Homeland Security

United States Coast Guard

Report of the International Ice Patrol in the North Atlantic

2003 Season
Bulletin No. 89
CG-188-58

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REPORT OF THE INTERNATIONAL ICE PATROL IN THE NORTH ATLANTIC

Season of 2003

CG-188-58

Forwarded herewith is Bulletin No. 89 of the International Ice Patrol (IIP), describing the Patrol's services, ice observations and conditions during the 2003 season. On March 1, 2003, the U.S. Coast Guard transitioned from the Department of Transportation to the newly created Department of Homeland Security. The Department of Homeland Security will continue to recognize and support the U. S. Coast Guard's traditional missions like the International Ice Patrol.

Pictured on the front cover of this bulletin is the deployment of a Compact Air Launched Ice Beacon (CALIB). IIP deployed this beacon and tracked the iceberg for 13 days. This allowed a comparison to IIP's present drift model and opened the door for future experiments in 2004. Drift model improvements will better focus reconnaissance efforts and ultimately improve the accuracy of IIP bulletins. Appendix D of this report provides further detail.

In 2003, IIP also participated in the Global Monitoring for the Environment and Security (GMES), a joint European Commission and European Space Agency initiative. As part of the Northern View Service Element, IIP worked closely with a Canadian company, C-CORE to evaluate an iceberg detection algorithm for satellite images. Along with validating the accuracy of this algorithm, IIP focused on the mechanics of incorporating this data into IIP's drift model. The capability to use satellite imagery operationally, while still several years away, will greatly improve iceberg reconnaissance efforts - especially in the planning phase for aircraft searches.

Efforts during the 2003 season advanced IIP's improvement of mission execution, directly supported the stewardship of valuable Coast Guard resources and moved IIP one step closer toward eliminating the risk of iceberg collision.

M. R. Hicks
Commander, U. S. Coast Guard
Commander, International Ice Patrol

International Ice Patrol
2003 Annual Report

Contents

List of Abbreviations and Acronyms

AOR	Area Of Responsibility
AXBT	Air-deployed eXpendable BathyThermograph
BAPS	iceBerg Analysis and Prediction System
CALIB	Compact Air Launched Ice Beacon
CAMSLANT	Communications Area Master Station atLANTic
CCG	Canadian Coast Guard
CIS	Canadian Ice Service
DFO	Department of Fisheries and Oceans
EEZ	Exclusive Economic Zone
FLAR	Forward-Looking Airborne Radar
GMES	Global Monitoring for Environment and Security
GS	Gulf Stream
GSFC	Goddard Space Flight Center
HF	High Frequency
HMCS	Her Majesty's Canadian Ship
IIP	International Ice Patrol
INMARSAT	INternational MARitime SATellite (also Inmarsat)
IRD	Ice Reconnaissance Detachment
LAKI	Limit of All Known Ice
LC	Labrador Current
LDEO	Lamont-Doherty Earth Observatory
MANICE	MANual of standard procedures for observing and reporting ICE conditions
MODIS	MODerate resolution Imaging Spectroradiometer
MSS5000	Marine Surveillance System 5000
M/V	Motor Vessel
NAC	North Atlantic Current
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NIC	National Ice Center
NSSI	Normalized Season Severity Index
NTIS	National Technical Information Service
RADAR	Radio Detection And Ranging (also radar)
RMS	Royal Mail Steamer
SOLAS	Safety Of Life At Sea
SLAR	Side-Looking Airborne Radar
SST	Sea Surface Temperature
WEFAX	WEather FAX
WOCE	World Ocean Circulation Experiment
WWW	World Wide Web

Introduction

This is the 89th annual report of the International Ice Patrol. It contains information on IIP operations, environmental conditions, and iceberg conditions for the 2003 season in the North Atlantic. IIP is supported by 17 member nations and conducted by the U. S. Coast Guard. IIP activities are delineated by U. S. Code, Title 46, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1974. IIP was initiated shortly after the sinking of the RMS TITANIC on April 15, 1912 and has been conducted yearly since that time with the exception of brief periods during the two World Wars.

Commander, International Ice Patrol is under the operational control of Commander, Coast Guard Atlantic Area. IIP conducts aerial reconnaissance from St. John's, Newfoundland to search the southeastern, southern, and southwestern regions of the Grand Banks of Newfoundland for icebergs. IIP also receives iceberg location reports from ships and planes transiting its area of responsibility. We salute *M/V BERGE NORD* who provided the most ship reports during the 2003 season. IIP analyzes iceberg and environmental data at its Operations Center in Groton, Connecticut. IIP predicts iceberg drift and deterioration using a computer model and produces twice-daily iceberg warnings that are broadcast to mariners as bulletins and charts. IIP also responds to requests for iceberg information.

Vice Admiral James D. Hull was Commander, U. S. Coast Guard Atlantic Area. CDR Robert L. Desh was Commander, International Ice Patrol through 15 August 2003 when he was relieved by CDR Michael R. Hicks.

For more information about International Ice Patrol, including iceberg bulletins and charts, see IIP's website at http://www.uscg.mil/lantarea/iip/home.html.

Summary of Operations

International Ice Patrol formally begins its seasonal ice observation and Ice Patrol service when icebergs threaten primary shipping routes between Europe and North America. This usually occurs in February and extends through July, but Ice Patrol commences operations when iceberg conditions dictate. Except during unusually heavy ice years, the Grand Banks of Newfoundland are normally iceberg free from August through January.

International Ice Patrol actively monitors the iceberg danger to transatlantic shipping in the region bounded by 40°N, 52°N, 39°W, and 57°W (Figure 1). Ice Patrol began issuing weekly products on 14 February 2003. Commander, International Ice Patrol opened the season on 24 March 2003 and daily products were distributed through the close of the season on 17 July 2003. Note: All of the statistics reported in this summary are from the time frame mentioned above (14 February through 17 July 2003).

International Ice Patrol's Operations Center in Groton, Connecticut analyzed 1,708 information reports from IIP IRDs, merchant vessels, the Canadian Government, the National Ice Center, and other sources (Figure 2). Of these reports, 425 contained ice information (Figure 3). These ice reports potentially contained single or multiple iceberg sightings, stationary radar targets, and sea ice information. From these reports, 2,454 individual targets were merged into the Ice Patrol's modeling system (BAPS). Figure 4 highlights the reporting source of sightings merged into BAPS.

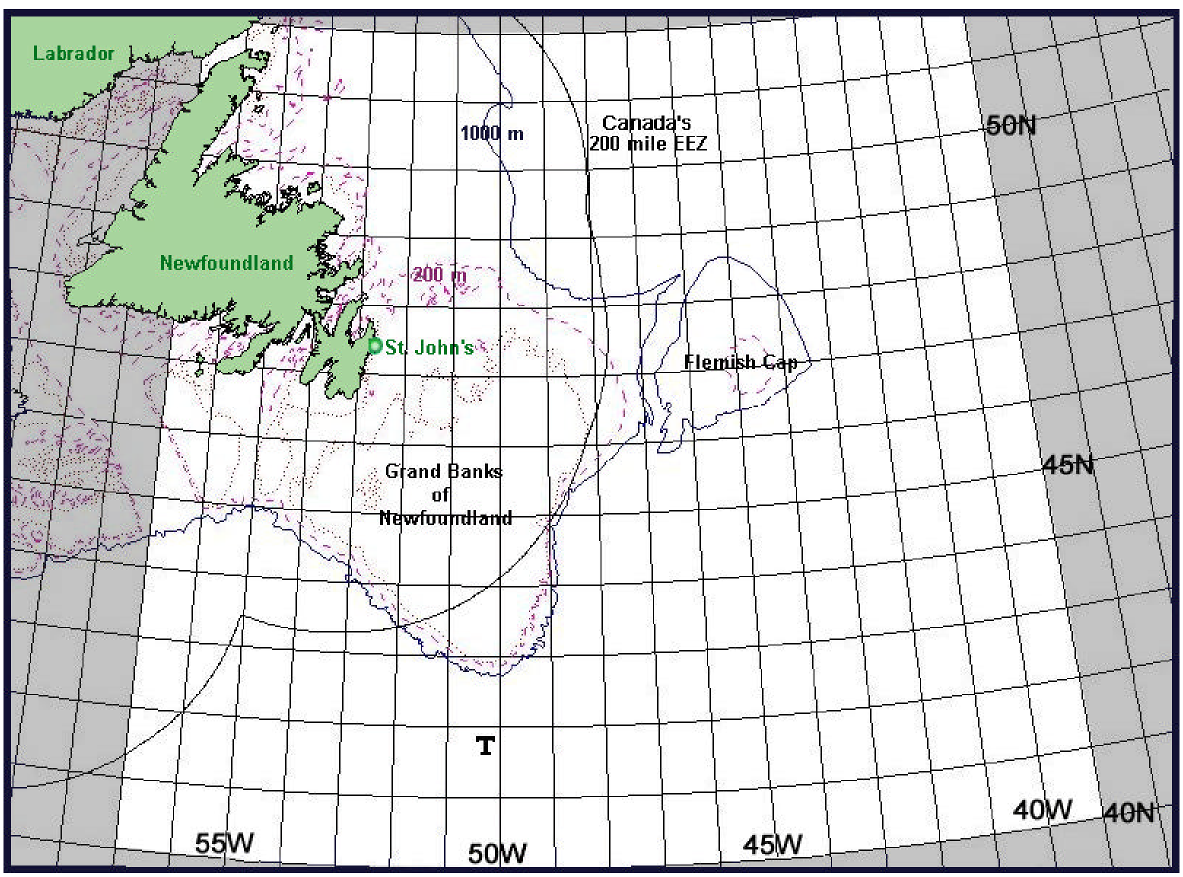

Figure 1. IIP's operating area. 'T' indicates location of TITANIC sinking

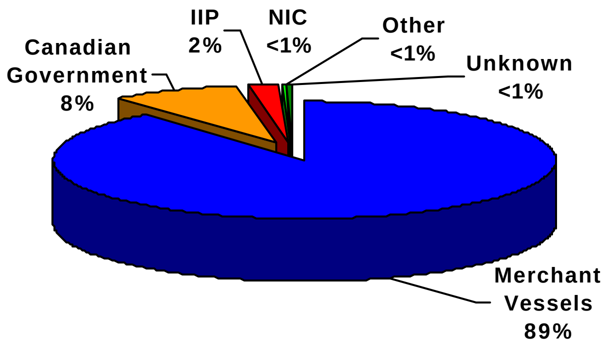

Figure 2. Reporting sources of the 1,708 information reports received at Ice Patrol during 2003. Information reports include ice, SST, and weather reports.

Information Reports

Voluntary reports were requested from all ships transiting the Grand Banks region. As in previous years, ships were asked to report ice sightings, weather, and sea surface temperatures via Canadian Coast Guard Radio Station St. John's/ VON, U. S. Coast Guard Communications Area Master Station Atlantic/NMF or Inmarsat-C or Inmarsat-A using code 42. Ships were encouraged to make ice reports even if "no ice" was sighted, as knowledge of the lack of ice is also fundamental to accurate product generation for the mariner. The continued success and viability of the International Ice Patrol depends heavily upon all contributors of ice reports.

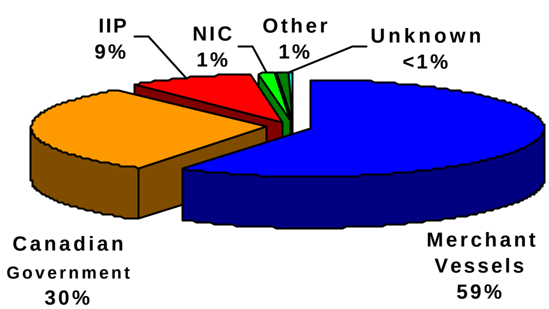

Figure 3. Reporting sources of the 425 ice reports received during 2003. Ice reports include individual iceberg sightings and stationary radar target information.

Merchant shipping provided the vast majority of reports received by IIP. In 2003, 247 ships from 39 different countries provided IIP with 1,512 or 89% of total reports. This demonstrated that the number of nations that used IIP services exceeded the 17 member nations that supported IIP under SOLAS. Furthermore, the international merchant fleet's high level of participation indicated the value placed on IIP products and services. In 2003, the merchant vessel that provided the most reports was BERGE NORD (Norway), submitting 70 separate reports. Appendix B lists all ships that provided information reports, including weather, ice, stationary radar target, and sea surface temperature reports. While the vast majority of information reports were received from merchant shipping, IIP received valuable information from other sources as well. For example, the Canadian Government, which included reports from the CIS reconnaissance airplane, contract reconnaissance flights by Provincial Airlines, HMCS vessels, CCG vessels, and even coastal lighthouses, provided 150 or 8% of the information reports received by IIP. Figure 2 provides a thorough breakdown of the sources for all information reports handled during 2003.

Ice Reports

Only a portion of the total reports sent to IIP contained ice information; specifically, 425 of the 1,708 information reports contained data on icebergs. Similar to information reports, the merchant fleet provided the greatest number of ice reports (59%) and the Canadian Government 30%. The remaining 11% of ice reports were received from IIP reconnaissance, the National Ice Center, and other resources. Refer to Figure 3 for a breakdown of ice report sources.

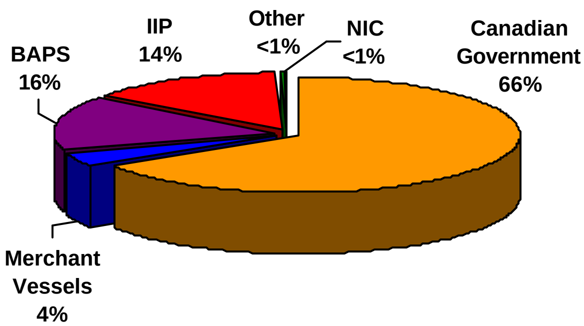

Figure 4. Reporting sources of the 2,454 individual targets merged into BAPS during 2003.

Merged Targets

The 425 ice reports received by IIP contained 2,454 targets that were merged into the drift and deterioration modeling system operated jointly between CIS and IIP (BAPS). The source responsible for reporting the most targets that were merged into IIP's BAPS model was the Canadian Government with 66%. BAPS transferred targets accounted for 16% of the targets in IIP's model. These targets were originally sighted north of IIP's AOR and then were passed to IIP's model when they drifted south of 52°N. The configuration of the BAPS model makes determining the original sources for targets of this type extremely cumbersome. Consequently, no attempts were made to determine the original sighting source of targets transferred to IIP via BAPS; so for statistical purposes BAPS did not submit reports to IIP and was not noted in Figures 2 or 3. IIP accounted for 14% of merged targets, merchant vessels 4% and the National Ice Center less than 1% (Figure 4).

LAKI Iceberg Sightings

Since IIP is mandated by SOLAS to guard the Southeast, South, and Southwest regions of the Grand Banks, IIP closely monitors those icebergs that set the limits. Additionally, IIP spends the majority of its resources in searching for the icebergs that are the most seaward. Therefore, the initial sighting source for icebergs that determine the LAKI is very interesting. IIP detected 60% of LAKI icebergs (Figure 5) and the Canadian government reported 11%. However, IIP also benefited significantly from the participation of ships of opportunity and from IIP's partnership with the National Ice Center. The merchant shipping industry was the original reporting source of 23% of LAKI icebergs and NIC reported another 4%. Finally, BAPS model transfers between IIP and the Canadian Ice Service accounted for 2% of LAKI icebergs.

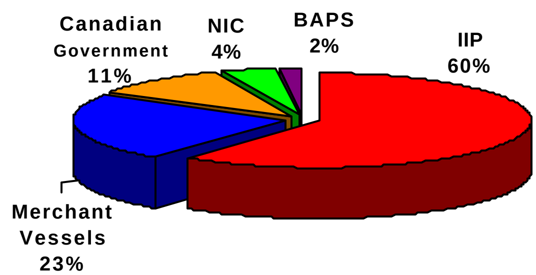

Figure 5. Initial reporting sources of LAKI determining icebergs during the 2003 season.

IIP Broadcasts/Products

For the second year, since the changes to SOLAS, ships were required to make use of International Ice Patrol services while in the IIP AOR. Throughout the iceberg season, IIP produced two products a day (0000Z and 1200Z) and distributed them by a wide variety of methods. Vessels received text ice bulletins at 0000Z and 1200Z daily to inform them of the Limit of All Known Ice. U. S. Coast Guard Communications Area Master Station Atlantic/NMF and Canadian Coast Guard Marine Communications and Traffic Service St. John's/VON were the primary radio stations responsible for the dissemination of ice bulletins. In addition, ice bulletins and safety broadcasts were delivered over the Inmarsat-C SafetyNET via the Atlantic East and West satellites. Another transmitting station for the bulletins was the Marine Communications and Traffic Services St. Anthony/VCM. IIP also prepared an ice chart depicting the 1200Z Limit of All Known Ice for broadcast at 1600Z and 1810Z daily. U. S. Coast Guard Communications Area Master Station Atlantic/NMF and the National Weather Service assisted with the transmission of the ice chart. On the eastern side of the Atlantic, the German Federal Maritime and Hydrographic Agency stations Hamburg/DDH and Pinneberg/DDK transmitted IIP's ice chart. Finally, both the bulletin and chart were placed on IIP's website. The ice chart was also made available via plain paper facsimile and e-mail on demand.

IIP transmitted 232 scheduled ice bulletins in 2003. IIP measured the quality and timeliness of the bulletins delivered to the mariner via the SafetyNET service, as this is the primary product for IIP's largest customer base. Of 232 total bulletins sent, 230 (99%) arrived at the system on time, or by 0000Z or 1200Z, respectively. The late deliveries were due primarily to minor technical difficulties in sending the product through IIP's commercial INMARSAT provider.

In 2003, IIP produced 116 ice charts that were distributed via HF radiofacsimile, e-mail on demand, and published on the WWW. Of these, 105 (91%) were delivered on time. Late ice charts were defined as those for which the radio frequency start tone began more than one minute later than the scheduled transmission time (1600Z or 1810Z). The primary cause of late ice charts was difficulty getting the signal from IIP through the line to CAMSLANT.

Safety Broadcasts

IIP sent 20 unscheduled safety broadcasts during the 2003 season for 29 iceberg or stationary radar target sightings near or outside the published LAKI. Of these 29 targets, 11 were icebergs reported outside the published LAKI, 4 were icebergs inside but near the LAKI, and the remaining 14 detailed stationary radar targets.

Historical Perspective

To compare ice years in a historical perspective, IIP uses two different measurements. The first is the season's length in days (Figure 6). The second is the number of icebergs south of 48°N (Figure 7). This measurement includes both icebergs detected south of 48°N and those that were originally detected north of

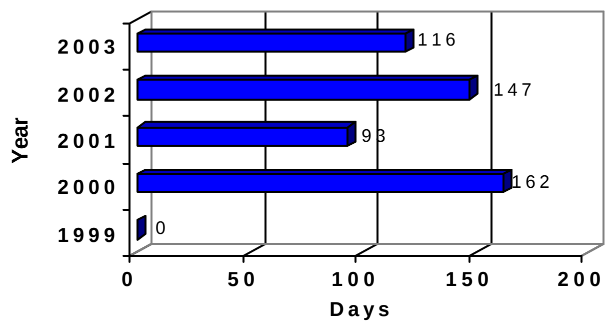

Figure 6. Length of ice season in days since 1999. The climatological (three year) mean is 120 days.

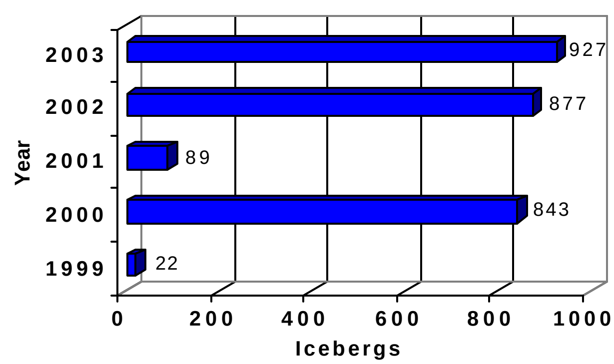

Figure 7. Count of individual icebergs (sighted and drifted) south of 48°N since 1999. The climatological (three year) mean is 631 icebergs.

48°N but were later predicted to have drifted south of 48°N. The 2003 season lasted for 116 days and saw 927 individual icebergs south of 48°N. The icebergs south of 48°N measurement is generally preferred by IIP because it places the emphasis on icebergs that represent a significant hazard to transatlantic shipping. Season length is coupled with the number of icebergs south of 48°N as Commander, International Ice Patrol considers the overall iceberg population and dates for the opening and closing of the ice season.

In the effort to classify ice season severity, various authors have discussed the appropriate measurements and criteria (Alfultis, 1987; Trivers, 1994; and Marko, *et al*., 1994). Comparing 2003 to the past five years and measuring the statistics against historical ice patrol data, 2003 was moderate in terms of season length and extreme in terms of the number of icebergs south of 48°N. Trivers (1994) defined an extreme ice season as one where more than 600 icebergs drifted south of 48°N. Trivers also defined a moderate season, in terms of length, as one between 105 and 180 days.

Canadian Support

The Canadian Government provided a great deal of support during the 2003 season, as they do every year. CIS conducted ice reconnaissance using a SLAR equipped Dash-7 airplane, focusing primarily on sea ice. Provincial Airlines is a private company that provided reconnaissance services on contract to DFO throughout the year, to CIS from June through December and to the offshore oil industry. DFO flights by Provincial Airlines monitored fishing vessel activity and frequently carried them into areas of high iceberg concentrations. Canadian support of BAPS was also an integral part of IIP's operations. The models are connected via the internet and "speak" to each other numerous times each day. For example, CIS retrieves environmental data (waves, currents, sea surface temperatures, etc.) that reside on IIP's BAPS. IIP received data on icebergs crossing into our AOR in a similar method.

Ongoing Research

In an effort to continuously improve through the use of technology, IIP participated in the Global Monitoring for Environment and Security (GMES) program, which was sponsored by the European Space Agency. IIP was an end user of ice products from the Northern View team, which was led by C-CORE. Envisat and Radarsat images were analyzed by the C-CORE iceberg/ship detection algorithm and the location of the targets were sent to IIP in MANICE code, approximately 4-5 hours after image acquisition. The C-CORE algorithm detected hard targets in the satellite imagery and distinguished ships from icebergs. IIP received data from 45 Envisat and Radarsat MANICE messages from May 1st through July 11th 2003. Ongoing analysis is taking place to evaluate the algorithm by comparing the MANICE messages received from C-CORE, with iceberg information from IIP's BAPS system. Ice Patrol hopes to continue its participation in GMES during the 2004 iceberg season.

References

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

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Iceberg Reconnaissance & Oceanographic Operations

Iceberg Reconnaissance

The Ice Reconnaissance Detachment is a sub-unit under Commander, International Ice Patrol partnered with Coast Guard Air Station Elizabeth City who provided the aircraft platform. IRDs were deployed to observe and report sea ice, iceberg and oceanographic conditions on the Grand Banks of Newfoundland. Oceanographic observations were used in support of operations as well as for research purposes.

Ice Patrol's pre-season IRD departed on 21 January 2003 to determine the early season iceberg distribution. The iceberg distribution noted during the pre-season IRD did not initially warrant regular (every other week) deployments to Newfoundland. Subsequently, only one IRD was deployed during the six weeks from the end of the pre-season until regular deployments were started on 19 March 2003. Regular IRDs operated from St. John's, Newfoundland until 13 July 2003. An average of four reconnaissance flights were made during each IRD. Iceberg reconnaissance operations concluded with the return of the post-season IRD on 5 September 2003.

Coast Guard aircraft were the primary means of detecting icebergs that form the Limit of All Known Ice. IIP utilized a Coast Guard HC-130H long-range aircraft equipped with the Motorola AN/APS-135 Side-Looking Airborne Radar and the Texas Instruments AN/APS-137 Forward-Looking Airborne Radar to conduct iceberg reconnaissance. IIP has used SLAR since 1983, incorporated the Maritime Surveillance System (MSS) 5000 to SLAR in 2000, and has used FLAR since 1993.

Environmental conditions on the Grand Banks permitted adequate visibility only 30% of the time during iceberg reconnaissance operations. Consequently, IIP relied heavily on its two airborne radar systems to detect and identify icebergs through cloudy and foggy conditions. The radar combination of SLAR and FLAR allowed detection and identification of icebergs in pervasive low visibility conditions minimizing the flight hours required to accurately determine the LAKI. The radar combination allowed IIP to use 30 NM track spacing throughout the season. The HC-130H with SLAR and FLAR facilitated coverage of a large ocean area while providing 200% radar coverage (Figure 8). IIP can currently cover 40,000 NM^2 at 30 NM track spacing in any visibility conditions. A detailed description of IIP's

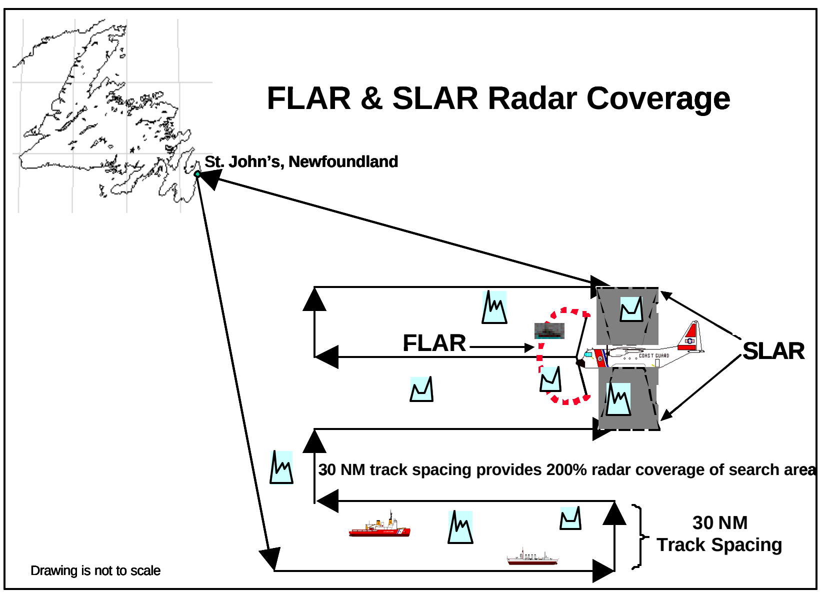

Figure 8. Radar reconnaissance plan.

reconnaissance strategy is provided at http://www.uscg.mil/lantarea/iip/FAQ/ReconnOp_10.shtml.

An IRD was deployed to IIP's base of operations in St. John's, Newfoundland for 94 days during the 2003 season (Table 1). IIP flew 70 sorties, 28 of which were transit flights to and from St. John's. Thirty-eight sorties were iceberg reconnaissance patrols to determine the southwestern, southern and southeastern LAKI. No research sorties were flown in 2003. Four sorties were logistics flights from Coast Guard Air Station Elizabeth City to maintain and repair the aircraft. Figure 9 details IIP flight hours for 2003.

IRD	Deployed Days	Iceberg Patrols	Flight Hours
Pre	9	1	18.0
1	Cancelled		
2	9	4	27.2
3	Cancelled		
4	8	3	28.2
5	9	3	42.7
6	8	4	38.0
7	8	4	39.2
8	9	5	52.9
9	9	4	27.9
10	8	4	39.1
11	7	4	40.6
12	5	2	22.7
Post	5	0	9.3
Total	**94**	**38**	**385.8**

Table 1. 2003 IRD summary.
NOTE: Flight hours include patrol and transit hours.
IRD#5 includes 10 and IRD#8 includes 9.9 logistic hours.

IIP used 385.8 flight hours in 2003, a 19% decrease from 2002 (Figure 10). This decrease was partially due to the addition of a patrol decision guide to aid the Tactical Commander. The patrol decision guide, using a point system, placed a given patrol into a green/amber/red model based on aircraft condition, environmental conditions and

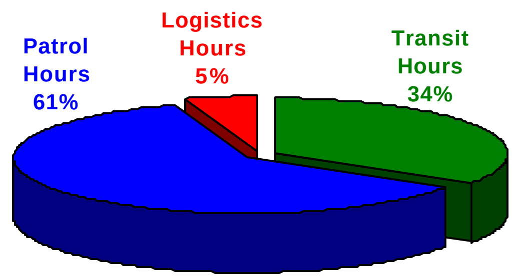

Figure 9. 2003 flight hours.

patrol area priority. This tool was designed to improve flight hour efficiency (i.e., ensure patrol results were the best possible). Figure 11 compares flight hours with the number of icebergs south of 48°N latitude since 1988. This figure demonstrates that IIP expends a fairly consistent number of flight hours while the number of icebergs varies significantly. A few icebergs can dramatically extend the geographic distribution of the LAKI even with a small number of icebergs passing south of 48°N. IIP is often in the position of having to patrol a large ocean area with widely distributed icebergs.

Differentiating the various types of targets on the Grand Banks is a continuous challenge for IIP reconnaissance. Visibility is frequently poor and targets are often identified solely from their radar image. Both SLAR and FLAR provide valuable

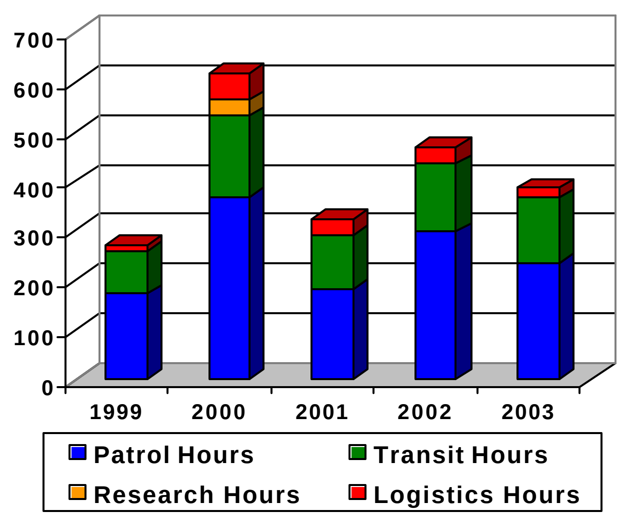

Figure 10. Breakdown of flight hours (1999-2003).

clues about the identity of targets. However, FLAR's superior imaging capability provides definitive target identification in most cases. Figure 12 displays the number and types of targets detected by reconnaissance patrols during the 2003 season. A total of 728 icebergs were detected by IRDs, 36% (264) were identified with radar alone (i.e., were never seen visually) while the remaining 64% (464) were identified using a combination of visual and radar information or by visual means alone. These data demonstrate IIP's reliance on radar information. Determining whether a radar target is an iceberg or a vessel is difficult with small vessels and small icebergs. The Grand Banks is a major fishing area frequented by fishing vessels ranging in size from 60 to over 200 feet. Small vessels and small icebergs sometimes present similar radar returns and cannot be differentiated. When there are no clear distinguishing features, a target is classified as a radar target.

Since 1997, the Grand Banks region has been rapidly developed for its oil reserves. In November 1997, Hibernia, a gravity-based oil production platform, was set in position approximately 150 NM offshore on the northeastern portion of the Grand Banks. Each year, there are several mobile drilling rigs in the Terra Nova and White Rose drilling fields on the Grand Banks. Increased development has increased air and surface traffic in IIP's area of responsibility, further complicating reconnaissance efforts.

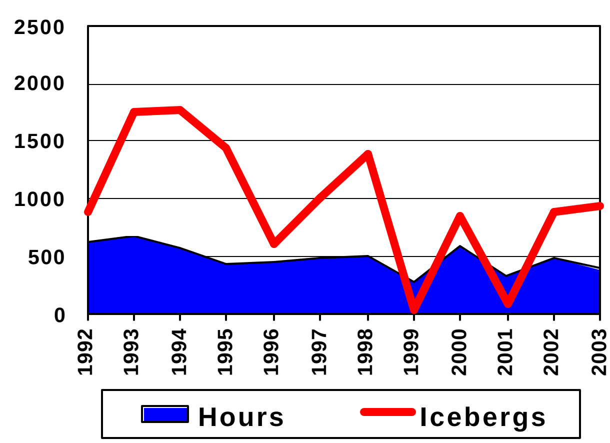

Figure 11. Flight hours versus icebergs south of 48°N (1993-2003).

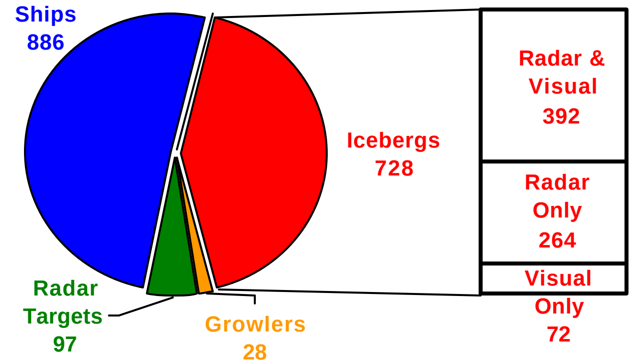

Figure 12. Breakdown of targets detected by IRDs in 2003.

Oceanographic Operations

Historically, IIP conducted extensive oceanographic surveys on the Grand Banks. Oceanographic operations peaked in the 1960's when the U. S. Coast Guard devoted substantial surface ship resources to collecting oceanographic data. Two factors combined to change the nature of IIP's oceanographic operations. First, increased competition among the various U. S. Coast Guard missions made it increasingly difficult for IIP to obtain ship resources. Second, there was a vast improvement in the capability and reliability of deployable oceanographic instruments.

IIP collected oceanographic data with air or ship-deployed satellite-tracked drifting buoys and Air-deployed eXpendable BathyThermograph probes. AXBT probes were dropped to determine the water temperature profile. This information helped IIP determine the location of the Labrador Current, validate temperatures from satellite-tracked drifting buoys, and obtain precise SST measurements for numerical models. Figure 13 displays AXBT drop locations

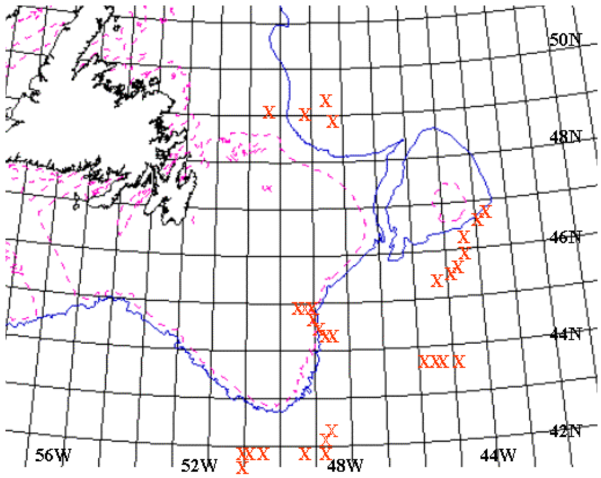

Figure 13. AXBT drop locations.

during the 2003 season. IIP dropped 30 AXBT probes and collected data from 25 of the drops for a failure rate of 16.6%. Figure 14 describes the development of IIP's AXBT program since 1999[1]. The marked reduction in AXBT drops during 2003 can be attributed to a change in AXBT drop policy that occurred following the 2002 season in an attempt to eliminate drops that interfered with the flight plan or otherwise reduced the effectiveness of the reconnaissance.

AXBT information was coded into a standard format and shared with the

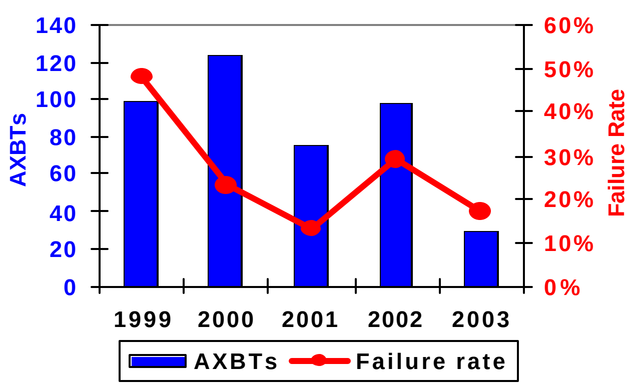

Figure 14. AXBT drops and failure rate (1999-2003).

[1] 1999 is used as the base year for these data because of the implementation of a new AXBT receiver system during that year. Software upgrades, planned for completion in 2004, are expected to further reduce failures.

Canadian Maritime Atlantic Command Meteorological and Oceanographic Center, IIP's supplier of AXBT probes. Data was also sent to the U. S. Naval Fleet Numerical Meteorological and Oceanographic Center where it was quality controlled and redistributed via oceanographic products.

Satellite-tracked drifting buoys, popularly known as WOCE buoys, were drogued at a depth of 15 or 50 meters and provided near real-time ocean current information. For operational use by IIP, WOCE buoys were deployed primarily in the inshore and offshore branches of the Labrador Current. The historical current database used by IIP's computer model was modified weekly using information from these drifting buoys. The 2003 iceberg season proved especially challenging in terms of current variability at the southern end of the Grand Banks and in the vicinity of the Flemish Cap, demonstrating IIP's requirement for this valuable information.

During the 2003 season, IIP deployed ten satellite-tracked drifting buoys, four from reconnaissance aircraft and six from volunteer ships. Figure 15 displays composite drift tracks for the buoys deployed in 2003. Figure 16 displays the shift from aircraft deployments to ship deployments over the last few seasons. Ship deployments are less costly and less traumatic to the buoy than aircraft deployments. IIP intends to maintain the capability to deploy buoys from aircraft, primarily for early season deployments to the north and isolated required deployments during the season. No buoy recoveries were planned or attempted in 2003. Detailed drifter information is provided in IIP's 2003 WOCE Buoy Drift Track Atlas (available from IIP upon request).

A Compact Air Launched Ice Beacon (CALIB) was deployed on a very large tabular iceberg in early May during a reconnaissance patrol. The CALIB provided 13 days of satellite tracking information. The iceberg drift information provided by the CALIB will be used for testing the current and future versions of BAPS. Please refer to Appendix D for full details of the CALIB drop and preliminary research.

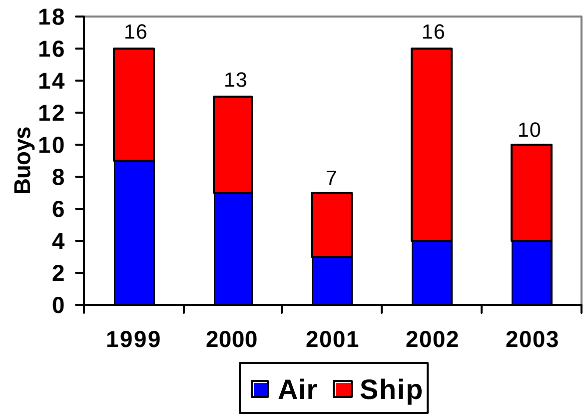

Figure 16. WOCE buoy deployments (1999-2003).

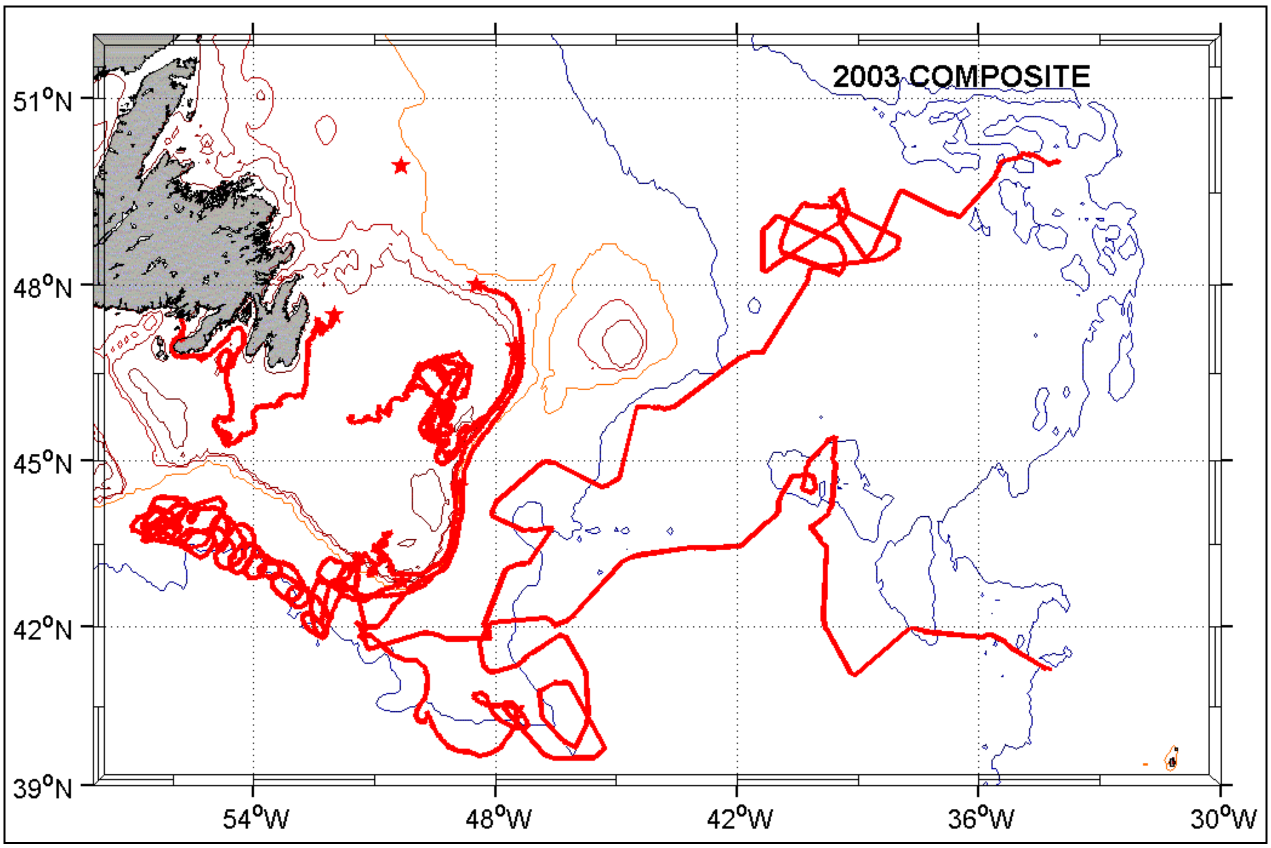

Figure 15. 2003 satellite-tracked drifting buoy tracks. Red stars indicate point of entry.

Ice and Environmental Conditions

Introduction

For the second year in a row, large numbers of icebergs entered the North Atlantic Ocean shipping lanes near the Grand Banks of Newfoundland (Figure 17), with an estimated 927 icebergs passing south of 48°N. This section describes progression of the 2003 ice season and the environmental conditions it accompanied.

The IIP ice year extends from October through September. The following month by month narrative begins as sea ice began forming along the Labrador coast in early December 2002, and concludes in mid July 2003 with the closing of the IIP's iceberg season. The narrative draws from several sources, including the Seasonal Summary for Eastern Canadian Waters, Winter 2002-2003 (Canadian Ice Service, 2003); sea ice analyses provided by CIS and NIC; and sea surface temperature anomaly plots provided by the U. S. National Weather Service's Climate Prediction Center (Climate Prediction Center, 2004); and, finally, summaries of the iceberg data collected by IIP and CIS. The plots on pages 31 to 40 document the LAKI twice a month (the 15th and last day of each month) for the duration of the ice season. In addition, the LAKI for the opening (24 March) and closing (17 July) days of the season are presented.

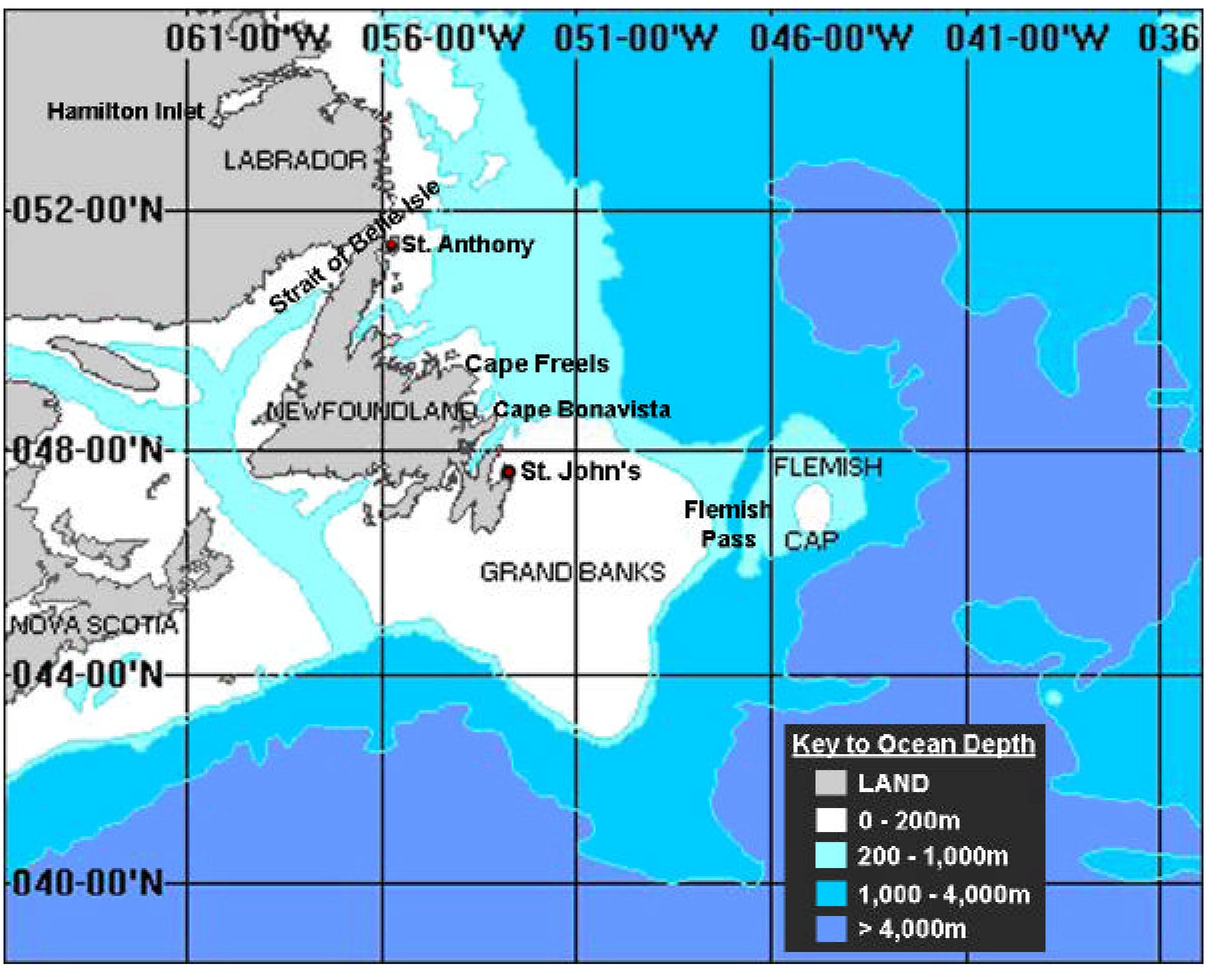

Figure 17. Grand banks of Newfoundland.

The progress of the 2002-2003 season is compared to sea ice and iceberg observations from the historical record. This places the season in perspective and helps to understand the variability of the ice distribution in the western north Atlantic. The sea ice historical data are derived from the Sea Ice Climatic Atlas, East Coast of Canada, 1971-2000 (Canadian Ice Service, 2001), which provides a 30 year median of ice concentration at seven day intervals for the period from November 26 through July 16. Historical iceberg information is derived from Viekman and Baumer (1995), who present iceberg limit climatology from mid-March to July 30 based on 21 years of Ice Patrol observations from 1975 through 1995. They provide the extreme, median, and minimum extent of the LAKI for the period. Finally, the average number of icebergs estimated to have drifted south of 48°N for each month was calculated using 103 years (1900 through 2002) of Ice Patrol records (IIP, 2004).

The pre-season sea ice forecast (Canadian Ice Service, 2002), which was issued in early December, predicted:

- near normal freeze-up along the Labrador coast and in east Newfoundland waters,
- movement of the southern ice edge into the Strait of Belle Isle during the first week of January 2003,
- sea ice would reach Cape Bonavista during the first week of February,
- maximum extent of the sea ice attained during the third week of March, with the ice edge approximately at the latitude of St. John's for most of the month,
- likely intrusions of the sea ice to 47°W at the latitude of St. John's,
- sea ice retreat beginning during the last week of the month and proceeding at a normal rate.

A series of five CIS reconnaissance flights conducted in late September through early October 2002 documented a population of 646 icebergs and radar targets from 61°N to 70°N, with the highest concentration between 64°N and 65°N (Desjardins, 2002). Desjardins (2002) predicted that the first of these would reach 48°N during early February 2003.

December 2002

Early in December, sea ice conditions in northern Labrador were near normal. The ice edge was immediately to the north of Cape Chidley, the northernmost point in Labrador, and ice had begun to form in the bays and along the coast. Ice continued to develop along the northern coast in early December, but by mid month it was a few days behind normal. The second half of December witnessed much warmer than normal air temperatures in southern Labrador and northern Newfoundland. Although ice continued to develop along the Labrador coast, the eastward extent was much less than normal. The elevated temperatures also delayed the movement of the southern ice edge into the Strait of Belle Isle by about a week. Mean December SSTs were near normal off the southern Labrador coast and on the northeast Newfoundland Shelf. At month's end, the Strait of Belle Isle was free of sea ice. No icebergs passed south of 48°N during December.

January 2003

During a normal January, the sea ice edge moves southward from Cape Bauld, near the entrance to the Strait of Belle Isle, to Cape Freels, a distance of 150 NM. January 2003 was far from normal.

The southern ice edge moved into the Strait of Belle Isle during the first week of January as predicted by Canadian Ice Service (2002). Throughout the first half of the month, northern Newfoundland and the southern Labrador coast experienced higher than normal air temperatures, while southern Newfoundland was close to normal. By mid month, the ice edge reached southward to about 20 NM south of St. Anthony and eastward approximately 50 NM east of the Northern Arm of Newfoundland. Both the southern and eastern extent were about a week to 10 days behind normal in their development.

After mid-month, the southern ice edge progressed slowly, but persistently, southward along the Northern Arm, but extending only about 60 NM offshore. At the same time, a large, blocking high-pressure system was settling into the central north Atlantic. Its presence altered the north Atlantic storm track, setting the stage for the passage of a series of intense low-pressure systems over Newfoundland. During the third week of January, three blizzards dropped nearly a meter of snow on St. John's. In all, January 2003 tied 1960 as the snowiest January on St. John's record. The storms brought strong southerly winds to northeast Newfoundland waters, resulting in widespread ice destruction and much warmer than normal air temperatures, a combination that precipitated a rapid retreat of the southern ice edge. January ended with the southern sea ice edge barely extending into the Strait of Belle Isle. In the last 35 years, only 1969 and 1979 have had a lower ice extent at the end of January than that of 2003 (Canadian Ice Service, 2003).

IIP deployed its pre-season Ice Reconnaissance Detachment (IRD) to Newfoundland on 23 January. The intent of the IRD was to monitor the progress of the icebergs toward the Grand Banks and help determine the start date for the 2003 season. A single reconnaissance flight over the sea ice free waters of the offshore branch of the Labrador Current between 49°N and 52°N found no icebergs. During January, no icebergs passed south of 48°N; the average for the month is 3. On 13 January 2003, the Canadian Coast Guard advised mariners that the Strait of Belle Isle was not recommended for transatlantic shipping due to sea ice conditions.

February

February was a month of dramatic change for both the air temperatures in Newfoundland and the sea ice extent in the waters east of the island. The first ten days were much warmer than normal in northern Newfoundland and southern Labrador. The change began early in the second week of February, when the blocking high in the central north Atlantic moved southward and the Icelandic low strengthened. This brought cold arctic air to Newfoundland and southern Labrador, a condition that would persist for the next six weeks. Colder to much colder than normal conditions supported a rapid expansion of the sea ice extent. Near mid-month, the southern ice edge reached Cape Bonavista, about a week later than predicted (Canadian Ice Service, 2002). During the first 19 days of February, the southern ice extent moved from the vicinity of the Strait of Belle Isle to Cape St. Francis, the northern tip of the Avalon Peninsula, a distance of 240 NM in the north-south direction. Put another way, the February sea ice extent went from well below normal at the start of the month to normal conditions by month's end.

No icebergs passed south of 48°N during February; the average for the month is 15.

March

Colder to much colder-than-normal conditions in Newfoundland and Labrador persisted during the first three weeks of March, resulting in unabated sea ice expansion during the period. The sea-ice extent was near normal on 12 March, with the southern extent immediately to the south of St. John's, and the eastern edge near the northern entrance to Flemish Pass. As predicted by the Canadian Ice Service (2002), the sea ice attained its greatest areal extent for 2003 by the end of the third week of March. On 19 March, the eastern extent was in the offshore branch of the Labrador Current well into Flemish Pass, while the southernmost extent was 60 NM south of Cape Race. In both cases, the ice edge position was far beyond normal and the pre-season prediction. Figure 18 is a natural color image from MODIS, an instrument flown on NASA's Terra satellite, taken on 20 March 2003. In the last week of March, the sea ice began to retreat with the exception of a narrow stream of ice in the cold water of the offshore branch of the Labrador Current.

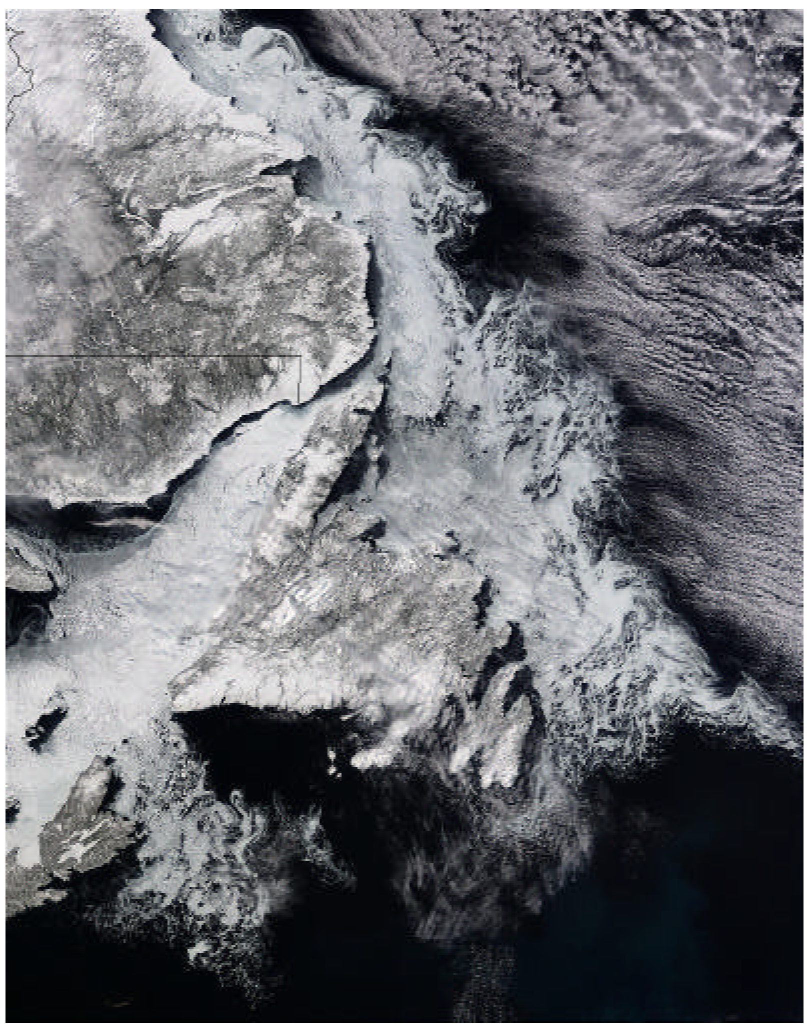

Figure 18. MODIS image from 20 March 2003 at 1455Z showing the ice edge at its maximum extent for 2003. Image courtesy of MODIS Rapid Response Project at NASA/GSFC.

The passage of two potent low pressure systems during the 27-30 March period brought strong offshore winds that pushed the sea ice eastward creating a wide shore lead. Throughout this period, the ice stream in the Labrador Current continued to extend further south, and by month's end its southern extent was at 44°40'N.

Five reconnaissance flights, three by IIP in late February and two by CIS in early March, found a small iceberg population between 48°N and 56°N, mostly located within the sea ice edge (Figure 19).

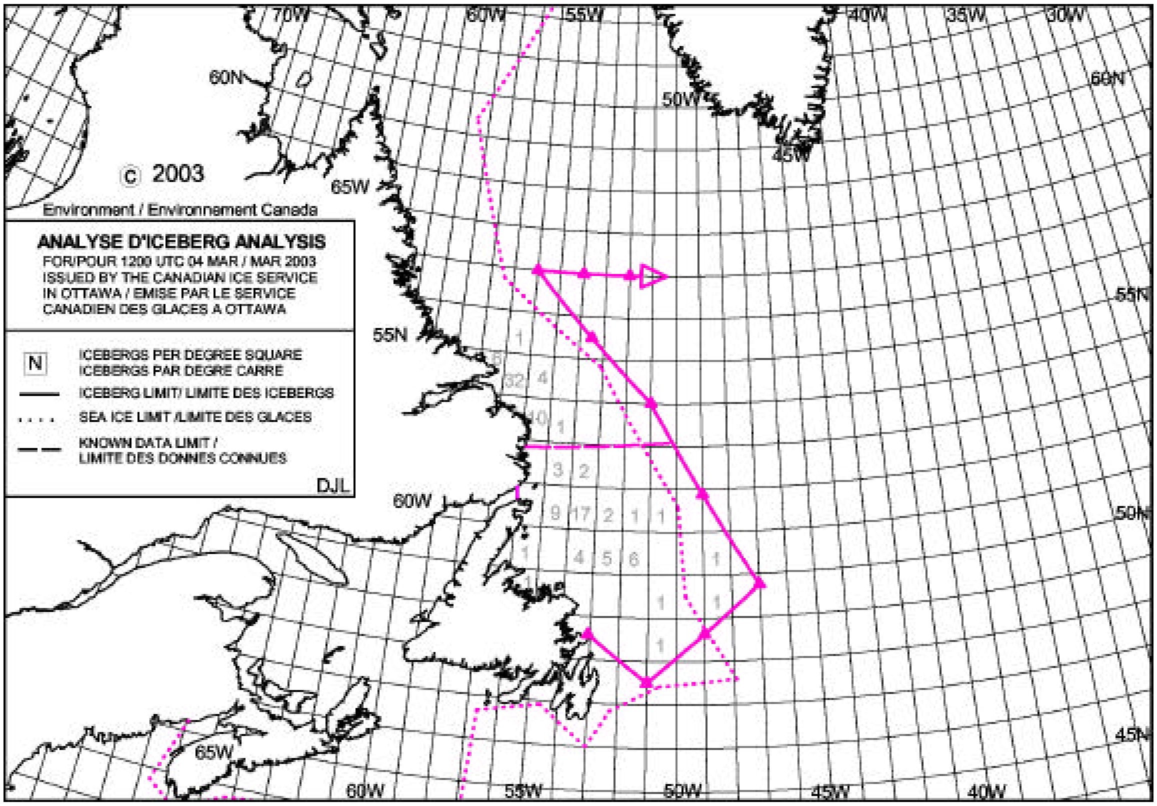

Figure 19. Iceberg distribution on March 4, 2003 from the iceberg analysis issued by the CIS. There are about 110 icebergs and radar targets shown on this plot, most within the sea-ice edge.

When IIP formally opened the 2003 season on 24 March, both the southern and eastern LAKI (page 31) were between the 75th percentile and the median according to Viekman and Baumer's iceberg climatology classification (Viekman and Baumer, 1995). As is common in the beginning of an iceberg season, most of the icebergs were within sea ice, so the LAKI was defined primarily by the location of the sea ice edge. Throughout the last week of March the southern LAKI stretched rapidly southward, as both the sea ice and icebergs within it moved under the influence of the Labrador Current. By month's end, the southern LAKI position was between the median and the 25th percentile while the eastern limit was between the 75th percentile and the median.

During March, an estimated 84 icebergs drifted south of 48°N, which is above the month's average of 61.

April

Persistent offshore winds kept the main ice pack offshore for the entire month, but the retreat was slowed somewhat owing to colder than normal air temperatures in Newfoundland and southern Labrador during the first three weeks. Indeed, sea ice persisted in the northern reaches of Flemish Pass until the last few days of April. By month's end, the southern sea ice extent was at the latitude of Cape Freels, about 40 NM south of its normal position for the date. The eastern extent was about 100 NM east of its normal position due to the persistent offshore winds.

The LAKI continued to expand in early April, and by mid month (page 33) the southern limit was between the 25th percentile and the extreme and the east was between the median and the 25th percentile. For the remainder of April the LAKI remained in approximately the same position, with the southern LAKI position near the 25th percentile and the eastern limit at the median.

The easternmost estimated iceberg position for the year was at 45°08.4' N and 43°20.0' W on 19 April 2003. In April, 263 icebergs passed south of 48°N, over twice the April monthly average of 121 icebergs.

May

With the exception of the third week, Newfoundland and southern Labrador experienced near normal air temperatures in May, resulting in a normal retreat of the sea ice (Canadian Ice Service, 2003). The anomalous temperatures in the third week were mixed with respect to location, with St. John's experiencing slightly lower than normal temperatures and northern Newfoundland and southern Labrador warmer than normal conditions.

During the first week of the month, the offshore winds that prevailed in May continued, keeping the main ice pack well off shore. This changed dramatically in the middle of the month with the passage of a intense low pressure system on 11-13 May. This storm brought strong (~35 kt) east winds to the region, packing the remaining ice against Newfoundland's Northern Arm and southern Labrador coast. By the last week of May, the southern ice edge had retreated to the Strait of Belle Isle, which is near normal.

By mid May, the southern LAKI moved southward to a position between the 25th percentile and the extreme for the date, while the eastern limit remained near the median. Both the southern and eastern LAKI remained stable for the remainder of the month. Although the day to day numbers fluctuate somewhat due to reconnaissance and predicted iceberg melt, throughout most of May IIP was tracking a steady population of approximately 250 icebergs south of 48°N.

On 5 May, the IIP reconnaissance airplane dropped a satellite-tracked beacon on a 250 m by 100 m fragment of an ice island located at 46°52.4' N, 47°56.6' W. The 13 day iceberg track was used to test IIP's iceberg drift model (Appendix D).

May was the busiest month of the 2003 iceberg season with 494 icebergs estimated to have passed south of 48°N, over three times the monthly average of 147.

On 20 May, the easternmost iceberg seen during the 2003 ice season was found by IIP aerial reconnaissance at 47°52.2' N, 44°40.0' W. May was also the month of the southernmost sighted and estimated icebergs, both for the same iceberg. On the 16th it was found at 40°16.2' N and 49°36.0' W by a merchant vessel. Five days later, on the 21st, IIP's drift model estimated it to have reached 39°18.6' N and 48°47.4' W.

June

June was a month of remarkable change in the iceberg conditions of east Newfoundland waters. At the month's outset, there was no significant sea ice south of 52°N, and the southern ice edge had begun its northward retreat up the Labrador coast. Because of the absence of sea ice in the Strait of Belle Isle, it was again recommended for transatlantic vessels beginning on June 3, 2003, although there were numerous icebergs in the eastern approaches and in the strait itself. The retreat of the sea ice edge was at a normal rate at first, but by mid month it was a week ahead of normal.

The month began with a formidable iceberg population of nearly 250 icebergs south of 48°N. However, during the next two weeks, seasonal warming began to take its toll. By mid month, the southern LAKI retreated northward over 60 NM, and the eastern limits moved westward about 70 NM. On 15 June, the southern limit was near the 25th percentile for the date, while the eastern limit was between the median and the 75th percentile (page 37). More importantly, the number of icebergs south of 48°N declined precipitously to fewer than 100 icebergs. During the second half of June this population declined even further, reaching 20 on 30 June. On this date there was one iceberg holding the southern LAKI at 42°N; however, the closest iceberg was nearly 240 NM to the north (page 38). The eastern LAKI at the time was between the 75th percentile and the median.

In June, Ice Patrol estimated that 76 icebergs passed south of 48°N, slightly below the monthly average of 85.

July

July brought Ice Patrol's 2003 ice season to its finish. On 1 July, there were 22 icebergs and a single growler south of 48°N, most of which were north of 46°N. The iceberg season closed on 17 July with nine icebergs between 47°N and 48°N and very few immediately to the north. When the ice season closed, the southern LAKI was between the minimum and the 75th percentile, while the eastern limit was at the 75th percentile.

Ten icebergs passed south of 48°N during July. The average for the month is 31. Ice Patrol's last 2003 ice reconnaissance detachment returned from Newfoundland on 13 July. Sea ice departed Labrador's coast by 6 July, about two weeks earlier than the norm.

Summary

With 927 icebergs estimated to have passed south of 48°N, the 2003 iceberg season falls into the extreme category (>600 icebergs) as defined by Trivers (1994). On the other hand, the 116-day season length places 2003 into the lower end of the average classification (105 to 180 days). According to the NSSI proposed by Futch and Murphy (2002), the 2003 index was 2.70, which places it in the moderate category.

Icebergs arrived at 48°N in late February, but early season indications, such as the later than normal arrival of sea ice in east Newfoundland waters and the low early season iceberg counts, suggested 2003 would be a light to average iceberg season. The explosive sea ice growth in March (Figure 20) and the extraordinarily large iceberg counts in April and May changed this notion radically. Sea ice attained its maximum areal extent at the end of the third week of March, with the southern ice edge approximately 60 NM south of Cape Race and a narrow stream of ice in the offshore branch of the Labrador Current well into Flemish Pass, far south of its normal position.

Despite the vast mid-March ice extent, the 2003 Total Accumulated Ice Coverage (CIS, 2003), calculated by summing the ocean area covered by sea ice for all the weeks of the season, was less than normal.

In many respects, 2003 was similar to the 2002 iceberg season. In both years, the number of icebergs estimated to have moved south of 48°N put the year in the extreme category, but, according to the length of season criterion, each year was classified as average. The NSSI for 2003 was 2.70 while the 2002 index was 2.80; both in the moderate NSSI rating category. For brief periods, the southern LAKI during both years was south of 40°N. Both had winter (December through March) North Atlantic Oscillation Indices that were weakly positive, 0.20 in 2003 and 0.76 in 2002 (Hurrell, 2004). There was one significant difference between the two years. For most of 2002, the eastern LAKI was farther east than normal, and during part of June was near the eastern extreme. On the other hand, the 2003 eastern limit hovered at or less than the median for the entire ice season.

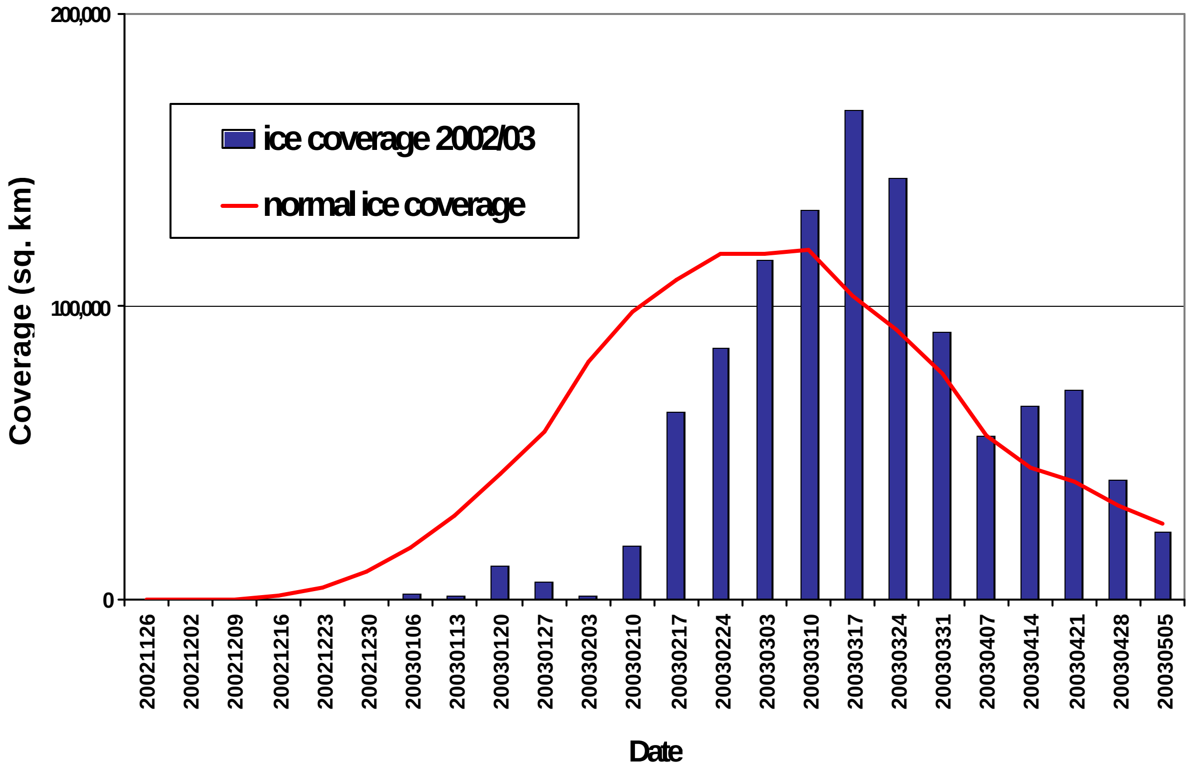

Figure 20. Comparison of 2002/2003 weekly coverage of sea ice in East Newfoundland waters with normal. (Canadian Ice Service, 2003).

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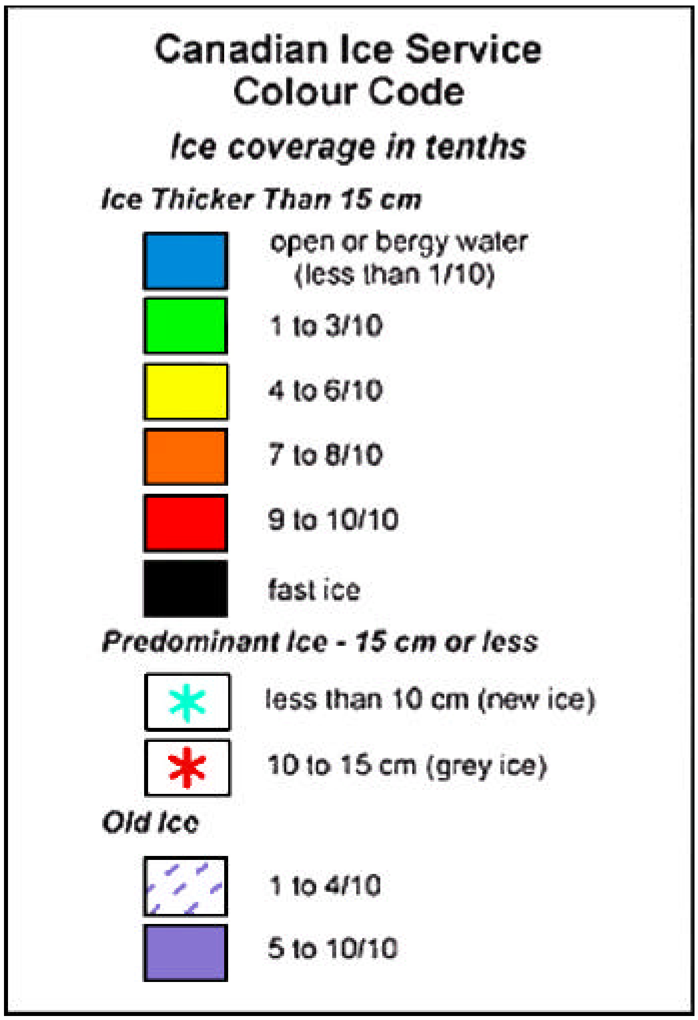
Monthly Sea Ice Charts



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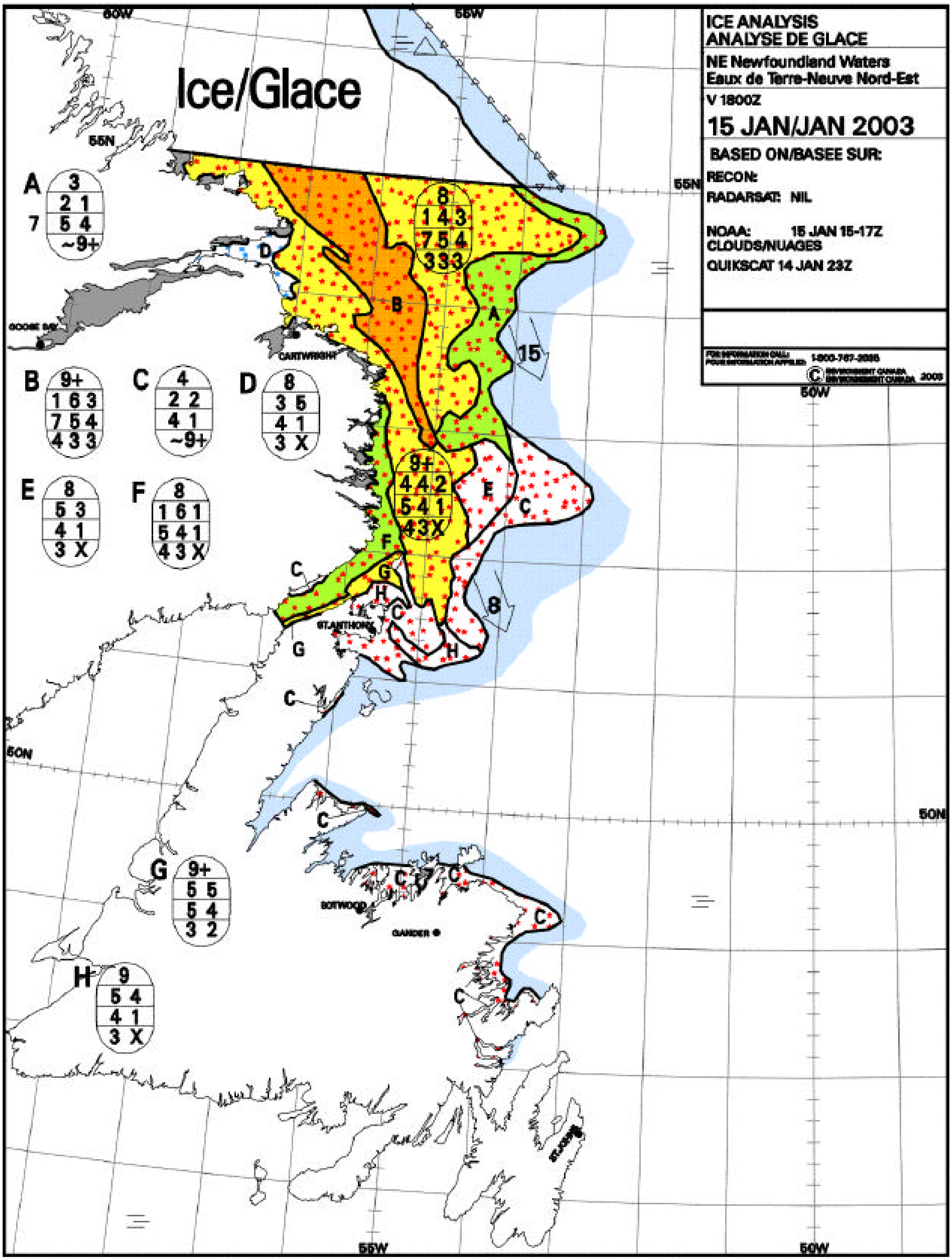

Ice/Glace
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NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 JAN/JAN 2003
BASED ON/BASEE SUR:
RECON:
RADARSAT: NIL
NOAA: 15 JAN 15-17Z
CLOUDS/NUAGES
QUIKSCAT 14 JAN 23Z
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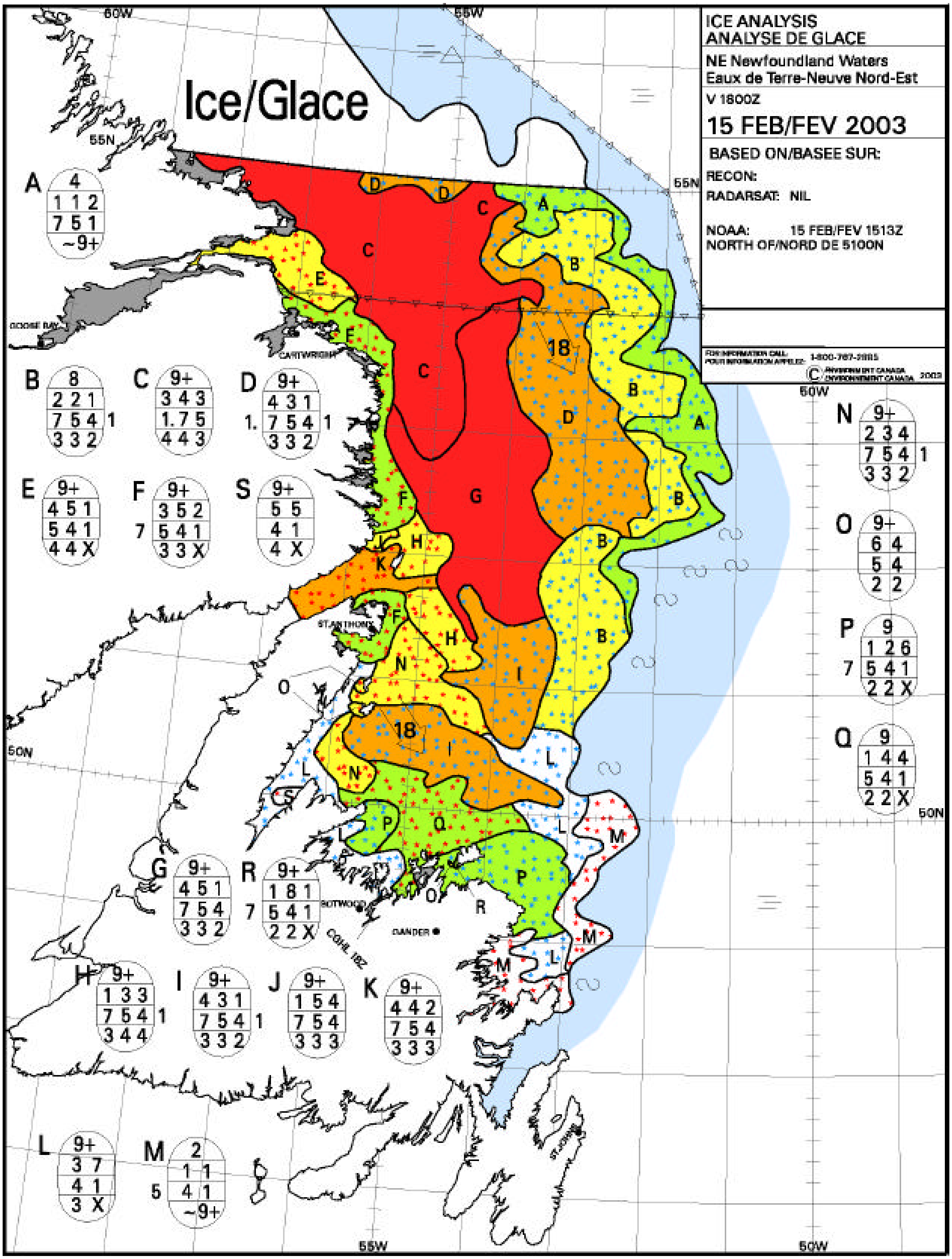

Ice/Glace
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V 1800Z
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RECON:
RADARSAT: NIL
NOAA: 15 FEB/FEV 1513Z
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ENVIRONMENT CANADA
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60W
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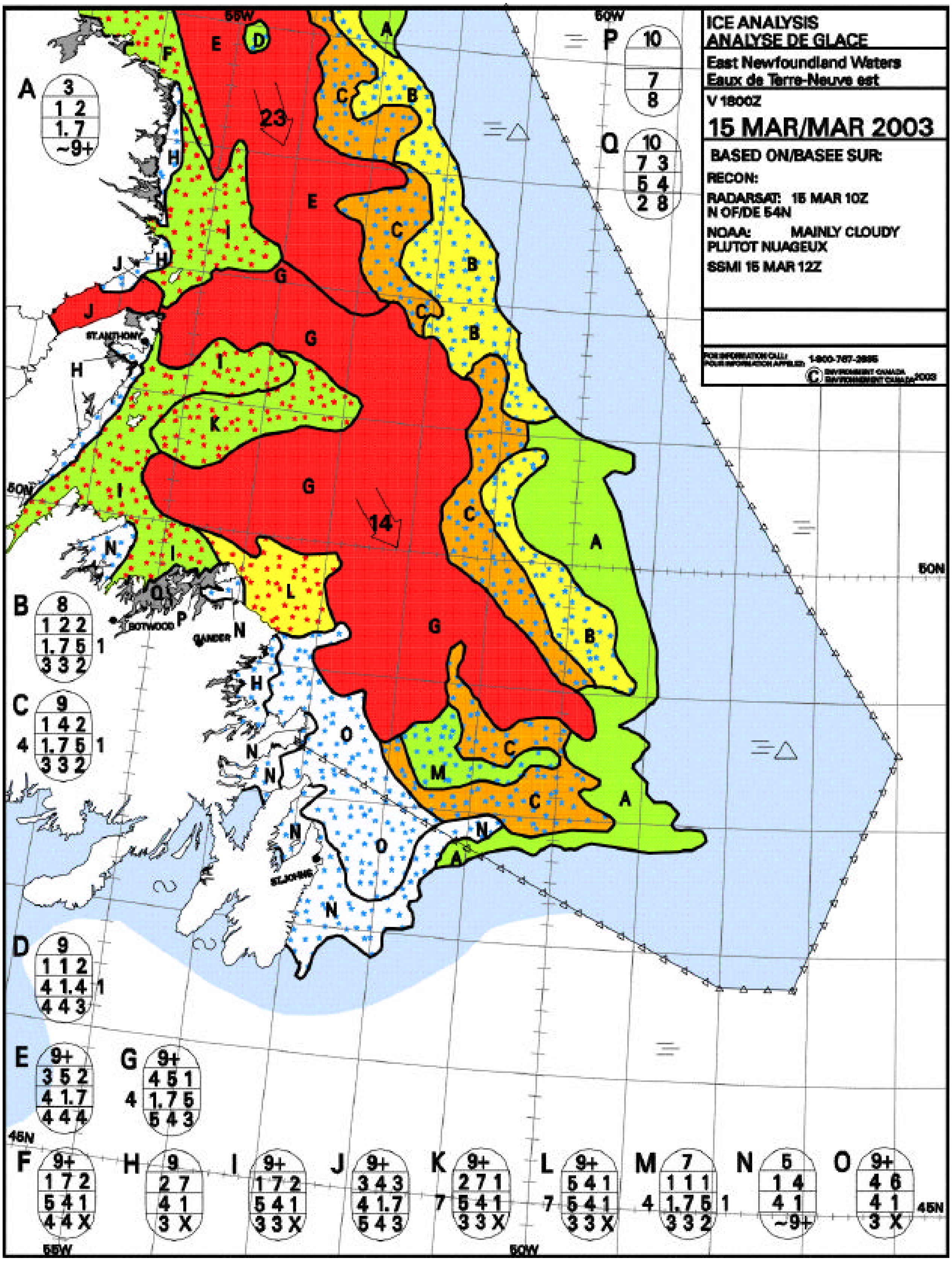
GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER

NOTE: CIS did not produce an ice chart for NE Newfoundland waters on this date.



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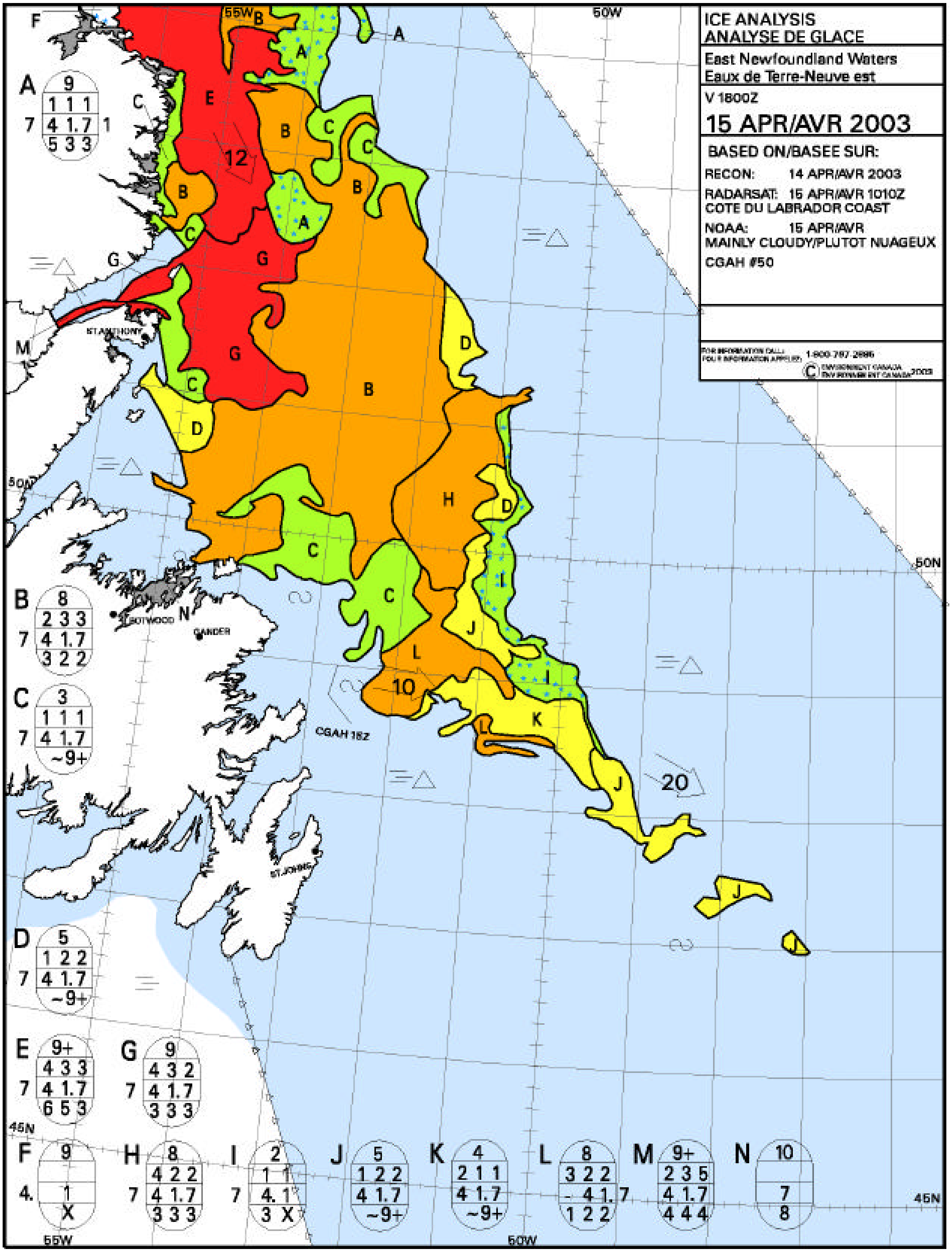

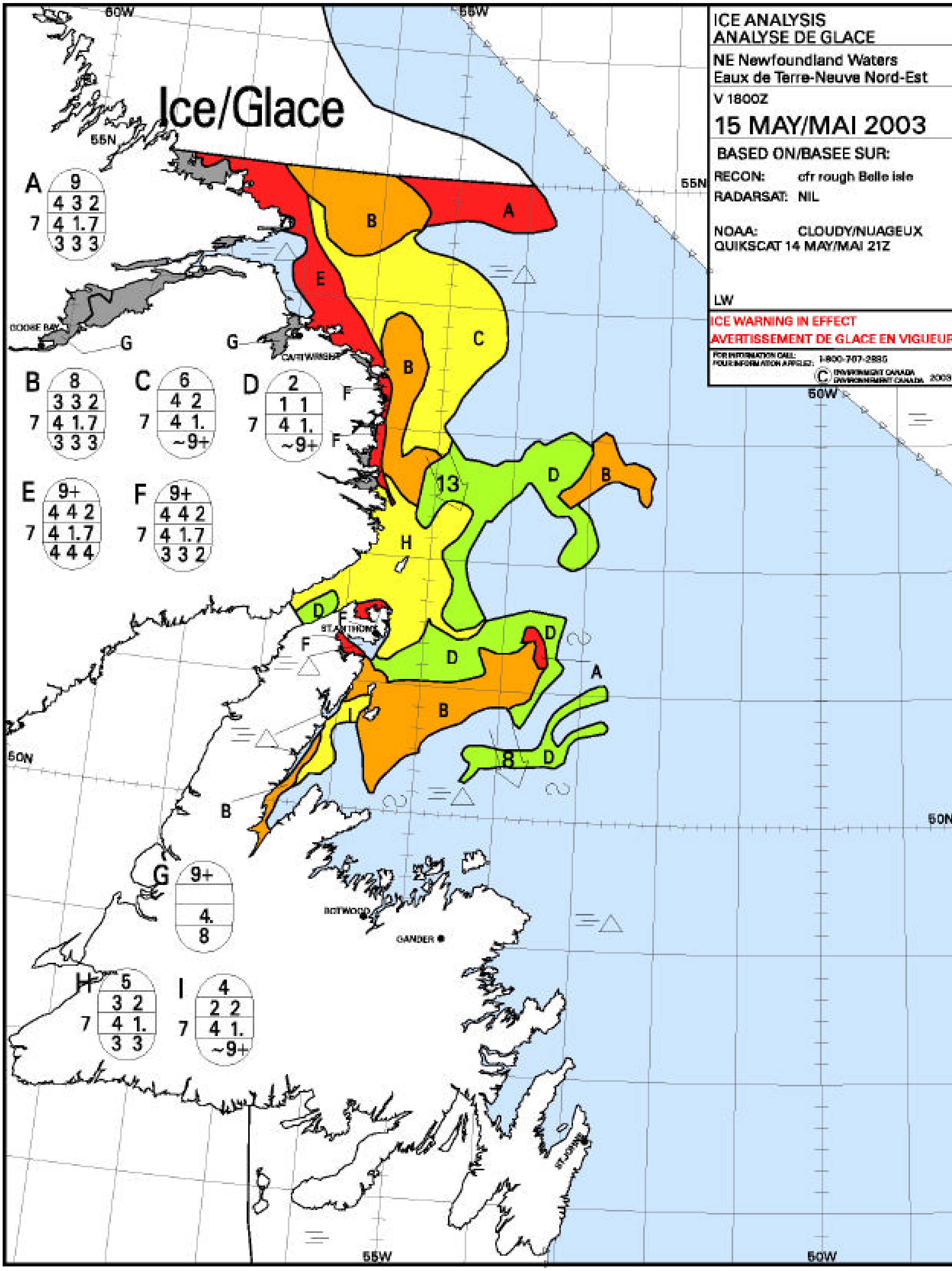

Ice/Glace
ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 MAY/MAI 2003
BASED ON/BASEE SUR:
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RADARSAT: NIL
NOAA: CLOUDY/NUAGEUX
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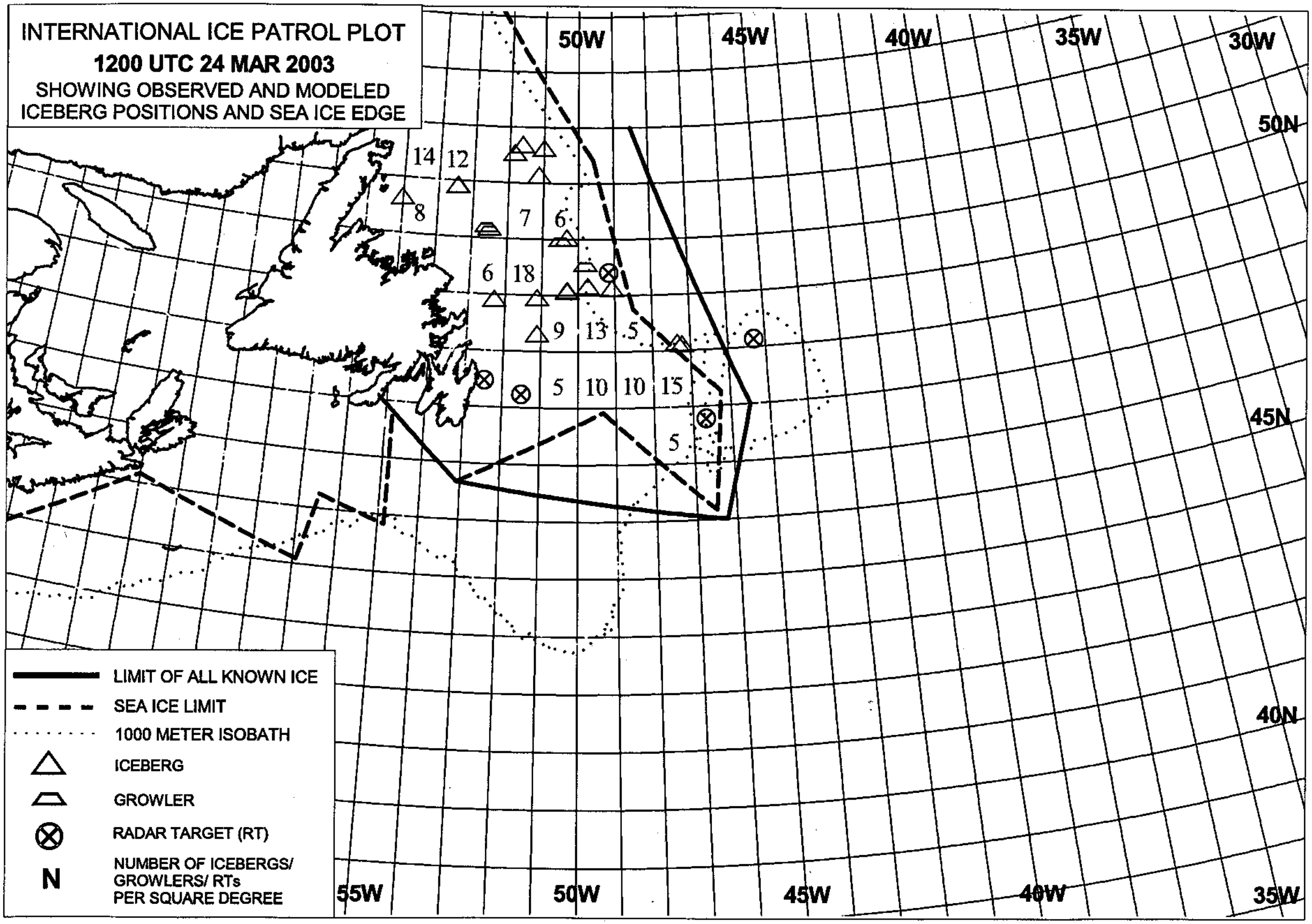
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER

Biweekly Iceberg Charts



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45W
40W
35W
30W
50N
45N
40N
55W
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40W
35W
14
12
8
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5
LIMIT OF ALL KNOWN ICE
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GROWLER
RADAR TARGET (RT)
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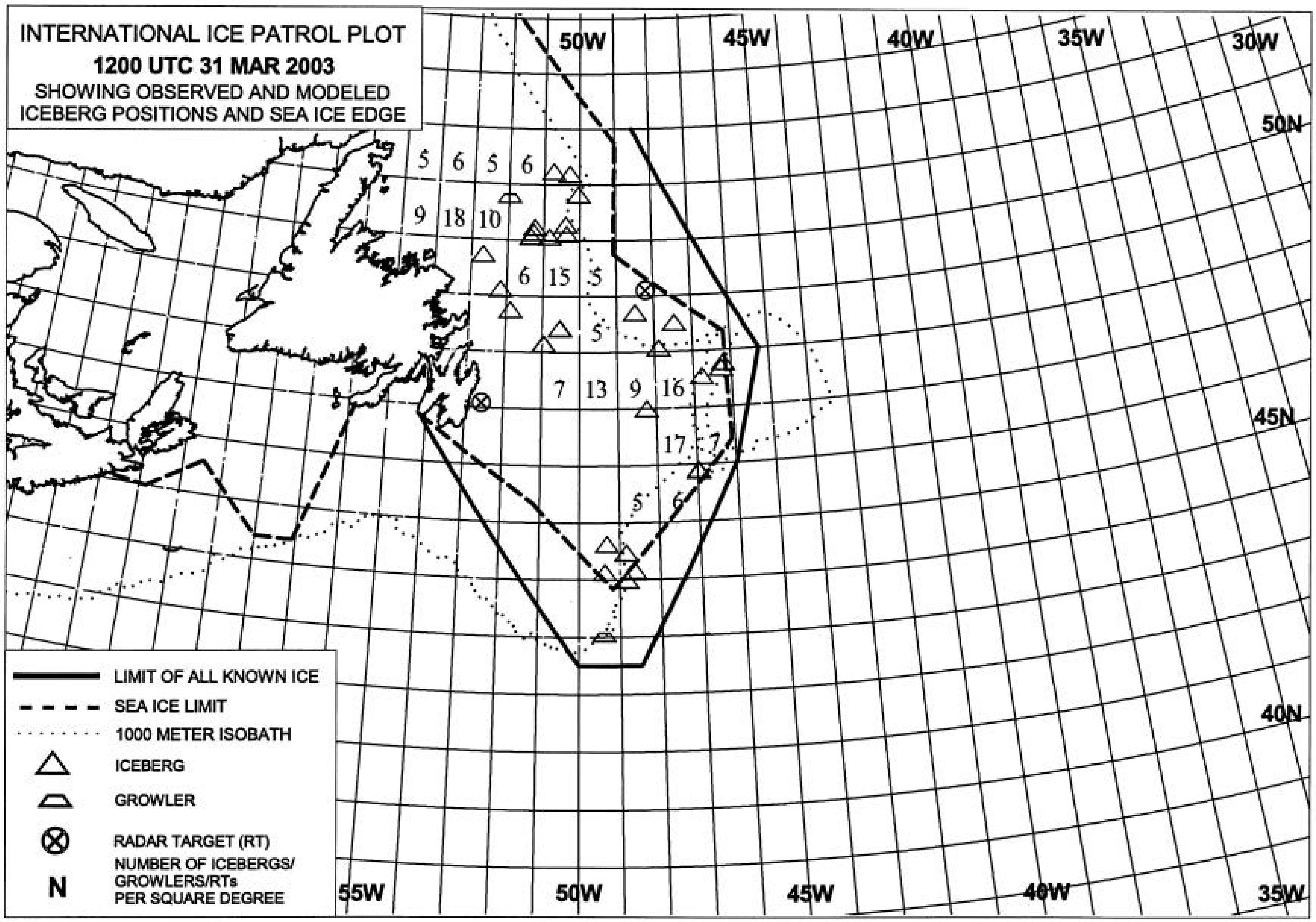
NUMBER OF ICEBERGS/ GROWLERS/ RTs PER SQUARE DEGREE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ICEBERG POSITIONS AND SEA ICE EDGE
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45W
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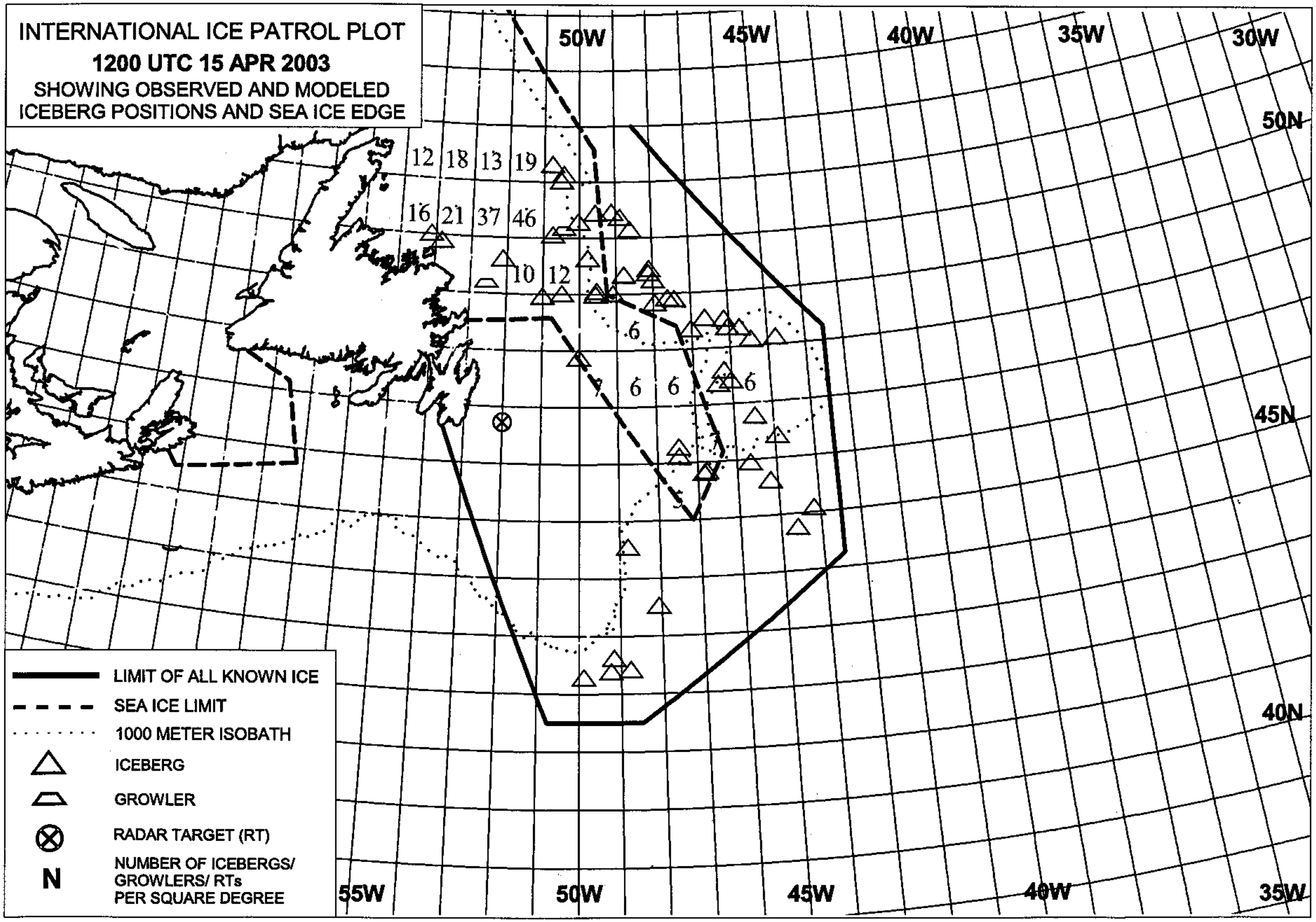
40N
55W
50W
45W
40W
35W
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/RTs
PER SQUARE DEGREE



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LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
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ICEBERG
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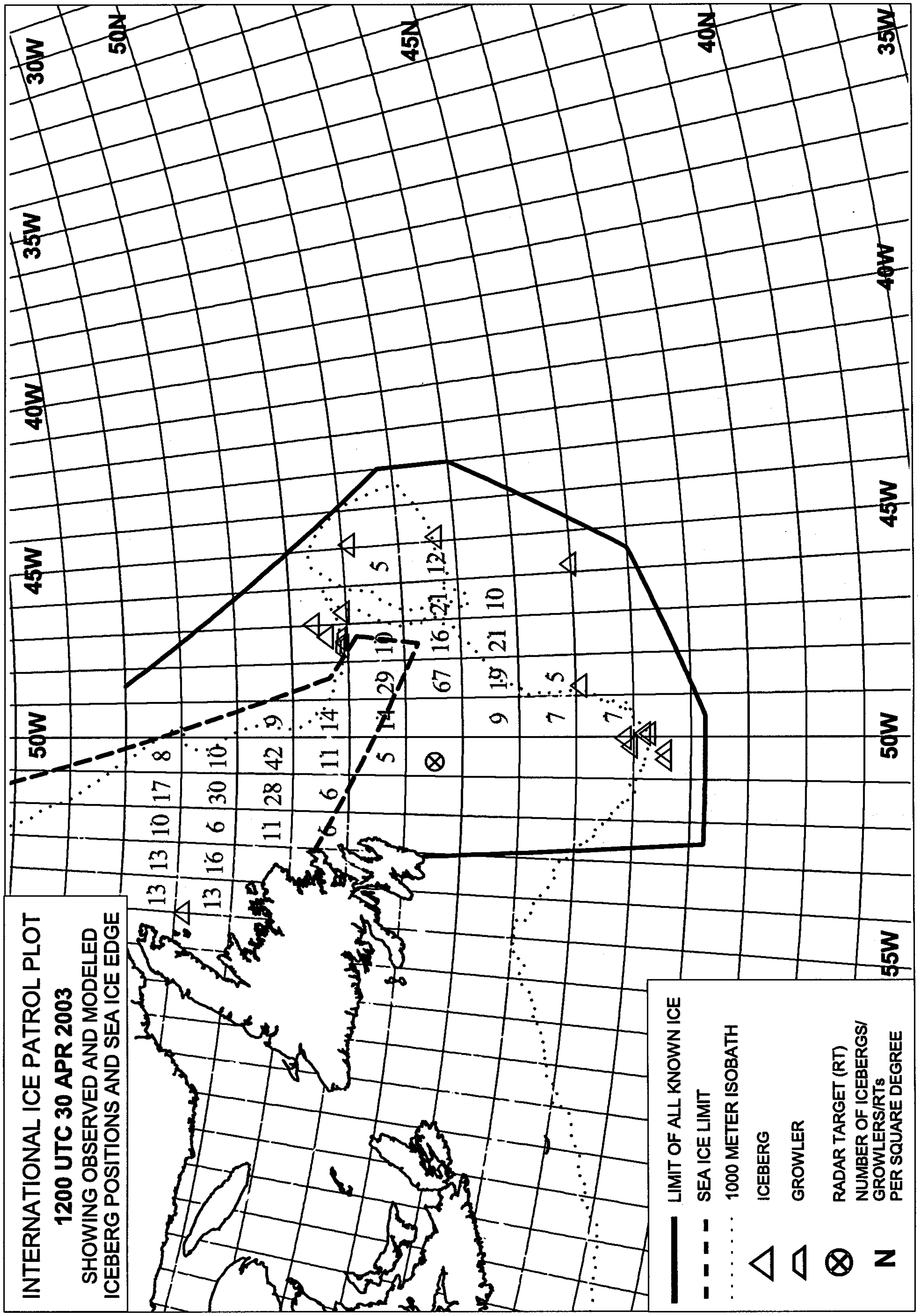

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LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/RTs
PER SQUARE DEGREE
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35W
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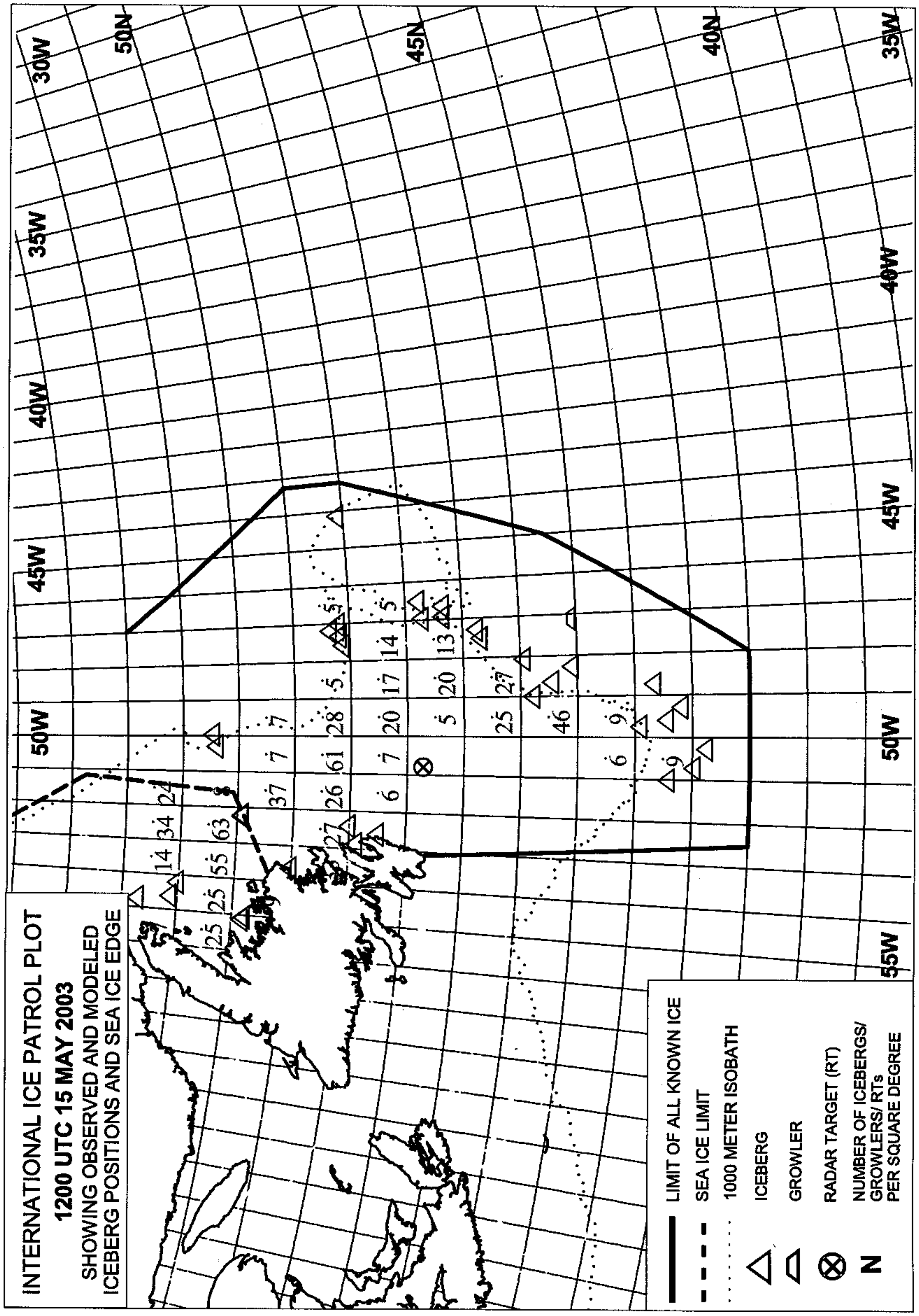
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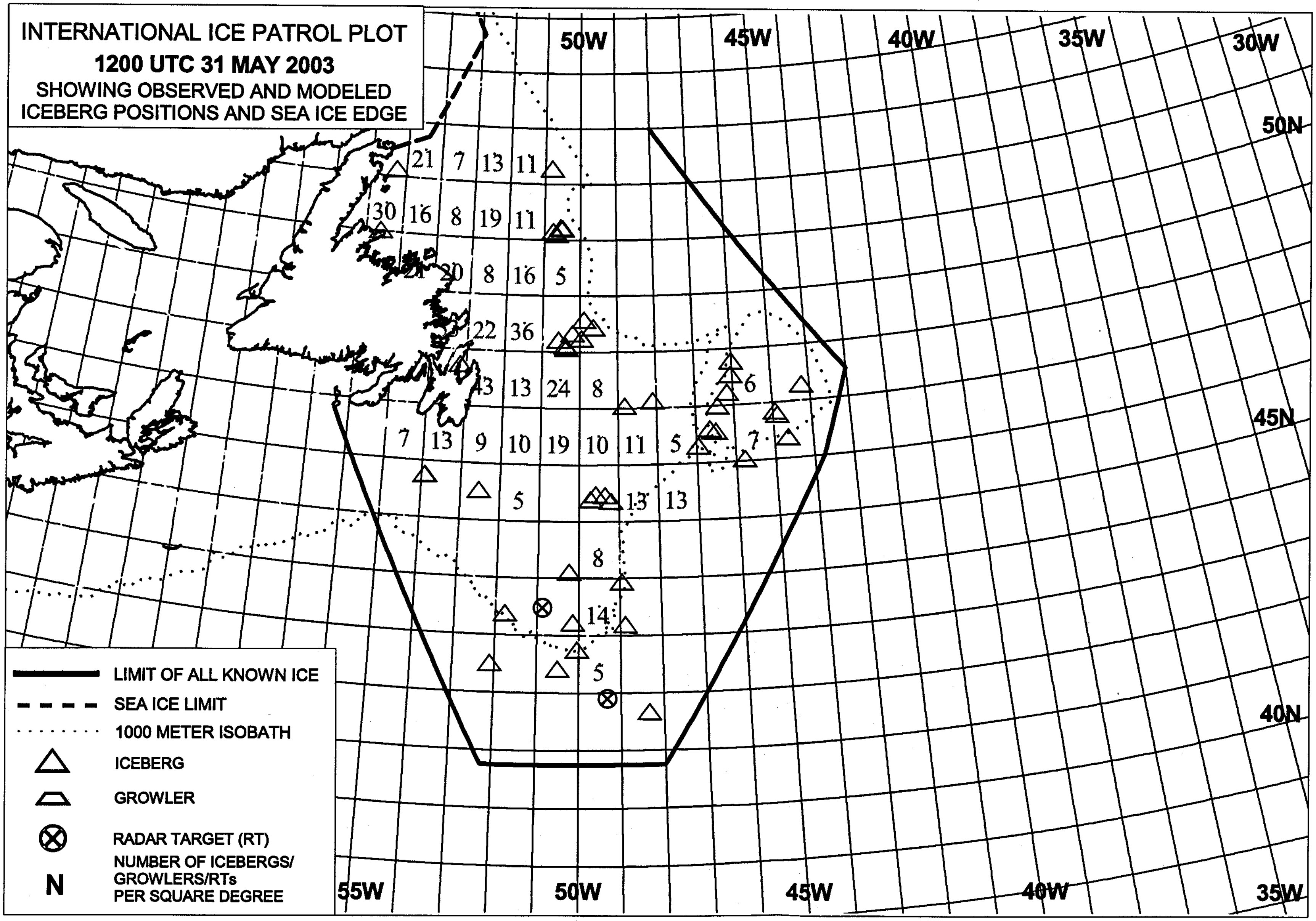
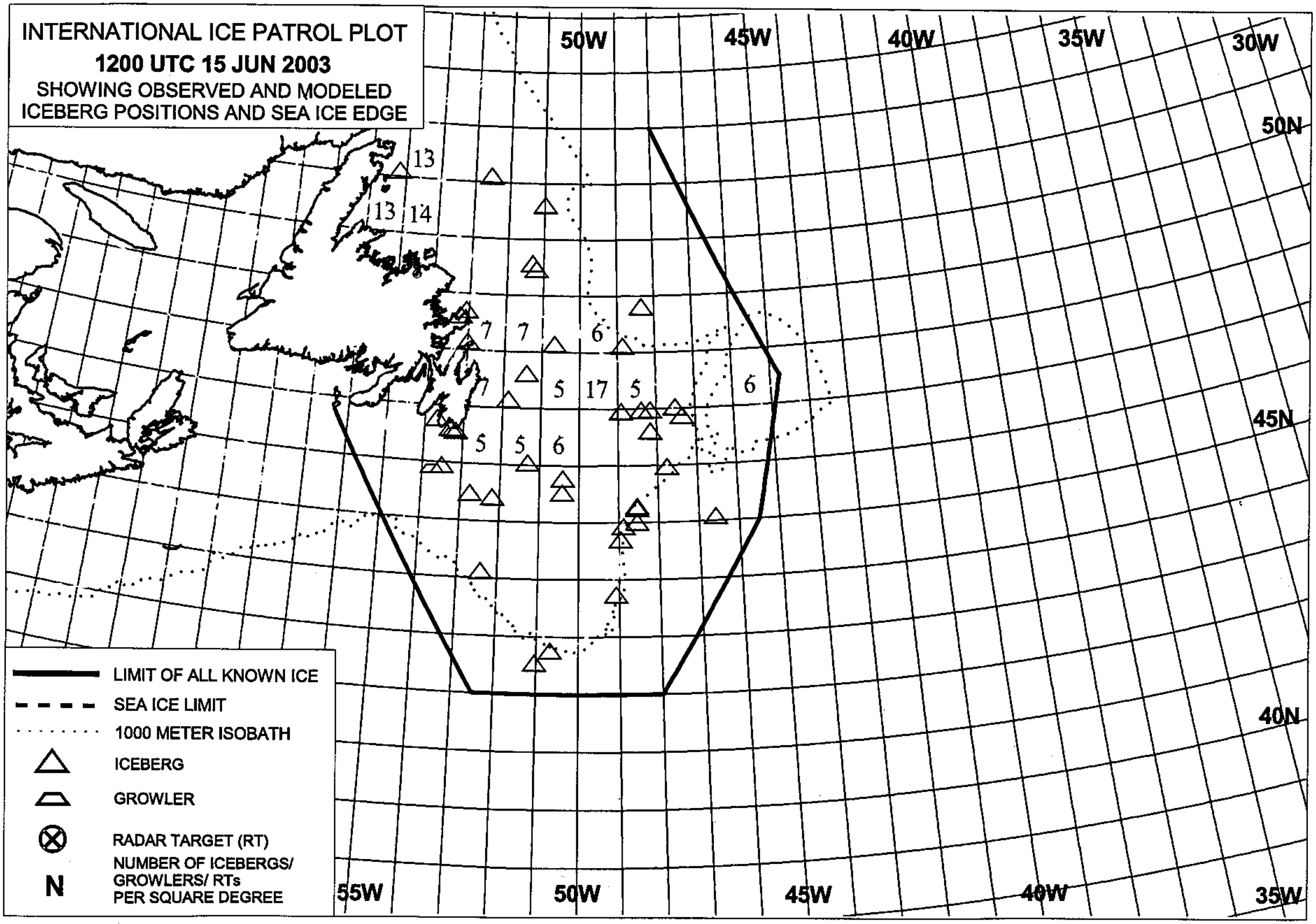
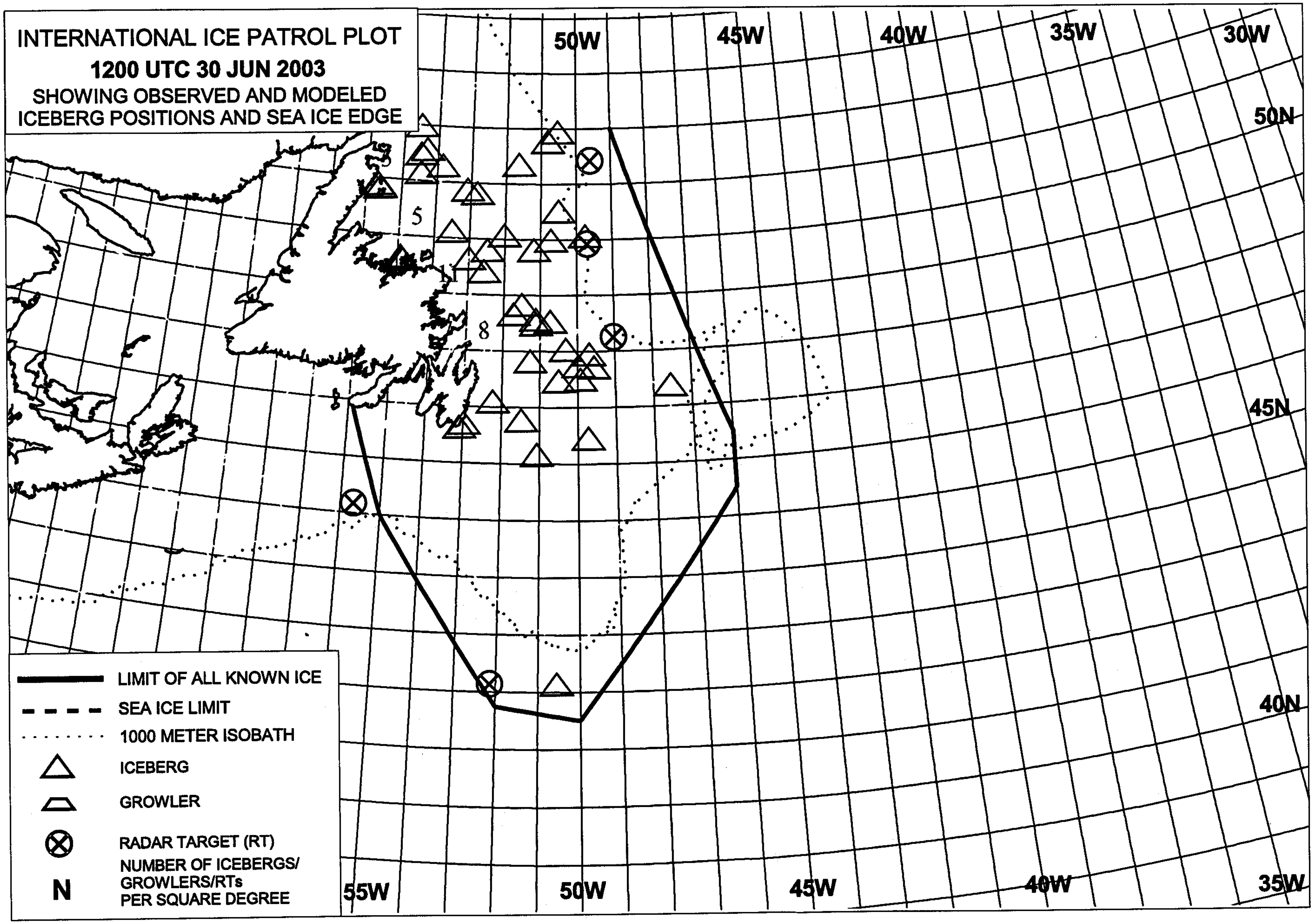
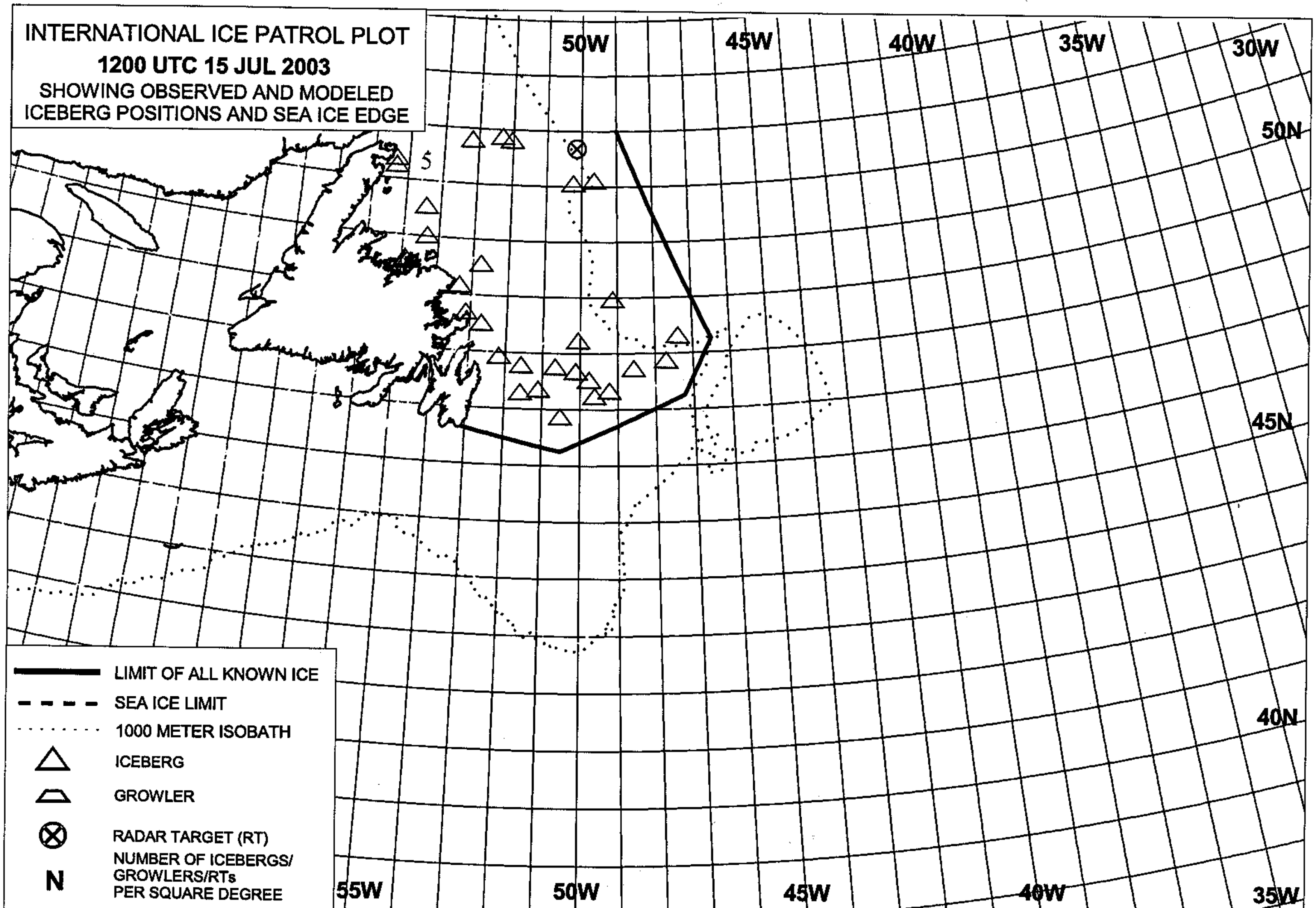
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
NUMBER OF ICEBERGS/ GROWLERS/ RTs PER SQUARE DEGREE
N
30W
35W
40W
45W
50W
55W
50N
45N
40N

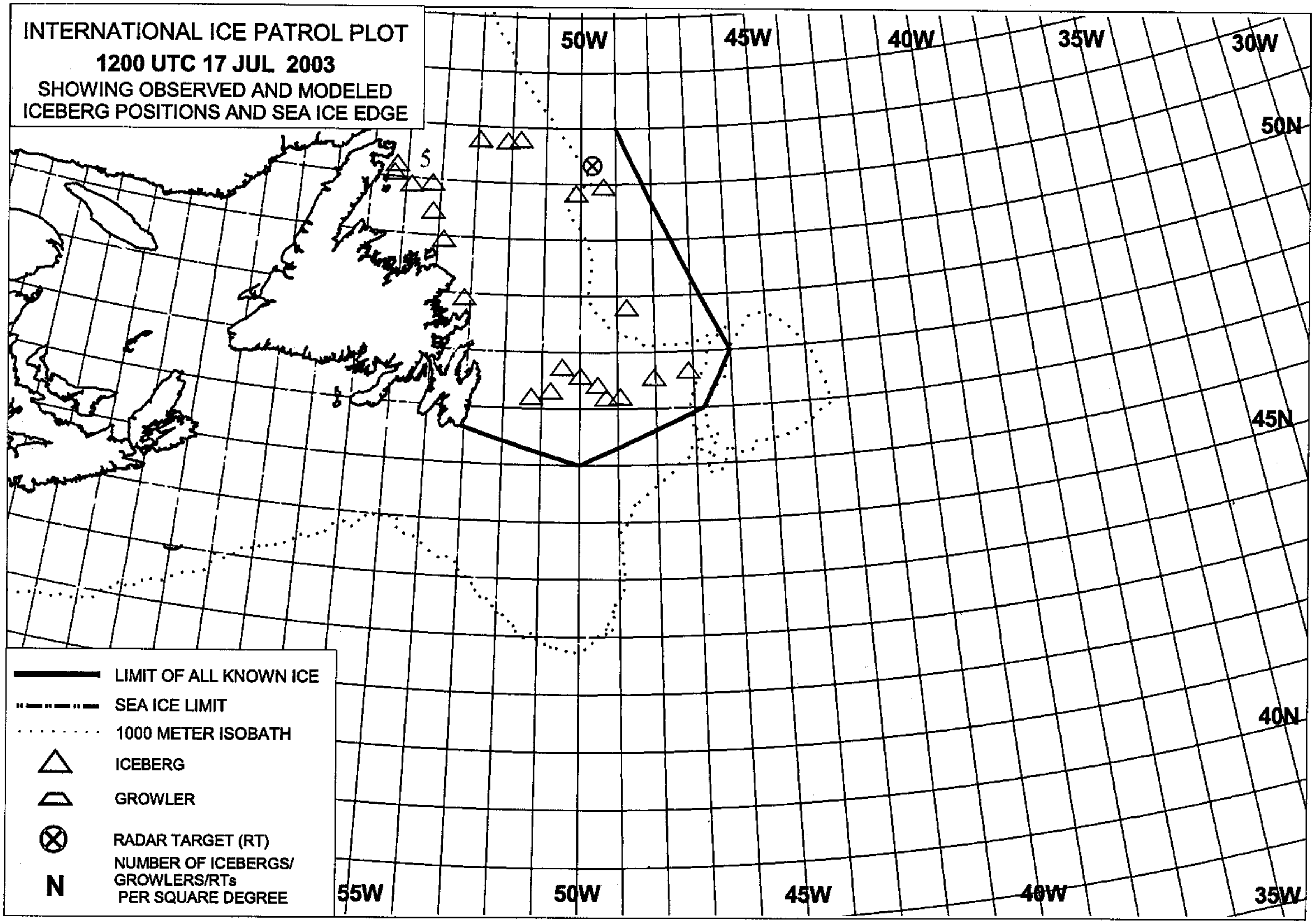


INTERNATIONAL ICE PATROL PLOT
1200 UTC 31 MAY 2003
SHOWING OBSERVED AND MODELED
ICEBERG POSITIONS AND SEA ICE EDGE
50W
45W
40W
35W
30W
50N
45N
40N
55W
50W
45W
40W
35W
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/RTs
PER SQUARE DEGREE


INTERNATIONAL ICE PATROL PLOT
1200 UTC 15 JUN 2003
SHOWING OBSERVED AND MODELED
ICEBERG POSITIONS AND SEA ICE EDGE
50W
45W
40W
35W
30W
50N
45N
40N
55W
50W
45W
40W
35W
13
13
14
7
7
6
7
5
17
5
6
5
5
6
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/ RTs
PER SQUARE DEGREE


INTERNATIONAL ICE PATROL PLOT
1200 UTC 30 JUN 2003
SHOWING OBSERVED AND MODELED
ICEBERG POSITIONS AND SEA ICE EDGE
50W
45W
40W
35W
30W
50N
45N
40N
55W
50W
45W
40W
35W
5
8
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/RTs
PER SQUARE DEGREE


INTERNATIONAL ICE PATROL PLOT
1200 UTC 15 JUL 2003
SHOWING OBSERVED AND MODELED
ICEBERG POSITIONS AND SEA ICE EDGE
50W
45W
40W
35W
30W
50N
45N
40N
55W
50W
45W
40W
35W
5
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/RTs
PER SQUARE DEGREE


INTERNATIONAL ICE PATROL PLOT
1200 UTC 17 JUL 2003
SHOWING OBSERVED AND MODELED
ICEBERG POSITIONS AND SEA ICE EDGE
50W
45W
40W
35W
30W
50N
45N
40N
55W
50W
45W
40W
35W
5
LIMIT OF ALL KNOWN ICE
SEA ICE LIMIT
1000 METER ISOBATH
ICEBERG
GROWLER
RADAR TARGET (RT)
N
NUMBER OF ICEBERGS/
GROWLERS/RTs
PER SQUARE DEGREE

Acknowledgements

Commander, International Ice Patrol acknowledges the assistance and information provided by:

Canadian Coast Guard
Canadian Forces
Canadian Ice Service
Department of Fisheries and Oceans Canada
National Ice Center
National Weather Service
Nav Canada Flight Services
U. S. Coast Guard Air Station Elizabeth City
U. S. Coast Guard Atlantic Area Command Center
U. S. Coast Guard Atlantic Area Staff
U. S. Coast Guard Automated Merchant Vessel Emergency Response System
U. S. Coast Guard Communications Area Master Station Atlantic
U. S. Coast Guard Operations Systems Center
U. S. Coast Guard Research and Development Center
U. S. Naval Atlantic Meteorology and Oceanography Center
U. S. Naval Fleet Numerical Meteorology and Oceanography Center

It is important to recognize the outstanding efforts of the personnel at the International Ice Patrol:

CDR R. L. Desh
CDR M. R. Hicks
LCDR S. D. Rogerson
Dr. D. L. Murphy
Mr. G. F. Wright
LCDR L. K. Mack
LT S. A. Stoermer
LTJG N. A. Jarboe
MSTCS V. L. Fogt
MST1 D. L. Alexander
YN1 T. J. DeVall
MST1 E. W. Thompson
MST1 T. T. Krein
MST2 J. P. Carew
MST2 J. Dale
MST2 D. A. Jolly
MST3 B. H. Grebe
MST3 E. P. Silman
MST3 D. N. Brown
MST3 A. L. Rodgers
MST3 J. E. Hutcherson
MST3 J. P. Buehner

International Ice Patrol staff produced this report using Microsoftâ Word 2000 and Excel 2000.

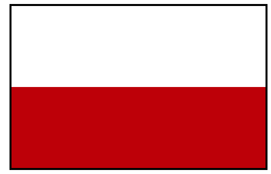
Appendix A

Nations Currently Supporting International Ice Patrol

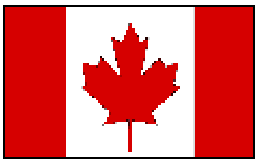
Belgium

Greece

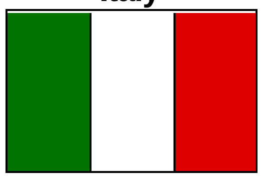
Poland



Canada

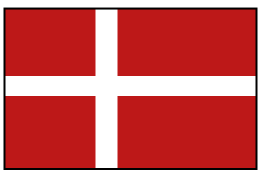


Italy

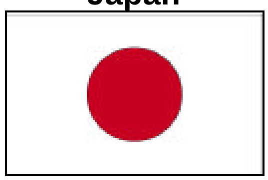


Spain

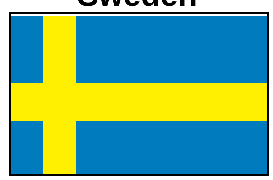
Denmark



Japan



Sweden

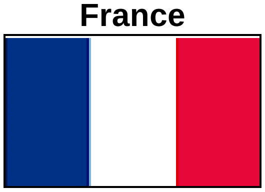


Finland

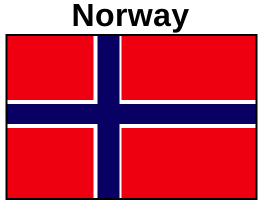
Netherlands

United Kingdom

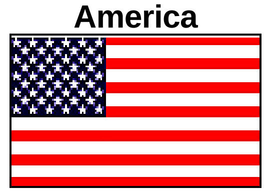
France



Norway

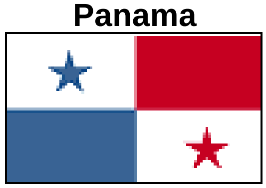


United States of America



Germany

Panama



Appendix B

Ship Reports

Ships Reporting By Flag	Reports
ANTIGUA & BARBUDA	
BBC ECUADOR	1
THEKLA	5

Ships Reporting By Flag	Reports
BAHAMAS	
AEGEAN SEA	1
AEGEN SPIRIT	14
ATLANTIC CARTIER	13
BLACK SWAN	5
DAVIKEN	1
GREEN ARCTIC	2
GULF NOMAD	8
HUAL TRITON	1
IBIS ARROW	1
JAEGER ARROW	1
JOH GORTHON	1
JUNIPER	1
MAYON SPIRIT	19
PELICAN ARROW	4
SOTRA SPIRIT	46
STENA CONFIDENCE	1
SUN CLAUDIA	1
TECAM SEA	1
VANCOUVER SPIRIT	3

Ships Reporting By Flag	Reports
BERMUDA	
CANMAR COURAGE	4
CANMAR FORTUNE	6
CANMAR GLORY	1
CANMAR VALOUR	23
CANMAR VICTORY	2
CAST POWER	2
MARGIT GORTHON	1

Ships Reporting By Flag	Reports
CAMBODIA	
CAPTAIN WAEL	1

Ships Reporting By Flag	Reports
CANADA	
ALGOFAX	8
ANN HARVEY	8
ARCTIC	2
ATLANTIC AIRWAYS	22
ATLANTIC PURSUIT	3
CAPE BONAVISTA LIGHTHOUSE	3
CAPE RACE LIGHTHOUSE	7
DES GROSEILLIERS	6
GAME II	1
GRAND BARON	1
GREENWHICH MAERSK	3
HENRY LARSON	1
JACQUES DESGAGNES	3
KOMETIK	12
LEONARD J. COWLEY	4
MAERSK BONAVISTA	1
MATTEA	69
NORTHERN WHALE	1
OOCL BELGIUM	1
PIERRE RADISSON	4
PROVINCIAL AIRWAYS	43
SHAWINIGAN	21
SIR WILFRED GRENFELL	1
SUMMERSIDE	1
TERRY FOX	2
TUKTU	12
TWILLINGATE LIGHTHOUSE	27
VINLAND	1

Ships Reporting By Flag	Reports
CAYMAN ISLANDS	
LIKON	11
PARNASSOS	5
PILION	4
STOLT ACHIEVEMENT	5
CYPRUS	
APEX	4
ARISTIDIS D	1
CATA PILAR	2
CINNAMON	2
FRIO LONDON	1
INDEPENDENT TRADER	1
ISADORA	8
ISNES	17
PEARLMAR	8
PUMPURI	1
STRANGE ATTRACTOR	2
TASSOS N	1
TEGESOS	1
DENMARK	
OLGA MAERSK	1
ESTONIA	
ANDVARI	1
TAURUS	1
FINLAND	
BIRKA FOREST	15
FRANCE	
MARION DUFRESNE	3
FRENCH ANTARCTIC TERRITORY	
BRO CATHERINE	2

Ships Reporting By Flag	Reports
GREECE	
AMAZON GLADIATOR	7
AQUAGRACE	1
CAP DIAMANT	1
CAP GEORGES	66
CAP JEAN	4
CAP ROMUALD	16
MAKRONISSOS	1
MARATHON	9
MILO	7
MONALISA	1
OLYMPIC MENTOR	10
SPYROS	8
STEMNITSA	7
TALISMAN	1
HONG KONG	
CASHIN	1
FEDERAL HUDSON	1
FEDERAL PROGRESS	1
FULL COMFORT	1
OCEAN FAVOUR	6
OOCL CANADA	1
SAGA SKY	3
ICELAND	
SUNNA	2
ISRAEL	
ZIM CALIFORNIA	5
ITALY	
GRANDE SPAGNA	9
ISOLA VERDE	2
SVART FALK	14

Ships Reporting By Flag	Reports
JAMAICA	
LAMAZON	2
KOREA (SOUTH)	
SABINA	2
LATVIA	
ERLA	2
LIBERIA	
ARCTURUS	3
ASOPOS	2
BERING SEA	2
CANADA SENATOR	1
CRUDE PRINCESS	4
DJANET	2
DUNDEE	4
HELENA OLDENDORFF	23
LIELUPE	1
LUCKY TRANSPORTER	1
LYDIA OLDENORFF	3
MSC BOSTON	15
NORDIC BLOSSOM	1
OBO VENTURE	1
ORION HIGHWAY	9
P&O NEDLLOYD MAIRANGI	1
REGINA OLDENDORFF	4
SANKO QUALITY	2
ST. PETERSBURG SENATOR	8
STOLT ASPIRATION	10
TRIBUTE	5
VOYAGER	10
LITHUANIA	
KAPITONAS A. LUCKA	11
KAPITONAS MARCINKUS	1
KAPITONAS STULPINAS	6

Ships Reporting By Flag	Reports
LITHUANIA cont.	
SVILAS	12
MALTA	
BALI SEA	1
BERING SEA	2
BREGEN	1
ENDEAVOR	1
GREEN SUMMER	5
JOHNNY K	2
KAPITAN ZHURAVLYOV	1
KING A	2
LATGALE	9
LIANO	6
LYKES RUNNER	4
MARGARA	5
MERIOM JOY	2
MOSTOLES	1
PILICA	1
TROGIR	2
ZIM CALIFORNIA	2
MARSHALL ISLANDS	
AMAZON	2
EURO SUN	1
LAKE ERIE	1
LAKE MICHIGAN	3
LAKE ONTARIO	5
LAKE SUPERIOR	28
YARMOUTH	7
YELLOWKNIFE	1
ZIEMIA GORNOSLASKA	6
ZIEMIA LODZKA	11
NETHERLANDS	
ARION	1
P&O NEDLLOYD AUCKLAND	3

Ships Reporting By Flag	Reports
NETHERLANDS cont.	
VLISTBORG	1

Ships Reporting By Flag	Reports
NETHERLANDS ANTILLES	
IVER EXCEL	2
JO ASK	4
JO LIND	6
LYNBAANSGRACHT	1
MARINUS GREEN	1
PELAGIA	1
SCHIPPERSGRACHT	1
SINGELGRACHT	1
SNOEKGRACHT	1

Ships Reporting By Flag	Reports
NORWAY	
BALBOA	3
BANASTAR	1
BERGE ARCTIC	62
BERGE NORD *	70
BERTHIA	2
BOW CENTURY	3
LANGENES	1
MARINETTE	22
MENOMINEE	20
NCC ASIR	6
ODIN EXPLORER	2
PROSPECT	1
SIBOTI	1
SPAR GARNET	1
SPAR THREE	3
STAR DIEPPE	2
STAR FUJI	1
STAR SKOGANGER	40
TAIKO	1
TEEKAY FAIR	8
TEEKAY FOUNTAIN	4
TOFTON	15

Ships Reporting By Flag	Reports
NORWAY cont.	
TRINIDAD	20

Ships Reporting By Flag	Reports
NORWEGIAN INT. REGISTER	
EMMA	1
GREEN COOLER	2

Ships Reporting By Flag	Reports
PANAMA	
AURORAL ACE	1
BUJIN	1
C.S. QUEEN	3
CAPE PAMPAS	1
CO-OP PHOENIX	3
FEDERAL SUMIDA	1
FIVOS	1
GECO SEARCHER	1
HANG TA	1
IKAN BELIAK	1
KENT RELIANT	3
LOWLANDS YARRA	1
MERIDIAN ACE	5
MEXICAN REEFER	3
MOL THAMES	13
NICON FRONTIER	5
NORD ACE	1
NORDGLIMT	3
NORTHSEA	2
PRIDE	10
RED CHERRY	2
SILVERMAR	1
SPAR TWO	1
SPICA	8
STOLT DORSET	1
SUPER RUBIN	1
WELSH VENTURE	4

Ships Reporting By Flag	Reports
PHILIPPINES	
STAR SAVANNAH	39
POLAND	
ZIEMIA CHELMINSKA	1
ZIEMIA TARNOWSKA	1
RUSSIA	
ZAPOLYARYE	1
SINGAPORE	
CSK GRANDEUR	8
ELISABETH MAERSK	27
EMILIE MAERSK	9
HSH UBIN	2
IKAN BELIAK	10
JULIA	4
STAR IKEBANA	8
STAR SIRANGER	4
ST. VINCENT	
REGINA	8
RHONE	8
SWEDEN	
ATLANTIC COMPANION	8
GLORY CREDO	2
MARIA GORTHON	2
SWITZERLAND	
GENERAL GUISAN	14
THAILAND	
TOLTECA	1

Ships Reporting By Flag	Reports
TURKEY	
CELINE-1	3
HACI HASAN YARDIM	1
UKRAINE	
MAKEEVKA	1
UNITED KINGDOM	
BRITISH HUNTER	1
CELTIC TERRIER	1
CIELO DI BISCAGLIA	4
GOSPORT MAERSK	6
JANET-C	5
JILL-C	14
LIA C	3
LYKES AMBASSADOR	1
MARIA KNUTSEN	2
UNITED STATES OF AMERICA	
GEYSIR	32
GUS W. DARNELL	1
MAERSK GEORGIA	5
MAERSK VIRGINIA	2
NATIONAL ICE CENTER	4
UNKNOWN	?
ANY SHIP	62
WHATS HAPPENING	1
VANUATU	
WISLANES	1

*DENOTES VESSEL PARTICIPATION AWARD WINNER

Appendix C

2003 Ice Chart Reception Project

MST2 Jonathan Dale
LT Scott Stoermer

During the 2003 ice season the International Ice Patrol (IIP) requested that mariners return ice charts received via high frequency (HF) weather fax (WEFAX) while at sea. The charts where then analyzed and studied in an effort to gain a better understanding of the reception quality as well as geographic extent of dissemination of our product.

IIP strives to continually improve the quality of the product provided to the North Atlantic mariner. In years past, IIP has conducted similar surveys of WEFAX reception. Through ongoing studies of our HF product, we hope to gain a better understanding of its use, its quality and how it might be improved.

The ice chart is a major navigational aid used and trusted by many North Atlantic mariners. The chart depicts the Limit of All Known Ice (LAKI) for mariners' use in voyage planning as well as underway decisions regarding ship tracking. It was requested that the mariner return any charts received via WEFAX, noting reception time, reception location and frequency of receipt. IIP monitors every ice chart broadcast from Groton with its own HF receiver and WEFAX software. Unfortunately, IIP's position relative to the transmitting antennae makes the reception, more often that not, poor. Consequently, IIP considers its HF reception capability as only a check of the fact that the ice chart is being transmitted, not its quality. So, IIP is more interested in how the product is received by vessels operating in the North Atlantic.

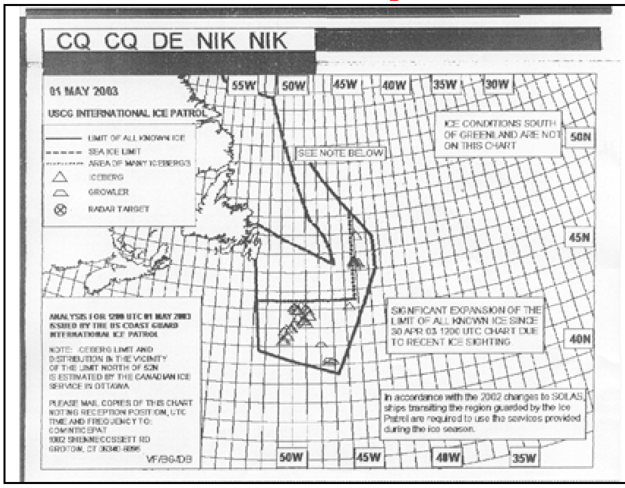
During the 2003 season, IIP received 82 ice charts from 14 different vessels (Table 1). Ice charts from all over the Atlantic Ocean where received. In an effort to gain better understanding of HF propagation in our area of responsibility, we narrowed the area of study to the region bounded by 39°N, 52°N, 35°W and 64°W.

Based on the returned charts, the quality of reception was divided into five categories as shown in Figure 1. Category 1 included charts with the best reception, Category 2 represented good reception, and Category 3 consisted of charts with fair reception. Category 4 included charts from which the date and LAKI were barely readable and Category 5 reception included charts considered useless to the mariner. Figure 2 displays chart reception position, frequency and quality.

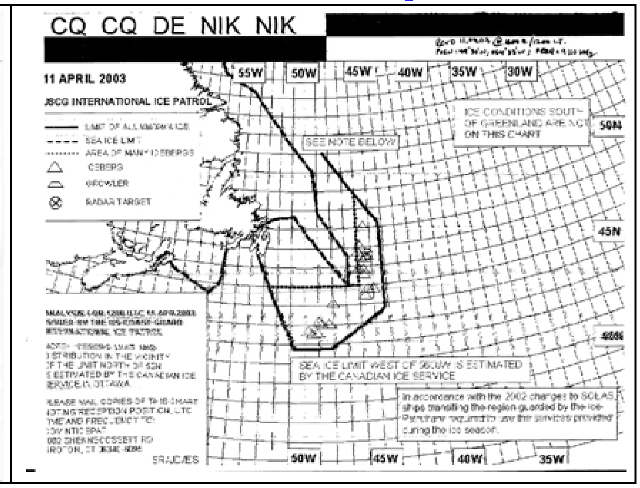
REPORTING VESSELS
BERGE NORD
BLACK SWAN
CSK GRANDEUR SINGAPORE
FEDERAL HUDSON
KAPITONAS A LUCKA
LYDIA OLDENDORFF
MATTEA
OCEAN FAVOUR
OFFENBACH
P&O NEDLLOYD AUCKLAND
PEARL MAR
PRIDE
SEA LAND PERFORMANCE
STAR IKEBANA
STAR SAVANNAH
TOFTON

Table 1. Listing of vessels returning ice charts in 2003.

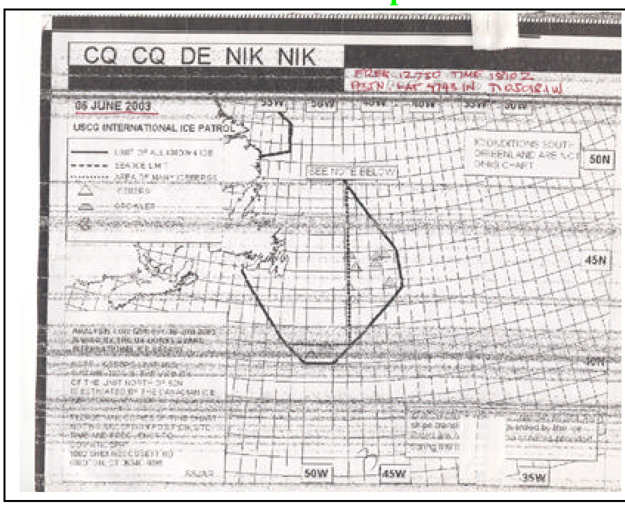
1. Best Reception



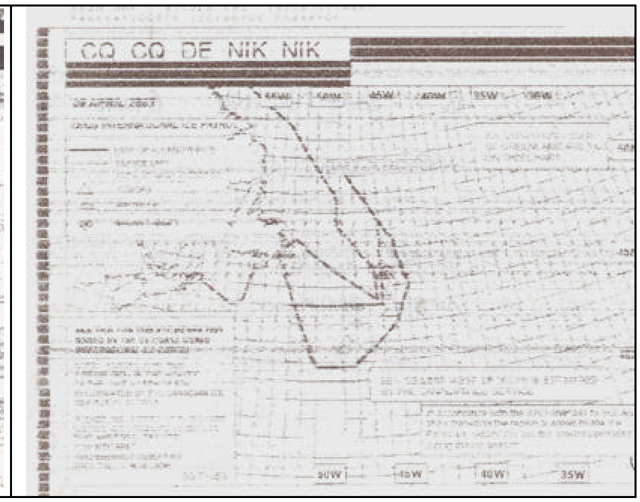
2. Good Reception



3. Fair Reception



4. LAKI Readable



5. Poor Reception

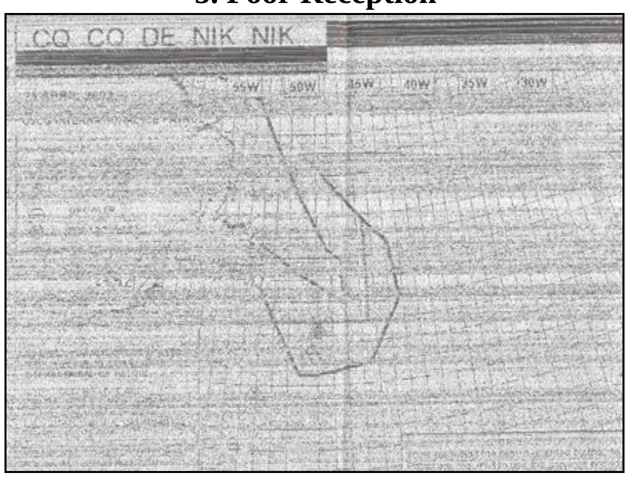


Figure 1. Ice Chart reception rating scale.

The data received by IIP shows that, of all the ice charts received, 94% had at least the LAKI and date readable. Assuming that the sample of 82 charts received is fairly representative of the larger population of HF received charts, this level of usefulness is promising. The data also shows that more than 53% of all ice charts were received on 9110 MHz (Table 2). The fact that the US Coast Guard transmits the chart on the most used frequency shows that the customer of the ice chart finds the US transmission satisfactory. The most used frequency found during this survey differs from that found during the 2000 survey in which 12750 MHz ranked the highest. Interestingly, the percentage of the charts received at the 12 MHz frequency also represented 53% of the sample (Dale and Strong, 2000, p.53)*. Based upon the combined data for both studies, it can be inferred that the higher frequencies generate a better, more reliable product for the mariner.

This study, when considered in conjunction with that of 2000, shows that the HF WEFAX ice chart remains a viable and trusted product dissemination method. Surveys of this nature, in addition to the customer satisfaction survey planned for 2004, give the Ice Patrol a real insight into customer feelings. The Ice Patrol Customer Relations work group stands ready to assist any and all Ice Patrol customers with questions about products or dissemination methods. Please do not hesitate to contact us:

Commander
International Ice Patrol
Attn: Customer Relations
1082 Shennecossett Road
Groton, CT 06340
(860) 441-2626
iipcomms@rdc.uscg.mil

Percent	Frequency
53.1%	9110 MHz
19.8%	12750 MHz
12.3%	6340 MHz
8.6%	4325 MHz
5%	7880 MHz
1.2%	Other

Table 2. Percentage of ice charts returned, broken down by frequency.

* Dale, J. and C. Strong, 2000. 2000 Fax Chart Reception Project. Appendix C in: *Report of the International Ice Patrol in the North Atlantic, Bulletin No. 86, 2000.*

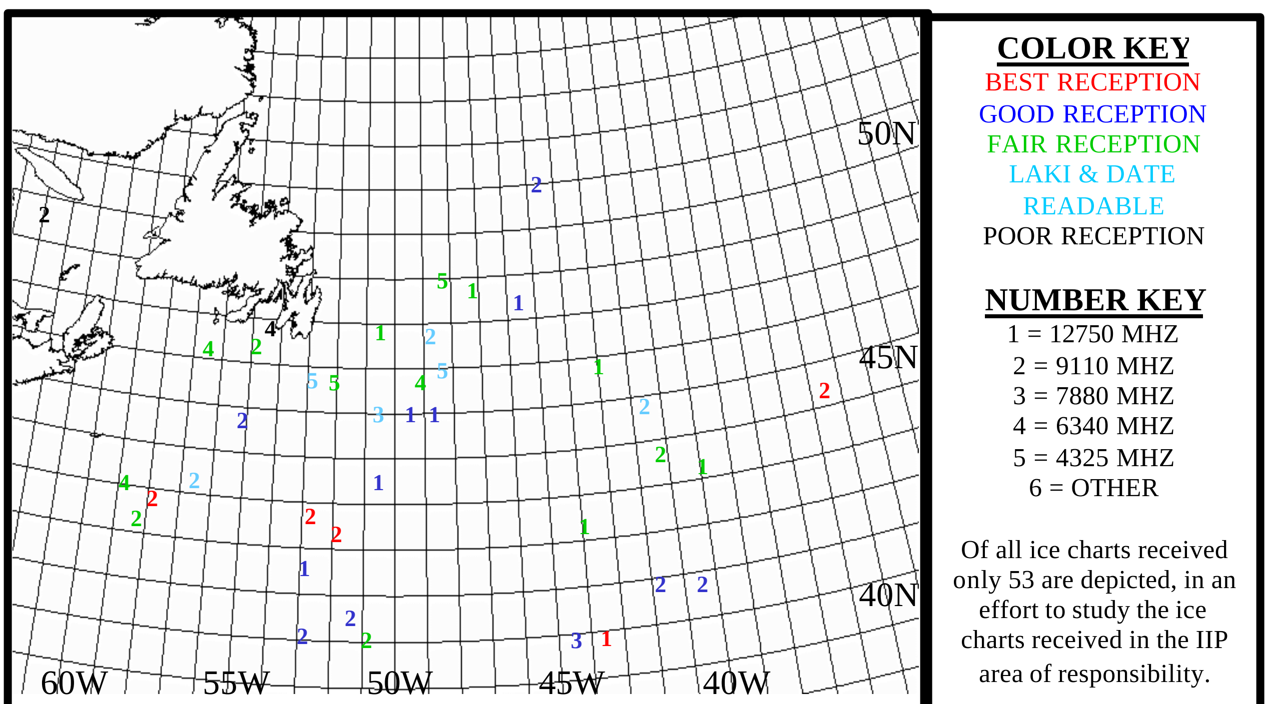


Figure 2. Distribution of ice charts within the analysis region.

Appendix D

Iceberg Drift Model Comparisons with Ice Island Position Data

MST3 Allie Rodgers
LT Scott Stoermer

Abstract

The analysis of 13 days of iceberg tracking data for the purposes of testing the drift characteristics of the International Ice Patrol's iceberg drift and deterioration model is presented. The data collection, methods and analysis are discussed. A historical background section follows the project conclusions and briefly outlines the historical aspects of Ice Patrol's iceberg marking and tracking techniques as well as Ice Islands.

Introduction

The iceBerg Analysis and Prediction System (BAPS) has been extensively tested over the years to help ensure that the Canadian Ice Service and the International Ice Patrol (IIP) use the best information possible to estimate iceberg drift and deterioration. The region of the North Atlantic Ocean that IIP is concerned about is highly complex as the Gulf Stream (GS), Labrador Current (LC) and North Atlantic Current (NAC) interact in a region of very shallow bathymetry. Coupled with dynamic, often harsh weather, the intricacies of this ocean-atmosphere system make its prediction very difficult and require IIP to constantly concern itself with the differences between the actual ocean and the BAPS ocean.

The appearance of very large tabular icebergs in the region of the Grand Banks of Newfoundland for the second consecutive year provided IIP with some unique opportunities during the 2003 ice season. Most notably, IIP was able to deploy a Compact Air Launched Ice Beacon (CALIB) and gather approximately two weeks of real-time iceberg position information during the late spring. IIP's archive of the environmental forcing files used by BAPS provided the means to test the model after the fact.

CALIB Data and Methods

The CALIB used by IIP during this experiment was provided by the Canadian Ice Service and originally procured from METOCEAN. On May 5, 2003 (during Ice Reconnaissance Detachment #7), CALIB #11247 was deployed onto an iceberg measuring approximately 250 m x 100 m in position 46.873°N/47.927°E (see photo collage on front cover and Figure 1). The beacon was deployed from an altitude of 350 feet at approximately 150 knots indicated air speed from the cargo ramp of a Coast Guard HC-130H. Data was gathered via the ARGOS system until 18 May at which time the CALIB stopped transmitting for unknown reasons. Presumably, the CALIB was lost to the ocean when the iceberg broke apart or rolled as it deteriorated.

Thirteen days of position data were gathered consisting of 110 individual position fixes (Figure 1). Each fix was placed in a confidence level category by ARGOS based on position fix quality. ARGOS uses a fix quality of one through three with three designating the highest level of confidence. For the comparison experiments conducted here, only the 57 highest quality fixes (fix category 3) were used.

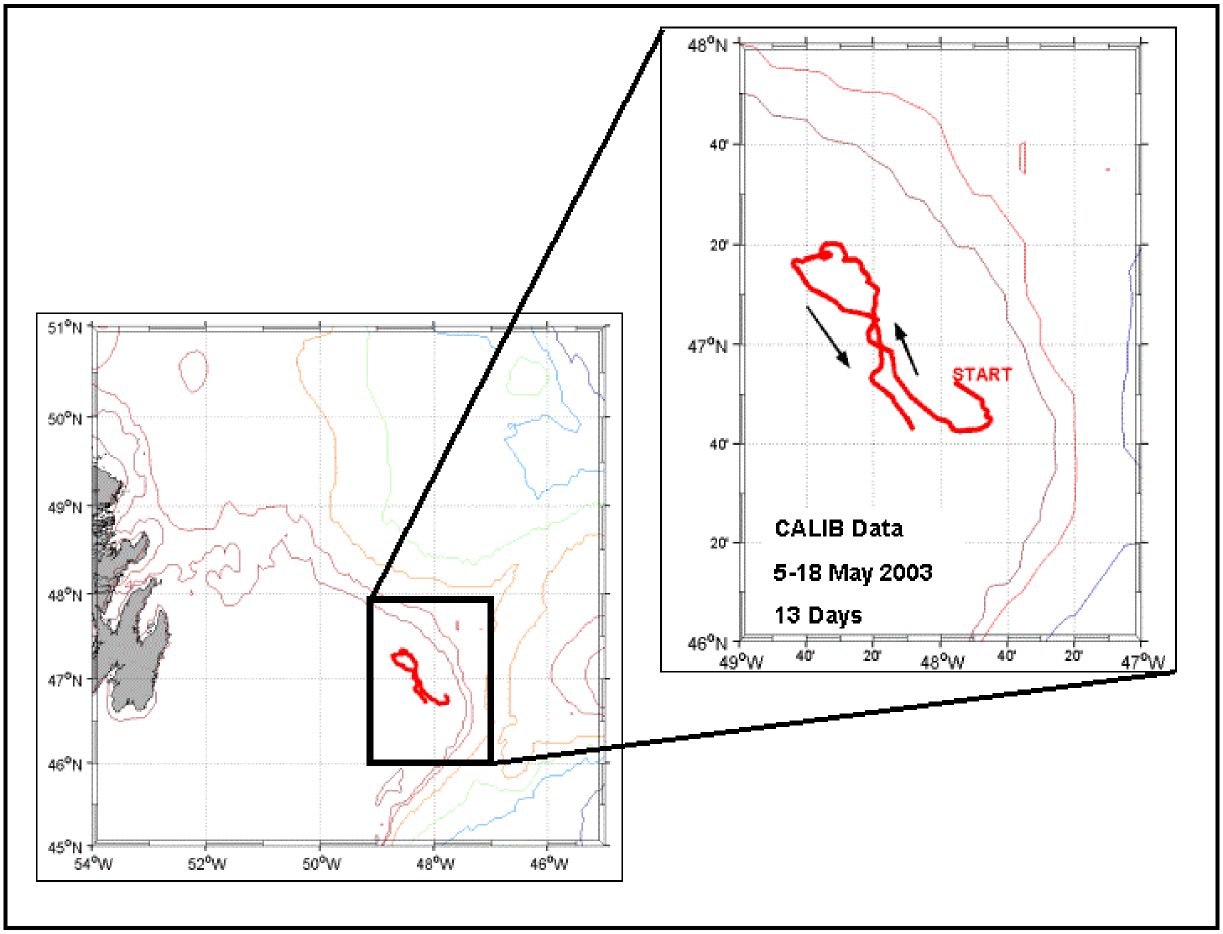


Figure 1. CALIB track.

Comparison Methods

BAPS is not truly intended to accurately model Ice Island shaped icebergs as they are rare and represent a small fraction of the icebergs seen in the Grand Banks region. Additionally, the above water height of Ice Islands is less than archetypical tabular icebergs which have significantly higher freeboards as well as deeper drafts. Subsequently, the comparisons attempted here were done with limited hope of high levels of correlation even when a very large, tabular iceberg was modeled. Therefore, in order to test the model, many permutations were attempted throughout this analysis. Table 1 details the tests performed. Basically, different iceberg shapes and sizes were modeled using the What-If functionality of BAPS. What-If model runs permit the user to alter virtually all of the model's parameters including iceberg size/shape, environmental forcing data fields and model timeframes. In the case of this experiment, What-Ifs were run using a 72-hour sliding window for each size/shape-forcing combination (Table 1). The 72-hour window was used in order to avoid any errors associated with longer model runs but still maintain a time frame allowing for response to changes in local forcing. The 72-hour window provided for 13 individual model runs per model permutation. The chosen sizes and shapes were based on the size and shape of the actual iceberg and a hypothesis that a growler might present a good representation (in the model) of real-world Ice Island drift. There were no modifications made to the environmental forcing data except that, for certain permutations, a particular forcing was switched off in order to determine the effect of wind or current alone.

Iceberg Size	Shape	Wind and Current	Wind Only	Current Only
Very Large	Tabular	X	X	X
	Non-tabular	X	X	X
Growler	N/A	X	X	X

Table 1. What-If model permutations conducted during this project.

Results

In general, the final positions of the What-If modeled icebergs were within 20 nautical miles (NM) of the true position of the tracked Ice Island. The 20 NM threshold is interesting because it represents the error circle radius presently used by Ice Patrol for an iceberg that has been in the model for 3 days. From that perspective, it can be stated that the model is a reasonable representation of the real ocean for the area being considered (on the Bank, away from more complex regions near the tail). Operationally, this result provides IIP with good support for the model error estimates currently employed in the system.

Counter-intuitively, the modeled very large tabular iceberg did not behave most like the tracked Ice Island. The very large tabular was greatly affected by current and to a lesser degree by the wind. In the case of the very large tabular drifted with wind and currents, the modeled iceberg was only within 20 NM of the actual position following 42% of the model runs. When the same iceberg was drifted with winds only, it was within 20 NM after 52% of the runs. Examples of the model results for the very large are presented in Figure 2.

The growler modeled with no currents provided the most accurate representation of actual Ice Island drift. Following 92% of the model runs, the wind-driven growler was within 20 NM of the Ice Island's actual position. With currents and wind however, the resultant growler was only 42% accurate.

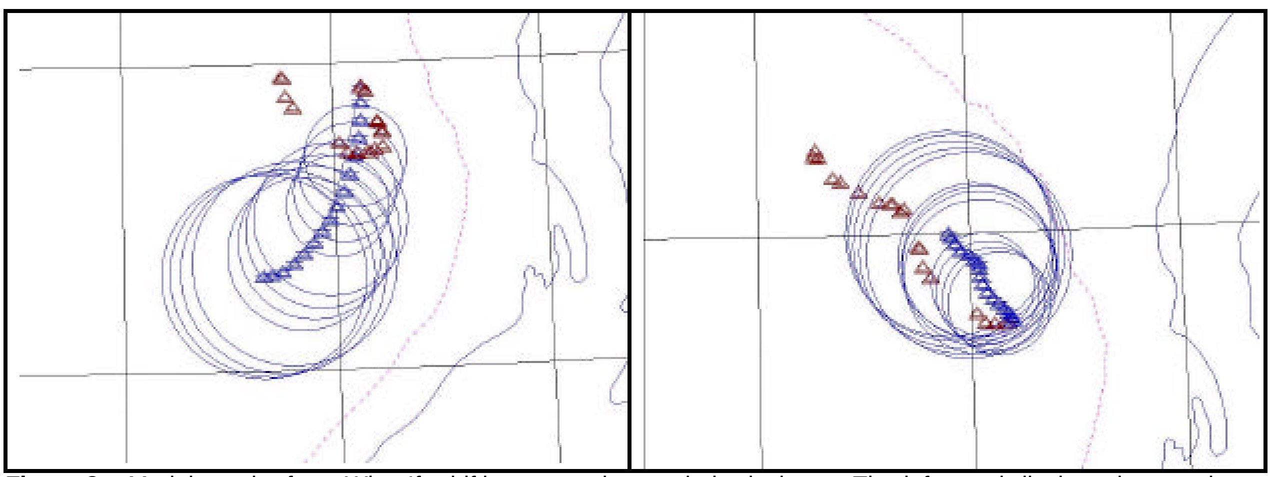


Figure 2. Model results from What-Ifs drifting a very large tabular iceberg. The left panel displays the very large drifted with winds and currents and the right displays drift with winds only. The blue symbols represent the modeled iceberg while the brown represents actual Ice Island position. Note the growth of the error circle as time in the model elapses from 1 day to 3 days (5 NM, 10 NM, 20 NM).

Figure 3 presents some examples of What-If/growler results. While not surprising, this result is a nice confirmation of the general assumption that Ice Island drift will tend to be dominated by wind effects because of their relatively shallow draft.

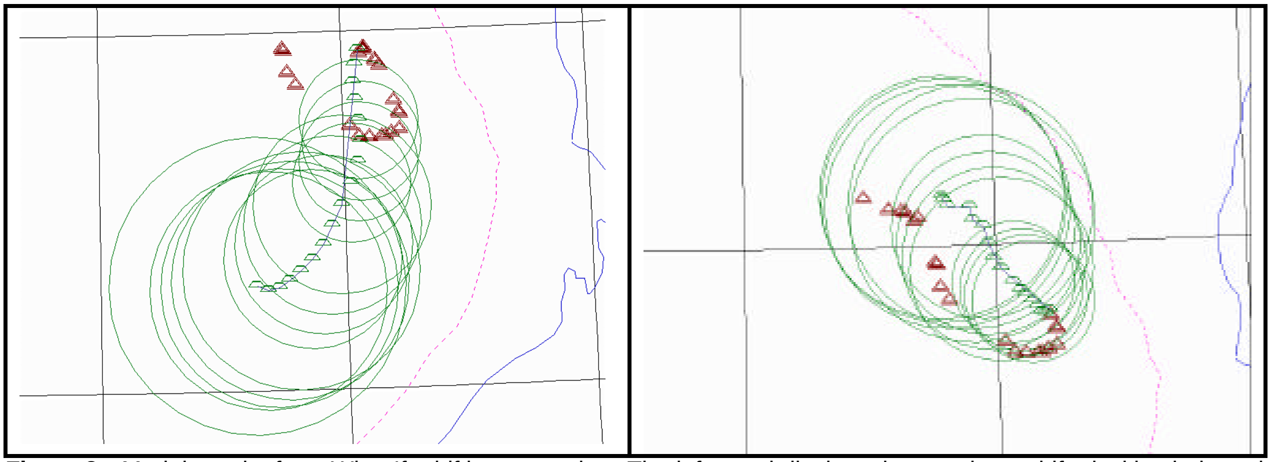


Figure 3. Model results from What-Ifs drifting a growler. The left panel displays the very large drifted with winds and currents and the right displays drift with winds only. The green symbols represents the modeled iceberg while the brown represents actual Ice Island position. Note the growth of the error circle as time in the model elapses from 1 day to 3 days (5 NM, 10 NM, 20 NM).

Conclusion

The accuracy of BAPS modeled iceberg drift was analyzed through the use of multiple What-If model runs drifting various icebergs. The modeled growler forced by winds alone best represented actual Ice Island drift. Additionally, it is of note that a large portion of the modeled results were within IIP's 20 NM (radius) error circle for three-day-old icebergs. This fact lends credence to the present error circle defaults used within BAPS.

While this experiment is a good first attempt at producing some data for model ground-truthing, it is not ideal given the drift characteristics of Ice Islands. For greater applicability, it would be more ideal to track icebergs that are both more populous on the Grand Banks as well as ones that BAPS is more suited to model. IIP has procured additional CALIBs for possible use during the 2004 season and will attempt to place them on other, more typical targets.

Historical Background

Iceberg Marking and Tracking

The need to track the drift of icebergs in the vicinity of the Grand Banks of Newfoundland has existed for many years. IIP has transitioned from the most rudimentary method of iceberg tracking to some of the most advanced during its 90+ year lifespan. Initially, the ships assigned to Ice Patrol drifted with the southern most iceberg(s) and reported their position, via radio, to warn shipping interests in the area. Currently, the Ice Patrol is able to monitor the position of icebergs with satellite positioning technology. Within the spectrum from drift tracking to satellite data, the Coast Guard has tried some interesting methods.

The vessels of the Ice Patrol, each year, would search for icebergs, drift, and report positions. As radio and navigation aid technology grew, ship-based reconnaissance data was used to generate radio and text ice warnings. As reconnaissance ability grew with the application of shipboard RADAR systems, the need to identify individual icebergs became necessary. Iceberg marking with dye became a common procedure to facilitate consecutive identification of icebergs and allow data on iceberg drift data to be collected (Figure 4). When the primary reconnaissance tool shifted from surface to airborne assets, iceberg marking remained an important facet of the scientific benefit of the North Atlantic Ice Service (Figure 5).

Figure 4. Ship-based iceberg marking. (Coast Guard Photograph)

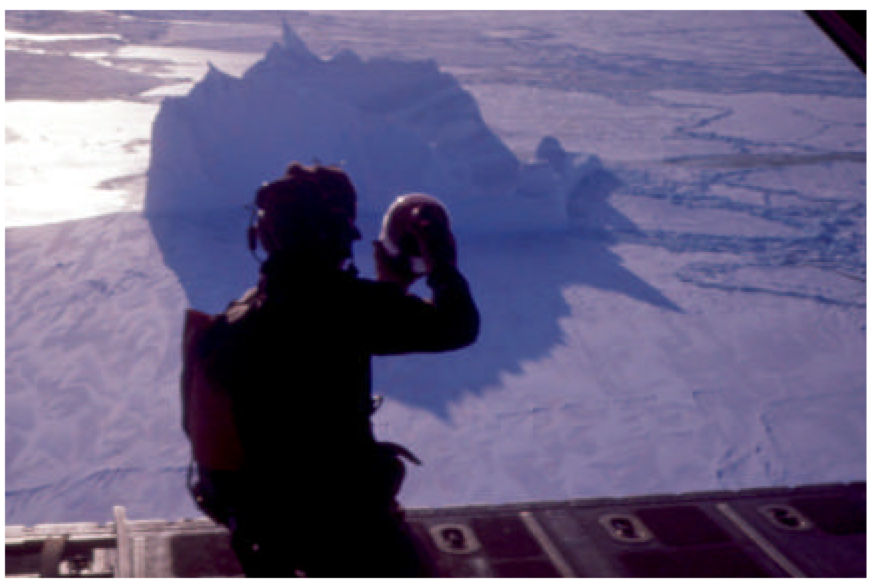


Figure 5. Air-deploy of iceberg marking dye from Coast Guard HC-130 aircraft. (Coast Guard Photograph)

The scientific data available for iceberg tracking was further increased by remote positioning technology currently including satellite positioning and communications technology. The CALIB provides position data, via the Global Positioning System, and communicates its position up to six times per day to a data collection system.

Ice Islands

The International Ice Patrol has monitored icebergs that drift south along the coast of Labrador and into the Grand Banks of Newfoundland region since the sinking of the TITANIC in April of 1912. The LC carries the icebergs that calve, or break away, from glaciers in Greenland and northern Canada southward from Baffin Bay and Davis Strait. Several glaciers are capable of producing icebergs that end their journey on the Grand Banks. Specifically, the Ward Hunt ice shelf, the Humboldt Glacier, and the Petermann Glacier are likely sources of Ice Islands, as the basin conditions seem to favor the production of large tabular icebergs with shallow draft (Robe, 1977).

As defined by Bowditch, an Ice Island is a piece of glacial ice that rises roughly 10 meters above the ocean's surface and has an overall thickness of about 50 meters. Often, Ice Islands will have a wave-like surface, appearing ribbed from the air. The surface area of an Ice Island can range from a few thousand square meters to hundreds of square nautical miles. Thusly, Ice Islands are not necessarily huge, in terms of surface area, but are unusually thin and flat-topped.

The detection and identification of Ice Islands has occurred during the last two years in the region of the Grand Banks of Newfoundland. Ice Islands that drift into the Grand Banks region potentially pose a greater threat to shipping and the oil and gas industry than other icebergs. The relatively thin drafts of Ice Islands allow them to drift into much shallower water than an iceberg of similar mass but non-tabular shape.

The tabletops of Ice Islands present an excellent target for tags and other tracking devices. The Canadian Ice Service has been using CALIBs to track very large icebergs and the ice sheet in the northern reaches of the Labrador Sea for many years (Desjardins, personal communication). During the 2003 ice season, IIP decided to attempt marking and tracking an iceberg for the purposes of gathering data such that model testing could be done after the fact. Additionally, since the skill set of actually hitting an iceberg with a tracking or marking device was last employed in the 1980's, the successful tagging discussed here is a nice confirmation that IIP can still deploy instruments with the necessary precision.

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