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DELIVERING A HIGHER STANDARD

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ARCTIC WINTER SHIPPING – PRACTICAL EXPERIENCE

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CANADIAN NORTHERN COMMUNITIES RELIANT ON MARINE TRANSPORTATION

FEDNAV LIMITED – ARCTIC EXPERIENCE

- 60+ years of Arctic Trading
- More than 35 Million tonnes of cargo carried
- In excess of 850 voyages
- The vast majority of voyages using Category C (light or no ice class) vessels
- 22 years of Winter Voyages into Polar Waters
- No environmental incidents

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Seasonal Evolution – Arctic Shipping Projects Through The Years

Category B Vessels

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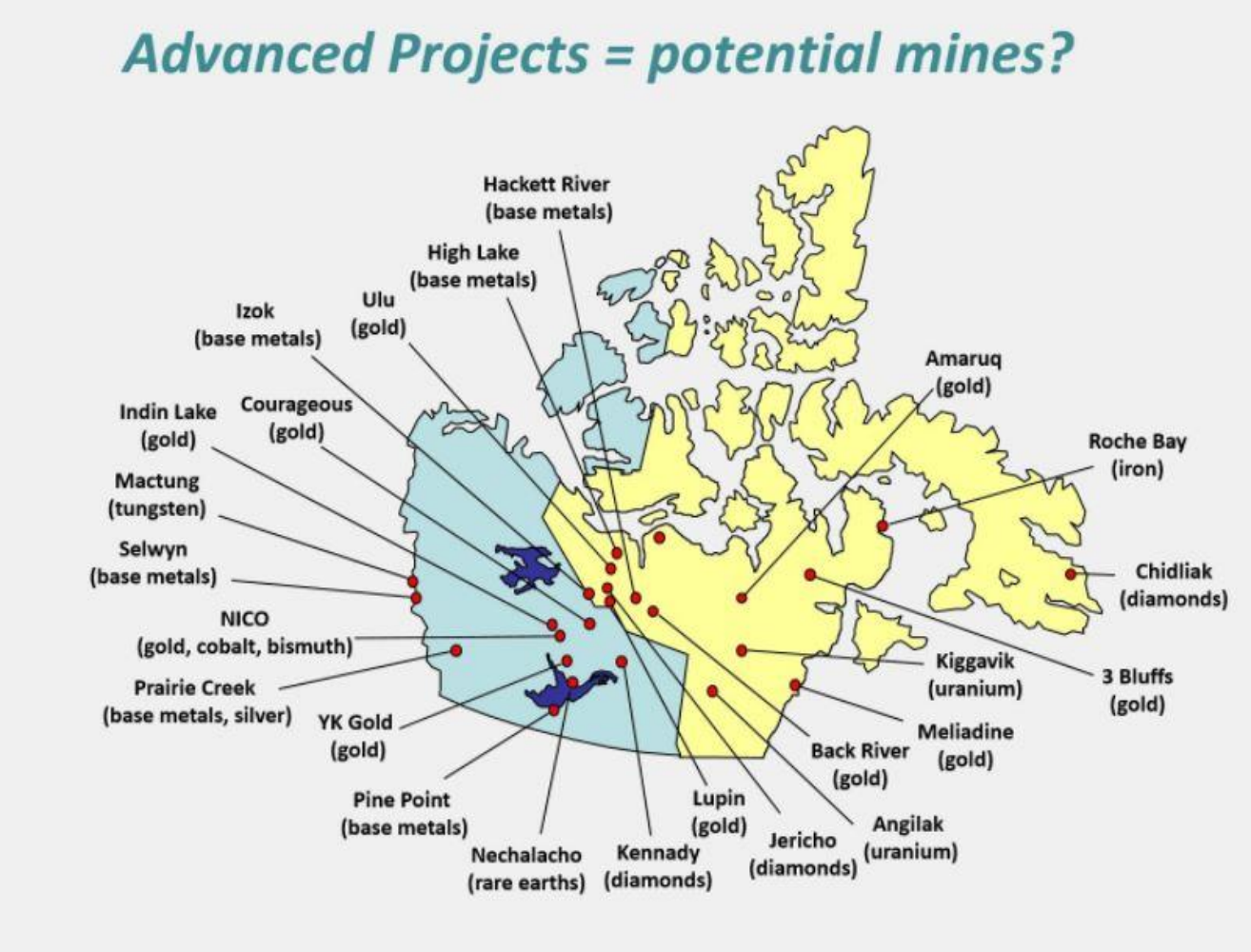
BAFFINLAND IRON MINE

NORTHERN RESOURCE WEALTH



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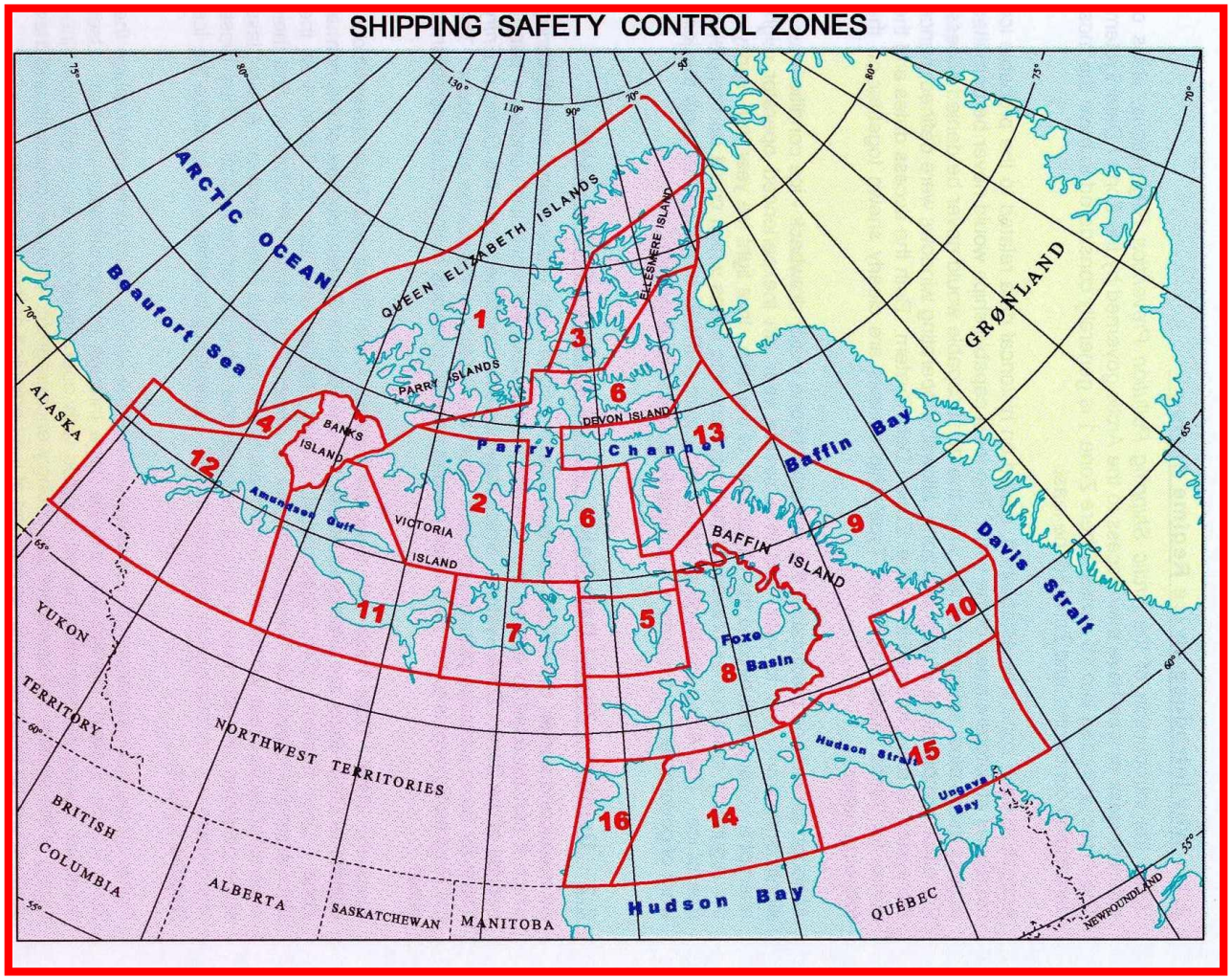
ZONE DATE SYSTEM



ARCTIC ICE REGIME SHIPPING SYSTEM

June, 1997 — *User Assistance Package*

Table of Ice Multipliers for the Arctic Ice Regime Shipping System (AIRSS)

AES / WMO Ice Codes	Ice Types	Thickness	Ice Multipliers for each Ship Category: Type E	Type D	Type C	Type B	Type A	CAC 4	CAC 3
7• or 9•	Old / Multi-Year Ice		-4	-4	-4	-4	-4	-3	-1
8•	Second-Year Ice		-4	-4	-4	-4	-3	-2	1
6 or 4•	Thick First-Year Ice	> 120 cm	-3	-3	-3	-2	-1	1	2
1•	Medium First-Year Ice	70-120 cm	-2	-2	-2	-1	1	2	2
7	Thin First-Year Ice	30-70 cm	-1	-1	-1	1	2	2	2
9	Thin First-Year Ice - 2nd Stage	50-70 cm							
8	Thin First-Year Ice - 1st Stage	30-50 cm	-1	-1	1	1	2	2	2
3 or 5	Grey-White Ice	15-30 cm	-1	1	1	1	2	2	2
4	Grey Ice	10-15 cm	1	2	2	2	2	2	2
2	Nilas, Ice Rind	< 10 cm	2	2	2	2	2	2	2
1	New Ice	< 10 cm	"	"	"	"	"	"	"
=Δ	Brash (ice fragments < 2 m across)		"	"	"	"	"	"	"
	Bergy Water		"	"	"	"	"	"	"
	Open Water		"	"	"	"	"	"	"

Decayed Ice: For the following ice types: MY, SY, TFY, and MFY that are 'Decayed', add **+1** to the Ice Multiplier.

Ridged Ice: For ice floes that are over 3/10ths 'Ridged' and in an overall ice concentration that is greater than 6/10ths, subtract 1 from the Ice Multiplier.

* Another version of this table can be found in TP 12259.

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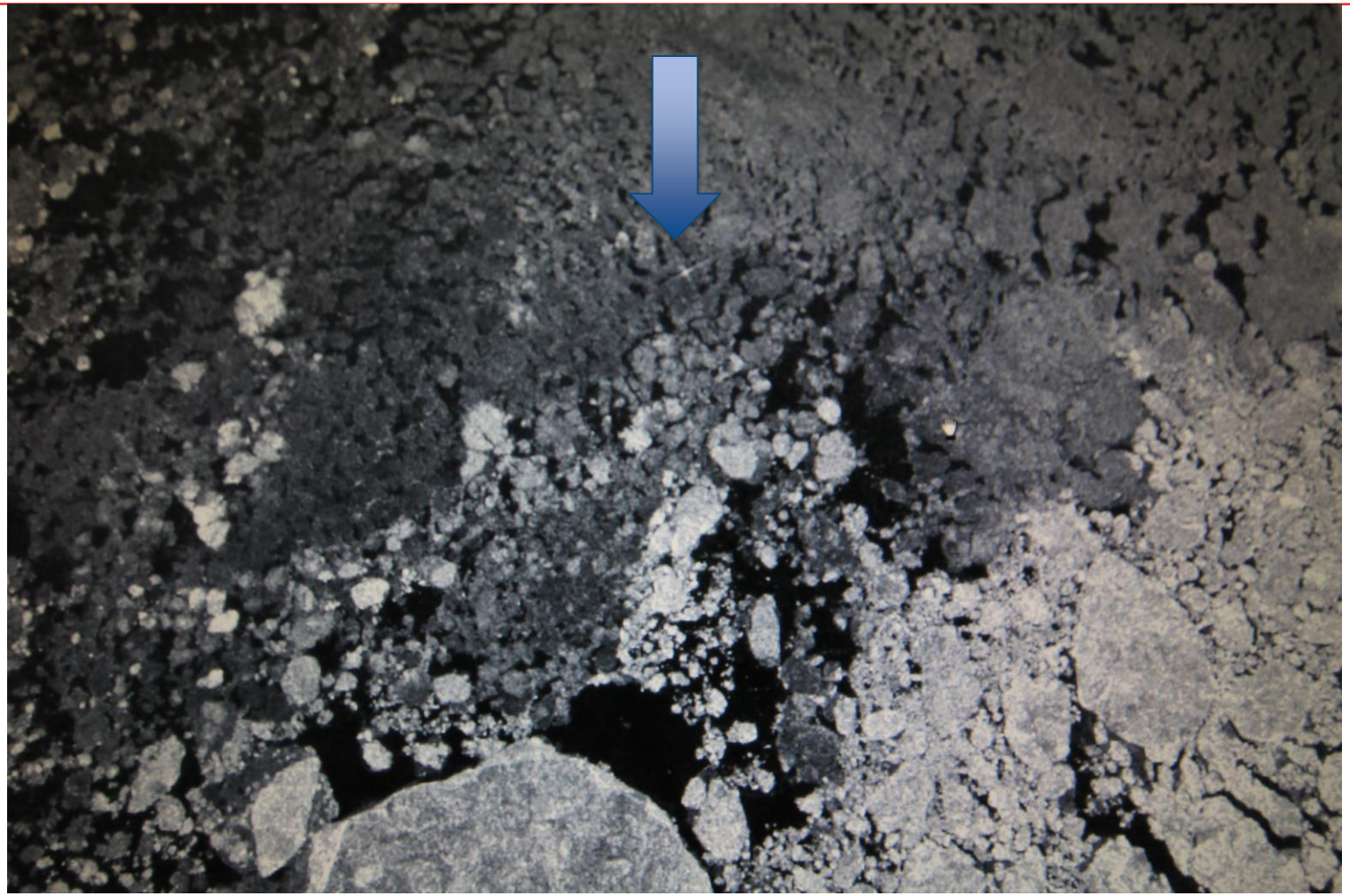
NUNAVIK IN ICE HEADING INTO PRINCE OF WALES STRAIT



SHEAR ZONE AT DECEPTION BAY – 7 METRE THICKNESS

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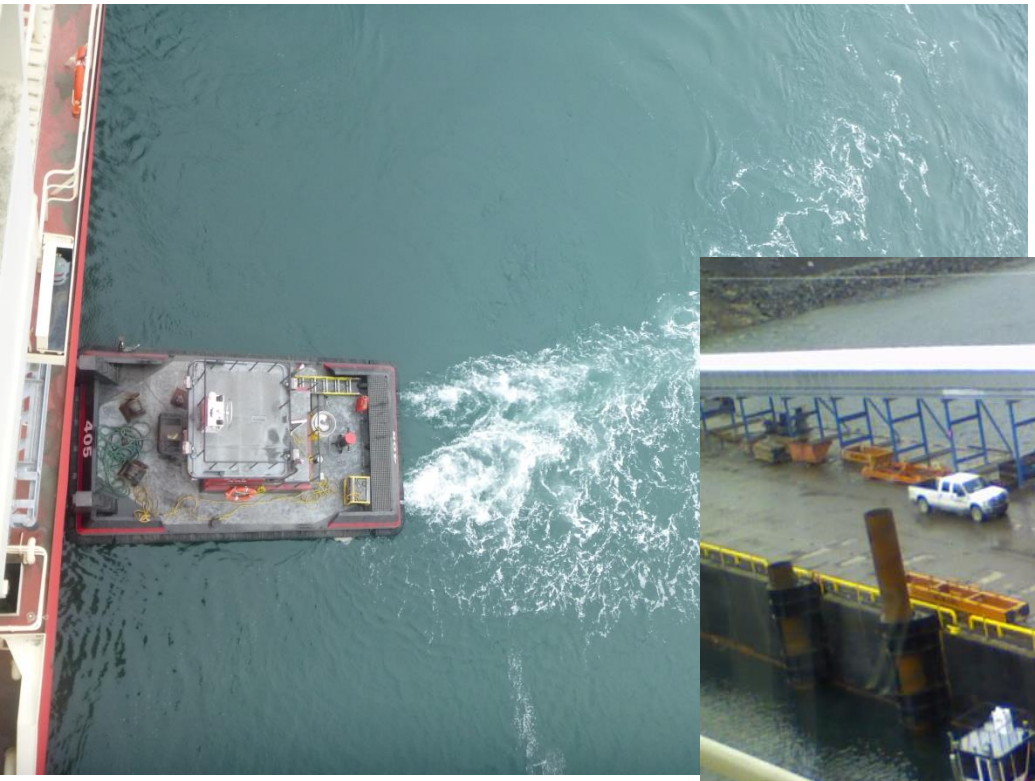
NIGHT NAVIGATION

LACK OF RESOURCES



VOYAGE-LOADING AT DECEPTION BAY

Loaded Nickel Ore 23000 MT from Canadian Royalties mine
19 Sept 2014 – 62°30'N 073° 56W

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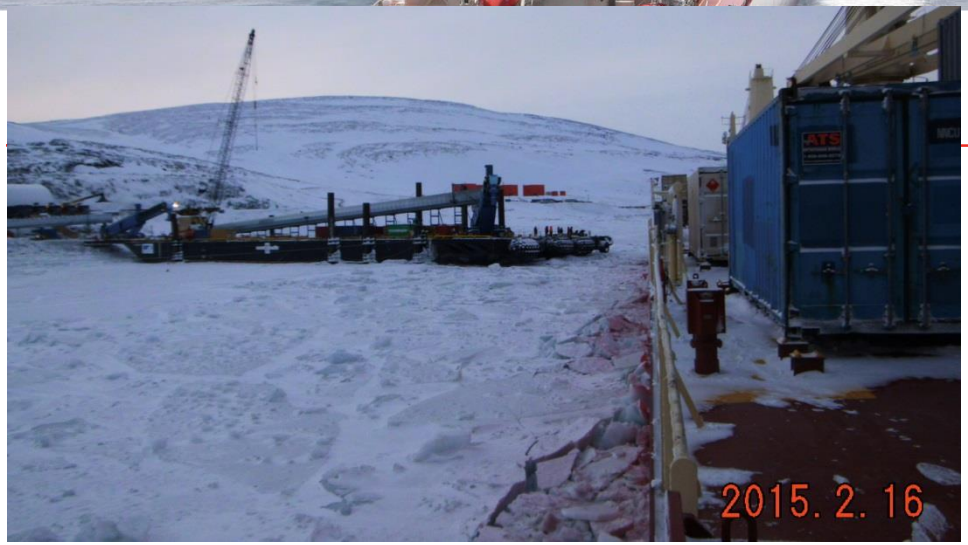

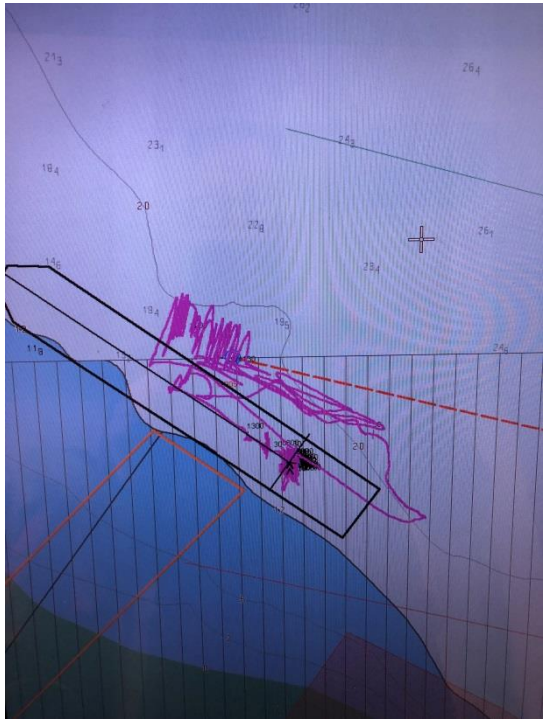

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grey ice, nickel dust contaminated
28/12/2013


deck ice-crusted
28/12/2013


retro disch. Mining machine, 28ts
28/12/2013


nickel contaminated ice chipped of, bagged & discharged for disposal
29/12/2013

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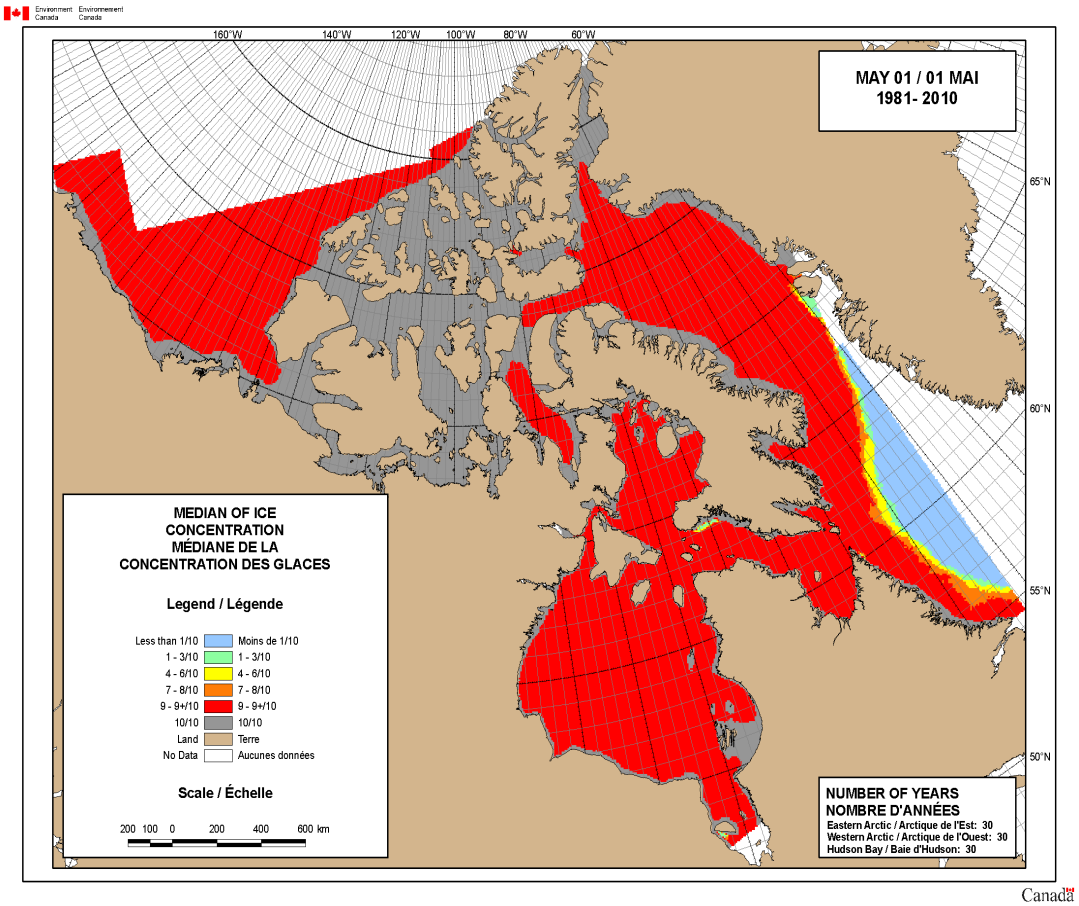
CANADIAN ICE SERVICE



MV ARCTIC BESETTING EVENT

The MV Arctic was beset for about 17 days in early June 2018 trying to transit from east of Charles Island into Deception Bay.

Ice chart showed a full ice cover of thick first year ice (>120 cm) in vast floes (2-10 km wide) along the southern half of the Hudson Strait.

Strong N / NW winds persisted for several days, causing the ice to be pushed against the northern Quebec shore. Heavy pressure occurred and kept the ship from being able to make any progress.

Based on ice charts, ice conditions in Hudson Strait in early June 2018 were quite similar to normal in terms of extent and concentration.

However, the MV Arctic had a great deal of difficulty transiting this area, which is uncommon for that time of the year, when ice is normally decayed and soft.

This was unexpected as none of the weather products that we had access to gave us any indication of the difficulty ahead.

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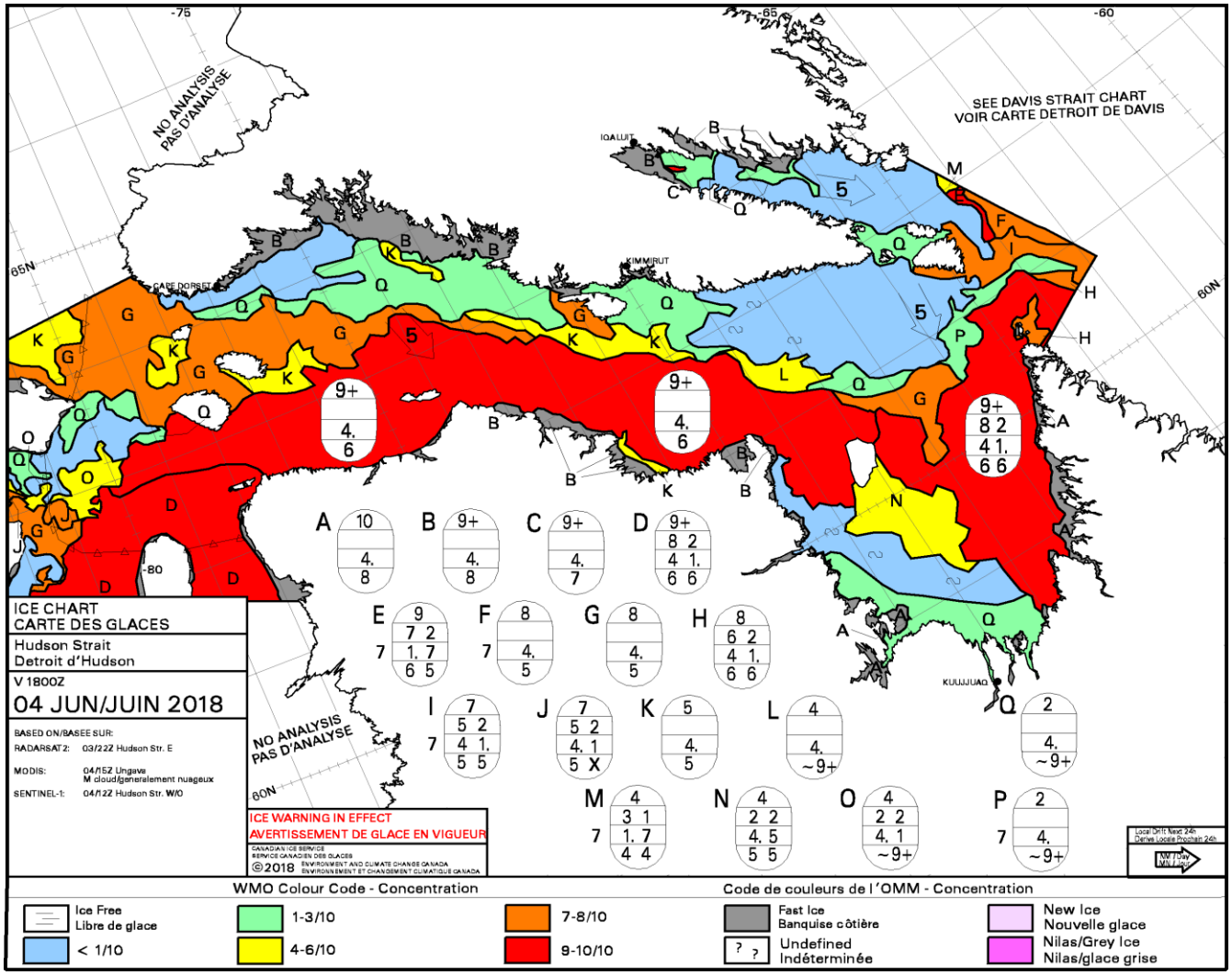
ICE CONDITIONS ON JUNE 4TH (2018)



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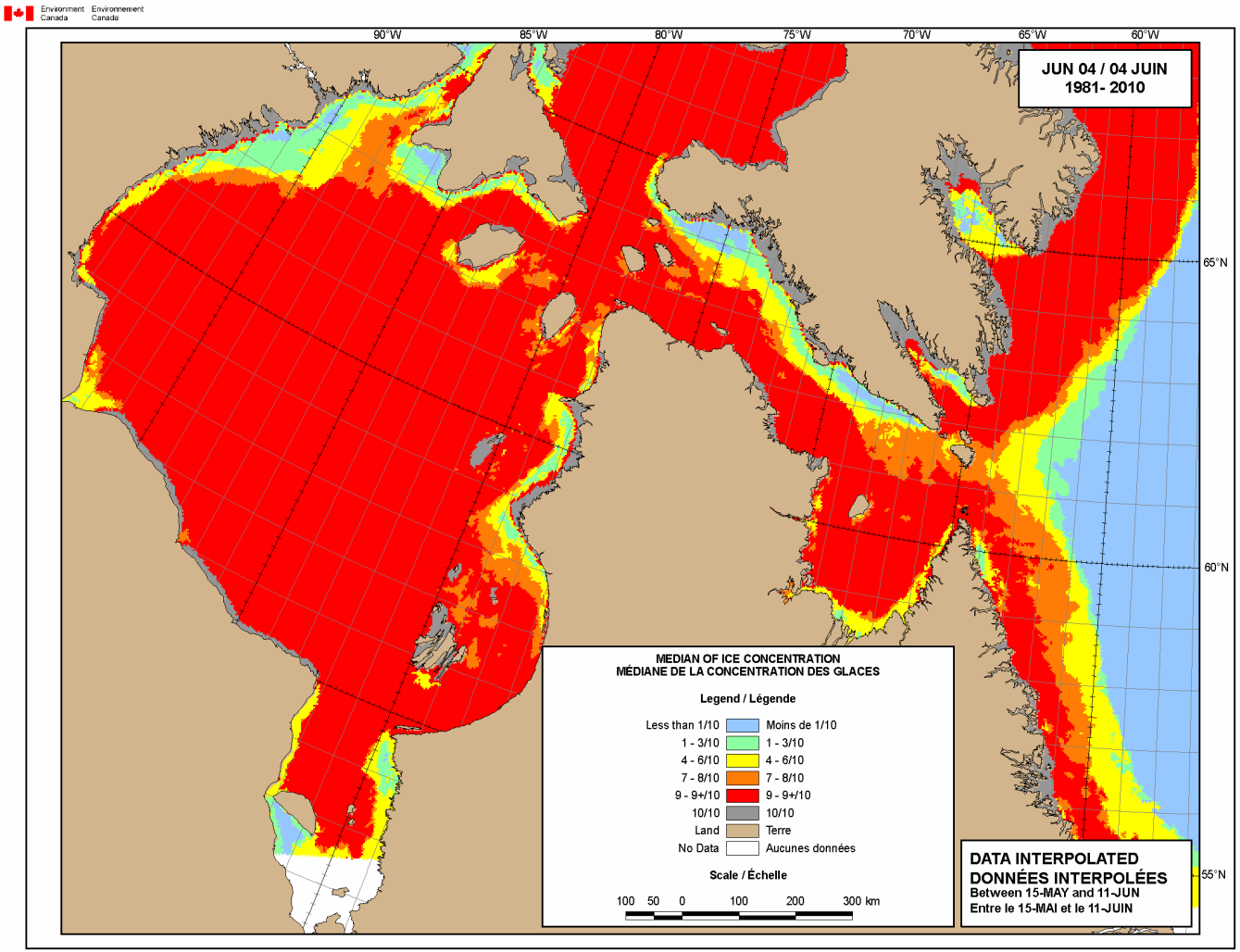
Normal (median) ice conditions on June 4th



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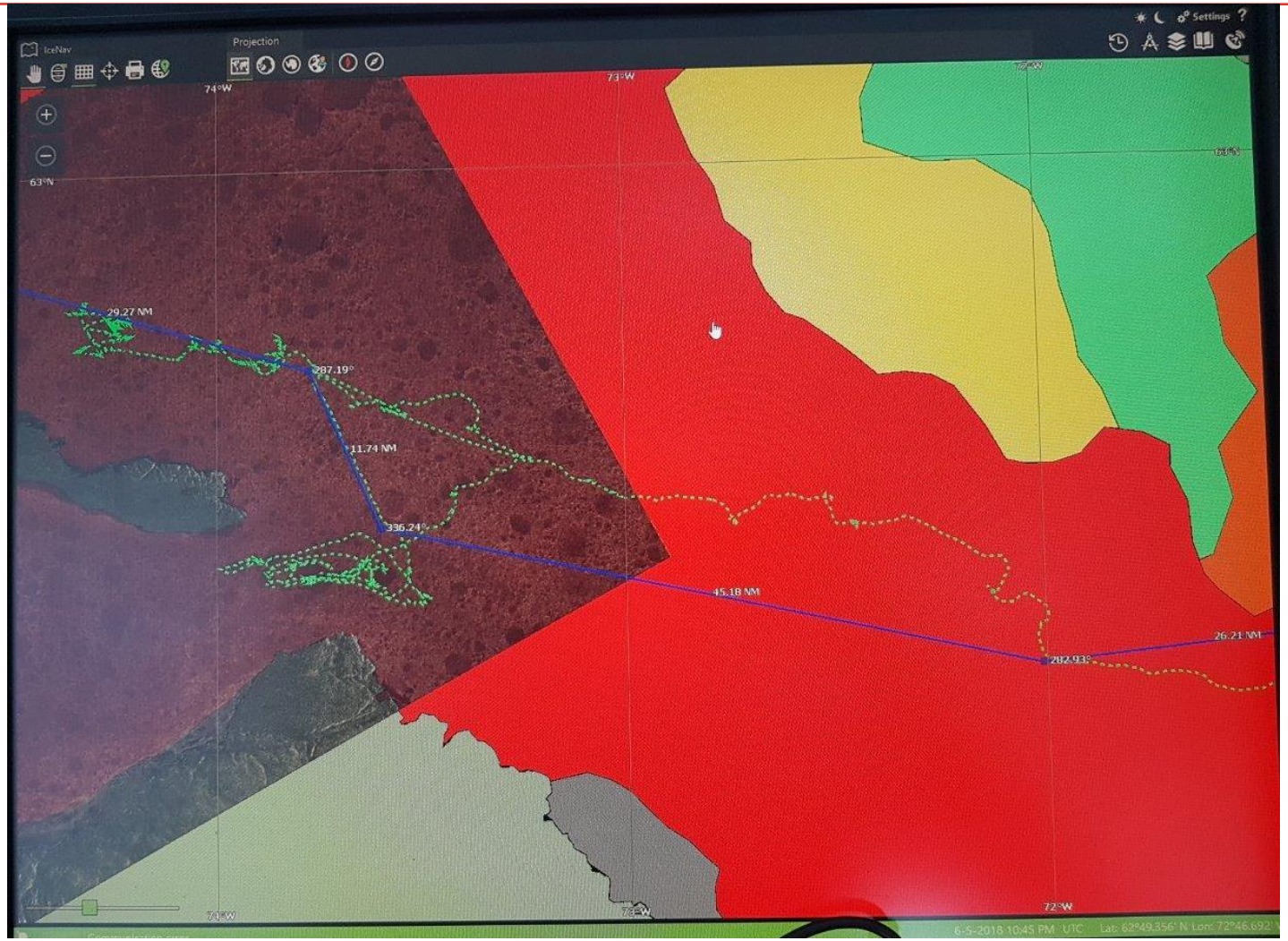
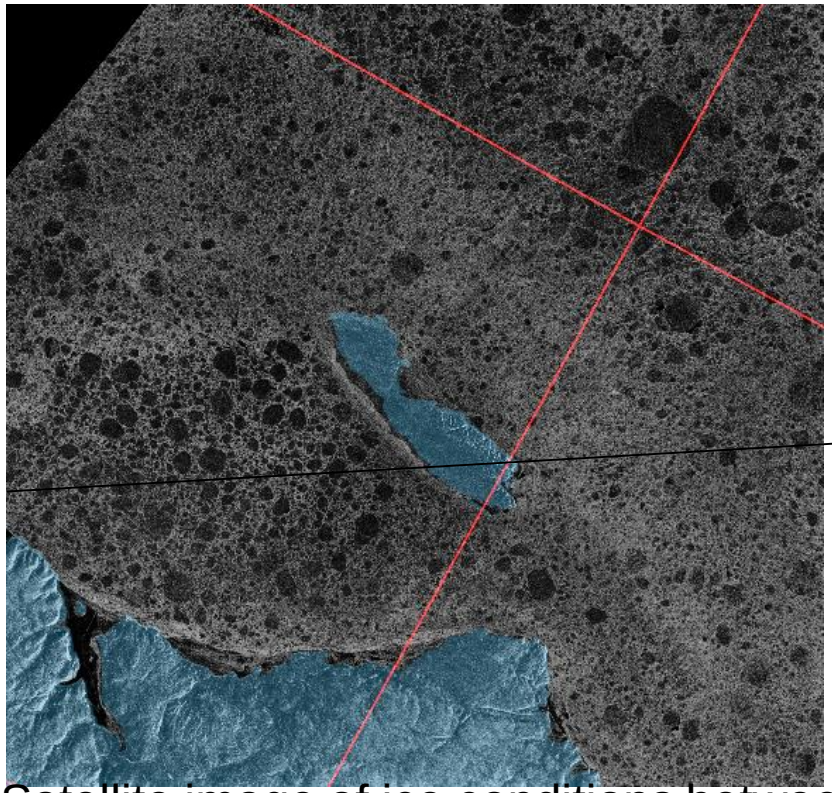

IceNav
Projection
Settings
74°W
73°W
63°N
29.27 NM
287.19°
11.74 NM
336.24°
45.18 NM
282.93°
26.21 NM
74°W
73°W
72°W

WHAT IS MISSING FROM ICE CHARTS AND CURRENT ICE INFORMATION PRODUCTS

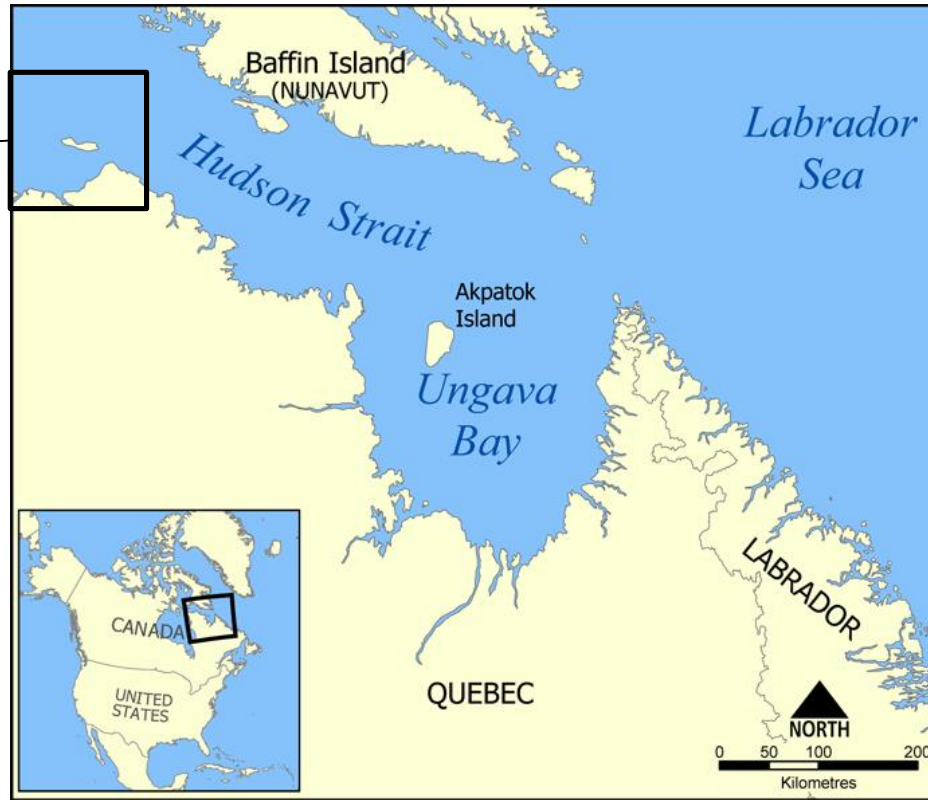
- Information on **features resulting from deformation**, such as ridges, rubble and shearing
- Information on **state of the ice**, in this specific case the level of decay
  - Normally, at that time of the year, the melting process is undergoing, therefore the ice is smoother than during winter and easier to break.
- Indication of **dynamics**, such as pressure
  - This information exists, for example with Canada's National Research Council Pressure forecast model. It should be integrated in Canadian Ice Service products in order to be readily available to any ship that needs it.

Without this information, it is difficult to determine if the ship is expected to encounter difficulties and delays in an ice cover that corresponds to its ice class (thickness)

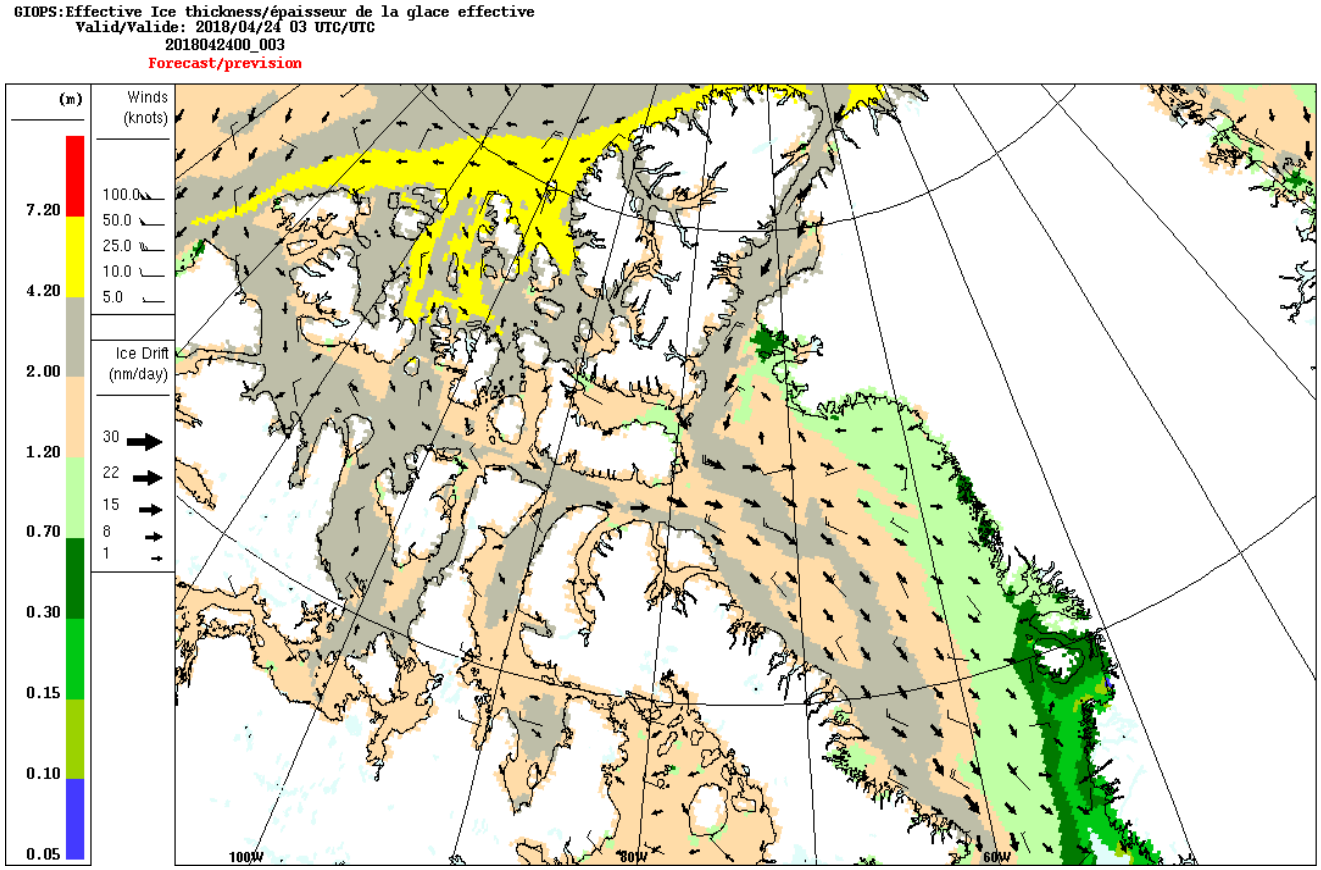
Remote sensing limitations



Satellite image of ice conditions between Charles Island and Deception Bay on June 3rd, 2018 (Source: Sentinel-1)



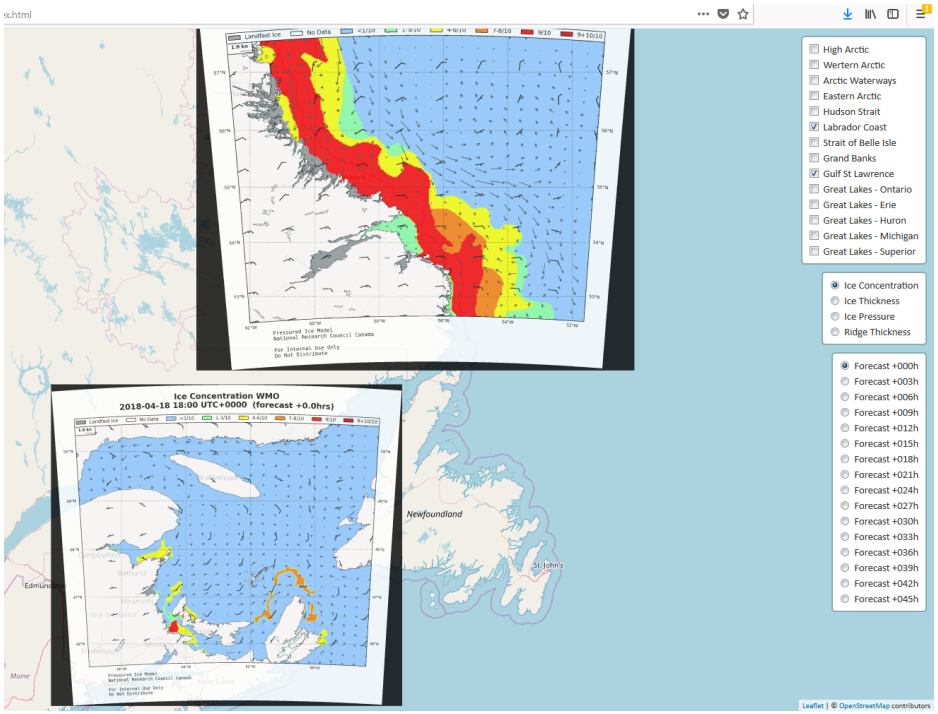
CANADIAN ICE SERVICE



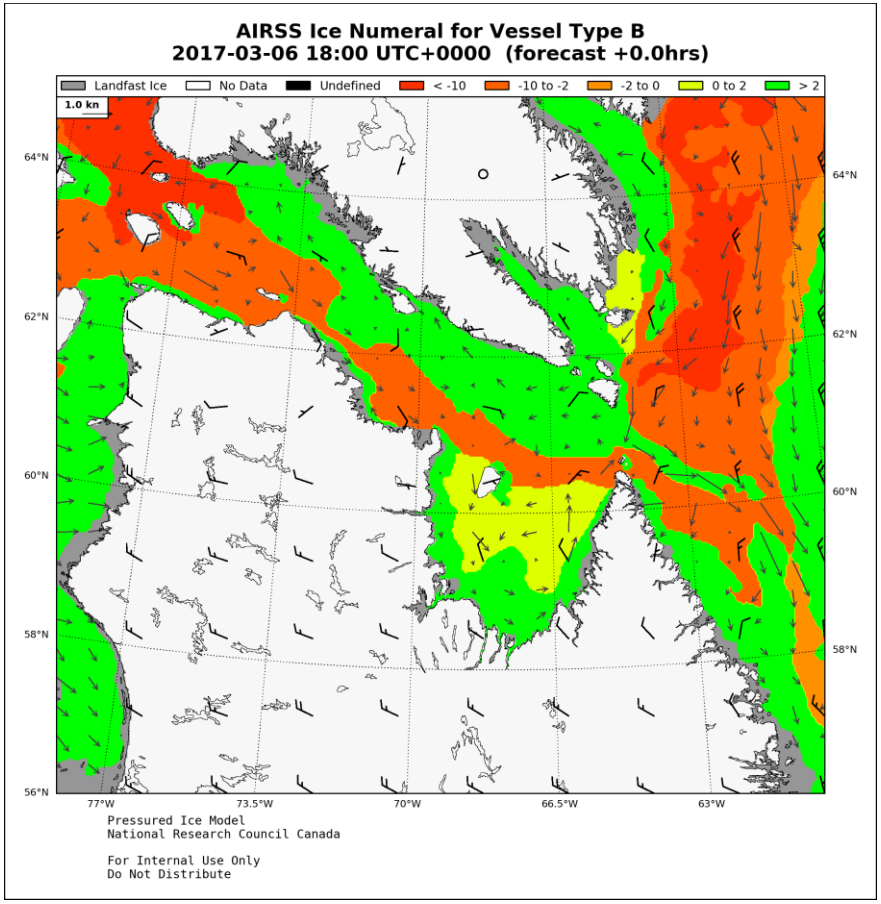
NRC PRESSURED ICE MODEL UPDATES

COURTESY IVANA KUBAT, NRC

NRC Pressured Ice model maps accessible through a web interface



Ice Numeral calculation forecast



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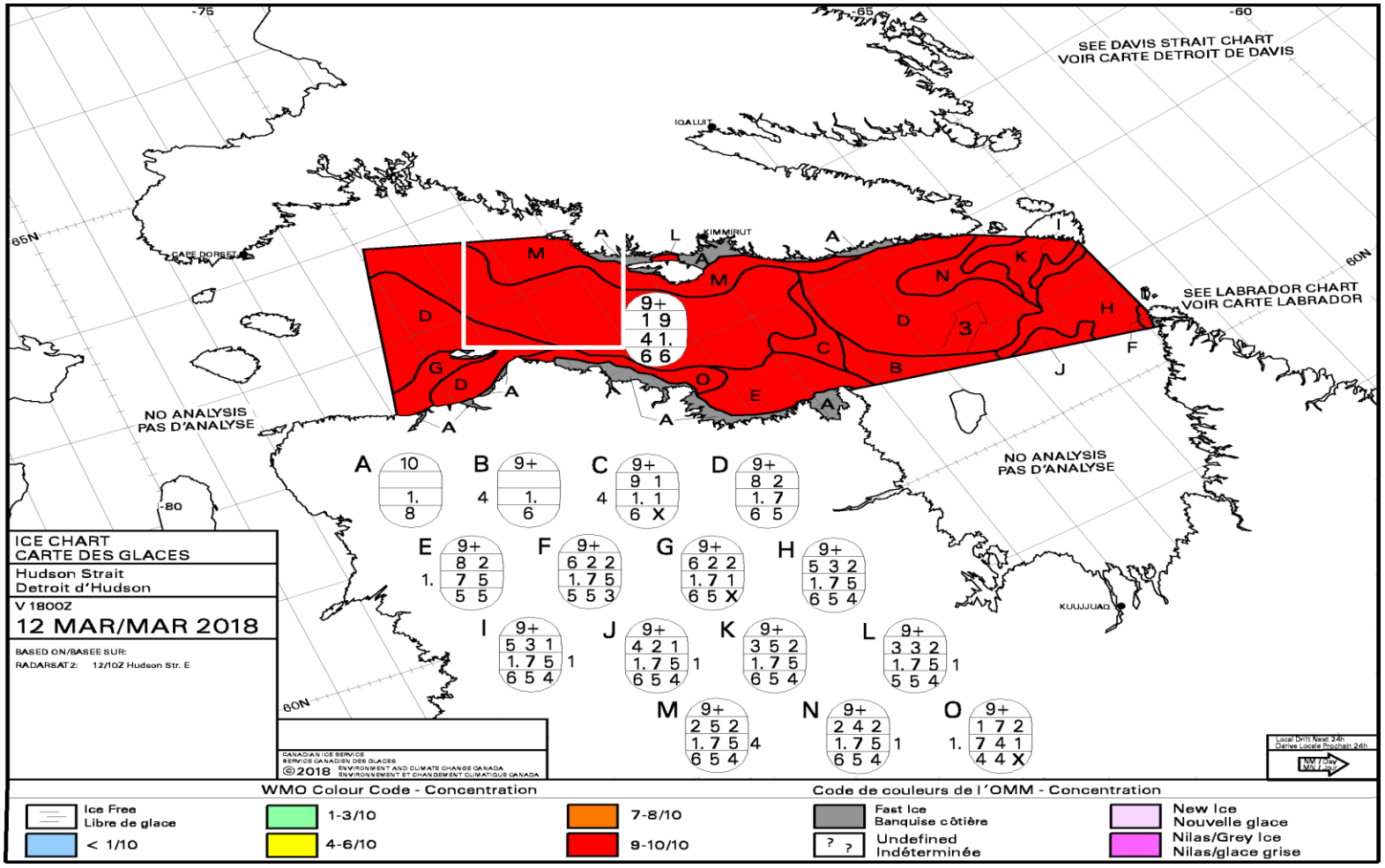
TERRA SAR-X

MARCH 12, 2018



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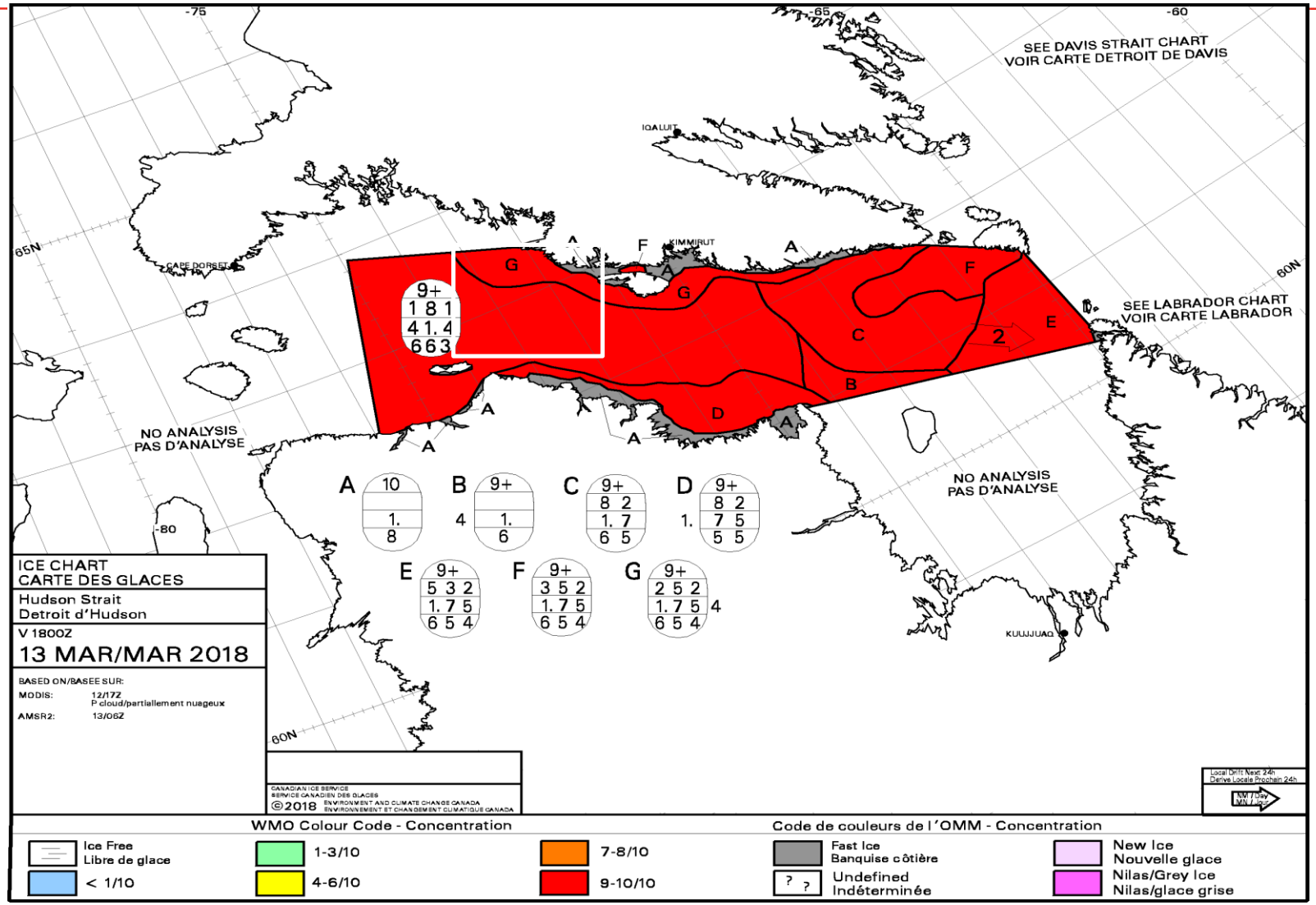
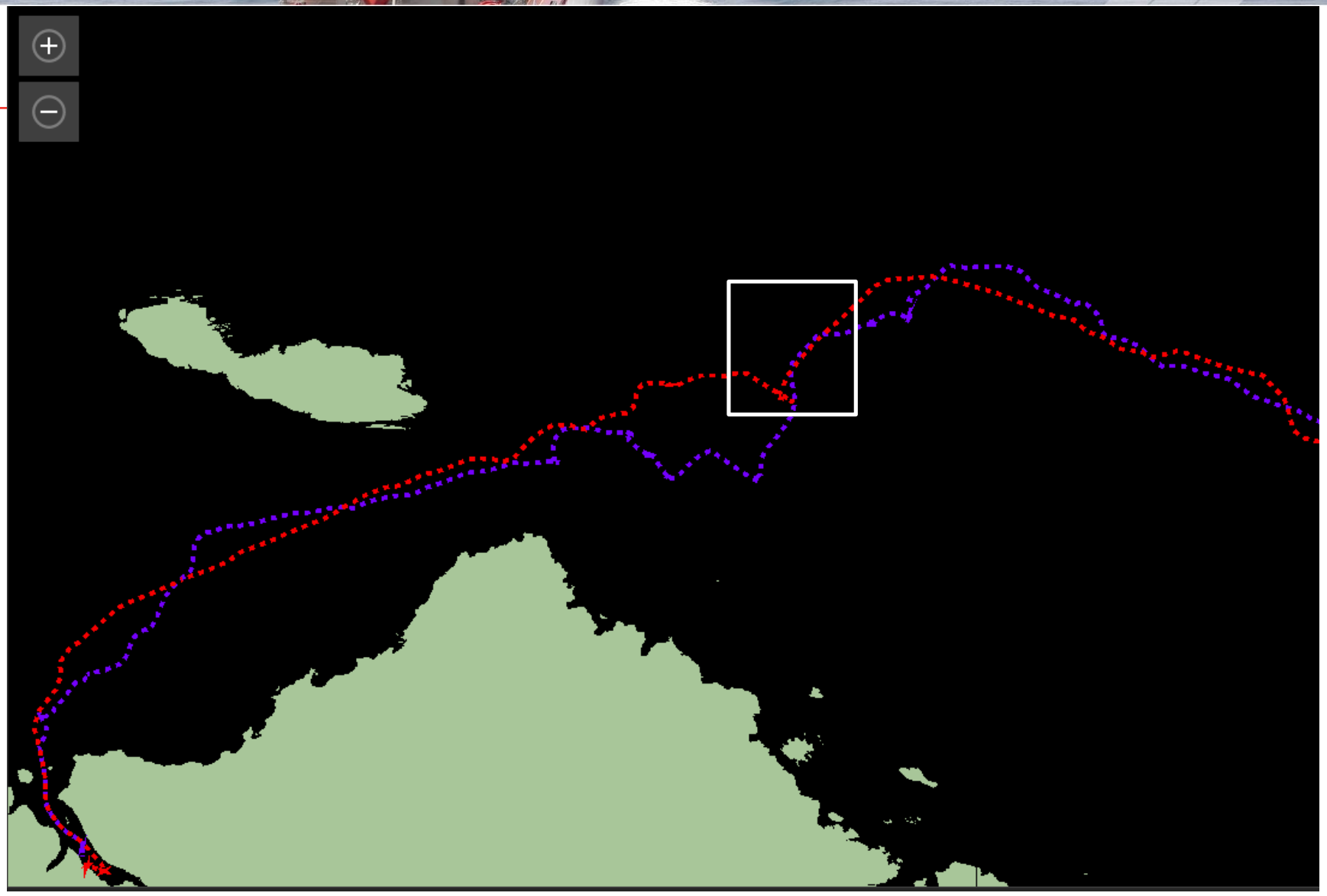
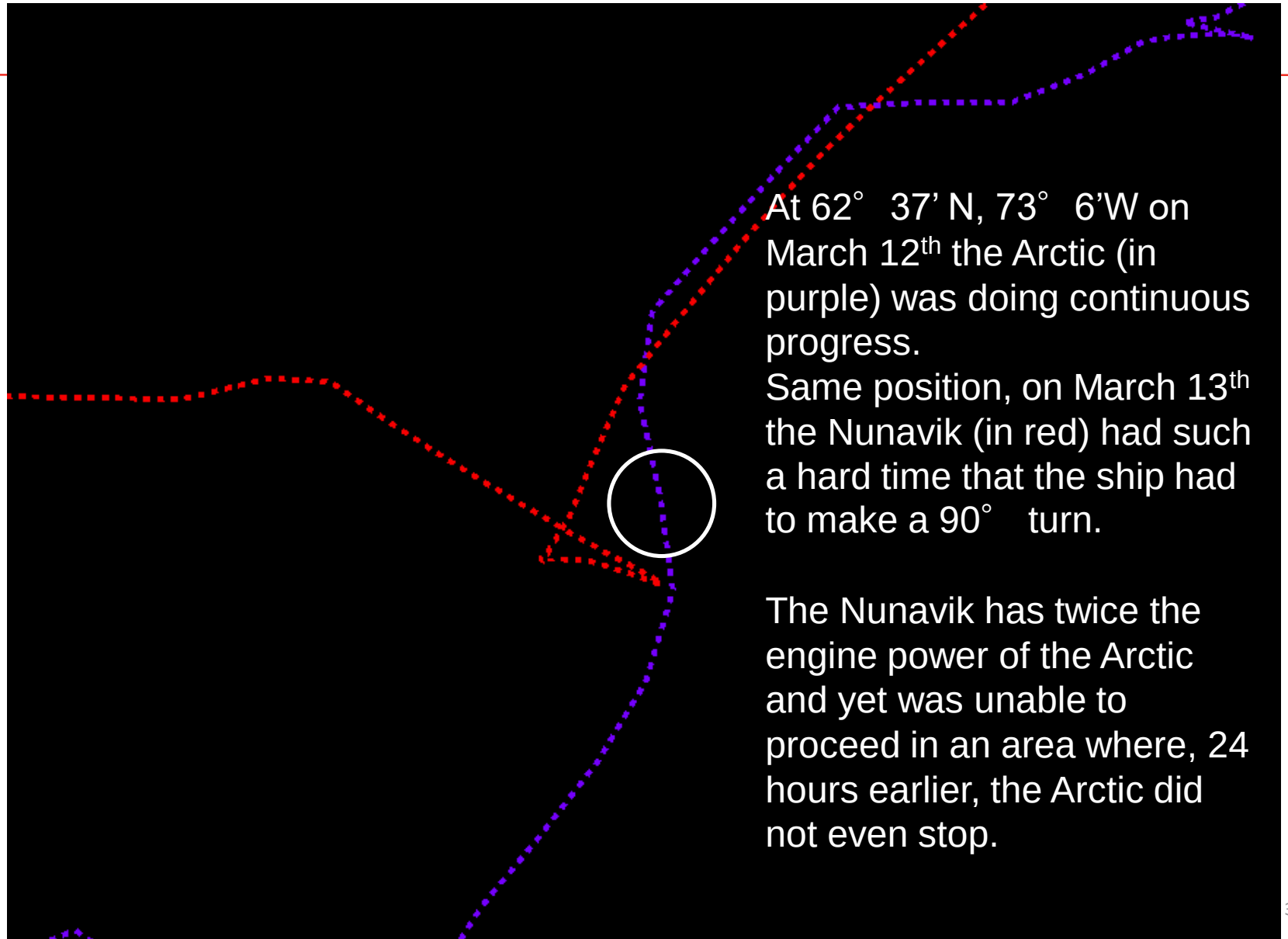
MARCH 13, 2018



- Charts are showing minimal difference between March 12 and 13
  - Ice regime on the 12th: 9+/10, mainly medium 1st year ice, in big (500-200 m) to vast (2-10 km) floes
  - Ice regime on the 13th: 9+/10, mainly medium 1st year ice with 1/10 of thick 1st year ice, in vast (2-10 km) floes
- The MV Arctic had little difficulty on the 12th, while the MV Nunavik (which has twice the engine power) struggled a bit on the 13th in the same area
  - Likely due to pressure on the ice pack
  - No indication of pressure on charts
  - Resulted in a significant difference in fuel consumption

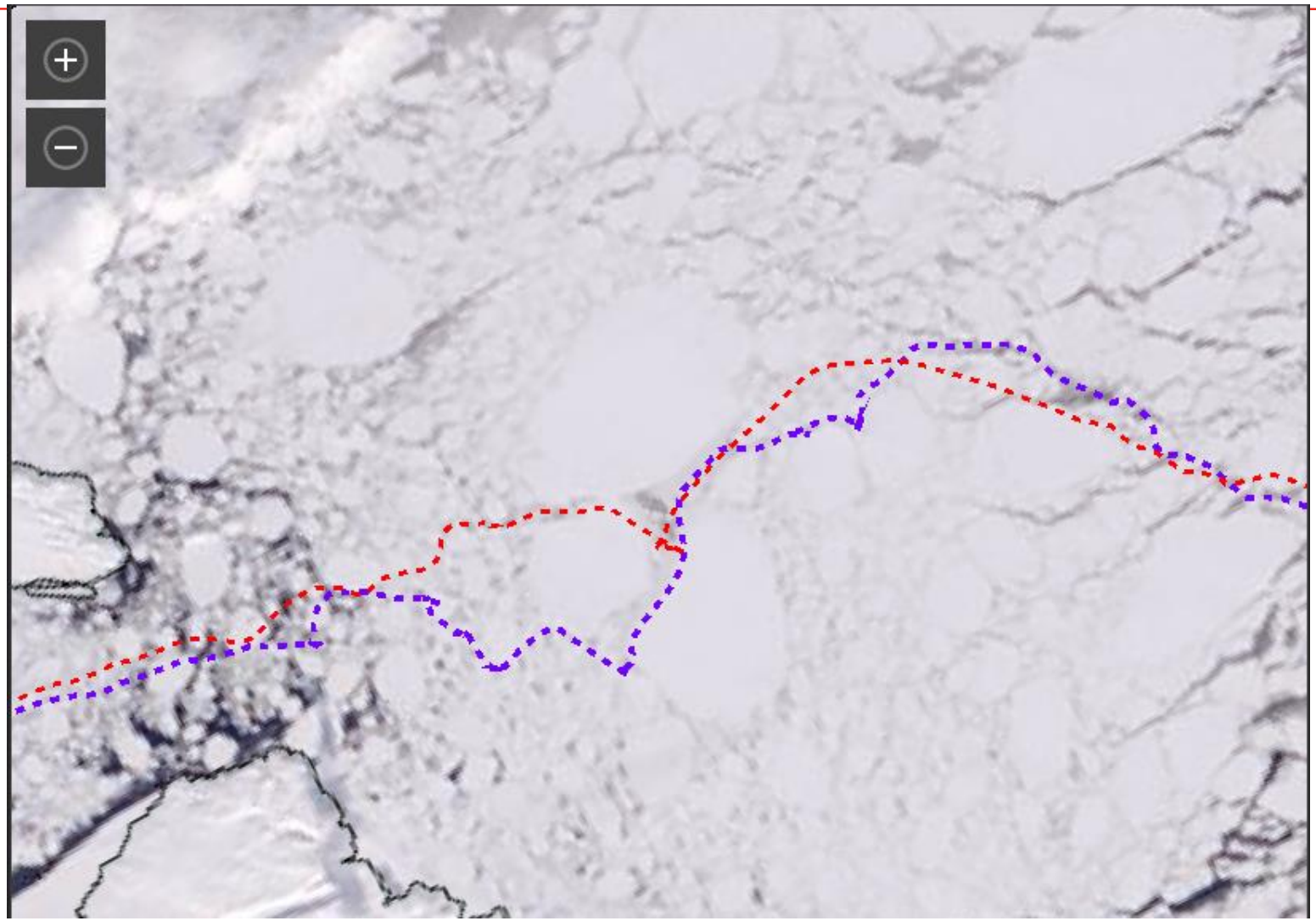




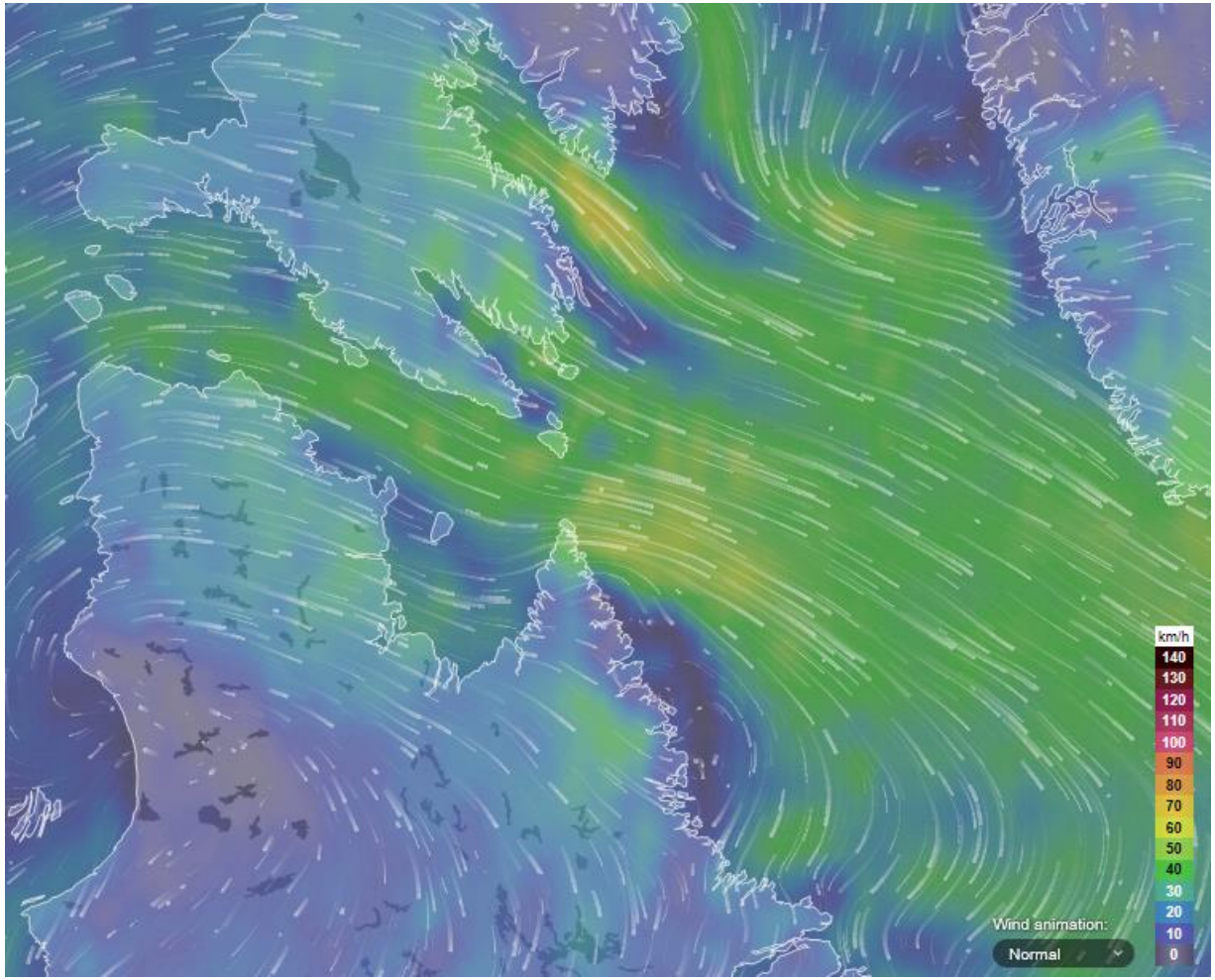
At 62° 37’ N, 73° 6’W on March 12th the Arctic (in purple) was doing continuous progress.
Same position, on March 13th the Nunavik (in red) had such a hard time that the ship had to make a 90° turn.

The Nunavik has twice the engine power of the Arctic and yet was unable to proceed in an area where, 24 hours earlier, the Arctic did not even stop.

MODIS IMAGE ON MARCH 13TH 2018



VENTUSKY


km/h
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Wind animation:
Normal

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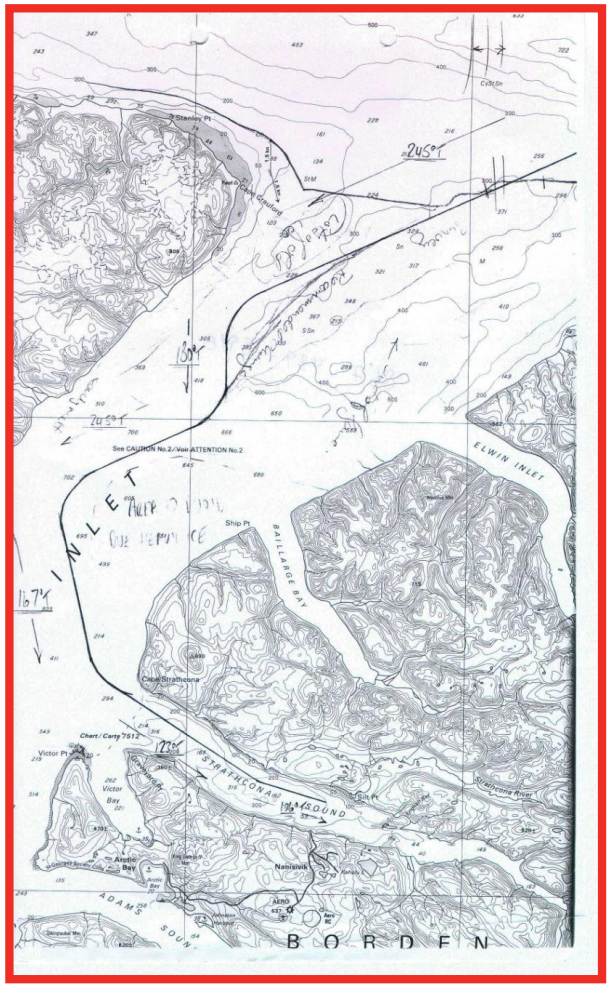
IMPORTANCE OF LOCAL INPUT

IMPORTANCE OF LOCAL INPUT

Modified Track of MV Arctic - Admiralty Inlet



Community consultation & cooperation

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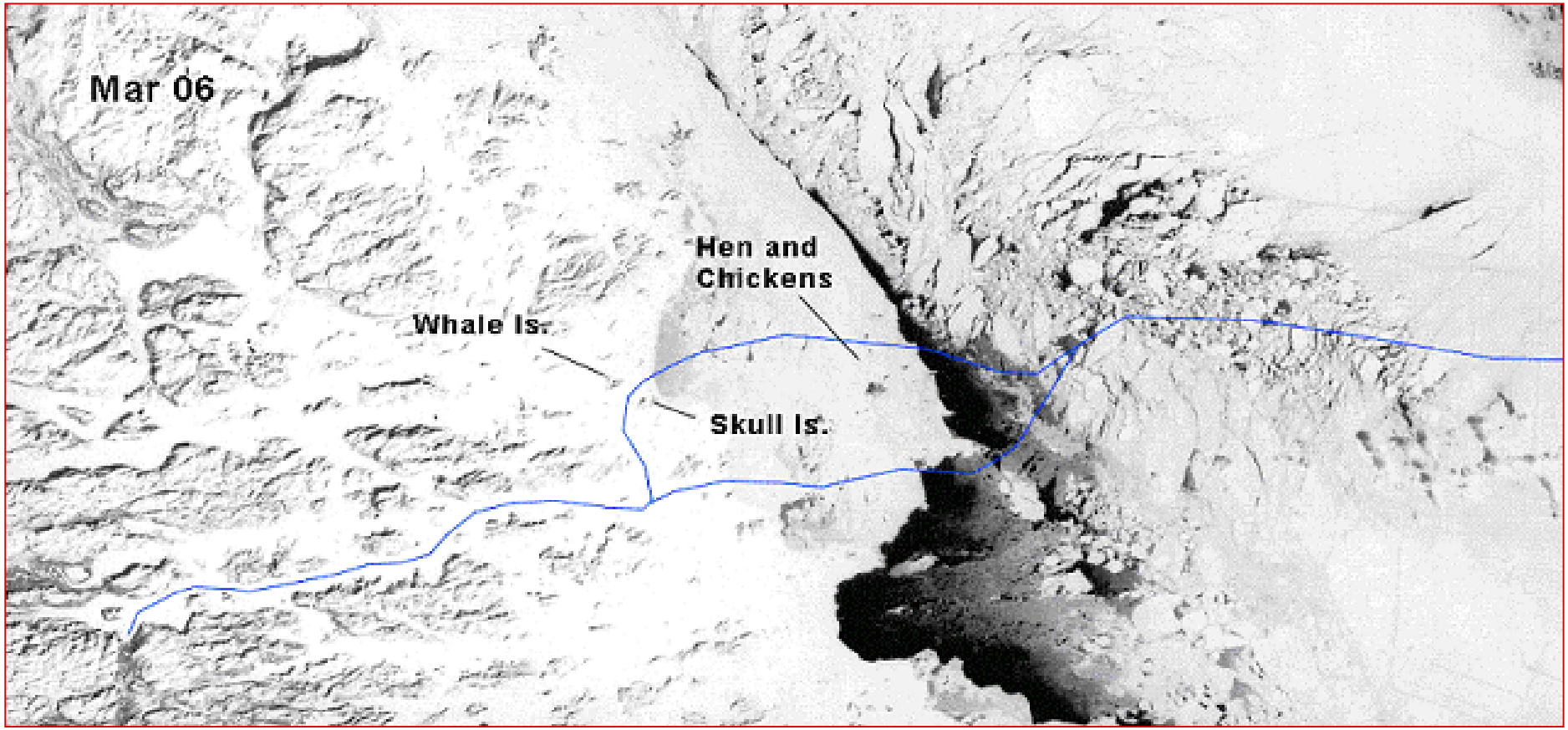
Community Engagement


Mar 06
Hen and
Chickens
Whale Is.
Skull Is.

TRAINING, EXPERIENCE AND CREW RETENTION

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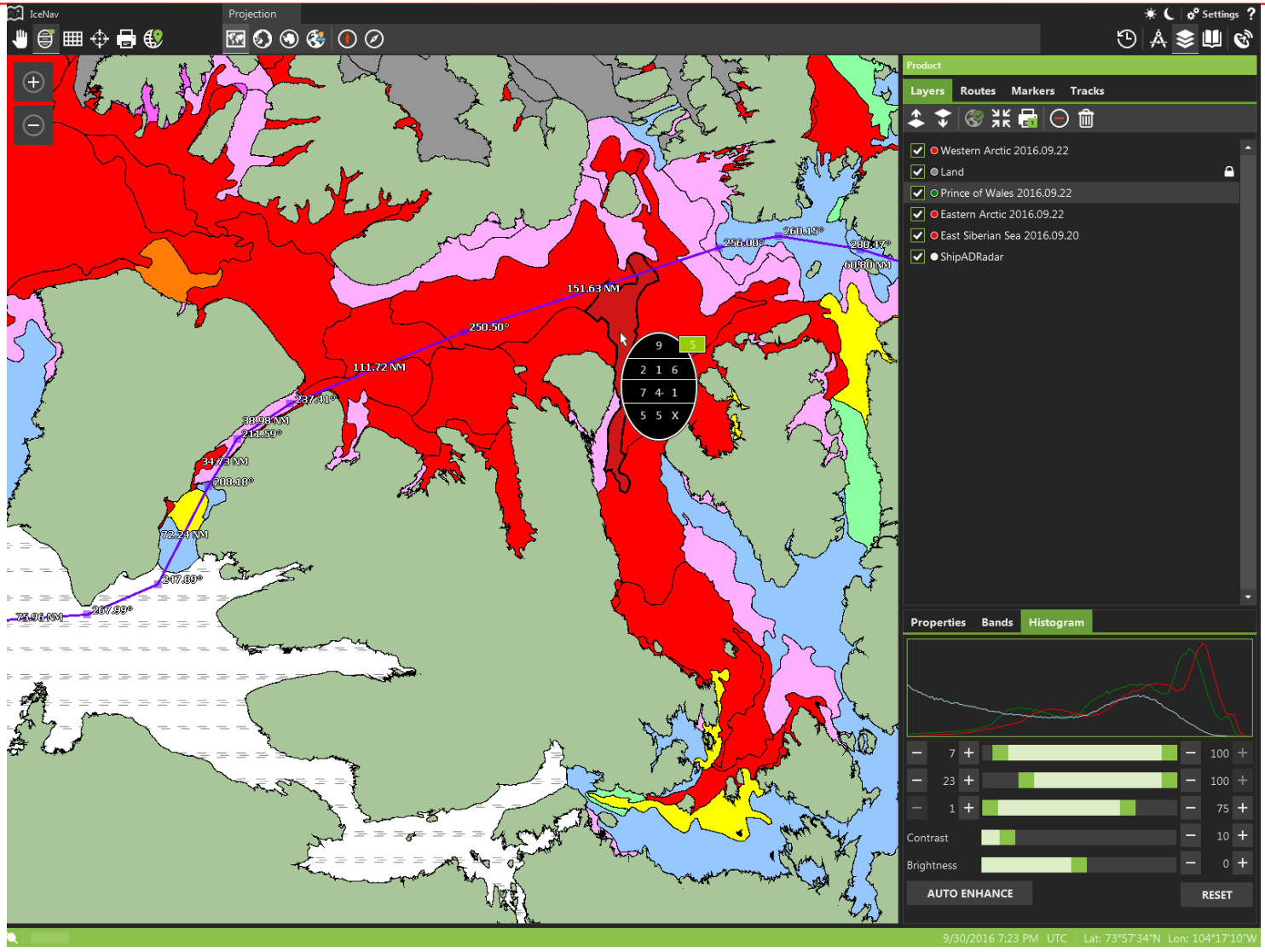
TOOLS OF THE TRADE



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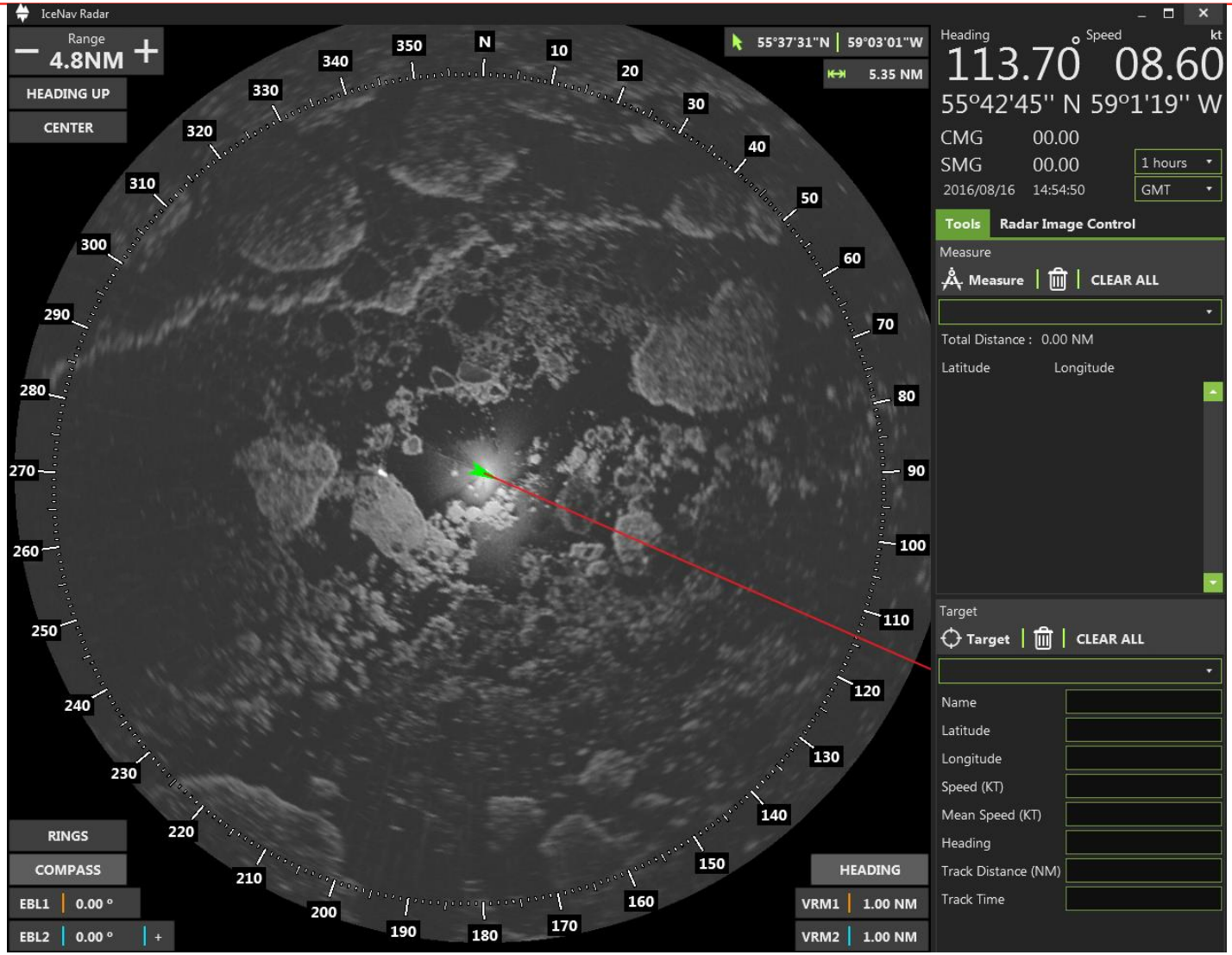
RADAR INTERFACE



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