Homeland Security

United States Coast Guard

Report of the International Ice Patrol in the North Atlantic

2014 Season
Bulletin No. 100
CG-188-69

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Season of 2014

CG-188-69

Forwarded herewith is Bulletin No. 100 of the International Ice Patrol (IIP) describing the Patrol's services and ice conditions during the 2014 season. With 1,546 icebergs drifting into the transatlantic shipping lanes, this year was the sixth most severe Ice Season on record dating back to 1900 and the heaviest Ice Season since 1994. The southern Iceberg Limit extended to 39°30'N, approximately the latitude of Baltimore, Maryland in the United States, and the eastern Iceberg Limit expanded to 33°30'W, halfway across the Atlantic Ocean. The Ice and Environmental Conditions section presents a discussion of the meteorological and oceanographic conditions that set up this severe season.

In 2014, IIP continued its efforts to incorporate satellite reconnaissance regularly into IIP operations. We initiated a process to acquire commercial satellite imagery from the National Geospatial-Intelligence Agency through the United States Coast Guard intelligence network. IIP was able to acquire 30 images and conducted several target correlation flights with different satellites to test the accuracy of this data. The results of these tests will feed an IIP Satellite Reconnaissance Concept of Operations planned for completion in 2015.

While managing the severe Ice Season and conducting satellite testing, IIP also used the heavy iceberg conditions to assess shipping behavior using methods developed during the contracted study completed by Shearwater Systems, LLC in 2013. The 2014 IIP study looked at transit data of transatlantic vessels to investigate if mariners altered their behavior based on the Iceberg Limit. The results are included in Appendix B. IIP plans to use these results to improve our products in order to create the most accurate and relevant iceberg warnings for mariners.

In June, IIP returned to a long-standing tradition to remember the lives lost by members serving on the Greenland Patrol during World War II. IIP hosted a ceremony at the U.S. Coast Guard Academy to commemorate the Ice Patrol members who formed the nucleus of this important unit. Using their expertise from serving in the North Atlantic, these Coast Guardsmen lost their lives working to prevent Germany from establishing critical radio and weather stations in Greenland. The cover of this year's report, a painting by William Ravell III, is in honor of their devoted service.

On behalf of the dedicated men and women of IIP, I hope that you enjoy reading this report on the 2014 season.

G. G. McGrath, CDR

G. G. McGrath
Commander, U. S. Coast Guard
Commander, International Ice Patrol

International Ice Patrol
2014 Annual Report

Contents

Previous IIP Annual Reports may be obtained from the following sources:

☑ IIP website: http://www.navcen.uscg.gov/?pageName=IIPAnnualReports

☑ National Technical Information Service (NTIS): information and a form provided inside the back cover for your convenience.

Cover art: “The Greenland Patrol” painted by William H. Ravell III.

Abbreviations and Acronyms

AIS	Automatic Identification System
ALC	Aviation Logistics Center
APN-241	HC-130J Tactical Transport Weather Radar
ARGOS	A worldwide satellite-based system used to collect Doppler-based position data from special transmitter built into drifting buoys.
AVHRR	Advanced Very High Resolution Radiometer
BAPS	iceBerg Analysis and Prediction System
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
C-CORE	Center for Cold Ocean Resources Engineering
CIS	Canadian Ice Service
CONOPS	Concept of Operations
D1	U. S. Coast Guard First District
DHS	Department of Homeland Security
ECAS	Air Station Elizabeth City
ELTA	ELTA Systems Ltd., a group and a wholly-owned subsidiary of IAI (Israel Aerospace Industries) specifically referring to the ELM-2022A Airborne Maritime Surveillance Radar aboard the HC-130J
ESRL	Earth Systems Research Laboratory
FNMOC	Fleet Numerical Meteorology and Oceanographic Center
FY	Fiscal Year - October through September
GHz	Gigahertz
HC-130J	Long Range Surveillance Maritime Patrol Aircraft
ICC	Intelligence Coordination Center
IDS	Iceberg Detection Software
IIP	U. S. Coast Guard International Ice Patrol
IRD	Iceberg Reconnaissance Detachment
ISAR	Inverse Synthetic Aperture Radar
KML	Keyhole Markup Language
LANTAREA	U. S. Coast Guard Atlantic Area
M/V	Motor Vessel
MANICE	Manual of Standard Procedures for Observing and Reporting Ice Conditions

m	meter
mb	millibar
MCTS	Marine Communications and Traffic Service
MIFC LANT	Maritime Intelligence Fusion Center Atlantic Area
MPA	Maritime Patrol Aircraft
NAFO	Northwest Atlantic Fisheries Organization
NAIS	North American Ice Service
NAO	North Atlantic Oscillation
NAVAREA	Navigation Area
NAVTEX	Navigational Telex
NGA	National Geospatial-Intelligence Agency
NIC	U. S. National Ice Center
NL	Newfoundland and Labrador, Canada
NM	Nautical Mile
NOAA	National Oceanographic and Atmospheric Administration
NOTSHIP	Notice to Shipping
NTIS	National Technical Information Service
NWS	National Weather Service
OPAREA	Operational Area
OPCEN	Operations Center
OSC	Operations Systems Center Martinsburg, WV
PAL	Provincial Aerospace Limited
POD	Probability of Detection
RMS	Royal Mail Steamer
RSA2	RADARSAT-2 Canadian satellite
R/T	Radar Target
SAR	Synthetic Aperture Radar
SITOR	Simplex Teletype Over Radio
SOLAS	Safety of Life at Sea
SST	Sea Surface Temperature
SVP	Surface Velocity Program
TSX	TerraSAR-X satellite
USCG	U. S. Coast Guard

Introduction

This is the 100th annual report of the International Ice Patrol (IIP). The report contains information on environmental and iceberg conditions and IIP operations in the North Atlantic between February and August of 2014. The Ice Patrol was formed after the RMS TITANIC sank on 15 April 1912. Since 1913, except for periods of World War, Ice Patrol has monitored the iceberg danger in the North Atlantic Ocean and provided relevant iceberg warning products to the maritime community. The activities and responsibilities of IIP are delineated in U.S. Code, Title 46, Section 80302 and the International Convention for the Safety of Life at Sea (SOLAS), 1974.

IIP was under the operational control of Commander, U. S. Coast Guard (USCG) First District (D1). Iceberg Reconnaissance Detachments (IRD) conducted aerial reconnaissance from St. John's, Newfoundland to search for icebergs in the North Atlantic Ocean and Labrador Sea. In addition to IIP reconnaissance data, Ice Patrol received iceberg reports from other aircraft and mariners in the North Atlantic. At the Operations Center (OPCEN) in New London, Connecticut, personnel analyzed iceberg and environmental data and used the drift and deterioration model within the iceBerg Analysis and Prediction System (BAPS) to predict iceberg movement and melt. Based on the model's prediction, IIP produced a daily ice chart and text bulletin in 2014 under the North American Ice Service (NAIS) Collaborative Arrangement. In addition to these routine broadcasts, IIP responded to individual requests for iceberg information.

RADM Daniel B. Abel was Commander, U. S. Coast Guard First District until 23 May 2014 when he was relieved by RDML Linda L. Fagan.

CDR Gabrielle G. McGrath was Commander, International Ice Patrol.

For more information about the International Ice Patrol, including historical and current ice bulletins and charts, visit our website at www.navcen.uscg.gov/IIP.

Ice and Environmental Conditions

Ice Year Summary

The 2014 Ice Year was the sixth most severe on record since 1900. By definition, the "Ice Year" covers from October to September. To determine the severity of an Ice Year, IIP uses two traditional measurements. The first measurement is the number of icebergs crossing south of 48°N, considered the northern boundary of the transatlantic shipping lanes. This number includes icebergs initially sighted or detected south of 48°N as well as those originally sighted or detected further north and drifted south, as modeled by BAPS. In 2014, 1,546 icebergs (not including bergy bits or growlers) crossed south of 48°N. **Figure 1** shows the historical variability from 1900 to 2014 for this measurement (blue columns) along with the five-year running average (red line).

The second measurement is Ice Season length. The Ice Season is generally defined by the number of days icebergs were present south of 48°N and threatening the transatlantic shipping lanes. IIP normally deploys IRDs during the entire Ice Season, but not the Ice Year. In 2014, IIP recorded icebergs south of this latitude from 13 February through 31 July 2014 and on three days in August when icebergs drifted south of 48°N for an Ice Season length of 173 days. IIP's modern aerial reconnaissance era is defined as the time period from 1983 through the present day when the use of aircraft equipped with radar for iceberg detection became standard. The average number of icebergs sighted or modeled south of 48°N during this period is 776, and the average Ice Season length during this time period is 123 days. This section describes the environmental conditions in the waters off of the Newfoundland and Labrador coasts (**Figure 2**). It will be followed by the Operations Center Summary and Ice Reconnaissance and Oceanographic Operations sections.

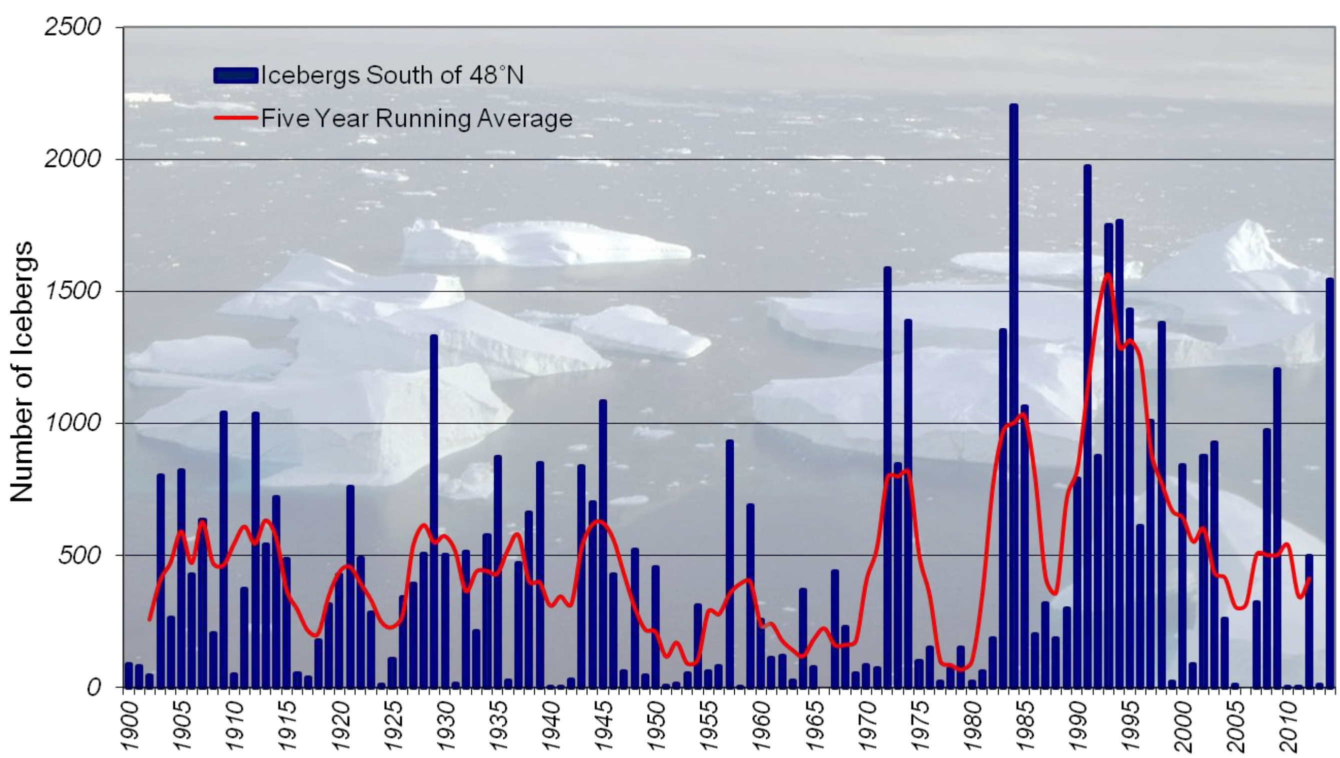

Figure 1. Icebergs crossing 48ºN and five-year running average (1900-2014).

Extensive sea ice and an extreme number of icebergs led to the sixth most severe Ice Year on record since 1900. Pre-season predictions and quarterly summaries beginning in October 2013 and continuing through the summer of 2014 are provided. Key atmospheric and oceanographic conditions that influenced iceberg flow throughout the Ice Year are also discussed. This section concludes with a discussion of four cases where icebergs and a stationary radar target (R/T) were observed outside of IIP's advertised Iceberg Limit.

IIP closely monitors the progress of the Ice Year by studying the interactions between the sea-ice coverage, the predominant wind patterns, and the iceberg population throughout the Ice Year. Comparing sea-ice observations provided by the Canadian Ice Service (CIS) to the historical record provides an early indicator of the severity of the upcoming season. Sea-ice historical data are derived from the *Sea Ice Climatic Atlas, East Coast of Canada, 1981-2010* (CIS, 2011). Sea-ice concentration charts for the fifteenth day of each month and IIP's published Iceberg Limit charts for the fifteenth and last day of each month are included at the end of this report.

Pre-season Predictions

CIS issued a Seasonal Outlook for winter 2013-2014 on 04 December 2013. The CIS Outlook provided expected sea-ice coverage for December through February for

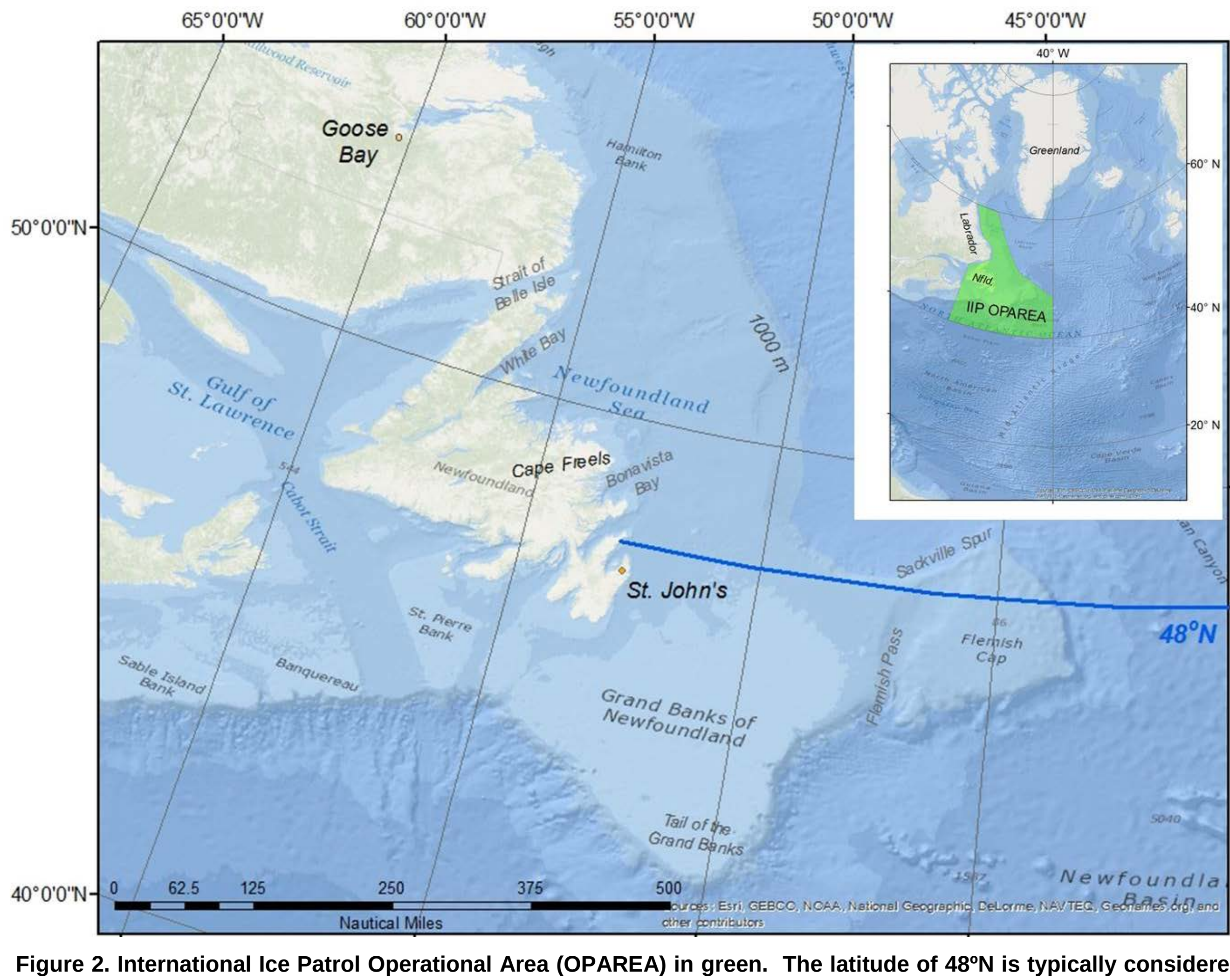

Figure 2. International Ice Patrol Operational Area (OPAREA) in green. The latitude of 48ºN is typically considered the northern boundary of the transatlantic shipping lanes. IIP measures season severity based on this line.

the Gulf of St. Lawrence, the East Newfoundland Waters, and the Labrador Coast. With average air temperature predictions at ‘normal to above normal’ for December, January, and February, the 2014 Ice Year was expected to have below normal ice conditions in all three locations (CIS, 2013). However, opposite of these predictions, it became evident in early February that 2014 would surpass the light conditions seen in 2013 and would likely exceed the CIS forecast. By the end of February, the severity of the Ice Year became more certain. **Figure 3** shows the expected sea-ice concentration (left panel) based on a four-year median and the actual sea ice observed for East Newfoundland and southern Labrador for 26 February 2014. While CIS accurately predicted the ice edge to be 120 to 180 nautical miles (NM) off the Labrador Coast in February, the ice conditions further south off of Cape Freels exceeded the forecast by more than 60 NM (see **Figure 3**). Of particular interest, a tongue of ice at 48°N stretched eastward past 48°W on 26 February and continued to move south, providing a clear indication of the location and strength of the Labrador Current. Further, sea ice covered the entire Gulf of St. Lawrence from Cabot Strait northeastward through the Strait of Belle Isle and well to the west of Anticosti Island. There was no specific iceberg severity forecast, but by the end of February, it became clear that the environmental conditions favored severe iceberg conditions for the coming months.

Quarterly Environmental Summaries

Conditions affecting sea-ice growth and iceberg distribution are summarized below. Much of the early ice growth was influenced by air temperatures along with changes of the wind direction and speed in central and southern Labrador early in the year and over Newfoundland as the year progressed. In contrast to the 2013 Ice Year, the dynamics of the Labrador Current as it moved southward and interacted with the North Atlantic Current became particularly relevant in 2014 causing extreme eastward iceberg drift and a complex oceanographic situation at the Tail of the Grand Banks. Examples are provided during corresponding time periods to illustrate this complexity. This

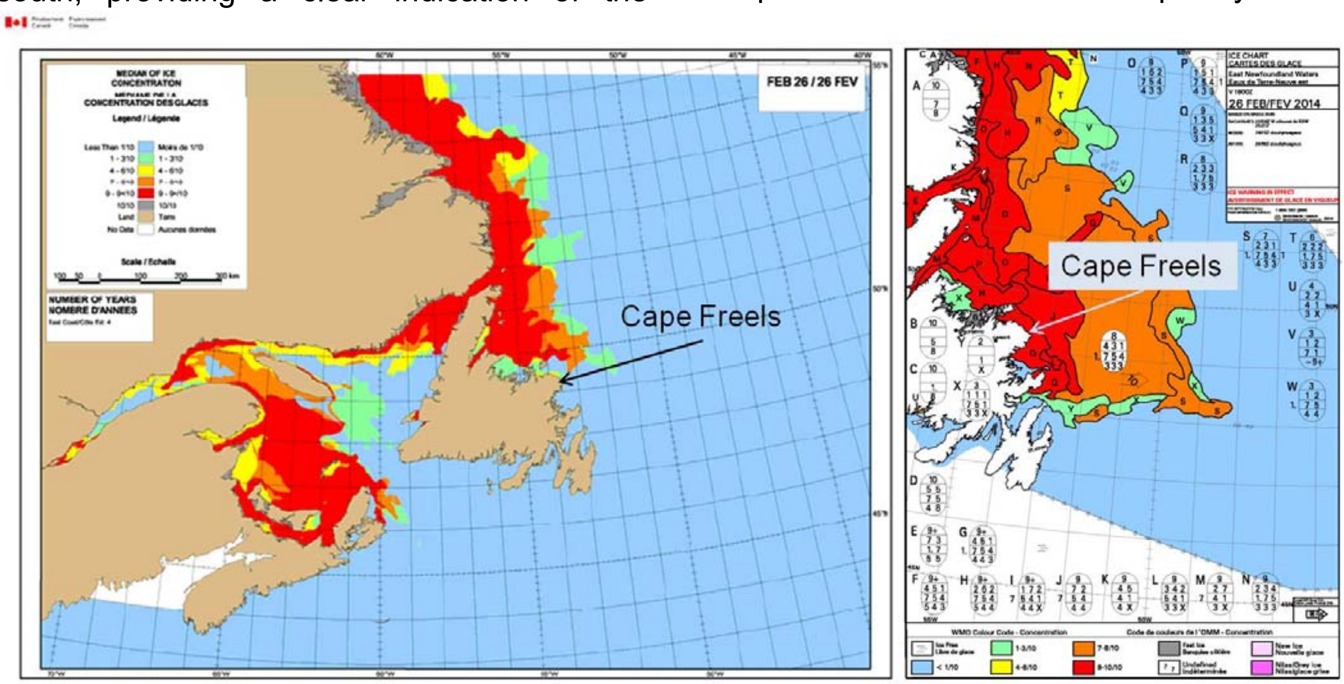

Figure 3. Expected (left panel) (CIS, 2013) and Observed (right panel) (CIS, 2014a) sea-ice concentration for 26 February 2014.

situation led to potentially hazardous conditions in the southern part of IIP's Operational Area (OPAREA) as evidenced by iceberg sightings outside of the Iceberg Limit. Three icebergs observed outside of the limit (of four total) were south of 48°N. The fourth was north of 50°N and inside the Gulf of St. Lawrence. These sightings will be discussed in more detail later in the report.

With exception of a brief, 15-day warming period in January, the year was characterized by periods of colder than normal temperatures from December until well into the summer. These cold air temperatures coupled with predominantly offshore winds during key periods of the year set the stage for the severe 2014 Ice Year.

October – December 2013

At the beginning of the Ice Year, CIS had the responsibility for producing and distributing daily NAIS iceberg charts. At this time, 24 icebergs, all north of 50°N, were sparsely distributed along the Newfoundland and Labrador coasts. While there were two icebergs offshore near the 1000 m contour in October, these deteriorated by the middle of October, and the Iceberg Limit remained largely inshore throughout the period. The known iceberg population in BAPS reached its peak in November, and by the end of the period, only eight icebergs were estimated to be present along the Labrador coast in the daily Iceberg Limit product. Since the Iceberg Limit remained north of 50°N and close to shore, CIS relied heavily on RADARSAT-2 (RSA-2) Synthetic Aperture Radar (SAR) satellite reconnaissance. Several aerial flights from Canadian government and commercial aircraft augmented satellite iceberg surveillance efforts.

Sea ice began forming along the Labrador Coast in early December. **Figure 4** shows air temperature fluctuations from September 2013 through August 2014 in Goose Bay (top panel) and St. John's (bottom panel) (NOAA/NWS, 2014a). As shown in **Figure 4**, both St. John's and Goose Bay observed an extreme cold outbreak that began in late November and lasted through the entire month of December with air temperatures more than 5°C below normal for Goose Bay and nearly 4°C below normal for St. John's. These cold air conditions promoted accelerated sea-ice growth such that by 16 December, the sea-ice edge (seven to eight tenths concentration) had reached just south of the latitude of Goose Bay. By the end of the month, the sea-ice edge had rapidly progressed south of 52°N, completely covering the Strait of Belle Isle and the northeastern portion of the Gulf of St. Lawrence (CIS, 2014b).

January – March 2014

Mean air temperatures in Goose Bay and St. John's remained several degrees colder than normal during the first week of

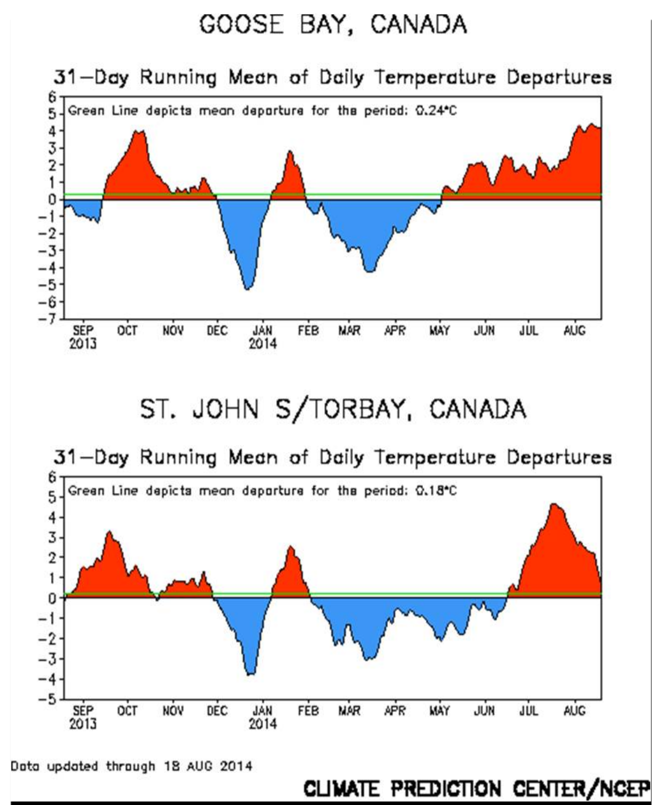

Figure 4. 31-day running mean of daily temperature departures for Goose Bay (top) and St. John's, Newfoundland (bottom). (NOAA/NWS, 2014a)

January, followed by a period of warmer temperatures at both locations until the first week of February (**Figure 4**) (NOAA,NWS, 2014a). This warmer period resulted from a series of low pressure systems that brought strong southerly and easterly winds to the region.

These conditions held sea-ice growth in check for the rest of January. Even with slowed growth, sea-ice coverage remained near the median reaching as far south as Bonavista Bay and approximately 130 NM offshore from Cape Freels (CIS, 2014b). Colder than normal air temperatures returned to the region in early February and remained until May in Goose Bay and until mid-June in St. John's. During February and March, major storm systems tracked predominantly north of Newfoundland. The predominant storm track, coupled with the presence of high pressure systems in the central Atlantic, maintained a pattern of offshore winds that supported intense sea-ice growth in the waters off of Labrador and Newfoundland. The sea-ice edge (one to three tenths concentration) reached its maximum southern extent on 15 March with a very narrow tongue closely following the path of the Labrador Current. **Figure 5** is the CIS sea-ice concentration chart for 15 March showing the maximum extend of the ice edge. **Figure 6** shows the departure from normal ice concentration for 17 March. In this figure, blue shades depict sea-ice concentration greater than normal and red shades show below normal sea-ice concentration based upon CIS statistics from 1981-2010 (CIS, 2014b). Note that below normal ice conditions were only found on the leeward side of Newfoundland and Nova Scotia, a condition consistent with offshore winds during the week prior to 17 March. With the exception of the last two weeks in January, sea-ice coverage remained well above normal through July and led to the severe iceberg conditions observed this year.

Provincial Aerospace Limited (PAL) conducted its first iceberg reconnaissance flight in support of CIS on 02 January and flew a second patrol on 05 January for the oil and gas industry. These two PAL flights detected seven icebergs – three that were well within sea ice in the bays along the north shore of Newfoundland and four in the offshore branch of the Labrador Current outside of the sea-ice edge. PAL continued active reconnaissance to assess sea-ice conditions and to determine the Iceberg Limit in support of CIS, the oil and gas industry on the Grand Banks, and other Canadian Government agencies. Through 28 January, PAL reported only isolated icebergs and none south of 48°N. The first indication of the severity of the 2014 Ice Year came on 29 and

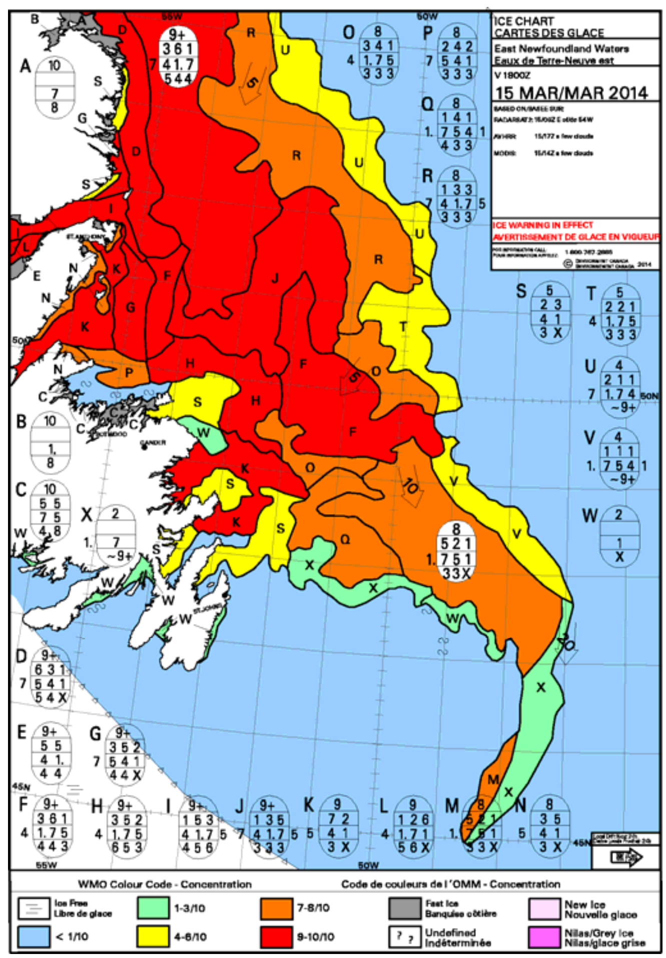

Figure 5. CIS Daily Sea-ice Concentration Chart for 15 March 2014. (CIS, 2014a)

30 January from two PAL flights that were conducted for CIS in the offshore branch of the Labrador Current (near the 1000 m depth contour) and up to 53°N. These two flights located and visually identified over 70 icebergs. Most of these icebergs were contained inside sea ice. Twenty-seven of these icebergs were classified by PAL as large icebergs (PAL, 2014). At the end of the month, IIP resumed responsibility for creating and distributing the NAIS iceberg warning products from CIS on 29 January.

IIP began its 2014 reconnaissance flights on 07 February and conducted four patrols over the following five days to verify the Iceberg Limit and to determine the iceberg feeder population. These flights covered areas east of the Strait of Belle Isle and out to approximately 46°W near Sackville Spur. IIP reconnaissance detected 19 icebergs, all north of 48°N, with the majority concentrated near the 1000 m contour near 50°N. By mid-February, the iceberg population was over 120 NM north of the shipping lanes and still well within the range of PAL reconnaissance. With the growing indications of a severe iceberg season, the Commander, IIP (CIIP) anticipated a need for more intense reconnaissance during the latter part of the season and, in order to save HC-130J flight hours, considered cancelling the remaining flights scheduled for February. CIIP requested support from the CIS Director for CIS-sponsored PAL flights to provide

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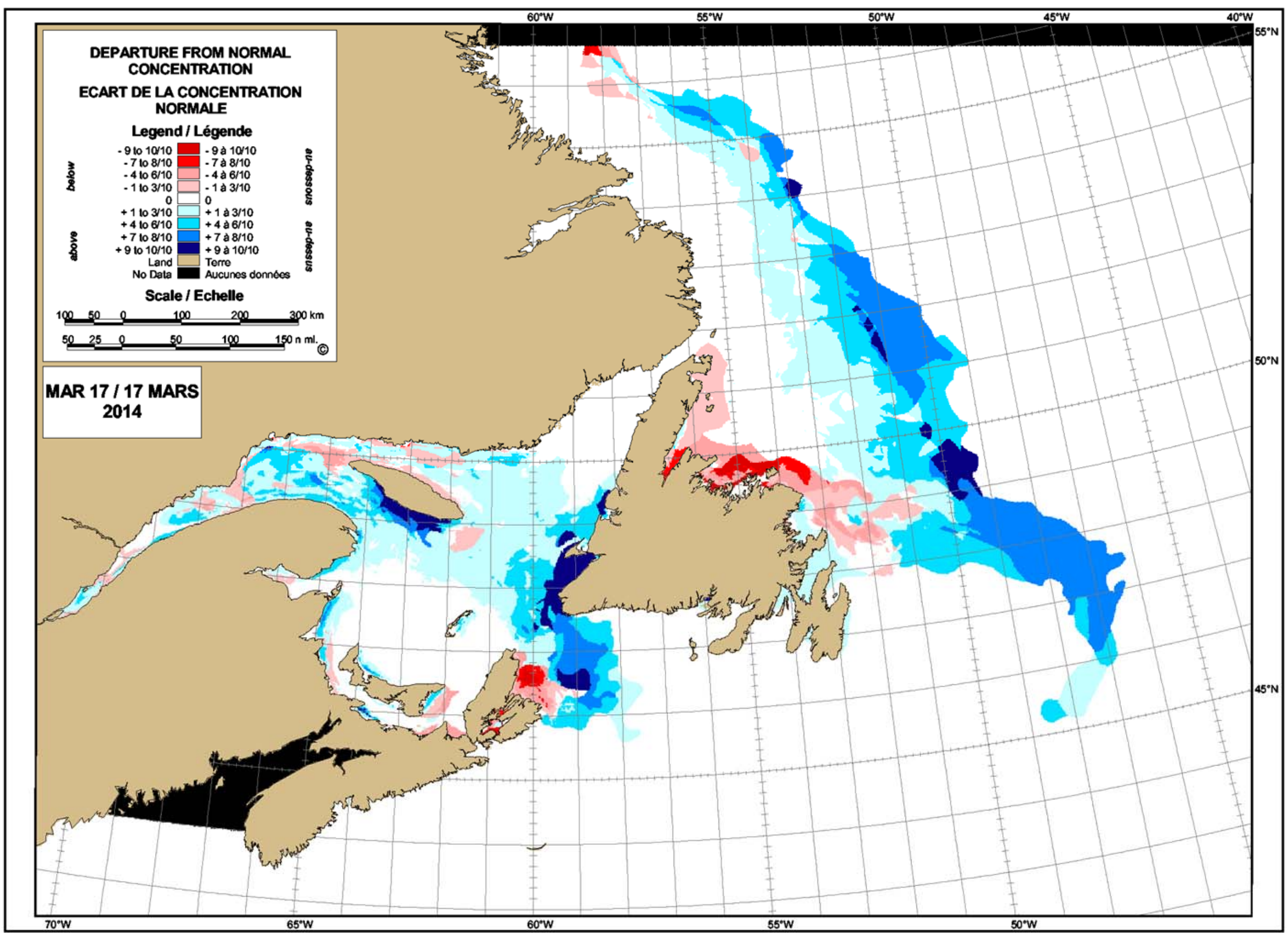

STATISTICS BASED UPON 1981-2010
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Figure 6. Departure from normal concentration for 17 March 2014. (CIS, 2014a)

reconnaissance over the iceberg danger area south of 48°N. Once this coverage was arranged, CIIP cancelled the IIP flights. This coordination was an excellent example of the importance and value of the NAIS partnership.

PAL continued to conduct sea-ice and iceberg flights throughout the month of February (PAL, 2014). As previously arranged under the NAIS partnership, IIP requested a PAL iceberg reconnaissance flight south of the oil production facilities down to 44°23′N to confirm that no icebergs had drifted outside of the Iceberg Limit. By the end of February, the southern Iceberg Limit had progressed to 45°15′N, and the eastern limit was already out to 42°30′W.

IIP resumed reconnaissance with a flight on 06 March 2014 to determine the western Iceberg Limit and to assess the interior population near the approach to the Strait of Belle Isle. Complementing PAL coverage, other IIP flights during early March investigated icebergs in the Flemish Pass, to the northeast of Sackville Spur, and south of the oil facilities in the Labrador Current. On 11 March 2014, IIP located 52 icebergs, most within sea ice, in the offshore branch of the Labrador Current south of the oil rigs. Several icebergs were detected and visually identified east of 45°W directly south of Flemish Cap. The location and subsequent movement of these icebergs confirmed the presence of an eastward flow south of Flemish Cap resulting from three clockwise-rotating, warm-core eddies that were visible in an Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) image from 23 February 2014 (**Figure 7**) (JHU, 2014). The approximate location of the southernmost iceberg on the date of the image is indicated as a white triangle in **Figure 7**. These eddies persisted throughout March and April, providing a mechanism to expand the Iceberg Limit eastward.

Icebergs drifting east of Flemish Cap posed a challenging reconnaissance scenario due to the extreme distance from St. John's. For example, IIP visually confirmed the easternmost iceberg for the season on 26 March 2014 at 46°49′N, 41°34′W, a distance of 460 NM east of St. John's. BAPS predicted that this iceberg and others in the area would continue to drift east from this position which expanded the Iceberg Limit. In May, the situation was further complicated when IIP went 15 days without a reconnaissance flight due to a combination of poor weather conditions, aircraft problems, and two high priority Search and Rescue cases for which the HC-130J assigned to IIP was the closest response asset. Although iceberg conditions presented a hazard to transatlantic shipping, response to distress at sea always takes precedence over an iceberg patrol. These Search and Rescue cases are described in detail in the Iceberg

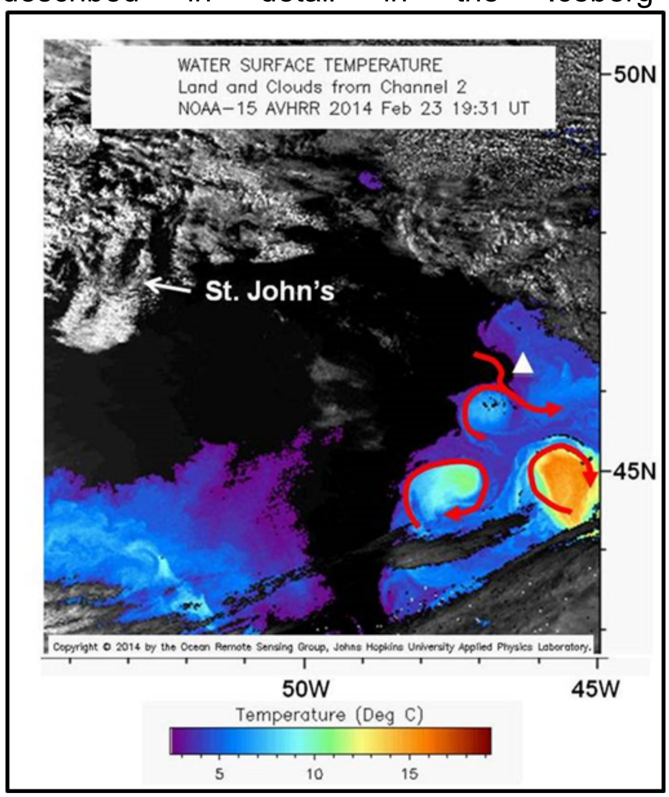


Figure 7. Advanced Very High Resolution Radiometer SST Image from 23 February 2014. Image provided by the Ocean Remote Sensing Group, Johns Hopkins University Applied Physics Laboratory. (JHU, 2014)

Reconnaissance and Oceanographic Operations section. Without adequate aerial coverage to verify these icebergs had melted, the Iceberg Limit expanded to the east, beyond 35°W by the end of May.

April - June 2014

Below average air temperatures continued throughout the month of April in both Goose Bay and St. John's. St. John's remained 1-2°C below average through the middle of June while Goose Bay temperatures turned above normal at the beginning of May for the remainder of the season (**Figure 4**). A strong low pressure system passing south of Newfoundland brought easterly winds to the area and destroyed the tongue of ice that had set the

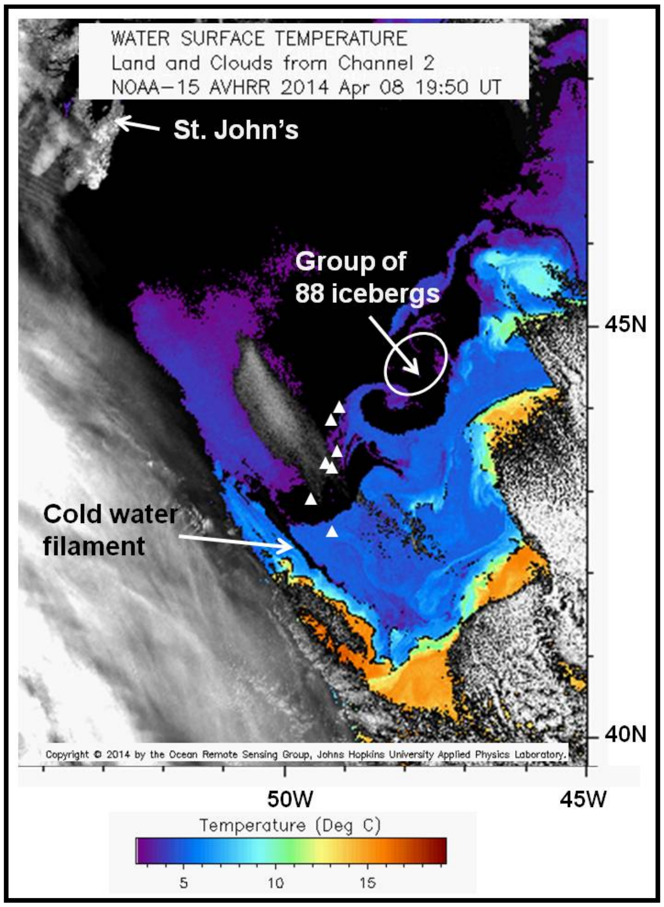


Figure 8. Advanced Very High Resolution Radiometer SST Image from 08 April 2014. Results from 08 April IIP flight are overlaid on the SST image. Image provided by the Ocean Remote Sensing Group, Johns Hopkins University Applied Physics Laboratory. (JHU, 2014)

southernmost sea-ice extent in late March. By the first week of April, the sea-ice edge had receded to approximately 48°N but remained 180 NM east of St. John's. Westerly and southwesterly winds during the first half of April caused the sea ice to concentrate in the eastern portion of the Gulf of St. Lawrence and created broad leads along the north coast of Newfoundland. Easterly winds during the last week of April shrunk the areas of open water in the Newfoundland bays and brought the sea-ice edge to within 70 NM of Cape Freels. Overall, the sea-ice coverage remained well above normal throughout the region, sustaining an environment that preserved the iceberg population well offshore (CIS, 2014a).

Sea-ice concentration steadily declined offshore as spring turned into summer, but lingered into June in the Strait of Belle Isle and White Bay. By the third week of June, the Strait of Belle Isle was free of sea ice and only a small amount remained in the Newfoundland bays. By the end of June, only a trace amount of sea ice was present in the operating area, all to the north of Goose Bay (CIS, 2014a).

The retreat of the sea ice left hundreds of icebergs free to drift southward into the shipping lanes. IIP continued its reconnaissance sending two detachments to Newfoundland per month throughout the remainder of the quarter. Flights were coordinated closely with PAL who also continued to actively patrol, sponsored primarily by the oil and gas industry with two flights for CIS to assess the western and southwestern Iceberg Limits in late May.

During April, IIP conducted a total of eight patrols that detected 2,034 icebergs. Five sorties focused on the extreme Iceberg Limits to the east, southeast, and southwest while three flights assessed the iceberg population in the Newfoundland Sea and northward along the 1000 m contour offshore of the Labrador coast. A single patrol off of the northeast coast of Newfoundland detected over half (1,132) of all the icebergs for the month. These icebergs were all within nine-tenths sea-ice coverage.

The eastward expansion of the Iceberg Limit (described above) demanded several long flights to positively determine the extent of the eastern Iceberg Limit. One patrol flew out to 34°W longitude (approximately 780 NM east of St. John's) to verify that a previously-sighted iceberg had melted as predicted by the BAPS model. Eastern limit patrols for the remainder of the season detected only a few icebergs. All of these were located between 60-90 NM south of Flemish Cap and none were sighted further east than 41°34′W. Fortunately, the wall of the North Atlantic Current, located at about 40°W and oriented on a north-south axis, served as a warm water boundary for the eastward advance of ice hazards.

Although the eastern limit was defined by a relatively small number of icebergs, a sizable group of icebergs began to drift southward in the Labrador Current toward the Tail of the Grand Banks, resulting in an expansion of the southern limit. On 05 April 2014, an IIP HC-130J detected 95 icebergs, all south of 46°N, which were in two distinct groupings. The first group contained a large collection of 88 icebergs, many of which were growlers that had pooled inside of a meander on the Labrador Current-North Atlantic Current interface. This feature can be clearly seen in a 08 April AVHRR image (**Figure 8**) and was likely associated with the eddy system observed in late February (JHU, 2014). The approximate location of this grouping of icebergs is depicted with a white oval.

The second group contained seven icebergs that were aligned with the Labrador Current and stretched as far south as 42°46'N. The approximate locations of these

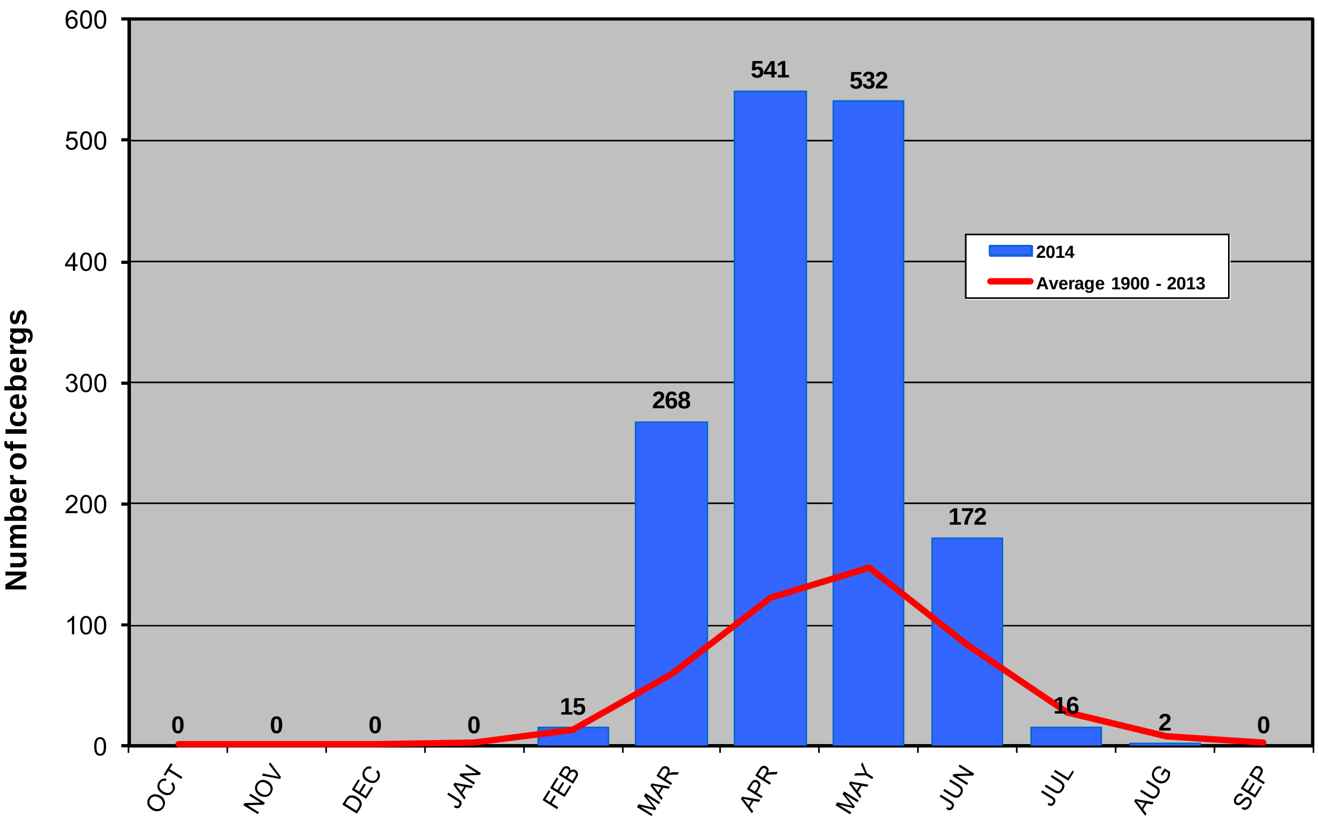


Figure 9. Estimated Number of Icebergs Passing South of 48ºN by Month (1546 total for 2014).

Extreme Icebergs	Sighted Source	Date	Lat	Long	Drifted Source	Date	Lat	Long
Southern	M/V Independent Concept	23-May-14	41-06.7N	49-29.4W	IIP C-130	4-Jun-14	40-22.9N	48-44.4W
Eastern	IIP C-130	26-Mar-14	46-49.0N	41-34.0W	IIP C-130	5-Jun-14	45-57.7N	35-00.0W
Western	Can Gov't Acft (GCFR)	2-Jun-14	49-54.0N	61-20.0W	Can Gov't Acft (GCFR)	22-Jun-14	50-09.5N	61-27.6W

Table 1. 2014 Extreme sighted and drifted (modeled) iceberg positions by original sighting source and date. Note: Western icebergs listed were those used to set the iceberg limit in the Gulf of St. Lawrence.

icebergs are shown as white triangles in **Figure 8**. Of note, a narrow filament of cold water extending southeastward from the Tail of the Grand Banks defined the western edge of the Labrador Current and provided a pathway for icebergs to drift southeastward to around 41°30′N. Meanwhile, a slower flow of relatively cold water moved northwestward from the Tail of the Grand Banks along the southwest contour of the Grand Banks. In addition to the SST image in **Figure 8**, this bifurcation of the Labrador Current was also observed through the trajectories of two satellite-tracked drifting buoys and likely provided the pathways for three icebergs (two in May and one in July) that were reported outside of IIP's published limit in this region. These sightings will be discussed more fully in the next section.

While IIP's reconnaissance efforts continued to focus on the extreme eastern and southern Iceberg Limits throughout May and June, the inshore branch of the Labrador Current began to transport icebergs south along the southeast coast of Newfoundland. IIP received numerous iceberg reports within 20-30 NM of the southeast coast of Newfoundland from the Canadian tanker, M/V HEATHER KNUTSEN during early May. In addition, diminishing sea ice in the Gulf of St. Lawrence allowed icebergs to move more freely from the Labrador Current in the northeast through the Strait of Belle Isle toward the southwest. IIP received reports from PAL of a large population of icebergs in the Strait of Belle Isle. As a result, IIP began including patrols of the areas south and west of Newfoundland and through the Strait of Belle Isle with additional support from PAL under CIS sponsorship in late May. Patrols in these areas continued throughout the end of July.

July - September 2014

During July and August, air temperatures in both St. John's and Goose Bay remained above normal. Sea surface temperatures on the Grand Banks and in the Labrador Current continued to increase throughout the remainder of the season. Despite the absence of sea ice and rising SSTs, the Iceberg Limit continued to encroach on the transatlantic shipping lanes through mid-July. An IIP flight on 13 July detected a small iceberg surrounded by 11 growlers north of Flemish Cap and east of 45°W longitude. These sightings continued to drift eastward and held the Iceberg Limit out to 42°W until an IIP flight in late July could verify that they had melted and were no longer a threat to shipping. These hazardous ice conditions required CIIP to send a twelfth IRD to Newfoundland on 23 July.

The last IRD conducted six patrols and searched over 229,000 square nautical miles. While these flights detected a total of 572 icebergs, all were well north of 48°N, and no longer posed a threat to transatlantic shipping. IIP concluded its reconnaissance for the 2014 Ice Year on 31 July with a final patrol through Flemish Pass and along the eastern edge of the Grand Banks to verify that there were no icebergs in this region.

Relying again on the NAIS partnership, CIIP requested PAL coverage to verify that no icebergs were positioned to drift south. From August until October, PAL conducted eight more patrols out to the 1000 m contour, through the Strait of Belle Isle, and over the Newfoundland Sea, all under CIS sponsorship (PAL, 2014). These flights detected a continually decreasing number of icebergs with none south of 48°N. In exchange for aerial coverage, CIIP offered to continue creating and distributing the daily NAIS product for an additional three weeks beyond the normally agreed upon product generation responsibility time periods. IIP transferred this responsibility to CIS on 23 September 2014.

In summary, **Figure 9** graphically shows the number of icebergs estimated to have drifted south of 48°N by month for the 2014 Ice Year. The monthly average was calculated using 114 years (1900 through 2014) of IIP records and is plotted as a solid red line for comparison. Extreme iceberg positions, both observed and modeled, along with the sighting source are also presented in **Table 1**. NOTE: The sighted icebergs are not necessarily the same as the drifted icebergs.

Atmospheric and Oceanographic Discussion

The significant variability in iceberg conditions observed by IIP over the past two Ice Years emphasizes the important roles that winter atmospheric and oceanographic conditions play in determining the iceberg severity for a given season. The connection between sea ice along the East Coast of Canada and icebergs drifting south of 48°N has been observed by IIP and well-studied through the years. Marko, Fissel, Wadhams, Kelly, and Brown (1994) observed that the presence of sea ice both suppresses iceberg melt rates and reduces the opportunities for icebergs to ground. An iceberg aground in the shallow waters along the Canadian coast may never enter the transatlantic shipping lanes. Further, in the absence of sea ice, an iceberg exposed to open water deteriorates relatively quickly due to wave erosion.

Rank	Year	NAO Index	Icebergs South of 48°N
1	1984	1.60	2202
2	1991	1.03	1974
3	1994	3.03	1765
4	1993	2.67	1753
5	1972	0.34	1588
6	**2014**	**3.10**	**1546**
7	1995	3.96	1432
8	1974	1.23	1387
9	1998	0.72	1380
10	1983	3.42	1352

Table 2. The 10 most severe ice seasons on record with corresponding NAO indices.

The production and extent of sea ice are governed by the atmospheric conditions present during the winter months (December through March) each year. The extent of the Iceberg Limit, in turn, depends both on the number of icebergs that reach the northern Grand Banks after the sea-ice edge retreats, as well as the strength and position of the Labrador Current south of Flemish Pass.

To assess winter atmospheric conditions, IIP closely monitors the North Atlantic Oscillation (NAO) index as a tool to provide insight to the conditions supporting sea-ice growth. The NAO index represents the dominant pattern of winter-time atmospheric variability in the North Atlantic, fluctuating between positive and negative phases. NAO dynamics have been extensively described by Hurrell, Kushnir, Ottersen, and Visbeck (2003).

Persistent offshore winds along the Labrador coast during winter are

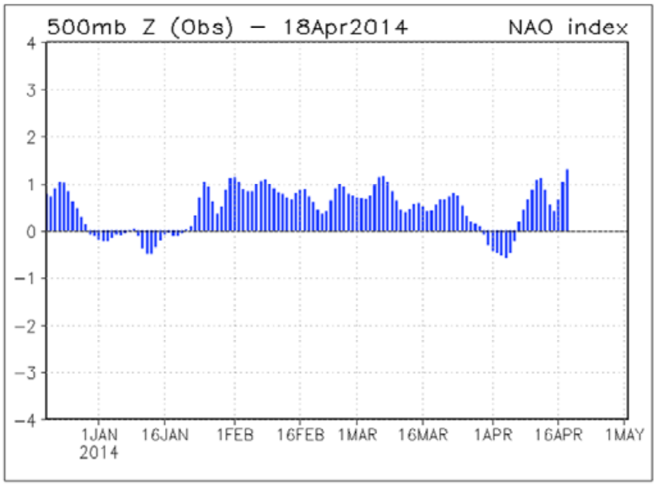


Figure 10. 500 mb NAO Index for late December through mid April. (NOAA/NWS, 2014b)

characteristic features of a positive phase of the NAO and favor extensive sea-ice growth. The winter station-based NAO index for December 2013 through March 2014 was strongly positive at +3.10. This value is calculated using the difference in normalized sea-level atmospheric pressure between Lisbon, Portugal and Stykkisholmu/ Reykjavik, Iceland (Hurrell, 1995). The winter-time NAO index has been closely correlated with iceberg season severity. The ten most severe seasons, with respect to the number of icebergs drifting south of 48°N, are presented along with corresponding NAO indices for each year in **Table 2**. The 2014 season is shown in red. Note that the 2013 NAO index was moderately negative at -1.97. 2013 was recorded as the eleventh lightest ice season on record with only 13 icebergs drifting south of 48°N.

The winter NAO index provides a useful measurement to understand and explain the atmospheric conditions leading to ice conditions but is not a predictive tool. IIP also tracks a daily NAO index that is constructed by the National Oceanographic and Atmospheric Administration/National Weather Service (NOAA/NWS) Climate Prediction Center. This index is based on the 500 mb height anomaly over the Northern Hemisphere projected onto the monthly mean 500 mb height (NOAA/NWS, 2014b). This index yields similar physical significance as the single, winter-time index described earlier, i.e. positive values indicate offshore winds with favorable sea-ice growth conditions and the opposite for negative values.

Figure 10 shows the daily NAO index calculated on 18 April 2014 with the preceding 120 days. It is remarkable that this index became positive during the third week of January and remained positive until late March, during the most critical months of the year for sea-ice growth. To further illuminate the physical context of this situation, **Figure 11** shows the mean sea level pressure for December 2013 through March 2014 in the North Atlantic (NOAA/ESRL, 2014). A red arrow has been added to the figure by IIP to illustrate the approximate mean wind direction throughout these months. As expected, the mean winds were predominantly offshore during the winter, favoring extensive sea-ice growth along the Newfoundland and Labrador

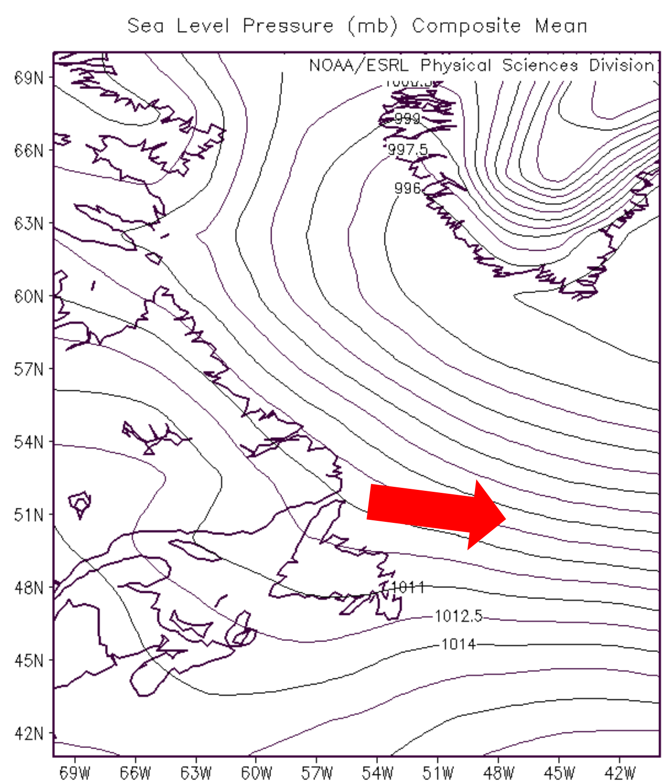


Figure 11. Mean winds at 1000 mb for December 2013 – March 2014. (NOAA/ESRL, 2014)

coasts. **Figure 12** shows the weekly ice coverage for east Newfoundland waters. With exception of the third week in January, ice coverage met or exceeded the 1981-2010 median, plotted in green on the graph. To put the 2014 sea-ice extent into perspective, **Figure 13** compares the Total Accumulated Ice Coverage (TAC) for the duration of each Ice Year from 1981 through 2014. The 2014 TAC was the largest since the 1994 Ice Year. (CIS, 2014d)

These extensive sea-ice conditions set the stage to allow an extraordinary population of icebergs to drift southward into the shipping lanes, especially when considering the light to moderate Ice Seasons recorded by IIP in recent years.

Sightings Outside of the Iceberg Limit

During the 2014 Ice Year, IIP received four reports of possible iceberg targets that were outside of the published Iceberg Limit. When viewed in the context of 1,546 icebergs south of 48°N, this was less than 0.3% of the total number of icebergs that IIP tracked south of this latitude in 2014. However, these cases represented a potentially dangerous situation for a vessel heeding IIP's Iceberg Limit. It is critical for IIP to document and learn from these instances to improve the future execution of the IIP mission.

Limitations in IIP's iceberg drift model, particularly near the complex region of the Tail of the Grand Banks, contributed to these

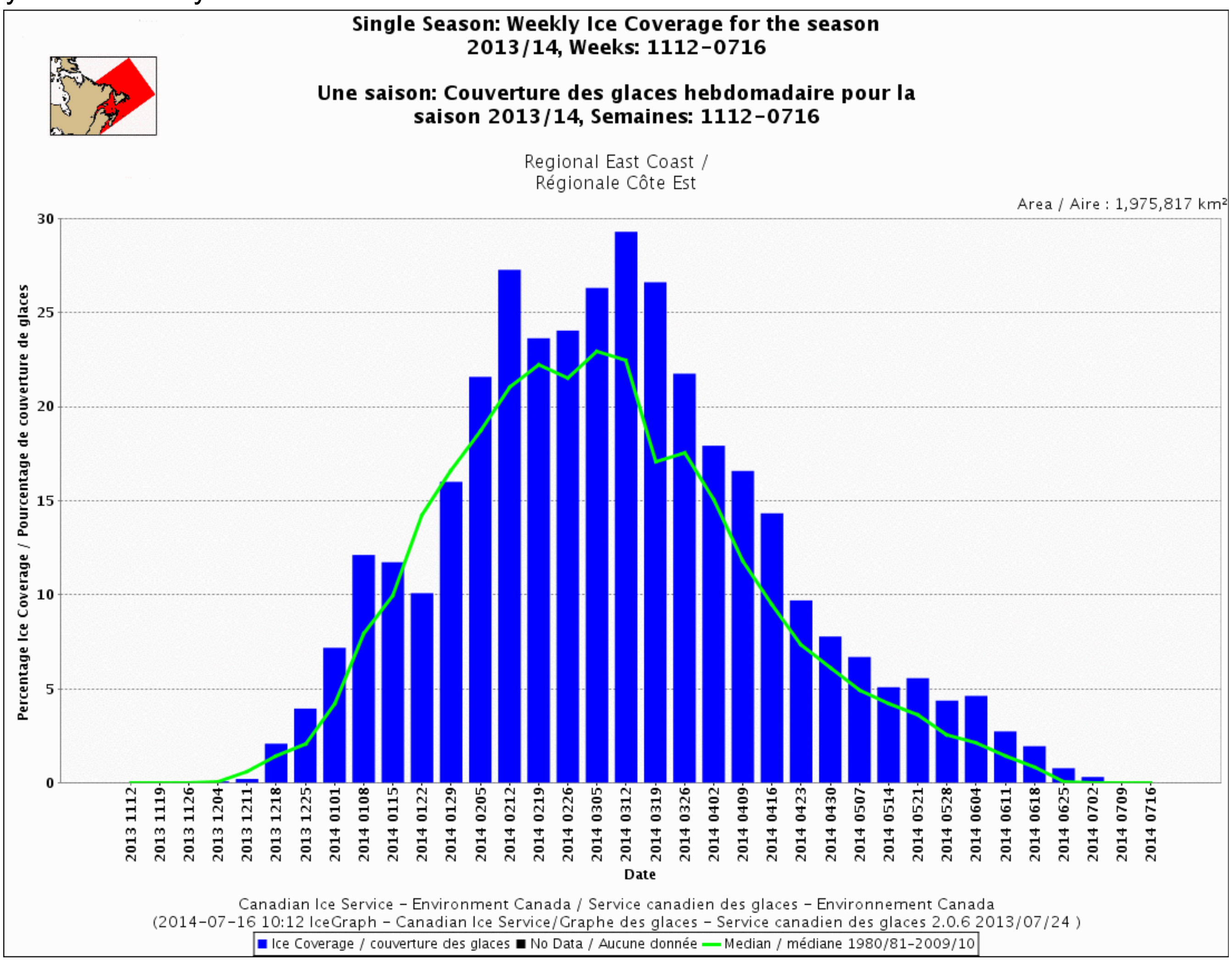


Figure 12. Weekly ice coverage for East Newfoundland Waters. The percent coverage is relative to the area shaded in red in the upper left map of this figure. (CIS, 2014d)

occurrences. The paths of two satellite-tracked drifting buoys with 50-m drogues illustrate the oceanographic conditions well (**Figure 14**). The trajectories shown represent the time period from 29 March through 15 July 2014. Both buoys were deployed at IIP's request by Canadian Coast Guard Ship (CCGS) Leonard J. Cowley in Flemish Pass on 29 March 2014. Data from these buoys yielded near real-time current information for BAPS and provided additional evidence characterizing the clockwise-circulating warm-core eddy shown earlier in **Figure 8**. The buoys followed a fairly consistent path until reaching the Tail of the Grand Banks. One (shown in red) turned to the northwest and drifted very slowly along the southwest edge of the Grand Banks. The second (shown in yellow) turned toward the southeast and eventually entered the much faster North Atlantic Current toward the east. Icebergs sighted outside of the Iceberg Limit are overlaid on **Figure 14** to emphasize the connection to the ocean currents at play during the height of the Ice Season. The circumstances behind each sighting by the reporting source are outlined below.

M/V MSC ANIELLO - IIP received the first report of an iceberg outside of the Limit on 09 May 2014, five days after an IIP flight in the same area. During this flight, IIP detected an ambiguous R/T in position 41°33′N,

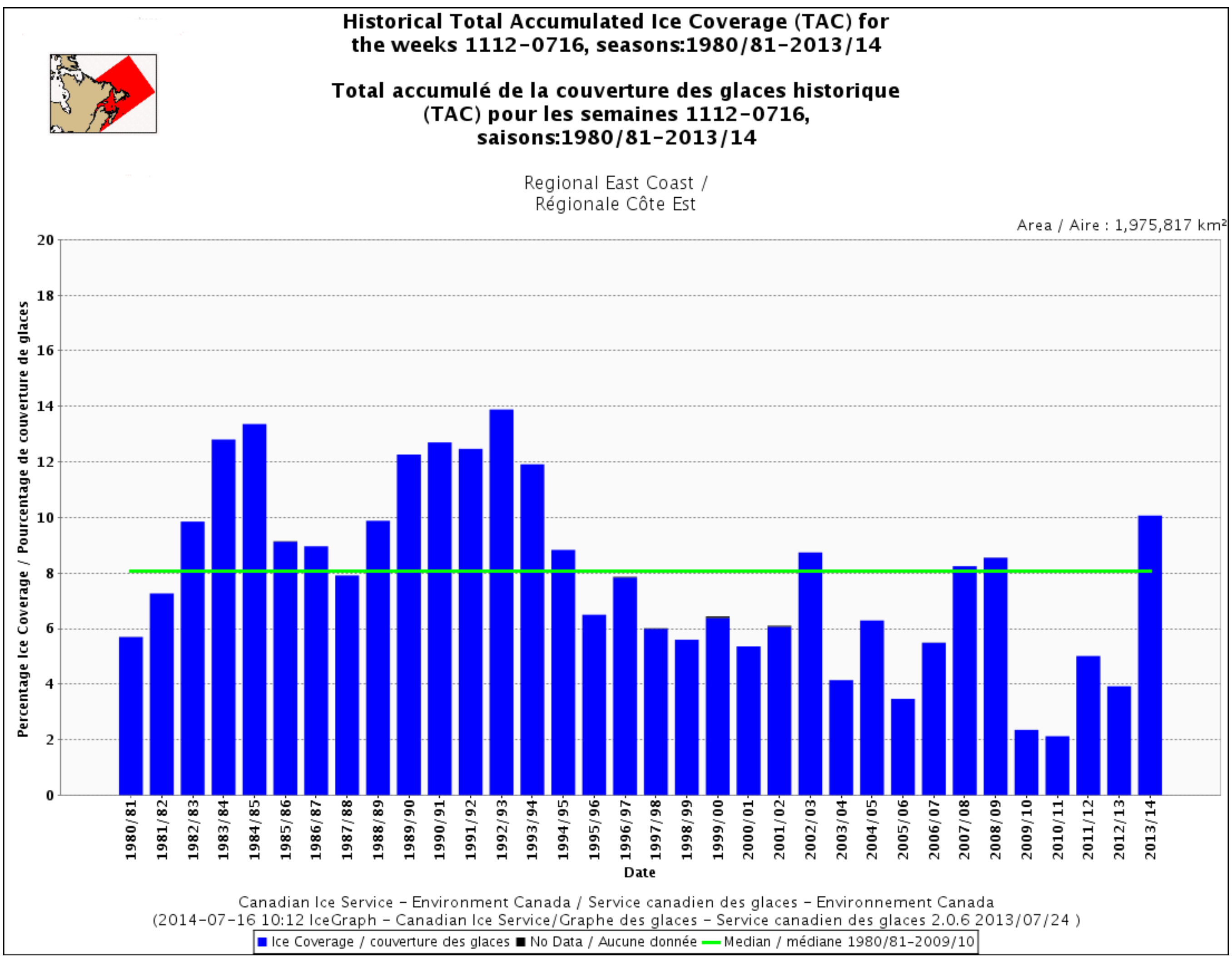


Figure 13. Historical Total Accumulated Ice Coverage for East Newfoundland Waters for 1980/81 through 2013/2014. The percent coverage is relative to the area shaded in red in the upper left map of this figure. (CIS, 2014d)

47°40′W. The approximate position is represented in **Figure 14** by an 'X' within a circle. Note the proximity of this R/T with respect to the yellow buoy trajectory. With no visibility to the surface and heavy storm activity in the area, the patrol aircraft could not safely descend to visually identify the R/T. In accordance with standard operating procedures, IIP moved the Iceberg Limit north of this target since it was not positively confirmed as an iceberg.

On 09 May 2014, a Mediterranean Shipping Company container ship, M/V MSC ANIELLO reported a "huge tabular iceberg" in position 42°19′N, 48°02′W, approximately 50 NM northwest of the R/T reported by the IIP flight and now outside of the adjusted Iceberg Limit. The approximate location is shown with a white triangle and labeled on **Figure 14**. IIP immediately shifted the Iceberg Limit south to incorporate this report and initiated actions to warn other mariners. While it cannot be positively confirmed that the R/T and the iceberg report from M/V MSC ANIELLO were the same targets, the direction and speed of drift were consistent with the buoy trajectory. It is plausible that the iceberg followed the southeastward meander seen in both the buoy plots and the AVHRR imagery.

M/V INDEPENDENT CONCEPT - IIP received a second report of an iceberg outside of the Iceberg Limit on 23 May 2014 from the container ship, M/V INDEPENDENT CONCEPT. This observation was the southernmost sighting for 2014, in position 41°07′N, 49°29′W and was located approximately 100 NM south of the Tail of the Grand Banks. Due to a combination of poor

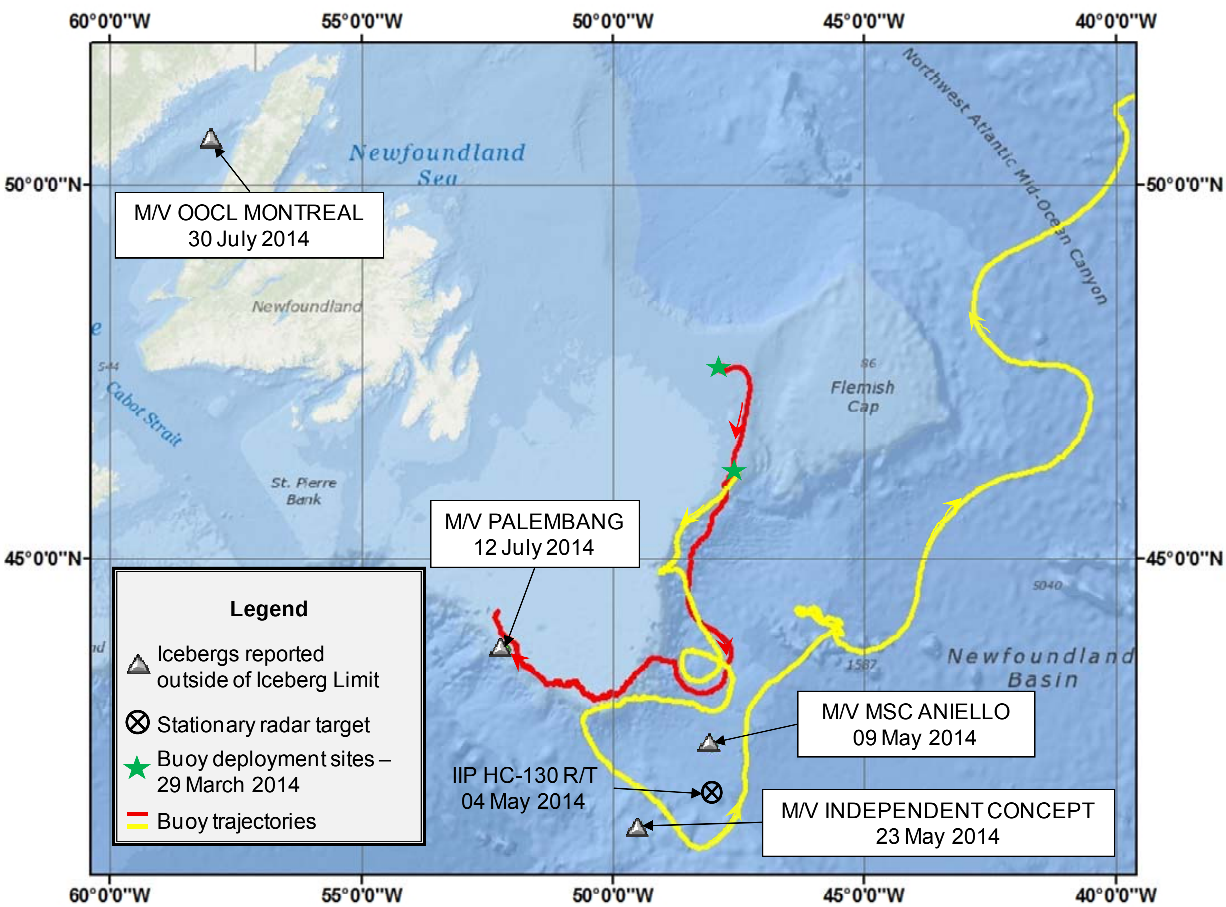


Figure 14. Sightings outside of the Iceberg Limit for 2014.

weather conditions, an aircraft problem, and the Search and Rescue cases described later in the Iceberg Reconnaissance and Oceanographic Operations section, nine days had elapsed since IIP's last aerial reconnaissance flight over this area. Of note, the accuracy of the IIP drift model decreases substantially after five days from an iceberg sighting, especially in this area of the ocean.

During a flight on 14 May 2014, IIP detected several icebergs, one of which was likely the same iceberg sighted by M/V INDEPENDENT CONCEPT, nine days later. A closer look at the yellow buoy track from **Figure 15** shows the most likely path traveled by the iceberg and highlights a significant limitation in the method used to incorporate buoy drift into the iceberg drift model. Specifically, this buoy moved through the area of the sighting from 03-12 May 2014 at speeds as high as 1.4 knots. This information was used to update historical currents for the iceberg drift model while the buoy was in this location (around 10-14 days prior to the iceberg sighting). However, the computer program used to update currents from buoy drift is designed to allow currents to relax back to the historical average over a two-week time period after a buoy has passed through the area. The difference between actual and historical currents was dramatic, as shown in **Figure 15**. In this figure, the green current vectors are a result of the buoy drift, and the blue vectors show historical current average. In this case, the drift model was using historical current data since the

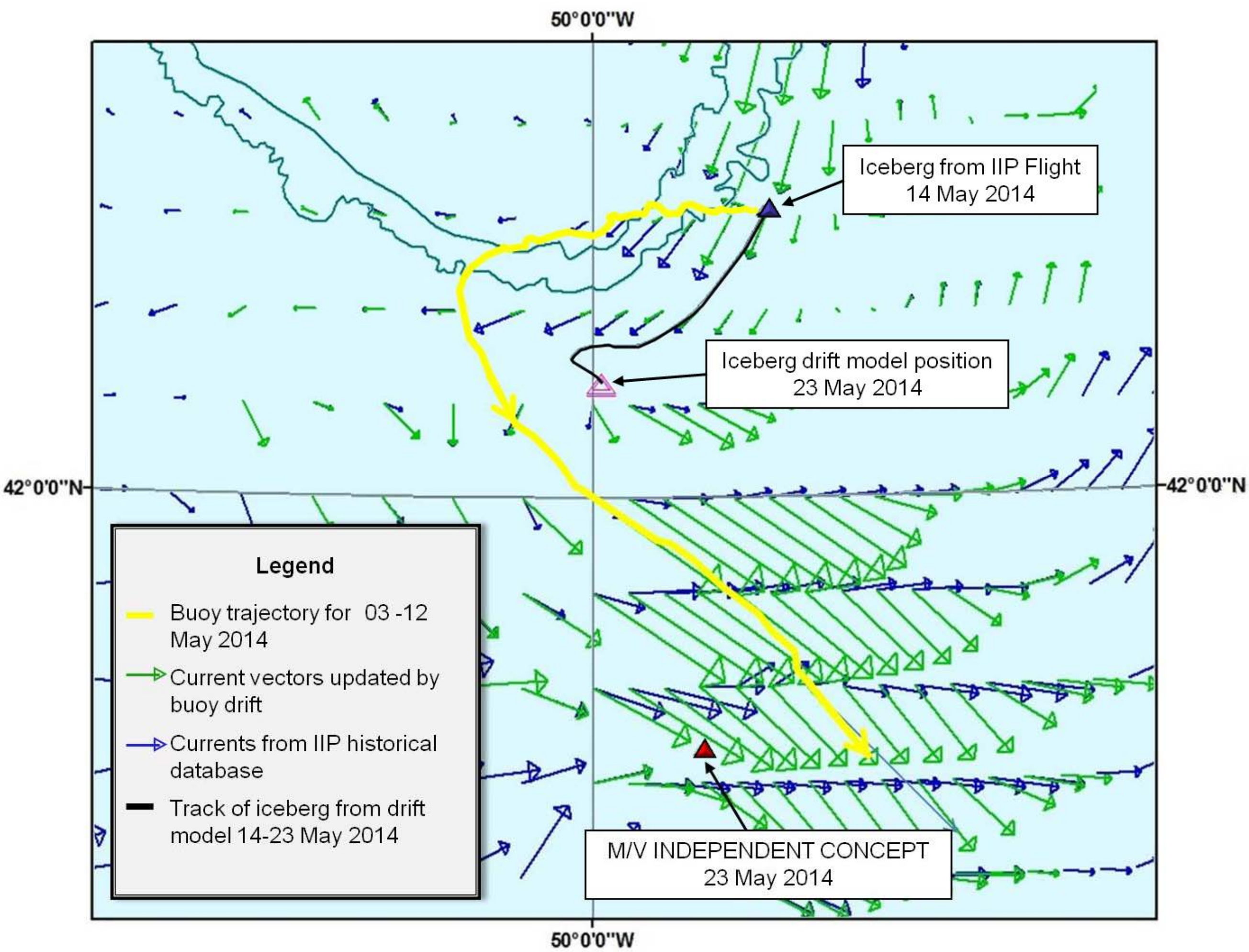


Figure 15. Current vectors and buoy track in the vicinity of M/V INDEPENDENT CONCEPT iceberg sighting.

buoy traversed the area 10-14 days prior to the sighting. IIP typically overcomes this modeling limitation by conducting more frequent aerial searches in these critical areas. The previously mentioned aircraft issues prevented IIP from revisiting this critical area while deployed on the 13-21 May 2014 IRD. As a result, this modeling limitation coupled with the aerial coverage gap resulted in an 85 NM error between the sighting and the closest iceberg in BAPS (shown as a magenta triangle in **Figure 15**).

M/V PALEMBANG - On 12 July 2014, M/V PALEMBANG, a dry bulk ship, reported a third iceberg outside of the Iceberg Limit in position 43°42′N, 52°09′W along the southwest contour of the Grand Banks. The approximate location is also shown with a white triangle and labeled on **Figure 14**. This iceberg most likely drifted around the Tail of the Grand Banks in the northwestward flowing extension of the Labrador Current described above (red buoy trajectory).

Two days before this sighting, IIP conducted a radar-only search in low visibility but did not locate this iceberg. The vessel estimated that the iceberg was 25 m long and 10 meters above the waterline. A digital photo (**Figure 16**), taken by M/V PALEMBANG, shows its size and exhibits evidence of recent calving. Since this was a fairly substantial target, it is unlikely that the HC-130J's sensors did not detect it. With calm seas and multiple small targets reported by the IRD in the area (for example, a small oceanographic buoy that was visually confirmed during a short glimpse to the surface), it is more likely that the target was detected but not correctly identified. The IRD returned to the area on 17 July 2014 to

Figure 16. Photo of iceberg sighted outside southwest limit on 12 July 2014. Photo courtesy of MV PALEMBANG.

conduct an abbreviated search while en route New London, CT but did not relocate the iceberg. With the SST exceeding 14°C, this iceberg had most likely melted by the date of the return flight. It was not reported again even with numerous vessels transiting the area.

M/V OOCL MONTREAL - While approaching the Strait of Belle Isle on an eastbound transatlantic voyage, the container ship, M/V OOCL MONTREAL, reported a stationary R/T outside of the western Iceberg Limit in the Gulf of St. Lawrence on 30 July 2014. The vessel detected this target at night in position 50°32′N, 57°57′W but did not visually confirm that it was an iceberg. This position is also included in **Figure 14** for reference. An IIP flight searched over the reported position on 26 July 2014 under excellent visual and radar conditions but did not detect any icebergs within 100 NM of the reported position.

Icebergs adrift outside of the published limit present a most dangerous situation for shipping. These cases highlight three key points. First, the region where the cold Labrador Current meets the warm Gulf Stream can be an extremely complex and dangerous oceanographic environment. Not only do these conditions support the frequent formation of fog that impedes visual identification, but the interactions of these currents also create small-scale features that are very difficult to represent with a mathematical drift model. Second, frequent reconnaissance is essential, particularly in the vicinity of dynamic oceanographic activity. Finally, in all of these cases, the icebergs outside of the Limit were reported by ships at sea. IIP relies on mariners to maintain a vigilant watch and to report all iceberg sightings – particularly those near the Iceberg Limits. IIP will continue to study these four cases to develop lessons learned in an effort to improve future reconnaissance and modeling efforts.

Operations Center Summary

The IIP OPCEN is the hub of IIP operations. IIP watch standers are responsible for receiving iceberg reports from various sources including aircraft, ships at sea, and satellite observations. These reports are incorporated into the iceberg database, and IIP personnel run the iceberg drift and deterioration model and produce iceberg warnings for distribution to mariners. IIP works within a collaborative arrangement with the Canadian Ice Service (CIS) and the U.S. National Ice Center (NIC) formally titled NAIS. The mission of NAIS is to leverage the strengths of the three services to monitor and provide the highest quality, timely, and accurate ice analyses to meet the needs of maritime interests in North America. NAIS agencies continued to work together during 2014 to improve the ice warning products for North Atlantic mariners.

Products and Broadcasts

IIP strives for accurate and timely reports to the maritime community. In 2014, IIP transmitted scheduled NAIS Iceberg Bulletins every day with 100% reaching SafetyNET and Navigational Telex (NAVTEX) on time (prior to 0000Z). SafetyNET is a satellite-based, worldwide maritime safety information broadcast service. One hundred percent of the Simplex Teletype Over Radio (SITOR) service bulletins via Communications Station Boston were delivered on time.

As described in the previous section, IIP will occasionally receive a report of an iceberg or R/T outside of the published limit which challenges the accuracy of the NAIS products and is a threat to safe navigation. Although IIP receives reports of icebergs by other means, the Canadian Coast Guard Marine Communications and Traffic Service (MCTS) St. John's receives most iceberg reports. If MCTS determines an iceberg or R/T is outside of the published limit, MCTS generates and transmits a NOTSHIP. The NOTSHIP is automatically forwarded to the National Geospatial-Intelligence Agency (NGA), and the information is disseminated through a NAVAREA IV warning. A NOTSHIP is the primary means of relaying critical iceberg information to the transatlantic mariner and allows time for IIP watch standers to produce and transmit a revised product. It also ensures the information is disseminated immediately. During the 2014 Ice Year, four icebergs were reported outside the limit with two requiring a NOTSHIP transmission. IIP received reports of icebergs outside of the southern limit on 09 May 2014 and 12 July 2014 from the M/V MSC ANIELLO and M/V PALEMBANG respectively. Both reports resulted in the generation of a NOTSHIP by MCTS. In the two other cases occurring on 23 May 2014 and 30 July 2014, IIP received reports of icebergs outside the published limits from M/V INDEPENDENT CONCEPT and M/V OOCL MONTREAL respectively. Both reports were received close to IIP's regularly scheduled product transmission time and did not require NOTSHIP transmissions. The Iceberg Limit accuracy for the 2014 Ice Year was 98.9%. Complete details on each case can be found in the Ice and Environmental Conditions section of this report.

Iceberg Reports

A critical factor contributing to IIP's successful safety record is the support received from the maritime community. This support is measured annually by the number of voluntary iceberg reports IIP receives in a fiscal year (FY) as listed in Appendix A. Iceberg reports from ships remain a critical source of information, and IIP encourages vessels transiting within the North Atlantic Ocean near the Grand Banks of Newfoundland to report iceberg sightings in a timely manner. Receiving on-scene and near real-time information further enhances the accuracy of IIP products.

As described earlier in this report, 2014 was one of the most severe seasons on record. Throughout the season, the iceberg population was well-dispersed and extended from the Newfoundland and Labrador coast east beyond the Flemish Cap and south beyond the Tail of the Grand Banks. In fact, the southernmost latitude of the Iceberg Limit was 39°30′N, the approximate latitude of Baltimore, Maryland in the United States. The IIP OPCEN received, analyzed, and processed 357 iceberg sighting messages. The number of reports was approximately 70% more than the 208 iceberg messages received in 2013 which is attributed to extreme iceberg conditions. The left bar graph of **Figure 17** shows the distribution of the percentage of iceberg reports received by IIP according to source. Commercially-contracted reconnaissance by PAL provided 220 (61.6%) messages. Merchant ships provided 67 (18.8%) messages. IIP aerial reconnaissance flights provided 49 (13.7%). Canadian Coast Guard (CCG) ships and aircraft combined to deliver 11 (3.1%) messages. Satellite reconnaissance was responsible for 5 (1.4%) messages. Scientific research and fishing vessels (Other category) combined to relay the remaining 5 (1.4%) messages.

These iceberg sighting messages contained a total of 20,013 icebergs, growlers, or R/Ts. Prior to entry into the iceberg drift and deterioration model, IIP watch personnel evaluated all messages for accuracy and viability. After this process, 18,661 icebergs of the original 20,013 sightings were incorporated (added or re-sighted) into BAPS. Several factors were considered during this evaluation, including

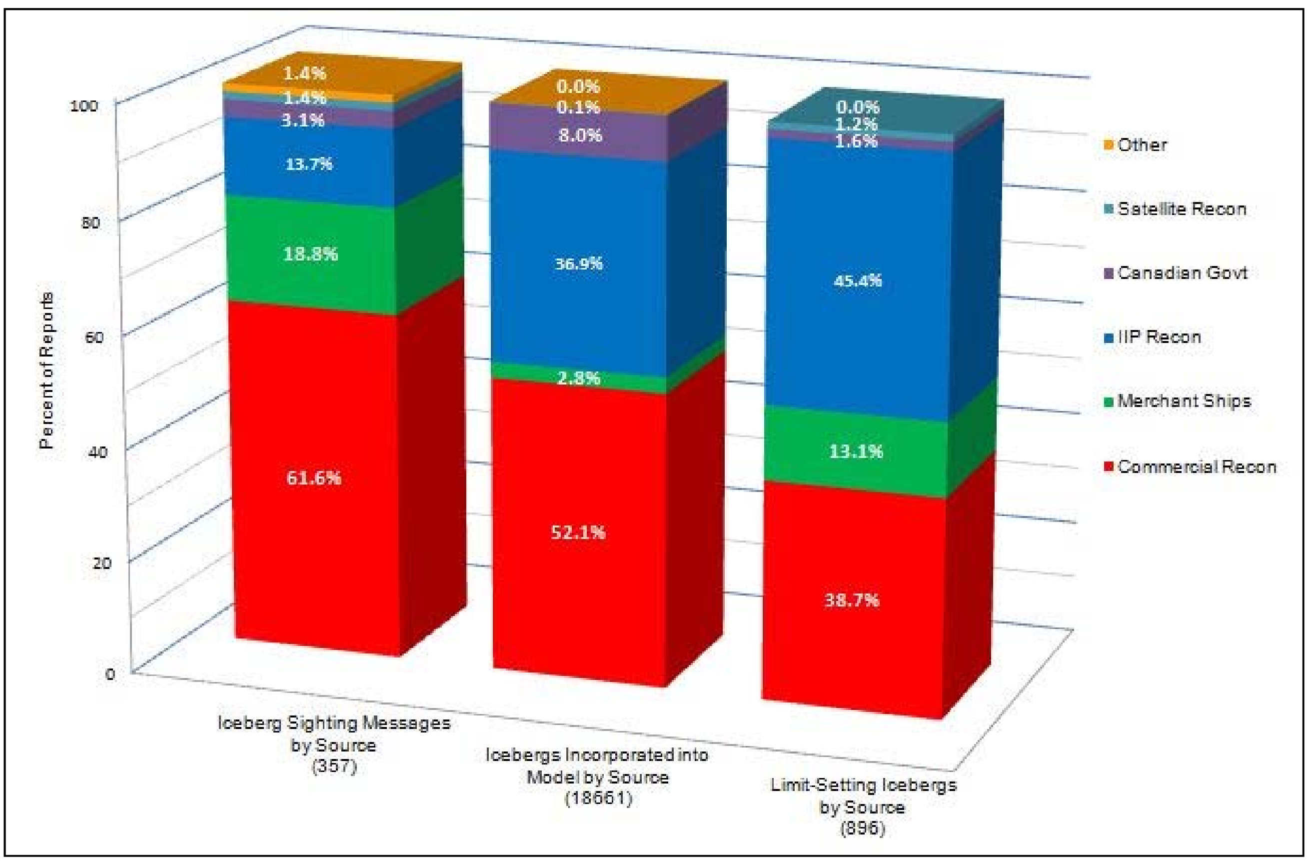


Figure 17. Percentage of iceberg messages, icebergs incorporated into model, and limit-setting icebergs by reporting source in 2014.

atmospheric and oceanographic conditions, recent reconnaissance in the area, method of detection, and any other amplifying information relayed with the ice report. This standard is applied to all ice reports, even IIP's own reconnaissance, to ensure accurate iceberg products are being broadcast to the maritime community. The percentage of updates to BAPS by reporting source is portrayed in the middle bar graph of **Figure 17**. Commercial flights provided the majority of the icebergs (52.1%) incorporated into BAPS this year. These flights were conducted in support of both the oil and gas industry operating on the Grand Banks and the Canadian Government. Due to the significant threat icebergs posed to oil rigs this season, PAL routinely performed several reconnaissance flights per day in the area of the oil platforms east of St. Johns, NL. IIP reconnaissance reported 36.9% of the total number of icebergs entered into BAPS in 2014.

Icebergs used to establish the limit are of critical importance because they define the boundary for ice-free ship navigation. As a result, IIP's reconnaissance flights normally focus on this boundary and typically provide the highest percentage of limit-setting iceberg reports. In 2014, the Iceberg Limit extended east as far as 33°30′W and south as far as 39°30′N, well past the endurance of PAL and Transport Canada air reconnaissance. The right bar graph of **Figure 17** shows the percentage of icebergs used to set the Iceberg Limit by reporting source. As expected, this figure shows that IIP flights made the most significant contribution to the number of limit-setting iceberg sightings at 45.4%. Commercial flights accounted for 38.7% of all limit-setting iceberg sightings or detections. In comparison, 2013 was a "light" season with only 13 icebergs drifting south into the shipping lanes, allowing PAL to observe the majority of the limit-setting icebergs since the Iceberg Limit never extended much south of 48°N. Busy seasons with large numbers of icebergs entering the shipping lanes highlight the importance of IIP reconnaissance with greater endurance.

Implementation of BAPS 1.12

As discussed in Appendix D the 2012 Annual Report, the BAPS software application was identified as being at risk of losing its Department of Homeland Security (DHS) authority to operate. The operating system was scheduled to stop receiving manufacturer's security updates in early 2014. The IIP Program Office received funding in late FY12 to accomplish a Technical Refresh of BAPS. The USCG Operations Systems Center (OSC) was contracted to perform the work, beginning with a feasibility study to determine the best approach.

The Feasibility Study was completed in December 2012 and recommended that the Technical Refresh move the operating system from Windows XP to Windows 7, upgrade the ArcGIS interface from ArcView 3.3 to ArcMap 10.1, and rewrite custom software from existing obsolete scripting languages to modern supported languages. Because the work needed to be completed before the end

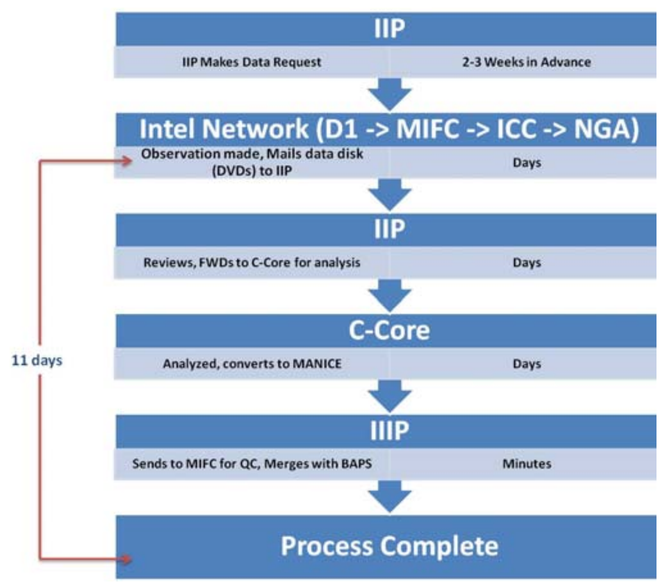


Figure 18. 2014 Ice Year satellite image ordering process.

of 2013, it was determined that all existing functionality of BAPS would be maintained, but no new functionality would be added. The BAPS Technical Refresh was named BAPS version 1.12.

By mid-2013, BAPS 1.12 was ready for user acceptance testing at IIP. In October 2013, acceptance testing was complete, and BAPS 1.12 was delivered and installed in the IIP OPCEN. IIP provided the 1.12 software to CIS in November 2013. Between October 2013 and January 2014, IIP personnel continued familiarization and testing of version 1.12. Integration of BAPS 1.12 into daily operations began on 02 February 2014 and coincided with the beginning of IIP's Ice Season.

From February to April, BAPS 1.12 was incrementally implemented into IIP operations while BAPS 1.11 was kept online as a back-up. During the transition period, there were several occasions where BAPS 1.11 was used to ensure products were delivered due to technical issues. By 01 April, BAPS 1.12 was fully implemented, and BAPS 1.11 was removed from service.

Since full implementation, BAPS 1.12 has performed well. ArcMap 10.1 provides additional mapping tools which were previously unavailable. As experience is gained on the system, IIP will be able to improve both the quality and variety of graphical products produced. As planned and described in the 2012 Annual Report, the USCG is continuing to investigate functional improvements to BAPS in the areas of automation, ingestion of satellite imagery, and product distribution.

Satellite Reconnaissance Research

In 2014, IIP continued to focus on the implementation of regular satellite observations of icebergs into its operations. This year, IIP developed a process to obtain unclassified, commercial satellite images through an ordering process from IIP, to USCG D1, the Intelligence Coordination Center (ICC) and finally to NGA for imagery acquisition. Most of these images were from the Canadian RSA-2. In April, five TerraSAR-X (TSX) images were also provided through this process. IIP submitted a request for this data several weeks in advance in locations

Date	Satellite	Mode	IIP HC-130J Validation	Source of Data	Comments
17-Apr-14	TSX	STRIP MAP		ICC/NGA	Swath = 15 km; Res = 7 m *Swath too narrow for IIP*
19-Apr-14	TSX	STRIP MAP			
20-Apr-14	TSX	STRIP MAP			
21-Apr-14	TSX	STRIP MAP	✓		
30-May-14	RSA2	OSVN			OSVN = Ocean Surveillance, Very wide swath, Near incidence Swath = 530 km; Res = 39m - 86m *OSVN resolution too low for small iceberg detection* * PAL aerial validation on 5/30
3-Jun-14	RSA2	OSVN	✓		
5-Jun-14	RSA2	OSVN			
6-Jun-14	RSA2	OSVN			
15-Jun-14	TSX	ScanSAR	✓	Airbus/Defence and Space	Swath = 100 km; Res = 18 m; *Coverage and resolution are appropriate for small iceberg reconnaissance*
26-Jun-14	TSX	ScanSAR	✓		
30-Jun-14	RSA2	WIDE-FINE		ICC/NGA	Swath = 150 km; Res = 8 m
30-Jun-14	RSA2	OSVN		ICC/NGA	*OSVN resolution too low for small iceberg detection*
3-Jul-14	RSA2	OSVN			
4-Jul-14	RSA2	OSVN			
6-Jul-14	RSA2	OSVN			
9-Jul-14	RSA2	OSVN			
10-Jul-14	RSA2	OSVN			
23-Jul-14	RSA2	WIDE-FINE	✓	ICC/NGA	Swath = 150 km; Res = 8 m *Coverage and resolution are appropriate for small iceberg reconnaissance*
26-Jul-14	RSA2	WIDE-FINE	✓		
27-Jul-14	RSA2	WIDE-FINE	✓		
30-Jul-14	RSA2	WIDE-FINE	✓		

Table 3. Description of satellite observations. Rose colored cells indicate the image swath was too narrow. Blue cells indicate the image swath was too wide. Green cells indicate appropriate image swath size.

most likely to have icebergs populations. After an observation was made, NGA provided IIP with a data disk of the specified image. As in years past, IIP contracted analysis of the images by the Centre for Cold Ocean Research Engineering (C-CORE), a not-for-profit research organization located in St. John's, Newfoundland. C-CORE uses a computer algorithm called the Iceberg Detection Software (IDS) which automates iceberg detections from commercial SAR imagery. C-CORE provided the IIP OPCEN a report in Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE) format based on IDS output. MANICE is the standard developed by CIS for observing all forms of Sea, Lake, and River Ice, as well as Ice of Land Origin. MANICE format is ingestible by the BAPS system for incorporation into the IIP iceberg drift and deterioration model. The reports were initially quality-controlled by the IIP OPCEN and then sent to the USCG Maritime Intelligence Fusion Center Atlantic (MIFC LANT) for further vetting. The data was obtained through the NGA via mailed disc. This process was not used operationally due to time latency. On average, it took approximately 11 days from image acquisition until data was available at IIP. A summary of this process is described in **Figure 18**. A description of a sampling of the satellite observations made in support of IIP efforts in the 2014 Ice Season can be found in **Table 3**.

In addition, IIP received data from two TSX images from Airbus Defense and Space, a German corporation operating the TSX satellite. These images were analyzed by C-CORE's IDS and by a different automated detection algorithm at Airbus Defence and Space for comparison. IIP attempted to provide ground validation of satellite collections as much as possible during the 2014 Ice Season. This process proved exceptionally challenging due to the severity of the season which placed a greater operational demand on flight hours and resources. IIP was able to provide two especially useful under flight validations for the TSX satellite images described above occurring on 15 June and 26 June. Analysis of the algorithms yielded 63% and 34% correlation for C-CORE's IDS and Airbus respectively between satellite and airborne observations as best shown in the analysis for 15 June (**Figure 19**).

For the 2015 Ice Year, IIP plans to continue work to integrate satellite data into operations on a regular basis. Continued ground validation flights and analysis of satellite imagery using detection algorithms will prove critical for the program's continued success. IIP plans to release a Concept of Operations (CONOPS) for satellite reconnaissance that will outline IIP's satellite needs and intended future use.

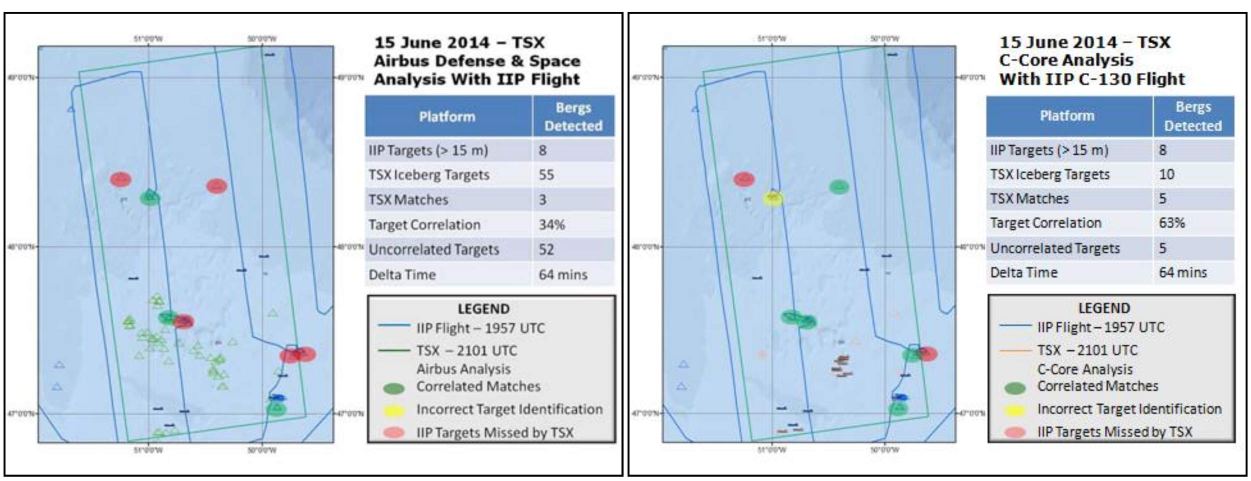


Figure 19. Airbus and C-Core analysis comparisons with IIP HC-130J flights.

Iceberg Reconnaissance and Oceanographic Operations

Ice Reconnaissance Detachment

The IRD is a sub-unit under CIIP, which is partnered with USCG Air Station Elizabeth City (ECAS). During the 2014 Ice Year, twelve IRDs deployed to observe and report icebergs, sea ice, and oceanographic conditions on and near the Grand Banks of Newfoundland. All observations were transmitted to the IIP OPCEN in New London, CT where they were entered into BAPS and processed. IIP's ice warning products were created and distributed to the maritime community.

Throughout the 2014 Ice Year, IRDs operated out of IIP's base of operations in St. John's, Newfoundland for a total of 103 days and conducted 49 iceberg reconnaissance patrols. The first IRD departed for St. John's on 06 February, and the last IRD returned to New London on 01 August. Eighteen flights were cancelled due to weather, and seven flights were cancelled for aircraft maintenance or repairs. From a historical perspective, this year was considered the sixth most severe Ice Season on record since 1900. While a hazard to shipping, the severe conditions provided valuable data and training and resulted in a highly qualified IIP crew. Despite the harsh conditions, the IIP upheld its perfect safety record: no vessel heeding IIP's warnings struck an iceberg in 2014. A summary of IRD operations is provided in **Table 4**.

Aerial Iceberg Reconnaissance

The 2014 aerial iceberg reconnaissance operations were conducted using the HC-130J, a long-range surveillance maritime patrol aircraft, from ECAS. The aircraft is equipped with two radars and an Automatic Identification System (AIS) integrated into the mission system suite. The ELTA-2022 360° X-Band (ELTA) radar is capable of detecting and discriminating surface targets. The AIS receives information transmitted by ships and is used to help differentiate vessels from icebergs. The APN-241 Weather Radar is capable of detecting surface targets but not identifying them.

Poor weather in IIP's OPAREA frequently made detecting and discriminating targets a challenge for IRD personnel. As a result, the use of radar in this environment is critical to IIP operations. The IRD relied heavily upon the detection and discrimination capability of the ELTA radar to enhance visual iceberg reconnaissance. In conditions where there was little or no visibility to the surface, the IRD relied on the ELTA's imaging capability as the primary means of classifying targets. However, managing high concentrations of R/Ts in the severe sea ice conditions of 2014 proved to be particularly challenging. This year, sea ice coverage off of Canada's east coast was the highest in the past two decades. As noted in the Ice and Environmental Conditions section, sea ice reached nine-tenths coverage during the first four months of the season in this region. The sea ice protected the icebergs from deterioration by the waves and allowed them to drift far to the east and south. These

IRD	Deployed Days	Iceberg Patrols	Transit Flights	Logistics Flights	Flight Hours
1	8	4	2	0	32.2
2	8	4	2	0	37.7
3	10	3	2	0	33.9
4	8	4	2	0	39.2
5	7	3	2	0	31.8
6	9	5	2	2	50.0
7	9	1	2	0	16.2
8	9	5	2	0	41.4
9	8	4	2	0	39.3
10	8	5	2	0	48.8
11	9	5	2	0	37.7
12	10	6	2	0	53.1
Total	**103**	**49**	**24**	**2**	**461.3**

Table 4. Summary of IRD Operations.

conditions tend to saturate the radar picture with automatically-acquired targets, making it virtually impossible to definitively distinguish icebergs from sea ice without visual confirmation. IRD crews quickly discovered it was easier to rely upon the aerial ice observers to record data visually while operating over sea ice, rather than attempt to electronically classify hundreds of targets automatically detected by the radar. Thus, most iceberg observations in sea ice were entered as visual sightings with radar information supplementing those entries.

IRDs conducted 49 patrols for a total of 324 patrol hours and experienced 38.5 hours of ELTA radar casualties. Radar casualties resulted in six visual-only patrols. IRDs operated without working radar for 11.9% of total patrol time this season. Although this is a 26-hour increase in radar casualty time from the 2013 Ice Season, which had a total of 12.5 hours of ELTA down time, the overall percentage was lower than 2013 since more than three times as many patrols hours were conducted this year.

The availability of 360° coverage provided by the ELTA radar supports the use of 25 NM track spacing for patrol planning (**Figure 20**). In 2013, IIP collected sweep width data under calm conditions. The analysis of this data resulted in a recommendation to expand track spacing to 30 NM in calm conditions while maintaining a 95% probability of detection (POD). This level of POD is established by IIP's Reconnaissance Requirements. In 2014, IIP implemented 30 NM track spacing when wind speeds were less than 10 knots and sea states in the patrol area were less than one meter. These conditions were met on 26 June and 12 July. In future seasons, IIP will collect sweep width data under different environmental conditions and at various flight parameters to continue to improve the efficiency of aerial reconnaissance.

As described in the Operations Center Summary section, 18,661 icebergs were incorporated into the BAPS model. IRD personnel detected 5,892 icebergs which accounted for 32% of the total. Icebergs are detected in one of three ways: (1) combination of radar and visual, (2) radar only, or (3) visual only. This year, 43% of the icebergs were detected by both radar and visual sightings. The remaining icebergs were either detected only by visual sighting (52%) or only by radar (5%) (**Figure 21**). The number of visual only sightings increased from 2013 (37%) while the radar only sightings decreased (17%). This increase in visual sightings is attributed to the significant concentration of icebergs embedded in heavy sea ice as described above.

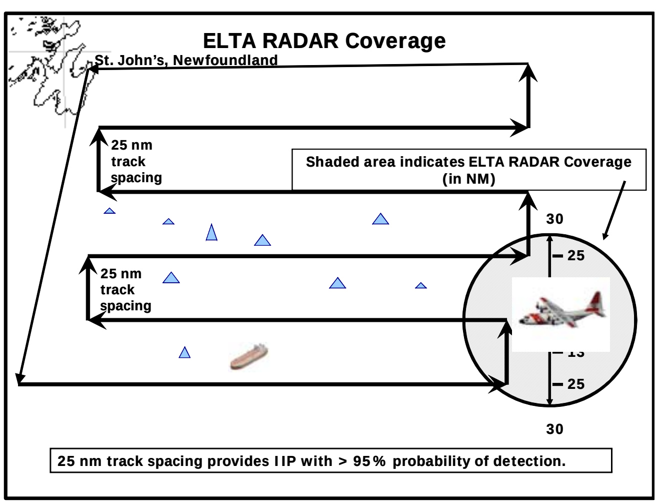


Figure 20. Radar reconnaissance plan.

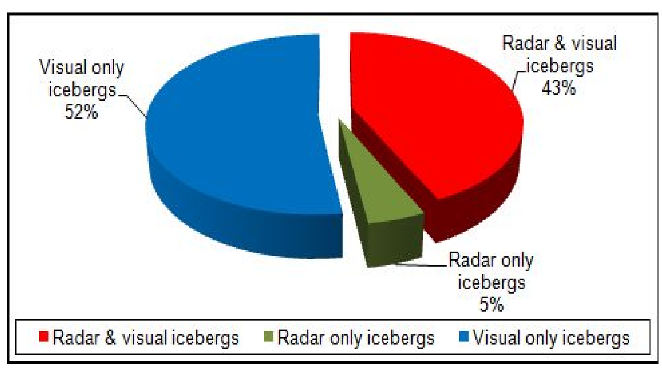


Figure 21. Iceberg sightings by method.

2014 Flight Hours

Historically, the Aviation Forces manager at USCG Atlantic Area (LANTAREA) allotted 500 Maritime Patrol Aircraft (MPA) flight hours for IIP operations at the beginning of each FY. Depending on season severity, any flight hours not used for IIP operations were transferred to other USCG missions once it was clear that IIP would not need the hours for iceberg reconnaissance. However, FY 2014 budget cuts forced across-the-board reductions in USCG aviation asset flight hours. As a result, LANTAREA reduced the IIP's allotment of MPA flight hours to 335 during strategic planning for FY 2014 based upon the 10-year average of flight hours used by IIP. At the beginning of the season, it was clear the 2014 Ice Season would be much more severe than the previous four seasons, and IIP would require additional flight hours to conduct adequate reconnaissance. In April, CIIP requested an additional 100 MPA hours from LANTAREA through D1 for a total of 435 hours. At the beginning of June, CIIP recognized that these flight hours were likely to be used prior to the end of the season and requested an additional 50 MPA flight hours. By the close of 2014 ice reconnaissance operations, IIP used over 461 flight hours.

In addition to the 49 iceberg patrols flown during the 2014 Ice Year, IRDs conducted 24 transit flights to and from St. John's. **Figure 22** shows the breakdown of the 461.3 flight hours used for IIP operations in 2014 compared with the previous four years. The flight hours are broken down into three categories: patrol hours, transit hours, and logistics hours. Patrol hours are the flight hours used for iceberg reconnaissance. IIP flew 324 patrol hours this season. Transit hours are flight hours used when the aircraft transited to and from specific locations in support of the IIP mission. There were 127.8 hours used this season for transits to and from St. John's or alternate airports. During the 2014 season, there were no requests to conduct concurrent D1 Northwest Atlantic Fisheries Organization (NAFO) patrols during IIP transit flights. Logistics hours are the flight hours used to support the overall IIP mission,

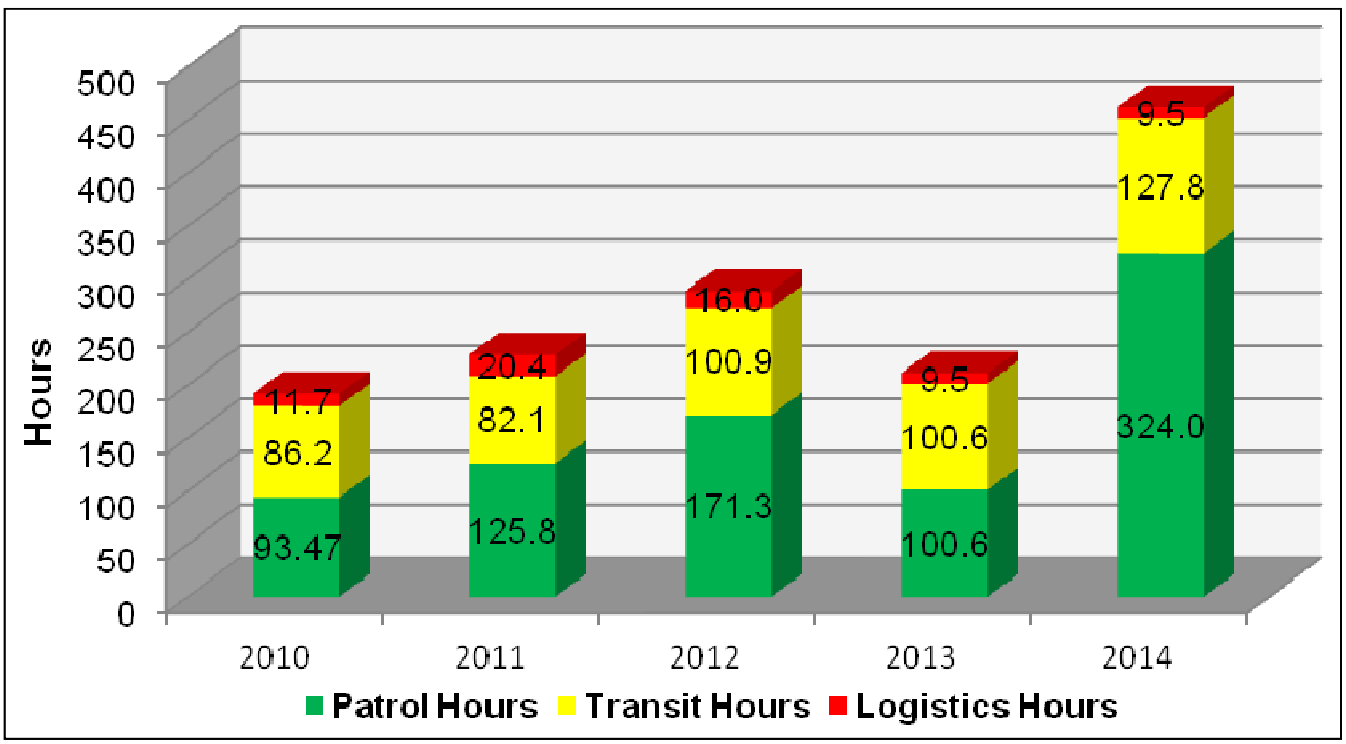


Figure 22. Summary of flight hours (2010-2014).

but do not fall into the previous two categories. Logistics hours are generally used to transport parts for an aircraft designated for use in the execution of the IIP mission. This year, 9.5 logistics hours were used to transport aircraft parts from ECAS to the IRD in St. John's.

During the 2014 Ice Season, two patrols were incorporated into transit flights. These flights were conducted to maximize the use of limited flight hours. On the first occasion, a patrol was completed in conjunction with the return transit to Groton, CT for the purpose of identifying a recent iceberg sighted by a ship outside of the published limit. Because the next scheduled IRD would not be patrolling for at least another week, execution of the search was critical to the integrity of IIP products. In the second case, a short patrol was conducted during the transit to Groton, CT in order to confirm the southwestern iceberg population. In addition to simultaneously conducting reconnaissance, this patrol was also used as an opportunity to drop a wreath commemorating the World War II Greenland Patrol. This flight provided a more accurate southern limit picture and honored an IIP memorial tradition.

The number of flight hours needed for IIP to monitor iceberg danger to transatlantic mariners is closely linked to the number of icebergs observed or drifted south of 48°N. **Figure 23** shows a comparison of flight hours to number of icebergs drifted south of 48°N from 2004 to 2014. The red line indicates the IIP total flight hours. The blue bars indicate number of icebergs observed or drifted south of 48°N. The figure shows the 2014 season used approximately the same amount of flight hours as the 2008 season. However, in 2008, 570 fewer icebergs entered the transatlantic shipping lanes. Leveraging resources from IIP's active partnership with CIS through NAIS enabled IIP to use similar HC-130J hours to conduct reconnaissance over an iceberg population that was 37% larger than the population in 2008.

HC-130J Radar Testing

A USCG Aviation Test and Evaluation Team from the USCG Acquisition Directorate (CG-9335) awarded a contract to Exelis/ELTA

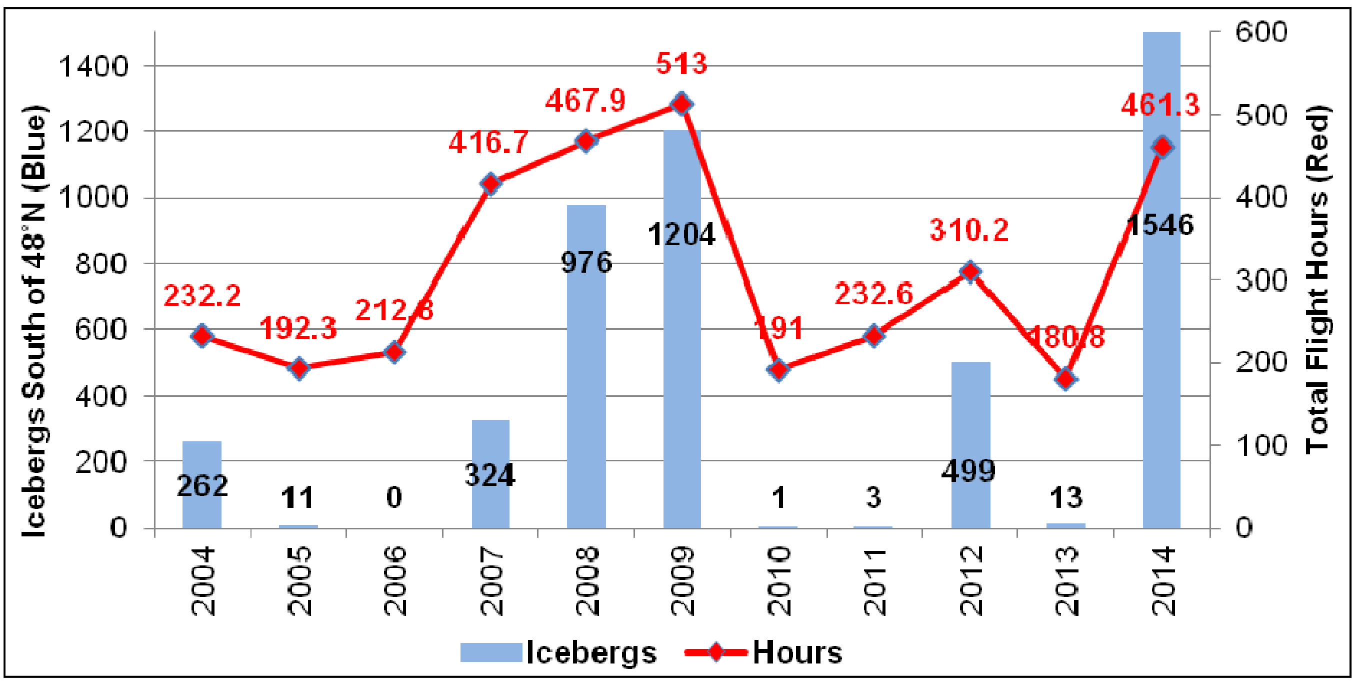
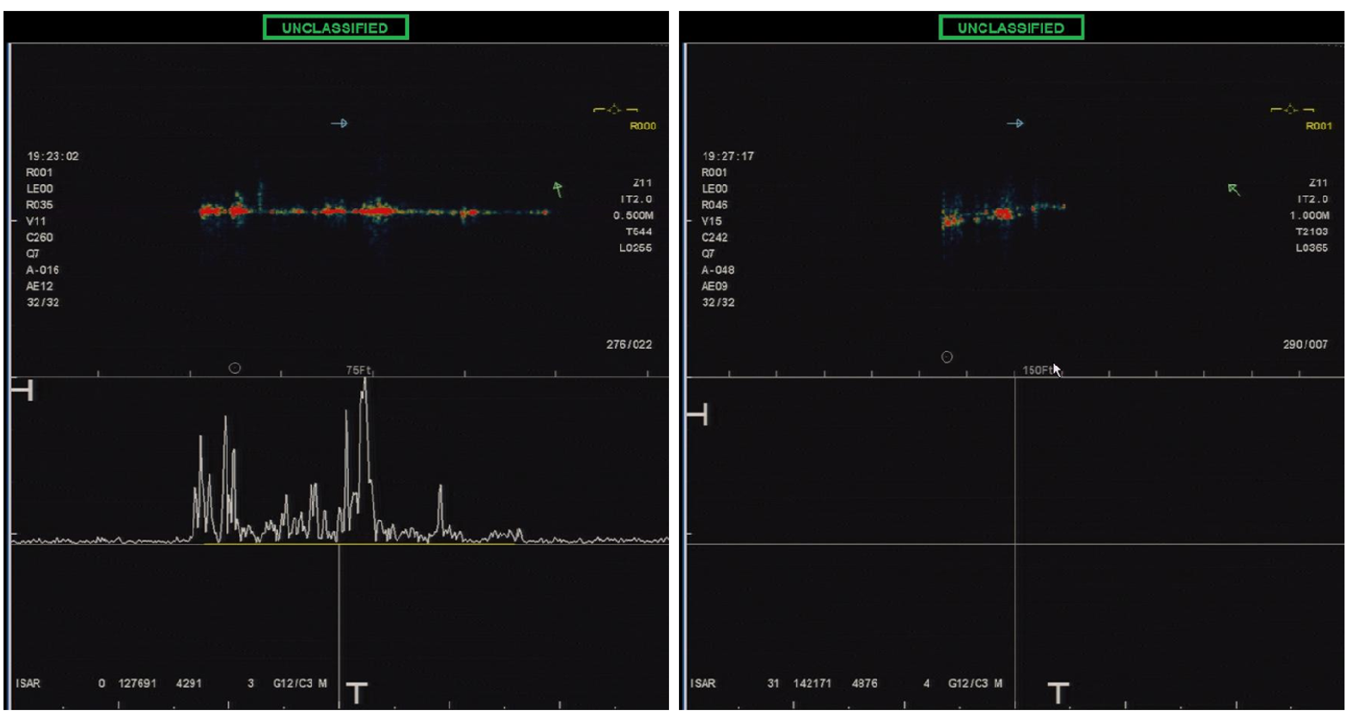


Figure 23. Flight hours versus icebergs south of 48ºN (2004-2014).

Systems Limited to update the current radar software installed on USCG fixed wing aircraft. The test team consisted of operators and engineers from Naval Air Systems Command, Johns Hopkins University, Exelis/ELTA, USCG Aviation Logistics Center (ALC), and USCG Headquarters. In support of this test, radar data were collected on the first IRD in 2014 to be used in the development of the replacement mission system called “Minotaur”. During this IRD, IIP met with the test team to discuss current capabilities and what future capabilities could enhance the mission system for the IIP mission.

Particularly relevant to IIP’s mission, a large part of the test was the functionality of High Resolution Inverse Synthetic Aperture Radar (ISAR) (0.5 m). The High Resolution ISAR clearly paints a clearer picture of the target. This function would significantly aid in the identification of icebergs by the ELTA radar. **Figure 24** shows a comparison of High Resolution ISAR versus the current capability ISAR images of a 300-foot container ship. Due to the operating frequency of 9.0 GHz to 9.3 GHz, this mode is only allowed to operate beyond 75 NM from shore since it may interfere with airports’ precision approach systems. One of the test objectives was to validate that a recent software upgrade would auto-inhibit transmissions within 75 NM from shore. This test was successful.

Another test objective was to review IIP iceberg detection methodologies with the ELTA radar. IIP is working to improve radar detection of icebergs in sea ice by evaluating the ELTA radar’s Strip SAR mode at different search altitudes for the optimal radar performance. During this radar testing, IIP enjoyed a rare opportunity for hands-on training from expert ELTA operators in the use of Strip SAR for detecting icebergs within sea ice. IIP will continue to experiment with this mode during the upcoming season and will execute a test of this mode by the Research and Development Center.



High resolution ISAR (0.5 m) with Range Profile **Current capability (1 m resolution)**

Figure 24. High resolution ISAR versus current ISAR of a 300-foot container ship.

NAIS Reconnaissance Results

In 2012, IIP began to leverage its partnership with CIS within NAIS to maximize the resources of both organizations and obtain comprehensive aerial reconnaissance. By coordinating flight planning, redundant reconnaissance was eliminated. This section describes how actual reconnaissance aligned with these efforts in 2014. **Figure 25** depicts the NAIS flight hours. Data provided includes hours flown by each service. CIS hours were totaled from February to August for accurate comparison with IIP hours. In 2014, coverage of the OPAREA was a joint effort between CIS and IIP. IIP flew 49 patrols for a total of 324 patrol hours. CIS contracted 18 patrols with PAL for a total of 126.03 hours. CIS also used Transport Canada to coordinate iceberg reconnaissance flights. Transport Canada flew five patrols for a combined 28.3 hours. During the 2014 season, CIS provided a total of 154.3 flight hours between commercial and government resources. In August 2014, as part of the NAIS partnership, IIP and CIS agreed IIP would retain iceberg product generation responsibilities through 22 September 2014, and CIS would provide additional aerial reconnaissance through contracted iceberg flights. CIS flew two patrols in September and October for a total of 10.4 hours. The combined total resulted in 98 flights and 615.6 hours in support of NAIS reconnaissance. On average, from 1999 to 2012 (prior to NAIS coordinated flights), IIP and CIS combined for a total of 450 hours each year to conduct iceberg reconnaissance. These numbers are included in **Figure 25**.

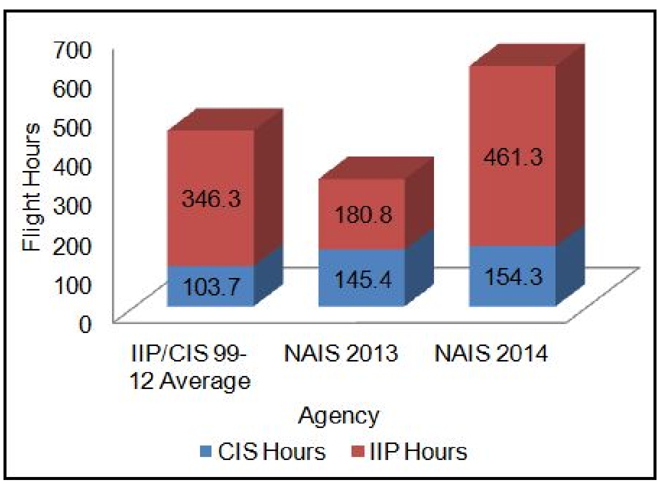


Figure 25. NAIS flight hours (February – August 2014).

Note: Ice Patrol flight hours (indicated in red) include transit and logistics hours. CIS flight hours do not record separate transit hours. For PAL flights, the patrol aircraft are typically based close to the OPAREA. These aircraft patrol immediately upon take-off. However, for Transport Canada flights, aircraft can originate outside of the province of Newfoundland and Labrador. In this scenario, the aircraft's transit time to the OPAREA will be inaccurately counted as patrol time.

The NAIS region is divided into five areas based on the risk of iceberg collision for vessels in the transatlantic shipping lanes. Areas "A" and "B" are monitored to determine the overall iceberg population early in the season and to predict the continued threat of icebergs drifting south in the Labrador Current. Once the Iceberg Limit has extended into areas "C", "D", and "E," iceberg reconnaissance flights are focused in these regions as the iceberg distribution dictates and with the frequency indicated. During the 2014 Ice Season, significant expansion occurred to the south and east, and area D was further divided into four quadrants to more clearly show coverage of the expansive limit. The IIP watch stander updated the NAIS Coverage figure daily to maintain an updated picture of the frequency of reconnaissance flights and satellite data. **Figure 26** shows a one-day snapshot of NAIS reconnaissance coverage from 16 June 2014.

Reconnaissance Challenges

The Grand Banks are a productive fishing ground frequented by fishing vessels ranging from 20 m to over 70 m in length. Even in low sea states, determining whether an ambiguous radar contact is an iceberg or a stationary vessel is particularly difficult. These contacts (small vessels and icebergs) often present similar radar returns and cannot easily be differentiated. When a radar image does not present a distinguishable feature, the IRD classifies the contact as an R/T in hopes of being able to identify it on a subsequent pass or patrol. During the 2014 Ice Season, the IIP recorded only one ambiguous R/T.

Additionally, the oil industry continues to develop and explore the Grand Banks region for its oil reserves. The escalated exploration and drilling have increased aircraft and vessel traffic in the IIP's OPAREA, further complicating target identification. Although the presence of these additional targets complicates IIP operations, these platforms also provide on-scene iceberg information reports which greatly aid IIP in the creation of an Iceberg Limit that is as accurate and reliable as possible.

It is not uncommon for deployed IRDs to conduct multiple missions during a normal deployment. These missions include standard ice reconnaissance patrols, oceanographic buoy drops from the aircraft, satellite under-flights, fisheries patrols, and occasional diverts for Search and Rescue missions. During the 2014 Ice Season, IIP personnel assisted HC-130J aircrews with two Search and Rescue cases. In May, IIP personnel assisted aircrew during a search for the Sailing Vessel TAO (**Figure 27**). Once located, the aircrew deployed life rafts, pumps, and radios. They were able to direct a Good Samaritan vessel to the distressed sailing vessel which facilitated the safe recovery of three people in the middle of the

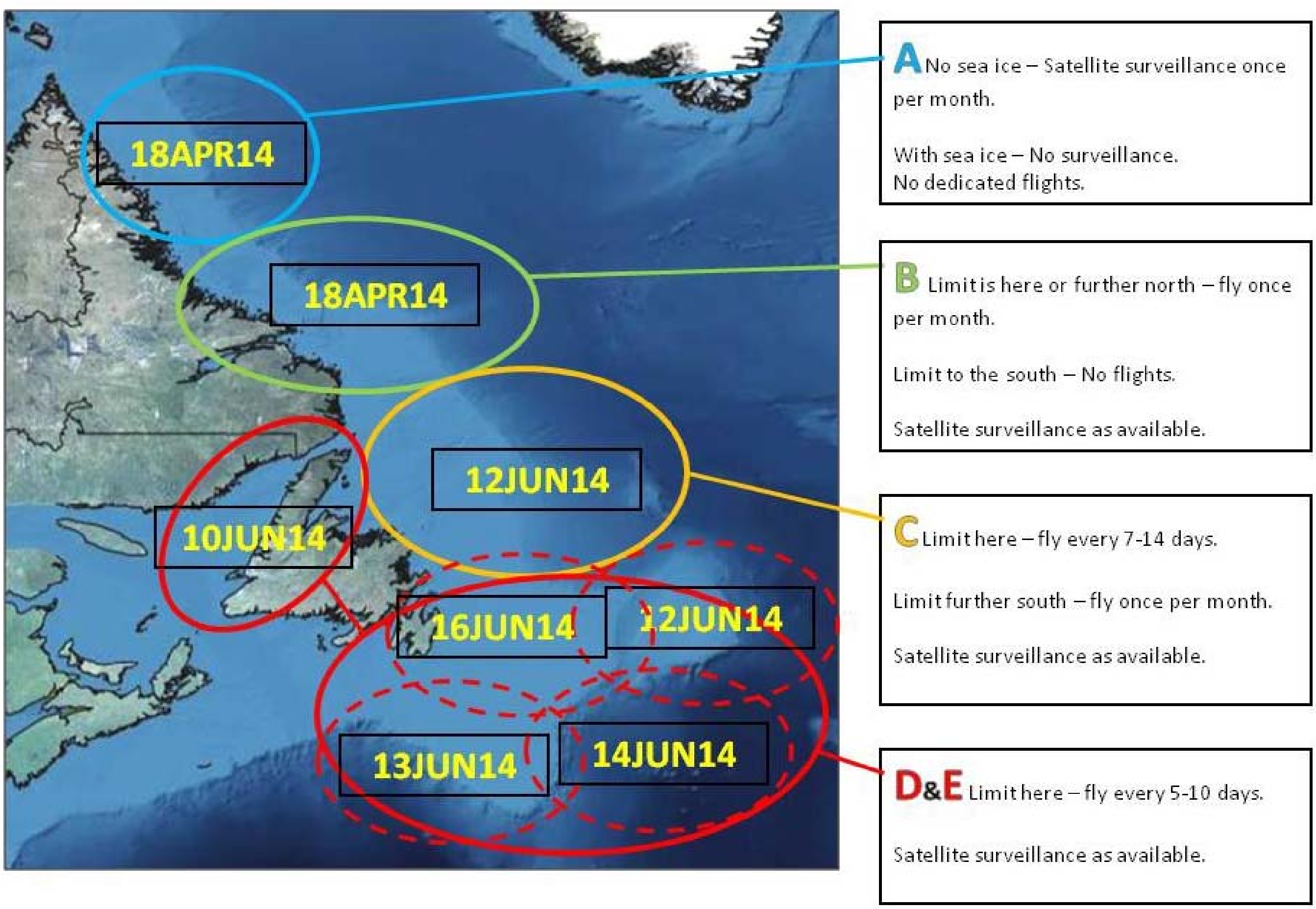


Figure 26. NAIS Coverage Status on 16 June 2014.

Atlantic Ocean. This case gained national attention in the media. On another case in June, an HC-130J was diverted to assist Canadian Forces with a rescue case within the published Iceberg Limit northeast of Newfoundland following an IIP sortie (**Figure 28**). The VLL VENTURE, a crab-fishing vessel, was taking on water after striking heavy sea ice, and the crew abandoned ship onto a nearby ice floe. The Canadian Forces Helicopter requested the USCG aircraft remain on scene until all of the crewmembers were safely recovered.

On two other occasions, the aircraft attached to IIP operations in St. John's deployed for Search and Rescue cases without IIP personnel aboard. IIP personnel remained in St. John's in the event that another HC-130J was available to complete the Ice Patrol mission. While these situations delayed iceberg reconnaissance patrols, the Search and Rescue mission will always take precedence. The primary focus of an IRD deployment is to conduct iceberg reconnaissance, but the remote operating location in St. John's occasionally puts USCG assets in an opportune position to save lives at sea.

Poor weather occasionally prevented an Ice Patrol aircraft from recovering in St. John's after a patrol. Alternate airports were used on two separate IRDs during the 2014 Ice Season. On 26 March 2014, a very powerful low pressure weather system necessitated a divert from landing in St. John's, Newfoundland to Goose Bay, Labrador. The aircraft was safely hangared, but a blizzard grounded the aircraft for 48 hours. The crew was lodged at Canadian Forces base berthing because commercial lodging for the entire crew was unavailable. A lack of reliable internet access on the airbase made it very difficult to transmit the flight results and monitor weather. Normally, the IRD e-mails the flight results from a patrol to the Operations Center in New London, CT where they are incorporated into BAPS by the watchstander. This connectivity issue could potentially cause a delay in providing accurate products to the mariner. Ultimately, the message was successfully sent using Wi-Fi accessed at a dining facility in town. Nevertheless, unreliable internet access made it difficult to monitor the weather conditions continuously. Additionally, due to limited availability, the rental vehicles in

Figure 27. Sailing Vessel TAO.

Goose Bay were not equipped with four-wheel drive, and the sedans became stuck in heavy snow drifts on several occasions.

On 27 June, the HC-130J diverted to recover in Stephenville, Newfoundland following completion of a patrol due to poor visibility at St. John's. Prior to departing St. John's that morning, the IRD team analyzed current and forecasted weather conditions. After careful evaluation, they determined the weather in St. John's would deteriorate and could potentially ground the next day's patrol, but the weather outlook at alternate Newfoundland airports, such as Stephenville, were much better. The patrol departed from St. John's knowing the weather would likely prevent recovering at St. John's that same afternoon. As planned, this divert to Stephenville provided much better weather and allowed patrol operations to continue the following day, despite poor weather at St. John's on the morning of 28 June where conditions were still below take-off minimums. The weather conditions at Stephenville and Gander airports often proved to be more favorable throughout the 2014 Ice Season. These decisions were made as far in advance as possible after weighing the cost and benefits of staying in St. John's versus operating out of an alternate airport where patrols might be conducted.

Oceanographic Operations

IIP deployed drifting buoys on and near the Grand Banks of Newfoundland in order to collect near real-time ocean current information. The data were used to modify the historical ocean currents database within BAPS and to improve the accuracy of the model-calculated drift for each iceberg. The drifting buoys also collected SST information that was incorporated into the SST analysis product developed by the U.S. Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC). BAPS used both the current data and SSTs along with other environmental data to forecast the drift and deterioration of icebergs. One of the buoys deployed this season was also equipped with a barometric pressure sensor. While this sensor functioned properly, the additional data did not prove useful enough to justify the significant increase in cost.

IIP used drifting buoys of the Surface Velocity Program (SVP) design. The buoys deployed in 2014 were drogued at 15 m and 50 m. The drifters with drogues centered at 50 m were deployed in deep waters of the

Figure 28. Fishing Vessel VLL VENTURE.

North Atlantic, most frequently in the offshore branch of the Labrador Current. This current brings icebergs southward along the edge of the continental shelf and into the shipping lanes. The drifting buoys with the drogue centered at 15 m, the standard SVP drogue depth, were used to measure the currents in the shallower waters on the Grand Banks and in the inshore branch of the Labrador Current.

IIP used reconnaissance aircraft and ships of opportunity to deploy the drifting buoys. Air deployments were conducted during reconnaissance missions using an air-drop package prepared by IIP and ECAS personnel. Ship deployments were conducted on or near the Grand Banks through a cooperative arrangement with CCG ships operating out of St. John's, NL. Air deployments were conducted offshore in regions outside of the range of the CCG ships.

In 2014, IIP deployed ten SVP drifting buoys. Three 50 m buoys were air-deployed, and seven buoys were deployed from CCG ships: three 15 m buoys and four 50 m buoys. All were successfully deployed without incident. A key component of the IIP aerial deployment package is a pyrotechnic cutter which releases the buoy from the packaging after being dropped from the aircraft. To date, these cutters are manufactured by a sole source and a shortage in supply of these releasing mechanisms forced IIP to rely heavily on CCG deployment of buoys. IIP is working with ECAS and ALC to approve and implement a revised deployment package which would use a water-activated release mechanism thus rendering the pyrotechnic cutters obsolete for aerial buoy deployments.

IIP used the ARGOS system to track buoy positions and transmit data to the IIP OPCEN. The ARGOS system is a worldwide satellite-based system used to collect doppler-based position data from special transmitters that are built into the drifting buoys. The buoys were tested, and transmission was verified through ARGOS prior to deployment. Following deployment, nine buoys functioned properly and transmitted oceanographic data until they drifted out of the IIP OPAREA. However, one buoy failed to consistently transmit usable data.

Figure 29 shows 2010-2014 air and ship SVP drifting buoy deployments.

Figure 30 depicts composite drift tracks for the SVP drifting buoys deployed in 2014. Detailed SVP drifting buoy information is provided in IIP's 2014 SVP Drifting Buoy Track Atlas, available upon request from IIP.

Commemorative Drops

Each year, IIP conducts commemorative drops in conjunction with reconnaissance operations to remember the lives lost at sea in the North Atlantic Ocean. This year, IIP delivered three flower arrangements to the CCG in St. John's for deployment by CCGS LEONARD J. COWLEY on 26 April 2014 in the North Atlantic to commemorate the 102nd anniversary of the sinking of the RMS TITANIC.

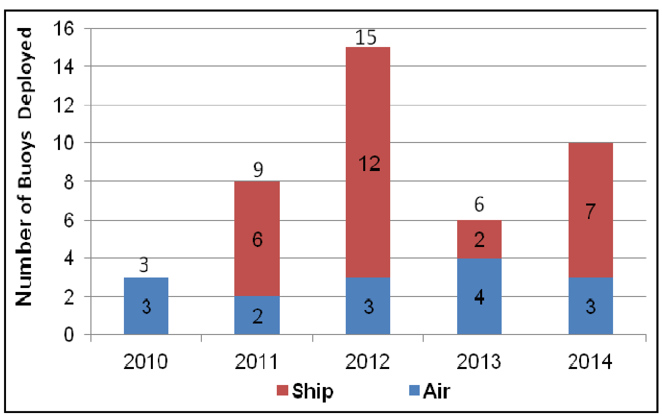


Figure 29. Deployed buoys by year.

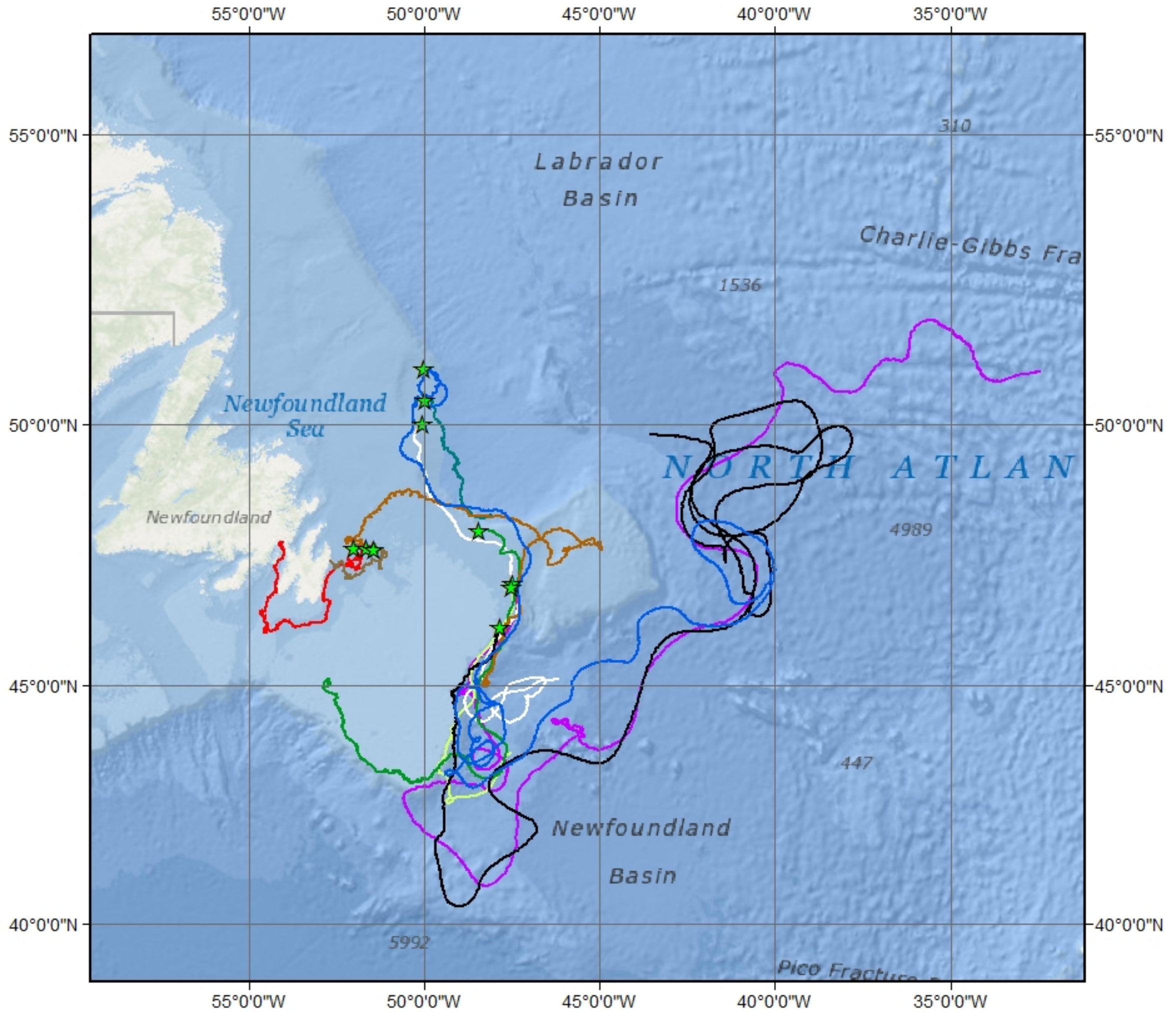


Figure 30. Composite buoy tracks.

On 06 June 2014, IIP held a memorial ceremony at the USCG Academy in New London, CT commemorating the sacrifice of those serving as part of the Greenland Patrol during World War II. The wreath dedicated at the memorial service was deployed in the North Atlantic on 18 June 2014.

Figure 31. Greenland Patrol Ceremony.

References

Canadian Ice Service. (2011). Sea Ice Climatic Atlas, East Coast 1981-2010. Retrieved from: http://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=090AF7D6-1&xml=AE4A459A-FFF4-4E38-A09E-7DF258873739

Canadian Ice Service. (2013). Seasonal Outlook, Gulf of St. Lawrence, East Newfoundland Waters and Labrador Coast, Winter 2013-2014. Issued by Canadian Ice Service of Environment Canada, 04 December 2013.

Canadian Ice Service. (2014a). Daily Ice Chart for North East Newfoundland Waters (WIS27CT) issued on 26 February 2014. Retrieved 27 February 2014 from: http://iceweb1.cis.ec.gc.ca/Prod20/page2.xhtml?CanID=11091&lang=en

Canadian Ice Service. (2014b). Seasonal Summary for Eastern Canada – Winter 2013-2014, Retrieved 07 August 2014 from: http://www.ec.gc.ca/glaces-ice/default.asp?Lang=En&n=F8C1F6D3-1

Canadian Ice Service. (2014c). Departure from Normal Concentration Chart. Retrieved 17 March 2014 from: http://iceweb1.cis.ec.gc.ca/Prod20/page2.xhtml?CanID=11091&lang=en

Canadian Ice Service. (2014d). Single Season: Weekly Ice Coverage for the season 2013/2014. Retrieved 08 October 2014 from: http://iceweb1.cis.ec.gc.ca/Prod20/page2.xhtml?CanID=11091&lang=en

Hurrell, J.W., Y. Kushnir, G. Ottersen, and M. Visbeck. (2003). The North Atlantic Oscillation: Climate Significance and Environmental Impact, Geophysical Monograph Series, 134, 279.

Hurrell, James. (1995). NAO Index Data provided by the Climate Analysis Section, NCAR, Boulder, USA, Hurrell. Updated regularly. Retrieved 29 October 2014 from: https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-station-based

IIP. (2012). Report of the International Ice Patrol in the North Atlantic (2011 Season), Bulletin No. 97, Appendix D.

Johns Hopkins University. (2014). Applied Physics Laboratory Ocean Remote Sensing Group, Water Surface Temperature, Land and Clouds from Channel 2 NOAA-15 AVHRR 23 February and 08 April 2014. Retrieved from: http://fermi.jhuapl.edu/avhrr/SW/

Marko, J.R., D. Fissel, P. Wadhams, P. Kelly, and R. Brown. (1994). Iceberg Severity off Eastern North America: Its Relationship to Sea Ice Variability and Climate Change. *J. Climate*, **7**, 1335–1351.

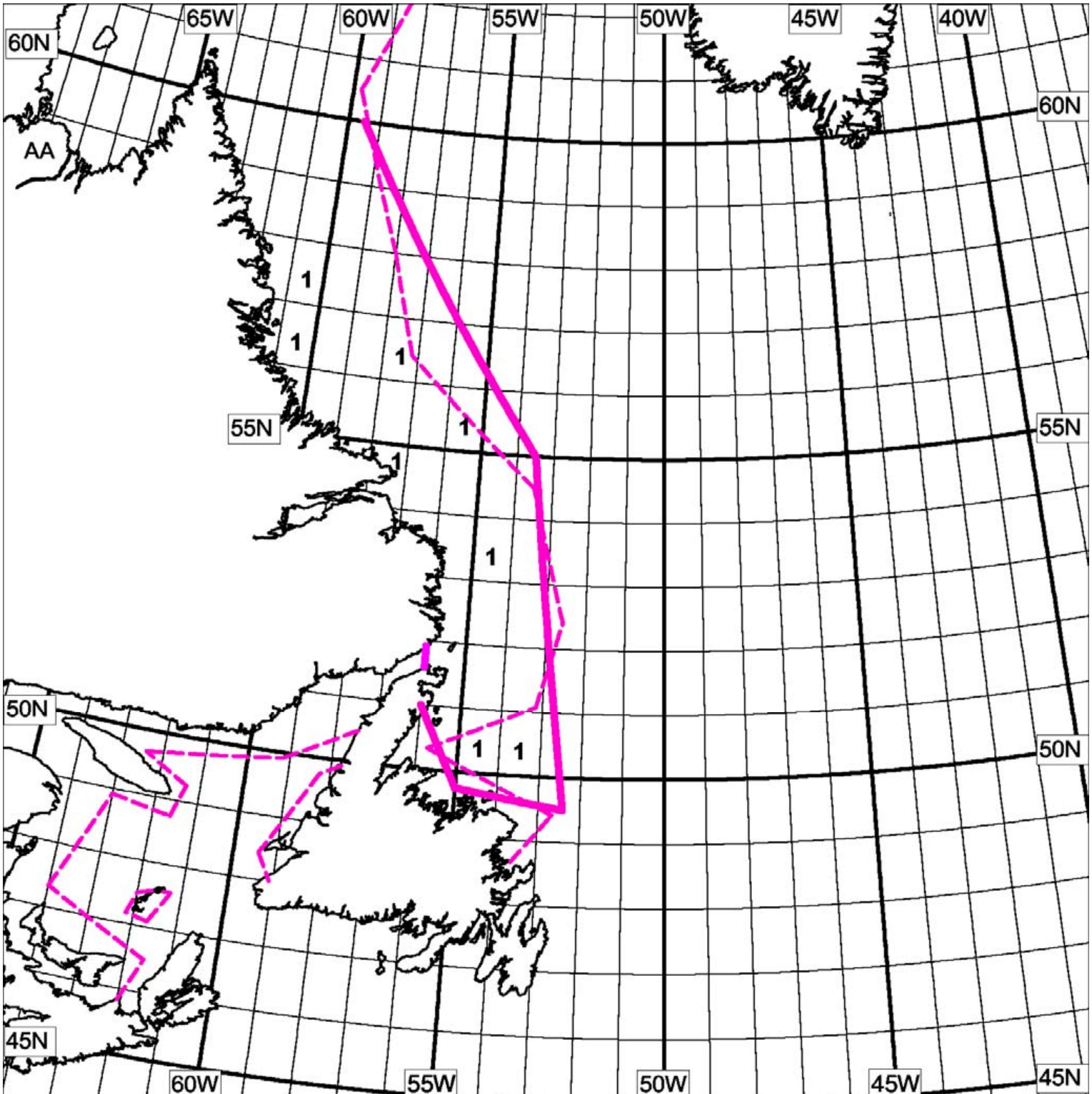
National Oceanic and Atmospheric Administration/Earth Systems Research Laboratory. (NOAA/ESRL) (2014). Physical Science Division. Sea Level Pressure, Monthly Mean Composite. Interactive Plotting and Analysis Pages. Retrieved 13 October 2014 from: http://www.esrl.noaa.gov/psd/cgi-bin/data/getpage.pl

National Oceanic and Atmospheric Administration/National Weather Service. (NOAA/NWS) (2014a). National Centers for Environmental Prediction, Climate Prediction Center. Retrieved 18 August 2014 from: http://www.cpc.ncep.noaa.gov/products/global_monitoring/temperature/ecanada_1yrtemp.shtml

National Oceanic and Atmospheric Administration/National Weather Service. (NOAA/NWS) (2014b). NOAA Climate Prediction Center, Daily NAO Index. Retrieved 18 April 2014 from: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao_index.html

Provincial Aerospace Limited (PAL). (2014). Ice and Environmental Services, Web-Based – Met / Ocean Reporting System. Retrieved 26 August 2014 from: http://idns.provair.com/Default.asp.

Semi-Monthly Iceberg Charts



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

01 JAN / JAN 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

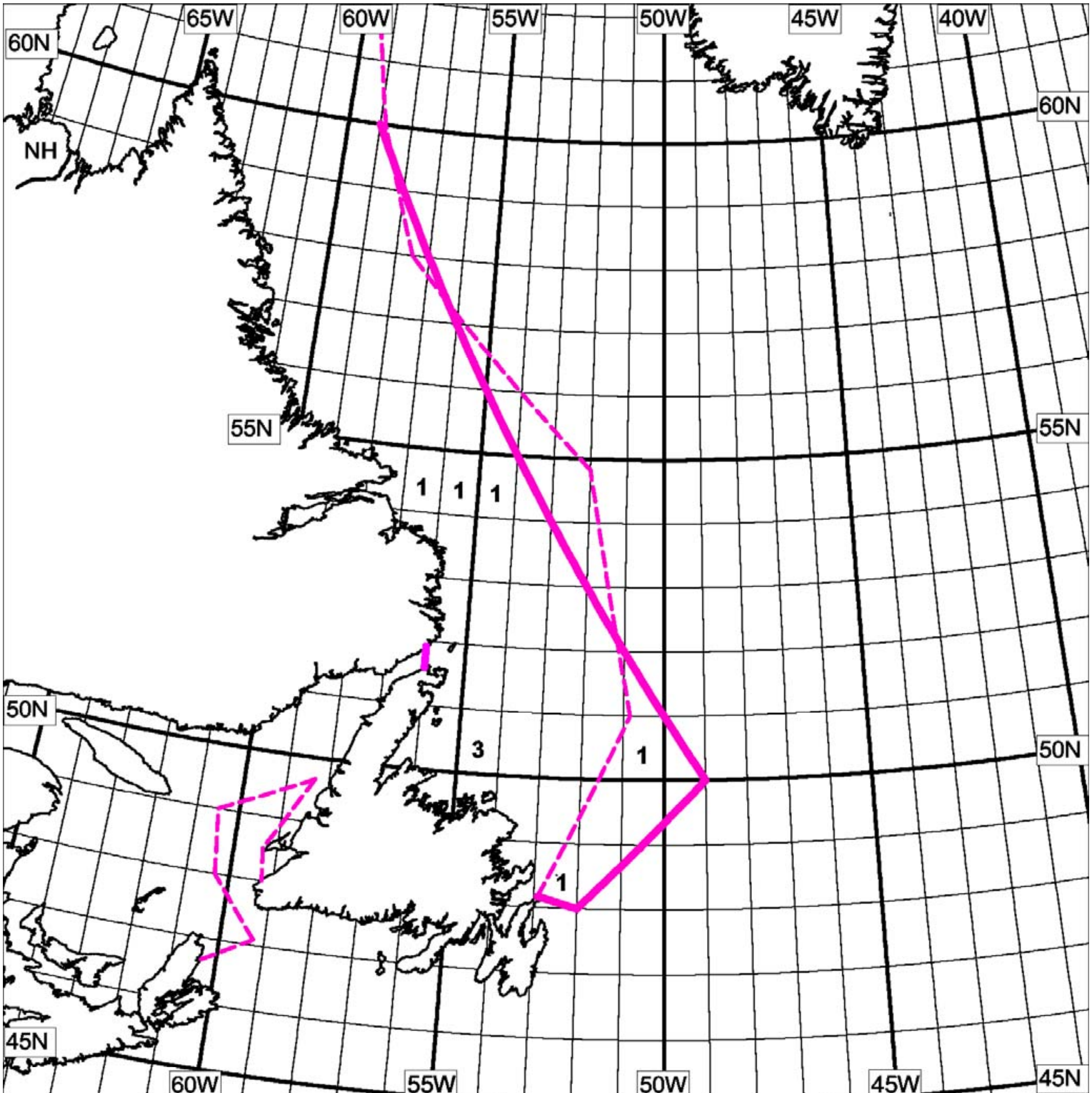
SEA ICE LIMIT / LIMITE DES GLACES

ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca



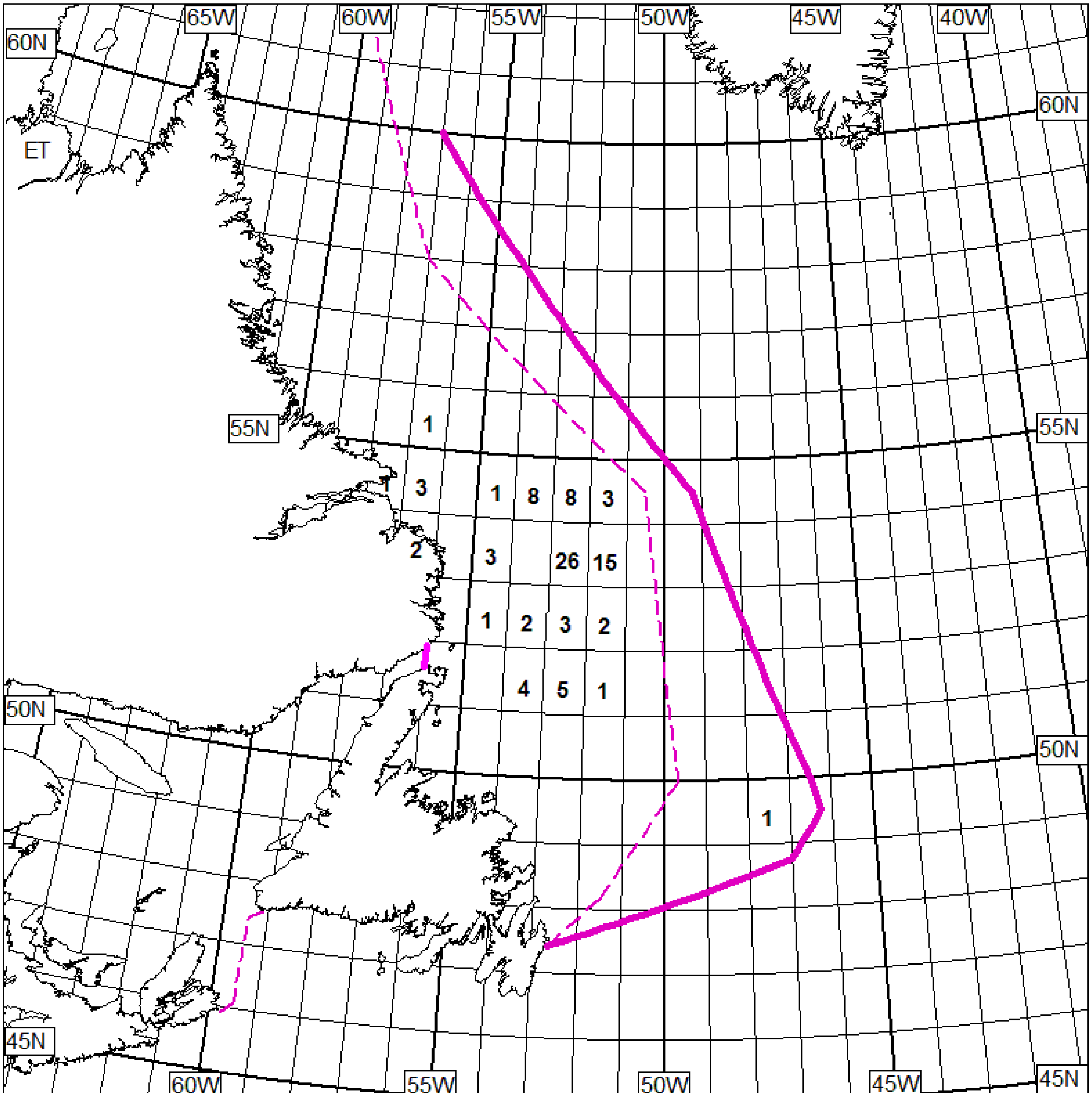
NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC
15 JAN / JAN 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS
SEA ICE LIMIT / LIMITE DES GLACES
ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

01 FEB / FEV 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

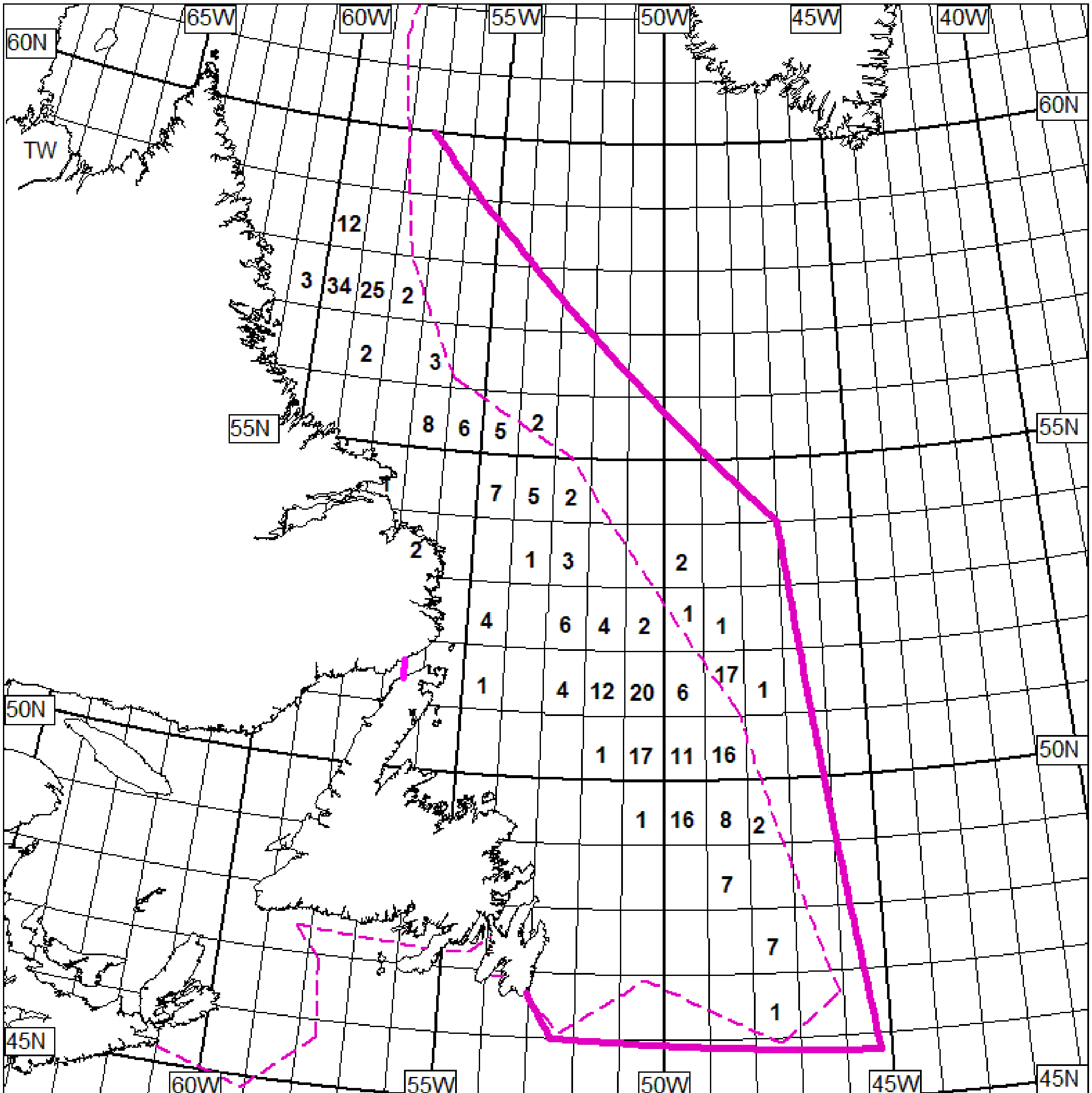
SEA ICE LIMIT / LIMITE DES GLACES

ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA
LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.uscg-iip.org
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

15 FEB / FEV 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

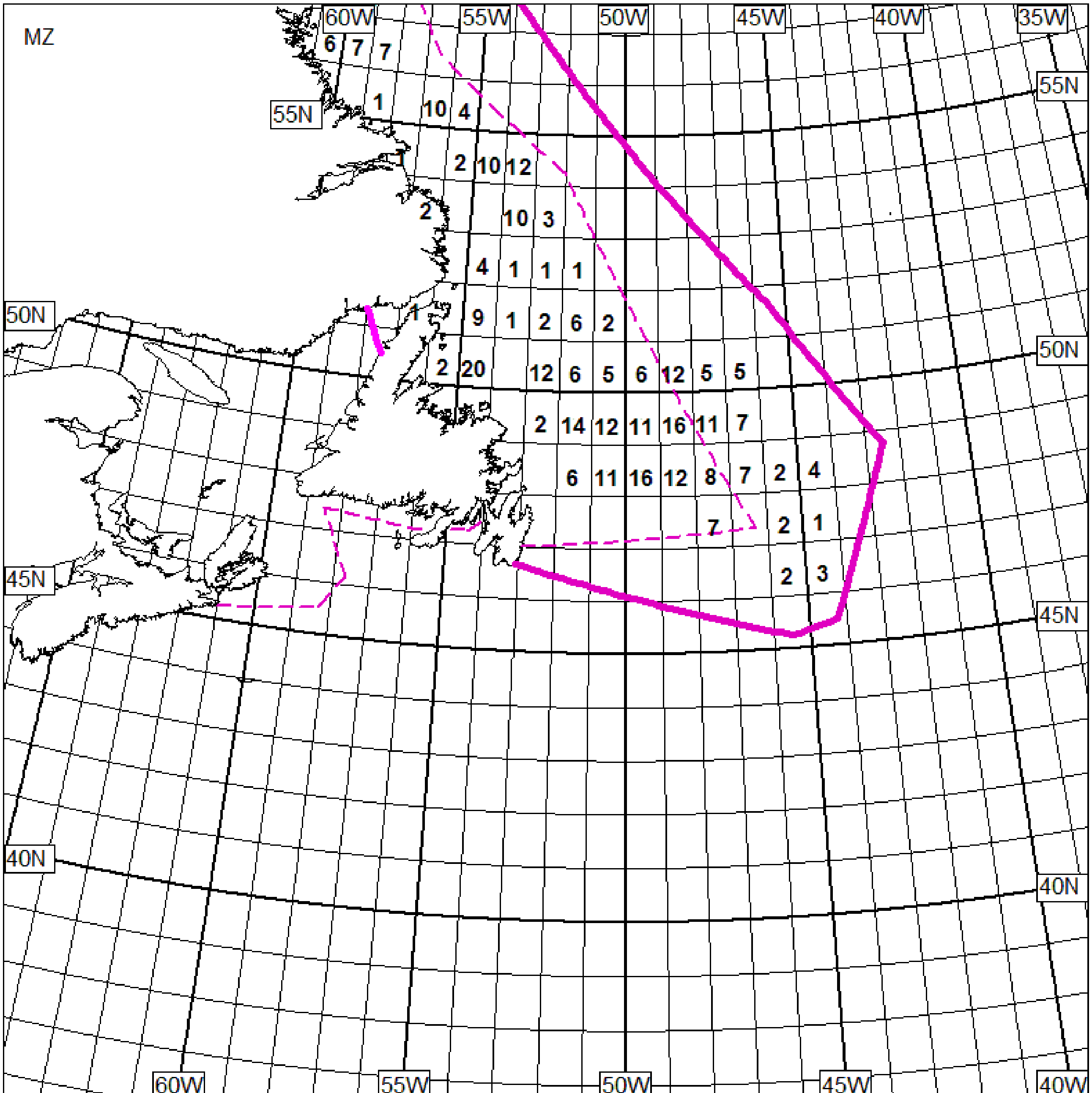
SEA ICE LIMIT / LIMITE DES GLACES

\# ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

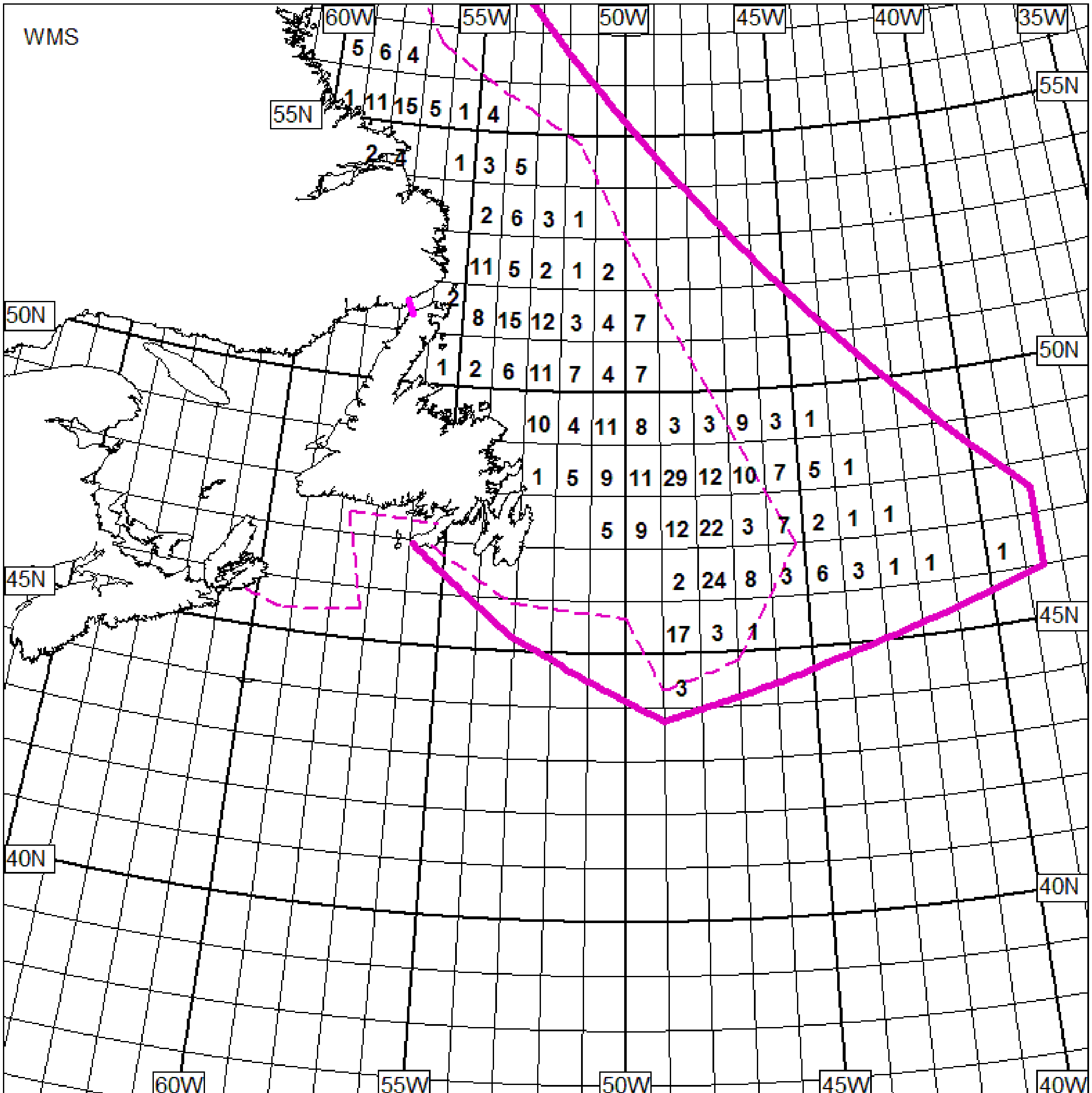
⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.uscg-iip.org
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE **SERVICE DES GLACES** **DE L'AMERIQUE DU NORD**	ICEBERG ANALYSIS / ANALYSE D'ICEBERGS FOR / POUR 0000 UTC **01 MAR / MAR 2014**
ICEBERG LIMIT / LIMITE DES ICEBERGS SEA ICE LIMIT / LIMITE DES GLACES # ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS	NOTE / NOTER: For more information: Pour plus de renseignement: www.uscg-iip.org www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

15 MAR / MAR 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

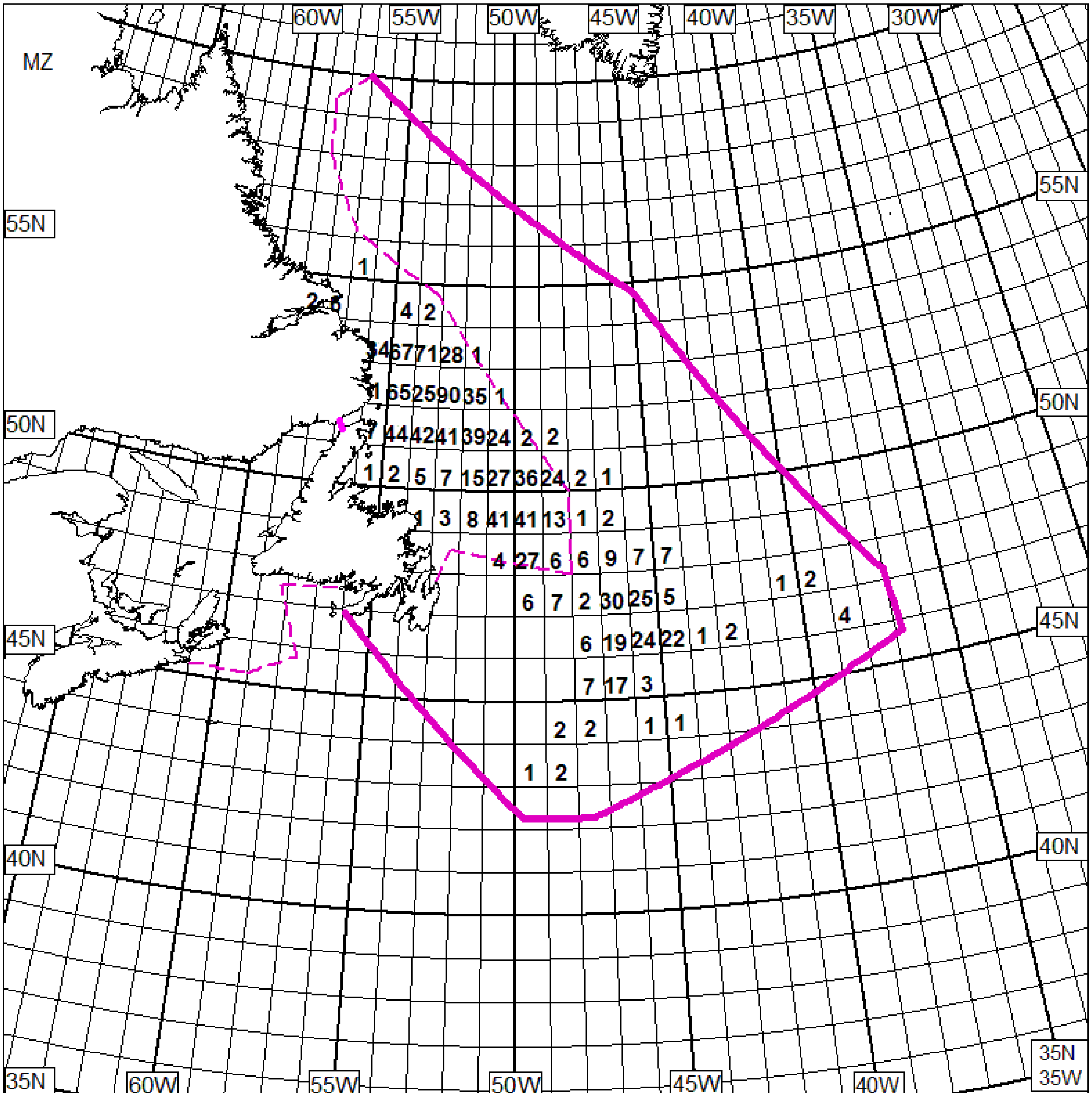
SEA ICE LIMIT / LIMITE DES GLACES

\# ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.uscg-iip.org
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

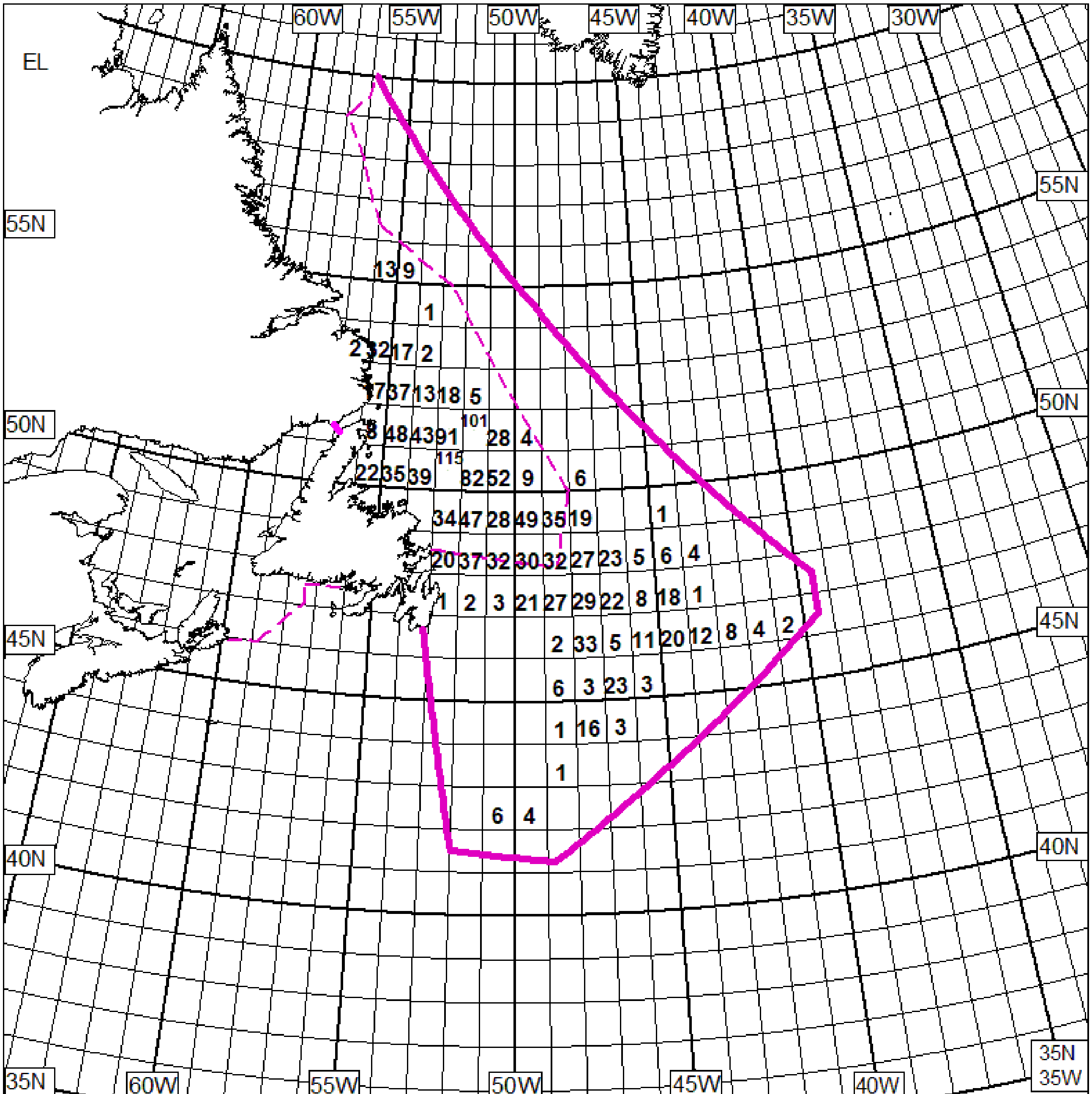
ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

01 APR / AVR 2014

(solid line)	ICEBERG LIMIT / LIMITE DES ICEBERGS
(dashed line)	SEA ICE LIMIT / LIMITE DES GLACES
#	ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE
⊗	RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.uscg-iip.org
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

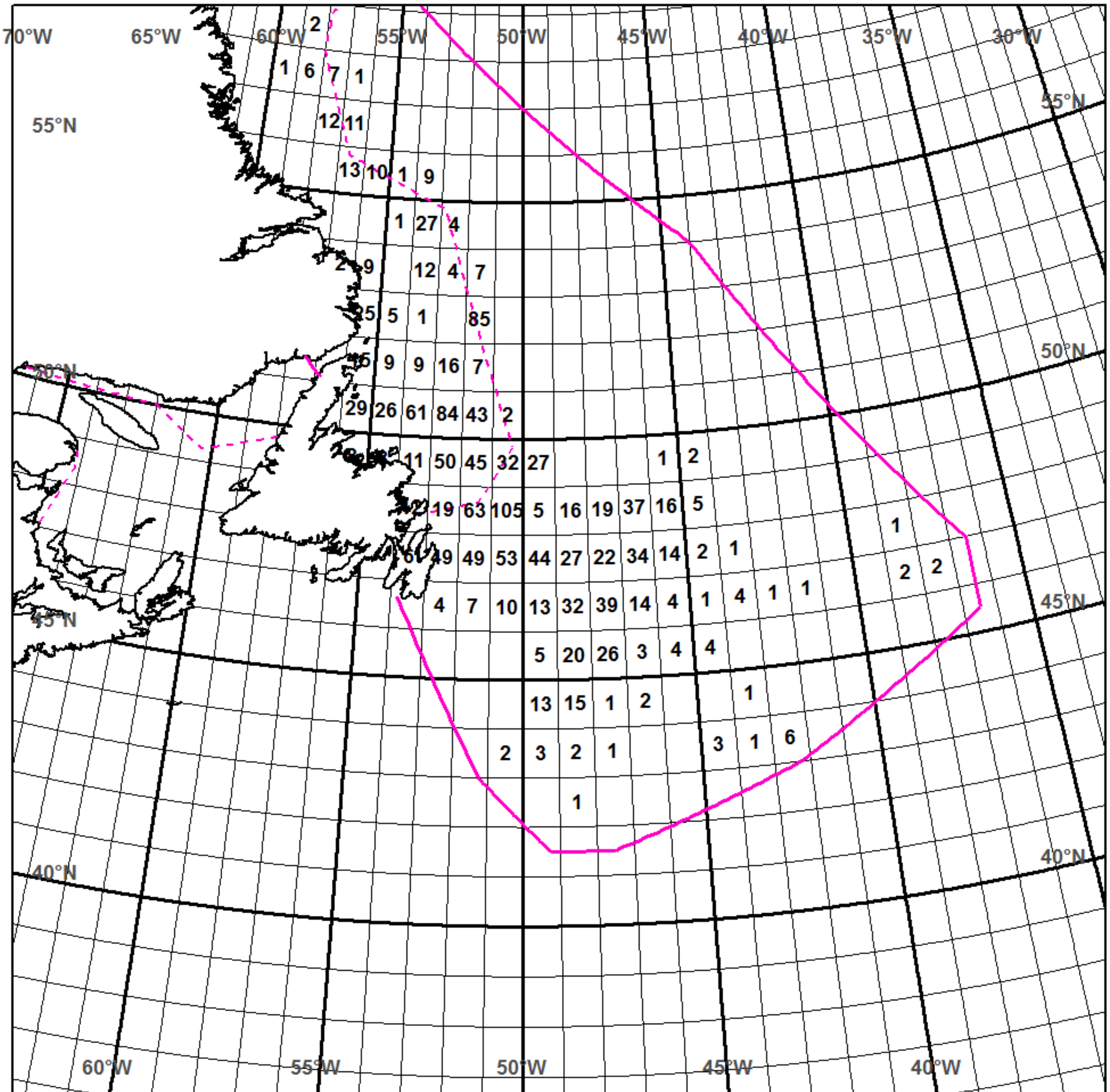
ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

15 APR / AVR 2014

━━━	ICEBERG LIMIT / LIMITE DES ICEBERGS
- - - -	SEA ICE LIMIT / LIMITE DES GLACES
#	ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE
⊗	RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.navcen.uscg.org
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

1 MAY / MAI 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

SEA ICE LIMIT / LIMITE DES GLACES

ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA
LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
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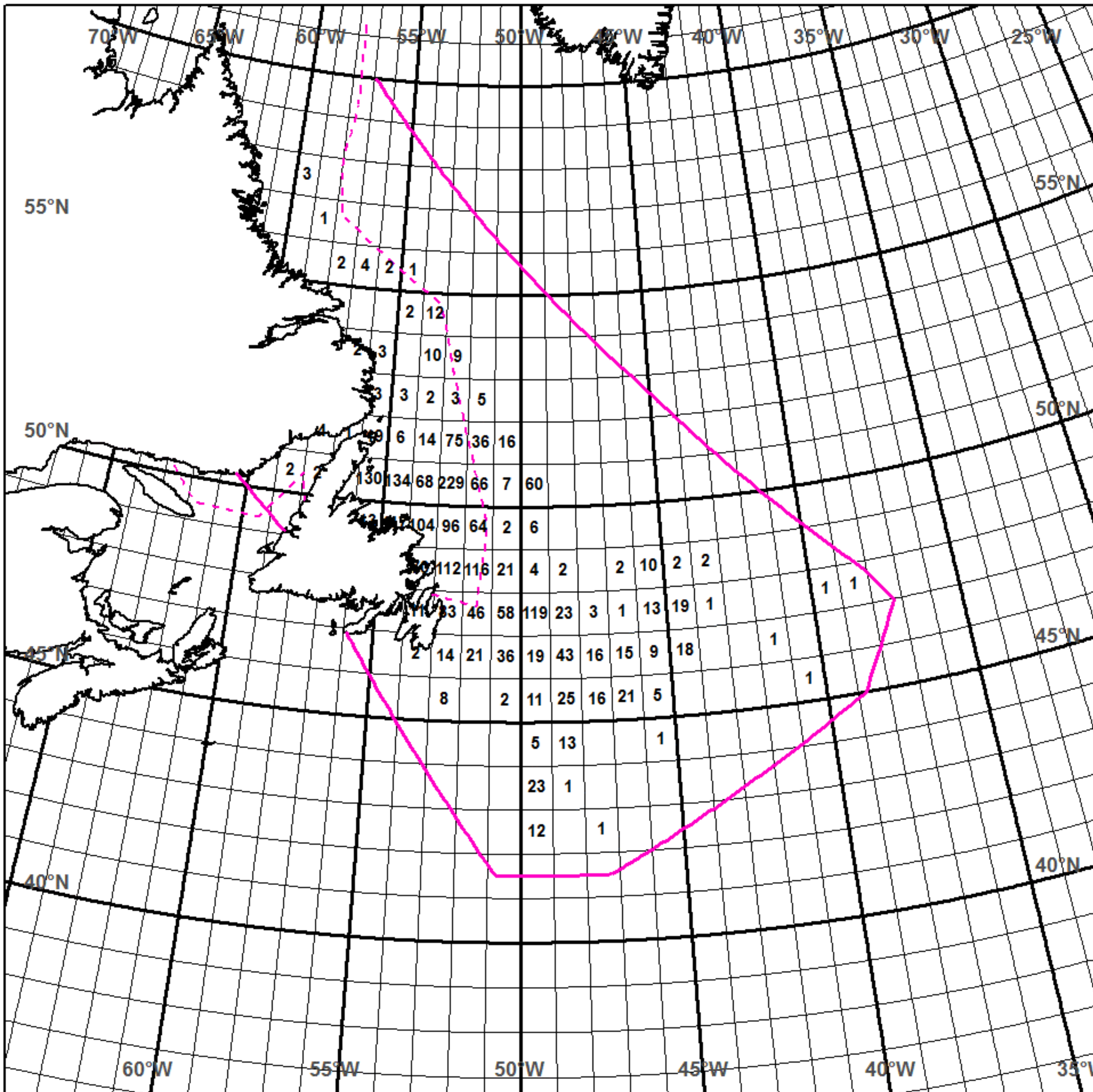
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

15 MAY / MAI 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

SEA ICE LIMIT / LIMITE DES GLACES

ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA
LIMITE DES ICEBERGS

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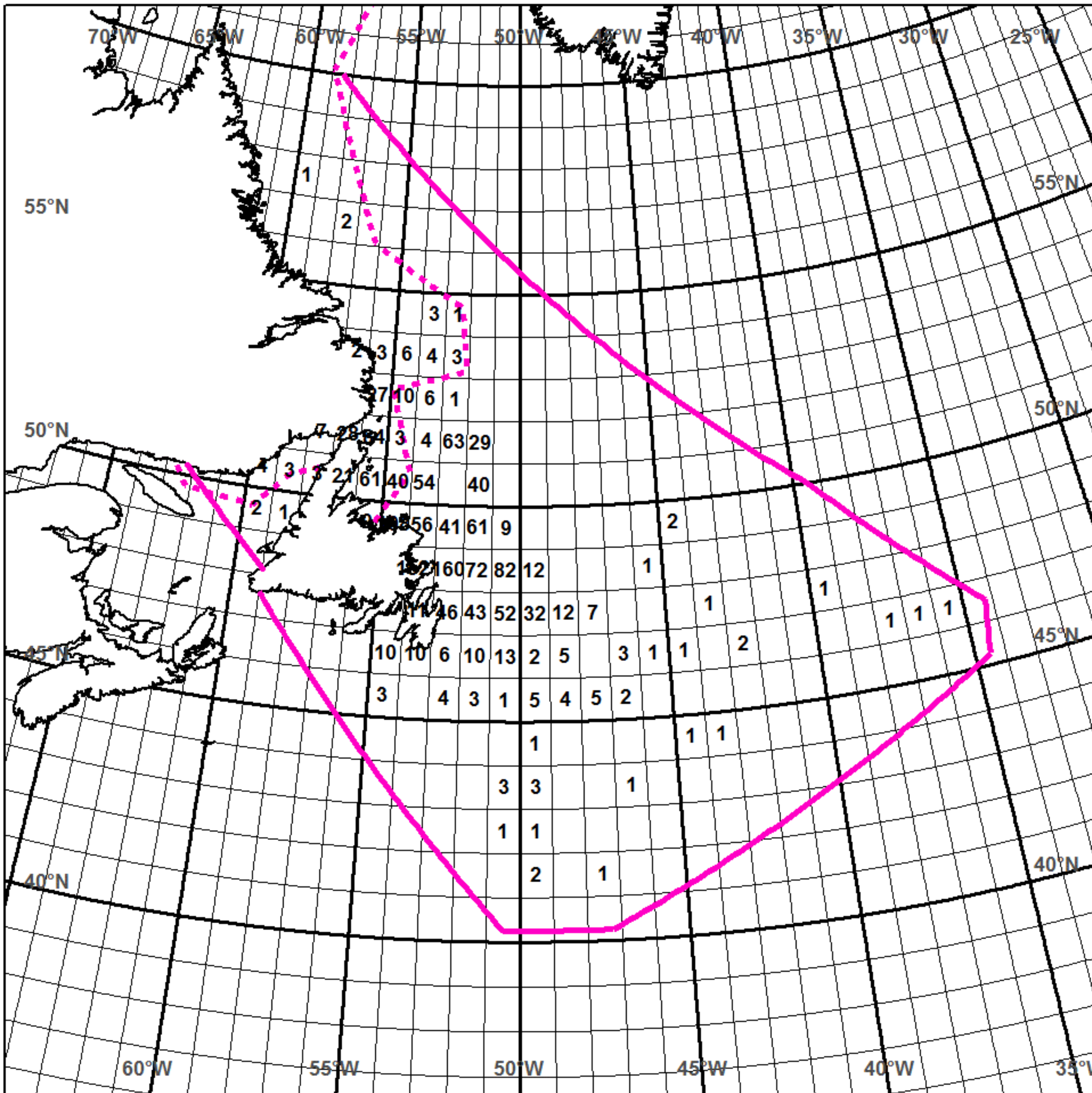


NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

01 JUN / JUN 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

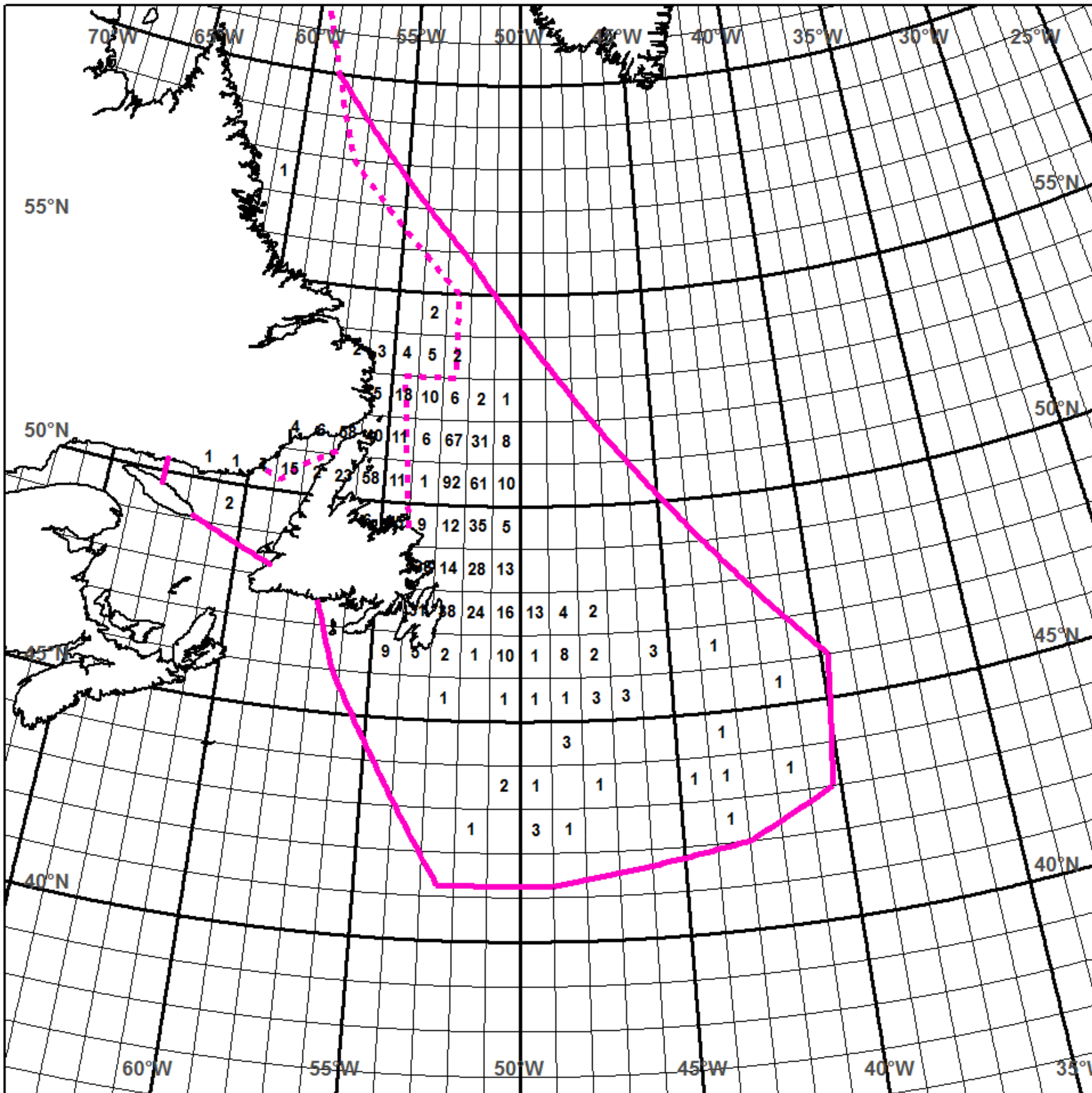
SEA ICE LIMIT / LIMITE DES GLACES

ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

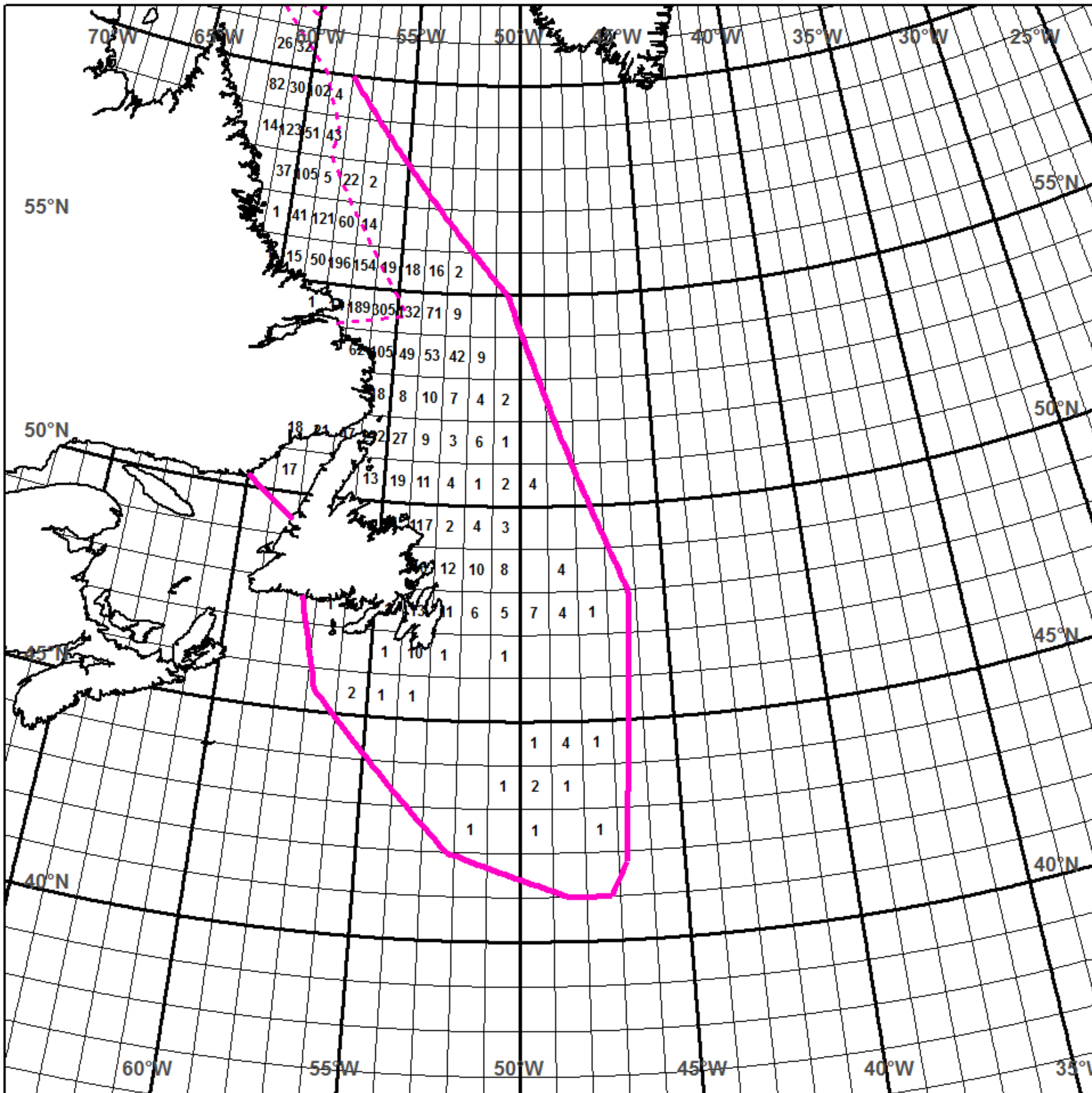
⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

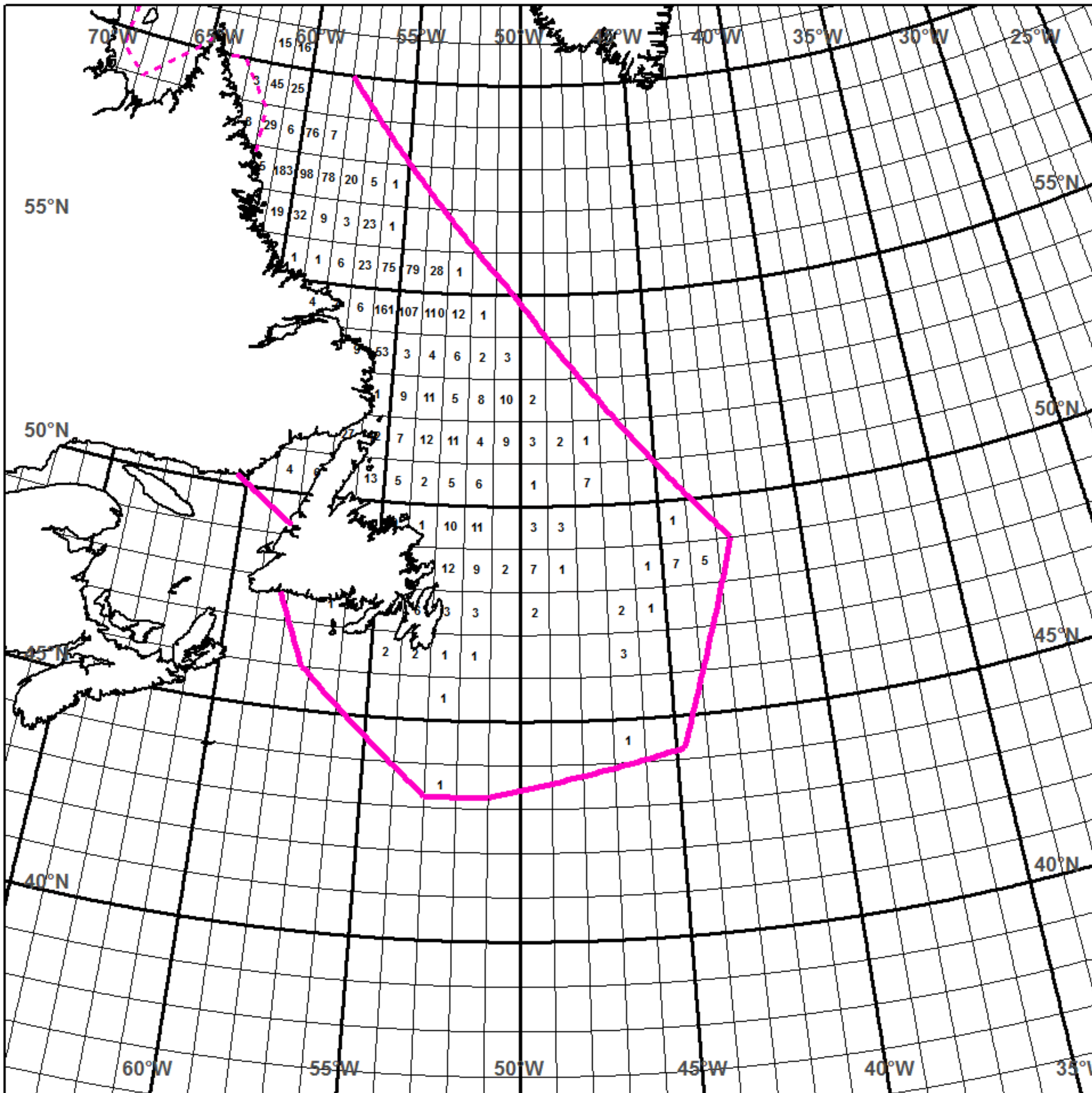
For more information:
Pour plus de renseignement:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca



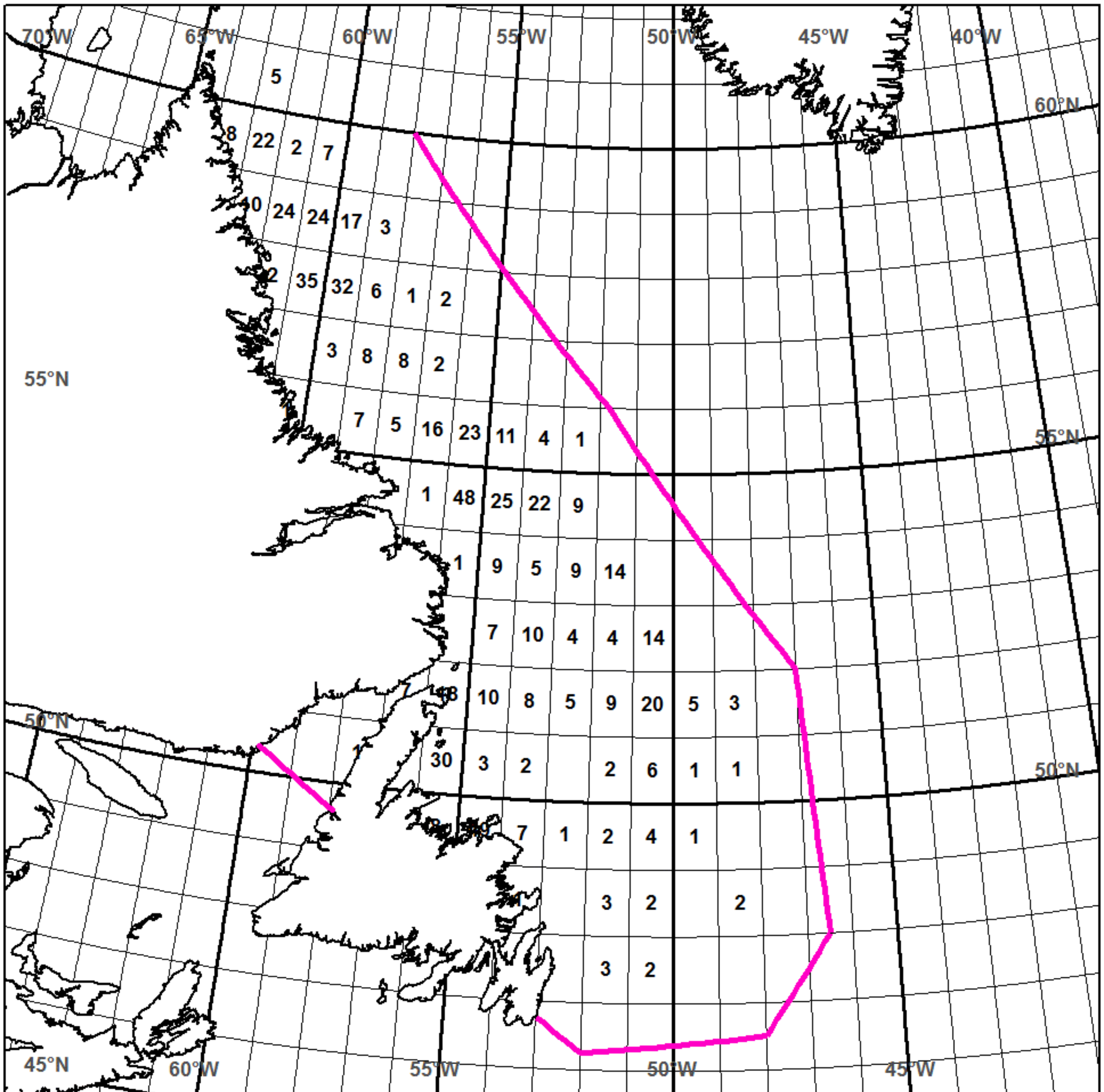
NORTH AMERICAN ICE SERVICE SERVICE DES GLACES DE L'AMERIQUE DU NORD	ICEBERG ANALYSIS / ANALYSE D'ICEBERGS FOR / POUR 0000 UTC **15 JUN / JUN 2014**
ICEBERG LIMIT / LIMITE DES ICEBERGS SEA ICE LIMIT / LIMITE DES GLACES # ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS	**NOTE / NOTER:** **For more information:** **Pour plus de renseignement:** **www.navcen.uscg.gov/iip** **www.ice-glaces.ec.gc.ca**



NORTH AMERICAN ICE SERVICE SERVICE DES GLACES DE L'AMERIQUE DU NORD	ICEBERG ANALYSIS / ANALYSE D'ICEBERGS FOR / POUR 0000 UTC **01 JUL / JUI 2014**
ICEBERG LIMIT / LIMITE DES ICEBERGS SEA ICE LIMIT / LIMITE DES GLACES # ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS	**NOTE / NOTER:** **For more information:** **Pour plus de renseignement:** **www.navcen.uscg.gov/iip** **www.ice-glaces.ec.gc.ca**



NORTH AMERICAN ICE SERVICE **SERVICE DES GLACES** **DE L'AMERIQUE DU NORD**	ICEBERG ANALYSIS / ANALYSE D'ICEBERGS FOR / POUR 0000 UTC **15 JUL / JUI 2014**
ICEBERG LIMIT / LIMITE DES ICEBERGS SEA ICE LIMIT / LIMITE DES GLACES # ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS	**NOTE / NOTER:** **For more information:** **Pour plus de renseignement:** **www.navcen.uscg.gov/iip** **www.ice-glaces.ec.gc.ca**



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

01 AUG / AOU 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

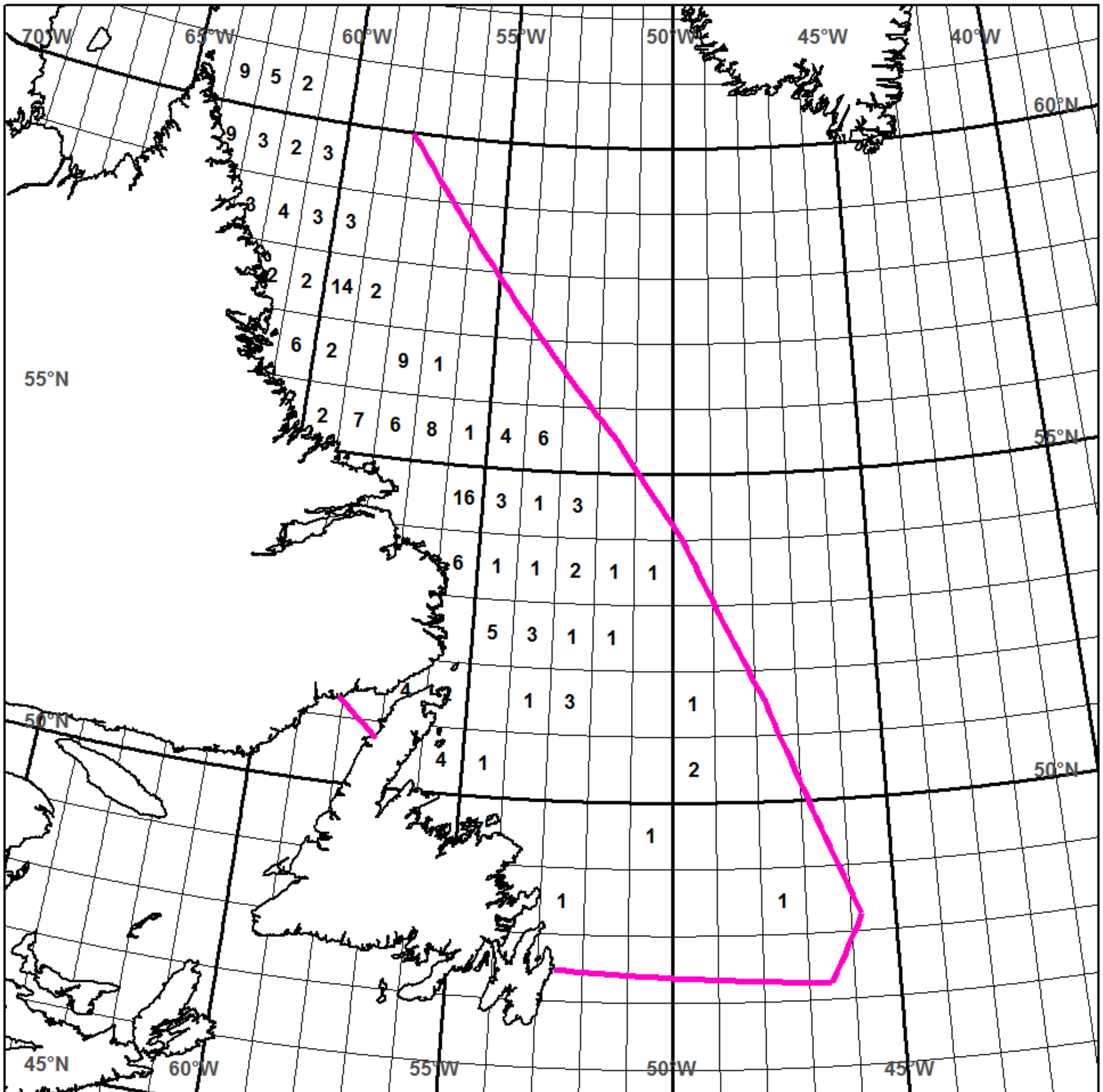
SEA ICE LIMIT / LIMITE DES GLACES

\# ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA
LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE SERVICE DES GLACES DE L'AMERIQUE DU NORD	ICEBERG ANALYSIS / ANALYSE D'ICEBERGS FOR / POUR 0000 UTC **15 AUG / AOU 2014**

ICEBERG LIMIT / LIMITE DES ICEBERGS

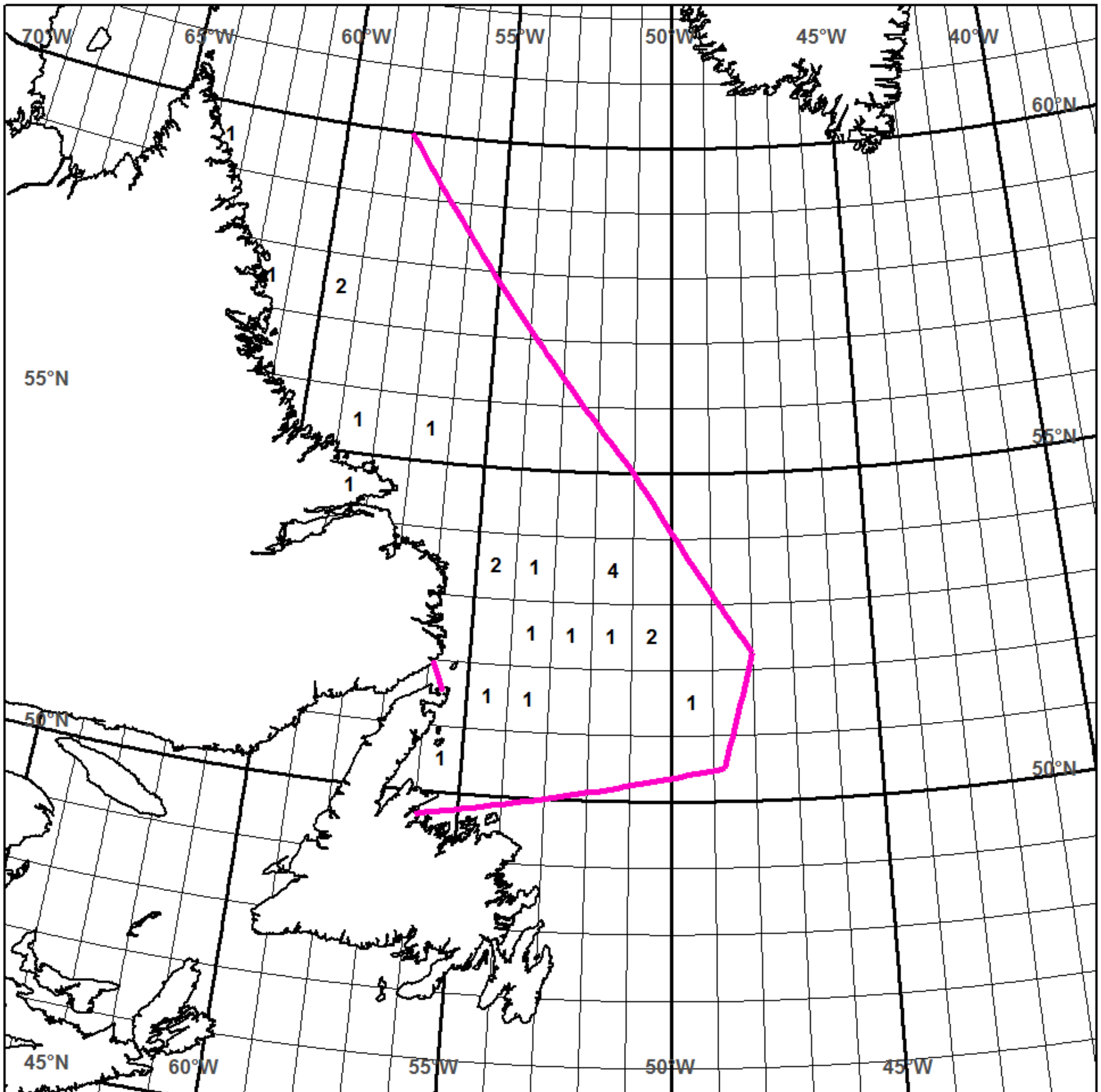
SEA ICE LIMIT / LIMITE DES GLACES

— ICEBERGS PER DEGREE SQUARE / ICEBERGS PAR DEGRE CARRE

⊗ — RADAR TARGET OUTSIDE ICEBERG LIMIT / CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca



NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES
DE L'AMERIQUE DU NORD

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR / POUR 0000 UTC

01 SEP / SEP 2014

ICEBERG LIMIT / LIMITE DES ICEBERGS

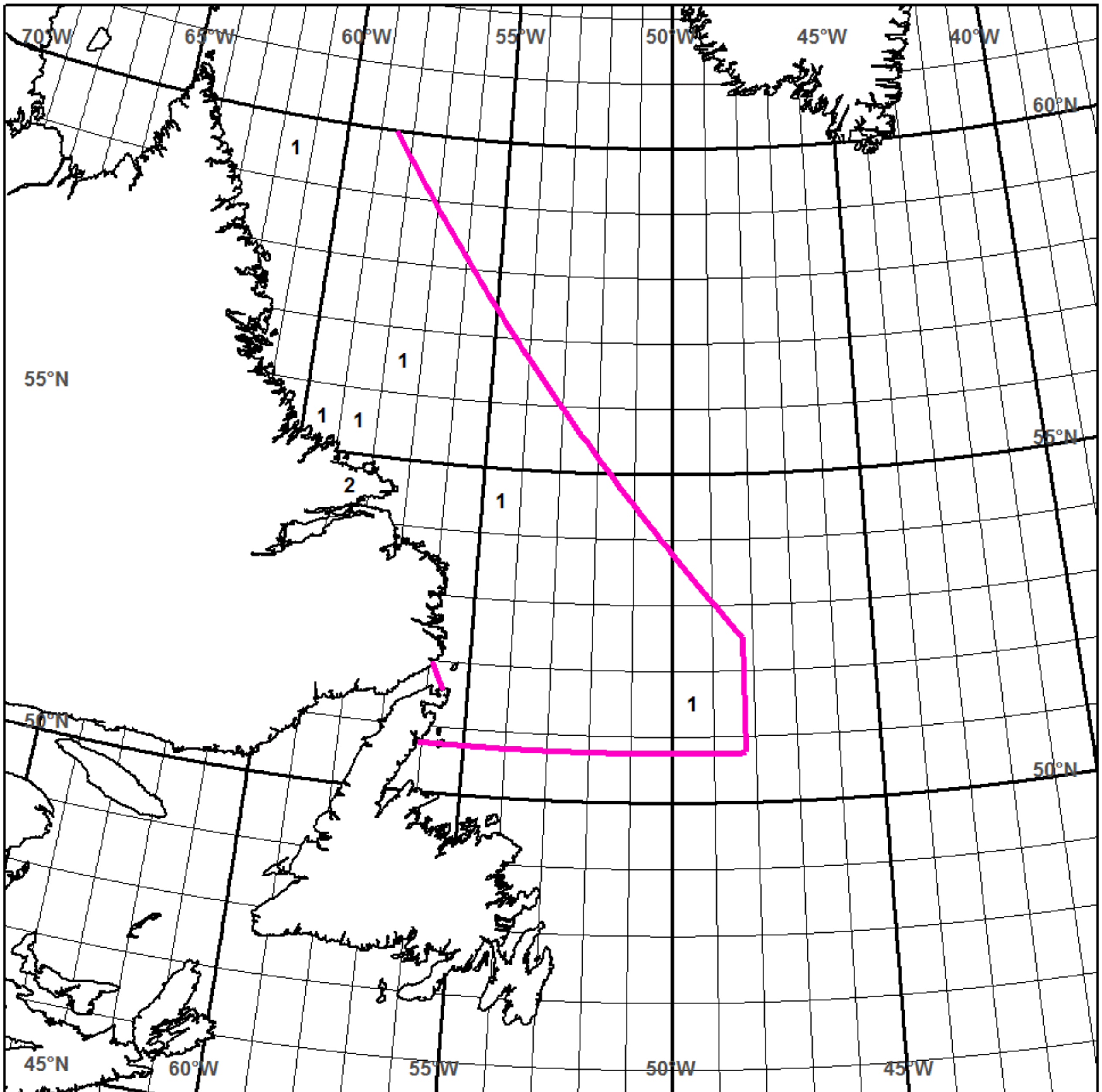
SEA ICE LIMIT / LIMITE DES GLACES

\# ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGREE CARRE

⨂ RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA
LIMITE DES ICEBERGS

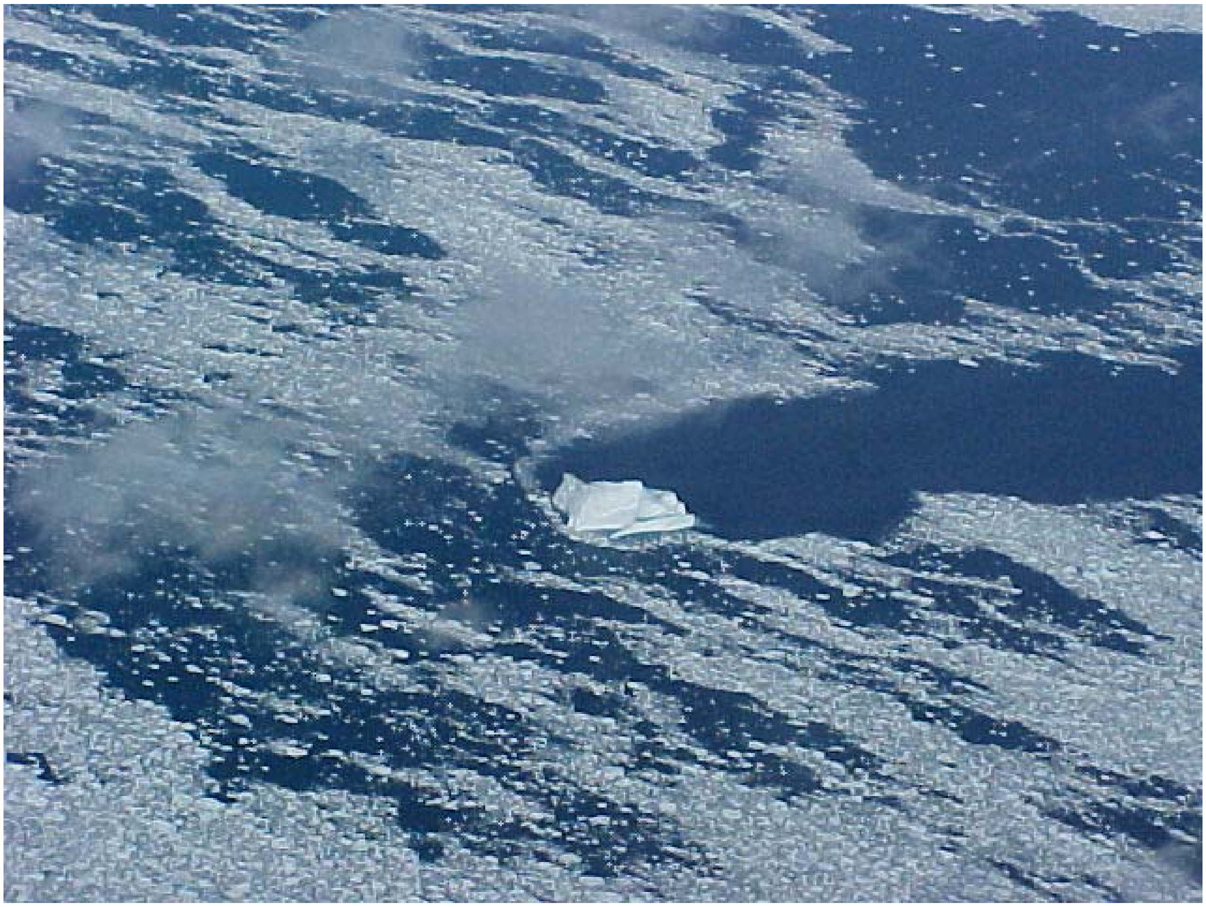
NOTE / NOTER:

For more information:
Pour plus de renseignement:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca



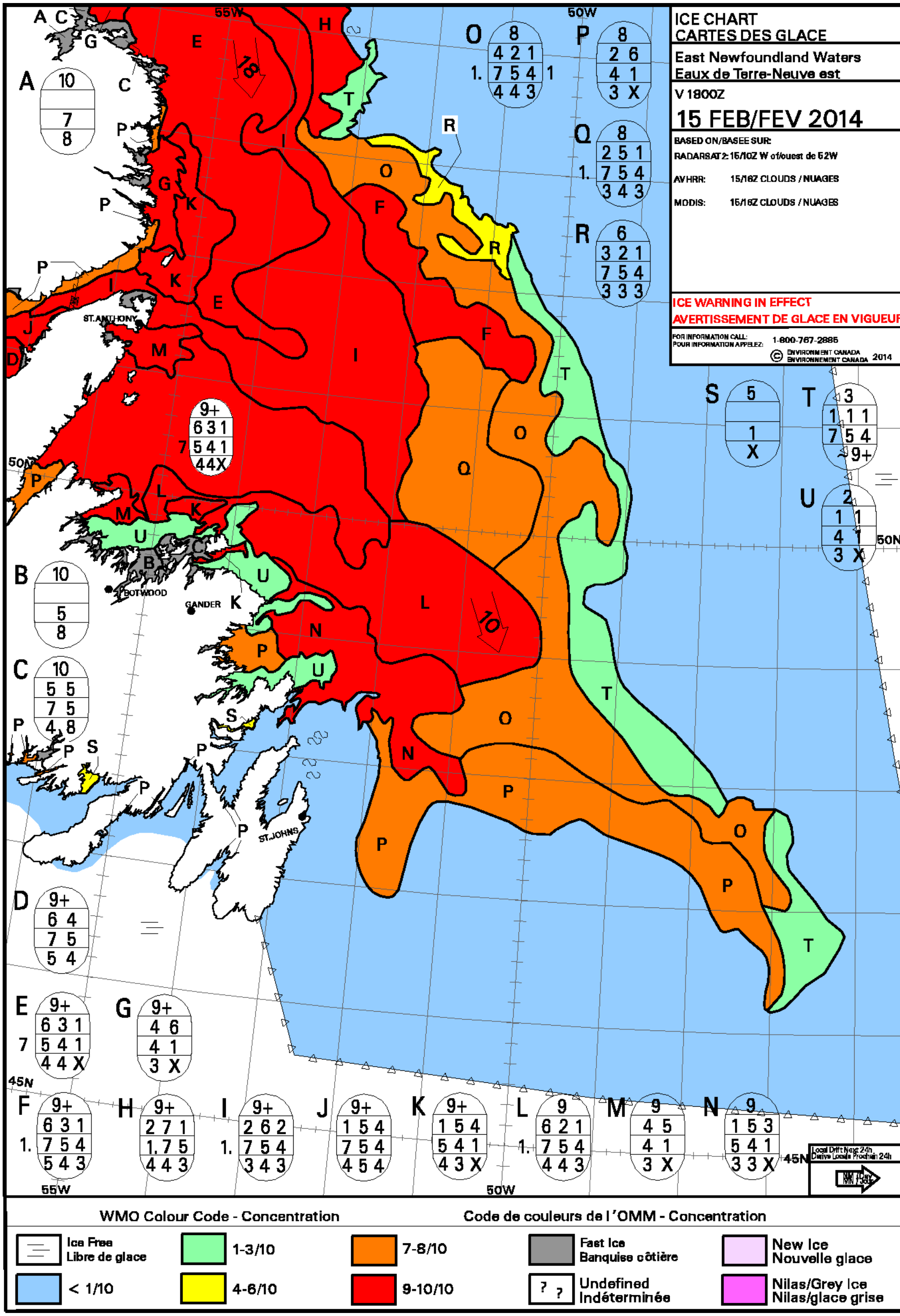
NORTH AMERICAN ICE SERVICE SERVICE DES GLACES DE L'AMERIQUE DU NORD	ICEBERG ANALYSIS / ANALYSE D'ICEBERGS FOR / POUR 0000 UTC **15 SEP / SEP 2014**
ICEBERG LIMIT / LIMITE DES ICEBERGS SEA ICE LIMIT / LIMITE DES GLACES # ICEBERGS PER DEGREE SQUARE ICEBERGS PAR DEGRE CARRE ⨂ RADAR TARGET OUTSIDE ICEBERG LIMIT CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS	**NOTE / NOTER:** **For more information:** **Pour plus de renseignement:** **www.navcen.uscg.gov/iip** **www.ice-glaces.ec.gc.ca**

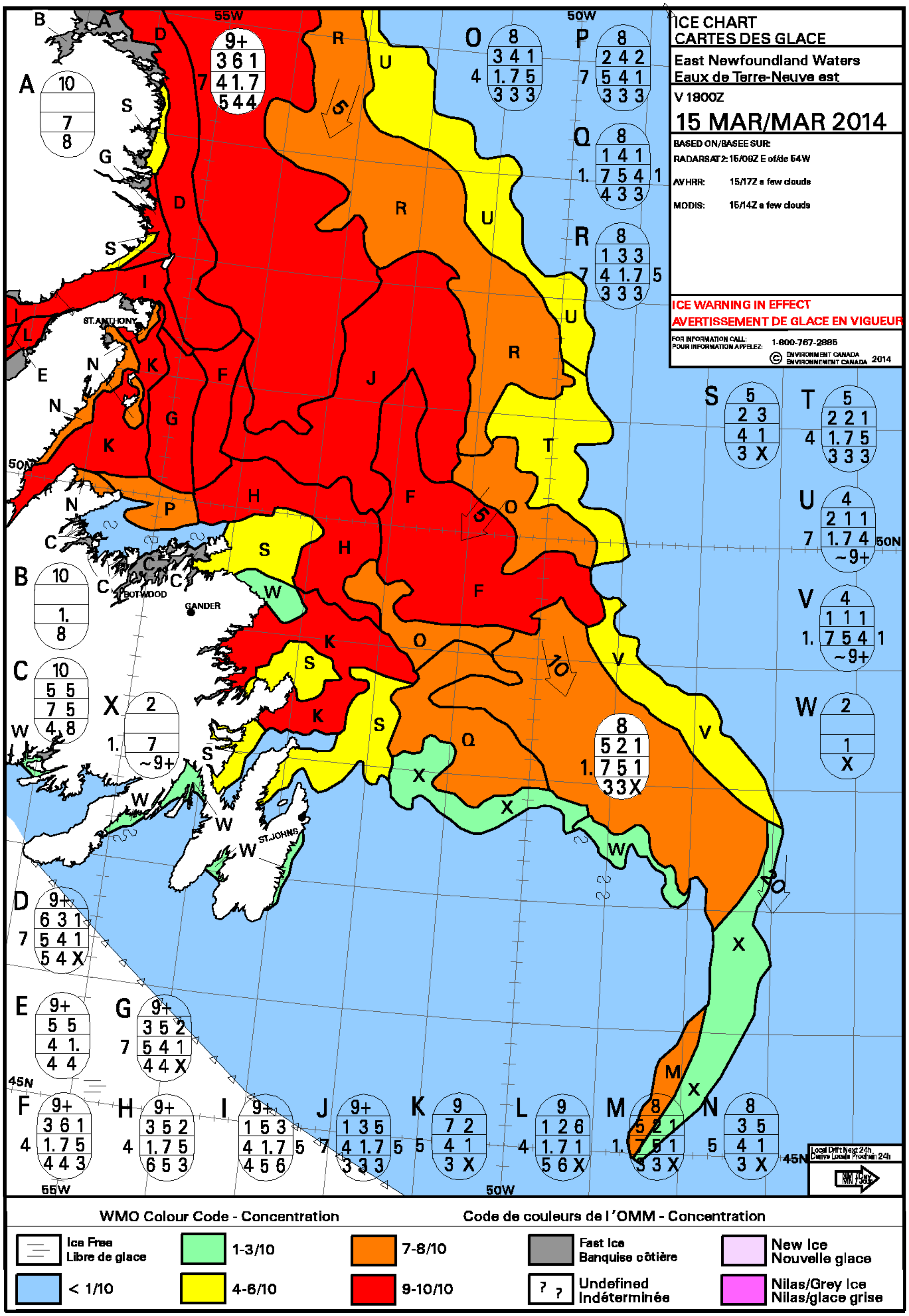
Monthly Sea-Ice Charts

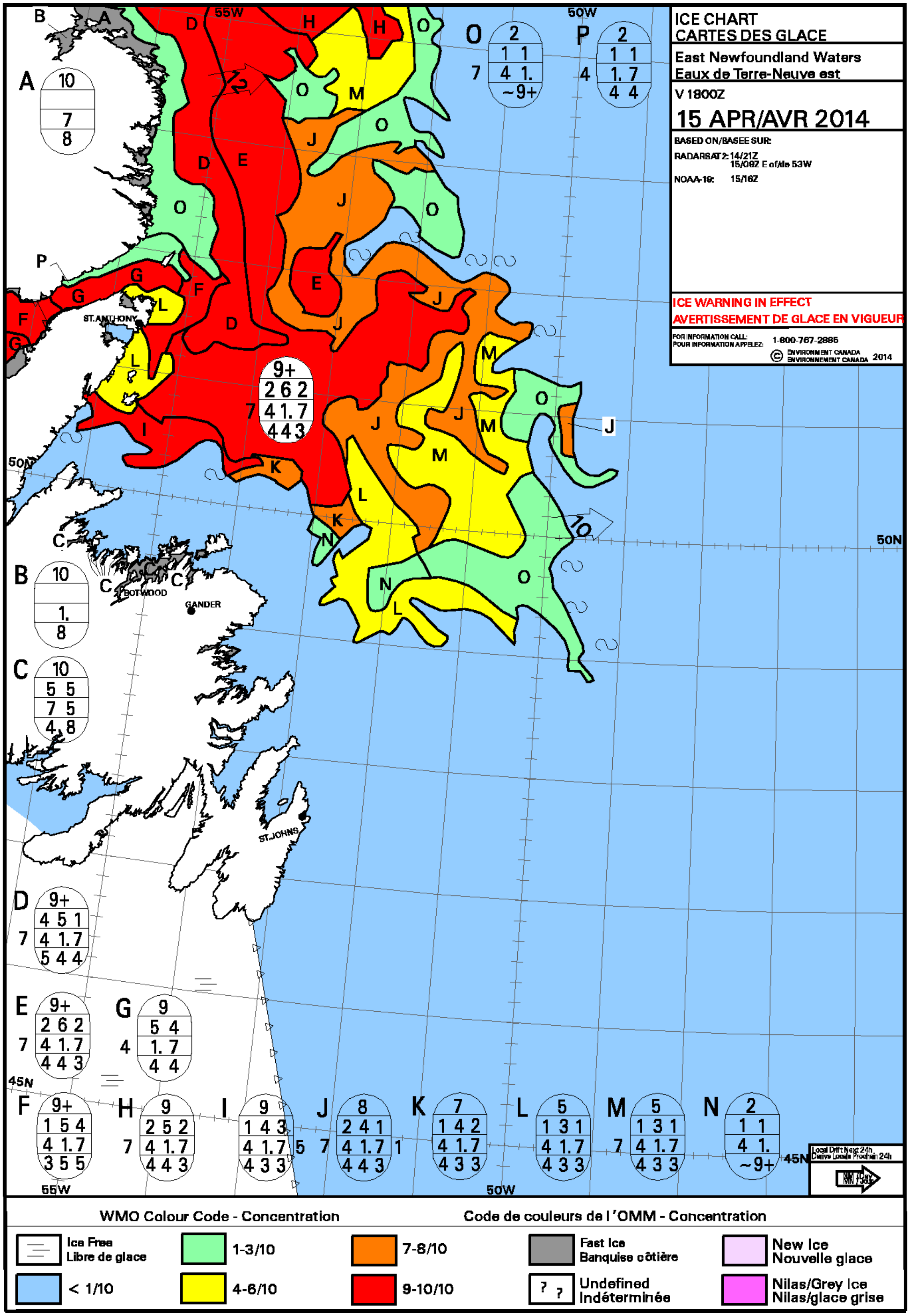


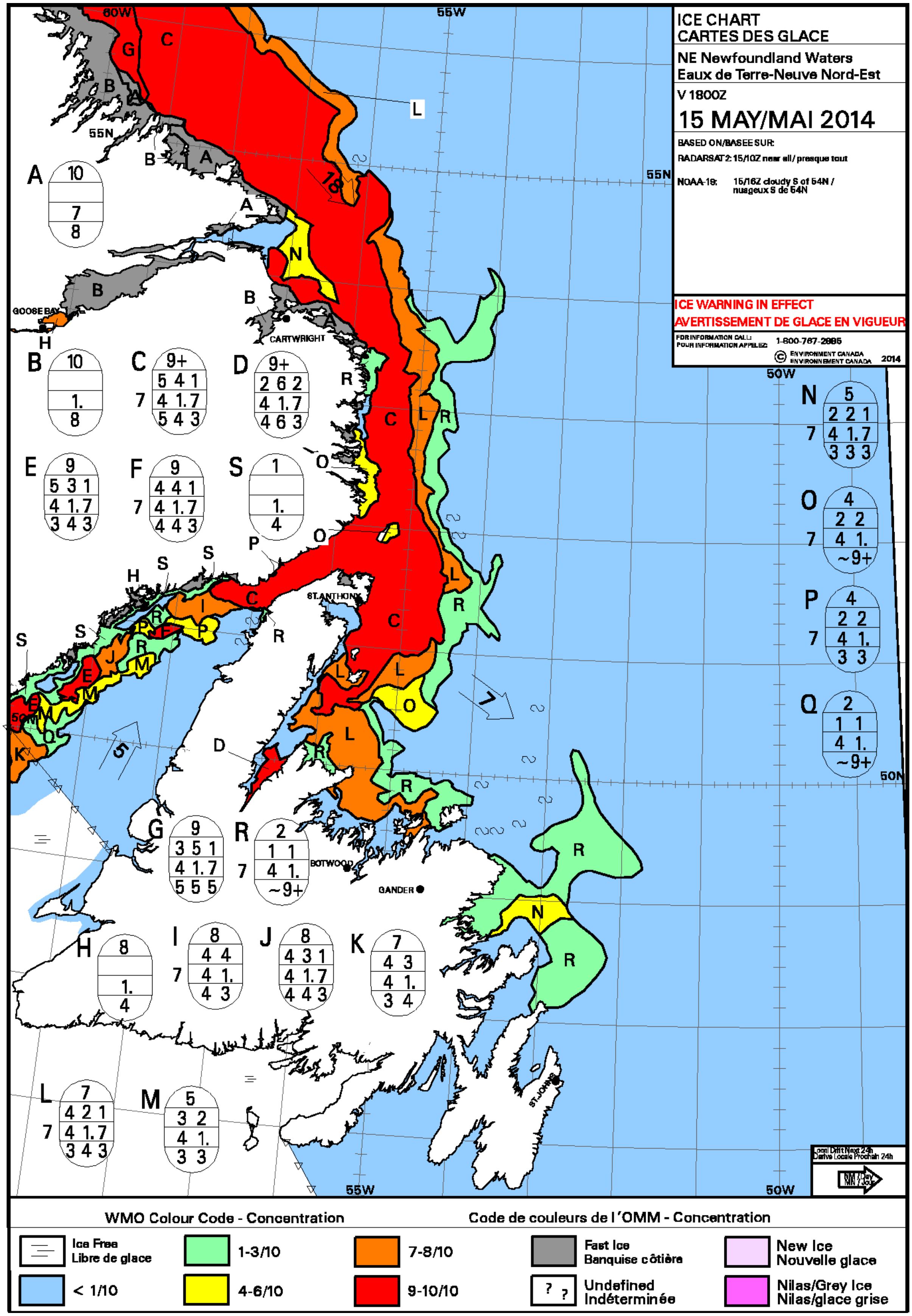
Sea-ice charts are reprinted with permission of the Canadian Ice Service.

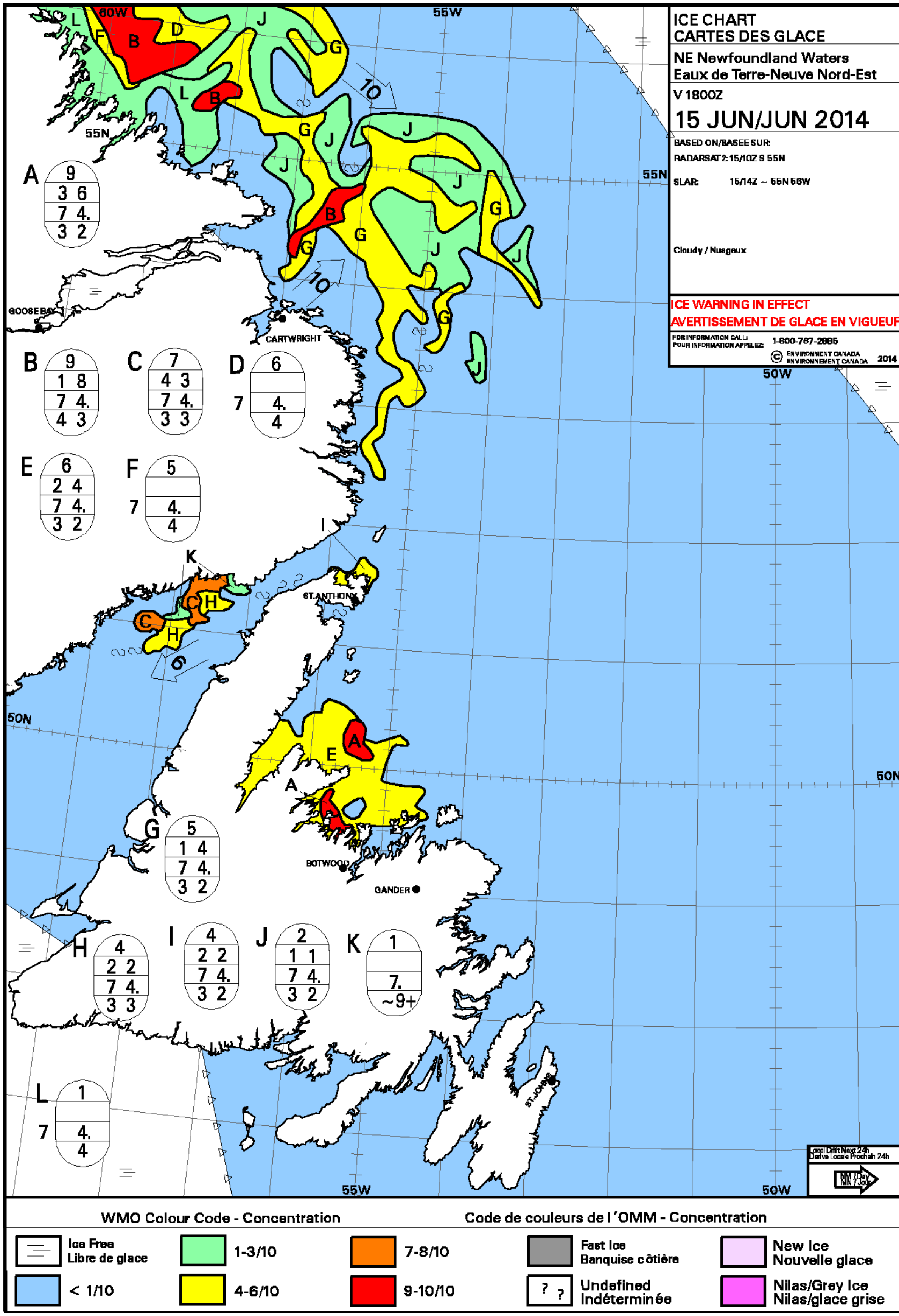
Sea ice symbols are in accordance with the World Meteorological Organization.

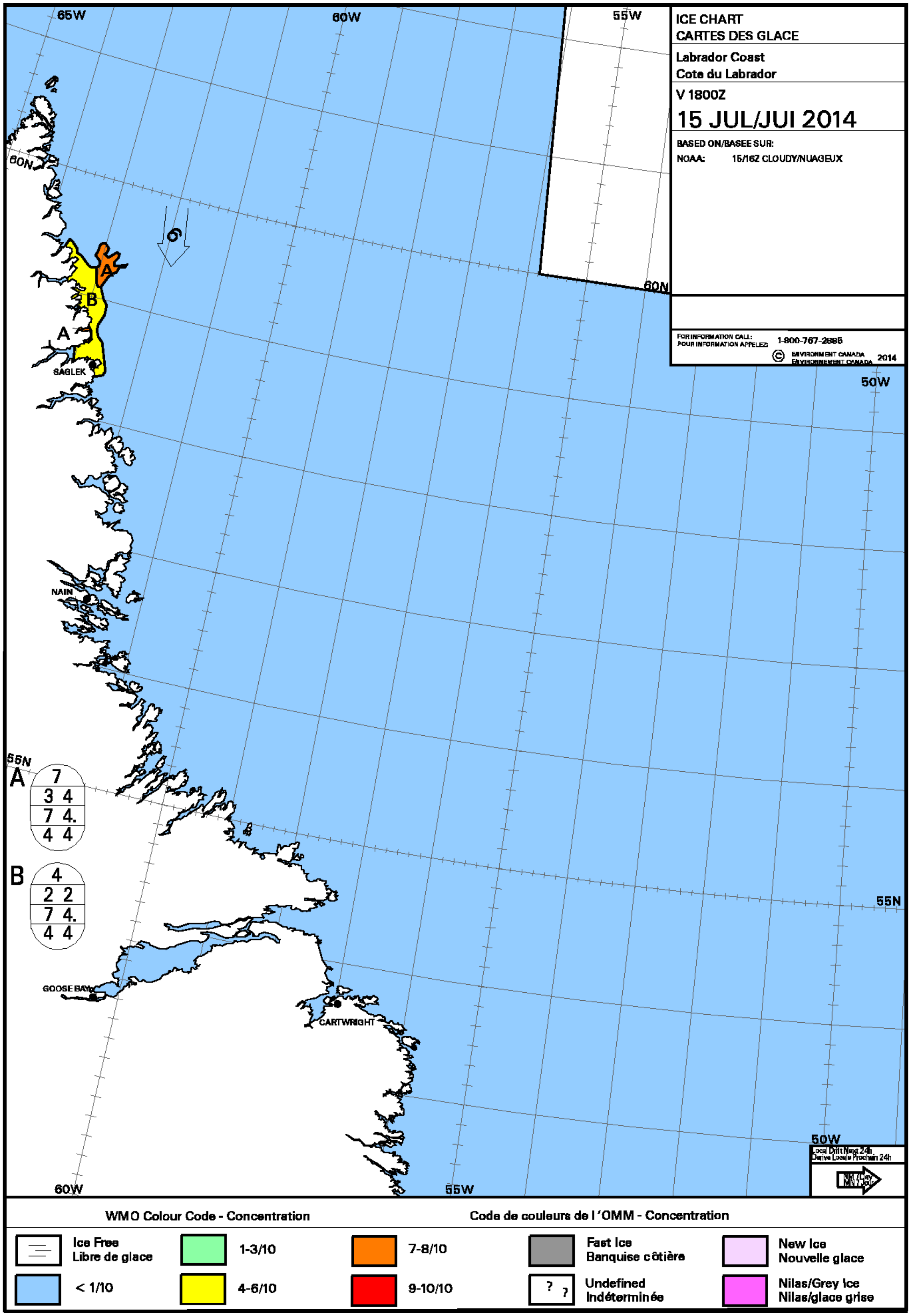

ICE CHART
CARTES DES GLACE
East Newfoundland Waters
Eaux de Terre-Neuve est
V 1800Z
15 FEB/FEV 2014
BASED ON/BASEE SUR:
RADARSAT2: 15/10Z W of/ouest de 52W
AVHRR: 15/16Z CLOUDS / NUAGES
MODIS: 15/16Z CLOUDS / NUAGES
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
FOR INFORMATION CALL: POUR INFORMATION APPELEZ: 1-800-767-2885
© ENVIRONMENT CANADA ENVIRONNEMENT CANADA 2014
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHNS
55W
50W
50N
45N
Local Drift Next 24h
Dérive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTES DES GLACE
East Newfoundland Waters
Eaux de Terre-Neuve est
V 1800Z
15 MAR/MAR 2014
BASED ON/BASEE SUR:
RADARSAT 2: 15/09Z E of/de 54W
AVHRR: 15/17Z a few clouds
MODIS: 15/14Z a few clouds
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
FOR INFORMATION CALL:
POUR INFORMATION APPELEZ: 1-800-767-2885
© ENVIRONMENT CANADA
ENVIRONNEMENT CANADA 2014
55W
50W
50N
45N
ST. ANTHONY
BOTWOOD
GANDER
ST. JOHNS
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTES DES GLACE
East Newfoundland Waters
Eaux de Terre-Neuve est
V 1800Z
15 APR/AVR 2014
BASED ON/BASEE SUR:
RADARSAT 2: 14/21Z
15/09Z E of/de 53W
NOAA-19: 15/16Z
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
FOR INFORMATION CALL:
POUR INFORMATION APPELEZ:
1-800-767-2885
© ENVIRONMENT CANADA
ENVIRONNEMENT CANADA 2014
55W
50W
50N
45N
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHNS
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTES DES GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 MAY/MAI 2014
BASED ON/BASEE SUR:
RADARSAT2: 15/10Z near all / presque tout
NOAA-19: 15/16Z cloudy S of 54N / nuageux S de 54N
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
FOR INFORMATION CALL: POUR INFORMATION APPELEZ: 1-800-767-2885
© ENVIRONMENT CANADA ENVIRONNEMENT CANADA 2014
GOOSE BAY
CARTWRIGHT
ST. ANTHONY
BOTWOOD
GANDER
ST. JOHN'S
Local Drift Next 24h
Dérive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTES DES GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 JUN/JUN 2014
BASED ON/BASEE SUR:
RADARSAT2: 15/10Z S 55N
SLAR: 15/14Z ~ 55N 56W
Cloudy / Nuageux
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
FOR INFORMATION CALL: POUR INFORMATION APPELEZ: 1-800-767-2885
ENVIRONMENT CANADA ENVIRONNEMENT CANADA 2014
GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHNS
Local Drift Next 24h
Dérive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTES DES GLACE
Labrador Coast
Cote du Labrador
V 1800Z
15 JUL/JUI 2014
BASED ON/BASEE SUR:
NOAA: 15/16Z CLOUDY/NUAGEUX
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65W
60W
55W
50W
60N
55N
SAGLEK
NAIN
GOOSE BAY
CARTWRIGHT
A
B
Local Drift Next 24h
Derive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Acknowledgements

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It is important to recognize the outstanding efforts of the personnel assigned to the International Ice Patrol during the 2014 Ice Season:

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	MST3 Z. P. Kniskern

International Ice Patrol Staff produced this report using Microsoft® Office Word and Excel 2007.

Appendix A

Ship Reports for Ice Year 2014

Ships Reporting by Flag	Reports
ANTIGUA AND BARBUDA	
HHL TOKYO	1
PALEMBANG	1
BAHAMAS	
AMERICAS SPIRIT	1
BARBADOS	
IT INTREPID	1
CANADA	
ARCTIC	1
DARA DESGAGNES	3
CCGS GEORGE R. PEARKES	6
EDWARD COURNWALIS	3
HEATHER KNUTSEN *	11
HMCS SHAWNIGAN	2
JASMINE KNUTSEN	1
KOMETIK	2
MAERSK CHANCELLOR	1
MAERSK DETECTOR	1
MAERSK NORSEMAN	1
MAERSK PLACENTIA	1
MATTEA	2
TRINITY SEA	1
UMIAK 1	7
FALKLAND ISLANDS	
RSS JAMES CLARK ROSS	1
FRANCE	
THALASSA	1
GREECE	
HERODOTUS	1
MINERVA ALEXANDRA	1
HONG KONG	
FEDERAL SETO	1
OOCL BELGIUM	3
OOCL MONTREAL	5
UNIQUE GARDEN	1

JAMAICA	
PUFFIN	1
LIBERIA	
HORIZON THEANO	1
INDEPENDENT CONCEPT	1
MARTHA OLDENDORFF	1
MALTA	
BEATE OLDENDORFF	1
MISS MARINA	1
N SCHELDE	1
MARSHALL ISLANDS	
APL GARNET	2
FEDERAL SWIFT	1
NUNAVIK	1
NETHERLANDS	
ARTISGRACHT	1
EEBORG	3
FINNBORG	1
JUMBO SPIRIT	2
REGGEBORG	1
VEENDAM	2
VIKINGBANK	2
PANAMA	
MSC ANIELLO	1
UNITED KINGDOM	
MONTREAL EXPRESS	1
UNKNOWN	
UNIDENTIFIED SHIPS	3

* Denotes the CARPATHIA award winner.

IIP awards the vessel that submits the most iceberg reports each year. The award is named after the CARPATHIA, the vessel credited with rescuing 705 survivors from the TITANIC disaster.

Appendix B

2014 Transatlantic Shipping Behavior

Mr. Michael R. Hicks

December 2014

Introduction

IIP has long recognized the value in understanding how transatlantic vessels respond when faced with the risk of encountering icebergs. This insight is essential to creating and providing the most accurate and relevant iceberg warning product possible to mariners. IIP formally codifies this tenet as a Critical Success Factor in its Strategic Plan as follows:

IIP creates an accurate and relevant iceberg product to allow mariners to manage the risk of iceberg collision.

For this reason, in 2013, IIP contracted Shearwater, LLC to conduct a study to identify IIP customers in the shipping industry, to assess their use of current IIP iceberg products, and to obtain input on product improvement (Fitzpatrick, Kamradt, Lersh, and Tebeau, 2013). Shearwater found that IIP's daily Iceberg Limit product is not only used by vessels at sea but is also a key component considered by weather routing services for transatlantic voyage planning. A transatlantic route is typically planned days in advance of the actual voyage. The presence and location of icebergs during the late winter and spring months can significantly impact the duration of a transatlantic voyage. IIP strives to balance vessel safety with mobility when setting the daily Iceberg Limit.

As a part of the 2013 study, Shearwater developed a system to visualize shipping traffic using Google Earth™ based on positions downloaded daily from a publicly available web site, SailWX.info (Mobile Geographics, 2014). The 2013 Ice Year was very light with only 13 icebergs drifting south of 48ºN for the entire year. IIP uses this latitude as a delineation of the northern boundary of the transatlantic shipping lanes since icebergs south of 48°N intersect great circle routes between northern Europe and North America. Consequently, the 2013 study could not make any positive correlations between ship behavior and IIP's daily Iceberg Limit since ships did not need to deviate from the most economical route due to the lack of icebergs in this region that year.

As described in the main body of the 2014 Annual Report, the 2014 Ice Year was one of the most severe years on record with 1,546 icebergs south of 48ºN. The iceberg limit extended well into the shipping lanes, as far south as 39º30′N in early June. Thus, 2014 provided a much better opportunity than in 2013 to study the behavior of transatlantic vessels in response to iceberg hazards adrift in the shipping lanes. With all environmental factors in place for severe iceberg conditions, IIP began using the method developed for the 2013 Study in early March 2014 and continued to collect ship position data through the end of July. Through the SailWX process, IIP identified 55 unique transatlantic vessels whose voyages passed near the Grand Banks region in 2014. Most vessels made multiple trips across the Atlantic during different times of year. IIP created plots showing all transits for each of these vessels during the 2014 calendar year and applied a color-coding scheme, based on the time of year for each reported position. This scheme defined key time periods that used the number of icebergs south of 48ºN to represent the level of risk of encountering an iceberg during a vessel transit. This Appendix documents the process used to identify these vessels for the 2014 Ice Year, provides a description of the color-coding scheme and discusses observed modifications of shipping routes by vessel type. The analysis attempts to answer a very basic question: Did these vessels modify their behavior when icebergs were present south of 48ºN? Recommendations for future study are also included.

Transatlantic Vessel Identification Process

In early March, IIP began downloading SailWX position data within a radius of 500 NM around a center point of 48ºN, 45ºW. For each day, the entire table of vessel positions from within this area was copied from SailWX to a Microsoft (MS) Excel® spreadsheet. The table was then copied and pasted into a second tab (values only) to allow ingestion into a MS Access® database for analysis. Once in MS Access®, IIP executed a script to generate a Keyhole Markup Language (KML) file for viewing in Google Earth™. Each KML file displayed all position data from the beginning of the study until the date of each download. In addition, the daily Iceberg Limit was also incorporated into the MS Access® database file. These KML files were reviewed weekly by IIP staff as a tool to gain insight on how IIP's primary customers were responding to changes in the Iceberg Limit. Fitzgerald et al. (2013) describes this process in detail.

An example from 28 March 2014 is shown in **Figure B-1**. On this date, all vessels with the exception of three were operating outside of the Iceberg Limit. The three vessels that were inside of the Iceberg Limit were all south of 45ºN where there were only seven icebergs distributed over an area greater than 70,000 NM^2, i.e. a relatively low risk of encountering an

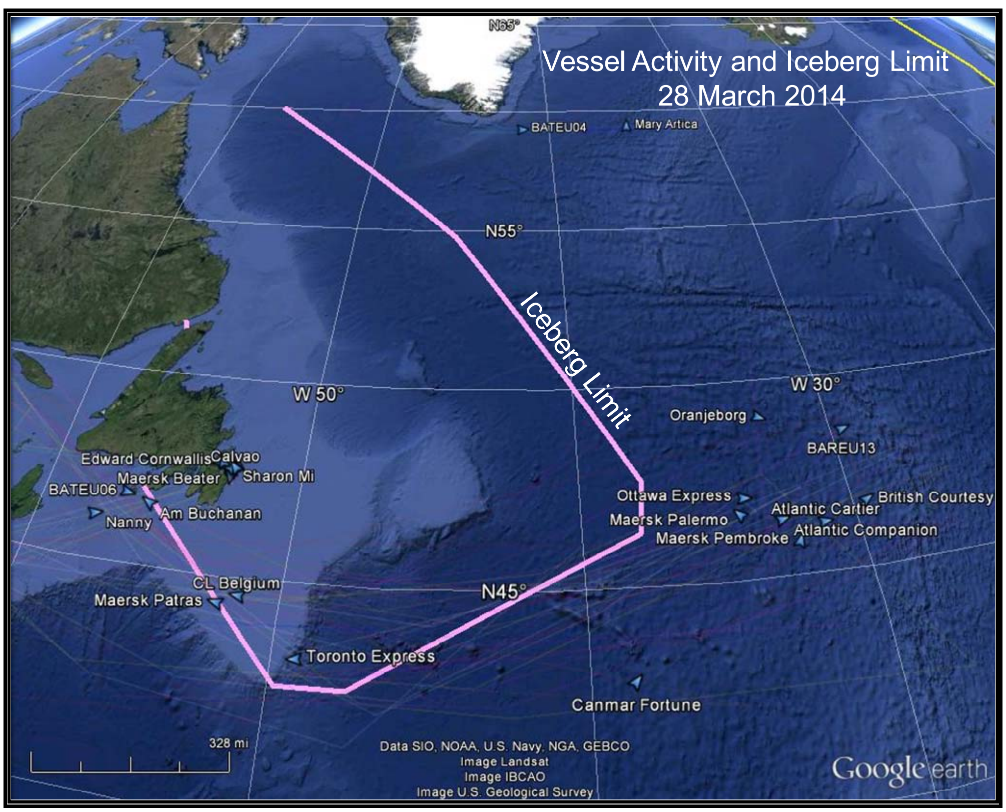

Figure B-1. Shipping Activity with Iceberg Limit for 25 March 2014 based on SailWX position data. (Mobile Geographics, 2014).

Time Period		Icebergs south of 48°N	Relative risk	Color code
1-Jan-14	12-Feb-14	0	Low	Green
13-Feb-14	28-Feb-14	< 15	Medium	Yellow
1-Mar-14	26-Jul-14	≥ 15	High	Red
27-Jul-14	1-Aug-14	< 15	Medium	Yellow
1-Aug-14	7-Nov-14	0	Low	Green

Table B-1. Time periods and assumed relative risk as defined by IIP.

iceberg. While an analysis of individual ship tracks with respect to iceberg distribution is beyond the scope of this Appendix, the observation from 28 March provides insight into a possible future approach to a risk-based iceberg product and deserves careful study. IIP is currently conducting a track by track analysis of this data to address this question. It is important to note that SailWX reports are not mandatory, so this data set represents a subset of all transatlantic vessel traffic during the year. Future studies should incorporate a comprehensive source of Automatic Identification System (AIS) ship position data to compile a more comprehensive data set.

IIP collected data through 31 July 2014. Through this process, IIP accumulated position data from 3,556 unique platforms that were reporting via SailWX during this time period. Over 2,500 of these platforms generated less than five reports and were excluded from further analysis. IIP then filtered the remaining data by visual inspection to remove platforms that were not involved in transatlantic voyages. For example, position data from stationary oil production facilities, Canadian domestic vessels operating locally out of Newfoundland and Labrador, Canadian Government vessels, ships operating along the coast of Greenland, and ships that transited well south of the Iceberg Limit were not considered in this analysis. After excluding these data, 55 vessels remained for further analysis.

Using this set of vessels, IIP then downloaded track histories for each ship from the SailWX website. For further analysis, IIP defined several time periods during 2014 based on the number of icebergs south of 48°N that were being reported on its daily product (**Table B-1**). IIP assigned the color-code scheme in **Table B-1** to each ship's position and plotted the ship's tracks. This system is intended to represent the likelihood of encountering an iceberg and is equated to a relative level of risk. Vessel positions were plotted using Esri® ArcGIS® 10.1. To simplify further discussions, the remainder of this Appendix will refer to a 'green' time period as a time when there were no icebergs south of 48ºN, a 'yellow' period as a time when there were less than 15 icebergs south of 48ºN, and a 'red' time period as a time when there were greater or equal to 15 icebergs south of 48ºN as per **Table B-1**. IIP acknowledges that this approach is not based on any probability calculations, but it provides a simple visualization tool to help address the question of ship behavior modification based on the presence of icebergs.

As a final step in this process, IIP categorized the 55 vessels into six different types as shown in **Figure B-2**. These included Container, General Cargo, Research/Weather, Vehicle Carriers, Bulk Carriers, and Passenger Ships. As shown in **B-2**, the majority of vessels studied were Container Ships. A sample plot from each category are presented and discussed in the following section.

Discussion

The color-coding scheme described above provided an effective visual tool to quickly assess whether or not a vessel modified its course from the shortest great circle route across the Atlantic. IIP compared routes followed during a 'green' or 'yellow' time of year to a 'red' period in order to determine whether or not a vessel modified its route during different times of the year. For vessels that only transited during the 'red' time period, IIP compared their route(s) to a great circle route. For reference, the shortest distance between the English Channel and Halifax is approximately 2,370 NM as shown in **Figure B-3** in light blue. In 2014, the Iceberg Limit extended to the southernmost latitude of the season at 39º30'N on 05 and 06 June. For a ship to completely avoid an iceberg encounter, it would need to follow the track shown in orange in **Figure B-3** (2700 NM) – a difference of 330 NM. This represents between 16 and 22 hours for a vessel steaming at 15 or 20 knots respectively. This example, while an extreme case, provided the basis for IIP to assume that a ship's preferred course would follow the shorter great circle route between these locations.

Using this approach, IIP found that a total of 35 out of the 55 vessels studied (64%) modified their course during the 'red' time period as compared to the preferred course. Without direct communication with the ship's Captain or the routing service used, IIP cannot state with certainty that these course modifications occurred due to IIP's iceberg warnings. However, this is a reasonable conclusion, and the vessels identified in the study provide a good candidate pool for future communications on IIP product improvements. Further, it is important to note that IIP is conducting a more detailed analysis that will compare these vessels' tracks with the specific Iceberg Limit on a particular day. To avoid any proprietary concerns, specific vessel names were omitted from this Appendix. **Figures B-4** through **B-9** present sample plots from each vessel category studied. In the following discussion, 'red', 'yellow' and 'green' time periods are assumed by this study to represent high, medium, and low risk of encountering an iceberg during that transit, respectively.

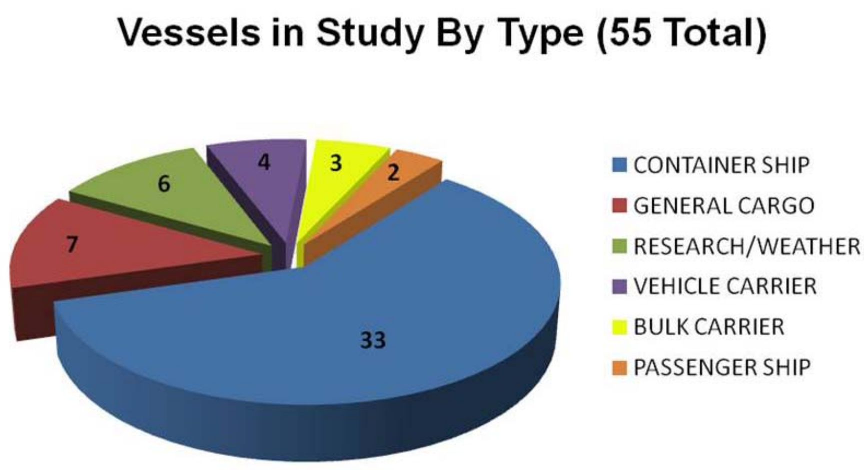

Figure B-2. Vessels used in study by type.

With 33 vessels total, Container Ships made up the largest number of vessels in this study, by far. Sample tracks for a vessel from this category are shown in **Figure B-4**. The primary route followed by this vessel went between the English Channel and Montreal through the Cabot Strait. It is clear that the vessel in **Figure B-4** chose the shortest route during the ‘green’ and ‘yellow’ time periods and remained well south of the Grand Banks during the ‘red’ period. Therefore, this vessel was counted among those modifying their behavior. Of the 33 vessels in this category, 21 modified their routes during a time when icebergs were reported south of 48ºN.

The sample tracks plotted for a General Cargo vessel (**Figure B-5)** show only two transatlantic voyages between the Irish and North Seas and Montreal. Both of these transits occurred during a ‘red’ time period. It is clear that this vessel did not make any course modifications from the shortest route across the Atlantic. In this category, only two of seven vessels appeared to modify their routes when icebergs were reported south of 48ºN. This case illustrates that there was considerable variability in both the number of transits and position reports from each of the vessels in this study.

Figure B-6 provides an excellent example of a Research/Weather vessel that made multiple transits with very consistent reporting between the Irish Sea and Halifax during 2014. This plot clearly shows that the vessel remained south of the Grand Banks for ‘red’ time periods and elected to follow the shorter routes during ‘green’ and ‘yellow’ times. Both this plot and **Figure B-5** for the General Cargo vessel highlight the need to further investigate the factors that made these vessel Captains decide to transit across the Tail of the Grand Banks while icebergs were present. As described above, this is the subject for ongoing study at IIP and is beyond the scope of this Appendix. In this category, five out of six vessels modified their routes when icebergs were reported south of 48ºN.

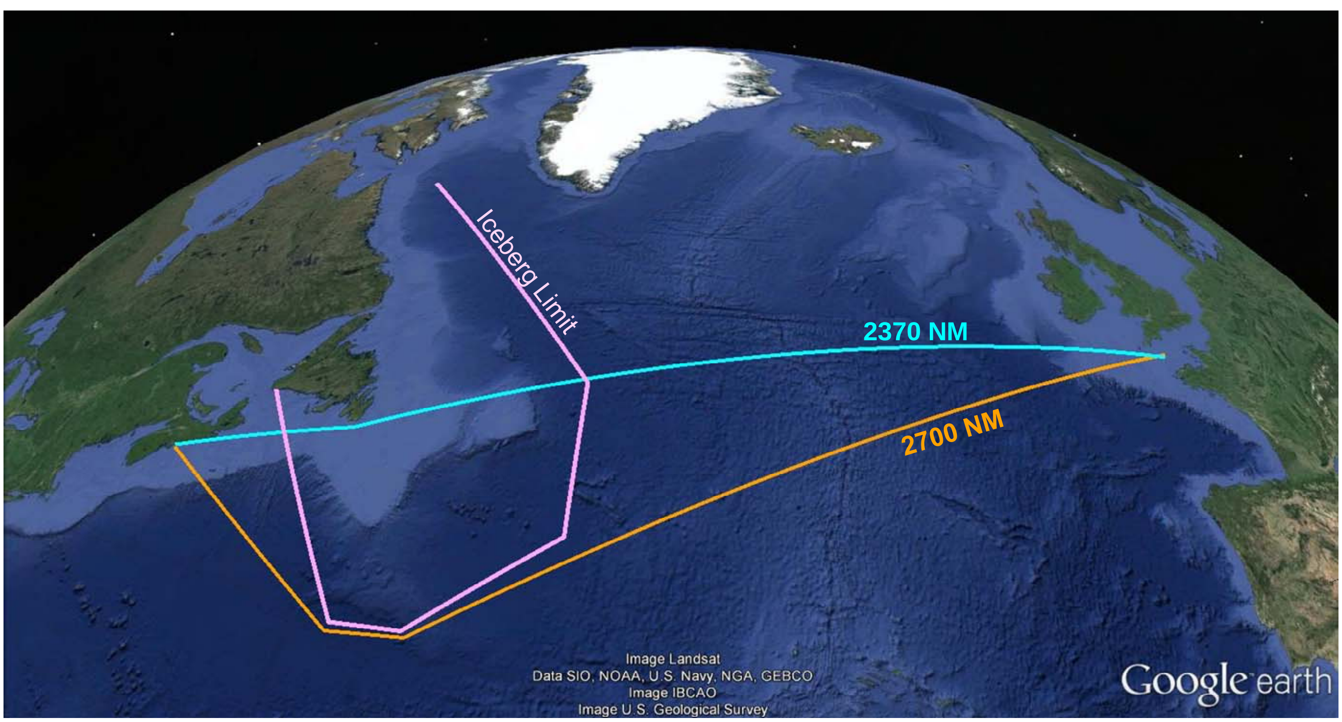

Figure B-3. Great circle (blue) and Iceberg Limit avoidance route (orange) for 06 June 2014.

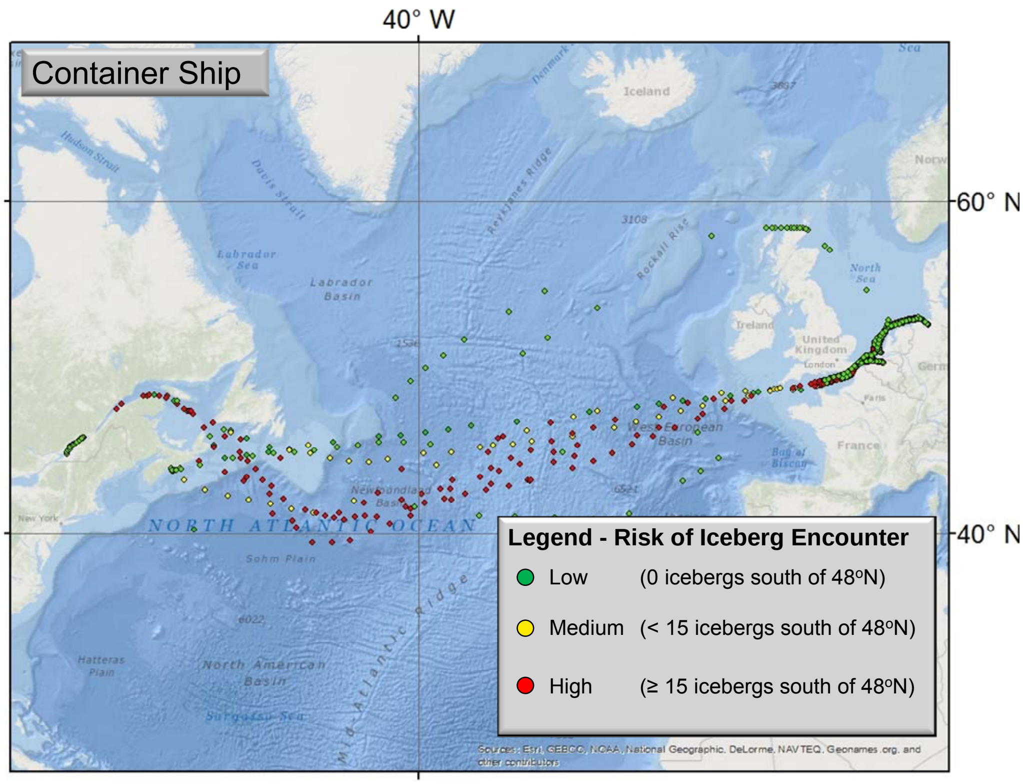

Figure B-4. Sample tracks for a Container Ship during 2014.

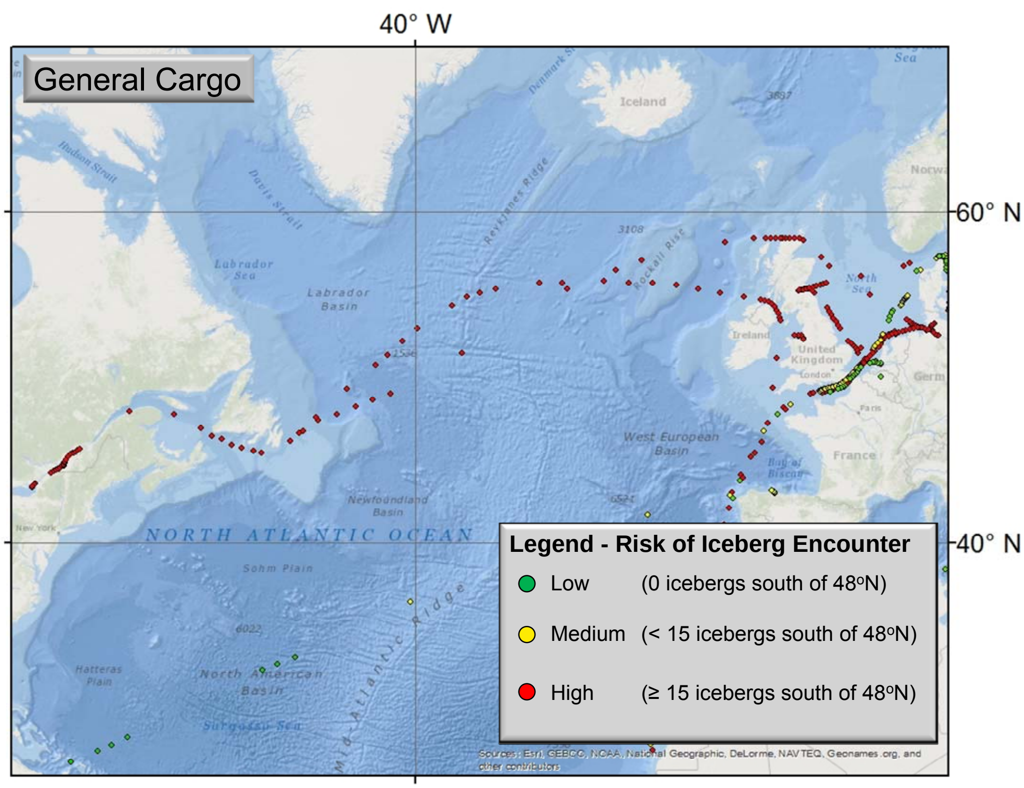

Figure B-5. Sample tracks for a General Cargo vessel during 2014.

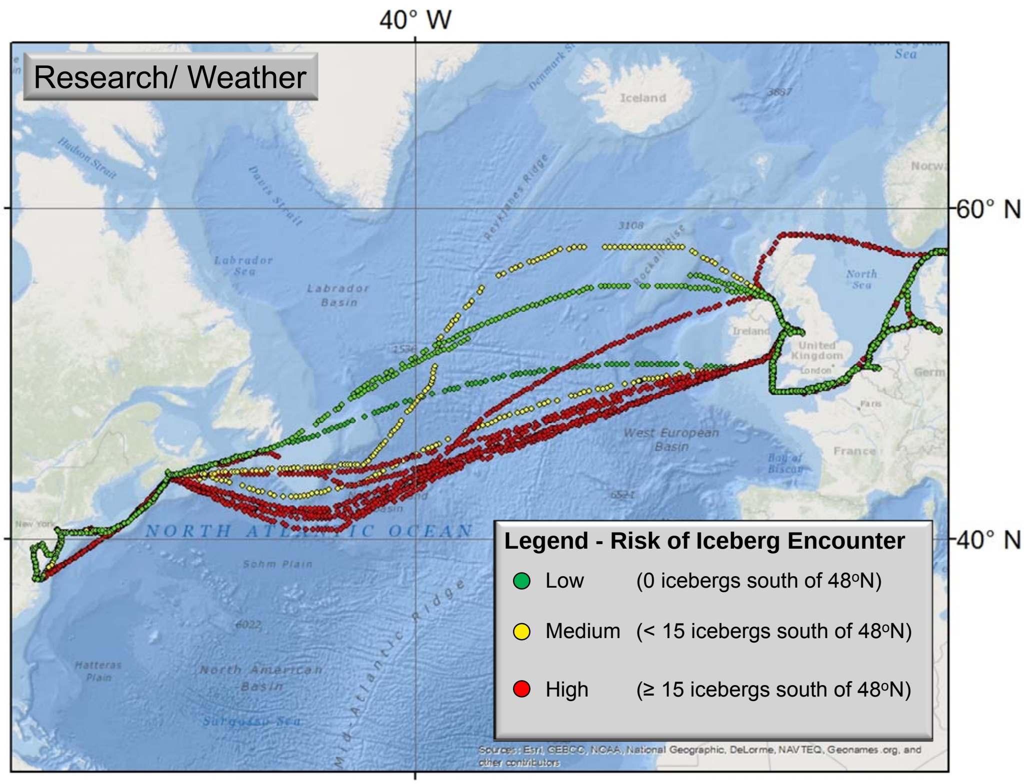

Figure B-6. Sample tracks for a Research/Weather vessel during 2014.

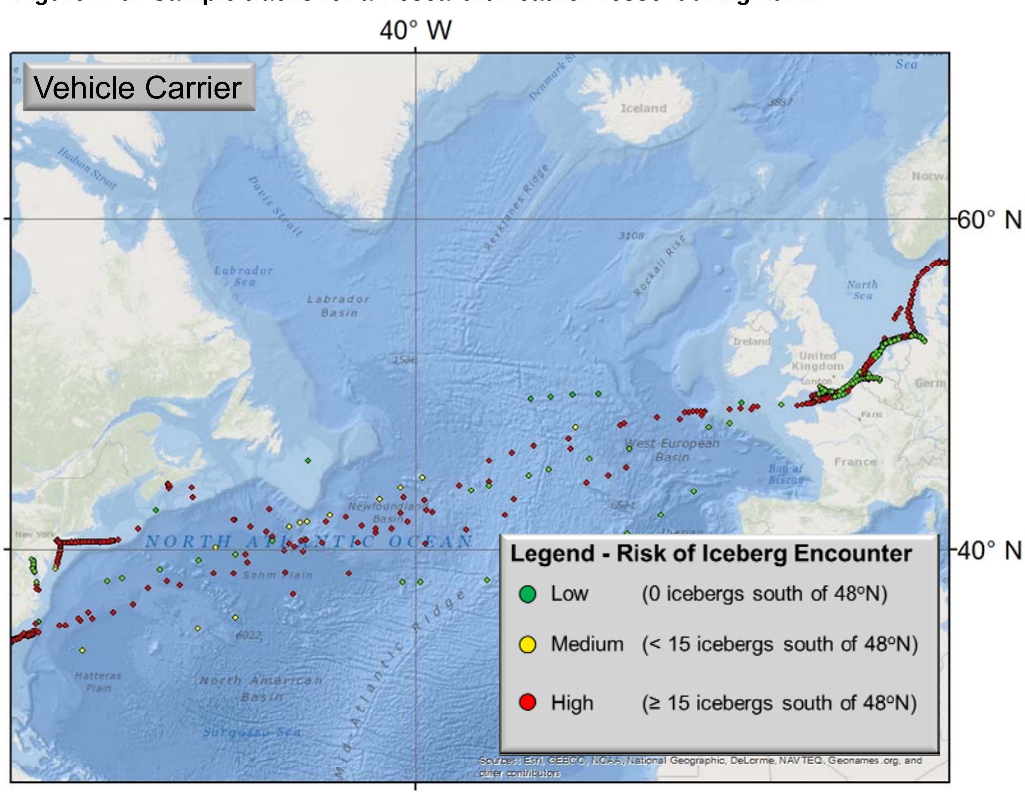

Figure B-7. Sample tracks for a Vehicle Carrier during 2014.

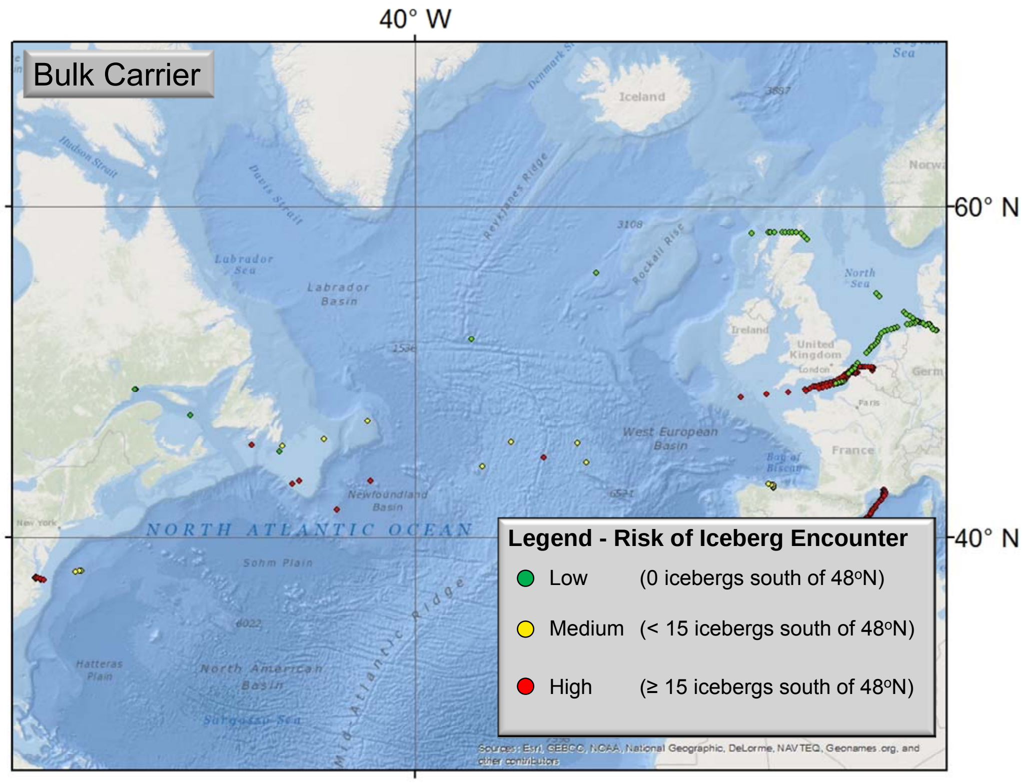

Figure B-8. Sample tracks for a Bulk Carrier during 2014.

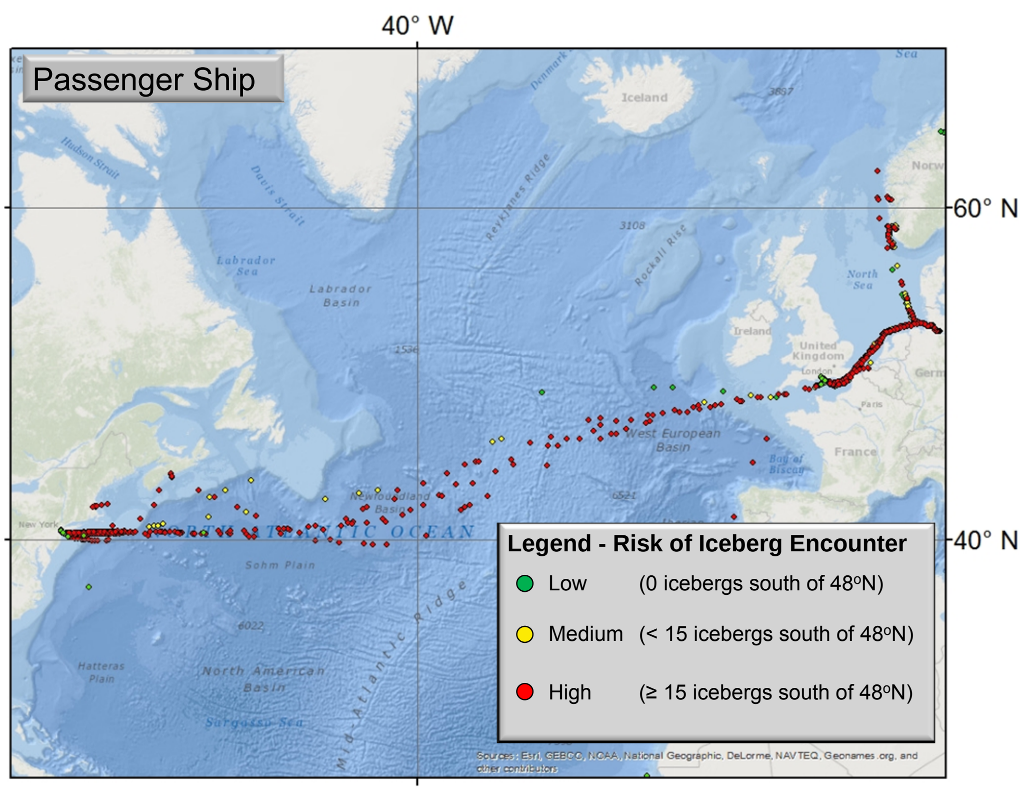

Figure B-9. Sample tracks for a Passenger Ship during 2014.

Sample tracks from a Vehicle Carrier are shown in **Figure B-7**. This plot shows several tracks between points in the southern U.S. and the English Channel in addition to transits to/from Halifax. The normal great circle route from the English Channel to the southern U.S. did not intersect the Iceberg Limit and were not considered in this example. Transits to/from Halifax clearly show a course modification when icebergs were reported south of 48ºN. In this category, two of four vessels modified their routes when icebergs were reported south of 48ºN.

Figures B-8 and **B-9** show sample tracks from the Bulk Carrier and Passenger Vessel categories, respectively. It appeared that the Bulk Carrier elected to follow the most direct route during a 'yellow' time period but modified course south during a 'red' period. Only three vessels from this category were included in the study and all modified their course during 'red' time periods. For the Passenger Vessel shown in **Figure B-9**, all transits were made during times of high or medium risk of iceberg encounter. Of the two vessels considered in this study, both modified their routes when icebergs were reported south of 48ºN.

Figure B-10 summarizes the number of vessels that modified their routes based on the time of year. As stated above, 35 of the 55 vessels (64%) studied modified their transatlantic route in the presence of iceberg danger. These results show that many vessels do modify their behavior to avoid iceberg encounters. Notably, there were 20 vessels in this study that did not modify their course while transiting through or near iceberg danger. The circumstances surrounding each Captain's decision to transit through iceberg danger areas is not clear from this study. Future study and actions by IIP should focus on improving communication with these, and all transatlantic vessels, to ensure that they are aware of the iceberg danger and the availability of IIP's daily product. IIP has a survey that is approved for use by the Office of Management and Budget to gather data from its customers. IIP will focus this survey towards the vessels identified in this study as a mechanism for getting information on the factors influencing vessel Captains' decisions in route selection. The use of an AIS-based automated messaging system may offer another means for ensuring mariners are aware of their location with respect to IIP's published Iceberg Limit.

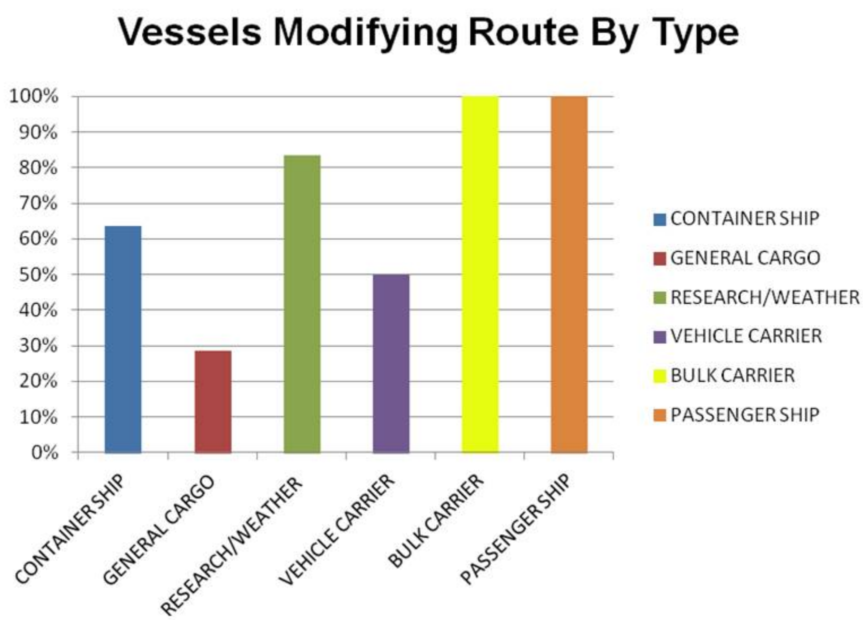

Figure B-10. Vessels modifying their transatlantic routes by type.

Summary

This Appendix documents the process used to identify and visualize the paths of transatlantic vessels during 2014. This study attempted to gain insight into shipping behavior during a severe Ice Year. Data were collected from ships voluntarily reporting to SailWX.info (Mobile Geographics, 2014) and plotted using a time-based, color-coded scheme with ArcGIS®. Vessel positions were plotted with a color that corresponded to the time of the year that the position report was made to SailWX. IIP defined these time periods according to the number of icebergs south of 48ºN and associated these times to a relative level of risk for encountering an iceberg during that time. It is important to restate that these dates were selected as an arbitrary starting point for a simple visualization to compare ship routes and were not based on any rigorous probability calculations.

Since the early days when Ice Patrol crew walked the docks in Halifax and St. John's talking to fishing vessel captains, IIP has long recognized the value of maintaining a close connection with its customers as they are both a source of iceberg observations as well as benefactors of the data. Given the challenges faced while conducting reconnaissance in the North Atlantic, IIP has relied on mariners to supply critical information that serves all shipping traffic passing near or through the iceberg danger area. The 2013 Shearwater study along with the work documented in this Appendix is testament to IIP's continued emphasis to continually improve its products and relationship with the transatlantic maritime community. The reason that IIP exists is to serve its customers by providing the most accurate and relevant iceberg warning products possible. Recommendations for continued study are presented below.

Recommendations

IIP recommends continued study of the following areas to strengthen its knowledge and understanding of the needs of transatlantic shipping toward promoting safe navigation:

- Expand ship position data collection by including a more robust AIS dataset since SailWX is a voluntary system.
- Conduct a detailed, track-by-track analysis to better determine the level of risk that vessels will accept based on actual iceberg distribution.
- Reinvigorate IIP's Customer Relations Working Group to improve communications with vessels identified in this study (and new vessels) using approved methods e.g., the Office of Management and Budget-approved IIP survey.
- Investigate an AIS-based system to automate warning messages to ships approaching IIP's published Iceberg Limit.

References

Fitzpatrick, M., Kamradt, E.K., Lersch, D.L., & Tebeau, P.A. (2013). NAIS Product Customer Focused Review Report. Final Report for USCG International Ice Patrol under USCG Research and Development Center Contract, August 2013.

Mobile Geographics LLC, (2014) 8015 28th Ave NW, Seattle, Washington 98117. webmaster@sailwx.info.

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SHIPPING AND HANDLING FEES

Value of Order	U.S. and territories	Canada and Mexico	Outside North America
$0 - $100	$6	$12	$30
$101-$999	6%	12%	30%
$1,000 - $4,999	4%	8%	
$5,000+	3.5%	7%	

SUB-TOTAL *(Value of Order)*	$
SHIPPING & HANDLING FEE SEE CHART	$
GRAND TOTAL	$

Thank you for your order!

Prices subject to change.

2009-07