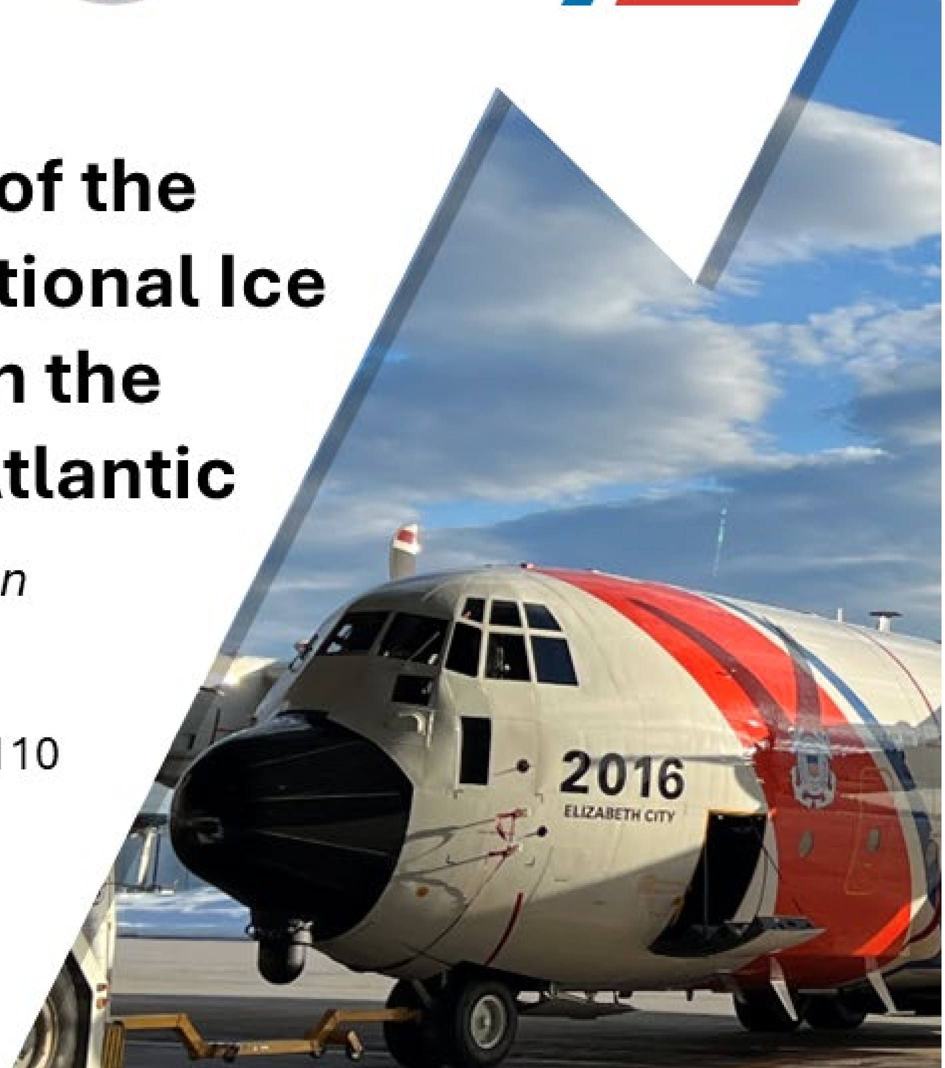
U.S. Department of
Homeland Security

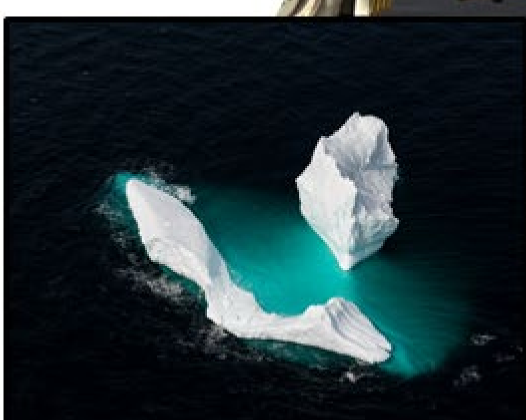
United States
Coast Guard

Report of the International Ice Patrol in the North Atlantic

2024 Season

Bulletin No. 110
CG-188-79





Bulletin No. 110

Report of the International Ice Patrol in the North Atlantic

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Forwarded herewith is Bulletin No. 110 of the International Ice Patrol (IIP) describing ice conditions and IIP operations during the 2024 Ice Year (1 October 2023 – 30 September 2024). In Ice Year 2024, 22 icebergs drifted into transatlantic shipping lanes, marking this year as a "light" year.

Satellite reconnaissance continues to serve as the primary means for iceberg detection along the coast of Newfoundland and Labrador and over the Grand Banks of Newfoundland. For the 2024 Ice Year, 87% of recorded icebergs were sighted by IIP, the Canadian Ice Service (CIS), or commercial satellite analysts using largely public imagery. While satellite imagery serves as the workhorse for finding icebergs longer than 20 meters, we have been unable to obtain a reliable solution to accurately track smaller icebergs and confirm ice-free waters like the HC-130 airframe. With the Coast Guard's shortage of HC-130s, IIP will continue to explore other remote sensing technologies to reduce its reliance on this airframe.

For the first time in recent history, IIP utilized the NATO airbase located at Happy Valley-Goose Bay in Newfoundland and Labrador. We received a wonderful reception from the Royal Canadian Air Force's 5th Wing staff and found a large amount of support and excellent flying conditions. The experience was so positive and our time so productive that IIP will return to Goose Bay in 2025 to assess if we want to permanently shift our forward base of operations from St. John's in Newfoundland.

IIP saw continued activity in our area of responsibility. Of particular note, IIP provided customized iceberg warning products in support of the naval exercise NANOOK that took place in the Canadian and Greenlandic Arctic and to NATO forces operating in the area. Using data provided by CIS and the Danish Meteorological Institute (DMI), these tailored iceberg products were critical for these non ice-strengthened vessels to avoid iceberg threats and conduct successful exercises. While our products are well-received, IIP continues to strive to be better than yesterday. We had the excellent opportunity to host a Navy Midshipman from the Webb Institute over the summer to review our tailored support products, and he identified several options for improvement. Most notably, he recommended a way to represent iceberg risk that better aligns with the International Ice Charting Working Group (IICWG) standards. His work was presented to IICWG in September where it received positive reviews. IIP will take his findings and work to put them in place in future products as we are able.

Each year, IIP honors the sinking of the Royal Mail Ship (RMS) TITANIC, the event that founded our history, by holding memorials and wreath dedications honoring those lost. This year, IIP held this annual ceremony in Halifax, Canada. The Titanic Society put on an exceptional event, and we were honored that the Honourable Arthur LeBlanc, the Lieutenant Governor of Nova Scotia, was able to serve as the keynote speaker. We are proud of our contributions to safe navigation in a highly dangerous part of the world and will continue to honor the lives of those lost last year and 112 years ago by continuing our mission to the best of our ability.

This 2024 Ice Year report was prepared by all members of the IIP team. On behalf of all of us, I hope that you enjoy reading it.

E. M. Caldwell
Commander, U. S. Coast Guard
Commander, International Ice Patrol

Acronyms and Abbreviations

AIS	Automatic Identification System
AOR	Area of responsibility
APN-241	Tactical Transport Weather Radar
ASEC	Air Station Elizabeth City
BAPS	IceBerg Analysis and Prediction System
CCGS	Canadian Coast Guard Ship
CBC	Canadian Broadcasting Corporation
CIIP	Commander, International Ice Patrol
CIS	Canadian Ice Service
CSA	Canadian Space Agency
CPC	Climate Prediction Center
CYHZ	Airport in Halifax Nova Scotia
CYYR	Royal Canadian Air Force Base in Goose Bay - Happy Valley
CYYT	St. John's International Airport
DHS S&T	Department of Homeland Security Science and Technology
DMI	Danish Metrological Institute
DSA	Duty Satellite Analyst
DWS	Duty Watch Stander
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA5	Fifth Generation ECMWF Reanalysis
EOIR	Electro-Optical Infrared
ERMA	Environmental Response Management Application
ESA	European Space Agency
FBO	Fixed Base Operator
GIS	Geographic Information System
HDMS	His/Her Danish Majesty's Ship
HMCS	His Majesty's Canadian Ship
ICC-GEOINT	Intelligence Coordination Center Geospatial Intelligence Branch

IDS	Iceberg Detection System
IFM	Isolated/Few/Many
IICWG	International Ice Charting Working Group
IIP	International Ice Patrol
IRD	Ice Reconnaissance Detachment
ISAR	Inverse Synthetic Aperture Radar
KADW	Joint Base Andrews Airport
KFMH	Cape Cod Airport
KML	Keyhole Markup Language
MCTS	Maritime Communication and Traffic Service
MSLP	Mean Sea Level Pressure
MWP	Mean Wave Period
NAIS	North American Ice Service
NAO	North Atlantic Oscillation
NAOI	North Atlantic Oscillation Index
NAVAREA	Navigational Area
NAVCEN	Navigation Center
NAVTEX	Navigational Telex
NAVWARN	Navigational Warning
NCEP	National Centers for Environmental Prediction
NGA	National Geospatial-Intelligence Agency
NL	Newfoundland
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Labratory
NSIDC	National Snow and Ice Data Center
NSOF	NOAA Satellite Operations Facility
NWS	National Weather Service
OPC	Ocean Prediction Center
OPCEN	Operations Center

POD	Probability of detection
R&D	Research and Development
Radiofax	Radio facsimile
RCM	Radarsat Constellation Mission
RMS	Royal Mail Ship
RS2	Radarsat-2
SAR	Synthetic aperture radar
SAT	Surface air temperature
SIM	Standard Iceberg Message
SITOR	Simplex Teletype Over Radio
SN1(A/B)	Sentinel-1 (A/B)
SN2	Sentinel-2
SOLAS	Safety of Life at Sea
SST	Sea surface temperature
SWH	Significant wave height
TC	Tactical Commander
UK	United Kingdom
US	United States
USCG	United States Coast Guard
USCGC	United States Coast Guard Cutter
USNIC	United States National Ice Center
WMO	World Meteorlogical Organization
WWNWS	World-Wide Navigational Warning Service

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1 Introduction

This is the 110th IIP annual report describing the 2024 Ice Year. It depicts IIP operations, along with environmental and iceberg conditions, in the North Atlantic from October 2023 to September 2024.

IIP deployed five Ice Reconnaissance Detachments (IRDs) to detect icebergs in the North Atlantic Ocean and Labrador Sea in Ice Year 2024. These IRDs used HC-130J aircraft from U.S. Coast Guard (USCG) Air Station Elizabeth City (ASEC). IIP also received iceberg reports from commercial aircraft and mariners in the North Atlantic region. Further, IIP continued to incorporate satellite data into its standard reconnaissance operations.

IIP personnel analyzed iceberg and environmental data using iceberg drift and deterioration models within the IceBerg Analysis and Prediction System (BAPS) at the IIP Operations Center (OPCEN) located in the National Oceanic and Atmospheric Administration (NOAA) Satellite Operations Facility (NSOF) at Suitland, MD. In accordance with the North American Ice Service (NAIS) Collaborative Arrangement, IIP used BAPS to produce daily iceberg charts and text bulletins from the model output. These iceberg warning products were then distributed to the maritime community daily. In addition to these routine broadcasts, IIP also responded to individual requests for iceberg information.

IIP remains unequivocally committed to maintaining mariner safety as it explores adding new technology and tools to its iceberg reconnaissance mission. While iceberg aviation missions will continue for the foreseeable future, IIP remains committed to its continual advancement of its satellite reconnaissance program as the primary method for iceberg reconnaissance. IIP intends to develop a diverse and resilient system of collection platforms to provide an iceberg detection capability that leverages the benefits of both air and space reconnaissance.

IIP was formed after the RMS TITANIC sank on 15 April 1912. Since 1913, except for periods of World War, IIP has monitored the iceberg danger in the North Atlantic and broadcast iceberg warnings 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.

For the 2024 Ice Year, IIP was under the operational control of the Director of Marine Transportation (CG-5PW), Mr. Michael D. Emerson. CDR Erin M. Caldwell was Commander, IIP (CIIP) from 28 July 2023 to present.

For more information about IIP, including historical and current iceberg bulletins and charts, visit our website at https://www.navcen.uscg.gov/international-ice-patrol.

2 Ice and Environmental Conditions

2.1 International Ice Patrol Oceanographic Area of Responsibility

This section describes the ice and environmental conditions in the IIP oceanographic area of responsibility (AOR) during the 2024 northern hemisphere Ice Year (1 October 2023 to 30 September 2024). IIP has the statutory mission, encoded in international (International Maritime Organization 1974) and United States (US) law (Title 46, United States Code § 80301 2021), to monitor and warn of iceberg danger in the North Atlantic Ocean. Under this mission, IIP's AOR encompasses the area of ocean around the Grand Banks of Newfoundland, Canada, where icebergs pose a threat to vessels traversing North Atlantic shipping lanes (**Figure 2.1**).

As a part of its mission, IIP collects and reports daily iceberg data (numbers, distribution, and extent, or "limit") in its AOR (International Maritime Organization 1974). IIP reports these data as estimates, because IIP uses a combination of direct, imperfect measurement (human visual sighting and remote sensing detection) of icebergs or their absence, and computer modeled drift and deterioration of previously detected icebergs to estimate the daily iceberg population.

IIP's iceberg dataset is unique: due to the long history and singular mission of IIP since its formation in response to the sinking of the RMS TITANIC in 1912, it is likely the largest and most continuous, comprehensive, and accurate North Atlantic iceberg record. It is the authoritative dataset, and the only of its kind, for icebergs in IIP's AOR. For more information on the methods IIP employs to monitor icebergs in its AOR, see **Sections 3** and **4**.

2.1.1 Ice Year and Iceberg Season

The northern hemisphere Ice Year begins and ends roughly when sea ice (frozen saltwater ocean surface) reaches its minimum extent in the Arctic Ocean (September, see **Figure 2.1a**). Thus, midway through the Ice Year (March, in the northern hemisphere, see **Figure 2.1b**) corresponds to maximum sea ice extent (Fetterer, et al. 2017). Within an Ice Year, IIP considers the Iceberg Season in the North Atlantic to span the months (typically January through September, **Figure 2.2**) during which icebergs (freshwater ice of land origin in the ocean) pose the greatest threat to the transatlantic shipping lanes by drifting south of 48°N latitude, which is nearly on parallel with St. John's, Newfoundland (**Figure 2.1c** through **e**).

Icebergs in IIP's AOR originate from Arctic glaciers along the coast of western Greenland (see **Figure 2.1f**, *white diamonds*). At these glacial termini, ice calves (breaks off) into the ocean to become icebergs (individual pieces of floating glacial ice), which, amid sea ice and in open ocean, drift generally south in major currents in Baffin Bay and the Labrador Sea until, after several years, they reach the Grand Banks and intersect with major transatlantic shipping lanes (Larsen, et al. 2015, Newell 1993, Marko, et al. 1994, Wilton, Bigg and Hanna 2015).

Outside of the Iceberg Season, typically October through December (see **Figure 2.2**), IIP transfers primary responsibility for monitoring and warning of icebergs in the North Atlantic and marginal Arctic seas to its close NAIS partner, CIS, as primarily Canadian vessels and coastline will be threatened during this time. During these

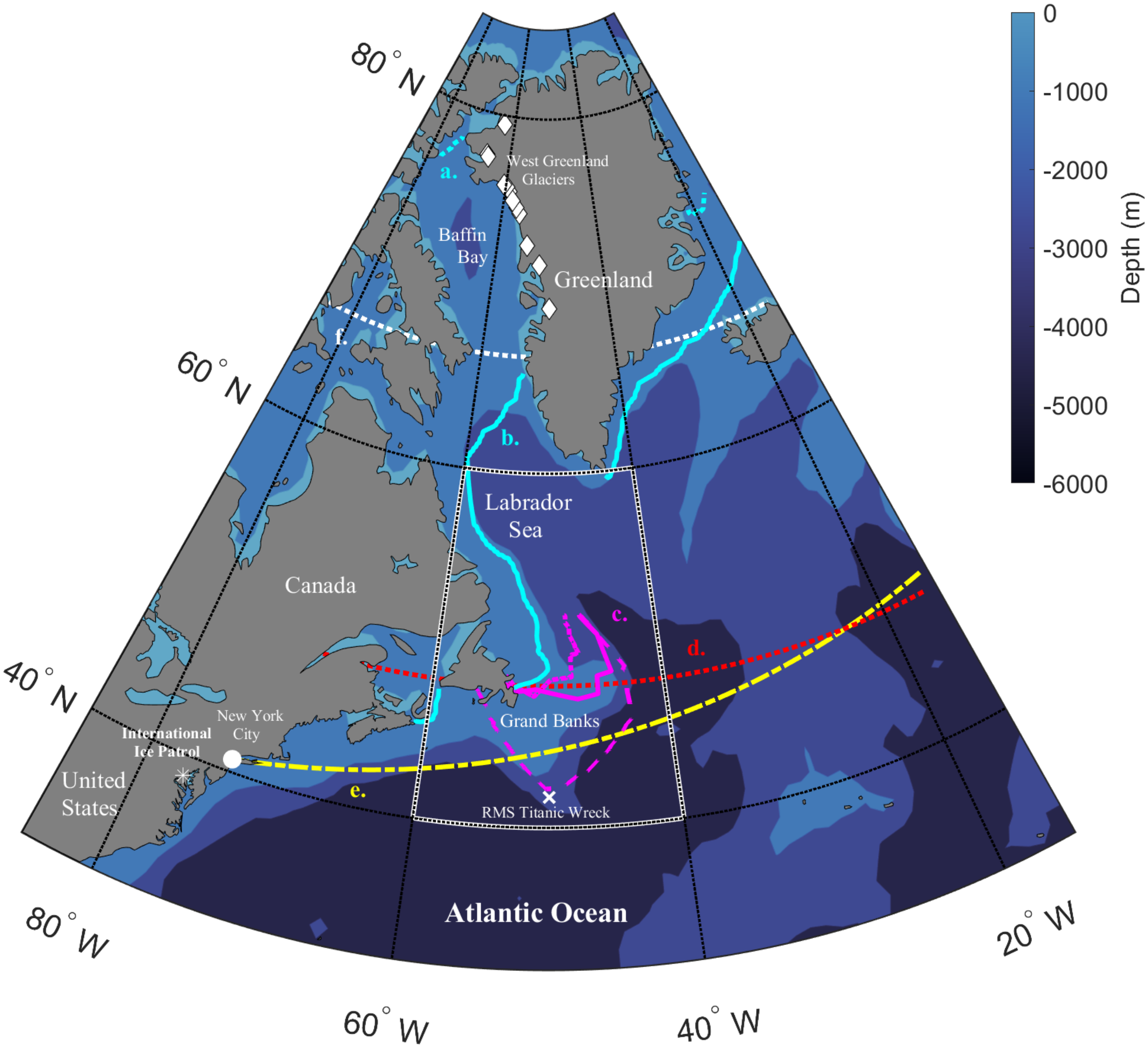

Figure 2.1. International Ice Patrol (IIP) approximate area of responsibility (AOR, *white outlined area*) around the Grand Banks of Newfoundland, Canada, in the North Atlantic Ocean, where icebergs threaten shipping lanes during the Iceberg Season. **a.** The median sea ice extent in September (at its yearly minimum, *cyan dotted line*) and **b.** March (at its yearly maximum, *cyan solid line*) for 1981 to 2010. **c.** The median mid-January (*dotted magenta line*), mid-May (*dashed magenta line*), and early-September (*solid magenta line*) iceberg limits for 1991 to 2020; prior to about 2010, IIP did not systematically monitor icebergs north of 52°N. **d.** 48°N (*red dotted line*); IIP considers this latitude as that south of which icebergs pose a significant threat to the shipping lanes, and records the daily, monthly, and yearly estimated number of icebergs which drift south of it. **e.** An example transatlantic shipping route *(yellow dashed line*) along a rhumb line between Southampton, United Kingdom (UK) and New York City, US. **f.** The Arctic Circle at roughly 66.5°N (*white dotted line*). Icebergs in IIP's AOR calve (break off) into the ocean primarily where Greenland glaciers terminate on the island's west coast (*white diamonds*) (Rignot and Kanagaratnam 2006). They drift south over years in major Arctic and North Atlantic currents and within sea ice, to IIP's AOR. The depiction of west Greenland glacial termini is not comprehensive but includes those which contribute most icebergs to IIP's AOR. Sea ice extents are from the National Snow and Ice Data Center (NSIDC) Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP. See discussion in Section 2.1.

months, IIP focuses on oceanographic research and scientific development of iceberg reconnaissance methods to advance the state of its iceberg warning and monitoring; however, IIP continues to accept reports of icebergs and actively communicates them to CIS.

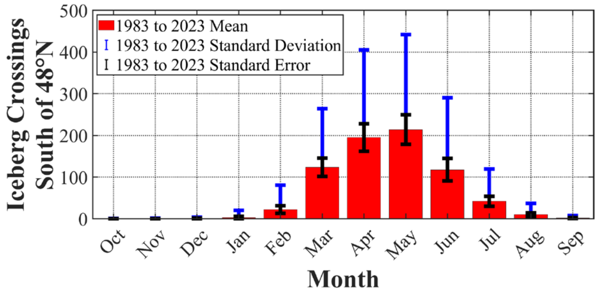

Figure 2.2. Mean estimated number of icebergs which cross south of 48°N each month for Ice Years 1983 to 2023 (*red bars*). The monthly standard deviation (absolute magnitude originating at the mean shown only, *blue capped lines*) and standard error (full range of error shown, *black capped lines*) of those estimated numbers are shown as error bars. 1983 marked the beginning of what IIP defines as the modern reconnaissance era, in which IIP began using modern airborne radar to detect icebergs and computer modeled iceberg drift and deterioration to estimate the daily iceberg population. Iceberg data is from IIP.

2.1.2 Iceberg Season Severity and the Environment

IIP considers one of the metrics of the severity of a given Iceberg Season to be the total number of icebergs that drift south of 48°N latitude in an Ice Year (**Figure 2.3**) (Smith 1926, Trivers 1994). IIP classifies Iceberg Season severity for this metric as light for an iceberg number of 230 or less, moderate for 231 to 1036, severe for 1037 to 1398, and extreme for greater than 1398 (International Ice Patrol 2018). In 2018, IIP reestablished these classes and their thresholds to account for differing iceberg detection and monitoring methods through its history and into what IIP considers as its modern reconnaissance era (1983 to present), during which it has employed sophisticated airborne radar, computerized iceberg drift and deterioration models, and more recently, spaceborne sensors, to monitor icebergs. For a detailed discussion on this classification, see International Ice Patrol, 2018.

Another metric historically used by IIP to characterize Iceberg Season severity is season length, in which a longer season would correspond to greater severity, as the iceberg threat to vessels traversing shipping lanes would be prolonged (Trivers 1994). Additionally, IIP has used the total areal extent of the known iceberg population over an Ice Year as a metric of Iceberg Season severity, given that a greater extent would correspond to icebergs threatening a greater portion of the ocean near the shipping lanes (Trivers 1994, International Ice Patrol 2018).

The absolute number of icebergs that drift into IIP's AOR and south of 48°N latitude, their corresponding spatiotemporal distributions, and the duration of the Iceberg Season vary each year. However, patterns in these parameters emerge due to large-scale and long-term environmental forcings (Bigg, et al. 2014). Notably, large scale atmospheric and regional sea ice conditions have been shown to relate to North Atlantic iceberg conditions. Specifically, higher sea ice concentrations and greater sea ice extent are correlated with greater iceberg numbers and extent, because sea ice protects icebergs from destructive open ocean forces (waves and melting), and conversely from grounding in shallow coastal waters to melt quickly, as they drift south (Marko, et al. 1994, Trivers 1994).

In addition, it has been shown that the mode of the North Atlantic Oscillation (NAO), a temporal pattern of modification of the strengths of a large-scale predominately low surface pressure over Greenland and the Labrador Sea and a large-scale predominately high pressure over the mid North Atlantic, may correlate to iceberg conditions (Hanna, et al. 2011). The normal mode, indicated by a positive NAO index (NAOI) corresponds to a stronger Greenlandic low, offshore winds along the Labrador and northern Newfoundland coasts, increased storms through IIP's AOR, and increased precipitation. These conditions favor offshore transport of icebergs and a potential expansion of the iceberg limit, but also expose icebergs to open ocean where they deteriorate faster. Conversely, a negative NAOI corresponds to a weaker gradient between the Greenlandic low and North Atlantic high, onshore and alongshore-winds along the Labrador and northern Newfoundland coasts, decreased storms through the AOR, and decreased precipitation

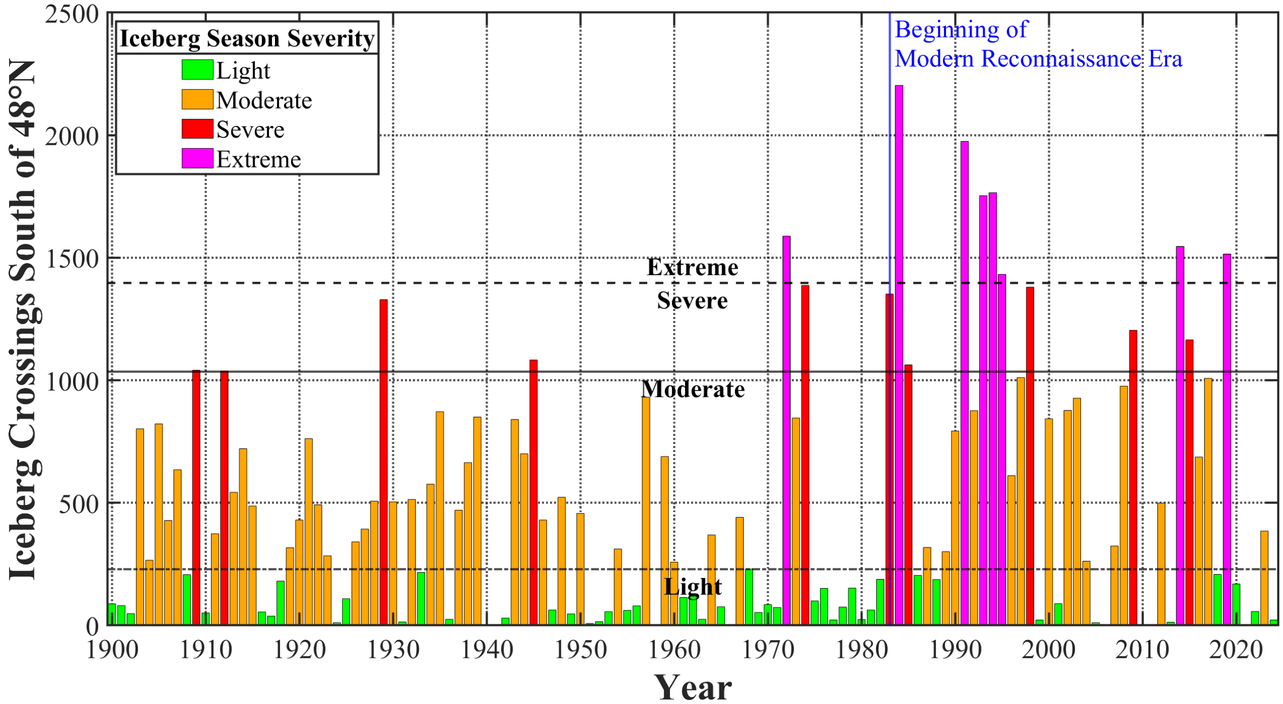

Figure 2.3. Estimated number of icebergs which crossed south of 48°N each Ice Year from 1900 to 2024. IIP classifies Iceberg Season severity in a given Ice Year for this metric as light (*green bars*) for an iceberg number of 230 or less (*black dot-dashed line*), moderate (*orange bars*) for 231 to 1036 (*black solid line*), severe (*red bars*) for 1037 to 1398 (*black dashed line*), and extreme (*magenta bars*) for greater than 1398 (International Ice Patrol 2018). Iceberg data is from IIP; prior to 1914, iceberg data is from the United States Hydrologic Office (Trivers 1994). The beginning of the modern reconnaissance era (1983) is shown as a blue solid line.

(Fettweis, et al. 2013, Noël, et al. 2014). These conditions instead favor onshore transport of icebergs and a contracted iceberg limit, but also harbor icebergs inshore within calmer ocean conditions and coastal sea ice.

While these relationships are known between sea ice, the atmosphere, and icebergs, they remain a topic of ongoing study.

2.2 Ice and Environmental Conditions in Ice Year 2024

In Ice Year 2024, 22 icebergs drifted south of 48°N (see **Figure 2.3**, *rightmost green bar*), classifying the 2024 Iceberg Season as having light severity for this metric, according to the approach adopted by IIP in 2018 (International Ice Patrol 2018). This number also remained well below normal in each month of Ice Year 2024 (**Figure 2.4a**). Icebergs first drifted south of 48°N in February 2024, two months later than the 1983 to 2023 mean, and stopped drifting south of this latitude after May 2024, four months earlier than the 1983 to 2023 mean (see **Figures 2.2** and **2.4a**), shortening the 2024 Iceberg Season from mean length by six months. Finally, iceberg extent in each month of the 2024 Ice Year was lesser than the 1990 to 2010 mid-monthly median (**Figure 2.5**) .

Ice Year 2024 was characterized by lingering extreme heat in both the atmosphere and ocean after record North Atlantic summer temperatures (Aubourg 2023, NOAA NCEI 2023), and weakened atmospheric forcing (relatively neutral near-normal NAOI) during the peak of the Iceberg Season (third Ice Year Quarter, **Figure 2.4b**). Additionally, heightened, largely above-normal offshore winds (**Figures 2.6** and **2.7**) associated with a strong, above-normal positive NAOI occurred during the first, second, and final quarters, likely pushing icebergs into destructive open ocean conditions without the protection of sea ice, which also remained within its 1981 to 2010 mean (see **Figure 2.5**) and developed slower

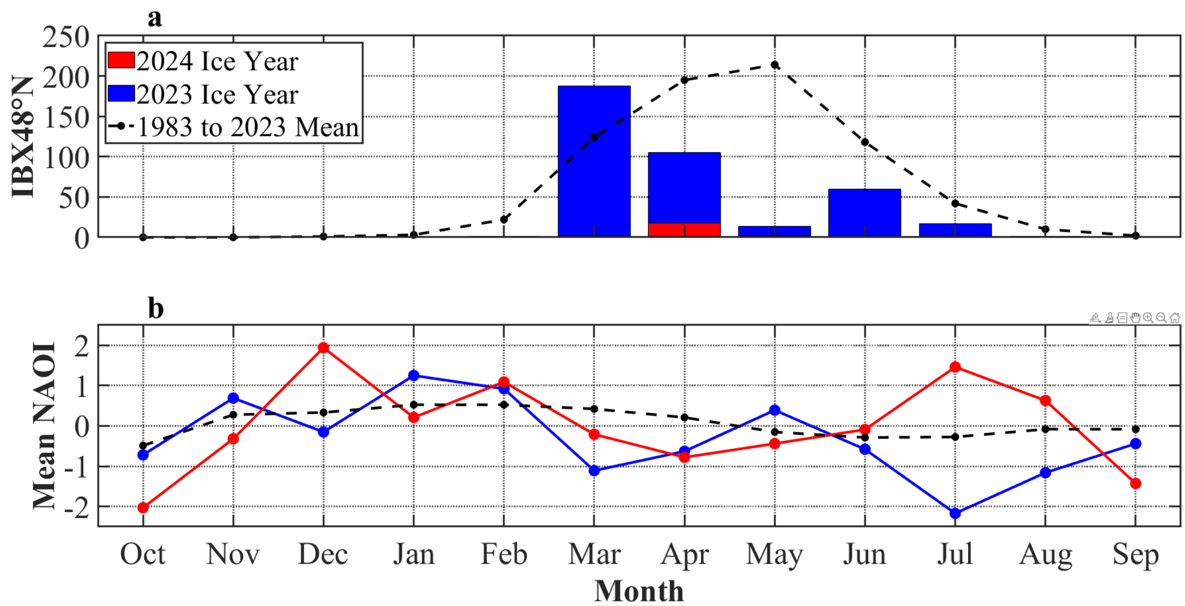

Figure 2.4 Iceberg and atmospheric conditions throughout the 2024 Ice Year as compared to 2023 and the 1983 to 2023 mean. **a.** Number of monthly icebergs which crossed south of 48°N (IBX48°N) in Ice Years 2024 (*red bars*) and 2023 (*blue bars*). The 1983 to 2023 mean number of monthly icebergs which cross south of 48°N is shown in black. **b.** Mean monthly North Atlantic Oscillation Index (NAOI) for Ice Years 2024 (*red dotted solid line*), 2023 (*blue dotted solid line*), and 1983 to 2023 (*black dotted dashed line*). Iceberg counts are from IIP. Mean monthly NAOI values are from the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) Climate Prediction Center (CPC) (NOAA/NWS NCEP Climate Prediction Center 2024).

than normal by several weeks (Canadian Ice Service 2024). The state of the ocean and atmosphere early on in Ice Year 2024 (high temperatures and winds) likely combined to melt icebergs while simulateously forcing them into further conditions which would detereriorate them quickly (open ocean waves) earlier than normal as they drifted south and increased in number along the Labrador Coast. This may have primed the iceberg extent and number to remain constricted for the season. Additionally, the weakened state of the atmosphere (calm weather and low winds) which occurred when iceberg extent typically reaches its yearly maximum may have further restricted the already reduced North Atlantic iceberg population from drifting farther offshore.

All NAOI values reported here are from the NOAA National Centers for Environmental Prediction (NCEP) Climate Prediction Center (CPC) (NOAA/NWS NCEP Climate Prediction Center 2024).

Sections 2.2.1 through **2.2.4** describe in detail the ice and environmental conditions in each quarter of the 2024 Ice Year.

2.2.1 October to December 2023

In the first quarter of Ice Year 2024, surface air temperatures (SATs, 2-m) cooled to freezing through November along the Labrador coast and over the Grand Banks, and over the majority of IIP's AOR north of the Gulf Stream by December (**Figure 2.8**). SATs were several degrees above normal in both October and December **(Figure 2.9**). Sea surface temperatures (SSTs) cooled through December, especially in the Labrador Current, but remained above freezing (**Figure 2.10**). SSTs were above normal throughout the AOR in October and normal to above normal through the rest of the quarter (**Figure 2.11**). All SATs and SSTs reported here are

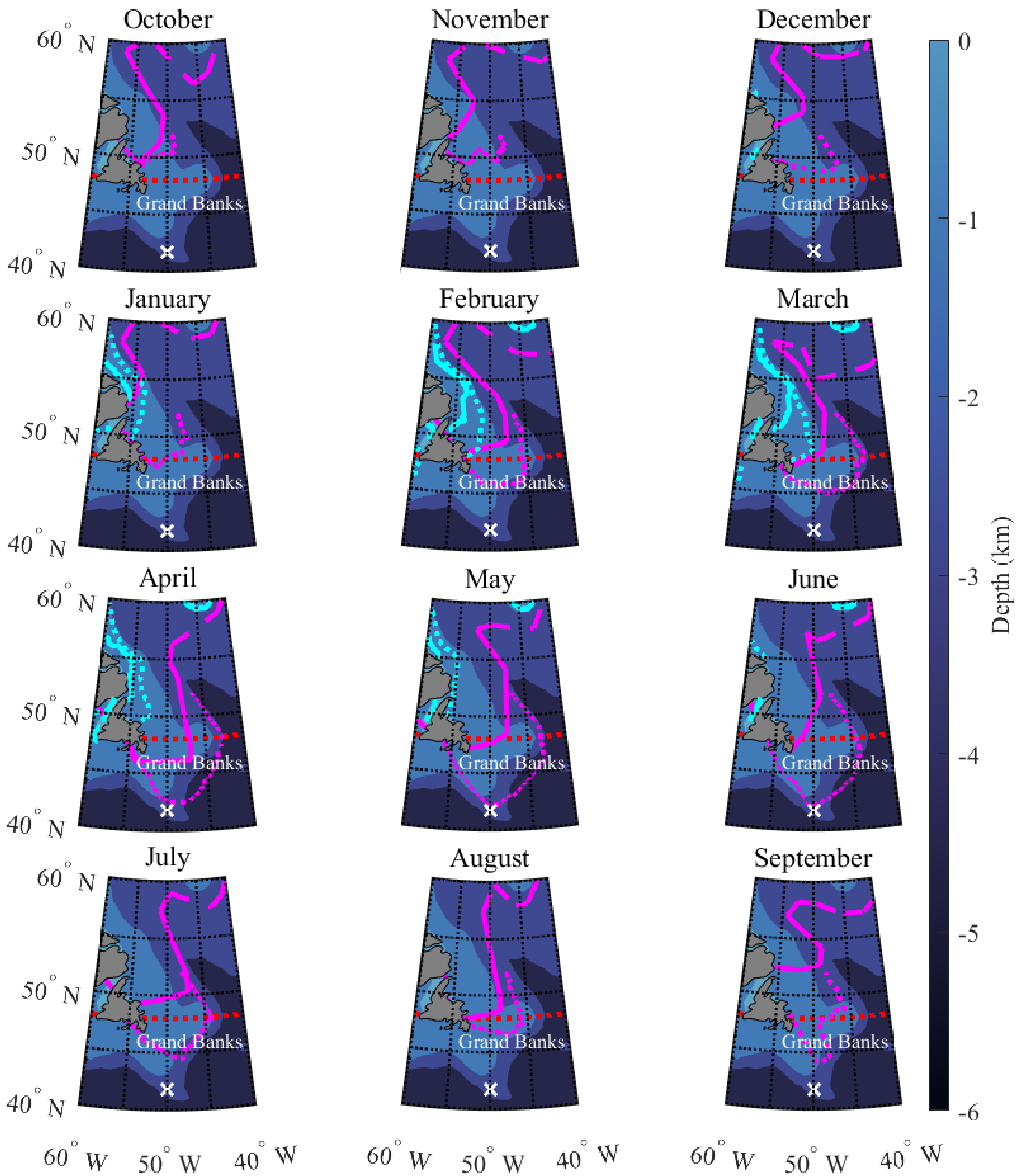

Figure 2.5. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg extents (*magenta solid lines*) in IIP's AOR throughout the 2024 Ice Year in comparison to median monthly sea ice extents for 1981 to 2010 (*cyan dotted lines*) and mid-month iceberg limits for 1991 to 2020 (*magenta dotted lines*). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

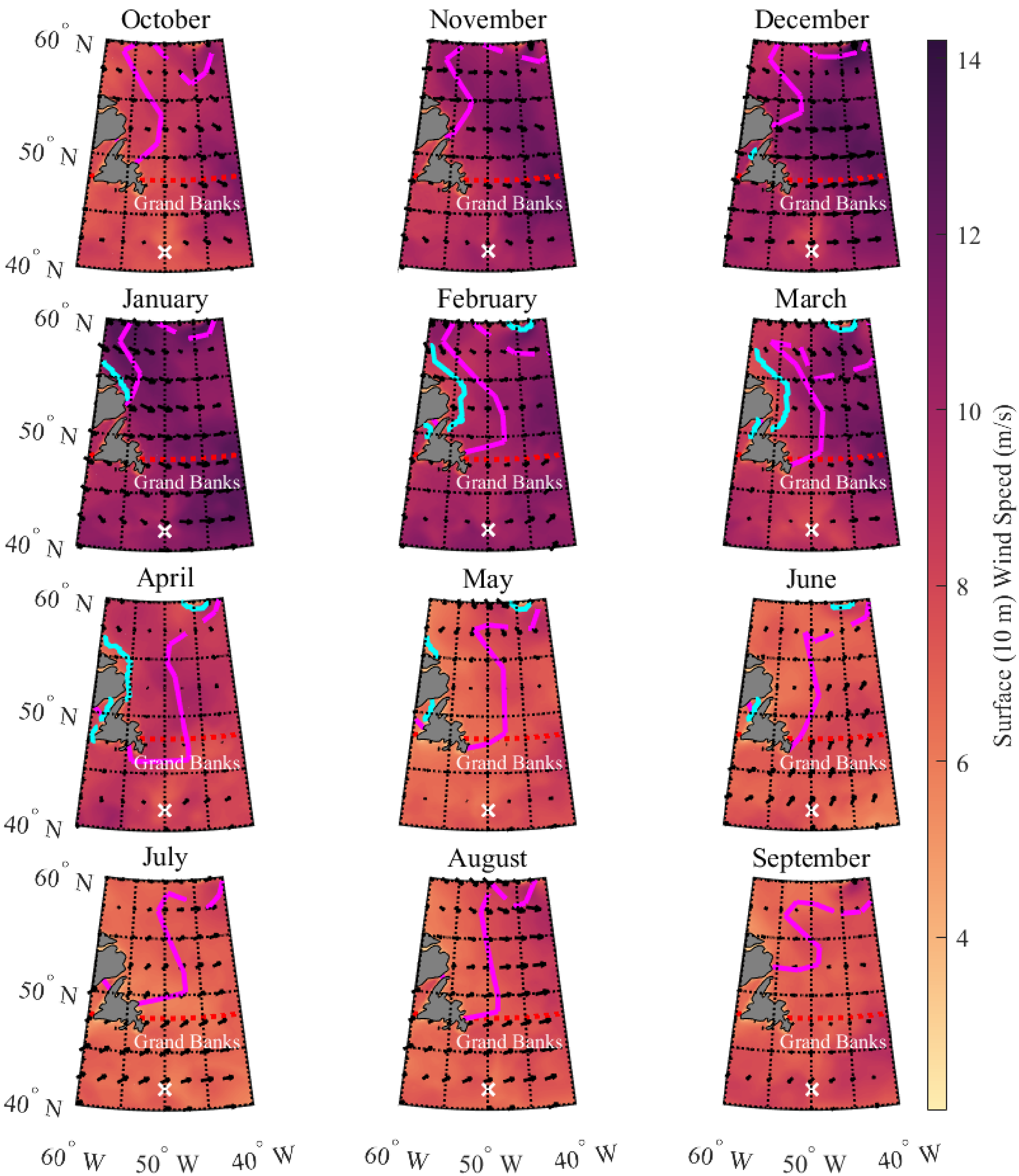

Figure 2.6. Mean monthly wind velocities (10 m) in IIP's AOR throughout the 2024 Ice Year. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. Wind data are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

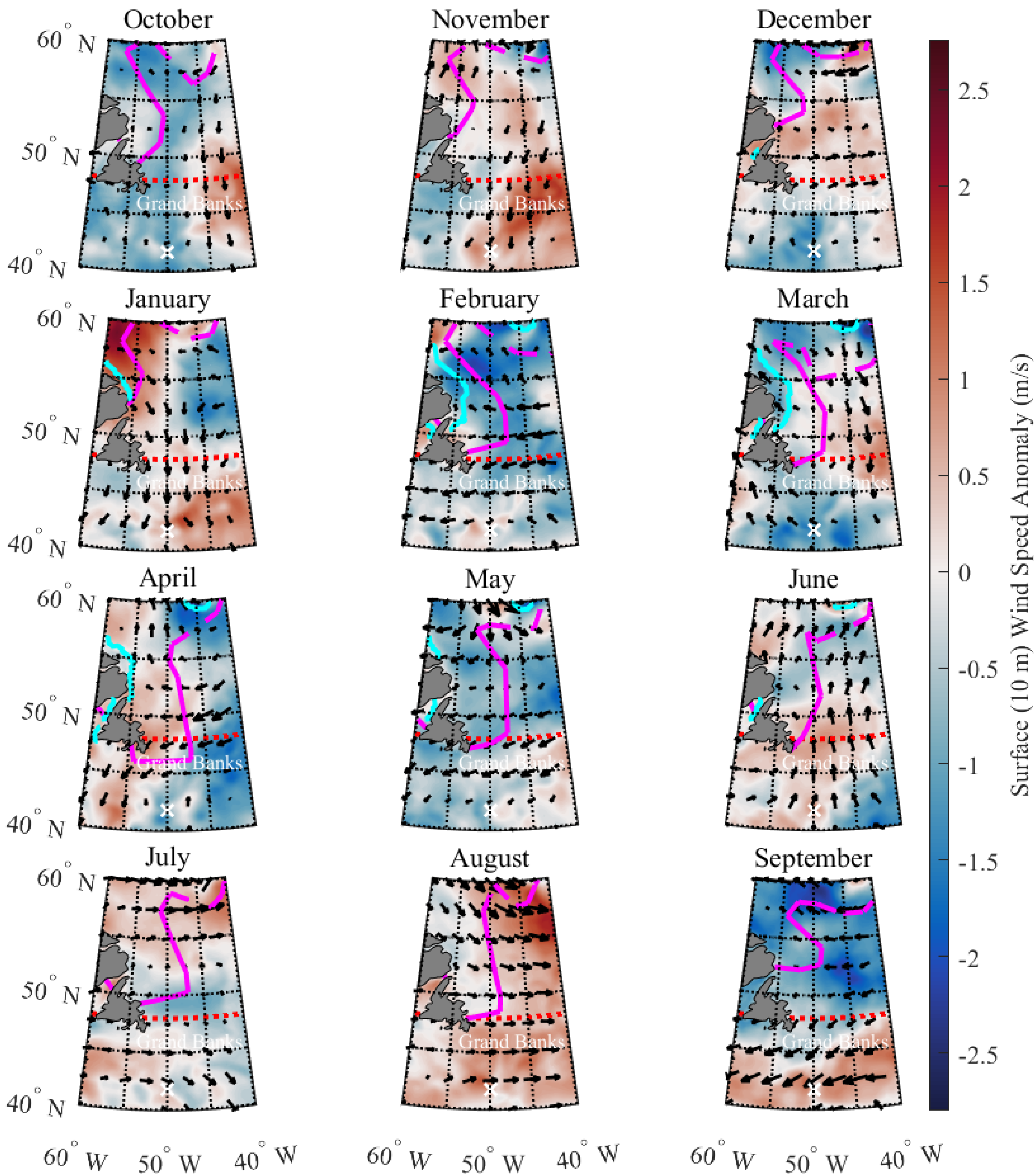

Figure 2.7. Mean monthly wind velocity (10 m) anomalies in IIP's AOR throughout the 2024 Ice Year. Wind velocity anomalies are calculated by subtracting 1983 to 2024 mean monthly wind velocities from the corresponding 2024 monthly wind velocities. Anomalies indicate how different observed values are from normal, and IIP takes environmental normals to be the mean monthly value for the relevant environmental parameter averaged over the modern reconnaissance era (1983 to present). Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SSTs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

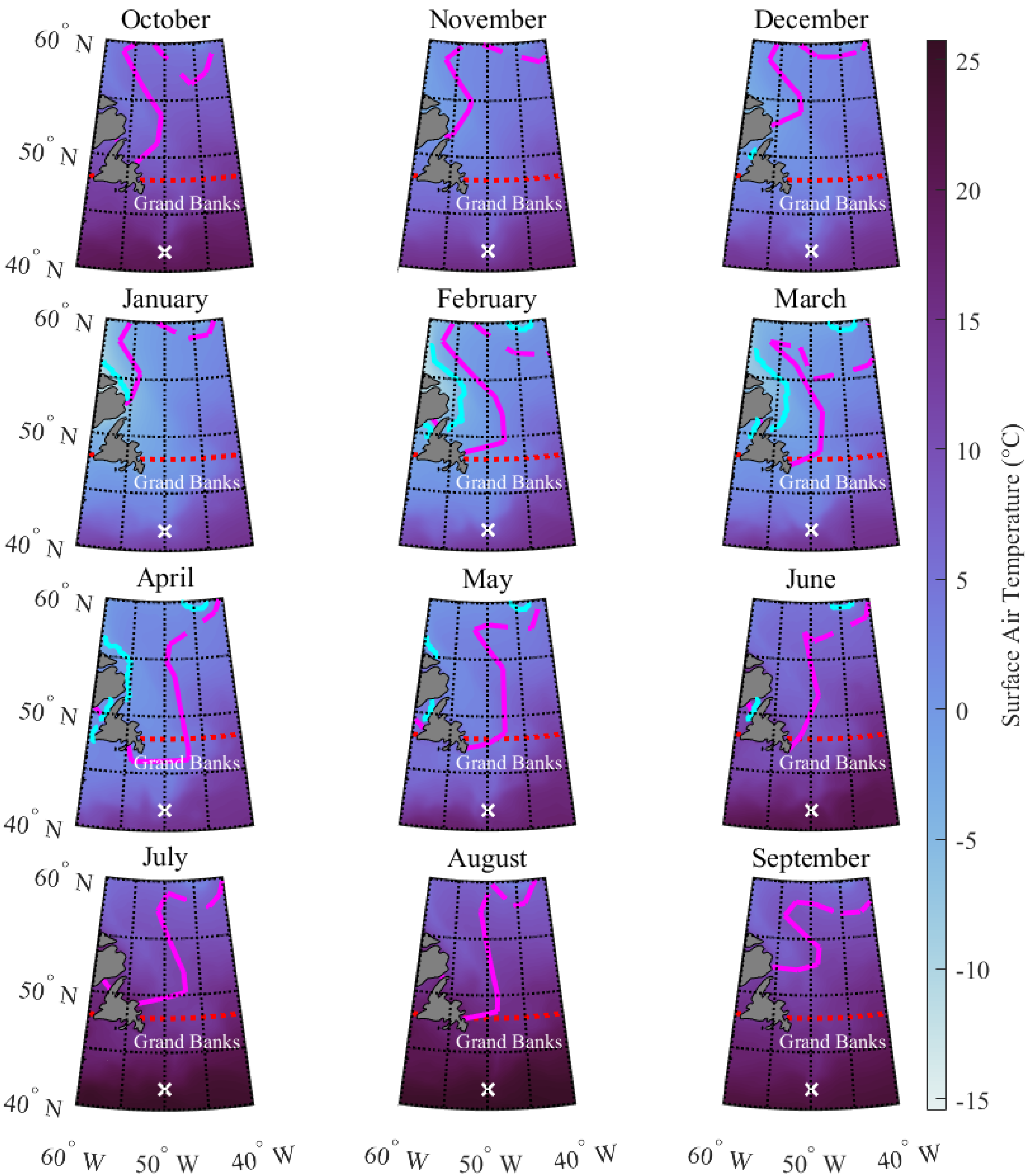

Figure 2.8. Mean monthly surface air temperatures (SATs, 2-m) in IIP's AOR throughout the 2024 Ice Year. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SATs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

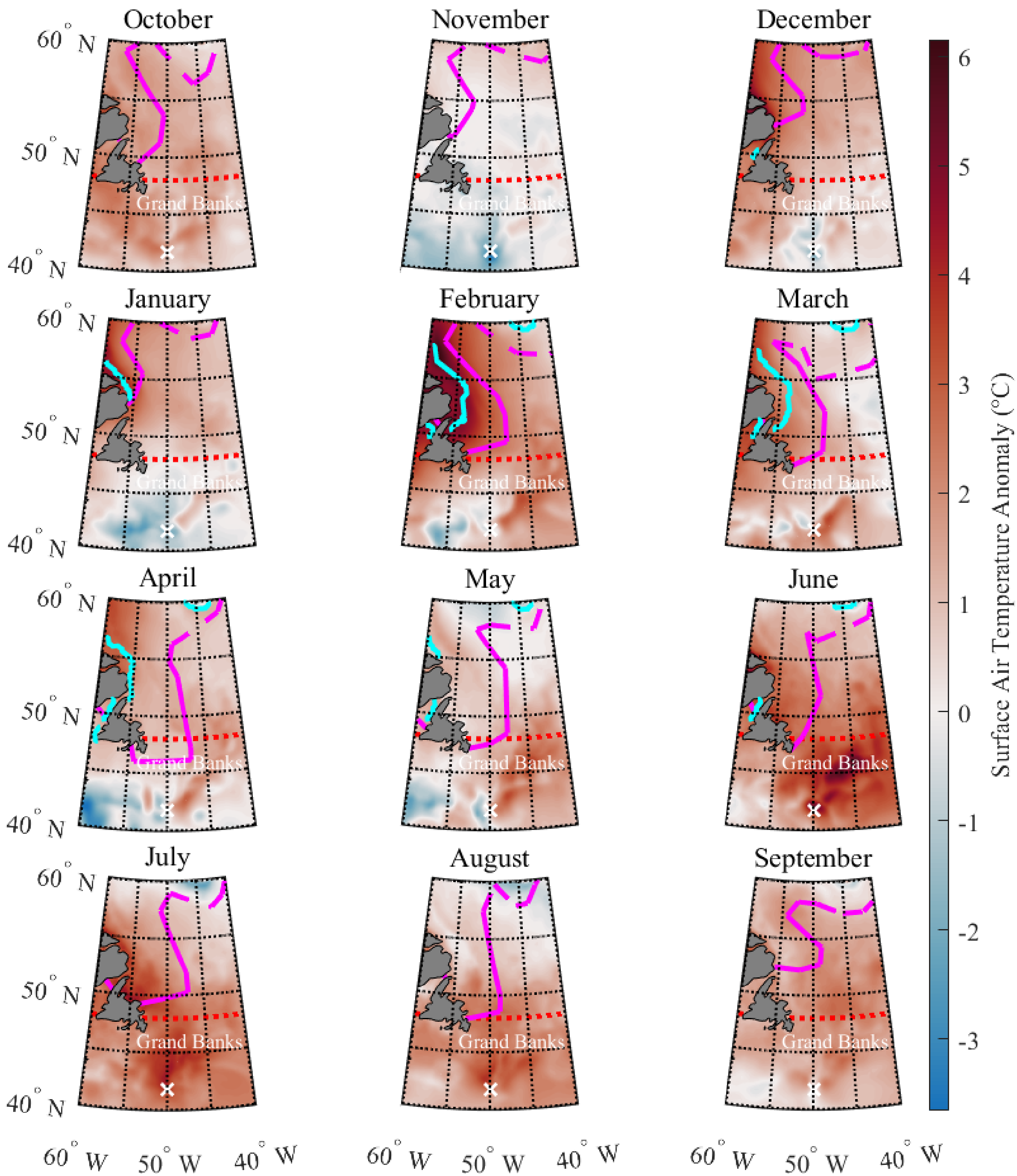

Figure 2.9. Mean monthly surface air temperature (SAT, 2-m) anomalies in IIP's AOR throughout the 2024 Ice Year. SAT anomalies are calculated by subtracting 1983 to 2024 mean monthly SATs from the corresponding 2024 monthly SATs. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SATs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

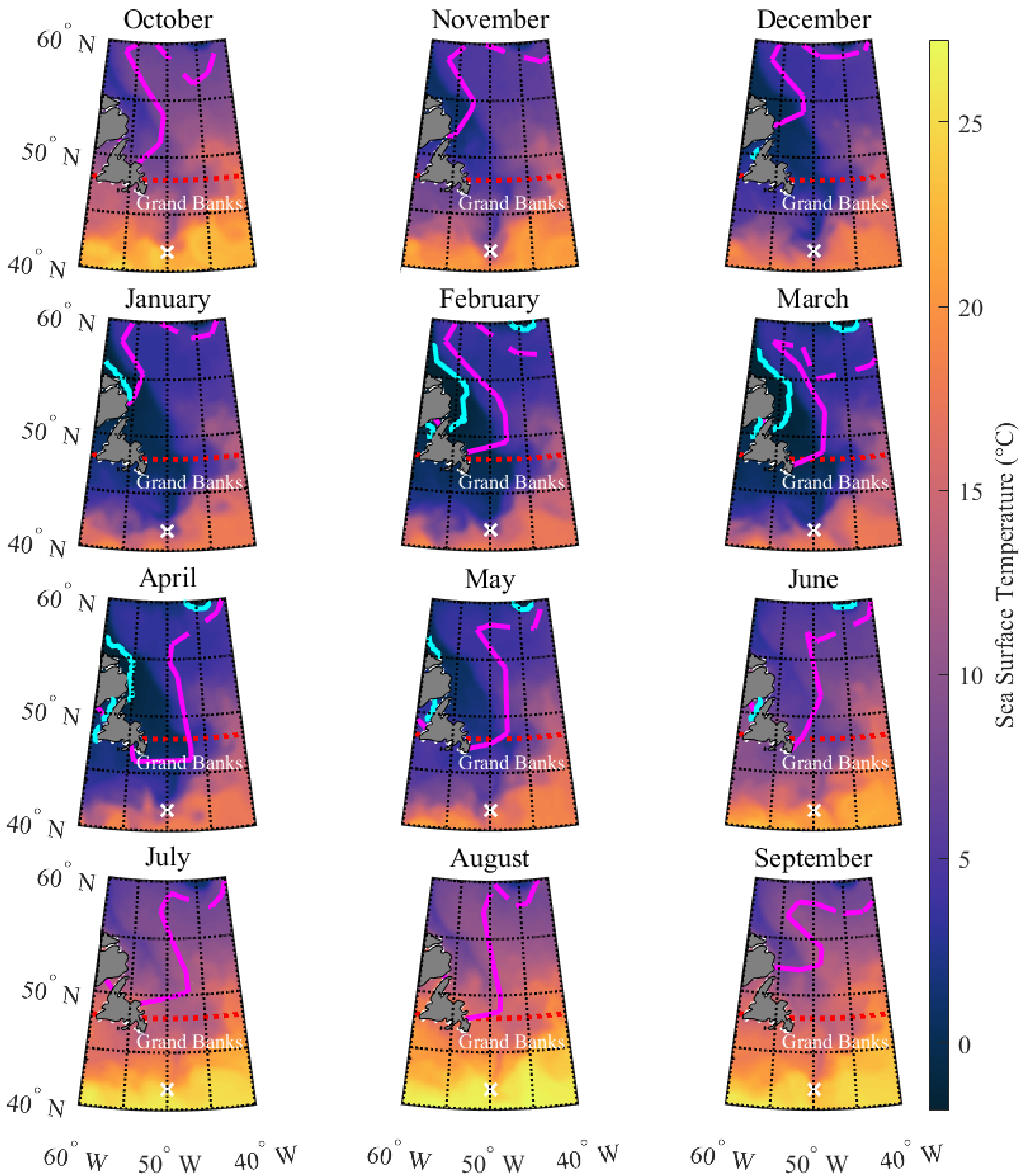

Figure 2.10. Mean monthly sea surface temperatures (SSTs) in IIP's AOR throughout the 2024 Ice Year. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SSTs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

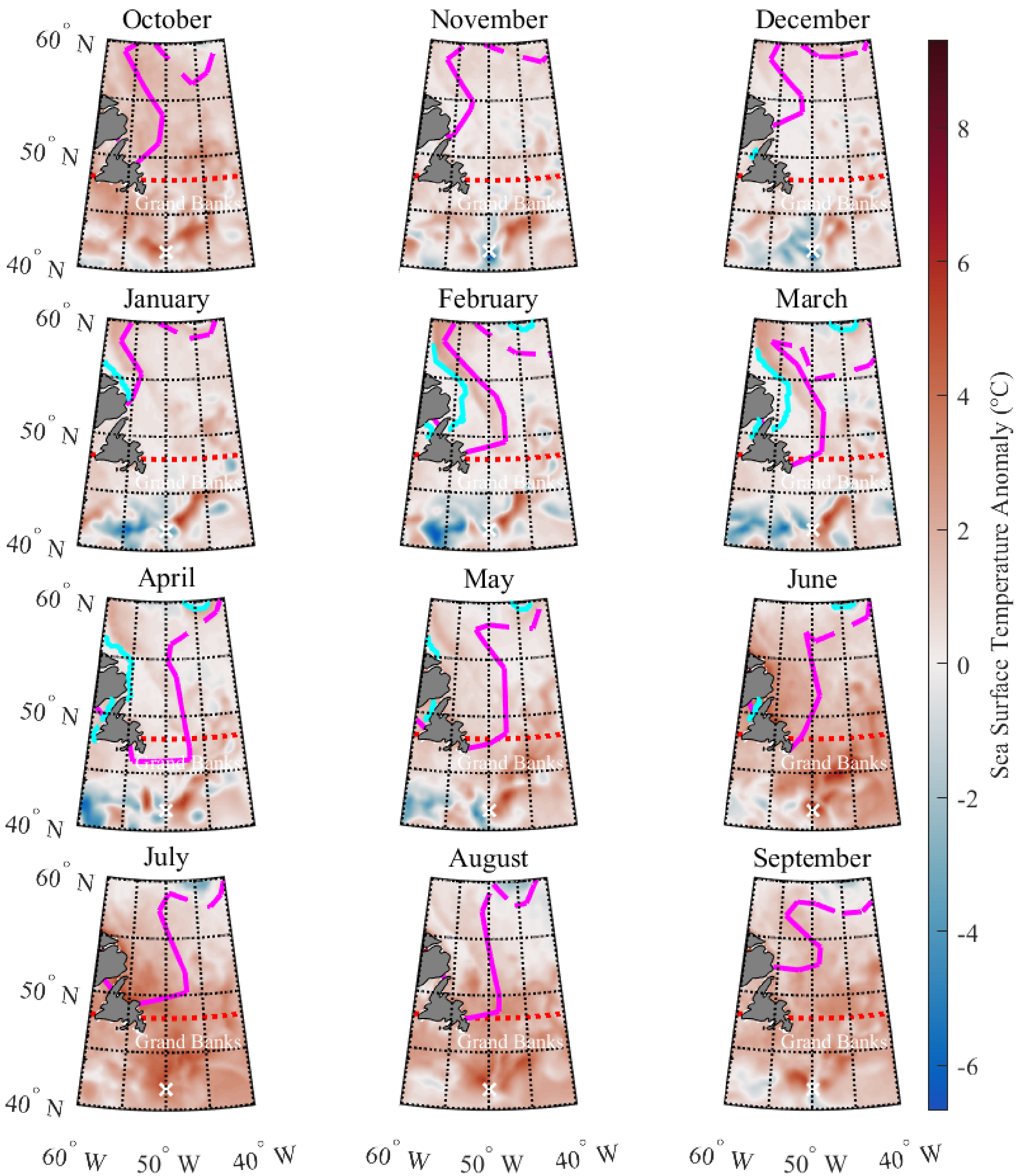

Figure 2.11. Mean monthly sea surface temperature (SST) anomalies in IIP's AOR throughout the 2024 Ice Year. SST anomalies are calculated by subtracting 1983 to 2024 mean monthly SSTs from the corresponding 2024 monthly SSTs. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SSTs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

from the Fifth Generation European Centre for Medium-Range Weather Forecasting (ECMWF) Reanalysis (ERA5) monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024).

Arctic sea ice reached minimum extent in mid-September 2023 (United States National Ice Center 2023). Sea ice expanded south through the first quarter but remained north and west of the AOR with the exception of ice growth under freezing temperatures in December along the western coast of Newfoundland within the Strait of Belle Isle (see **Figures 2.5** and **2.8**). All sea ice extents reported here are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017).

The mean monthly NAOI increased sharply from roughly negative two in October (below-normal, see **Figure 2.4b**) to roughly two in December (above-normal). Mean sea level pressure (MSLP) gradients correspondingly sharpened into December between the normal-mode low and high pressures over the Labrador Sea and mid North Atlantic respectively (**Figure 2.12**). MSLPs shifted from well below to well above normal over the AOR through this quarter (**Figure 2.13**). Consistent with the return to a strong positive sign (normal mode) of the NAOI, winds strengthened offshore into December (see **Figure 2.6**), reaching above-normal speeds over most of the AOR during November and December (see **Figure 2.7**). Total precipitation increased to well above normal values in November especially (**Figures 2.14** and **2.15**). All MSLPs, wind data, and precipitation rates are from the ECMWF ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024).

Wave energy increased correspondingly through the quarter, with above-normal significant wave heights (SWHs) in October and November throughout much of the AOR, and especially to the southeast of Newfoundland outside of the iceberg limit (**Figures 2.16** and **2.17**). In December, SWHs remained above normal along the iceberg limit. All SWHs and Mean Wave Periods (MWPs) are from the ECMWF ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024).

Exposed to above-normal temperatures and ocean waves under strong offshore winds and growing storm activity, the iceberg limit contracted from 49°N in October to 53°N in December 2023. The iceberg limit remaining within each mid-month median iceberg extent for 1991 to 2020 (see **Figure 2.5**), retreating far north of normal extent by December. No icebergs crossed south of 48°N during this first quarter of the Ice Year (see **Figure 2.4a**).

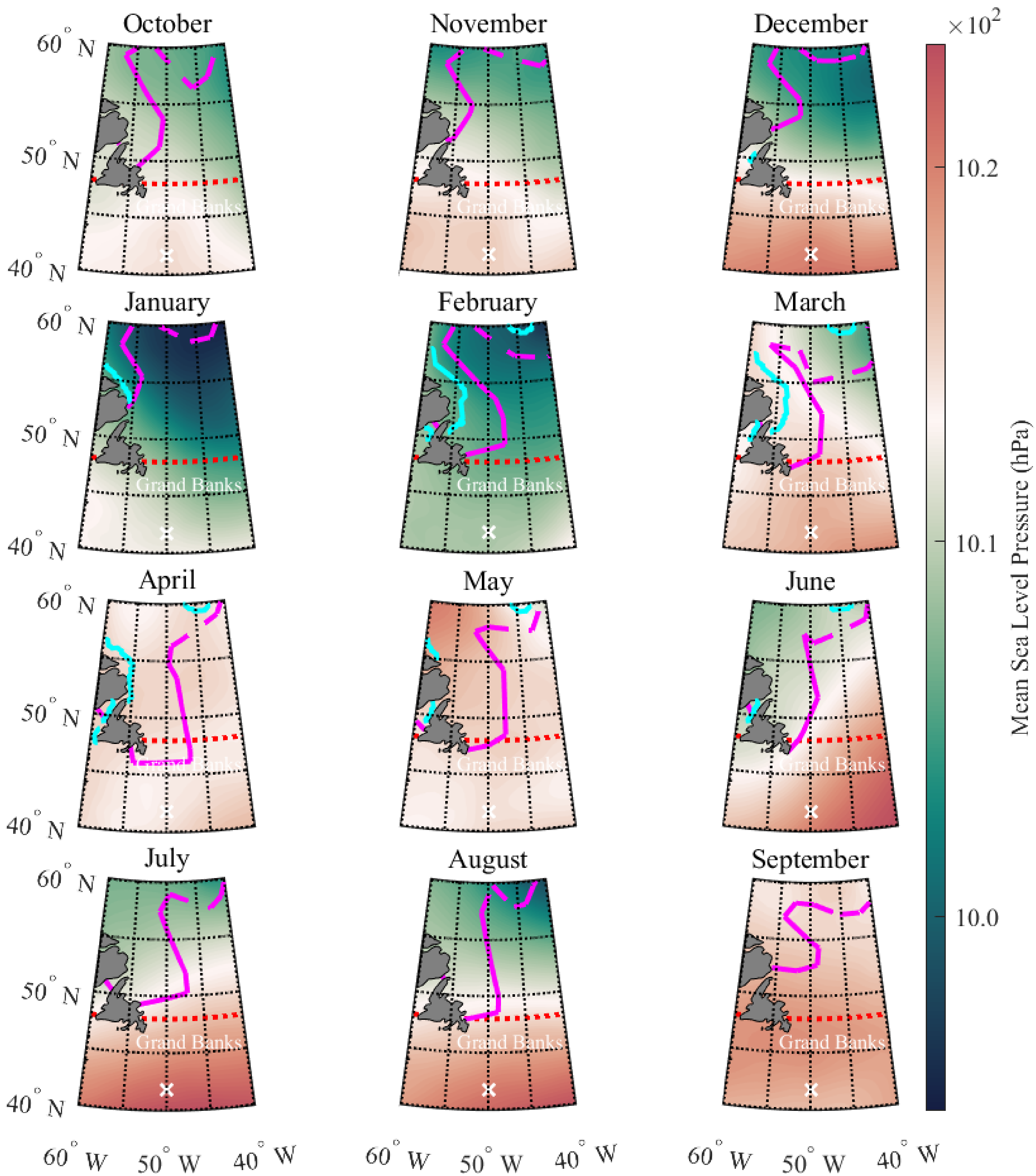

Figure 2.12. Mean monthly mean sea level pressures (MSLPs) in IIP's AOR throughout the 2024 Ice Year. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. MSLPs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

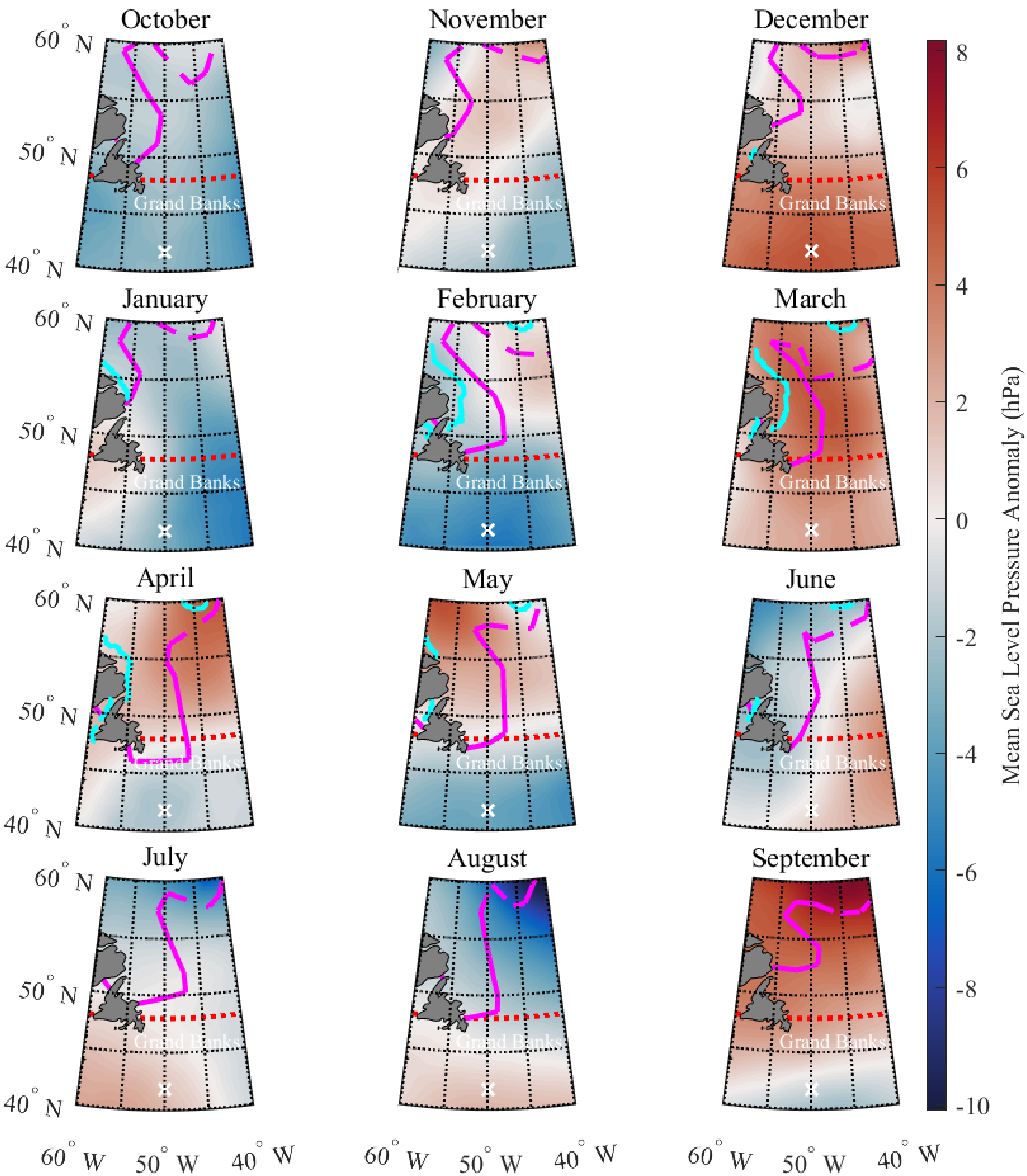

Figure 2.13. Mean monthly sea level pressure (MSLP) anomalies in IIP's AOR throughout the 2024 Ice Year. MSLP anomalies are calculated by subtracting 1983 to 2024 mean monthly MSLPs from the corresponding 2024 monthly MSLPs. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. MSLPs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

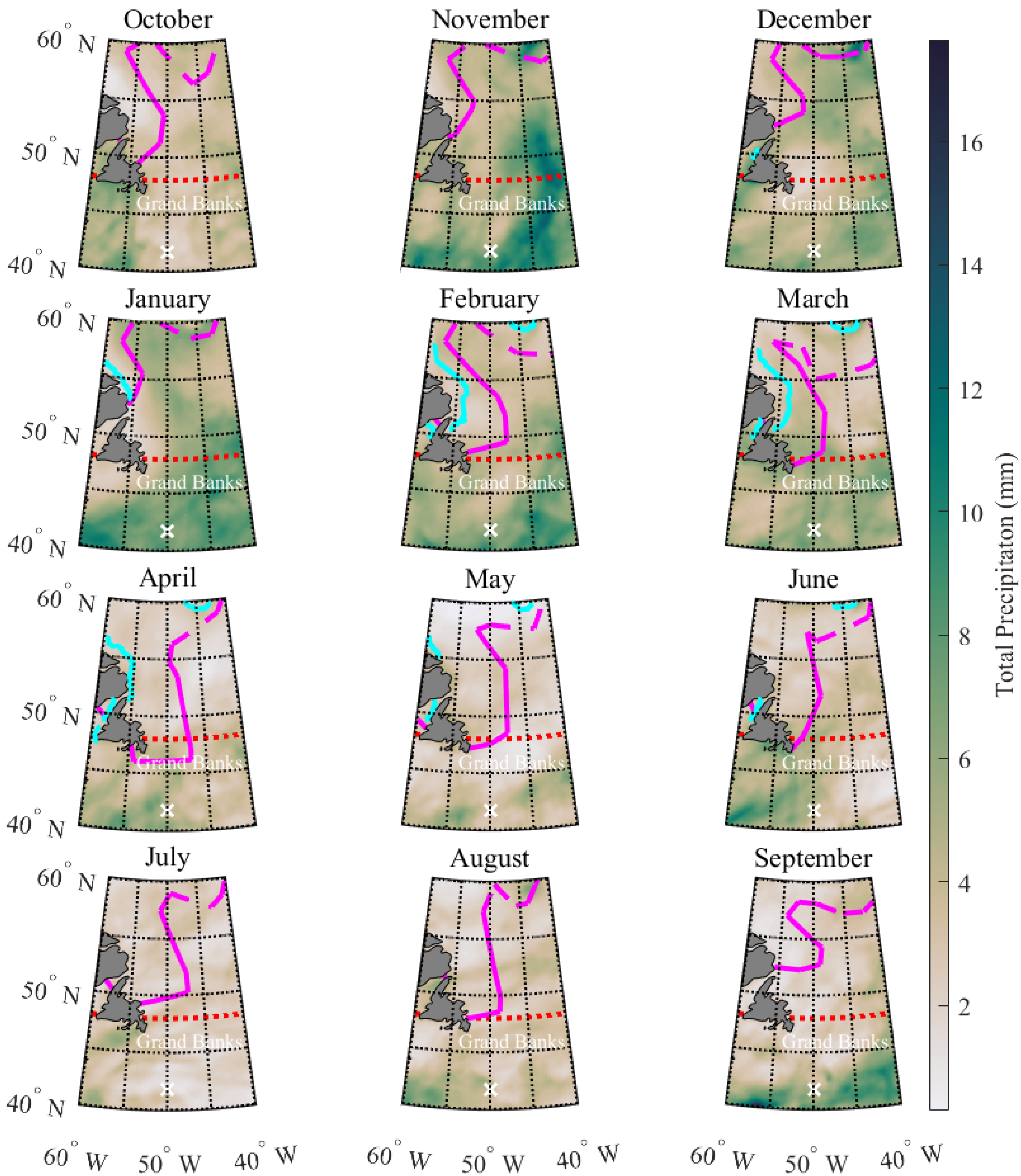

Figure 2.14. Mean monthly total precipitation in IIP's AOR throughout the 2024 Ice Year. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. Precipitation data are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

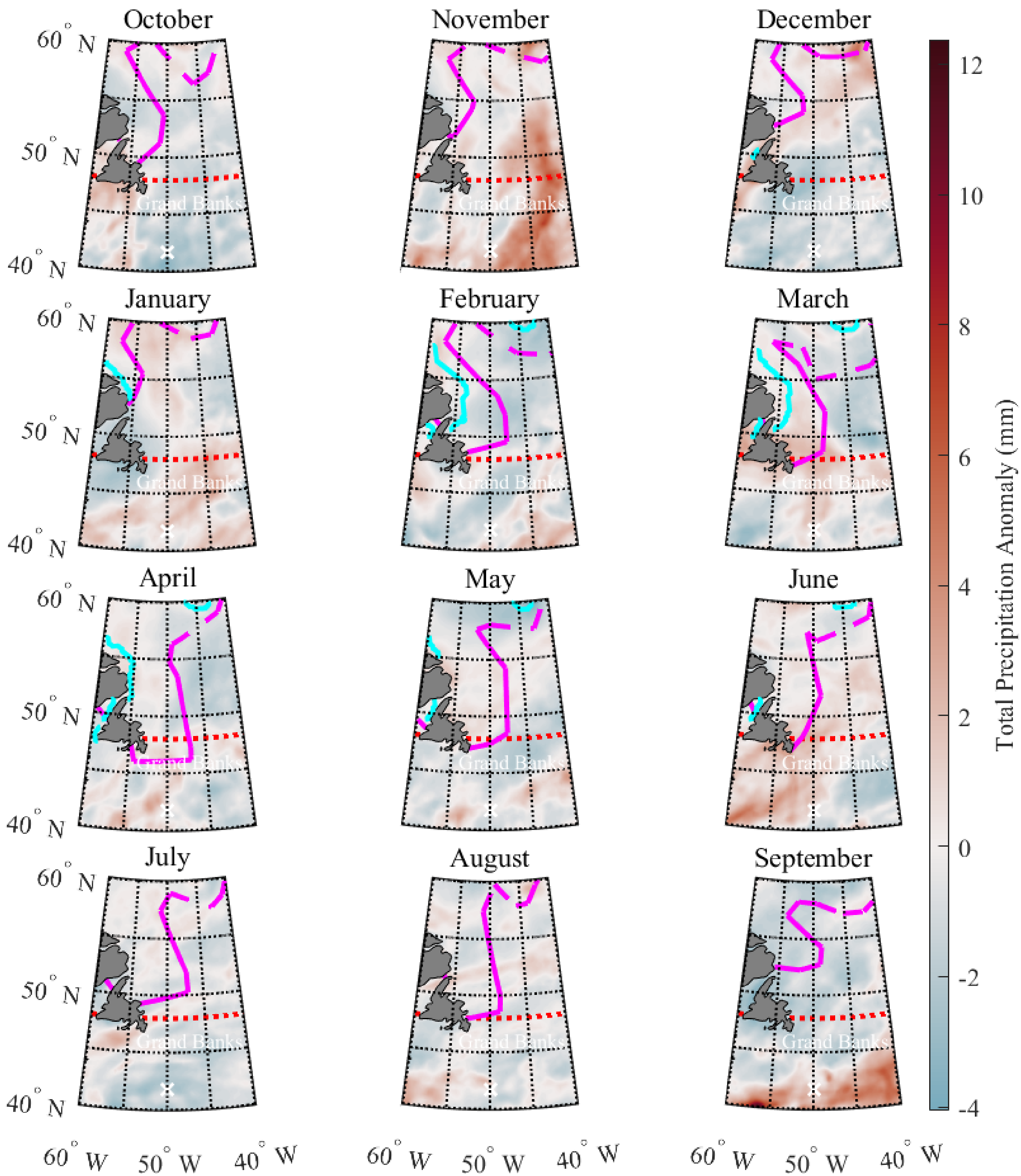

Figure 2.15. Mean monthly total precipitation anomalies in IIP's AOR throughout the 2024 Ice Year. Total precipitation anomalies are calculated by subtracting 1983 to 2024 mean monthly total precipitation from the corresponding 2024 monthly total precipitation. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SSTs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

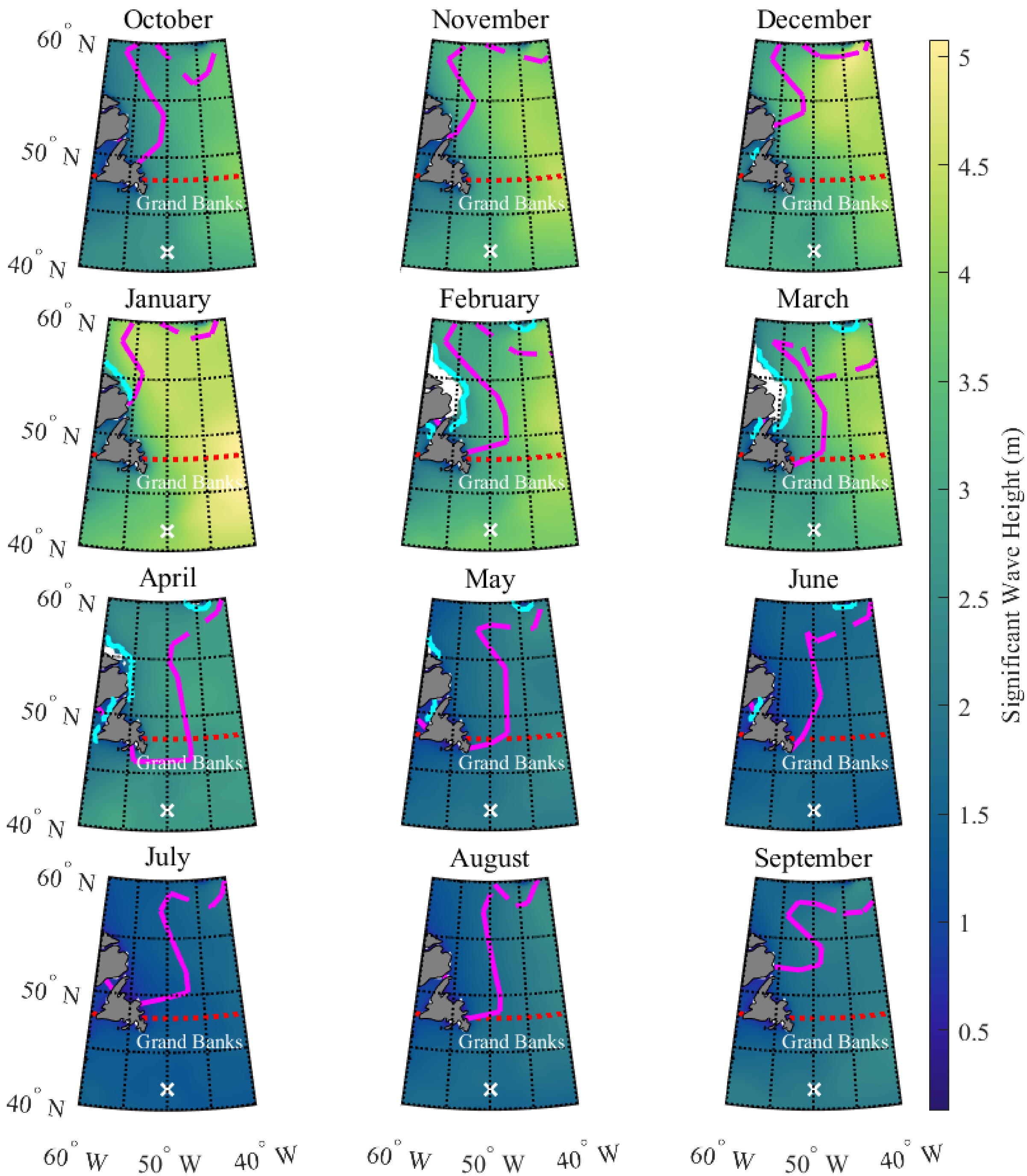

Figure 2.16. Mean monthly significant wave heights (SWH) in IIP's AOR throughout the 2024 Ice Year. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SWHs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Areas in white indicate no data. Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

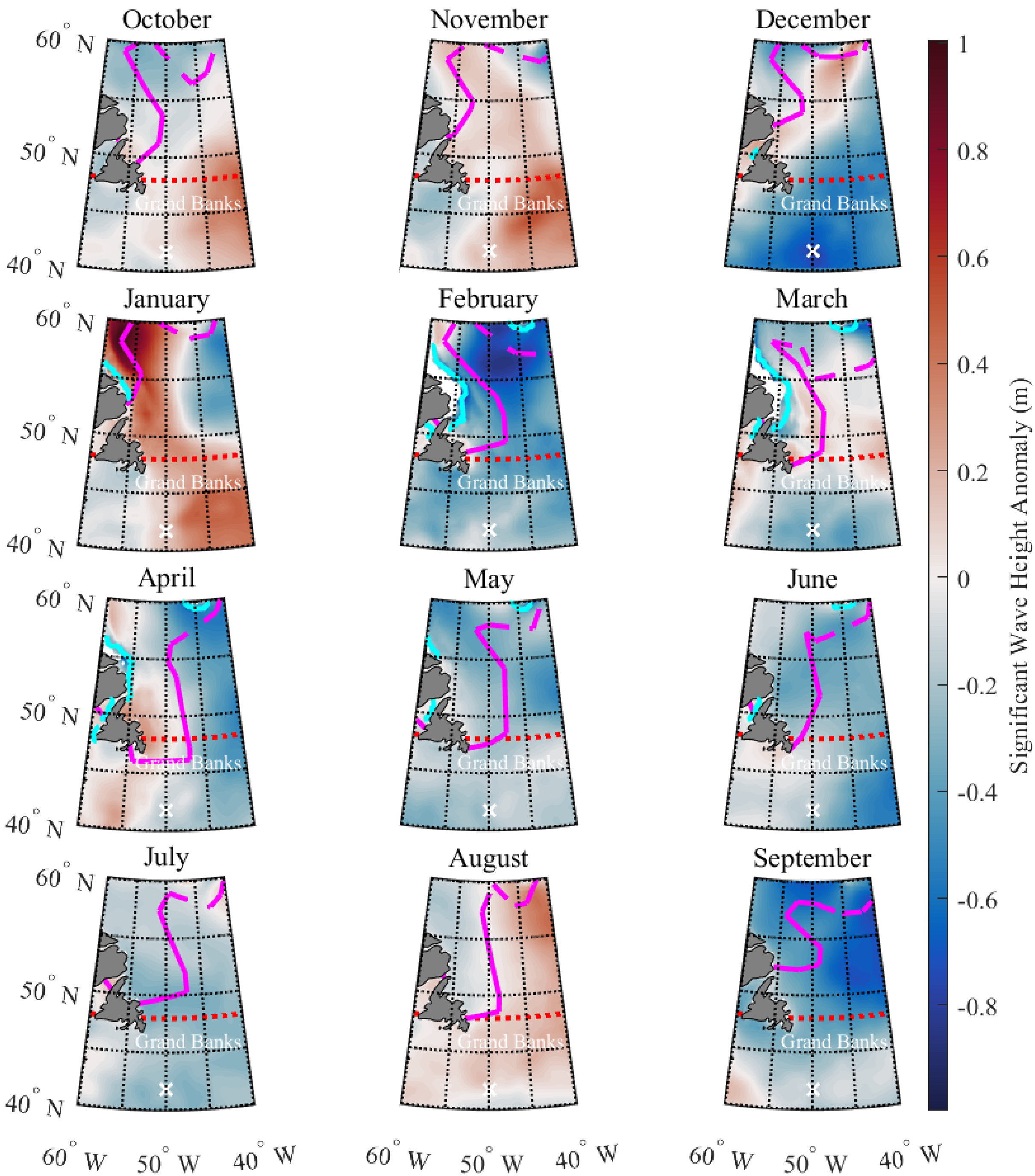

Figure 2.17. Mean monthly significant wave height (SWH) anomalies in IIP's AOR throughout the 2024 Ice Year. SWH anomalies are calculated by subtracting 1983 to 2024 mean monthly SWHs from the corresponding 2024 monthly SWHs. Median monthly sea ice extents (*cyan solid lines*) and mid-month iceberg limits (*magenta solid lines*) are shown. SSTs are from the ERA5 monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024). Areas in white indicate no data. Sea ice extents are from the NSIDC Sea Ice Index, Version 3 (Fetterer, et al. 2017). Iceberg limits are from IIP.

2.2.2 January to March 2024

SATs in the AOR continued to cool to below freezing in the quarter, reaching minimum values for the year over the Labrador Sea and Grand Banks in February (see **Figure 2.8**). However, SAT anomalies reached their maximum (5°C above normal) over the Labrador Sea in the same month (see **Figure 2.9**). SSTs continued to cool throughout the AOR through March and to freezing in the Labrador Current (see **Figure 2.10**). SSTs were several degrees above normal in October throughout the AOR and remained slightly warmer than normal through the quarter (see **Figure 2.11**). Well above-normal atmospheric and ocean temperatures in the North Atlantic during this winter quarter indicate that extreme heat lingered in the AOR after shattering summer records in 2023.

Subfreezing SATs governed sea ice formation and the location of the sea ice edge during the quarter (see **Figure 2.5**); sea ice expanded south and east from the Labrador coast to its maximum extent at 50°N, 57°W in March. Limited by exceptionally warm air over the ocean, maximum sea ice extent was well below normal and the sea ice edge remained 2° farther north than at the same time in 2023 (International Ice Patrol 2023). In addition, the sea ice edge remained north of the 1981 to 2010 median through the quarter, approaching median eastern extent only in February and March in the Labrador Sea, but never reaching it in Newfoundland waters. In 2023, sea ice extended as far south as St. John's, Newfoundland for the first time since 2017 (International Ice Patrol 2023), but did not extend much farther than the northern Newfoundland peninsula in 2024.

The mean monthly NAOI decreased to near-zero values in the second quarter of the Ice Year, rising again to unity in Febuary alone (see **Figure 2.4b**). MSLPs remained low to near-normal over most of the AOR into February and MSLP gradients shoaled through March with the weakening of the Greenland low (see **Figure 2.12**). MSLPs were above normal for the region (by 2 to 4 hPa) in March (see **Figure 2.13**). Consistent with the near-neutral sign of the NAOI and the weaknening of surface pressure gradients, wind speeds decreased to near- to below-normal values through the quarter while remaining weakly offshore as a part of a larger normal cyclonic wind pattern over the region (see **Figures 2.6** and **2.7**). Total precipitation increased again in January and decreased again through March over the AOR (see **Figure 2.14**) but remained slightly above normal over the Grand Banks and the Labrador Current through the quarter (see **Figure 2.15**).

The ocean responded to these calmer atmospheric conditions in the second quarter: SWHs, which increased in January to above-normal maximum values (~5 m) for the Ice Year, decreased through March to near- to below-normal values (~3 m) over the Grand Banks (see **Figures 2.16** and **2.17**).

From January to March, the iceberg limit expanded south and east outside of the sea ice edge, reaching into the major transatlantic shipping lanes south of 48°N by March (see **Figure 2.5**). The iceberg limit remained well within the mid-month median for 1991 to 2020 through the quarter. Only two icebergs drifted south in the quarter – one at the end of February and one in March – much fewer than the 1983 to 2022 mean number for these months (see **Figure 2.4a**). While decreased ocean activity may have protected icebergs from breakup by waves, lingering extreme atmospheric and ocean heat coupled with calmer atmospheric conditions favoring weakened offshore winds may have ensured the constriction of the sea ice maximum and iceberg limits in this quarter.

2.2.3 April to June 2024

In the third quarter of the Ice Year, SATs warmed rapidly, rising above freezing (see **Figure 2.8**) and well above normal (see **Figure 2.9**) in June over the entire AOR; in June, extreme air temperatures for the time of year blanketed waters over the

Grand Banks and in the North Atlantic Current especially. SSTs warmed rapidly through June, with freezing water dissappearing over the Grand Banks and in the southern Labrador Current by May, (see **Figure 2.10**). SSTs were above normal throughout the quarter, but rose quickly in June to maximum anomalous values for the Ice Year (see **Figure 2.11**).

Under quickly rising temperatures, sea ice retreated rapidly northwest through the quarter, all but disappearing from the AOR by June (see **Figure 2.5**). Sea ice extent remained inside the 1981 to 2010 median in every month except for June, during which a band of sea ice in the Strait of Belle Isle remained. June was the last month in which sea ice was present in the AOR during the 2024 Ice Year.

The mean monthly NAOI rose to zero again by the end of the quarter after nearing a value of negative one in April (see **Figure 2.4b**). MSLPs rose to mean to above-mean atmospheric pressure values accordingly over the AOR through the quarter (see **Figure 2.12**), with below-mean atmospheric pressure values moving over the north Labrador Sea in June. For April and May, MSLPs were above-normal over the north Labrador Sea, and below-normal over the southern Grand Banks and the North Atlantic Current (see **Figure 2.13**). This spatial pattern largely reversed in June, with below-normal pressures covering the northwestern AOR and western Grand Banks, and above-normal pressures over the eastern Grand Banks and North Atlantic Current. MSLP gradients sharpened in this quarter, especially in May. Corresponding to the NAOI, winds turned weakly on- and alongshore and decreased throughout the AOR to below-normal minimum values for the Ice Year in May (see **Figures 2.6** and **2.7**), increasing again slightly northeastward offshore in June. Precipitation also dropped to mimimum values for the Ice Year (see **Figure 2.14**) and largely remained below normal for the AOR, with the exception of above-normal precipitation in June over the southern Grand Banks (see **Figure 2.15**).

Ocean waves continued to attenuate rapidly (see **Figure 2.16**) to below-normal values (see **Figure 2.17**) over the entire AOR through June, when SWHs reached no greater than a few meters even in the open ocean.

An already depleted iceberg popluation was further kept from severely threatening the shipping lanes during this quarter (the height of the 2024 Iceberg Season) by lingering heat and calm weather. The icebergs that were drifting south to threaten the lanes at this point were kept from being pushed far to the southeast by weak winds and were likely well on their way to full deterioration. As a result, a below-mean number of icebergs drifted south of 48°N (for the quarter sum of twenty, see **Figure 2.4a**), and the iceberg limit remained well within the 1991 to 2020 median in each month of the third quarter (see **Figure 2.5**). Even so, the southern iceberg limit continued to threaten shipping lanes, remaining south of 48°N through the quarter.

2.2.4 July to September 2024

SATs continued to warm rapidly (see **Figure 2.8**) over the AOR and remained well above normal (see **Figure 2.9**) in the final quarter of Ice Year 2024; they reached maximum values in August. SSTs also continued to warm rapidly (see **Figure 2.10**) to above-normal summer maxima (above 25°C over the southern Grand Banks, see **Figure 2.11**) similar to the record-shattering North Atlantic temperatures in summer 2023, continuing a year-long marine heatwave (Thiem 2024). SSTs reached a maximum in August as well, with southern AOR ocean tempartures exceeding 25°C (77°F).

The remaining sea ice in the AOR melted fully in July and the sea ice edge remained well north through the rest of the Ice Year (see **Figure 2.5**).

The mean monthly NAOI continued to rise to positive values in the final quarter of the Ice Year (see **Figure 2.4b**, hitting a local peak in July) before returning to negative in September. MSLPs correspondingly continued to decrease (see **Figure 2.12**) in the northern AOR and began to increase in the southern AOR with a sharpening gradient between, reflecting the return to a normal North Atlantic Oscillation mode. Only MSLPs in the northern AOR in this quarter were remarkably anomolous, with values approaching 10 hPa below normal (see **Figure 2.13**). Winds increased offshore into August (see **Figure 2.6**), when they reached above-normal offshore speeds over the entire (but especially northern) AOR and decreased markedly and turned onshore in September (see **Figure 2.7**). Precipitation rates remained low (see **Figure 2.14**) into August but increased to above-normal values within the Gulf Stream in the southern AOR in September (see **Figure 2.15**).

The ocean kept relatively calm through the quarter (see **Figure 2.16**), with SWHs well below-normal throughout most of the AOR in September (see **Figure 2.17**). SWHs increased slightly above normal in August outside of the iceberg limit.

The iceberg limit correspondingly retreated rapidly north through the quarter (See **Figure 2.5**), reaching 48°N again only in August. No icebergs drifted south of 48°N in this quarter.

2.3 Summary of Ice and Environmental Conditions in Ice Year 2024

Icebergs were pushed offshore outside of sea ice protection by strong winds and exposed to extreme open ocean conditions early in the 2024 Ice Year. Extremely warm ocean and air temperatures and exceptionally stormy conditions including destructive ocean waves and heightened rainfall may have served to deteriorate potential limit-setting icebergs early in the Ice Year. At the height of the 2024 Iceberg Season, iceberg trespass into shipping lanes was limited by a calm atmosphere and ocean, and rapidly increasing temperatures. Finally, in the fourth quarter, returning offshore winds may have hastened the destruction in open ocean of any remaining icebergs near the lanes.

The 2024 Iceberg Season severity was light based on the well-below normal total number of icebergs that crossed south of 48°N (22), the below-mean season length (four months), and the below-normal monthly iceberg extents. Still, iceberg extent continued to threaten shipping lanes into June and approached them again in August—a reminder that regardless of Iceberg Season severity, the presence of icebergs at all poses a danger to the mariner navigating nearby.

3 Operations Center Summary

The OPCEN is the hub of IIP's iceberg information processing and dissemination. OPCEN personnel stand watch to receive and process iceberg reports, analyze ice and environmental conditions, and create and distribute daily iceberg warning products. Iceberg reports are generated and received primarily through both internal and commercial aerial and satellite reconnaissance. Iceberg reports can also be generated and received from vessels and shoreline reports. IIP processes iceberg reports to update sighted iceberg locations and characteristics within IIP's iceberg database. Positions of icebergs within the database are then predicted for the same times (0000Z and 1200Z) daily via iceberg drift and deterioration computer models using BAPS. Finally, iceberg limits are generated to contain the modeled iceberg positions for 0000Z the next day and distributed to mariners and the public within the NAIS daily warning products.

3.1 Iceberg Warning Products

IIP and CIS partner to create and distribute the NAIS daily iceberg warning products. IIP takes responsibility for product generation and dissemination, including deploying personnel to Newfoundland and Labrador for aerial iceberg reconnaissance, generally during the active Iceberg Season. In Ice Year 2024, IIP took this responsibility from 30 January to 5 September 2024. The operational statistics contained in this section are taken exclusively from this period. CIS publishes the iceberg warning products generally outside of the Iceberg Season (usually September to January) when the iceberg population threatens primarily the Canadian coastline.

The NAIS iceberg warning products are generated in text (NAIS-10 bulletin) and graphic (NAIS-65 chart) form. The NAIS-10 bulletin lists the latitude and longitude points along the predicted iceberg limit and reported sea ice limit and the NAIS-65 charts the predicted iceberg limit and estimated number per square degree. Semi-monthly NAIS-65 iceberg charts are shown in **Section 5**. Both products include information on the most recent relevant iceberg reconnaissance, including date, type, and coverage. The products are released daily between 1830Z and 2130Z and are valid for 0000Z the following day. During the 2024 Ice Year, all iceberg warning products were released on time.

IIP publicly disseminates the NAIS iceberg warning products through various means. The NAIS-10 bulletin is broadcast over SafetyNET, Navigational Telex (NAVTEX), and Simplex Teletype Over Radio (SITOR); the NAIS-65 chart is broadcast over radio facsimile (Radiofax) and posted to the National Weather Service (NWS) Marine Forecast (https://www.weather.gov/marine/marsh) and NOAA Ocean Prediction Center (OPC) (https://ocean.weather.gov/Atl_tab.php) websites. Both products are posted daily on IIP's product webpage (https://www.navcen.uscg.gov/north-american-ice-service-products).

The daily iceberg and sea ice limits are also posted to the IIP product website as geographic information system (GIS) compatible files (Keyhole Markup Language, KML, and ESRI shapefiles). Additionally, the daily iceberg limit is available as a displayable layer within several online mapping applications: NOAA's Environmental Response Management Application (ERMA) mapping tool for the Arctic (https://erma.noaa.gov/arctic) and Atlantic (https://erma.noaa.gov/atlantic), and the USCG Navigation Center (NAVCEN) website (https://www.navcen.uscg.gov/international-ice-patrol-map).

3.1.1 Iceberg Warning Product Changes for 2024

Each year, IIP and its NAIS partners, CIS and DMI, review NAIS iceberg products, procedures, and distribution processes to improve product content, delivery, and value for the mariner. For 2024, one minor update was agreed upon and applied to the NAIS-65 chart: the font color for iceberg numbers per square degree was changed from black to "ginger pink". This font color matches the limit color and enhances the differentation between the coastline and iceberg numbering.

3.2 Iceberg Reports

During the 2024 Iceberg Season, the OPCEN received reports of icebergs from IIP reconnaissance flights, satellite reconnaissance from IIP, CIS, commercial flights, and ship reports. The wide variety of reporting sources helps IIP to better estimate the state of the iceberg population by diversifying available iceberg reconnaissance data for comparison. This comparison is particularly important for analysts verifying targets in satellite imagery against those sighted by aircraft and increases confidence in semi-automated satellite analysis routines.

Mariners transiting the AOR remain a vital source of iceberg reporting for IIP to maintain its positive safety record. **Table 3.1** lists ships that made voluntary iceberg reports while IIP was responsible for the iceberg products.

Once received, iceberg reports (**Figure 3.1**) are converted into standard iceberg messages (SIMs) which include specific iceberg characteristics (time of sighting, position, size, shape) and other relevant information. Iceberg messages are still transmitted even if the message does not include any reported icebergs. A message with no reported icebergs can be useful for confirmation of their absence, especially when generated with high-confidence source (e.g., aerial reconnaissance or cloud-free optical imagery). In the 2024 Ice Year, IIP received, analyzed, and processed 968 SIMs, 838 from satellite reconnaissance, 110 from aerial reconnaissance, and 20 from other sources. Most satellite SIMS originated from IIP satellite imagery analysis (66%), followed by C-CORE (commercial) satellite reconnaissance (21%). **Table 3.2** provides further detail on the number and source of SIMs received while IIP held product responsibility.

Icebergs which enforce the shape of the drawn iceberg limit due to their proximity to the maximum iceberg extent are termed "limit-setting" icebergs. The number of limit-setting icebergs is limited by product generation procedure to eight or less. Icebergs further inside the maximum extent (interior to the iceberg population or near land) do not affect the shape of the iceberg limit. The number of limit-setting icebergs per reporting source can be seen in **Table 3.2** and **Figure 3.1**.

A total of 8,139 icebergs, growlers, and radar targets were added or resighted in the model from iceberg reports, a decrease of year 2023 by 60% (20,225 icebergs, growler, and radar targets). This decrease corresponded to both a smaller population of icebergs in the area and a reduced number of targets reported by commercial partners.

Reported icebergs that could be correlated with existing icebergs in IIP's database are "re-sighted" to the database with their more recently reported position. If an iceberg cannot be correlated to an existing database iceberg, it is added to the database. In an Ice Year, the number of icebergs added corresponds to the number of unique iceberg sightings. In Ice Year 2024, there were 1,993 icebergs added to the database, which was 14% of all database actions taken (add, delete, re-sight, no action) through the year.

Reported icebergs that are not added to or resighted (no action) in the iceberg database often originate from coincident reports from multiple sources. In these circumstances, the OPCEN will only include the most recent position and size of the most complete iceberg report received.

Additionally, multiple coincident reports from different sources may conflict. In these cases, only unique targets across the reports are added to the database. In this document, the term "incorporated" means the iceberg, growler, or radar target was added or re-sighted to the database.

Ships Reporting by Flag

CANADA	
CCGS Amundsen*	16
CCGS Ann Harvey	6
CCGS Des Groseilliers	2
CCGS Henry Larsen	2
CCGS Kopit Hopson	2
CCGS Louis S St-Laurent	2
CCGS Pierre Radisson	5
CCGS Vincent Massey	4
CJD7 Tuvaq W	1
HMCS Harry Dewolf	7
HMCS Margaret Brooke	5
VEBN Jean Goodwill	1
NETHERLANDS	
PCJS Fraserborg	3
PHBC EEMC Transporter	1
PHLV Trica	1

Table 3.1. 2024 Ship reports by Nation of Origin. IIP recognizes the vessel that submits the most iceberg reports each year. This distinction is named for the CARPATHIA, the vessel that rescued 705 survivors from the TITANIC disaster. *Denotes the CARPATHIA award winner.

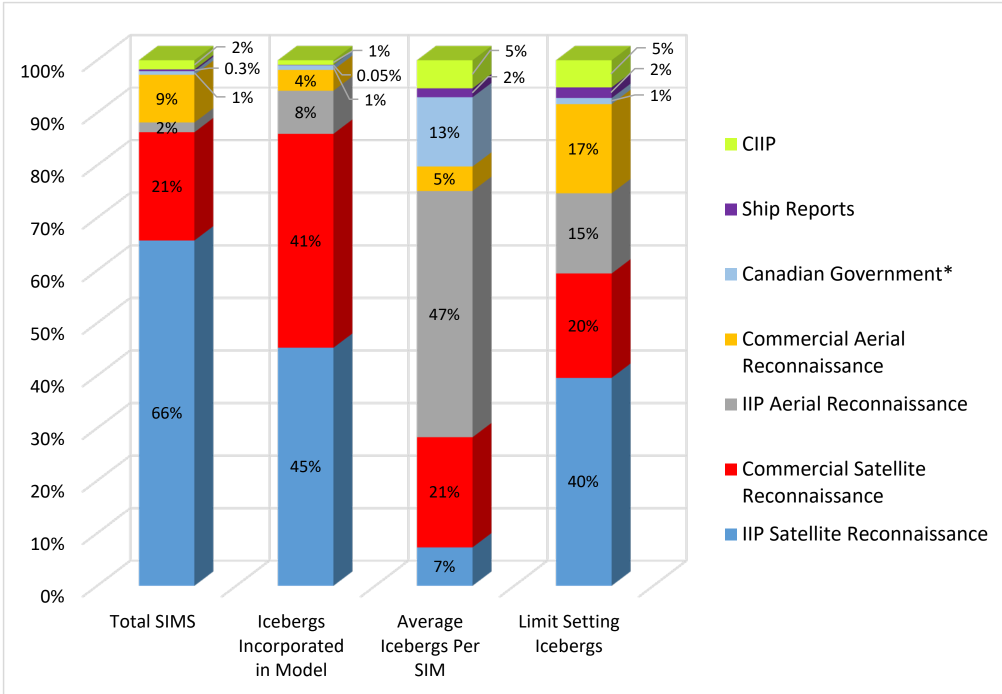

Figure 3.1. Proportion of total SIMs, icebergs incorporated into the model, average icebergs per SIM, and limit-setting icebergs by reporting source.

Source	Total SIMS	Icebergs Incorporated in Model	Average Icebergs Per SIM	Limit Setting Icebergs
IIP Satellite Reconnaissance	638	3,686	6	275
Commercial Satellite Reconnaissance	200	3,314	17	138
IIP Aerial Reconnaissance	18	667	37	106
Commercial Aerial Reconnaissance	88	323	4	118
Canadian Government*	7	73	10	8
Ship Reports	3	4	1	14
CIIP	17	72	4	36
Total	**971**	**8,139**	8	**695**

Table 3.2. Detailed information of this year's icebergs received from each SIM source. The Canadian Government row does not include Government-funded Commercial Aerial Reconnaissance (which are included in the Commercial Aerial Reconnaissance source) and is mostly made up of Canadian Coast Guard reports.

3.3 Iceberg Reconnaissance

3.3.1 Satellite Iceberg Reconnaissance

IIP both generates iceberg reports from internal (OPCEN) satellite analysis and receives reports from externally generated (commercial) satellite analysis. In the 2024 Ice Year, 1,230 icebergs, 0 growlers, and 1 radar targets from 638 iceberg reports (**Table 3.2**) generated by IIP satellite reconnaissance were added to the database. Commercial satellite reconaissance added 465 icebergs, 0 growlers, and 4 radar targets from 200 reports to the database. In Ice Year 2024, commercial satellite reconnaissance was provided by C-CORE, a company in St. John's that monitors icebergs for oil and gas industry clients.

Overall, 1,700 icebergs, growlers, and radar targets from satellite reconnaissance iceberg reports were added to the iceberg database, accounting for 85% of database additions. See **Section 4** for detailed information on IIP satellite iceberg reconnaissance.

3.3.2 Aerial Iceberg Reconnaissance

This season IIP conducted a total of 18 iceberg reconnaissance patrols and two transit/patrols over the course of 5 IRDs, from which IIP incorporated 667 icebergs, 6 growlers, and 7 radar targets in the iceberg database from IIP operations alone. See **Section 4** for detailed information on IIP aerial iceberg reconnaissance.

Commercial aerial reconnaissance from PAL Aerospace (a private contracted company) incorporated an additional 323 icebergs, 25 growlers, and 22 radar targets into the iceberg database. Unlike the IRDs conducted by IIP, many commercial flights by PAL Aerospace are not flown primarily for iceberg reconnaissance. As a privatized company they conduct other primary missions for different clientel alongside their iceberg specific reconnaissance missions for CIS and the oil/gas industry. **Figure 3.2** differentiates the PAL Aerospace flights that were dedicated to ice reconnaissance (funded by CIS or the oil/gas industry) and other flight operations that resulted in iceberg reports as a byproduct. This commercial aerial reconnaissance data is described further in **Table 3.2.**

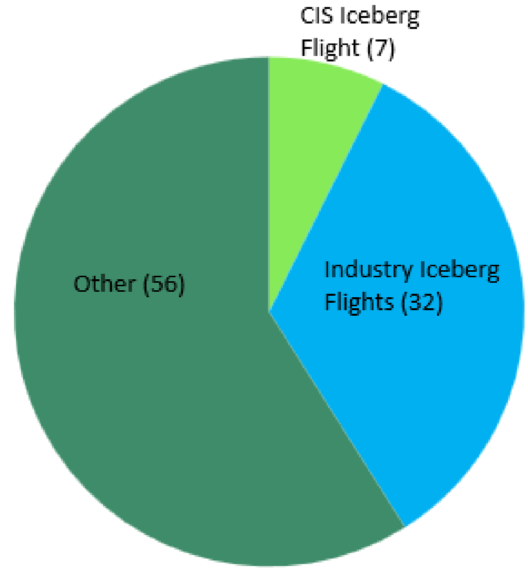

Figure 3.2. PAL Aerospace flights by primary mission type that reported icebergs. The "Other" category includes flights that reported icebergs but with a primary mission other than iceberg reconnaissance.

More than half, 59%, of the PAL Aerospace flights that reported icebergs were flown for primary missions other than iceberg reconnaissance. PAL flights funded by the oil and gas companies concerned with icebergs in the vicinity of offshore oil rigs accounted for 34%. The smallest portion, less than 7%, were funded by CIS specifically for iceberg reconnaissance in areas designated by either IIP or CIS. **Figure 3.1** reflects these percentages. The willingness of PAL Aerospace to identify and share iceberg reconnaissance information regardless of their source of funding demonstrates a notable and significant commitment to maritime safety across the region.

3.4 Iceberg Deletions

The drift and deterioration of icebergs in the IIP database was estimated via numerical models executed in BAPS. Icebergs were deleted from the active iceberg database based on modeled deterioration, time since last sighting, or recent reconnaissance results. This season, 234 icebergs, growlers, and radar targets were deleted when no icebergs were detected during IIP aerial reconnaissance flights in the vicinity of the modeled position. An iceberg may be deleted from the database based on one of three factors: 1) its modeled positional circle of uncertainty ("error circle") must be declared iceberg-free based on recent reconnaissance, 2) its "time on drift" must exceed 30 days, or 3) its predicted degree of melt must be between 125 to 150%, based on its proximity to the iceberg limit.

An iceberg error circle may be declared free of icebergs from either a high-confidence reconnaissance flight or, from cloud-free, high-resolution optical imagery. While satellite imagery usually covers an error circle, it may not allow for high-confidence iceberg deletion due to cloud-cover, imagery resolution, ocean wave radar backscatter, target ambiguity, or other factors. Currently, for this reason, IIP rarely deletes database icebergs using satellite imagery; the exception is for high-resolution optical (e.g., Sentinel-2, or SN2) imagery with little cloud cover and reduced ocean noise, which allows the analyst to have high confidence in the absence of icebergs.

Similarly, a commercial flight might fly over a modeled position, but may not cover the error circle entirely, leaving a chance that the iceberg was missed. For this reason, deletes are also not typically based on the results of commercial flights. In 2024, PAL Aerospace flew two CIS-funded iceberg reconnaissance flights using IIP-drawn flight plans. This allowed IIP to plan commercial flights based on internal criteria for deleting modeled icebergs. This season, 11 modeled icebergs were deleted from CIS-funded PAL flights.

In the case of predicted melt, IIP employs a conservative approach for estimating when an iceberg melted entirely. The model provides a melt factor based on the original sighted position between 0-500%. An iceberg that has melted 100% by deterioration calculations has theoretically melted to nothing, while an iceberg that has melted to 500% has endured enough environmental factors (wave action, sea surface temperature, etc.), that it could have melted five times over. IIP typically deletes icebergs at 125% or 150% based on their proximity to the iceberg limit.

3.5 Limit-Setting Icebergs

The single most important icebergs monitored by IIP are limit-setting icebergs. Typically, an average of four icebergs (minimum of one and maximum of seven) set the iceberg limit at any time.

In Ice Year 2024, the maximum extent of the iceberg limit was during a period of reduced reconnaissance, in which the entire iceberg limit was estimated. It stretched 356 NM East of St. John's to 49°00N 044°05W, at its maximum Easternmost extent on 04 April (**Figure 3.3**). Soon after, on 13 April, the limit reached its

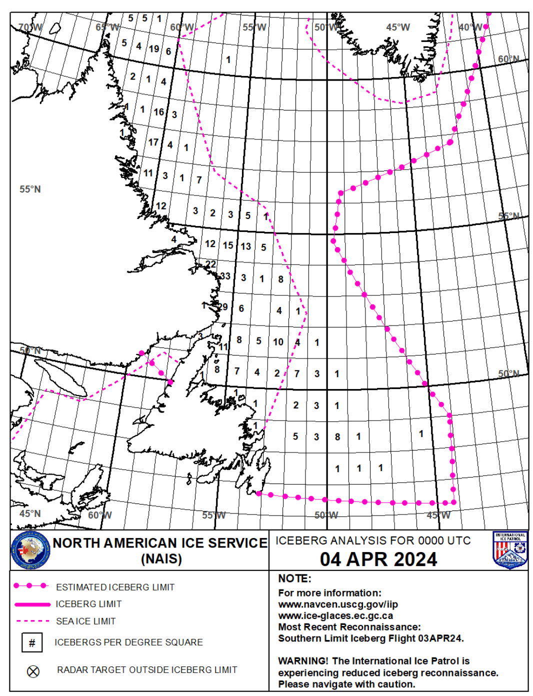

Figure 3.3. Easternmost extent of the iceberg limit on 04 April.

Southernmost extent at 44°40N 046°20W, 317 NM South of St. John's (**Figure 3.4**).

Reconnaissance from satellite imagery was the leading source for spotting limit-setting icebergs (63%) in 2024. This was a decrease from 2023 (65%).

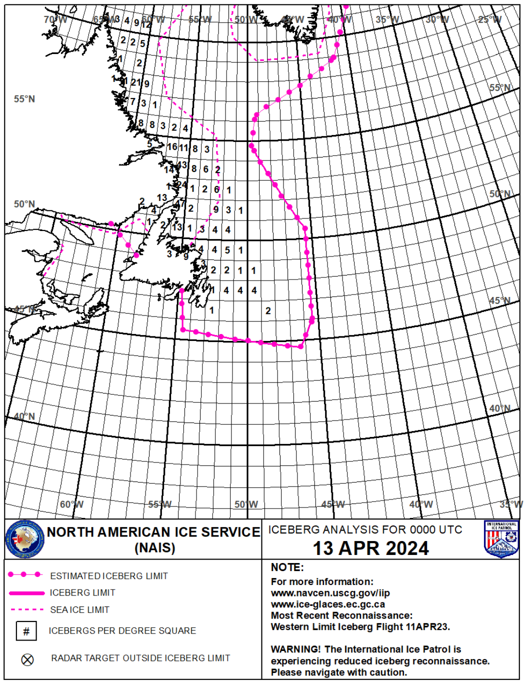

Figure 3.4. Southernmost extent of the iceberg limit on 13 April.

Although many of the icebergs incorporated into the model and setting the iceberg limit were observed by satellite, it is often difficult to reliably determine ice-free conditions from synthetic aperture radar (SAR) imagery due to low confidence in analysis (the difficulty in eliminating false positives and false negatives).

A false positive result is one in which a target is determined to be an iceberg where, in fact, there is not one. This can result in the needless expansion of the iceberg limit, negatively impacting shipping without a corresponding increase in safety.

However, of greater concern are false negatives, in which it is determined there are no icebergs where icebergs do, in fact, exist. This situation is especially dangerous and can result in the iceberg limit not encapsulating the iceberg hazard and placing ships in harm's way.

Continued development of satellite imagery analysis is aimed at reducing these errors through increased understanding of the impact of satellite parameters, image quality, and environmental conditions on detection and classification of targets.

For now, IIP considers the most reliable method for monitoring the iceberg limit to be aerial reconnaissance. It should be noted that this may change as IIP continues to exploit satellites for iceberg reconnaissance and gains confidence in the method. Currently, in-flight observation of limit-setting icebergs, especially those nearest transatlantic shipping lanes, remains a critical part of completing IIP's mission.

3.6 Icebergs Reported Outside of the Iceberg Limit

If an iceberg or radar target is reported outside of the published iceberg limit, the Operations Center (OPCEN) Duty Watch Stander (DWS) takes prompt action to warn the maritime community.

Typically, the first step is for the DWS to notify the Canadian Coast Guard (CCG) Maritime Communication and Traffic Service (MCTS) Port aux Basques. In turn, MCTS issues a Navigational Warning (NAVWARN), which is the primary means of relaying immediate iceberg information to the transatlantic shipping community, while IIP watch standers generate and transmit revised products. The NAVWARN is sent via NAVTEX and forwarded to the U.S. National Geospatial-Intelligence Agency (NGA). NGA broadcasts the message as a Navigational Area (NAVAREA) IV warning message over satellite (SafetyNET) and posts it to their website. NAVAREA IV is one of 21 navigational areas, designated by the World-Wide Navigational Warning Service (WWNWS); the United States is the coordinator for NAVAREA IV.

If the report of an iceberg or radar target outside the limit is received by IIP during watch hours (1200Z to 0000Z), products will be immediately revised by the OPCEN valid for 1200Z or 0000Z, depending on the time received. If the report reaches IIP outside of these hours, products will be revised by 1400Z the following morning valid for 1200Z.

Categorizing targets in SAR imagery as icebergs, vessels, or "other" (such as marine life, fishing gear, or weather artifact) remains a challenge. SAR backscatter can generate noise that looks similar to potential iceberg or vessel targets, and can be unintuitive for analysts to interpret. In cases where SAR analysis yields ambiguous target results outside of the iceberg limit, IIP takes a conservative approach and categorizes this target as an iceberg, ensuring the maritime community receives a timely warning and keeps the target in the database until subsequent reconnaissance verifies otherwise. IIP relies on coordination with other data sources such as those vessels providing an Automatic Identification System (AIS) and Coast Guard Intelligence to help reduce target ambiguities.

In past years, several cases of icebergs outside of the iceberg limit were closely linked with the sea ice limit, in which they were undetected within sea ice (from deteriorated aerial or satellite reconnaissance), but subsequently broke free and drifted outside of the published iceberg limit. In response, IIP policy requires the thick sea ice limit generated by CIS (and thus the leading edge of sea ice) be contained within the iceberg limit.

3.6.1 Icebergs Detected Outside of the Iceberg Limit in 2024

14 March 2024

The OPCEN received a NAVWARN from the Canadian Coast guard of an iceberg outside the advertised iceberg limits in position 48°36'N, 052°15'W. IIP watch standers made notifications to MCTS and NGA, and warnings were issued. IIP revised products to reflect the new iceberg sighting and redistributed products. With this report, IIP coordinated with PAL to plan a flight to confirm the iceberg reportings. PAL was able to confirm the Iceberg reports and the new limit reflected the effort. **Figure 3.5** demonstrates limits and actions taken for the iceberg outside the limits.

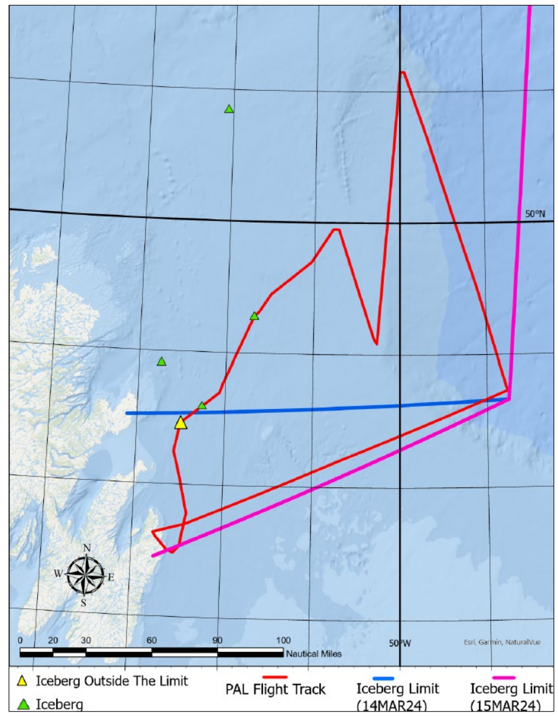

Figure 3.5. Iceberg outside of the limit case, 14 March 2024

3.7 Risk-Based Iceberg Products and Tailored Support

When IIP is tasked with supporting vessels inside the iceberg limits, IIP develops an additional daily experimental iceberg hazard chart known as the "Isolated/Few/Many" (IFM) product. The IFM product can be used to inform vessel risk assessments for intended movements. In 2024, IIP continued support for specific customers transiting north to eastern Canada and western Greenland for two different operations.

The first operation IIP supported with IFM products was during April and May 2024. The Portugese Navy Submarine NRP ARPAO, a 222-ft Tridente-class attack submarine, in coordination with the Arctic Submarine Laboratory, operated in the waters of Baffin Bay to explore under-ice capabilities in near-Arctic conditions. Nine total products were producted and distributed by three analysts between April 24 and May 8 2024.

The second operation IIP supported with IFM products was during August 2024. The USCGC NORTHLAND, USS Delbert D Black, HMCS Margaret Brooke, HMCS Harry DeWolf, and HDMS Lauge Koch operated in the waters of the Labrador Sea and Baffin Bay in support of the Canadian exercise Operation Nanook (OPNANOOK). Operation Nanook is an an annual exercise led by the Canadian Armed Forces and supported by the US 2nd Fleet, US Coast Guard, and the Royal Danish Navy. OPNANOOK delivers Arctic training, develops partnerships, and improves maritime multi-national cooperation among allied navies. 22 total products were produced and distributed by eight analysts between August 11 and August 26 2024.

Neither set of customers had useful experience operating near icebergs and depended on IIP for daily updates on the iceberg population in their respective operating areas. Each set of vessels received a daily IFM product.

New to 2024 was a significant effort to develop an experimental update to the IFM product via a dedicated research project conducted by IIP intern, Midshipman Andrej Klema, who worked with the IIP Chief Scientist through the summer to bring the IFM product inline with the International Ice Charting Working Group (IICWG) and World Meteorological Organization (WMO) standards for iceberg hazard characterization. The resulting experimental product update depicts iceberg density (number per degree square) instead of overlapping error circle count. IIP aims for this experimental product to provide customers with a more accurate representation of the iceberg positional uncertainty. Midshipman Klema's experimental work is being continued and finalized in concert with IIP, who will report the final results at a later date.

The IIP capability to generate IFM products is the result of much effort and collaboration between IIP and DMI, as well as with other government and commercial agencies through IICWG. In these two cases of customized support, IIP relied heavily on its NAIS partnership with DMI. DMI employs an automated iceberg detection and classification algorithm that quickly and accurately sorts through satellite images to find the thousands of icebergs in its waters surrounding Greenland. IIP relied on that output to create IFM products, drifting the icebergs using the NAIS drift and deterioration model to predict the location of relevant icebergs when vessels were transiting nearby. These modeled positions were used to depict iceberg concentration and results were sent out daily to the supported vessels.

IIP expects the demand signal for IFM tailored support products to continue to grow as more Navy and Coast Guard assets not accustomed to ice navigation begin to push farther and farther north for transits and training operation

4 Iceberg Reconnaissance Operations

4.1 Iceberg Reconnaissance Detachments (IRDs)

The IRD is a partnership between IIP and ASEC to conduct aerial iceberg reconnaissance. During the 2024 Ice Year, IRDs were deployed to observe and report icebergs, sea ice, and oceanographic conditions in the North Atlantic Ocean. These critical observations are reported to the IIP OPCEN in Suitland, MD for processing and incorporation into BAPS, which is then used to create and distribute the daily NAIS iceberg warning products and Iceberg Limits. See **Section 5** for semi-monthly NAIS iceberg warning products for Ice Year 2024.

Between the months of February and June, IIP conducted 16 iceberg reconnaissance patrols over the course of 40 deployed days (Five total IRDs) on a HC-130J aircraft. The flight season spanned 117 days, slightly less than the five-year average of 138 days (derived from statistics from 2017-2021). Five out of the 12 planned IRDs were flown as scheduled (IRD 2, 5, 6, 8 and 9), the rest were canceled for various reasons including funding constraints, redirection of the aircraft to assist with operations in Haiti, and redirection of aircraft for a parts delivery to a stranded cutter. **Table 4.1** contains a summary of operations for each IRD.

4.2 Aerial Iceberg Reconnaissance Equipment

IRDs were conducted using HC-130J aircraft equipped with two radars and an integrated AIS in the mission system suite. One radar is the ELTA-2022 360° X-Band surface-search radar, which can detect and differentiate surface targets automatically (as iceberg, ship, or "other") by utilizing AIS input. The other is the HC-130J Tactical Transport Weather Radar (APN-241), which can detect surface targets, but cannot differentiate them automatically.

The 360° coverage provided by the ELTA radar allows IIP to plan for patrols with up to 30 NM flight ground track spacing. This Ice Year, IIP planned 16 out of 18 flights with 30 NM ground track spacing while maintaining the probability of detection (POD) of small icebergs (15 to 60 m) at 95%. The remaining flights were planned with 10 NM ground track spacing due to malfunctioning aircraft radar.

When the ELTA radar was inoperable, the IRD drew flight plans under "visual-only"

IRD	Deployed Days	Iceberg Patrols	Transit Flights	Patrols en Route	Logistics Flights	Flight Hours
1	*0*	*0*	*0*	*0*	*0*	*0.0*
2	**9**	**4**	**2**	**0**	**0**	**39.4**
3	*0*	*0*	*0*	*0*	*0*	*0.0*
4	*0*	*0*	*0*	*0*	*0*	*0.0*
5	**9**	**4**	**2**	**1**	**0**	**39.1**
6	**9**	**2**	**2**	**1**	**0**	**25.8**
7	*0*	*0*	*0*	*0*	*0*	*0.0*
8	**7**	**3**	**2**	**0**	**0**	**34.7**
9	**6**	**3**	**2**	**0**	**0**	**29.6**
10	*0*	*0*	*0*	*0*	*0*	*0.0*
11	*0*	*0*	*0*	*0*	*0*	*0.0*
12	*0*	*0*	*0*	*0*	*0*	*0.0*
Total	**40**	**16**	**10**	**2**	**0**	**168.6**

Table 4.1. An overview of days and flight hours used during the scheduled IRD's for the 2024 Ice Season.

specifications using 10 NM ground track spacing which covers 40% less area compared to flights with radar coverage. Good reconnaissance conditions (at least 50% visibility and few to no white caps) are preferred for visual-only patrols, but they are relatively rare in IIP's meteorologically active AOR.

All IRDs were flown with Minotaur Mission System-equipped aircraft. Minotaur is a software and hardware suite that allows for onboard networking of cameras, radars, navigational instruments, and communications. This also allowed OPCEN watch standers to communicate directly with aircraft personnel in flight.

IRD crews also frequently utilized the inverse synthetic aperture radar (ISAR), a function of the ELTA radar. ISAR uses target motion to generate high-resolution images of such targets. ISAR imagery is analogous to the satellite SAR imagery IIP analyzes, in that it is created using radar energy pulses in the microwave band of the electromagnetic spectrum. However, SAR relies on the motion of the platform carrying the radar (e.g., satellite motion in orbit), while ISAR relies on the motion of the target, to generate an image. This technology has proven extremely useful for identifying and distinguishing icebergs from ships, especially in poor visibility and for those ships which do not transmit AIS (**Figure 4.1**).

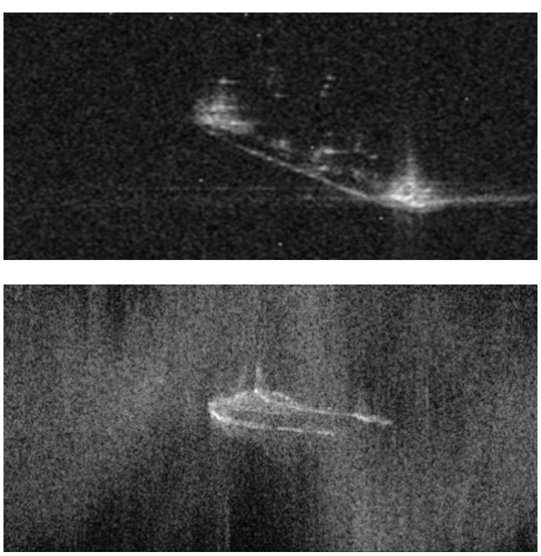

Figure 4.1. ISAR imagery of a ship (top) and an iceberg (bottom).

4.3 Deployment Season Summary

Figure 4.2 shows the use of IIP's deployment days during the 2024 Ice Year by category (Operational, Transit, Patrol/Transit, Weather, Maintenance, Crew Rest, and Other). The Other category includes IIP partner meetings, higher priority aircraft tasking (e.g., search and rescue), and logistics flights. During the 2024 Ice Year, there was no occurence of Other. In accordance with USCG regulations, the IRD normally takes one day of crew rest and one maintenance day per nine-day deployment; otherwise, the intent is to fly every day. Operations took up the most deployment days in 2024 (40%).

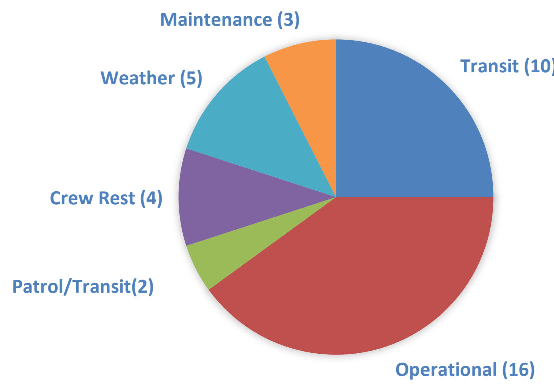

Figure 4.2. Utilization of days for the 2024 Ice Season.

The prevailing weather in the AOR contributed significantly to the number and effectiveness of reconnaissance patrols. Weather conditions prevented patrols on 12.5% of the days deployed. The majority of those weather delays, 80%, occurred in St. John's, Newfoundland. The IRD crews capitalized on poor weather opportunities, when possible, to meet the required rest and maintenance days. This maximized operational iceberg reconnaissance on favorable weather days.

Unlike years past, no unscheduled maintenance days were required. In past seasons, IRDs based out of St. John's, Newfoundland encountered significant logistical challenges with transporting spare parts to the deployed aircraft.

Table 4.2 shows a further breakdown of the crew rest and maintenance days into days taken when the weather conditions did not permit flights (opportunity days), when crew rest or maintenance was required (scheduled), and when issues with maintenance occurred (unscheduled).

	Crew Rest	Aircraft Maintenance
Opportunity (Weather at FBO/OPAREA)	1	1
Scheduled	3	2
Unscheduled	*0*	*0*
Total	4	3

Table 4.2. Crew rest and aircraft maintenance days for the 2024 Ice Season.

4.3.1 IRD Summaries

There were 12 IRDs scheduled for the 2024 season. Due to budget constraints and assest reallocation, only 5 IRD's were completed. A total of 18 iceberg reconnaisance flights over the course of the 5 IRD's were completed. Historically, IRD's have been staged out of St. John's, Newfoundland, with hangar space provided through a commercial partnership with PAL. However, due to an expanding fleet, PAL was unable to provide hangar space for the 2024 ice season and IIP shifted the IRD staging site to Happy Valley-Goose Bay in the province of Newfoundland and Labrador, to ensure aircraft protection from snow, ice, and high winds. Goose Bay was a welcome find and a gracious host, IIP looks forward to a continued partnership.

IRD 1 was cancelled due to budget constraints. With IRD 1 being early in the season and not enough funding to cover all of the IRDs, canceling IRD1 was determined to be a low-risk way to fund later IRDs during the busy season.

IRD 2 was the first IRD of the season, and notably, the first to be based out of Goose Bay, Labrador. IRD 2 departed Joint Base Andrews (airport code KADW) on 28 Feb and arrived at the Royal Canadian Air Force Base in Goose Bay, Labrador (airport code CYYR). On 29 February, the aircraft was grounded and there was no patrol due to high winds and low cloud ceilings. On 01 March, a patrol of the Western Limit and Interior found only a single iceberg and was cut short due to turbulence. On 02 March, a patrol of the Interior and the 1,000-meter contour re-sighted several icebergs recently acquired by a PAL flight from a few days earlier. On 03 March, a 9-hour Southern Limit flight found zero icebergs and was key in justifying a major reduction of the iceberg limit above 48°N. On 04 March, the Western Limit was revisited to assess if any icebergs predicted to drift into that area were present in the Strait. No icebergs were sighted in the Strait, and CCGS Jean Goodwill also reported via radio no iceberg sightings within the past 24 hours. The flight continued out to the 1,000-meter contour where turbulence forced several search legs to be skipped, and then north along the contour and down the Labrador coast. 135 icebergs were sighted during this flight. On 05 March, scheduled maintenance was conducted; IIP members conducted training and administrative work. On 06 March, there was a crew rest day due to flight hours. On 07 March, IRD 2 departed Goose Bay, Labrador and returned to Joint Base Andrews disembarking six IIP members before returning to AIRSTA Elizabeth City. IRD2 was an excellent start to the season's operations, and successfully established a working operational and logistical relationship with the Royal Canadian Air Force 5 Wing at Goose Bay.

IRD3 and IRD4 were canceled due to aircraft reallocation to other Coast Guard operations, specifically migrant operations.

IRD 5 was the second IRD of the season and the second to be based out of Goose Bay, Labrador. IRD5 departed Joint Base Andrews on 10 April and proceeded to Halifax, Nova Scotia in preparation for the Titanic Memorial Ceremony. On the morning of 11 April, IIP conducted the annual Titanic Memorial Ceremony for numerous dignitaries, to include the Deputy Governor of

Nova Scotia. Later that afternoon, IRD 5 departed for Goose Bay, Labrador and conducted a patrol enroute over the Western Limit, as well as a ceremonial wreath drop to honor those who died during the Titanic's sinking. On 12 April, a Southern Limit patrol found no icebergs, however, it did sight 17 ships and conducted securite broadcasts. This patrol enabled a significant reduction to the iceberg limits. Due to weather, on 13 April, an Interior patrol was conducted, resulting in 33 resighted icebergs and 27 additions. On 14 April, a Southern Limit patrol spotted 17 icebergs which included a resight of the southern limit-setting iceberg. On 15 April, scheduled maintenance was conducted; IIP members conducted training and administrative work. On 16 April, a revisit to the Western Limit and Interior provided a resight of the limit-setting iceberg and situational awareness to the movement of the iceberg population; 21 icebergs and 32 ships were sighted. On 17 April, there was a crew rest day due to flight hours. The IRD returned to Joint Base Andrews on 18 April and disembarked six IIP members before returning to AIRSTA Elizabeth City. In total, this IRD resulted in reducing the iceberg limit by 250 nautical miles.

IRD 6 was the third IRD of the season and the first one this season based out of St. John's, Newfoundland. IRD 6 departed Joint Base Andrews on 24 Apr and arrived at Halifax, Nova Scotia (airport code CYHZ) after being diverted from St. John's, Newfoundland (airport code CYYT) due to weather. On 25 April, IRD 6 departed Halifax, Nova Scotia to patrol the Southern Limit while enroute to St. John's, Newfoundland. Two icebergs were sighted near the coast, but low cloud ceilings and high waves were encountered in the eastern patrol area. On 26 April, a patrol of the Western Limits, Eastern Limits, and the Interior, found 87 icebergs, predominantly in the Strait of Belle Isle. On 27 April, a patrol of the Interior and along the 1,000-meter contour found 166 icebergs, predominantly towards shore, but a few were out in open water. Due to low cloud ceilings and freezing precipitation on 28 April, there was no patrol, and the crew was given a rest day. On 29 April, continued low cloud ceilings and fog grounded the aircraft and the crew conducted aircraft maintenance and training. On 30 April, continued low ceilings prevented a patrol, and the day was utilized for training. On 01 May, the IIP TC (Tactical Commander) met with the PAL Fixed Base Operator (FBO) staff and discussed aerial reconnaissance plans for the remaining 2024 season and future availability of hangar space. Due to PAL's expanding fleet, there is no timeline on available hangar space in St. John's, Newfoundland for IRDs. An attempt was made to depart St. John's, Newfoundland, but was aborted due to low cloud ceilings returning during the aircraft fueling. The IRD returned to Joint Base Andrews on 02 May and disembarked six IIP members before returning to AIRSTA Elizabeth City. Despite challenges with weather and an unplanned divert to Halifax, this was a successful first IRD of the ice season staged out of St. John's, Newfoundland.

IRD 7 was cancelled due to aircraft reallocation to other Coast Guard operations, specifically a critical request of aircraft support and delivery of repair parts.

IRD 8 was the fourth IRD of the season and the second one this season based out of St. John's, Newfoundland. IRD 8 departed Joint Base Andrews on 23 May and arrived at St. John's, Newfoundland, (airport code CYYT). On 24 May, aircraft was grounded due to a combination of fog, low cloud ceilings and thunderstorms. On 25 May, continued fog and low cloud ceilings grounded the aircraft. On 26 May, a patrol of the Western Limit was conducted through the Strait of Belle Isle and along the 1,000-meter contour, sighting 27 icebergs. Most of these icebergs were within the vicinity of Belle Isle. On 27 May, a patrol of the Southern Limit was conducted and found no icebergs. However, there was a large amount of fishing gear and vessels in the area. On 28 May, an Interior patrol was conducted, sighting 50 icebergs, mostly concentrated along the northeastern coast of Newfoundland and within the Strait of Belle Isle. Upon return to St. John's, Newfoundland on 28 May, a mechanical issue was discovered with the aircraft, which required an early return to AIRSTA Elizabeth City for repair. IRD 8 departed St. John's, Newfoundland on 29 May, disembarking four IIP members at Joint Base Andrews before returning to AIRSTA Elizabeth City.

IRD 9 was the fifth IRD of the season and the first one this season based out of Cape Cod, RI (airport code KFMH). This made it the third IRD of the season to be based out of an alternative location to the historic staging site of St. John's, Newfoundland. On 06 June, IRD 9 departed Joint Base Andrews and arrived at Cape Cod. On 07 June, a Western Limit patrol was conducted, sighting five icebergs in the vicinity of Belle Isle. On 08 June, a Northern Survey patrol was conducted and found 53 icebergs. On 09 June, there was a crew rest day due to flight hours. On 10 June, a Southern Limit patrol was conducted and found no icebergs. IRD 9 departed Cape Cod, RI on 11 June, disembarking five IIP members at Joint Base Andrews before returning to AIRSTA Elizabeth City.

IIP determined the season could be closed due to the "light" year, availability of satellite reconnaissance, and continued partnership with PAL. The IRD season officially closed on 11 June 2024. IRDs 10, 11 and 12 were cancelled.

4.4 2024 IRD Iceberg Detections

IRD personnel detected 667 icebergs over the five IRDs. All but seven of these icebergs were incorporated into the iceberg database, accounting for 35% of icebergs incorporated in 2024. No action was taken on those seven icebergs because the reconnaissance occurred outside of the geographical boundaries of the model or because of conflicting coincident reconnaissance.

During IRDs, iceberg detections are categorized in one of three ways: 1) both visually and by radar or by camera alone, 2) by radar alone, or 3) only visually. Iceberg detections made with the Electro-Optical Infrared (EOIR) camera onboard are counted as both visual and radar sightings because of the camera's ability to see much farther than the human eye and in the infrared. The EOIR camera is equipped to identify more precise geographical positions of icebergs than observers in flight, who rely on range and bearing to estimate position.

In 2024, 29% of the icebergs detected by an IRD were sighted via concurrent radar observations and visual sightings, or by the camera alone. Only 1% of the remaining icebergs were detected by radar only, and 70% were detected by visual only (**Table 4.3**). Concurrent visual detection has generally increased since 2014, illustrating how significant the radar and camera sensors have become to aerial iceberg reconnaissance methods and accuracy.

Year	Radar & visual icebergs	Radar only icebergs	Visual only icebergs
2014	43%	5%	52%
2015	29%	45%	26%
2016	20%	32%	48%
2017	21%	39%	40%
2018	24%	31%	45%
2019	44%	26%	30%
2020	67%	3%	30%
2021	69%	8%	23%
2022	38%	2%	60%
2023	71%	1%	28%
2024	29%	1%	70%

Table 4.3. IRD iceberg detections by method from over the last ten years (2014-2024).

IIP personnel employed a two-tiered iceberg reconnaissance approach in favorable environmental conditions to maximize detection efficiency, focusing visual observations near the aircraft and radar observations farther away. This tactic often resulted in visual-only reported iceberg detections because, even when these icebergs were within range of and detected by the radar, observers needed to sight and record high volumes of icebergs in flight and time did not allow for corroboration of those sightings with the radar.

4.5 2024 Flight Hours

As in previous seasons, IIP was allotted 500 Maritime Patrol Aircraft flight hours for its operation during the Iceberg Season. IIP utilized 168.6 of those hours in 2024 for patrol, transit, and maintenance/logistics. A break down of these hours is depicted in **Figure 4.4**. A total of 331.4 hours were cancelled due to reasons specified in and Section 4.3.

Transit hours are the hours the aircraft is traveling between specific locations in support of the IIP mission, without conducting reconnaissance. Those locations include Elizabeth City, NC and the forward operating area with a brief stop at Joint Base Andrews in Prince George's County, MD to onload IIP personnel and equipment. Overall, 72.5 hours were used for transit this season.

Patrol hours are those which the IRD uses to conduct iceberg reconnaissance, including flight time to and from the reconnaissance area. IIP flew 96.1 patrol hours this season, of which 49.6 hours (52% of total patrol hours) were used for transiting to/from the reconnaissance area. On average, it took three hours to transit to and from the reconnaissance area from IIP's forward operating locations in 2024 (**Figure 4.5**). When a patrol is conducted during a regularly planned transit flight, such as a patrol while transiting back to Joint Base Andrews, the hours are accounted for accordingly.

Logistics hours are the hours used to support the IIP mission, but do not fall into the previous two categories. Logistic hours accrue when a Coast Guard aircraft is used to transport parts for an aircraft deployed on an IIP mission. This season there were no round-trip logistics flights.

The spatial and temporal distribution of icebergs, as well as the number drifting south of 48ºN, all contribute to the amount of reconnaissance needed to effectively monitor the iceberg danger and provide relevant warning products. **Figure 4.6** shows a comparison of flight hours to the number of icebergs that drifted south of 48ºN from 2013 to 2024.

In Ice Year 2024, IIP flew 168.6 hours and estimated a total count of 22 icebergs which drifted south of 48ºN. This was an Iceberg Season with light severity, with 22 icebergs being lower than the threshold (300) for light season severity. For further details on Iceberg Season severity, see **Section 2**.

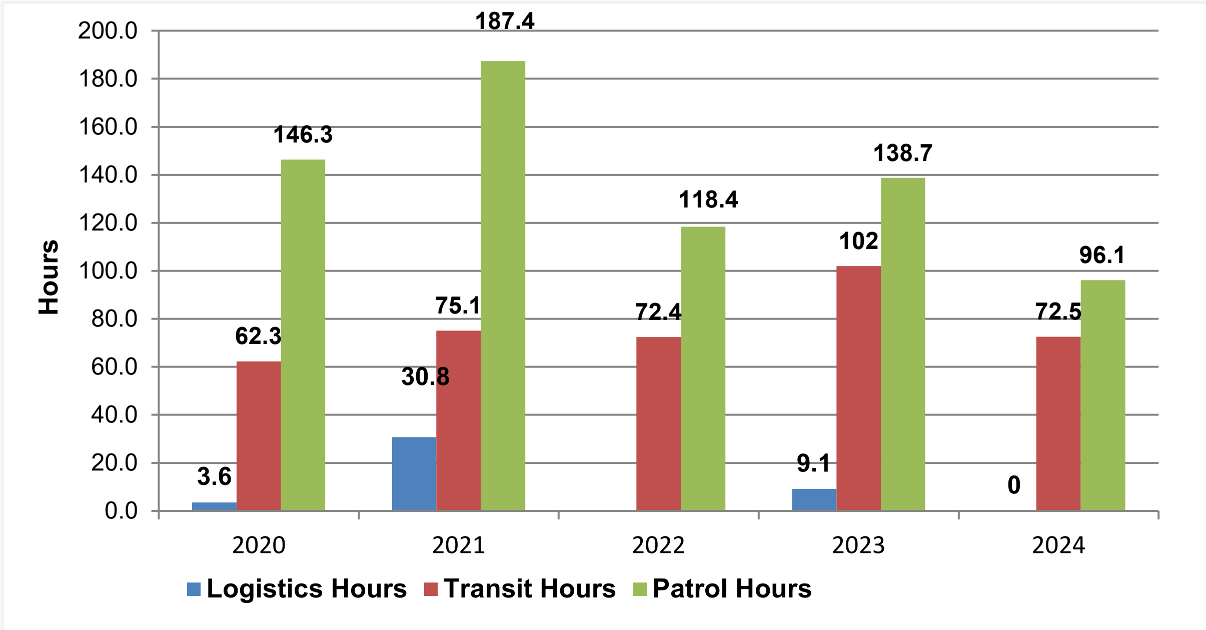

Figure 4.4. Flight hours broken down by patrol, transit, and logistics hours over the past five years.

Figure 4.5. 2024 Flight hours broken down by IRD. FBO refers to a Fixed Base of Operations, the staging area for reconnaissance flights.

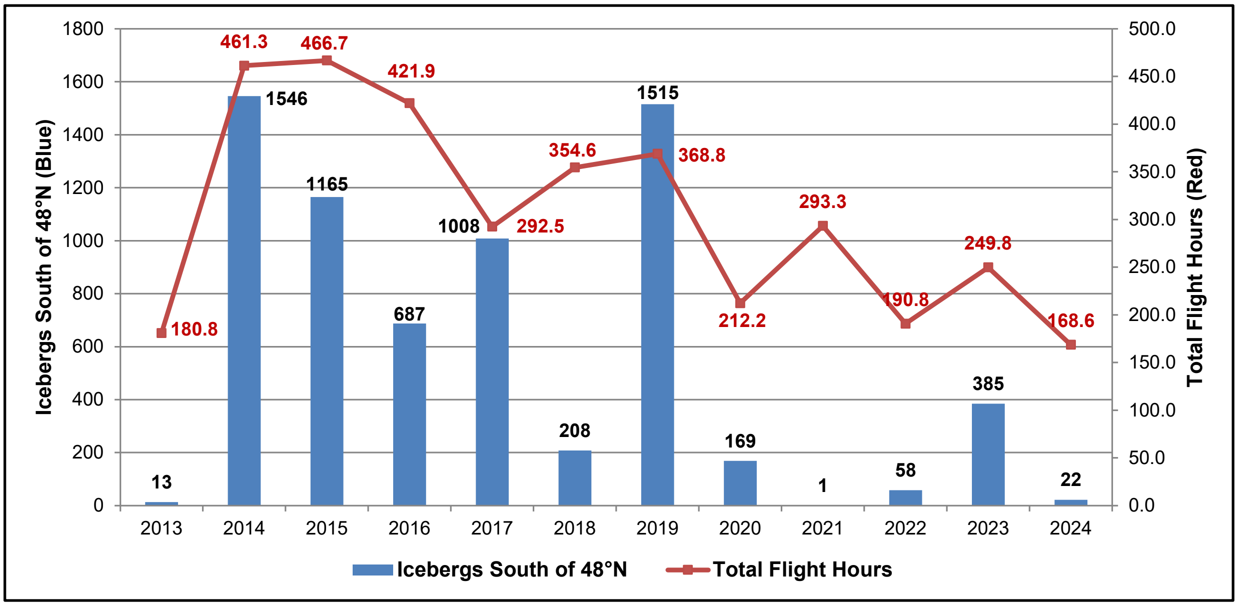

Figure 4.6. Comparison between total IRD flight hours per season and season severity, measured by number of icebergs sighted or drifted below 48ºN for the past 10 years. More icebergs south of 48ºN may require increased reconnaissance efforts.

4.6 Satellite Reconnaissance

4.6.1 Satellite Collections

IIP iceberg satellite reconnaissance is conducted daily by a qualified watch stander (Duty Satellite Analyst, DSA) when IIP has responsibility for the NAIS iceberg warning products. Each morning, the DSA is responsible for communicating with the OPCEN for daily or emergent reconnaissance requirements and to deconflict (avoid redundancy) with commercially provided iceberg reconnaissance. The DSA will take in all relevant information and determine image priority based on sensor characteristics and strategic region (**Figure 4.7**).

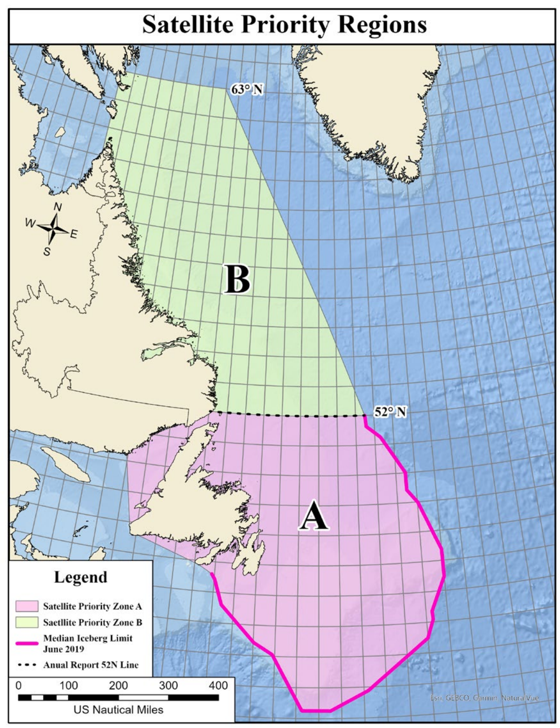

Figure 4.7. Graphic depicting satellite reconnaissance priority regions within the IIP AOR. South of 52°N is generally the area analysts should consider high priority for satellite imagery, where icebergs pose the greatest threat to shipping lanes.

The satellite reconnaissance strategic regions help analysts prioritize which satellite imagery to download each morning. Strategic Region A is the portion of the IIP AOR south of 52°N, where icebergs pose the greatest threat of collision with transatlantic vessels in the vicinity of the Grand Banks and the Strait of Belle Isle. Higher resolution satellite imagery is required for monitoring this area, as icebergs here are smaller due to advanced deterioration, and are usually in the open ocean. Generally, there are also more ships and fishing gear in this region, making discrimination of ship and iceberg targets more challenging for analysts.

Region B is the portion of the IIP AOR north of 52°N, where DSAs analyze satellite imagery of greater coverage, but reduced resolution. Such imagery allows the DSA to identify larger, slower moving icebergs, often trapped in sea ice, in a greater area. This region contains the population of icebergs which may eventually drift into high-traffic shipping lanes ("feeder" icebergs). The presence of sea ice in this region early in the season can make target detection more difficult.

IIP continues to rely on the European Space Agency's (ESA) SN1A and SN2 sensors, which both follow a consistent collection schedule and remain publicly available online in near real-time. It is worth noting the SN1B failure in December 2021 still hinders IIP's satellite reconnaissance capabilities tremendously, as satellite passes cover the AOR half as frequently. This reduced coverage and frequency makes consistent satellite analysis more difficult. Despite this, SN1A remains a useful sensor for reconnaissance of Region A due to its spatial resolution, as noted in **Table 4.4**.

Satellite Reconnaissance Priority Matrix				
Priority	**Sensor**	**Revisit Time**	**Resolution**	**Mode**
1	Sentinel-1A (IW)	12 days	20 m	HH/HV
2	Sentinel-2	5 days	10 m	EO
3	Radarsat Constellation Mission (RCM)	Daily	50 m	HH/HV

Table 4.4. Satellite systems and capabilities used by IIP satellite analysts.

Multispectral imagery from SN2 can be an incredibly useful resource for IIP satellite reconnaissance as it results in very high confidence iceberg classifications. The scenes, imaged in the optical band, are more intuitive for analysts to determine what is and what is not an iceberg compared to SN1A, due to the similarity in visual appearance to objects in life and photography. However, frequent cloud cover in the AOR renders many SN2 images unusable for analysis.

This year, IIP also continued operational use of imagery from the Canadian Space Agency's (CSA) Radarsat Constellation Mission (RCM), a direct result of the important partnership between IIP and CIS. While previously RCM has been used for monitoring the northern AOR, and usually a lower priority sensor for DSAs, several medium to large icebergs that drifted south of 52°N were detected and tracked using RCM imagery (generated in lower resolution modes) in these higher priority southern regions.

Radarsat-2 (RS2) and ICEYE imagery were not available to IIP this year.

4.6.2 Satellite Analysis

Once sensor and region priority are considered, analysts download the chosen images from the previous 24 hours, or download relevant imagery as directed by the watch supervisor or IIP Chief Scientist. The DSA will proceed to run the selected satellite frames through an Iceberg Detection System (IDS). IIP analyzes most SAR imagery using a commercial IDS provided by C-CORE. For SN2 images, an electro-optical sensor, IIP utilizes an algorithm written in-house which exploits the spectral properties of image targets to detect icebergs.

The DSA then reviews an IDS-generated shapefile that contains up to hundreds of potential iceberg targets. By looking at the size, shape, location relative to sea ice, and pixel properties of each individual target, the DSA can make a classification determination and decide if a target is an iceberg, ship, or noise/clutter. The DSA will then generate a SIM, which is handed off to the OPCEN watch standers for incorporation into BAPS, where the satellite detected icebergs are added or resighted to the IIP iceberg model.

4.6.3 Satellite Iceberg Detections

IIP satellite reconnaissance during the 2024 Iceberg Season relied primarily on SN1A, SN2, and RCM. Watch standers at IIP analyzed 616 individual satellite images, also referred to as frames, to generate a total of 638 SIMs during the 2024 Ice Year. Sometimes, SIMs are erroneously duplicated which explains the difference between number of images analyzed and SIMs generated. The breakdown of total frames analyzed at IIP can be seen in **Figure 4.8**. SN1A remains the primary workhorse of IIP satellite reconnaissance.

IIP's analysts identified a total of 4,163 icebergs in satellite imagery in Ice Year 2024, of which 3,686 were incorporated to the database. The total number of images analyzed in-house by IIP decreased from 754 frames in 2023 to 616 frames in 2024, as seen in **Figure 4.9**. As IIP continues to improve its satellite program, streamline analysis methods, and develop DSA expertise and training, an increase is expected in future satellite reconnaissance in balance with IIP aerial reconnaissance.

Interestingly, the percentage of icebergs detected by all satellite sources incorporated into the iceberg model slightly increased, as seen in **Figure 4.10**, from 85% in 2023 to 87% in 2024. This may be attributed to an increase in satellite reconnaissance as a consequence of reduced flight hours, increased satellite training, and increased experience of IIP observers and analysts. There was a steep increase in the percentage of icebergs detected by satellite between 2014 and 2020, after which this number approaches a plateau between 80-90% of total icebergs detected. IIP expects the percentage will remain around that plateau while the IIP aerial reconnaissance mission continues.

At first glance, this metric indicates that satellite reconnaissance is the primary method for iceberg detection and has been since 2019. However, it is important to note the current difficulties in achieving criteria for iceberg detection and database deletion using satellite imagery alone.

Also important is the critical role IRDs play during the height of the ice season in validating icebergs near the limit, outside the limit, and in satellite imagery. Until satellite imagery is proven to provide the same level of confidence in detecting icebergs less than 20 meters or better, IIP continues to recommend aerial reconnaissance as IRD's currently provide a higher confidence in detecting these icebergs.

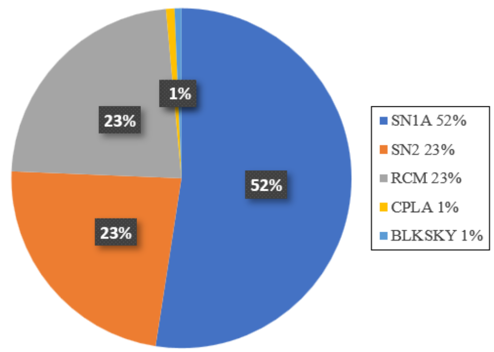

Figure 4.8. Percentage of total frames analyzed by satellite at IIP.

Figure 4.9. Frames analyzed each year by IIP satellite analysts.

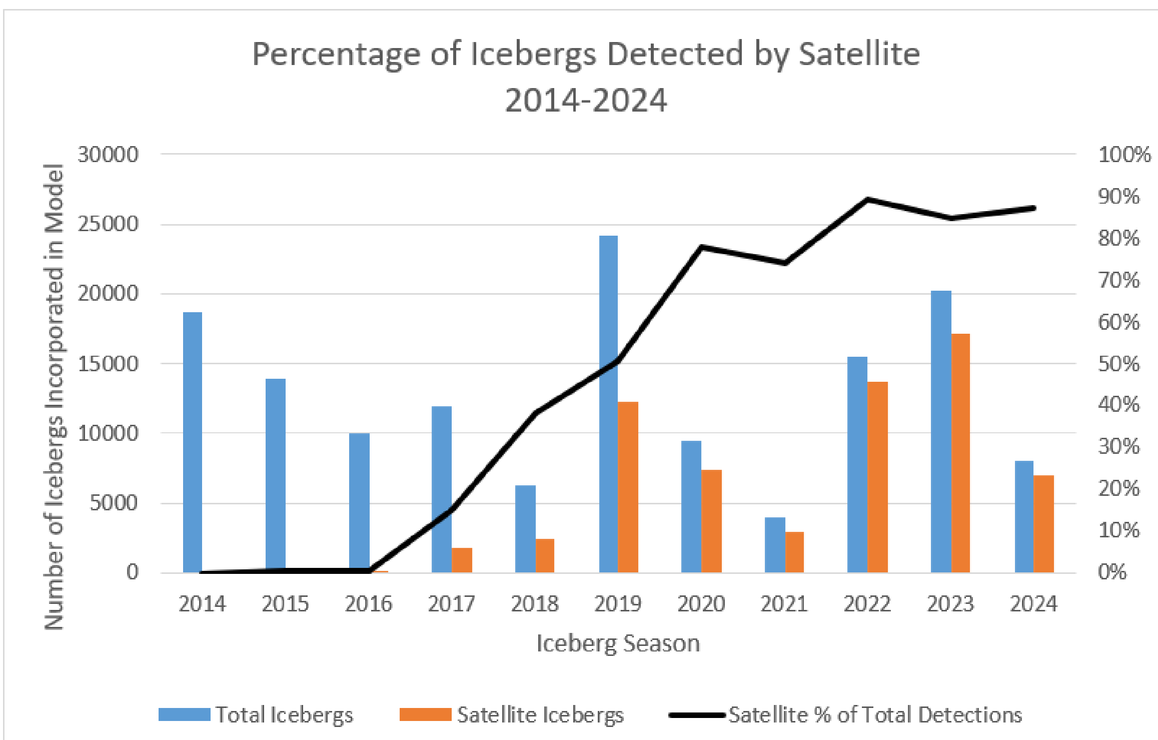

Figure 4.10 Number and percentage of icebergs identified by satellite and incorporated into the model compared to total incorporated icebergs between 2014 and 2024.

4.6.4 Northern Survey

In December 2023, IIP conducted a satellite Northern Survey between 55°N and 70°N along the coast of Labrador, east coast of Baffin Island, and southwestern Baffin Bay. The goal was to estimate the "upstream" iceberg population that could drive aerial reconnaissance decision-making in the early part of IIP's iceberg reconnaissance season.

The survey investigated 26 RCM images from 04 to 08 December 2023, detecting a total of 183 icebergs. Analysis distilled these total detections down to 183 individual icebergs, as seen in **Figure 4-11**.

Within the survey area, 34% of the icebergs were detected in gray-white to first-year sea ice. Sea ice helps to insulate icebergs from ocean waves which quickly deteriorate them. For that reason, these icebergs were deemed the most likely to drift south through the winter, and potentially into shipping lanes, with the movement of the sea ice.

IIP's satellite analysts continue to refine the methodology for repeatable Northern Survey results year to year, building a data set that may be useful in correlating season severity (number of icebergs detected south of 48°N) with icebergs detected in a Northern Survey. This year, the scope of the survey area was confined to the Canadian East Coast.

The data collected since IIP started implementing satellite analysis in 2017 can be seen in **Figure 4.12**. Continuing to build a comprehensive data set may be useful in the future for attempting to predict season severity several months before the peak of the iceberg season.

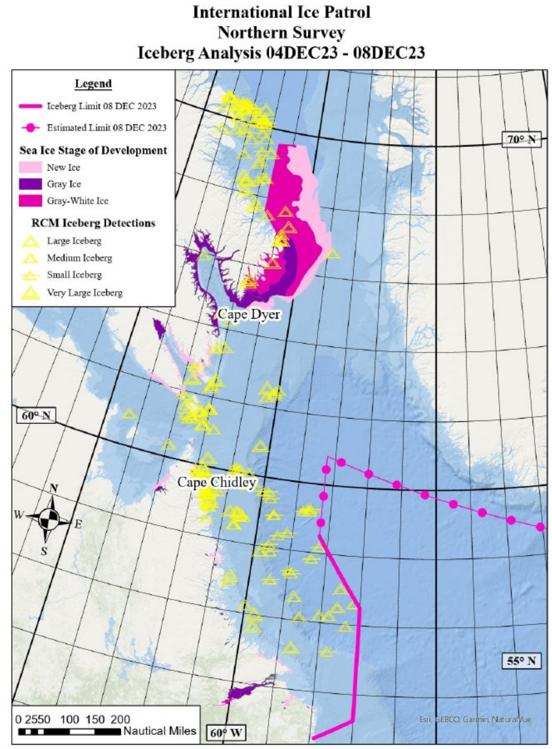

Figure 4.11. Results of the December 2023 Northern Survey. Iceberg data collected using the Canadian Space Agency's (CSA) Radarsat Constellation Mission (RCM) satellite.

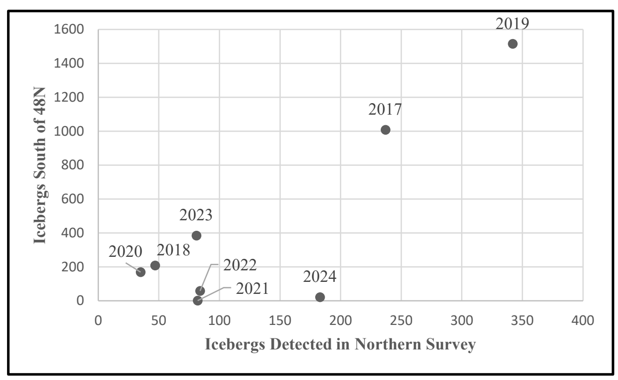

Figure 4.12 Comparison between iceberg detections in Northern Surveys and iceberg crossings South of 48 N between 2017 and 2024.

4.7 Other Reconnaissance Activities

4.7.1 NAIS Collaboration

IIP continued to leverage its NAIS partnership with CIS in 2024. IIP coordinated flight plans with CIS during periods when IRDs were not deployed to St. John's. CIS contracts flights year-round, however only seven flights were contracted to PAL Aerospace during the 2024 Ice Year. **Figure 4.13** depicts the hours flown this year and the past five years.

4.7.2 Ship Interactions

IRD on-scene patrol time in the HC-130J aircraft is mainly focused on locating and classifying icebergs using visual and radar reconnaissance methods. However, during patrols, the IRD will also communicate directly with the maritime community to request recent iceberg sighting information. This communication takes two forms: a sécurité broadcast to all vessels in the vicinity of the aircraft, and direct call outs to vessels identified by AIS. The information from the individual vessels is especially useful during periods of reduced visibility, or when numerous small vessels not equipped with AIS are present in the reconnaissance area. Vessel observations are valuable for confirmation of data provided by the aircraft's radar. During the 2024 season, IRDs made eight general sécurité broadcasts and two direct vessel callouts.

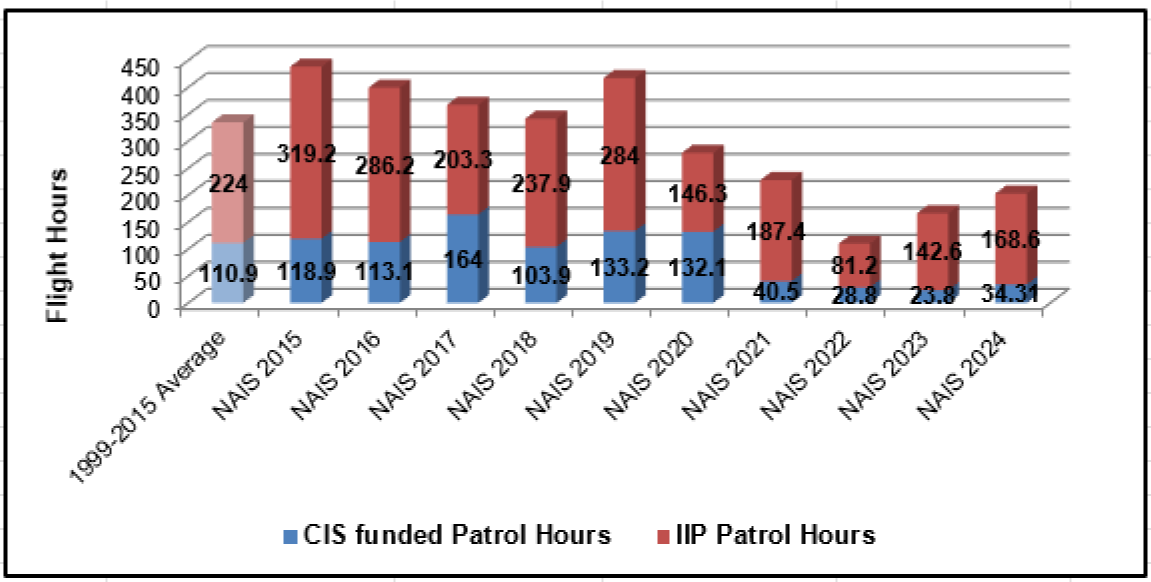

Figure 4.13. NAIS flight hours, a combination of IIP patrol hours and CIS funded PAL Aerospace patrol hours compared to the previous 10-year average. More icebergs south of 48°N may require increased reconnaissance efforts.

5 Semi-Monthly Iceberg Charts

5.1 Chart Description

The NAIS-65 Iceberg Chart is released daily by IIP (in the active Iceberg Season) and CIS (generally outside of the active Iceberg Season). It depicts the iceberg limit which delineates the iceberg population from open water, the estimated distribution of icebergs within this limit, and the sea ice limit.

The iceberg limit is comprised of the following: the iceberg limit over the Grand Banks and east of Newfoundland and Labrador (**Figures 5.1** through **5.24**, *solid magenta line to the south and east of Newfoundland and Labrador*), the iceberg limit to the west of Newfoundland (western limit, *solid magenta line within the Strait of Belle Isle and the Gulf of St. Lawrence*), and the Greenland iceberg limit (*dotted magenta solid line south of Greenland*, from DMI). The Grand Banks iceberg limit is the primary component of the chart, as it affects transatlantic navigation, and IIP allots the most detection and monitoring efforts to ensure its accuracy and reliability.

The western iceberg limit is drawn when icebergs drift south into the Strait of Belle Isle and the Gulf of St. Lawrence, which is a heavily trafficked area. If icebergs begin to approach Anticosti Island, IIP may elect to split the western limit into two segments to account for icebergs to the north and south of the island. Rarely, when icebergs drift south of the line between Port aux Basques, Newfoundland and the southeastern tip of Anticosti Island, IIP may draw the iceberg limit across Cabot Strait between Newfoundland and Cape Brenton Island. This would likely adversely affect shipping traffic, as vessels headed to the St. Lawrence Seaway would have to cross the iceberg limit.

The Greenland iceberg limit (termed the "estimated iceberg limit") is provided by DMI to IIP and CIS semi-weekly. DMI uses an automated approach to detect icebergs around Greenland and does not model an individual iceberg's drift and deterioration as IIP does. For this reason, the Greenland iceberg limit is assigned a lower level of confidence and reported in the NAIS iceberg warning products as estimated. The Greenland iceberg limit affects primarily specialized ice navigators who take on their own risk by crossing it.

The sea ice limit (see **Figures 5.1** through **5.24,** *dashed magenta line*) is provided daily by CIS and delineates ice-covered from ice-free waters. The sea ice limit provides no additional information on sea ice concentration or stage of development and is meant only as a rough indicator of the presence or absence of sea ice.

Finally, the estimated distribution of icebergs is depicted as the estimated number of icebergs per square degree. IIP does not report the individual estimated locations of the icebergs in the database due to uncertainties associated with iceberg detection and modeling. The reported iceberg distribution should not be used for navigation.

It should be noted that IIP may report radar targets within the NAIS iceberg warning products. Radar targets are targets detected by spaceborne, aircraft, or vessel radars that were observed with low confidence (were indistinguishable as icebergs, vessels, or other targets). In the NAIS-65 chart, radar targets are depicted as small circles encompassing an "x". IIP attempts to minimize the number of radar targets reported and prioritizes reconnaissance to investigate and accurately classify them.

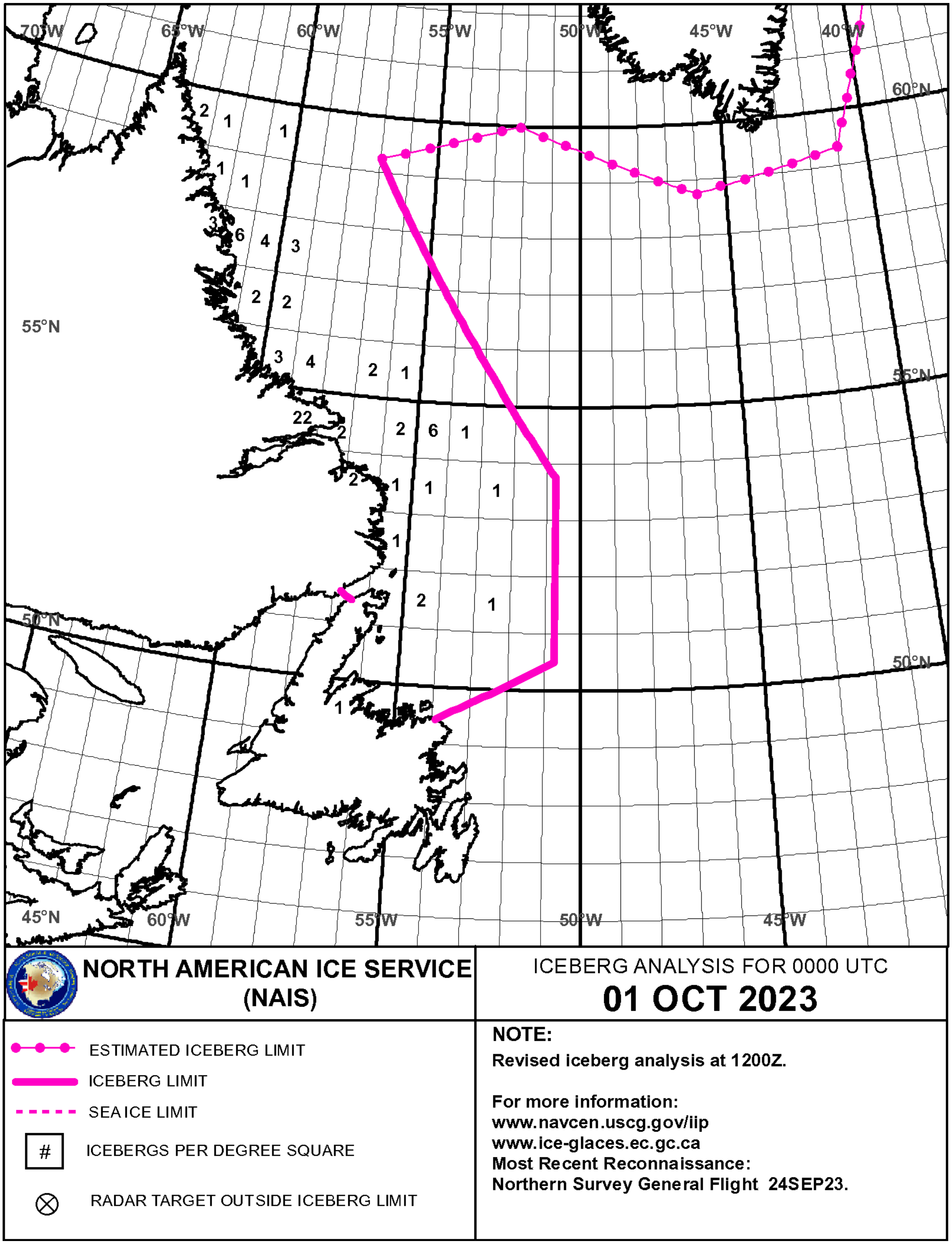

Figure 5.1. NAIS-65 Iceberg Chart for 1 October 2023

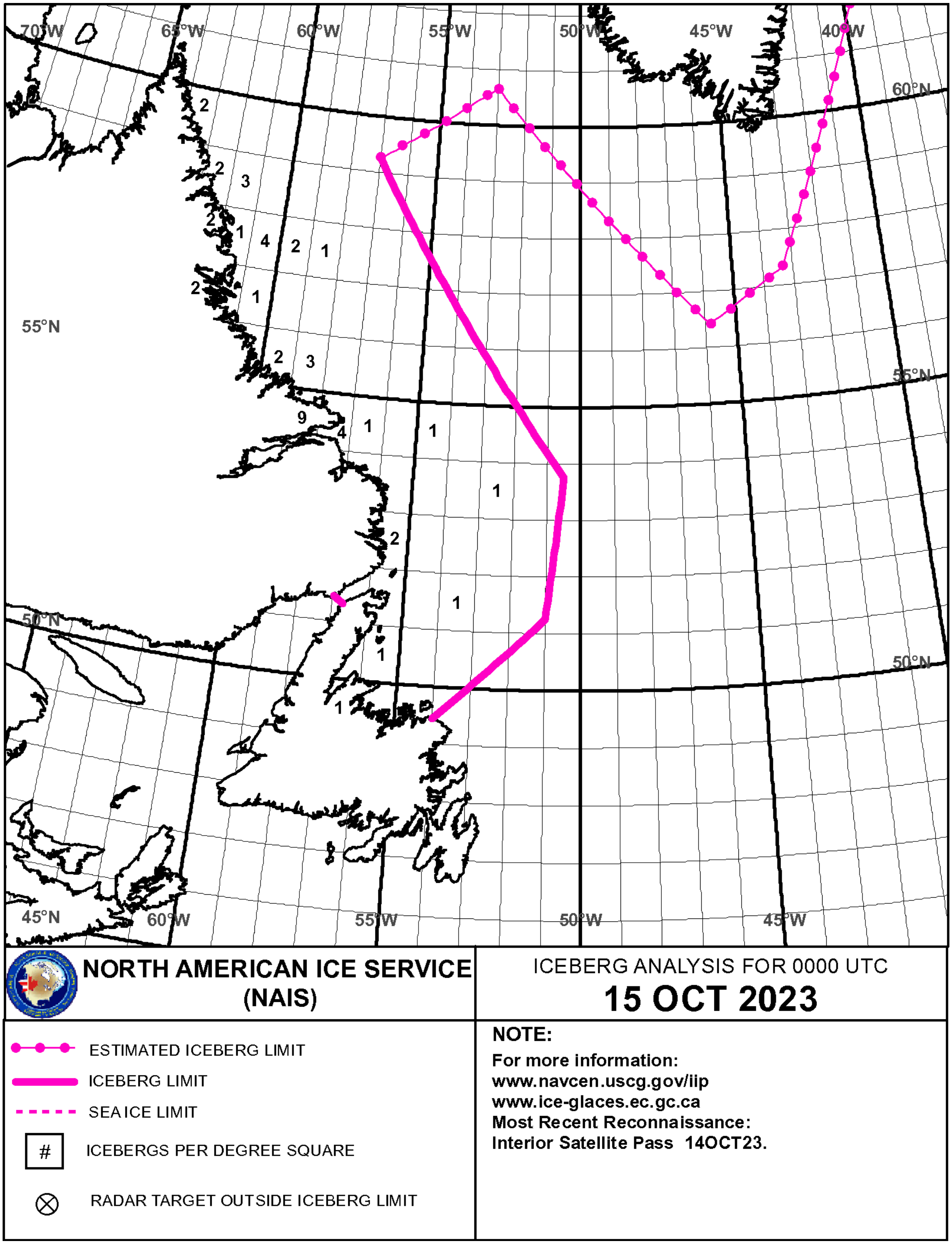

Figure 5.2. NAIS-65 Iceberg Chart for 15 October 2023

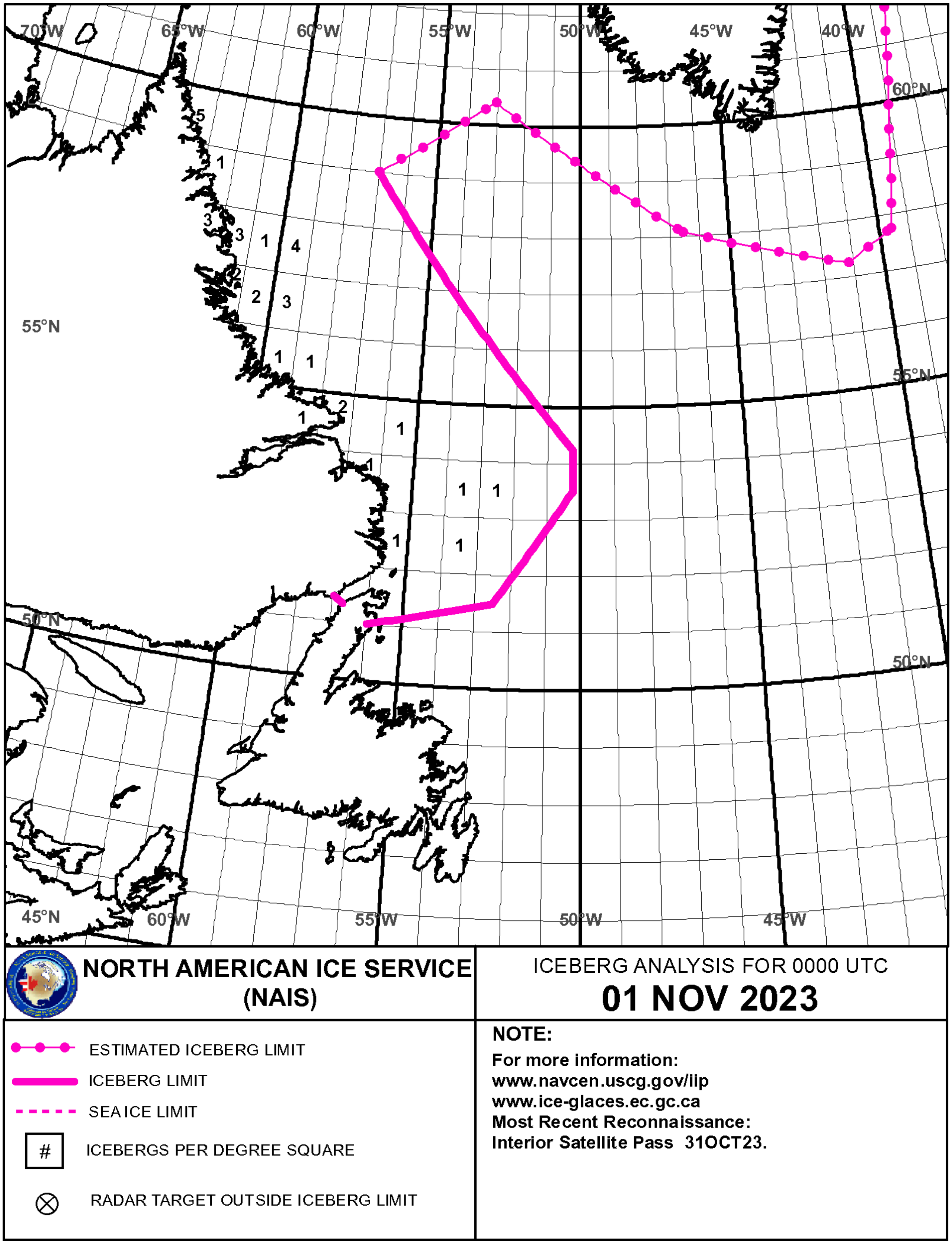

Figure 5.3. NAIS-65 Iceberg Chart for 1 November 2023

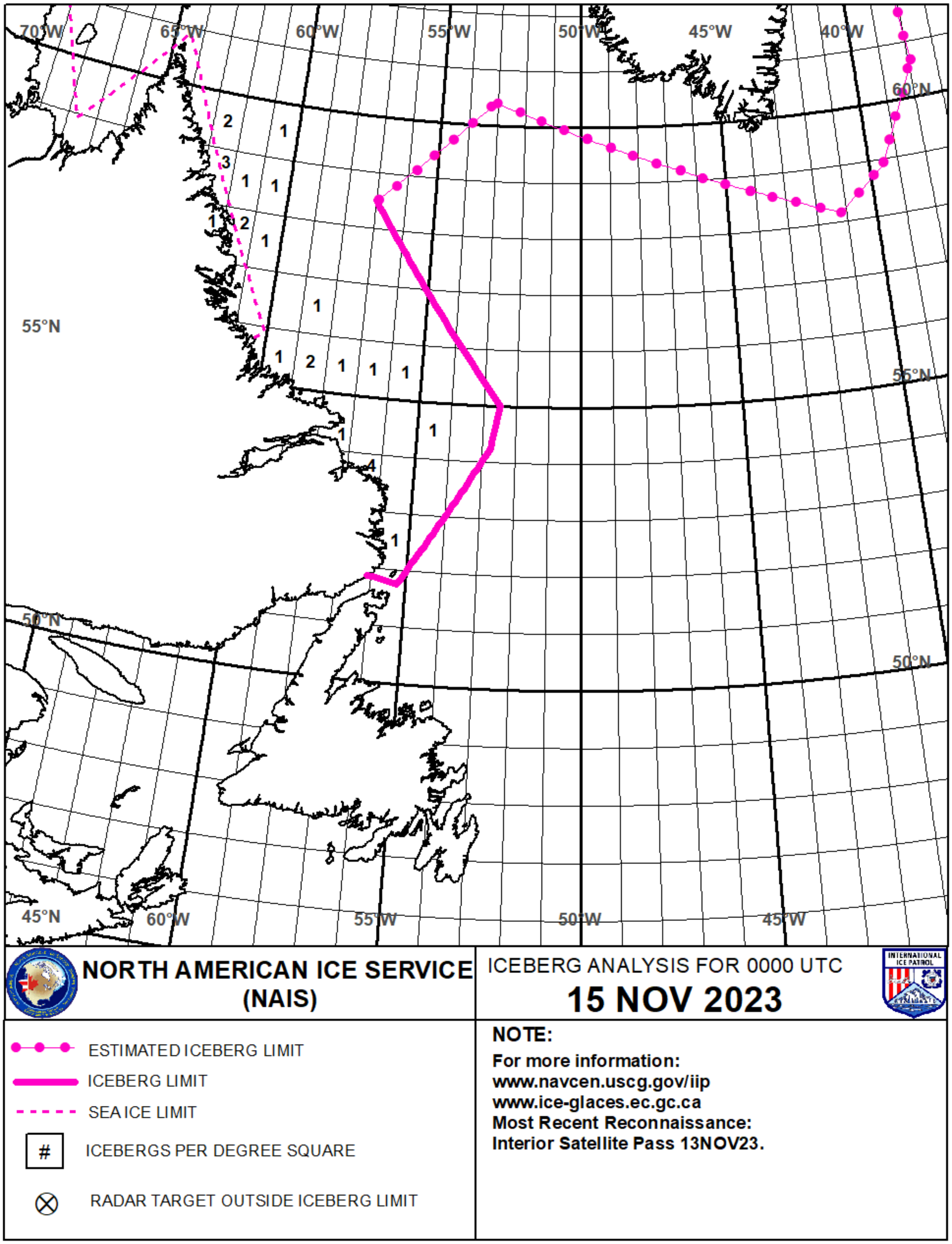

Figure 5.4. NAIS-65 Iceberg Chart for 15 November 2023

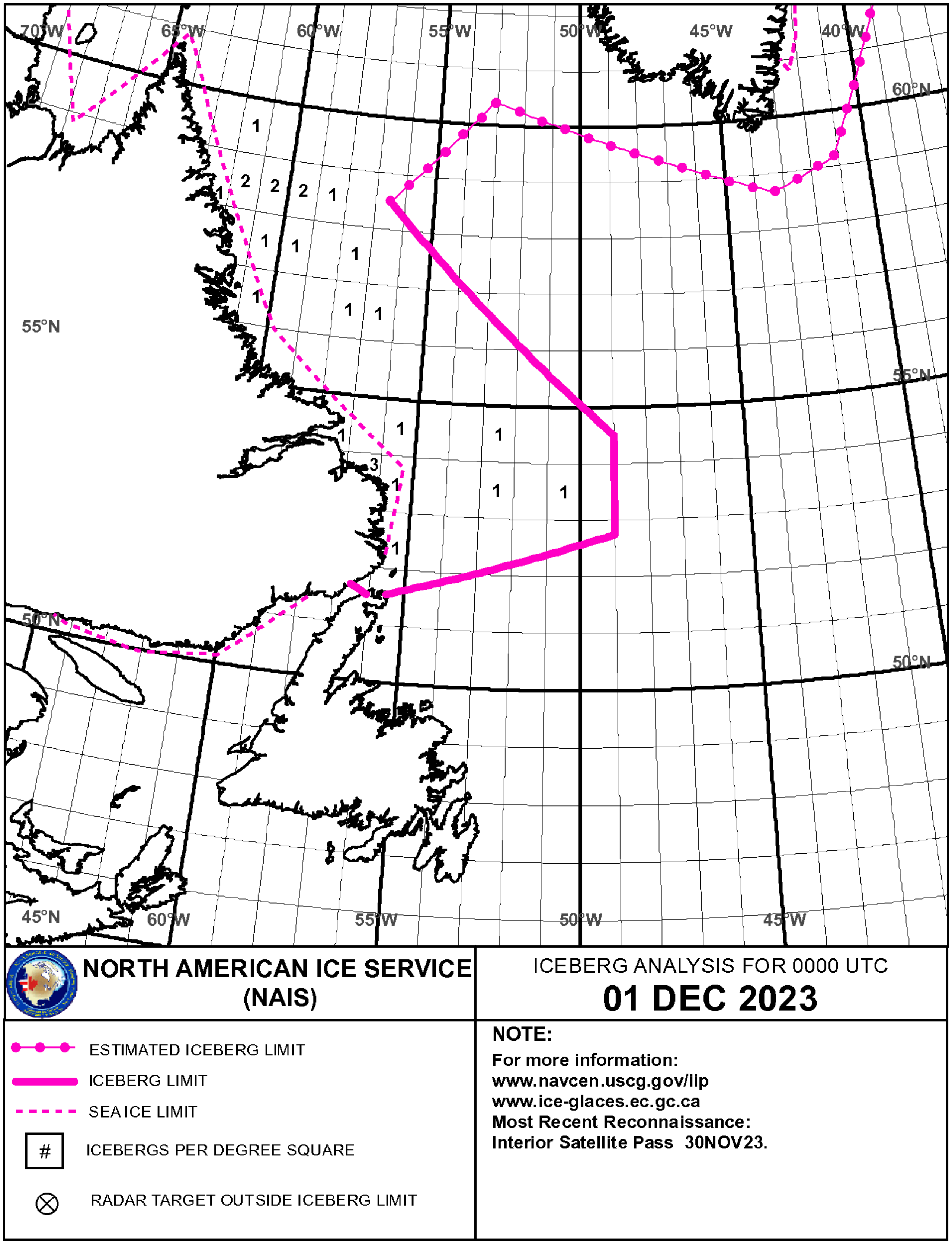

Figure 5.5. NAIS-65 Iceberg Chart for 1 December 2023

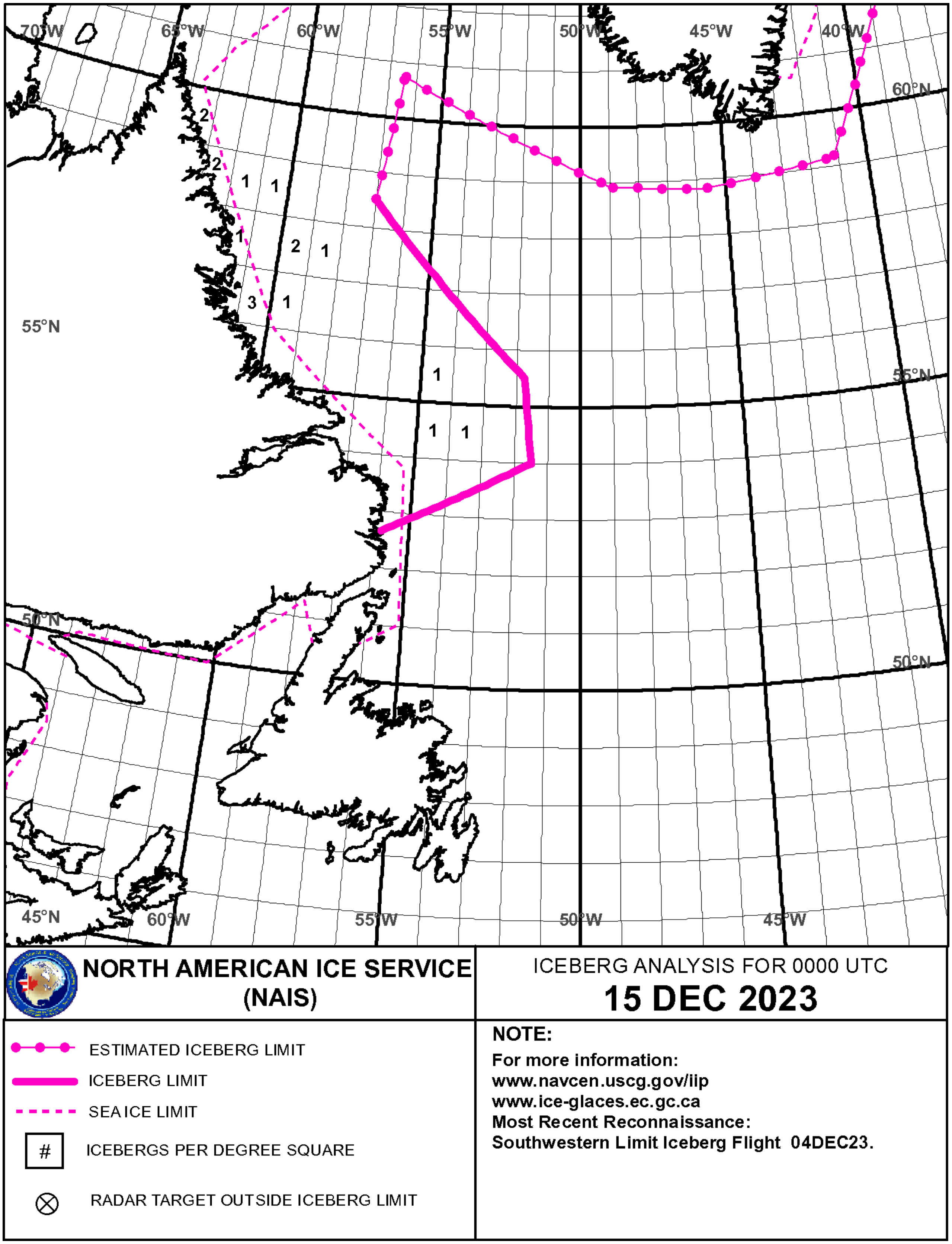

Figure 5.6. NAIS-65 Iceberg Chart for 15 December 2023

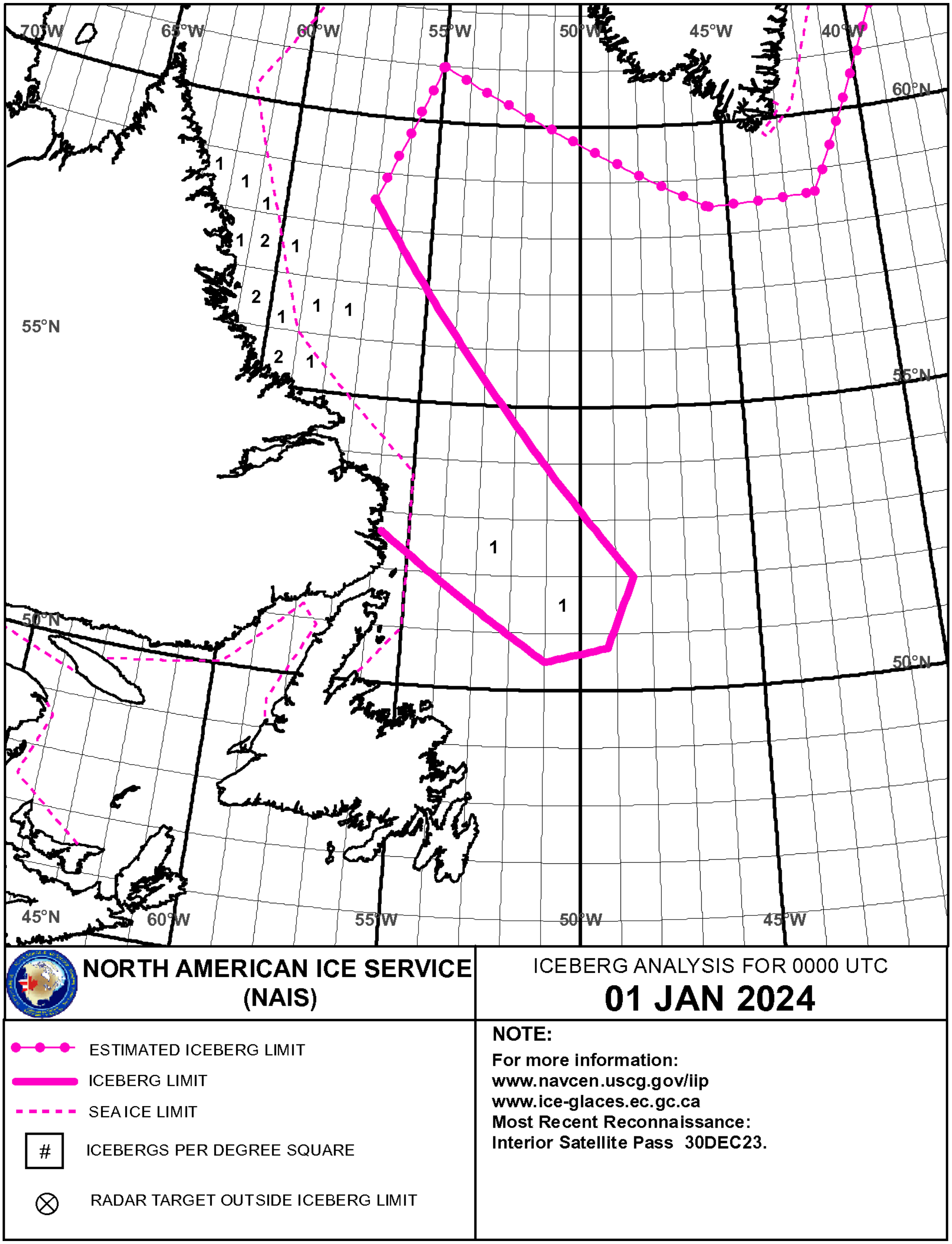

Figure 5.7. NAIS-65 Iceberg Chart for 1 January 2024

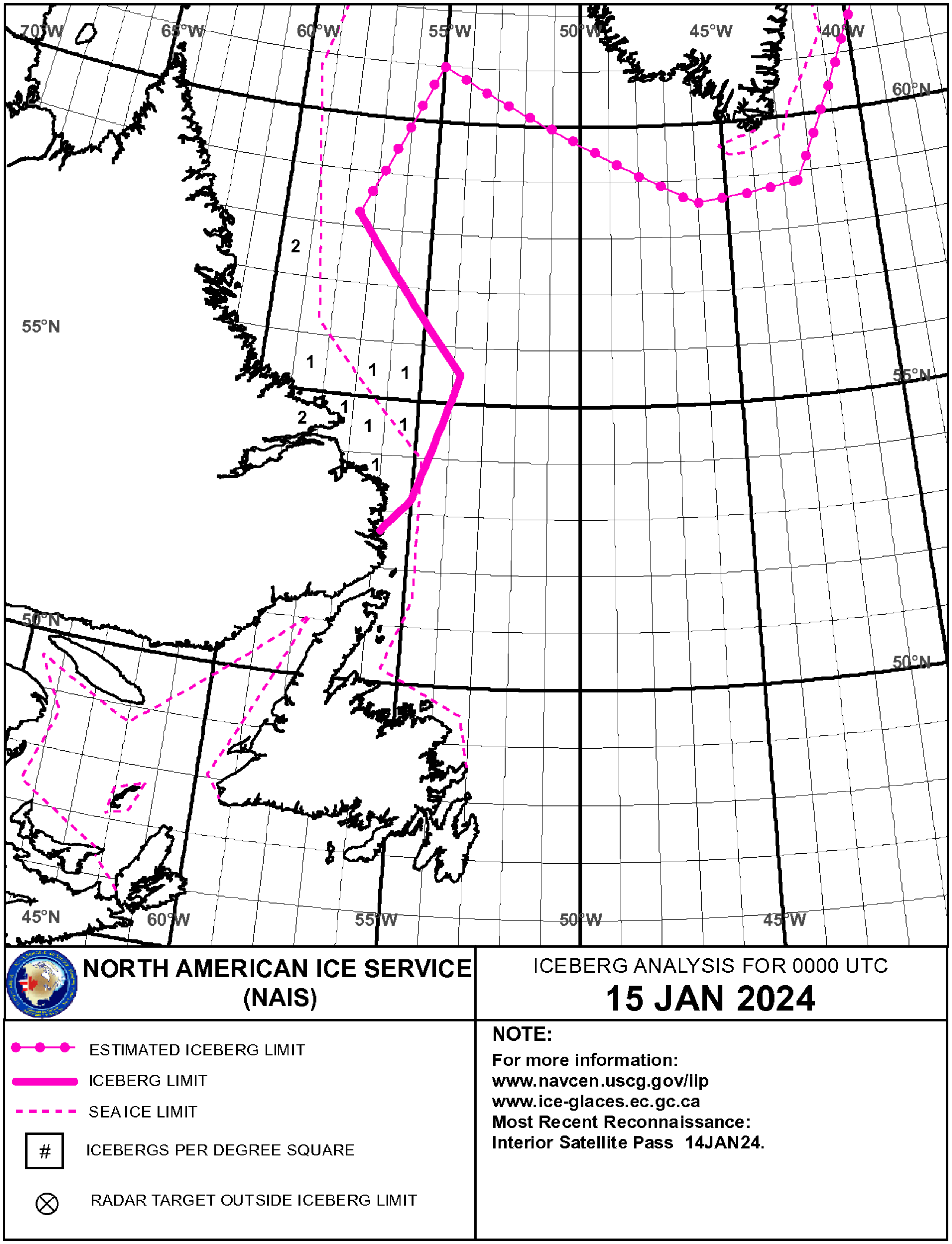

Figure 5.8. NAIS-65 Iceberg Chart for 15 January 2024

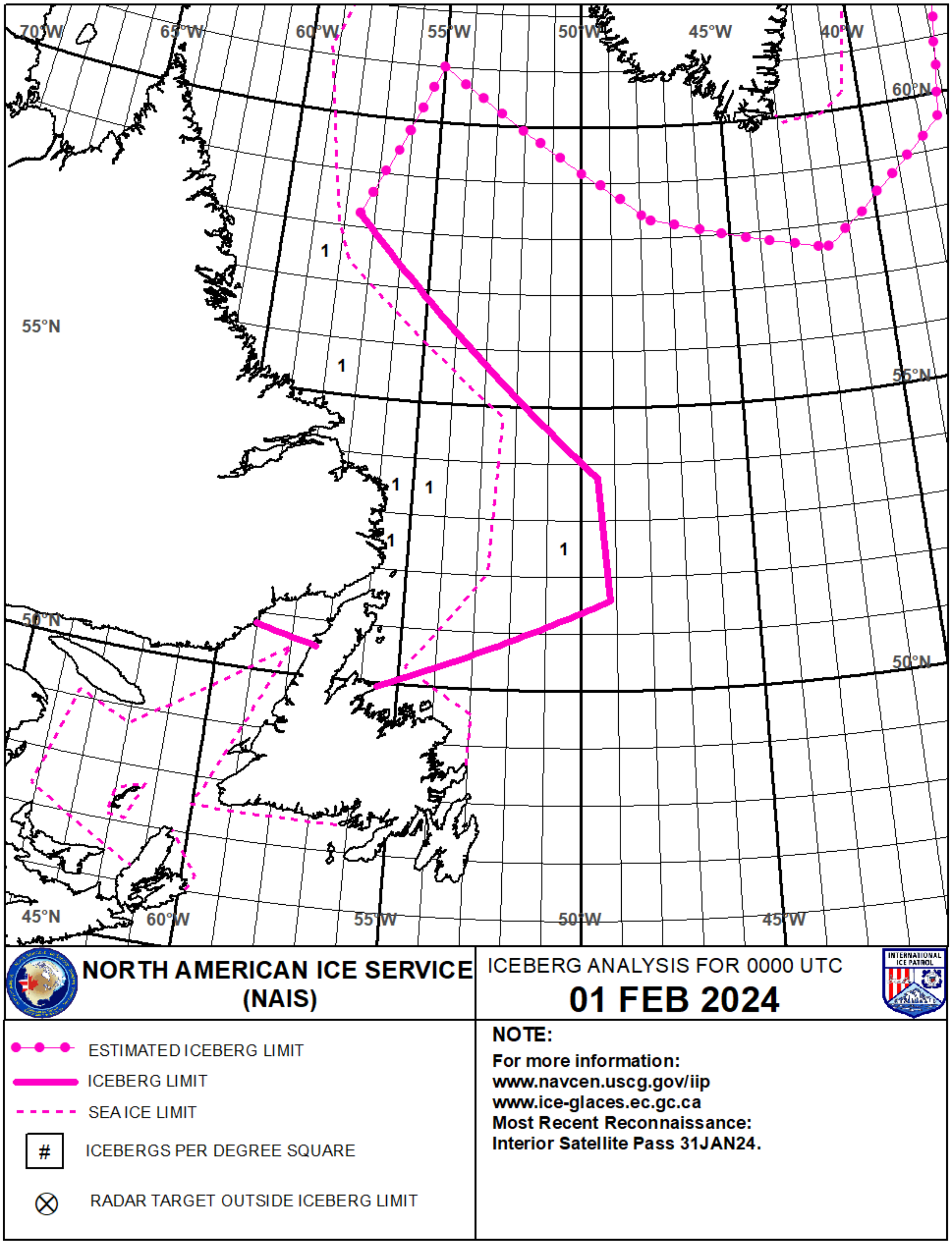

Figure 5.9. NAIS-65 Iceberg Chart for 1 February 2024

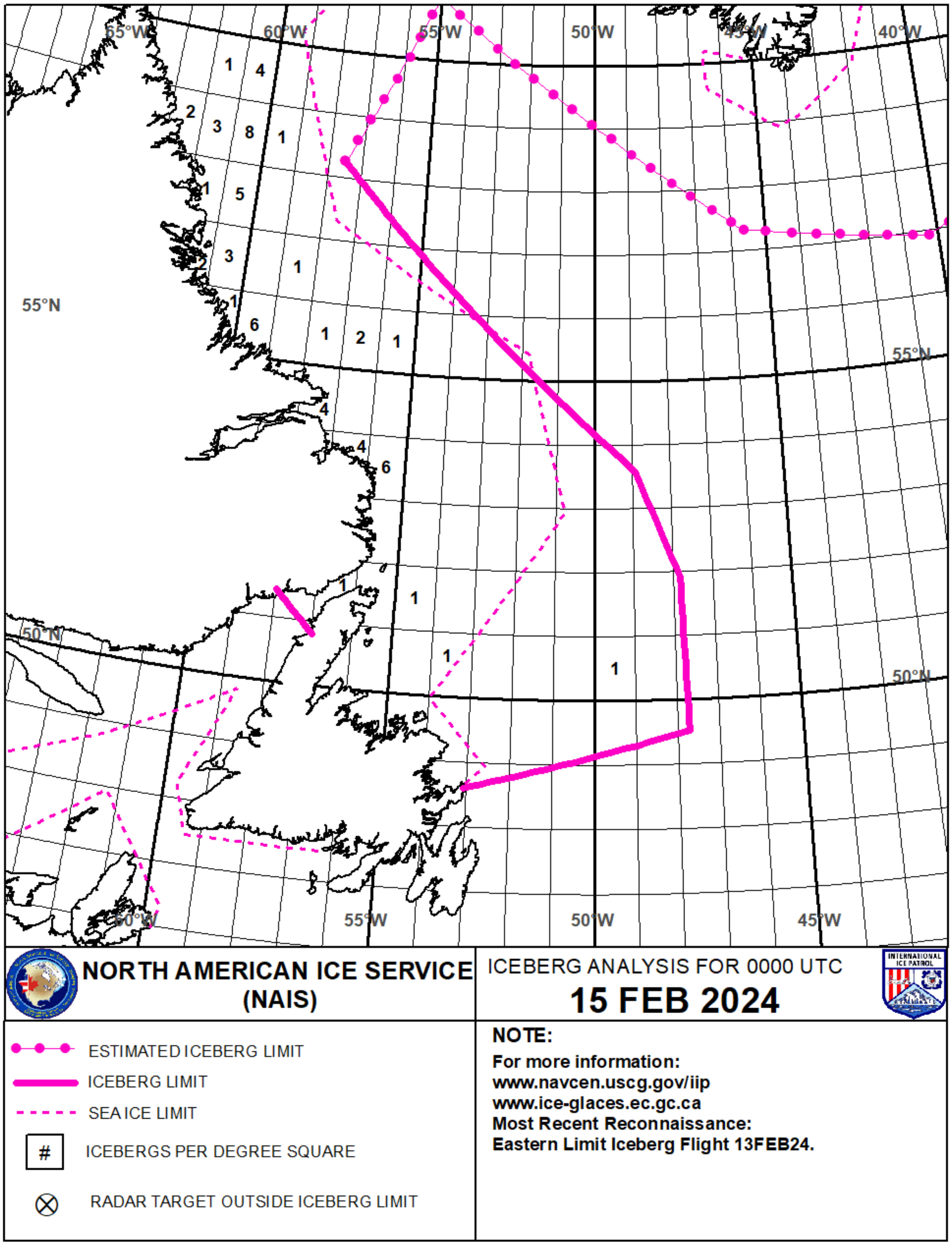

Figure 5.10. NAIS-65 Iceberg Chart for 15 February 2024

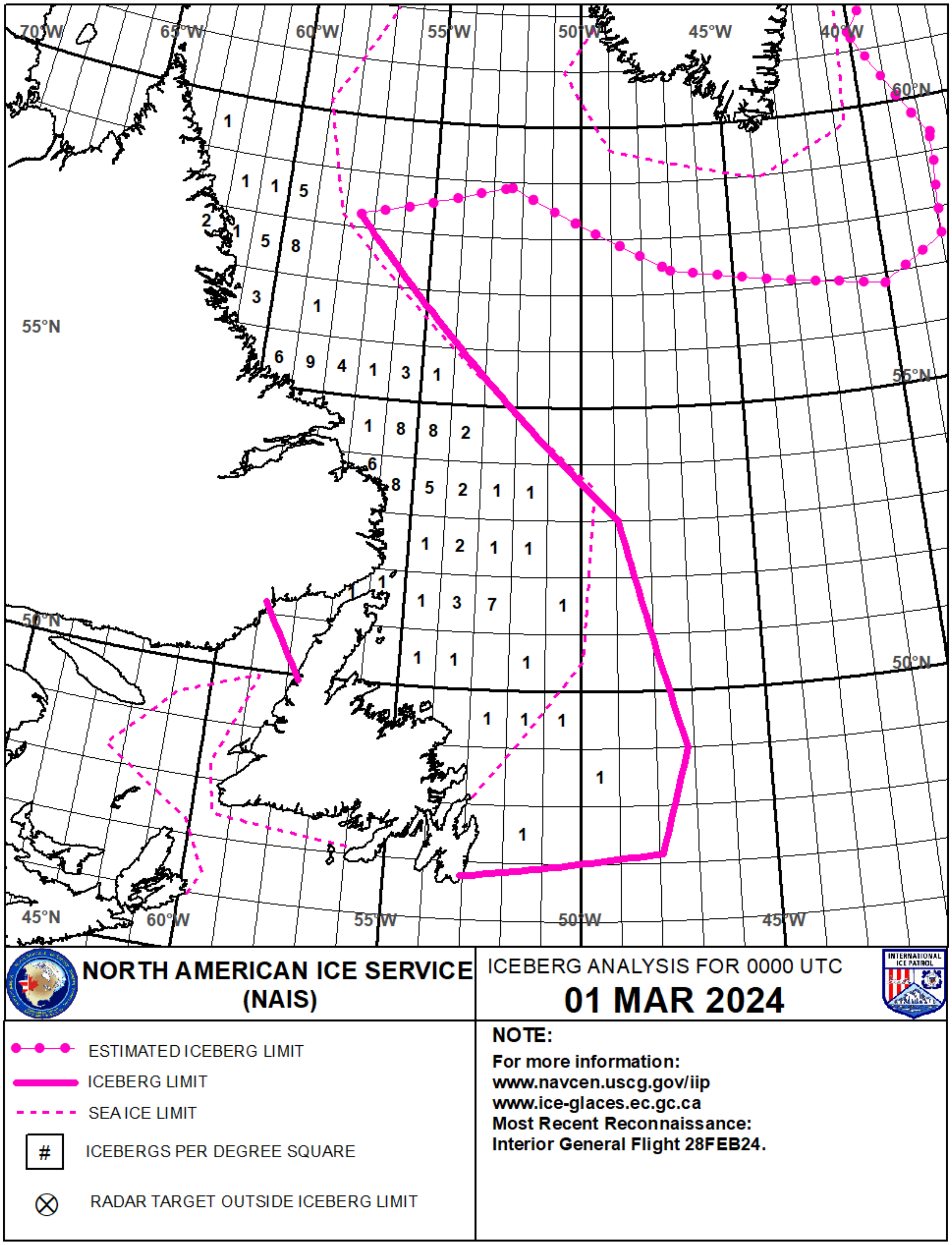

Figure 5.11. NAIS-65 Iceberg Chart for 1 March 2024

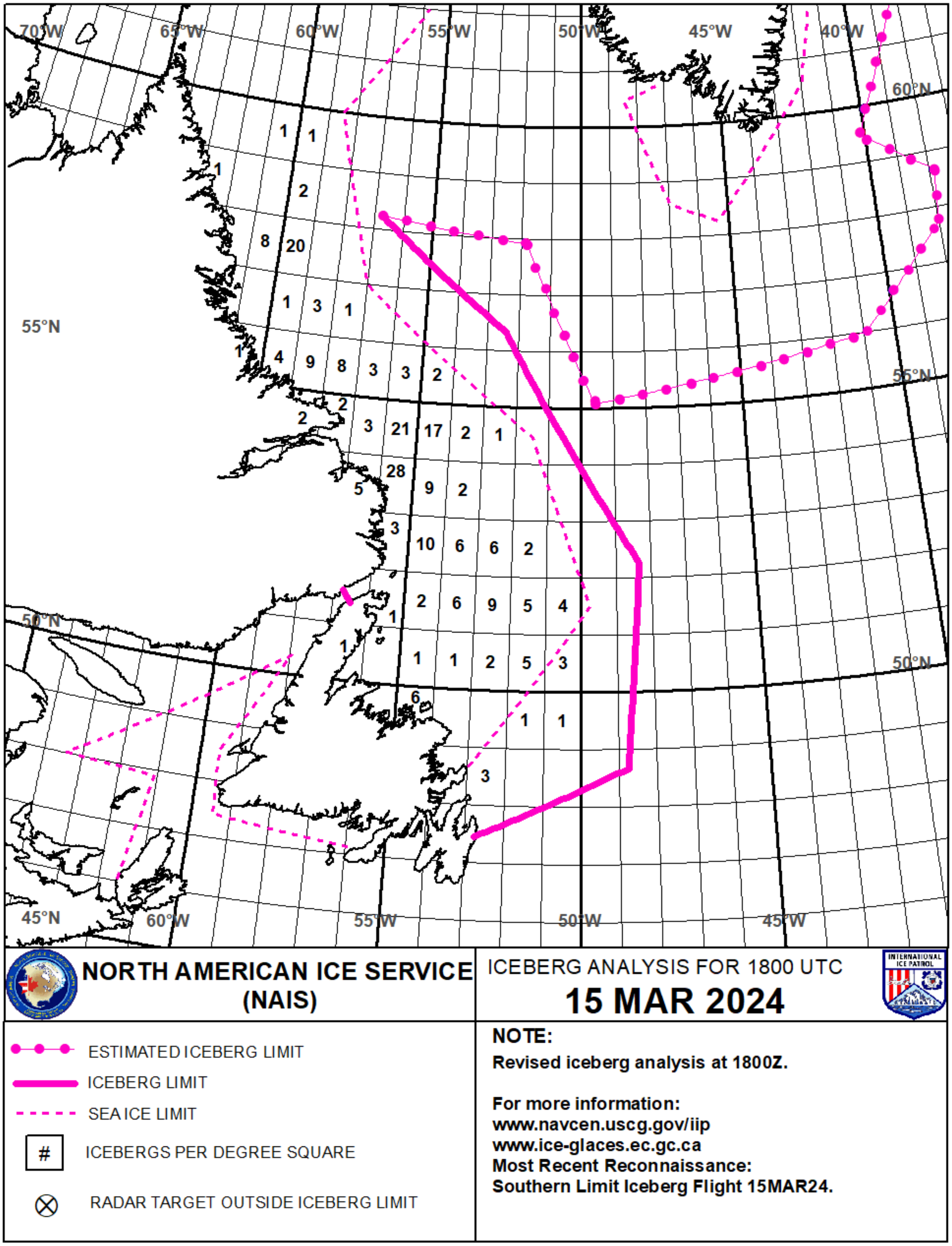

Figure 5.12. NAIS-65 Iceberg Chart for 15 March 2024

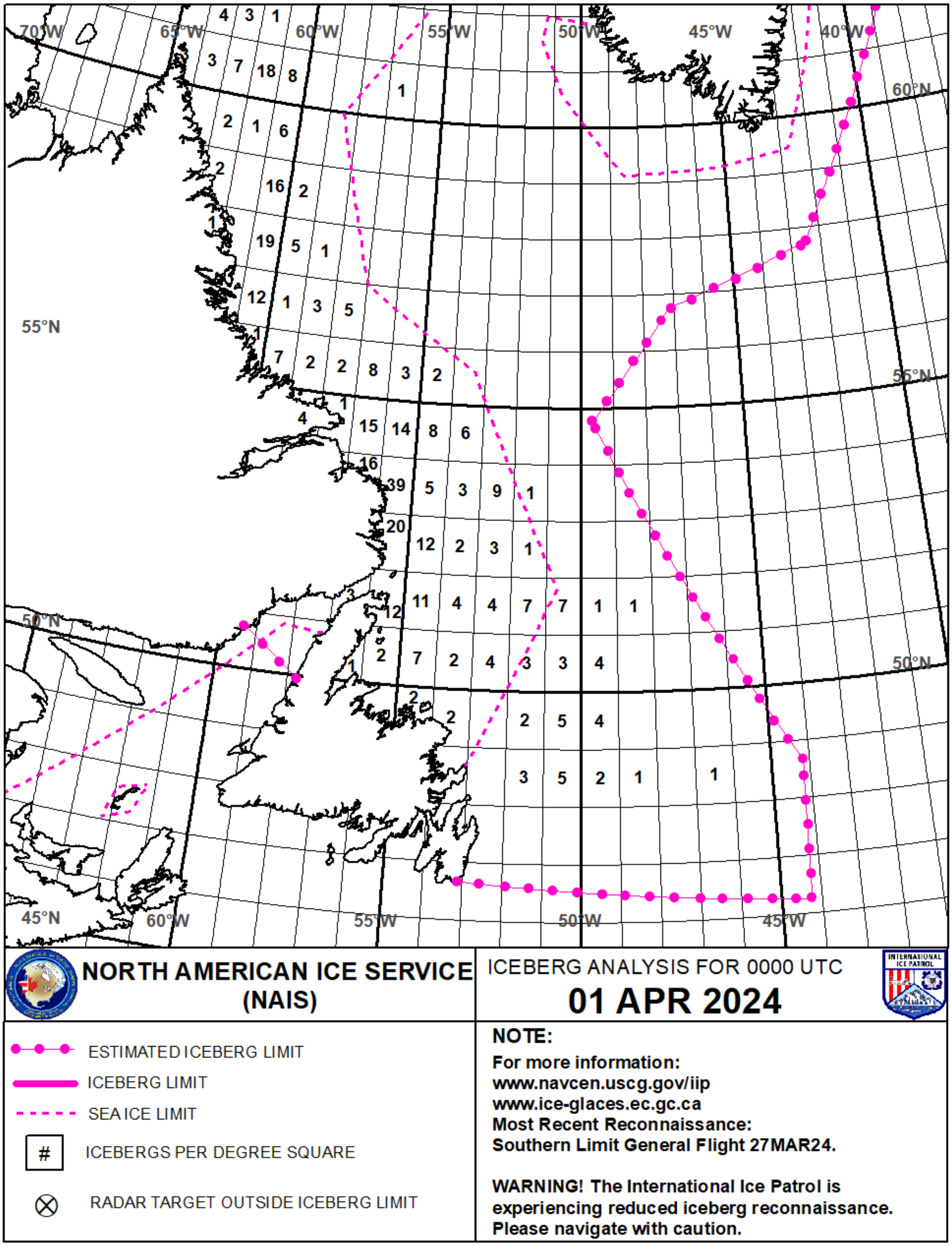

Figure 5.13. NAIS-65 Iceberg Chart for 1 April 2024

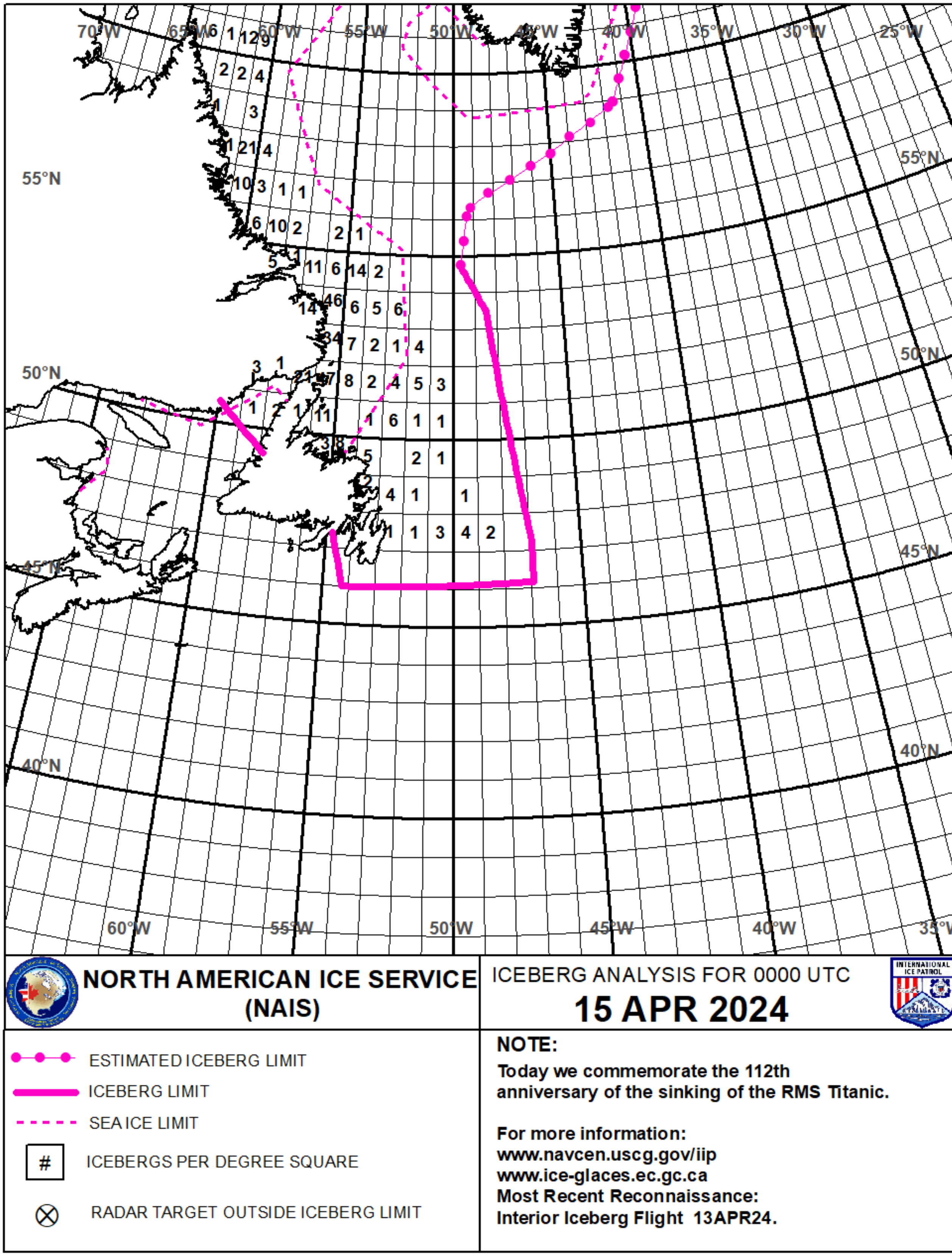

Figure 5.14. NAIS-65 Iceberg Chart for 15 April 2024

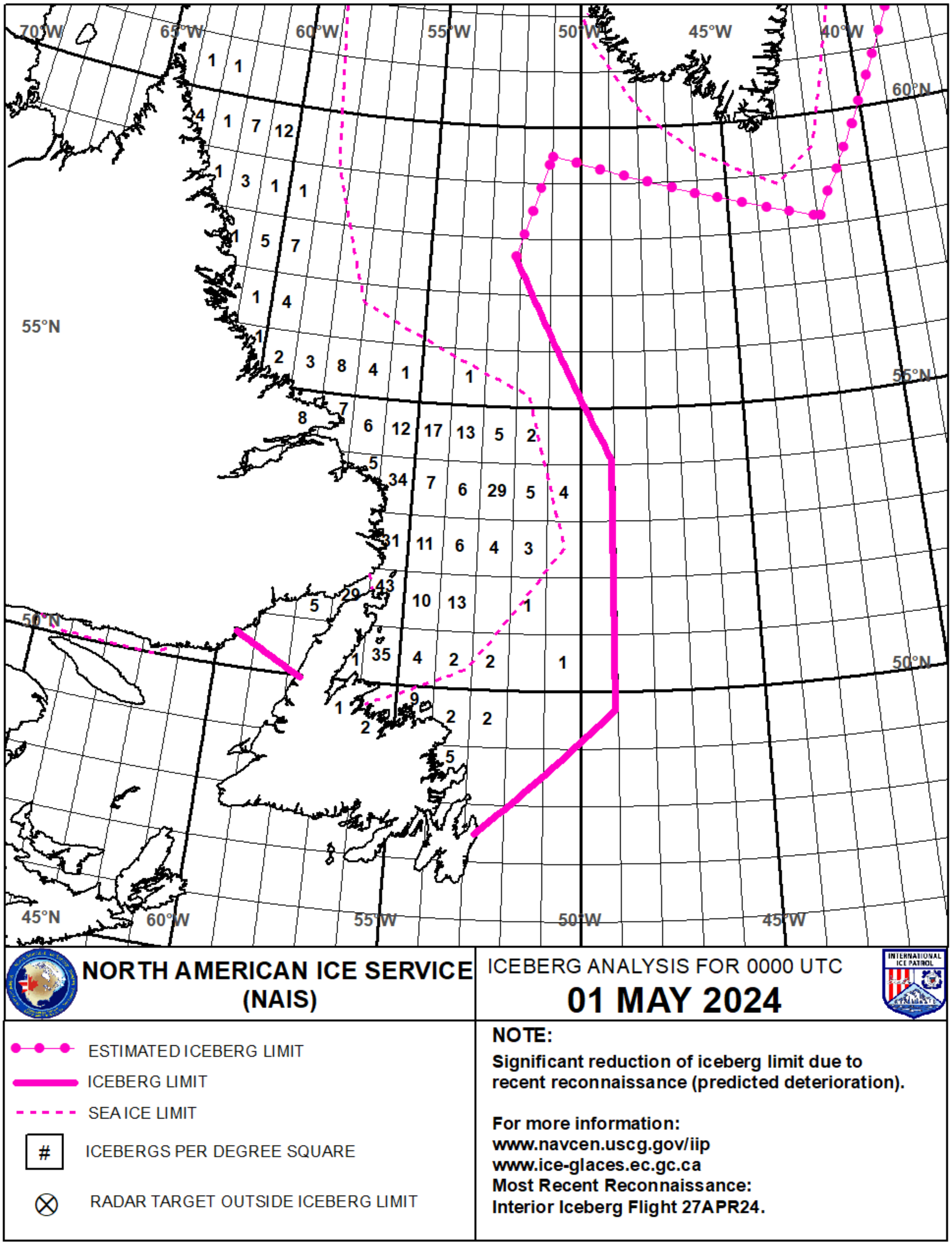

Figure 5.15. NAIS-65 Iceberg Chart for 1 May 2024

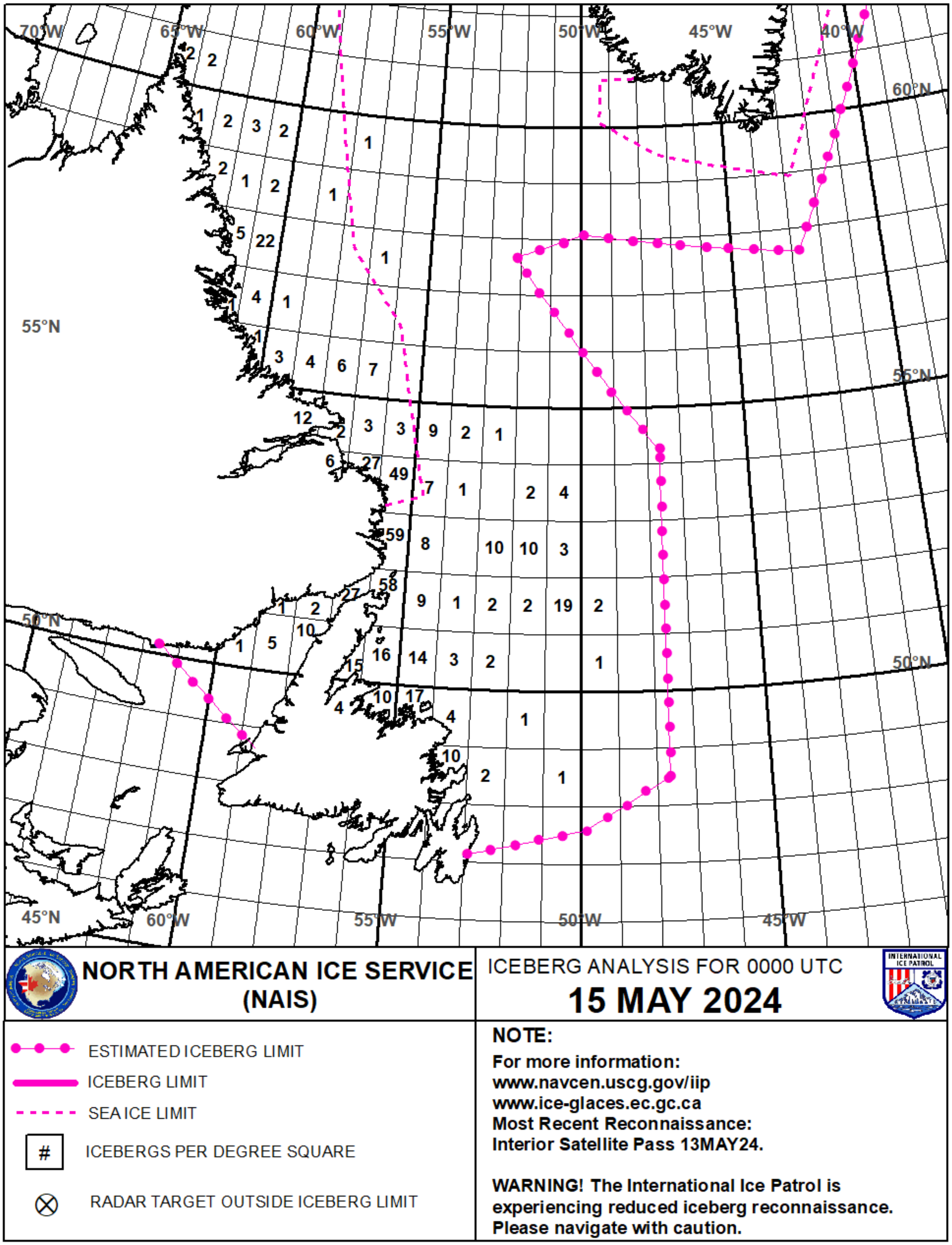

Figure 5.16. NAIS-65 Iceberg Chart for 15 May 2024

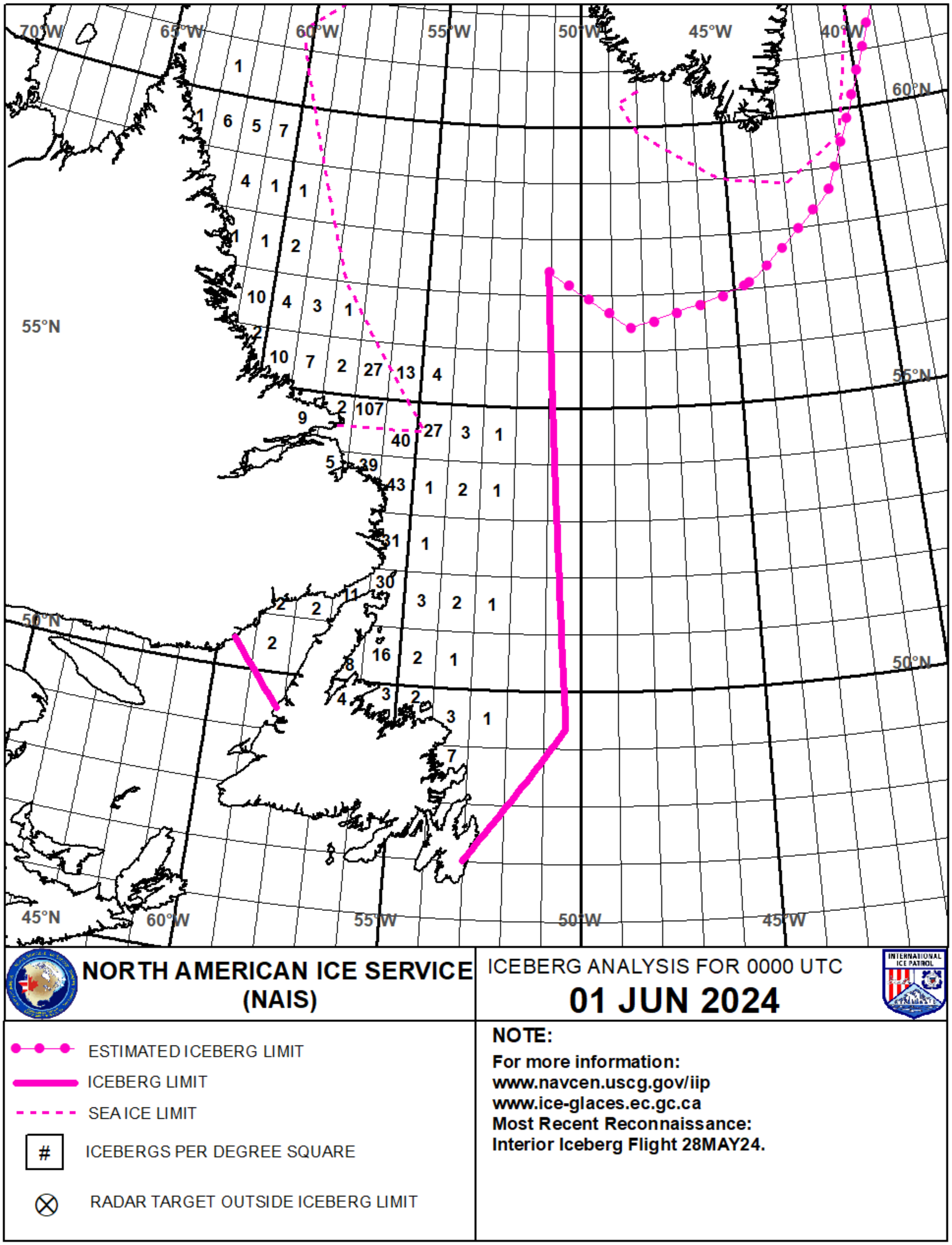

Figure 5.17. NAIS-65 Iceberg Chart for 1 June 2024

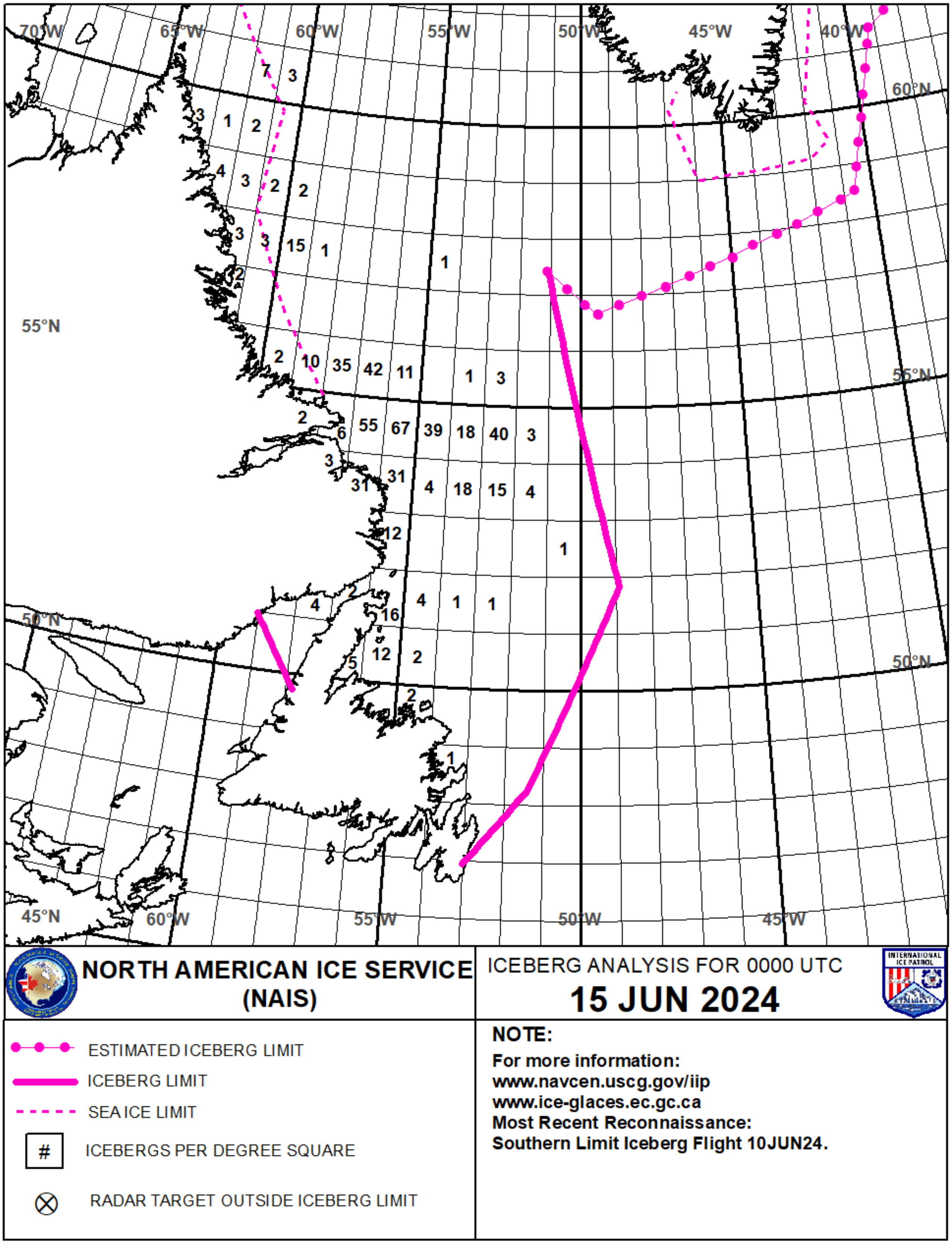

Figure 5.18. NAIS-65 Iceberg Chart for 15 June 2024

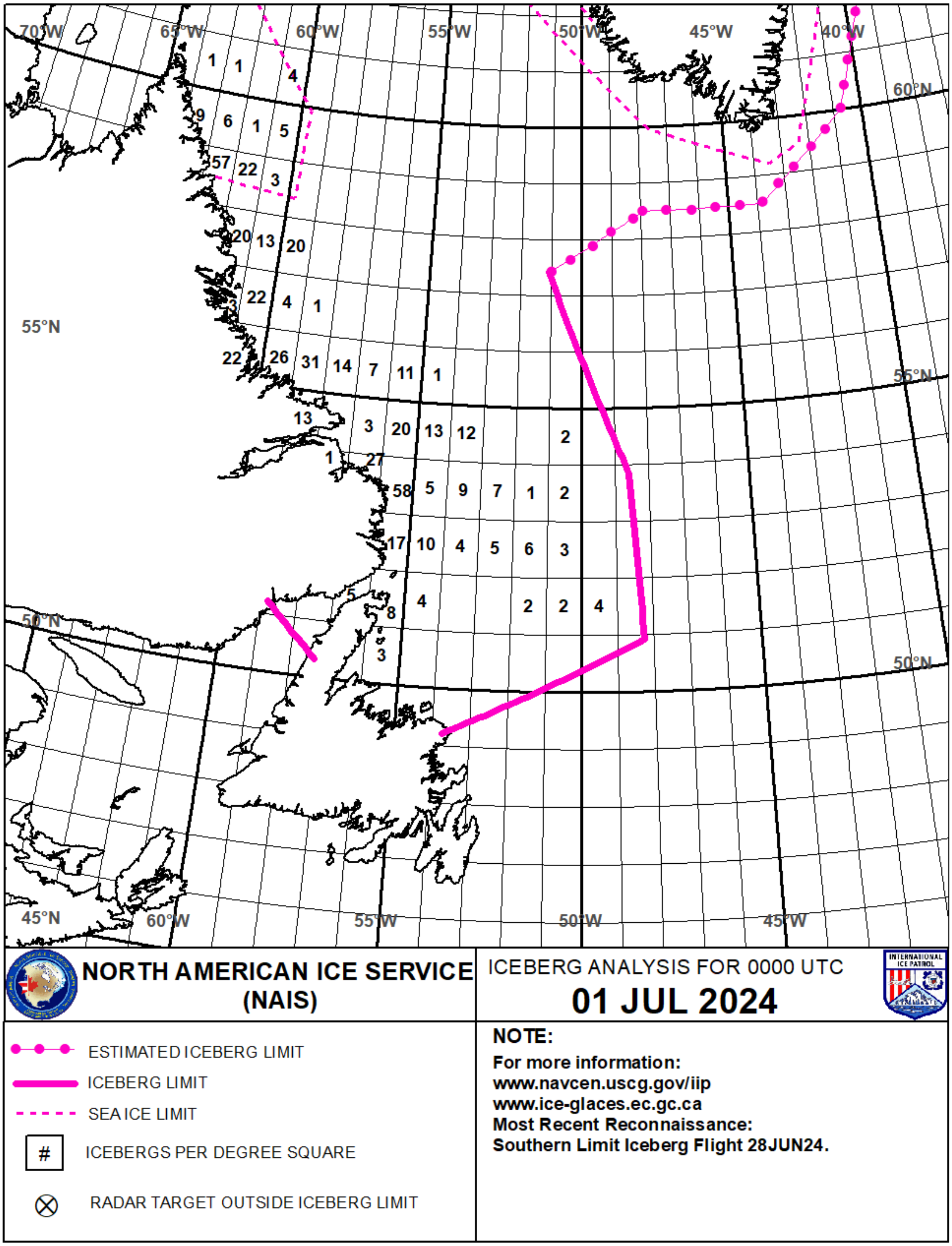

Figure 5.19. NAIS-65 Iceberg Chart for 1 July 2024

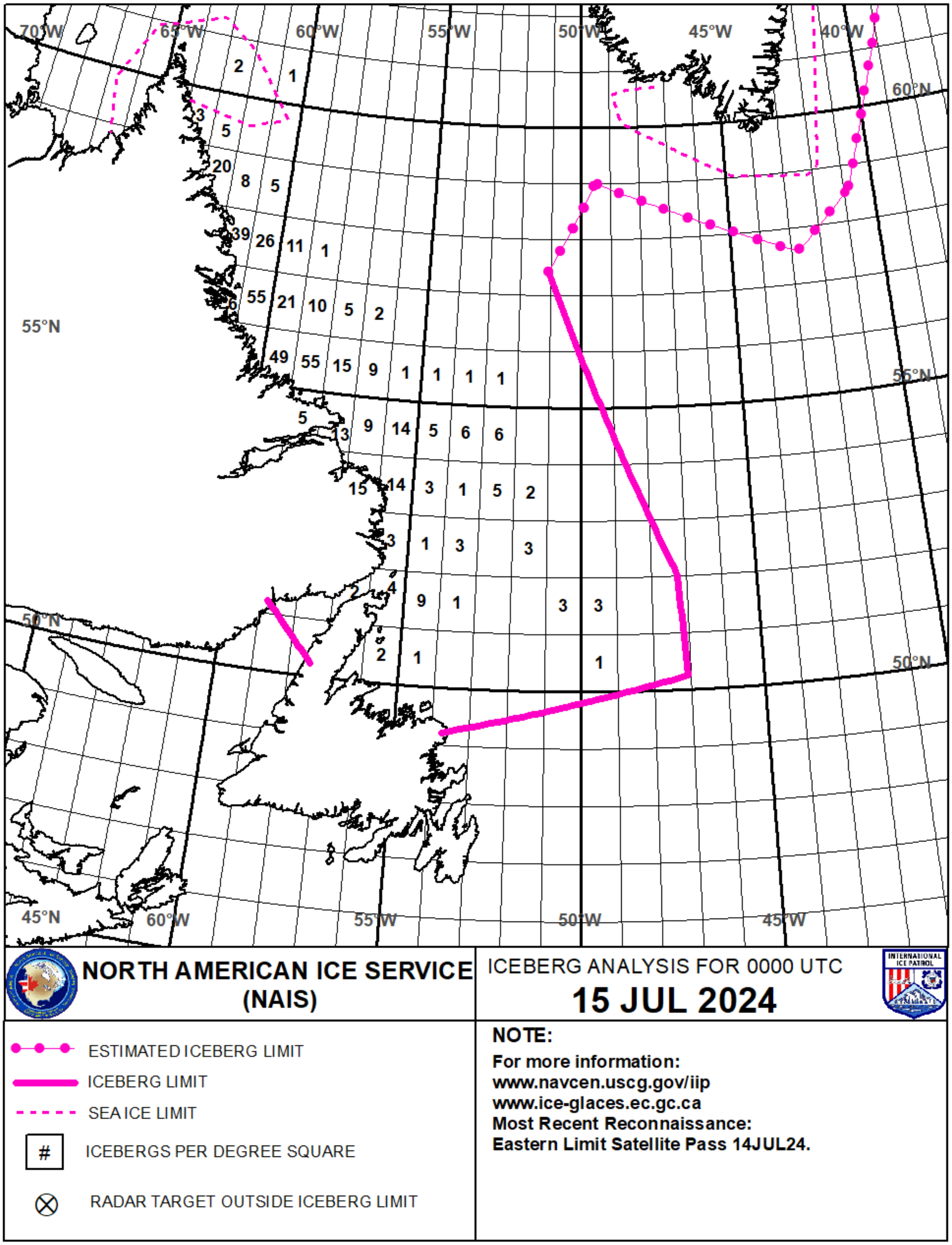

Figure 5.20. NAIS-65 Iceberg Chart for 15 July 2024

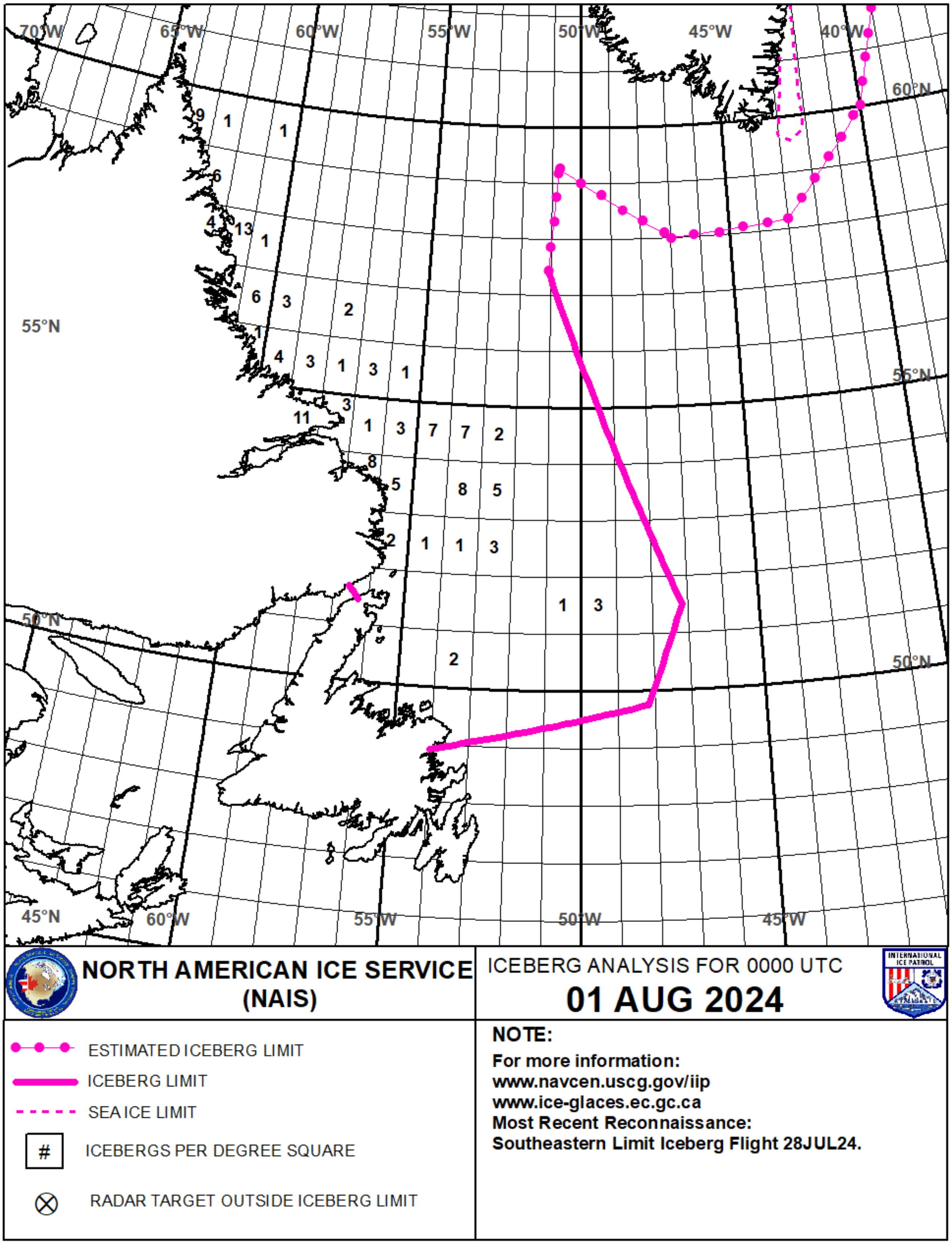

Figure 5.21. NAIS-65 Iceberg Chart for 1 August 2024

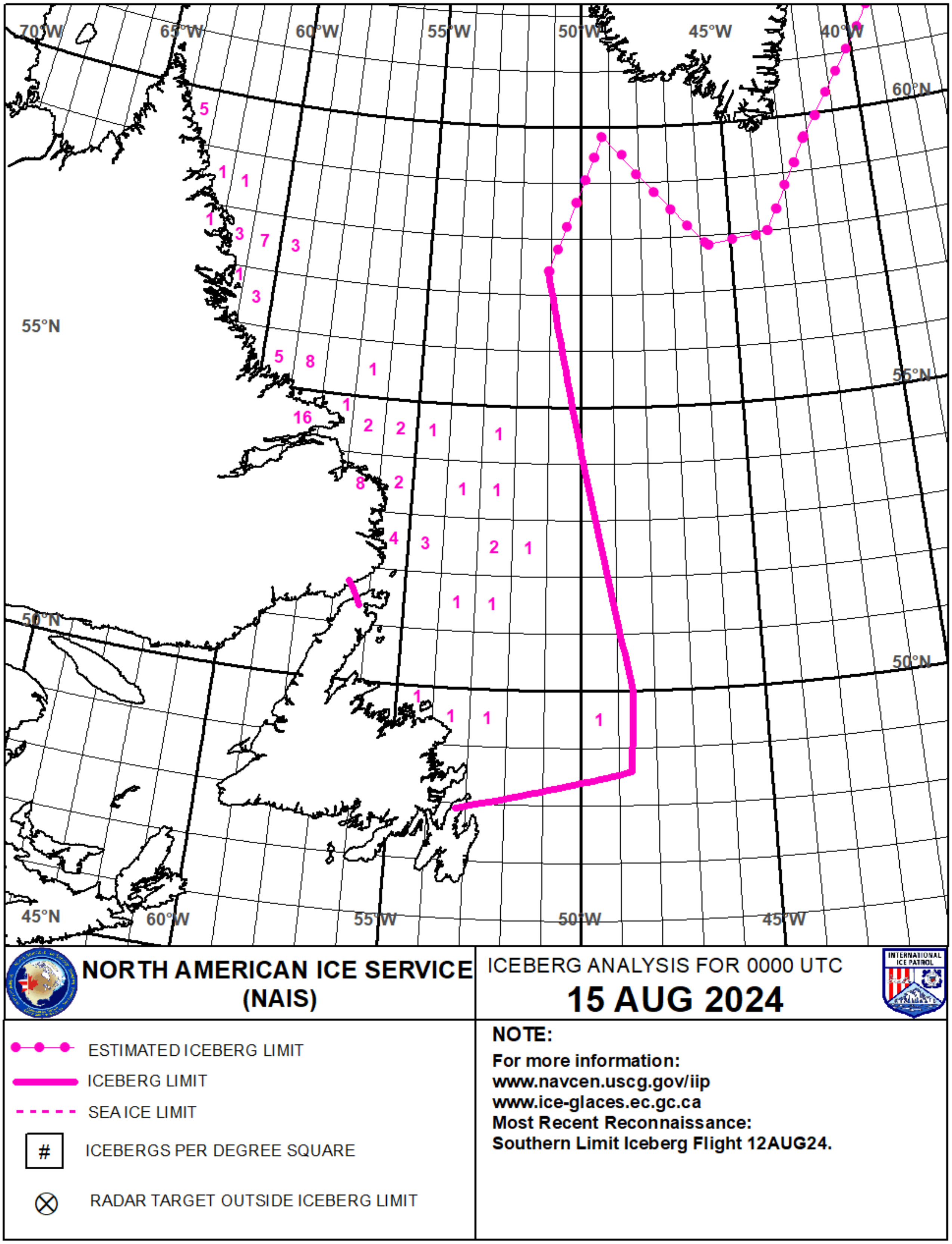

Figure 5.22. NAIS-65 Iceberg Chart for 15 August 2024

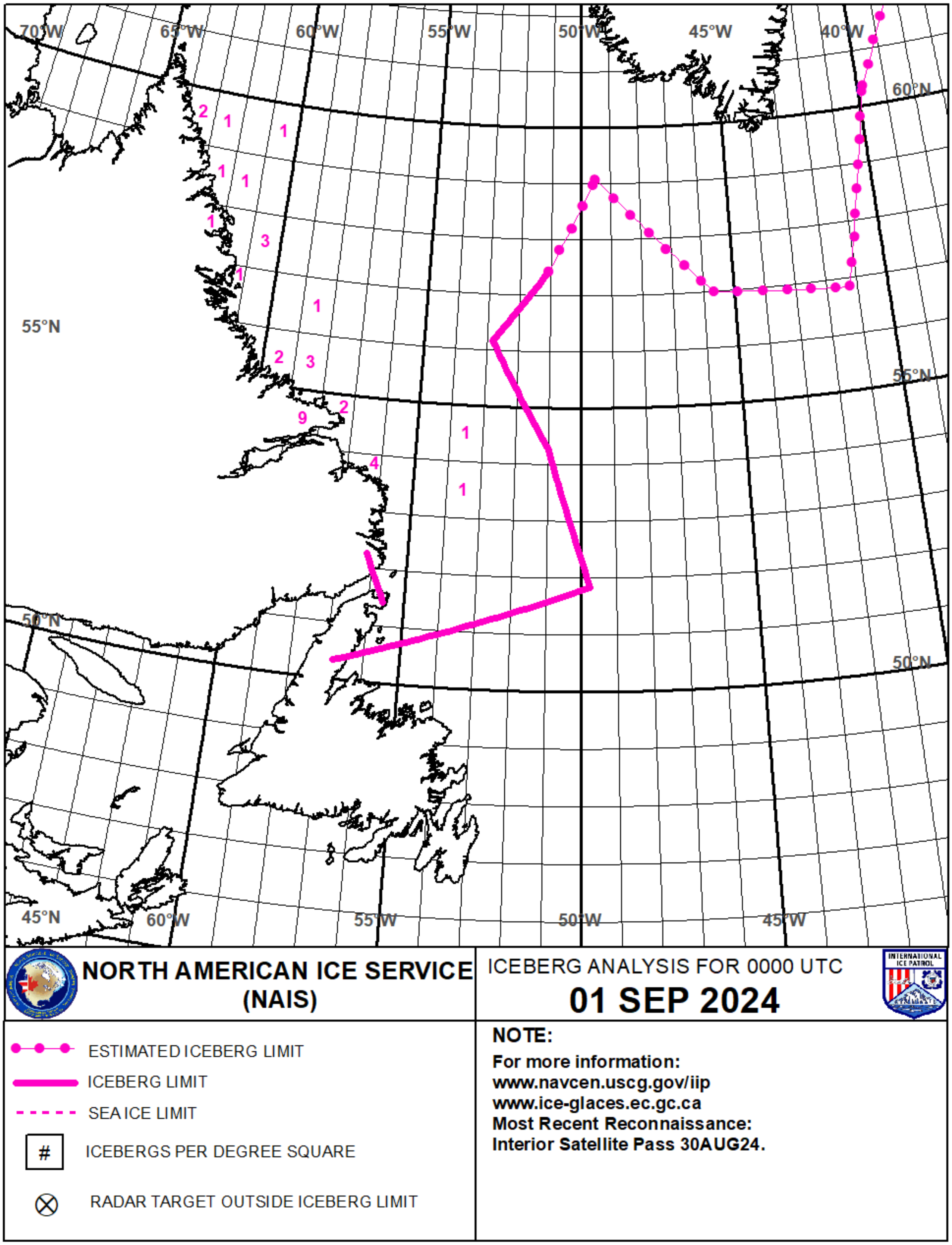

Figure 5.23. NAIS-65 Iceberg Chart for 1 September 2024

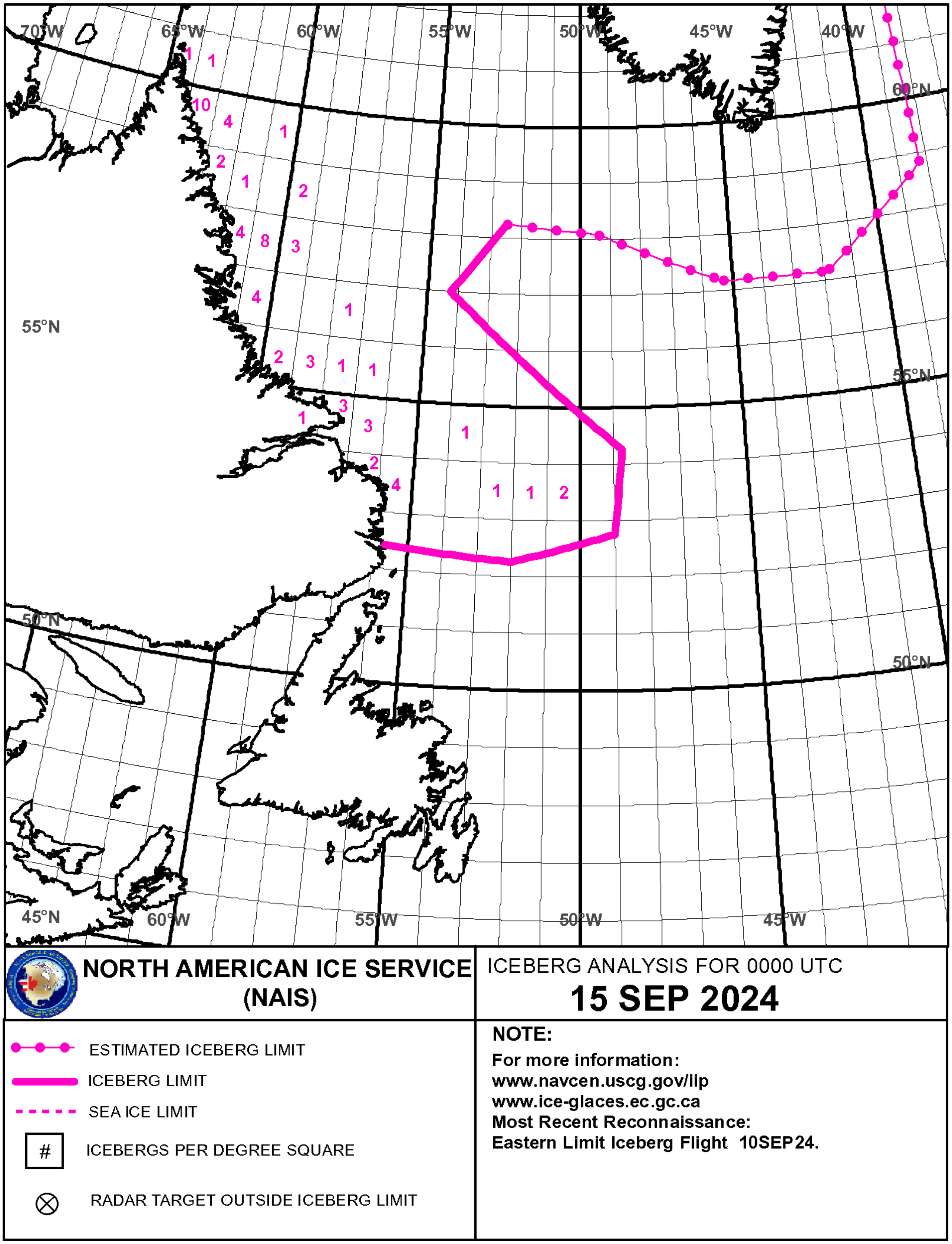

Figure 5.24. NAIS-65 Iceberg Chart for 15 September 2024

INTERNATIONAL ICE PATROL

Data and Acknowledgements

Iceberg data is from IIP. Sea ice extents are from the NSIDC, Sea Ice Index, Version 3 (Fetterer, et al. 2017). NAOI values are from the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) Climate Prediction Center (CPC) (NOAA/NWS NCEP Climate Prediction Center 2024). Temperature, pressure, wind, precipitation, and wave data are from the ECMWF ERA5 Reanalysis monthly averaged data on single levels from 1940 to present (Hersbach, et al. 2024).

IIP Commander, CDR Erin Caldwell, wrote **Section 1** and **Appendix A**. IIP Chief Scientist and Oceanographer, Dr. Alexis Denton, wrote **Section 2**. IIP Iceberg Operations Branch Chief, LT Megan Toomey, coordinated, compiled, and edited **Sections 3** and **4.** The following 10 Branch members contributed to the following sections: IS1 Dallas Shaw wrote **sections 3.2** and **4.7.2**; IS3 Christian Nieves wrote **sections 3.4** and **4.6.1**; IS3 Josiah Hansen wrote **sections 3.5** and **4.6.2**; YN1 Amelia Lawrence and IS2 Jonathon Ruegg cowrote **section 3.7**; IS3 Tyler Romaine wrote **sections 3.3.1** and **4.6.3**; IS3 Olivia Mckenzie wrote **sections 3.3.2**, **4.1**, and **4.5**; IS3 John Samyn wrote **sections 3.6** and **4.6.4**; IS2 Erik Balboa wrote **sections 3.6.1** and **4.3**; and IS3 Jeffrey Rojas wrote **sections 4.2** and **4.4**. IIP Command Chief, ISC Trevor Doubek, compiled **Section 5.** CDR Erin Caldwell, LCDR Rebecca Prendergast, Dr. Alexis Denton, Ms. Jennifer Sabal, LT Megan Toomey, LT Shelby Griswold, and ISC Trevor Doubek contributed to the editing of all sections.

IIP Members During the 2024 Ice Year

The following people were IIP members ("Ice Picks") and contributed to the 2024 Ice Year (in alphabetical order by surname): IS2 Erik Balboa, CDR Erin Caldwell, CWO James Carew, IS2 Nicole Columbus, Dr. Alexis Denton, IS2 Jacob Dominguez, LT Shelby Griswold, IS3 Josiah Hansen, ISC Trevor Doubek, LCDR Alex Hamel, Midshipman Andrej Klema, YN1 Amelia Lawrence, MST2 Jason Leser, MST2 Maite Loughlin, IS3 Olivia McKenzie, IS3 Christian Nieves, LCDR Rebecca Prendergast, IS2 Jonathon Ruegg, IS3 Tyler Romaine, IS3 Jeffrey Rojas, Ms. Jennifer Sabal, IS3 John Samyn, IS1 Dallas Shaw, and LT Megan Toomey.

IIP acknowledges all of its 2024 Ice Year members for their individual and collective contribution to the IIP mission and relentless work on data collection, statistical analysis, and figures which are reported here.

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Appendix A – Automatic Detection Algorithms for Iceberg

A.1 Introduction

In 2018, IIP began testing a Naval Research Laboratory (NRL) ship detection algorithm for use in iceberg detection. The algorithm leveraged ingested satellite imagery and a correlator that would filter out ships in order to produce a MANICE listing of identified icebergs in the frame. The project goal was to determine if satellites and algorithms could replace the HC-130 airframe for iceberg reconaissance and reduce IIP's manpower needs to conduct IIP's mission. The Department of Homeland Security Science and Technology (DHS S&T) acted as the project manager in concert with CG-26, CG-257, and the Intelligence Coordination Center's Geospatial Intelligence Branch (ICC-GEOINT). The effort was named "Project Titanic," but it has also been referred to as the Titanic Prototype and the Iceberg Detection Analysis in other documentation.

A.2 Training the Algorithm

In order to "train" or calibrate NRL's ship detecting algorithm, DHS S&T arranged to use geotags on icebergs for the alogrithm to detect and locate them on correlating satellite imagery. The geotagging expedition took place in 2019 with the goal of tagging 140 different icebergs via drone on a variety of iceberg sizes down to at least 15-meters in length at one side. However, due to the irregular shape of icebergs, the drones had difficulty landing on the icebergs to place the geotag. Additionally, small icebergs (<60 meters) rolled a considerable amount making tagging these small icebergs nearly impossible. As a result, the majority of the tagged targets used to refine the algorithm were tabular icebergs, each over 60 meters in length at the waterline.

The team utilized commercial imagery coordinated with the geotagging in order to train and assess the prototypes ability to target icebergs successfully. The assessment was carried out by DHS S&T and the Aerospace Corporation.

A.3 Results

Due to problems with the geotagging, the testing was done against 49 icebergs and 8 vessels. The initial testing results revealed the prototype could accurately detect at a rate of 60%. False positive data was not included in the results.

In order to test the algorithm in the operational environment, IIP compared Titanic's ability to target icebergs against visually acquired targets from traditional IIP IRD flights in 2023 and 2024. With the bulk of the icebergs being under 60 meters, IIP found that Titanic could only detect these small targets correctly about 4 percent of the time. In order to ensure the prototype had every possible chance at success, IIP handed the prototype to US Government partners for testing with a wider range of satellites and analytic techniques. While partners were able to gain some improvement, it was marginal, particularly for small icebergs.

A.4 Conclusion

This multi-year effort was incredibly illuminating regarding the need for human intervention in remote sensing technologies. IIP's area was quite challenging for the OSA to target the icebergs without a high rate of false positives. Ships, wave caps, and sea ice create a great deal of "noise" in IIP's area of operations and current algorithms are not sophisticated enough to find icebergs in an image without human review. As IIP continues to work towards more satellite reconnaissance, it is not a guarantee that personnel requirements will decrease as initially thought. This effort also highlights that tracking icebergs is not the same as tracking ships. With differing reflectivity compared to metal and a lack of electronic or radar signatures, an iceberg is a true dark target and will continue to pose a challenge for IIP to detect accurately and consistently in imagery.