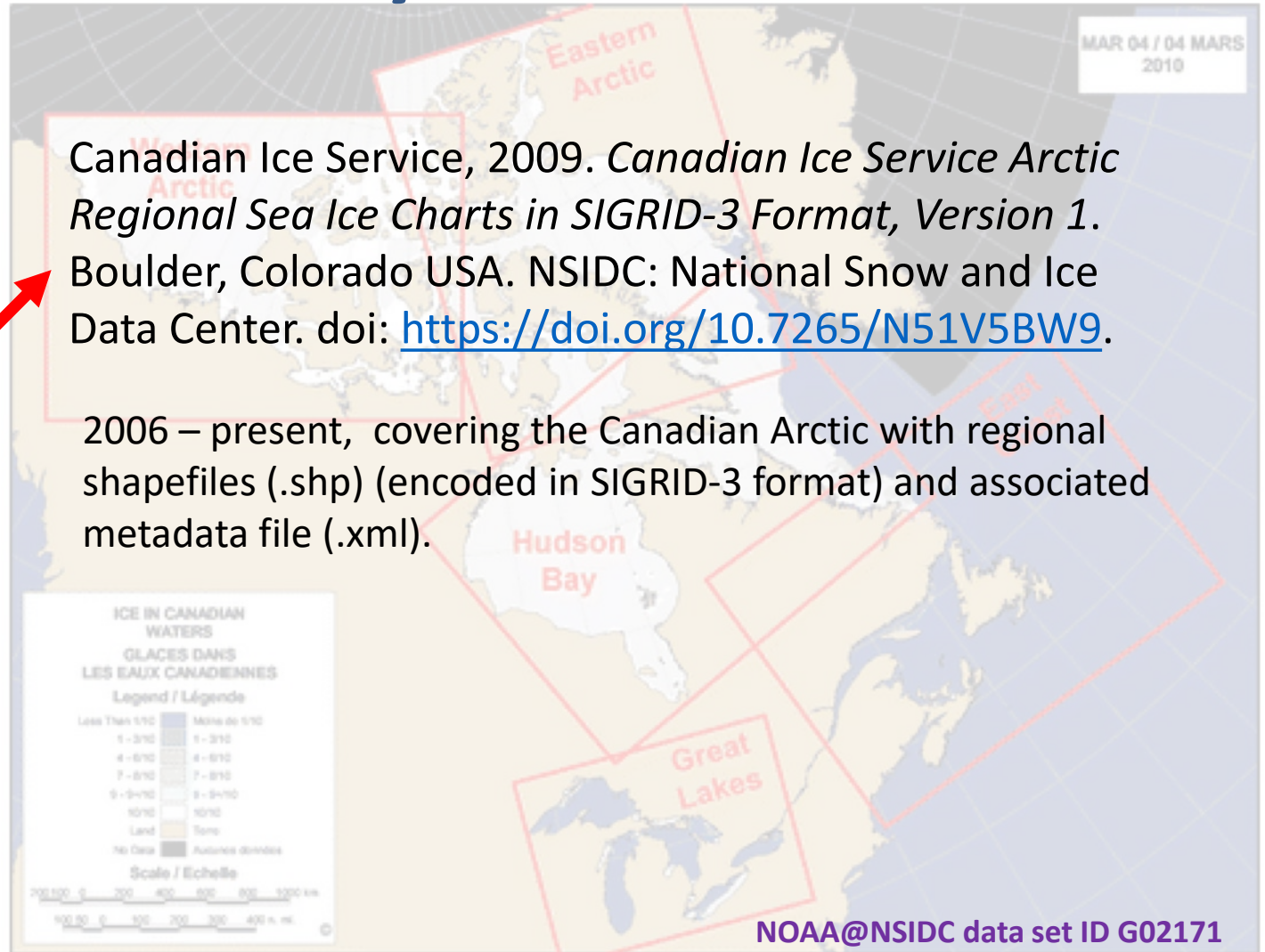
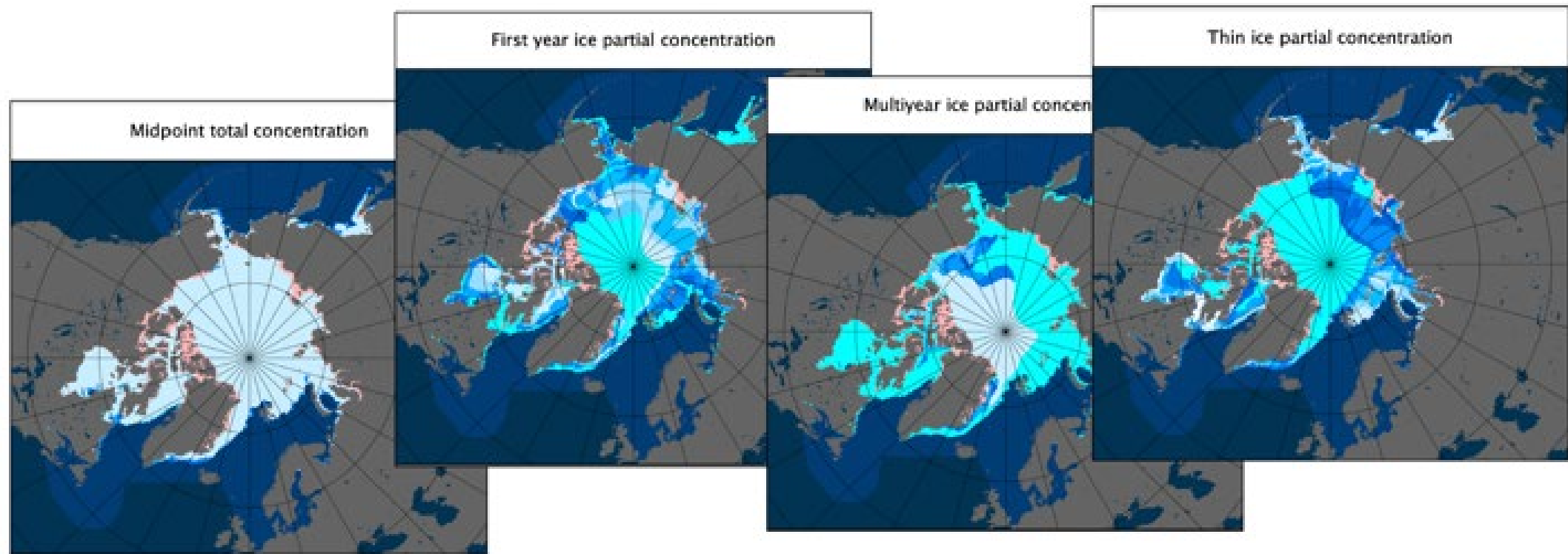


Figure from the G02171 User Guide. Image courtesy of the Canadian Ice Service.

Sea ice information from operational services; data archived and served by NOAA@NSIDC

- USNIC ice chart climatologies derived from SIGRID-3



Concentration (%)



Ice is present but no ice of layer type

Fast ice

NetCDF format

NOAA@NSIDC data set ID G10033

Case study

A naval architect was working on specifications for a new polar research vessel.

- Help National Science Foundation decide on the design ice environment
- To determine which ABS Polar Ice Class will be the design standard for an icebreaker to work in the Southern Hemisphere.

“What they want is a clear understanding of how much they may be able to extend their current operating season for science missions (looking at three locations specifically) if they select Polar Class 3 rather than PC4. ”

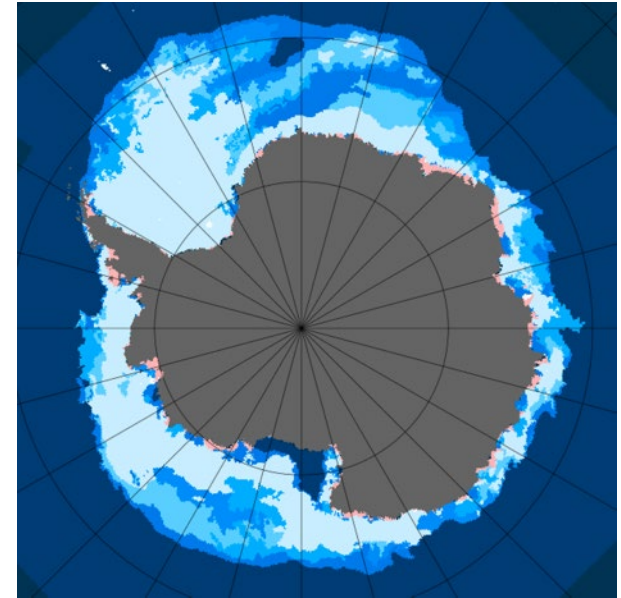
“I think you can use our new product G10033.”

“2nd year ice is the thinnest in our multiyear category. If you do an analysis using our G10033 product for the earliest that *any* ice in our Multiyear category is present in Pine Island Bay, it will tell you the earliest date that a PC-4 icebreaker would be ‘prohibited’ from going in, because 2nd year, or older ice, is there.

And if you do an analysis for the earliest that *any* ice in our First-year ice category is present in Pine Island Bay, it will be conservative, because it will tell you that Thick FY ice, or any thinner FY type, is there.

Or, you can use the US NIC Antarctic shapefiles, which have all the info that the analyst decided to stuff into SIGRID (the egg code).”

INFORMATION GAP: This user noted that SIGRID-3 format chart data he needed were not readily available. He needed a way to search calendar dates for Antarctic stage-of-development ice data.



From NOAA@NSIDC data set ID G10033
Midpoint of total concentration on
12.24.20

Forecasting ice conditions

- **“Information insufficiency is a challenge” for mariners** -From the Salienseas [survey report Mapping Weather, Water, Ice and Climate Knowledge & Information Needs for Maritime Activities](#)
 - Mariners need forecasts of hazards and conditions that impact operational capacity
 - Products showing areas of ridging, leads, compression, thickness are requested but not routinely available. Forecasting these is still in early stages.
 - Pilot project for forecasting ice pressure is underway at CIS.
- **Improving forecast accuracy is a challenge for ice modelers**
 - Ice is increasingly mobile
 - Accurate initialization fields (of ice concentration, for example) are increasingly important
- **Sea ice is changing, and forecast models are working to adapt but can't move fast enough**

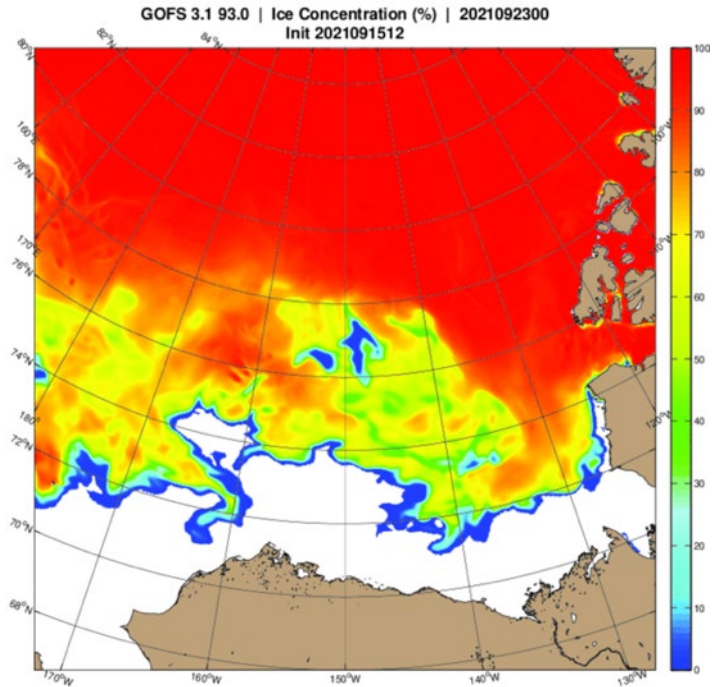


“Dr. Jackie Richter-Menge, Commissioner, U.S. Arctic Research Commission, said the *trend of thicker, older ice changing to thinner, younger ice* strains operations in the Arctic. Dr. Richter-Menge participated in the IceX 2018 exercise with the U.S. Navy Arctic Submarine Laboratory and encountered dangers that underscored **increasingly unpredictable marine operations**, with direct impacts on national security.” (from 8TH BIENNIAL SYMPOSIUM ON THE IMPACTS OF AN ICE-DIMINISHING ARCTIC ON NAVAL AND MARITIME OPERATIONS, July 17 and 18, 2019)

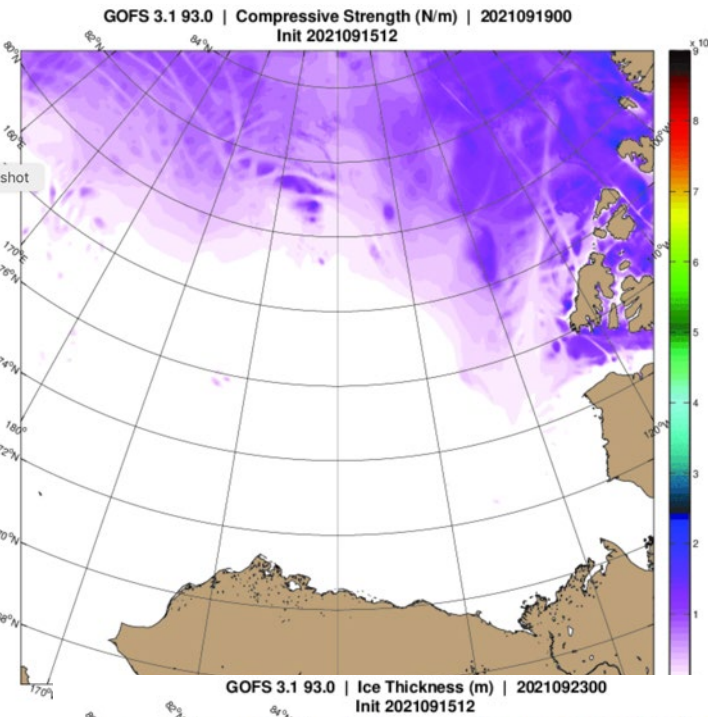
Shown here: Forecast for 9/23/21
initialized 9/15/21. (7-day forecasts)
<https://www7320.nrlssc.navy.mil/GLBhycomcice1-12/>

Also see
https://salienseas.com/?page_id=3428
Demonstration Ice Services page
includes several forecast pages. Rely on
HYCOM-CICE model (so like Navy
model)

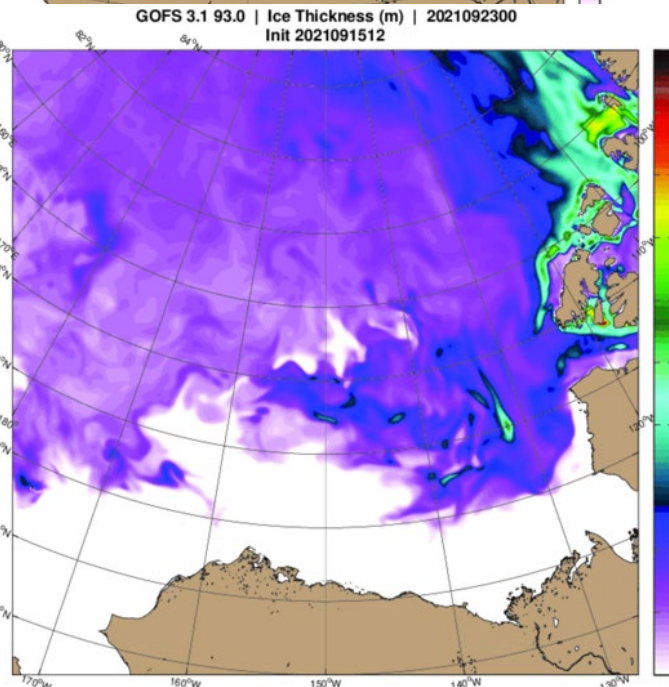
7-day forecast of ice concentration



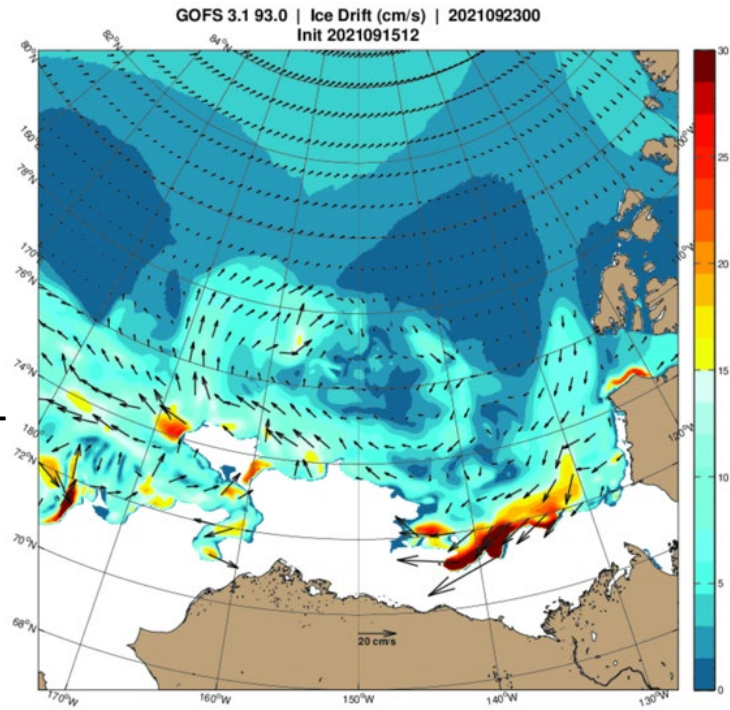
7-day forecast of ice compressive strength



7-day forecast of ice thickness



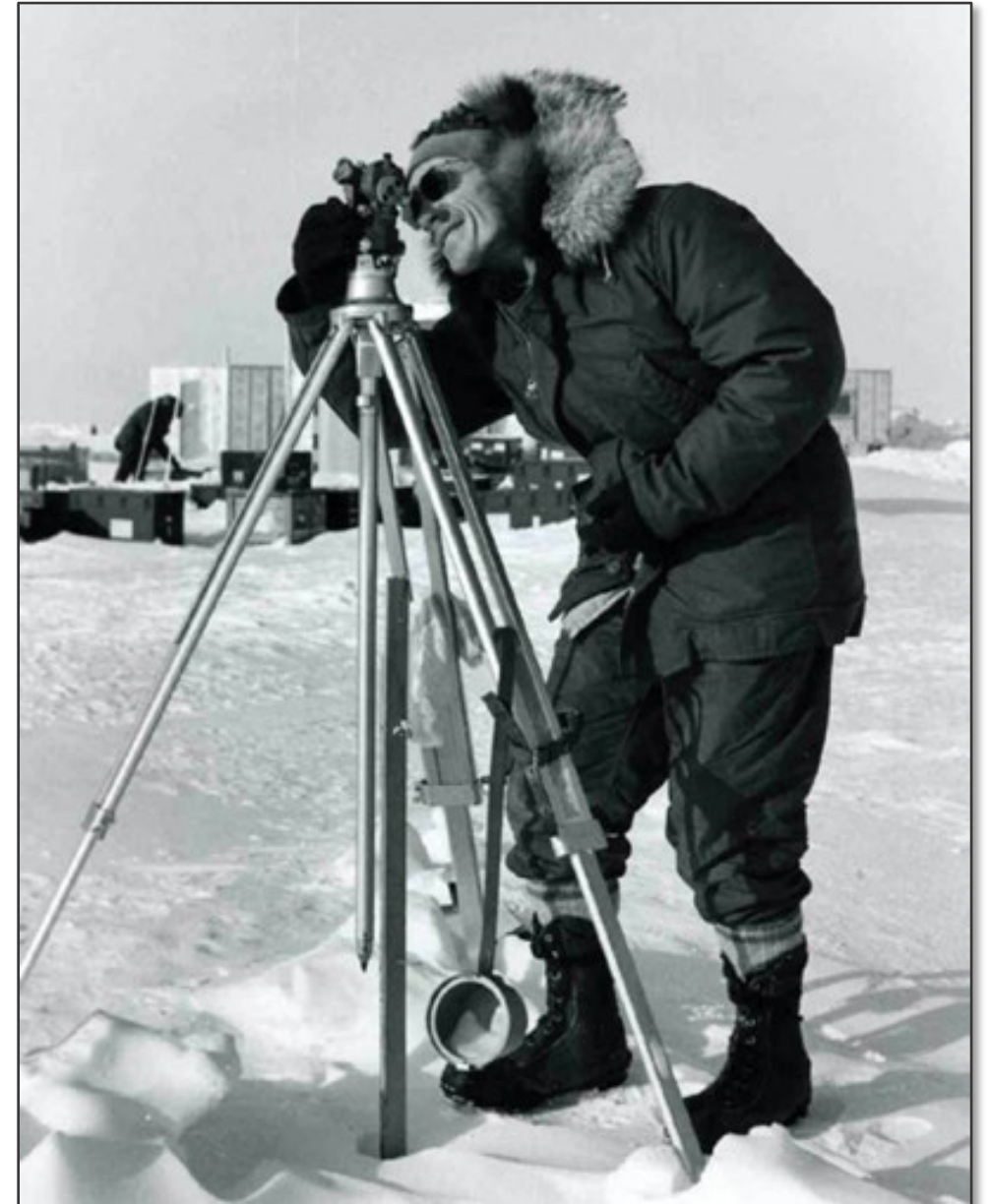
7-day forecast of ice compressive drift



Also see Data and Products of
the Regional Ice Ocean
Prediction System (RIOPS)
from [https://eccc-
msc.github.io/open-data/msc-
data/nwp_riops/readme_riops_e
n/](https://eccc-msc.github.io/open-data/msc-data/nwp_riops/readme_riops_en/)

Notable about forecasting

- **Regional models are better at ice forecasts than global models. Model configuration and running environment matters¹.**
- **No forecasts predict partial concentrations, or advance ice chart polygons forward in time.**
 - Model forecasts from the research community are limited in utility for mariners as far as Polar Code is concerned, but numerical prediction is getting better at predicting ice thickness, ice edge, ridging/difficult ice conditions, rapid freeze-up
- **Weather scale ice forecasts need to be better.**
 - Focus on regional forecasting, and a move away from initializing ice concentration with low-res passive microwave-derived satellite products will help.
- **Seasonal scale forecasts have come a long way**
 - “...many groups have now shown that pan-Arctic and regional SIE can be predicted 0-4 months in advance, with some regions (e.g. Barents, Labrador Seas) showing skill at lead times up to a year in advance...”
 - Newly available ice thickness data from satellite altimeters has helped.
 - Better initialization data is still needed²,
- **Collaborative approaches are spurring progress**
 - HYCOM (HYbrid Coordinate Ocean Model) *consortium*
 - The Sea Ice Prediction **Network** SIPN <https://www.arcus.org/sipn>
 - **WMO** WWeatherRP WClimateRP Subseasonal to Seasonal Prediction Project (S2S) Objectives
 - **Community** Ice Code (CICE) is shared forecast model code

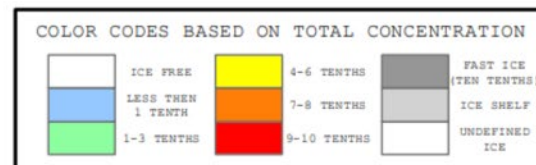
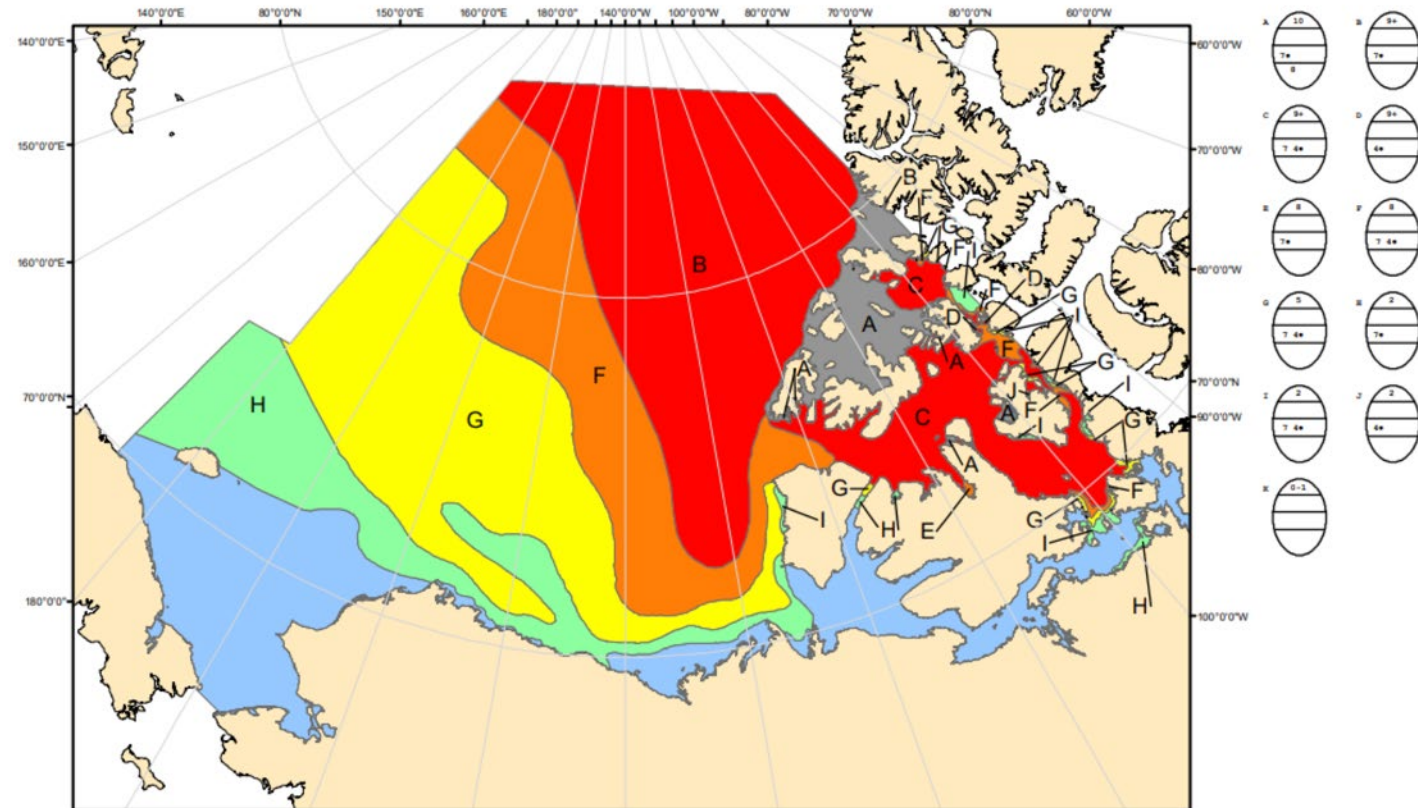


From AIDJEX, a seminal ice dynamics experiment in the 1970s

Outlooks and forecasts from ice services - examples

Example of a 30-day Outlook from the North American Ice Service (CIS and USNIC)

FECN14 CWIS 011800
 THIRTY DAY ICE OUTLOOK
 FOR THE WESTERN AND
 CENTRAL ARCTIC FOR
 ISSUED BY ENVIRONMENT
 CANADA ON 01 JULY 2021.
 THE NEXT 30 DAY
 OUTLOOK WILL BE ISSUED
 ON 15 JULY 2021.








North American Ice Service /
 Service des glaces de l'Amérique du Nord
 ICE FORECAST - 30 DAY
 PRÉVISIONS DES GLACES - 30 JOURS
 VALID/VALIDE: 31 JUL/JUIL. 2021

U. S. NATIONAL ICE CENTER
48 HOUR ICE EDGE FORECAST
ARCTIC ATLANTIC

FORECAST FOR: 02 OCT 2021
PRODUCED: 30 SEP 2021



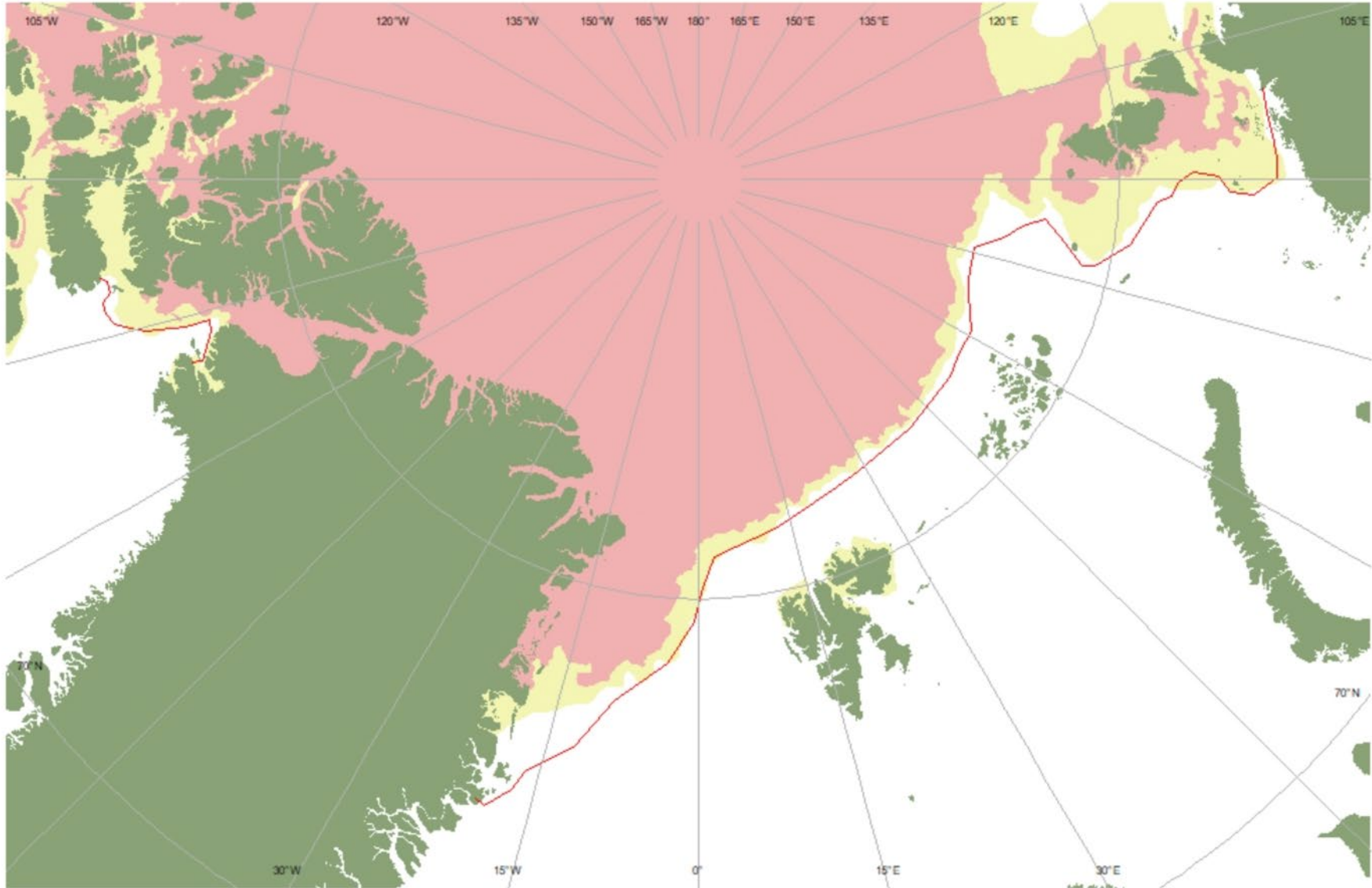
USNIC
US National Ice Center
4251 Suitland Road NSOF
Washington, DC 20395
www.natice.noaa.gov 301-817-3975

-  48 hr Forecast Ice Edge
-  8 - 10/10ths ice coverage
-  1 - 8/10ths ice coverage
-  Ice Free
-  Land

US NIC forecast of outer ice edge.
Sea ice current for date produced.

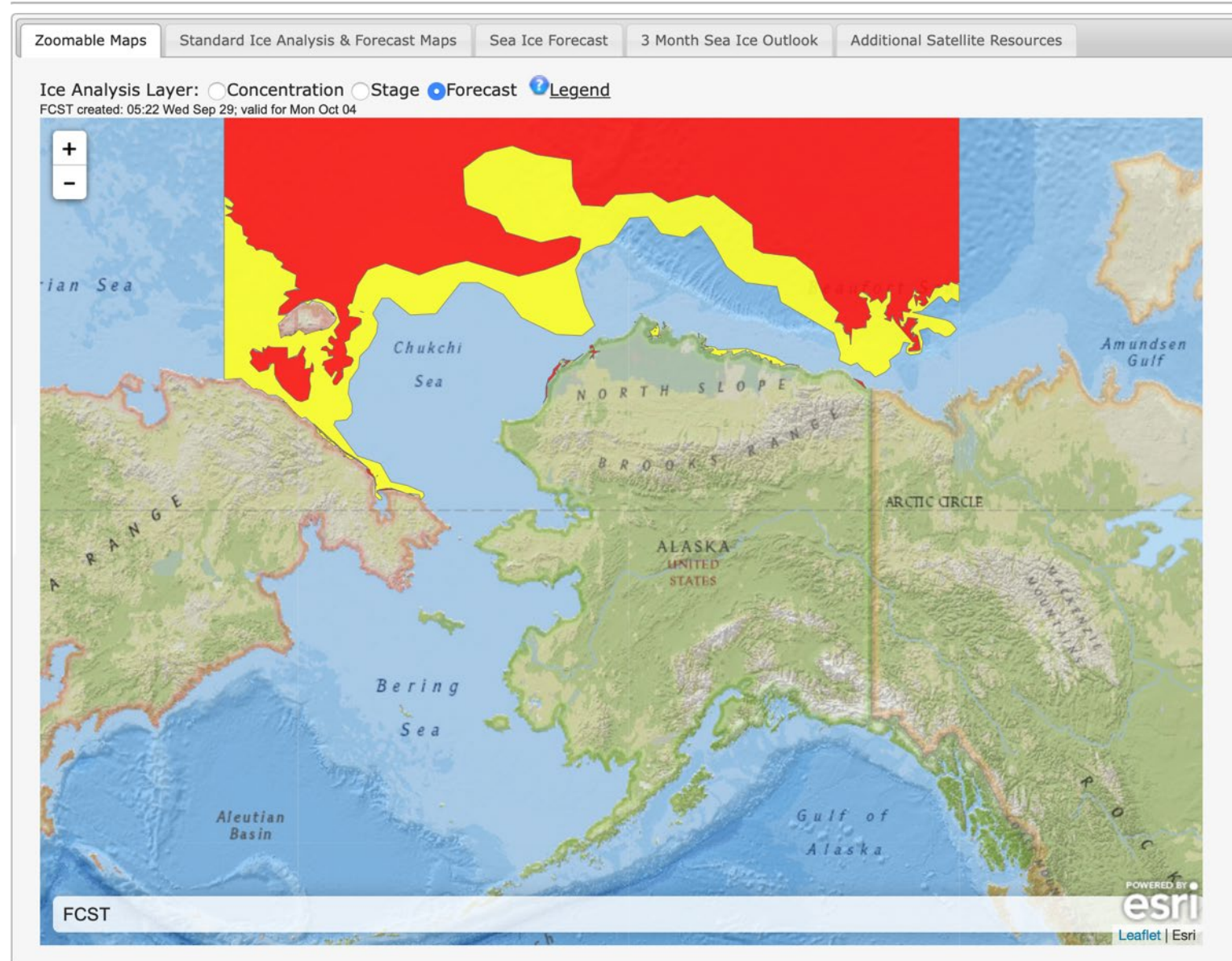
scale: 1: 13350000
projection: Azimuthal Stereographic
standard parallel 60°

**48-hour
forecast
of ice
edge
position
from
USNIC**



Our ASIP is staffed 7 days a week from 6:30 am to 3:30 pm
Operations Phone Line: 907.266.5138
Operations Email: nws.ar.ice@noaa.gov

5-day forecasts of pack and MIZ



Take-away points

- To conform with the Polar Code, one must determine the Risk Index Outcome for a ship when planning a voyage. Must know the composition of the ice it will encounter. Partial concentrations, i.e. concentration by ice stage of development (also called *ice type*), must be known. Charts from national operational ice services have these. Also can get from Polar View.
- To research *past ice conditions* in a region, use archived operational charts. NOAA@NSIDC has archives of U.S. National Ice Center and Canadian Ice Service charts.
- Short-term forecasts of total ice concentration and ice edge position are available but not relied on by operational services. Forecasts of concentration by type are not on the horizon, but numerical forecasts of hazards like ridged ice are being developed. 30-day “Outlooks” that do include ice type information are available. These rely on analysts with regional expertise.
- The International Ice Charting Working Group should be your first stop when looking for ice charting information. You’ll find a list of all national ice services on that site.
- IICWG and Polar View are consolidating ice information sources for mariners.

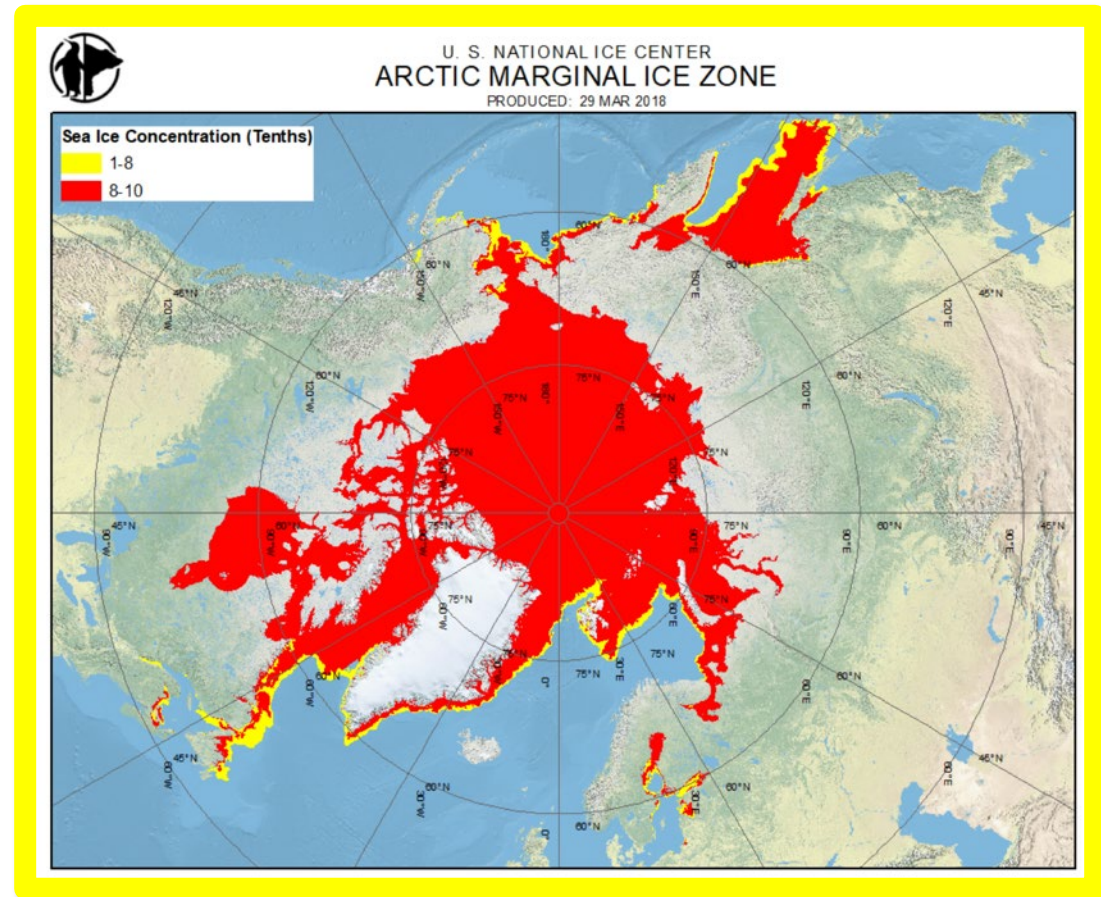
Thank you!

Miss Marilene Tide
Category B ship



Sea ice information from operational services, data archived and served by NOAA@NSIDC

- Other products from operational services
 - Several IIP Iceberg data sets, including
 - G00807 [International Ice Patrol Iceberg Sightings Database](#)
 - G10028 [International Ice Patrol Annual Count of Icebergs South of 48 Degrees North, 1900 to Present](#)
 - U.S. National Ice Center Daily Marginal Ice Zone Products [NOAA@NSIDC data set ID G10017](#)
 - IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions.
 - Derived from IMS:
 - [Multisensor Analyzed Sea Ice Extent - Northern Hemisphere \(MASIE-NH\)](#)
 - MASAM2: Daily 4 km Arctic Sea Ice Concentration



Yellow: 10% - 80% MIZ Red: greater than 80% pack
Daily archive of charts 2004 - present