U.S. Department of Transportation

United States Coast Guard

Report of the International Ice Patrol in the North Atlantic

Edward "Iceberg" Smith
Oct. 29, 1889 - Oct. 29, 1961

2001 Season
Bulletin No. 87
CG-188-56

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REPORT OF THE INTERNATIONAL ICE PATROL IN THE NORTH ATLANTIC

Season of 2001

CG-188-56

Forwarded herewith is Bulletin No. 87 of the International Ice Patrol, describing the Patrol's services, ice observations and conditions during the 2001 season. While hundreds of icebergs once again made their annual sojourn south, 2001 turned out to be an "inshore year" with much of the iceberg population remaining close to the coast of Labrador and Newfoundland. The low number (fewer than 90) of icebergs reaching the primary transatlantic shipping lanes despite the large total population once again served to reinforce the challenges of monitoring and predicting iceberg drift and deterioration in the unpredictable weather conditions and dynamic ocean currents that influence the Grand Banks region of the North Atlantic.

This year's report also contains an excerpt (Appendix C) from the Safety of Life at Sea (SOLAS) convention outlining the rules for management, operation and financing of the Ice Patrol. Several significant changes go into effect beginning with the 2002 ice season including a requirement making use of the Ice Patrol's services mandatory--***"Ships transiting the region of icebergs guarded by the Ice Patrol during the ice season are required to make use of the services provided by the Ice Patrol**."*

We have chosen a photo of Rear Admiral Edward "*Iceberg*" Smith, U. S. Coast Guard (a Lieutenant Commander at the time of the photo), to adorn the cover of this year's report. While 40 years have passed since Rear Admiral Smith died on his birthday, Sunday October 29, 1961, his pioneering oceanographic work with the International Ice Patrol remains the foundation for the Patrol's operations and successes today. I take great pleasure in this opportunity to honor Iceberg Smith for he is a long time personal hero. He truly embodied the persona of *Lifesaver, Guardian, and Warrior* that is the heritage, essence, and strength of the U. S. Coast Guard. Appendix D contains additional information on Rear Admiral Smith's long and distinguished U. S. Coast Guard career and his many accomplishments both with the International Ice Patrol and later as Director of the Woods Hole Oceanographic Institution. I hope you will take time to learn more about this important figure in International Ice Patrol history.

R. L. DESH
Commander, U. S. Coast Guard
Commander, International Ice Patrol

International Ice Patrol
2001 Annual Report

Contents

List of Abbreviations and Acronyms

AXBT	Air-deployed eXpendable BathyThermograph
BAPS	iceBerg Analysis and Prediction System
CAMSLANT	Communications Area Master Station Atlantic
CCGS	Canadian Coast Guard Ship
CIS	Canadian Ice Service
DFO	Department of Fisheries and Oceans
FLAR	Forward-Looking Airborne Radar
GPS	Global Positioning System
HMCS	Her Majesty's Canadian Ship
IGOSS	Integrated Global Ocean Services System
IIP	International Ice Patrol
IMO	International Maritime Organization
INMARSAT	International Maritime Satellite
IRD	Ice Reconnaissance Detachment
IRI	International Research Institute
KT	Knots (nautical miles per hour)
LAKI	Limit of All Known Ice
LAN	Local Area Network
LDEO	Lamont-Doherty Earth Observatory
M/V	Motor Vessel
MSS	Maritime Surveillance System
NAO	North Atlantic Oscillation
NIC	National Ice Center
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
PRF	Pulse Repetition Frequency
RADAR	Radio Detection And Ranging (also Radar, radar)
RMS	Royal Mail Steamer
SDP	Sensor Data Processor
SOLAS	Safety of Life at Sea
SLAR	Side-Looking Airborne Radar
SSC	Swedish Space Corporation
SST	Sea Surface Temperature
USCG	United States Coast Guard
USS	United States Ship
WOCE	World Ocean Circulation Experiment

Introduction

This is the 87th annual report of the International Ice Patrol. It contains information on Ice Patrol operations, environmental conditions, and iceberg conditions for the 2001 season in the North Atlantic. Ice Patrol is supported by 17 member nations and conducted by the U. S. Coast Guard. Ice Patrol 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. Ice Patrol 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, U. S. 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 2001 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 John E. Shkor was Commander, U. S. Coast Guard Atlantic Area through 27 June 2001 when he was relieved by Vice Admiral Thad W. Allen. CDR Robert L. Desh was Commander, International Ice Patrol.

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

IIP actively monitored iceberg danger during 2001 within the area bounded by 40°N, 52°N, 39°W and 57°W (Figure 1). IIP's pre-season Ice Reconnaissance Detachment departed on 27 January 2001. IIP opened the ice season on 29 March 2001. Regular IRDs operated from Newfoundland from early March through 13 June 2001. IIP closed the season on 29 June 2001.

IIP's Operations Center in Groton, Connecticut analyzed 930 information reports from IRDs, merchant ships, Canadian Ice Service iceberg and sea ice reconnaissance flights, the National Ice Center, and other sources during the ice season (Figure 2). Of these reports, 238 contained ice information (Figure 3). These ice reports contained 1,085 reported targets, of which 584 individual targets were merged into IIP's iceBerg Analysis and Prediction System model (Figure 4).

Merchant shipping provided the vast majority of reports received by IIP. In 2001, approximately 100 ships from 31 different nations provided IIP with 721 reports or 78% of total reports (Figure 2). This demonstrates that the number of nations using IIP services far exceeds the 17 member nations supporting IIP under SOLAS. Furthermore, the merchant industry's continued active participation indicates the value placed on IIP's services. Appendix B lists the ships that provided information reports, including ice, "no ice," stationary radar targets, and sea surface temperature reports. In Appendix B, a single report may contain multiple targets. In 2001, the merchant vessel that provided the most reports was M/V *Berge Nord*, submitting 77 separate reports. Though not all of the 721 information

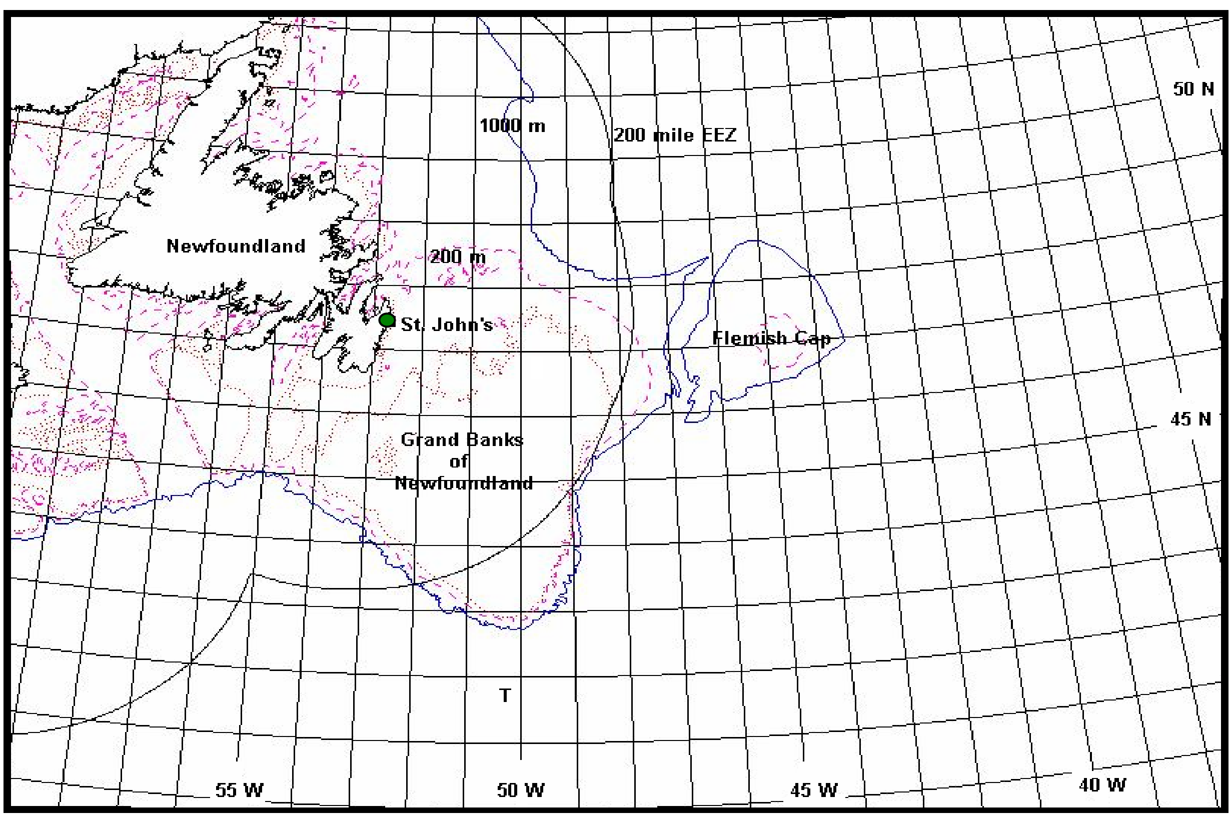


Figure 1. IIP's operating area. 'T' indicates location of TITANIC sinking.

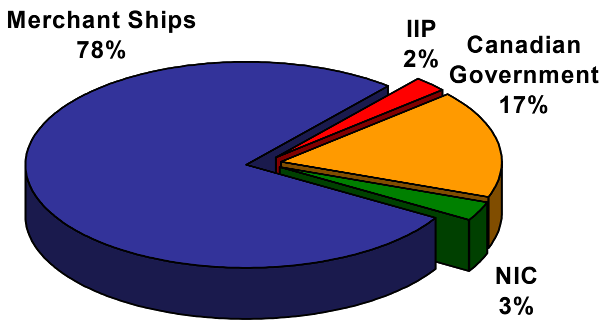


Figure 2. Sources of reports received in 2001, including ice, "no ice," and SST reports.

reports submitted by merchant vessels contained ice information, those that did (55 ice reports) still constituted 23% of the ice reports received by IIP (Figure 3).

The Canadian Government provided the next highest number of reports with 17% of total reports and 56% of the ice reports received by IIP (Figures 2, 3). The Canadian Government category encompasses reporting from the CIS reconnaissance airplane, contract reconnaissance flights by Provincial Airlines, HMCS vessels at sea, and coastal lighthouses (Table 1). CIS conducts ice reconnaissance using a SLAR-equipped Dash-7 airplane, focusing primarily on sea ice. Provincial Airlines is a private company that provides 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 monitor fishing vessel activity, frequently carrying them into areas of high iceberg concentrations.

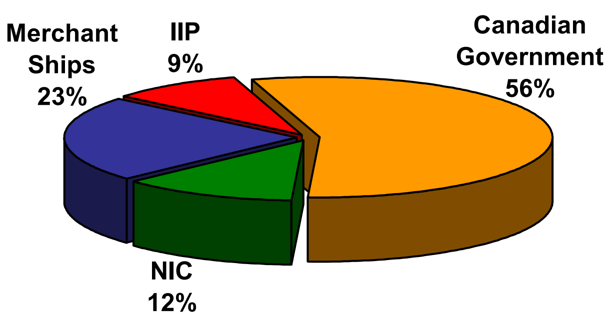


Figure 3. Sources of ice reports received in 2001.

Lighthouse	Ice Reports
Baccalieu	12
Cape Bonavista	8
Green Island	1
Puffin Island	29
Surgeons Cove	3
Twillingate	30
Total	**83**

Table 1. Newfoundland lighthouse reports.

The reporting source that was responsible for the most targets being merged into IIP's BAPS model was from BAPS transferred targets. During the 2001 ice season, 46% of the targets in IIP's model came from BAPS transfers. These targets are those that are originally sighted north of 52°N and are passed on to IIP's model when they cross this line between IIP's area of responsibility and that of the Canadian Ice Service. The configuration of the BAPS model makes determining the original sources for targets of this type extremely cumbersome. Consequently, no attempt is made to determine the original sighting source of targets transferred to IIP in this manner. Therefore, although the BAPS category accounted for 46% of merged targets, it did not represent any reports submitted to IIP.

The source with the second most targets merged into IIP's BAPS model was the Canadian Government with 21% (Figure 4). Part of the reason for this is that this category includes the use of aerial reconnaissance to cover a larger area in a shorter time. As a result, these reports usually contain multiple targets within the same report in comparison to ships that report fewer, if any, targets per report. Ships, which accounted for 23% of ice reports, provided 14% of merged targets (Figures 3, 4). Finally, the National Ice Center and IIP accounted for 10% and 9% of targets merged into the BAPS model, respectively. The continued success and viability of the International Ice Patrol

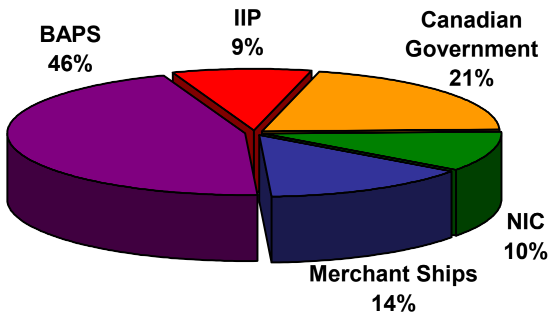


Figure 4. Sources of targets merged into BAPS model in 2001.

depends heavily upon all contributors of ice reports.

During the 2001 season, IIP flew 29 reconnaissance flights. Because IIP is mandated to determine the limit of all known ice, IIP generally flies well offshore in the vicinity of the 1000-m bathymetric contour (Figure 1). The different areas covered by Canadian flights and IIP flights combine to form a complementary system that achieves good coverage of the entire Grand Banks area. This system allows for more comprehensive and efficient coverage than either organization could achieve separately. As a result of the focused reconnaissance, IIP detected 36% of LAKI icebergs (Figure 5). 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 source of 17% of LAKI icebergs and NIC reported another 13%. The BAPS model transfers between IIP and the Canadian Ice Service accounted for 30% of LAKI icebergs.

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 48°N but were later predicted to have drifted 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. Additionally, the total number of targets merged into the BAPS model is not used because IIP does not necessarily merge all reported targets. Sightings of targets outside IIP's area of responsibility and coastal icebergs are usually not merged as they represent little threat to transatlantic shipping. Thus, the total number of merged targets is not necessarily an objective and unbiased measurement from year to year.

Season length is intertwined with the number of icebergs south of 48°N, as Commander, International Ice Patrol considers the iceberg population when determining when to open and close the season. Various authors have discussed the appropriate measurement for ice season severity (Alfultis, 1987; Trivers, 1994; Marko, *et al*., 1994). Comparing 2001 to the past five years and measuring the statistics against historical standards in various papers, 2001 was light both in terms of season length and the number of icebergs south of 48°N. A light season length is defined as less than 105 days (Trivers, 1994). A light season for icebergs south of 48°N is defined as fewer than 300 icebergs (Trivers, 1994, Marko, *et al.*, 1994).

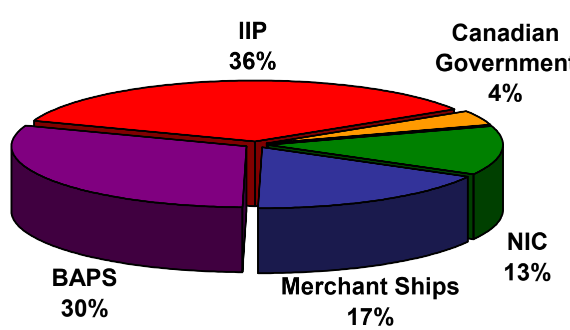


Figure 5. Sources of limit-setting icebergs in 2001.

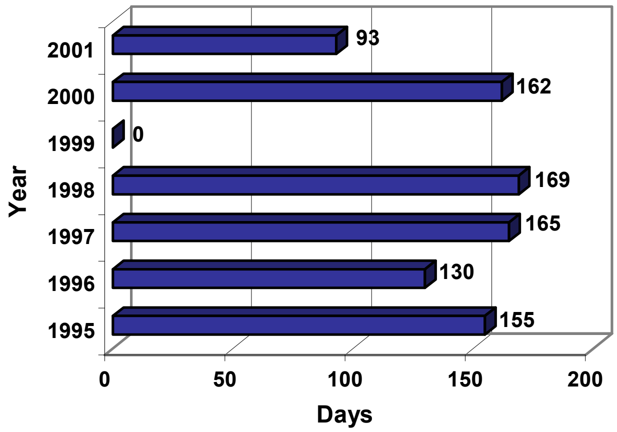


Figure 6. Ice season lengths since 1995.

During the ice season, IIP prepares and distributes ice bulletins at 0000Z and 1200Z daily to warn mariners of the southwestern, southern, and southeastern LAKI. U. S. Coast Guard Communications Area Master Station Atlantic/NMF and Canadian Coast Guard Marine Communications and Traffic Service St. John's/VON are the primary radio stations responsible for the dissemination of ice bulletins. In addition, ice bulletins and safety broadcasts are delivered over the INMARSAT-C SafetyNET via the Atlantic East and West satellites. Another transmitting station for the bulletins is the Marine Communications and Traffic Services St. Anthony/VCM. IIP also prepares an ice chart depicting the 1200Z limit of all known ice for broadcast at 1600Z and 1810Z daily. U. S. Coast

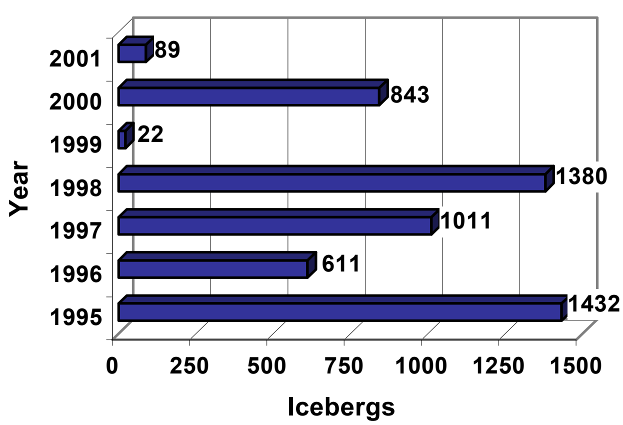


Figure 7. Icebergs south of 48°N since 1995, excluding growlers, bergy bits, and radar targets.

Guard Communications Area Master Station Atlantic/NMF and the National Weather Service assist 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 transmit IIP's ice chart. Finally, both the bulletin and chart are placed on IIP's website.

IIP transmitted 186 scheduled ice bulletins in 2001. IIP measures the quality and timeliness of the bulletins it delivers to the mariner via the SafetyNET service, as this is the primary product for IIP's largest customer base. Of 186 total bulletins sent, 182 (98%) arrived at the system on time, or by 0000Z or 1200Z, respectively. Of the 186 bulletins, 185 (99%) were error free when delivered. The late deliveries were due primarily to minor technical difficulties in sending the product through IIP's commercial INMARSAT provider, and the one erroneous bulletin was due to human error.

IIP also sent 18 safety broadcasts during the 2001 season. IIP sends these special broadcasts whenever late-breaking ice information is received. Of these 18 broadcasts, seven were for icebergs outside the LAKI and resulted in a LAKI change. The remaining 11 were for stationary radar targets and did not result in a LAKI change. Four of the icebergs outside the LAKI were reported by the National Ice Center and three were reported by merchant ships.

In 2001, IIP created 93 ice charts graphically depicting the limit of all known ice. The ice charts were transmitted twice daily for a total of 186 transmissions via radio facsimile. Of these, 177 (95%) were delivered on time. Late ice charts were defined as those for which the radio frequency start tone began more than one minute after 1600Z and 1810Z, the scheduled start times. The primary cause of late transmissions was difficulty getting the signal from IIP through the line to CAMSLANT. In all cases of late transmission, the entire chart was still visible to the mariner; however, due to the late start, a part of the header was cut off.

As in previous years, International Ice Patrol requested that all ships transiting the Grand Banks 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 are encouraged to make ice reports even if "no ice" is sighted. Knowledge of where ice is not found is also very important to IIP. IIP tabulated the number of SST reports received during the 2001 ice season in Table 2.

Source	Number
Ships providing reports	100
Total reports received	721
Ships providing reports with SST	70
Reports received with SST	605

Table 2. Iceberg and SST reports.

References

Alfultis, M. 1987. Iceberg Populations South of 48°N Since 1900. Appendix B in *Report of the International Ice Patrol in the North Atlantic*, 1987 Season, Bulletin No. 73, CG-188-42, 63-67.

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.

Trivers, G., 1994. International Ice Patrol's Iceberg Season Severity. Appendix C in *Report of the International Ice Patrol in the North Atlantic*, 1994 Season, Bulletin No. 80, CG-188-49, 49-59.

Iceberg Reconnaissance & Oceanographic Operations

Reconnaissance 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. The 1992 season, the longest on record, ran for 203 days from 7 March through 26 September. Except during unusually heavy ice years, the Grand Banks of Newfoundland are normally iceberg free from August through January.

IIP utilizes a U. S. Coast Guard C-130 long-range aircraft equipped with a Motorola AN/APS-135 Side-Looking Airborne Radar and a Texas Instruments AN/APS-137 Forward-Looking Airborne Radar to conduct iceberg reconnaissance. Reconnaissance flights are made on the average of five days every other week during the ice season. U. S. Coast Guard aircraft are the primary means of detecting icebergs that form the limit of all known ice. When iceberg reconnaissance is not being conducted, IIP relies on computer modeling to predict iceberg drift and deterioration and determine the LAKI.

The Ice Reconnaissance Detachment is a sub-unit under Commander, International Ice Patrol with U. S. Coast Guard Air Station Elizabeth City providing the aircraft platform. The IRD is deployed to observe and report ice and oceanographic conditions on the Grand Banks of Newfoundland. Oceanographic observations are used for operational and research purposes.

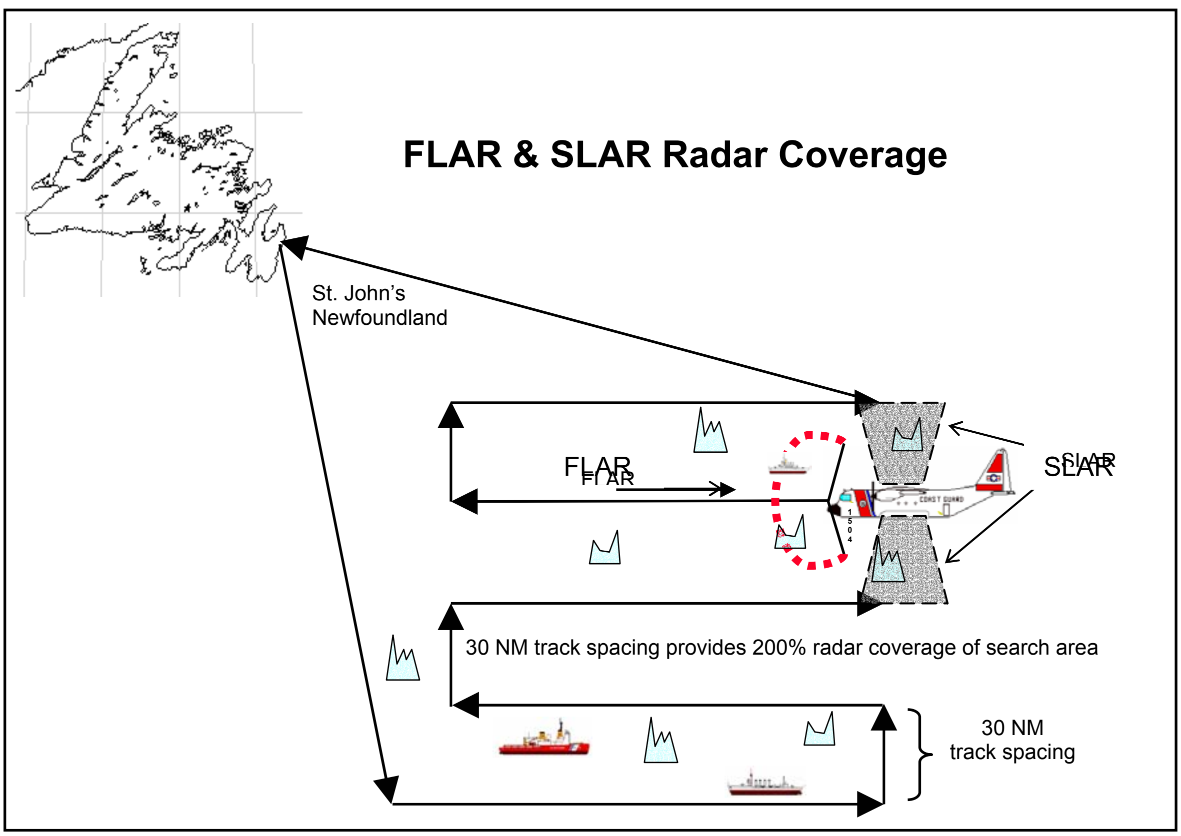


Figure 8. Radar reconnaissance plan.

Environmental conditions on the Grand Banks allow adequate visibility only 30% of the time during iceberg reconnaissance operations. Therefore, IIP relies heavily on its two airborne radar systems to detect and identify icebergs through cloudy and foggy conditions. IIP has used SLAR since 1983 and FLAR since 1993. The combination of SLAR and FLAR to detect and identify icebergs in pervasive low visibility conditions minimizes the flight hours required to accurately determine the LAKI. The radar combination allows IIP to use 30 NM track spacing. The C-130 with SLAR and FLAR covers 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 reconnaissance strategy is provided at http://www.uscg.mil/lantarea/iip/FAQ/faq25.html.

An IRD was deployed to IIP's base of operations in St. John's, Newfoundland for 83 days during the 2001 ice season (Table 3). IIP scheduled airborne reconnaissance every other week. IIP flew 58 sorties, 23 of which were transit flights to and from St. John's. 29 sorties were iceberg reconnaissance patrols to determine the southwestern, southern and southeastern LAKI. Three of the 29 patrol sorties were operational evaluations of the Maritime Surveillance System 5000, a new digital display system for SLAR (see Appendix E). No research sorties were flown in 2001. Six sorties were logistics flights from U. S. Coast Guard Air Station Elizabeth City to maintain and repair the aircraft. Figure 9 displays associated IIP flight hours for 2001.

IIP used 324.5 flight hours in 2001, a 56% decrease from 2000 (Figure 10).

IRD	Days Deployed	Patrol Sorties	Flight Hours
Pre	7	2	21.9
1	9	5	36.8
2	7	3	28.4
3	7	1	17.2
4	9	5	37.7
5	10	4	42.4
6	16	4	58.1
7	6	1	18.4
8	8	4	32.1
Post	4	0	11.9
Total	**83**	**29**	**324.5**

Table 3. 2001 IRD summary.
Note: 19.6 hours were funded by U. S. Coast Guard Atlantic Area for operational evaluation of MSS 5000.

This decrease was due to a light ice season in 2001 compared to a moderate ice season in 2000. Figure 11 compares flight hours with the number of icebergs south of 48°N latitude since 1987. This figure demonstrates that IIP expends a fairly consistent number of flight hours but the number of icebergs varies significantly. A few icebergs can extend the geographic distribution of the LAKI even with a low 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.

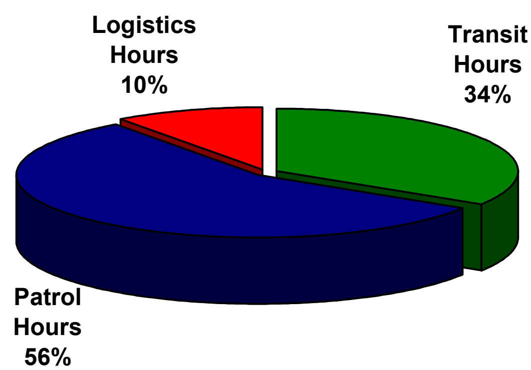


Figure 9. 2001 flight hours.

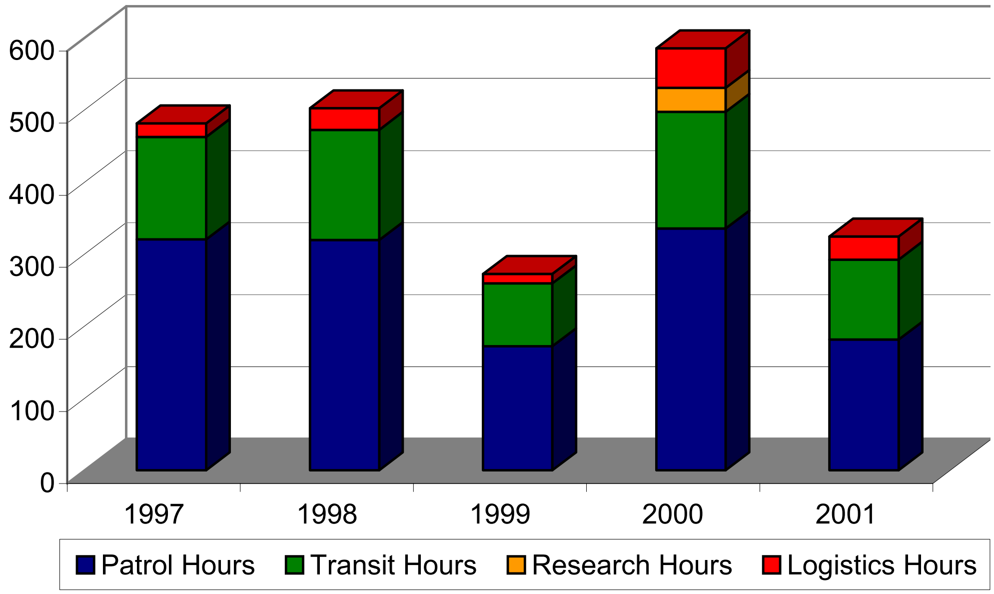


Figure 10. Breakdown of flight hours (1997-2001).

Differentiating among 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 clues about the identity of targets. However, in most cases, FLAR's superior imaging capability provides definitive target identification. Figure 12 displays the numbers and types of targets detected by reconnaissance patrols during the 2001 season. Of 98 icebergs detected, 57% were detected and identified with radar only, demonstrating IIP's reliance on radar identification. However, 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, the target is classified as a radar target.

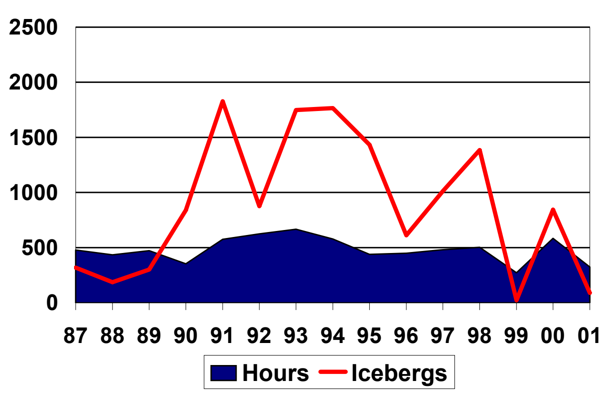


Figure 11. Flight hours versus icebergs south of 48°N.

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. This emphasizes the need to pursue technological innovations in reconnaissance equipment and strategy.

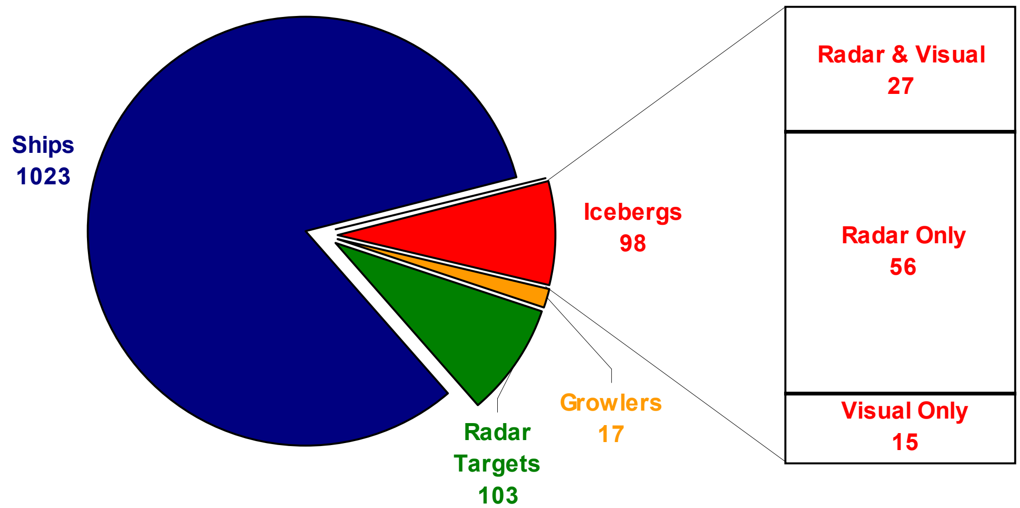


Figure 12. Breakdown of targets detected by IRD in 2001.

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 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 collects oceanographic data with air or ship-deployed satellite-tracked drifting buoys and air-deployed expendable bathythermograph probes. AXBT probes are dropped to determine the water temperature profile. This information helps IIP determine the location of the Labrador Current, validate temperatures from satellite-tracked drifting buoys, and obtain precise SST measurements for numerical models. During the 2001 season IIP dropped 76 AXBT probes. Data was collected from 66 of the AXBT drops, a failure rate of 13%. Figure 13 shows the development of IIP's AXBT program since 1999. IIP awarded a contract in 1999 to replace the AXBT receiver with a more reliable system. The new system was tested and used operationally during the 2000 and 2001 seasons. Experience with the new system continues to reduce failures.

AXBT information is coded into a standard format and shared with the Canadian Maritime Atlantic Command Meteorological and Oceanographic Center, IIP's supplier of AXBT probes. Data is also sent to the U. S. Naval Fleet Numerical Oceanographic and Meteorological Center

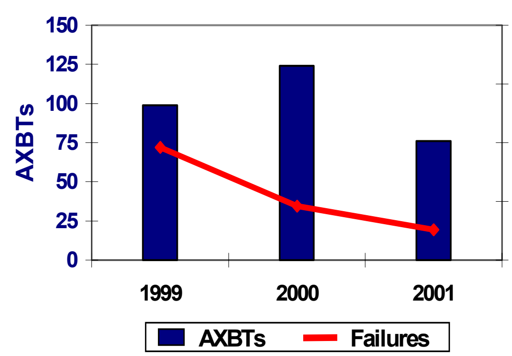
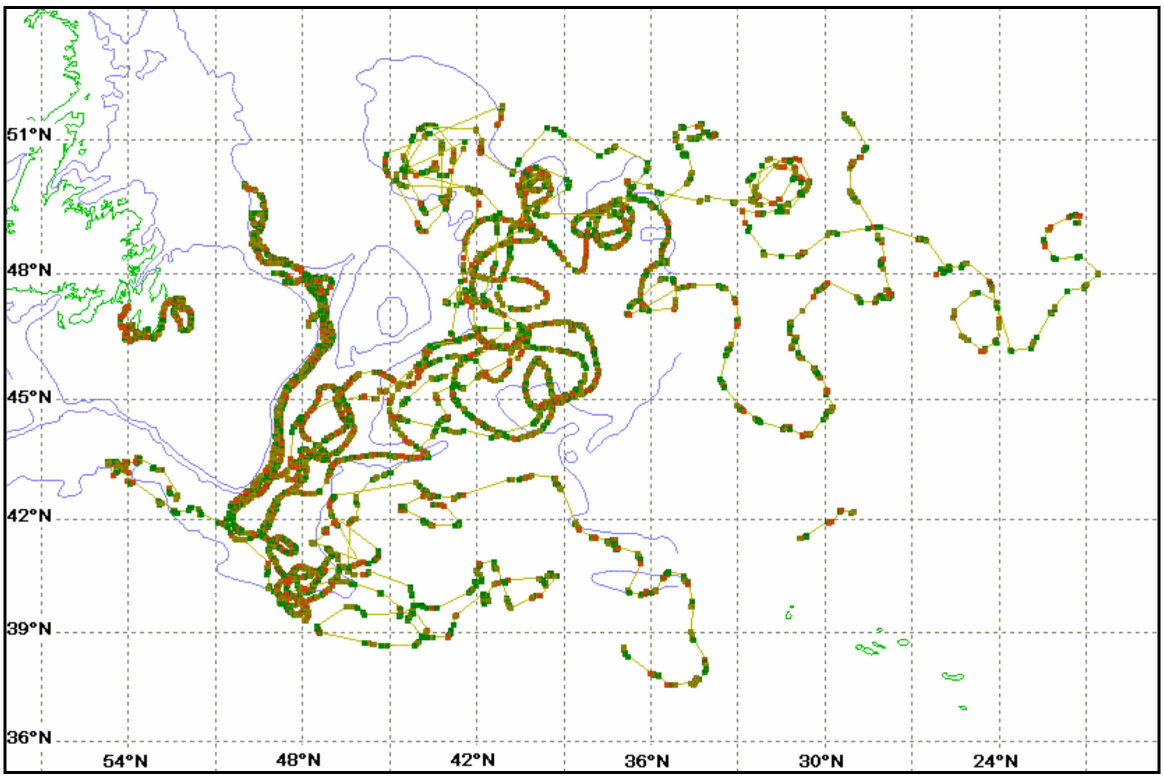


Figure 13. AXBT drops and failure rate (1999-2001).

where it is quality controlled and redistributed via oceanographic products.

The satellite-tracked drifting buoys, popularly known as WOCE buoys, are drogued at a depth of either 15 or 50 meters and provide valuable current information. The historical current database used by IIP's computer model is modified weekly using the current information from the drifting buoys.

During the 2001 season, IIP deployed seven satellite-tracked drifting buoys, three from reconnaissance aircraft, and four from volunteer ships. Figure 14 shows composite drift tracks for the buoys deployed in 2001. No buoy recoveries were planned or attempted. Detailed drifter information is provided in IIP's 2001 WOCE Buoy Drift Track Atlas that is available from IIP upon request.



Ice and Environmental Conditions

Introduction

By any measure, the International Ice Patrol's 2001 ice year was light, with only 89 icebergs estimated to have passed south of 48°N and a 93-day season length. This section describes evolution of the 2001 iceberg season and the environmental conditions it accompanied.

The IIP ice year extends from October through September. The following month-by-month narrative of the progress of the 2001 ice season begins as sea ice began forming along the Labrador coast in early December 2000, and concludes in early July 2001 as the last remnants of the sea ice left the Labrador coast. The narrative draws from several sources, including the Seasonal Summary for Eastern Canadian Waters, Winter 2000-2001 (Canadian Ice Service, 2001a); sea ice analyses provided by the Canadian Ice Service and the National Ice Center; and the Integrated Global Ocean Services System Products sea surface temperature anomaly (IRI/LDEO Climate Data Library, 2001); and, finally, summaries of the iceberg data collected by Ice Patrol and CIS. Monthly maps of the sea ice distribution are shown on pages 23 to 28. Pages 30 to 36 document the limit of all known ice twice a month for the duration of the season.

Comparing the 2000-2001 sea ice and iceberg observations to the historical record emphasizes the departures from normal and gives a greater appreciation for the variability of the ice distribution in the western North Atlantic. For sea ice, Sea Ice Climatic Atlas, East Coast of Canada, 1971-2000 (Canadian Ice Service, 2001b) provides a 30-year median of ice concentration at seven-day intervals for the period from November 26 through July 16. Viekman and Baumer (1995) present an iceberg limits 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 limit of all known ice for the period. Finally, the average number of icebergs estimated to have drifted south of 48°N for each month was calculated using 101 years (1900 through 2000) of IIP records.

The pre-season sea ice forecast (Canadian Ice Service, 2000), which was issued in early December, predicted:

- one week later than normal freeze-up along the Labrador coast and in east Newfoundland waters,
- movement of the ice edge into the Strait of Belle Isle during the first week of January 2001,
- sea ice reaching Cape Bonavista during the first week of February ,
- maximum extent of the sea ice in mid-March, with the ice edge slightly farther north than normal, and
- normal retreat of the southern ice edge in the spring.

December 2000

Much warmer than normal air temperatures along the Labrador coast during the second half of December 2000 delayed freeze-up along the coast and in the Strait of Belle Isle by two weeks. At month's end the Strait of Belle Isle was mostly free of sea ice, with only patchy sea ice along the north side of the Strait.

December set the stage for what was to become an extraordinary winter in southern Newfoundland, particularly in St. John's, which was on the threshold of the snowiest winter in its history. A well-defined negative phase of the North Atlantic Oscillation was in place with the attendant southward displacement of the North Atlantic storm track (Wagner, 2001). During the second half of the month, a series of strong storms passed over Newfoundland, bringing high winds and record December snowfall amounts to St. John's. Newfoundland's air temperatures for the month of December averaged about 2°C above normal. Along Newfoundland's Northern Peninsula, much warmer than normal air temperatures and storm-force winds delayed freeze-up by two weeks.

January 2001

The North Atlantic storm track remained far south of its normal position in January, which caused a series of storms to pass just south of the Avalon Peninsula. Despite prevailing moderate northwesterly winds and air temperatures that averaged about 1°C colder than normal in Newfoundland, conditions that generally favor sea ice expansion, it grew slowly. The strong wind associated with the storms was the limiting factor in the expansion of the sea ice extent. Thus, by month's end, the ice growth was about two weeks slower than normal.

On 20 January, a CIS reconnaissance flight found 13 visually confirmed icebergs and nine radar targets in the sea ice along the Labrador coast north of 55°N. During the last week of January, Ice Patrol deployed its pre-season Ice Reconnaissance Detachment to Canada. The intent of the IRD was to monitor the progress of the icebergs toward the Grand Banks to help determine the start date for the season and to test IIP's new SLAR display system (MSS 5000). Two survey patrols (28 and 30 January) located 20 icebergs south of Cape Chidley, the southernmost of which was at 50°-10'N and 51°-21'W. Thus, based on very limited aerial ice reconnaissance, the January population of icebergs appeared sparse. No icebergs passed south of 48°N during the month.

February

The weather in Newfoundland was again dominated by a series of storms that passed through the province. Although mean air temperatures for the month were approximately normal, with mean west and northwest winds, the stormy conditions continued to slow the expansion of the ice edge. During the first week of the month, the southern sea ice edge reached Cape Freels. By mid-month the ice edge was not as far south as normal nor as far east, reaching the vicinity of Cape Bonavista during the third week of February, about two weeks later than normal. By the end of the month, the southern sea ice extent was well less than normal. During the last week of the month the eastern ice edge began a dramatic retreat westward.

A series of reconnaissance flights, conducted in good visibility conditions by CIS and Provincial Airlines in mid-February, documented a sparse population of icebergs in the sea ice along the southern Labrador coast and in northeast Newfoundland waters (Figure 15). International Ice Patrol deployed its first Ice Reconnaissance Detachment on 28 February 2001.

On 26 February, the easternmost observed iceberg for the 2001 ice year was reported by the National Ice Center at 48°-08.4'N and 46°-15'W. The easternmost predicted iceberg position for

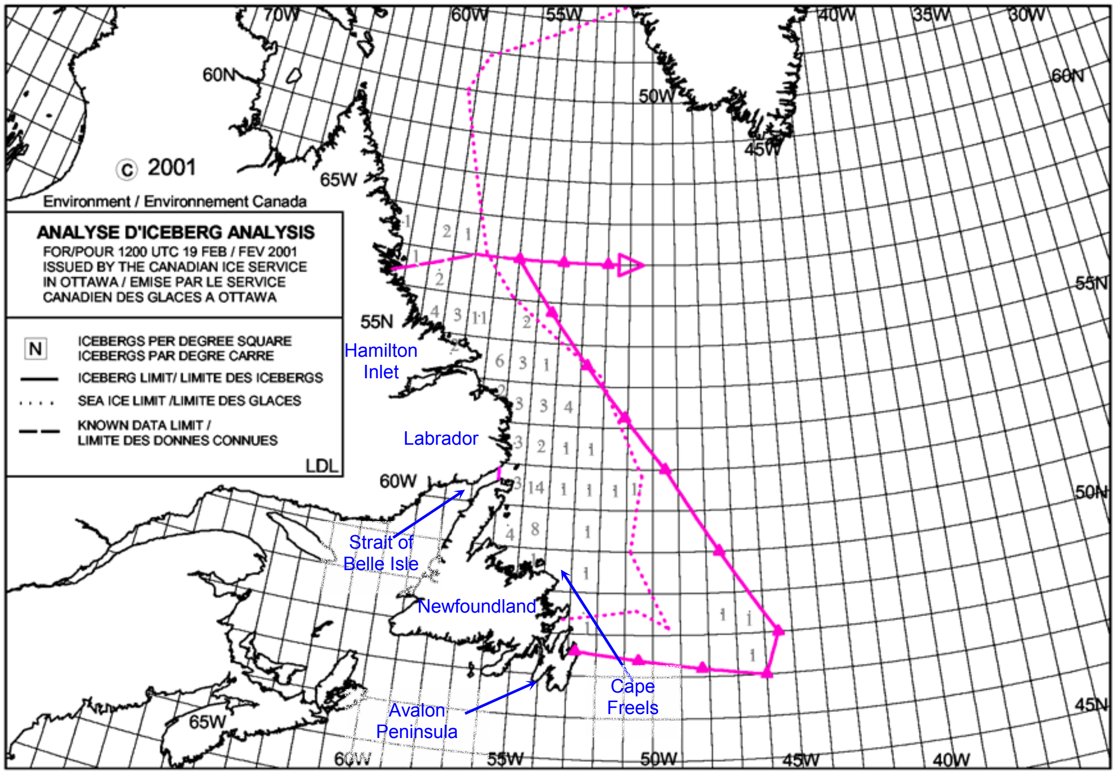


Figure 15. Iceberg distribution on February 19, 2001 from the iceberg analysis issued by the Canadian Ice Service. There are approximately 98 icebergs shown on this plot, most within sea ice.

the year was at 48°-06'N and 46°-00'W on 25 February. Ice Patrol estimated that four icebergs passed south of 48°N during February.

March

Intense storms continued to batter southern Newfoundland during March, bringing extended and frequent periods of strong northeast winds to the northeast Newfoundland shelf. Air temperatures on the island varied from a few degrees above normal in the first part of the month to near normal temperatures in the latter half. The southern Labrador coast experienced much warmer conditions, with mean air temperatures 4°C to 8°C warmer than normal.

The winds associated with the storms had a dramatic effect on the sea ice distribution along the northern Newfoundland and southern Labrador coasts. The storm-driven northeast winds moved the sea ice toward shore resulting in a mid-month eastern sea ice edge that was approximately 100 NM farther to the west than normal. As a result, the outer continental shelf was freed of any significant sea ice concentrations for the remainder of the year, leaving any icebergs that might be near or in the offshore branch of the Labrador Current exposed to wave attack as they moved southward. The southern extent of the sea ice was approximately normal throughout the month.

The mean sea surface temperature anomaly (Figure 16) distribution for March shows colder than normal values near the Newfoundland and southern Labrador coast. Thus, it is not likely that the disappearance of the sea ice was related

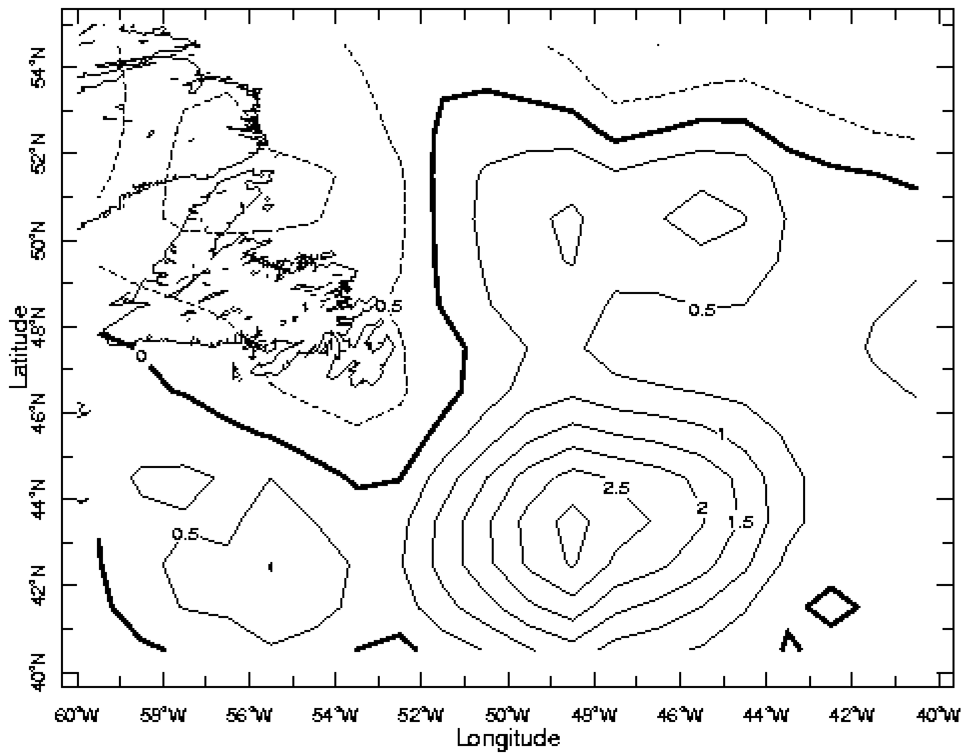


Figure 16. Mean sea surface temperature anomaly for March 2001 (from IRI/LDEO Climate Data Library and blended from ship, buoy, and bias-corrected satellite data).

to abnormal SST conditions. The large positive SST anomaly shown in the figure is well to the south of the sea ice edge and the March iceberg population.

On 29 March, Ice Patrol formally opened the 2001 ice season. On this day, the distribution of icebergs for the southern extent and easterly extent were near the 75th percentile according to Viekman and Baumer's iceberg climatology classification (Viekman and Baumer, 1995). This means that for the 21 years of the study, 75% of the iceberg limits were more extensive than those in 2001. During March, an estimated 31 icebergs drifted south of 48°N, about half the 101-year average of 61 for the month.

April

April was a month of change. During the first half of the month, stormy conditions prevailed in southern Newfoundland, continuing the weather pattern that had persisted since December. Again, storms moving along the Atlantic storm track south of the Avalon Peninsula brought strong northeast winds to east Newfoundland waters and along the southern Labrador coast. Mean air temperatures in both Newfoundland and Labrador were 1°C to 2°C colder than normal. The storms abated in the second half of the month, and Newfoundland experienced a mean southwesterly flow and slightly less than normal air temperatures.

The persistent onshore winds of early April continued to hold the sea ice close to the coast and tightly packed in the bays along the northern and eastern Newfoundland coasts. This resulted in an eastern sea ice edge that was significantly less than normal. The southern ice edge, which extended to the Avalon Peninsula, was greater than normal. The southwesterly flow during the second half of the month began to move the ice offshore, expanding the eastern limit, while, at the same time, accelerating ice destruction. By month's end, the southern ice extent was approximately 60 miles southeast of Fogo Island, somewhat further south than normal. The eastern extent was slightly west of its normal position.

The mid-month distribution of icebergs was at the 75th percentile for the eastern LAKI. A few isolated icebergs at approximately 55°W caused a short-lived bulge in the southern LAKI, but for the most part, the southern limit was near the 75th percentile. By the end of April, both the eastern and southern LAKI were near the 75th percentile. In April, 31 icebergs were estimated to have drifted south of 48°N, again, well below the month's average, which is 120.

May

East Newfoundland waters and the southern Labrador coast experienced light north winds during May. Air temperatures were near normal with the exception of lower than average air temperatures in Newfoundland during the second half of the month.

The sea ice retreat continued at a normal pace during the month and by mid-month, the southern sea ice extent was near normal and the eastern extent was slightly farther east than normal. During the second half of the month, the sea ice retreat accelerated somewhat and by 31 May, other than some locally heavy concentration of sea ice in the vicinity of White Bay and strips and patches along the northern Peninsula, there was no significant sea ice south of Hamilton Inlet.

During May, a small number of icebergs passed southward in the inshore branch of the Labrador Current, near the Avalon Peninsula. Although they moved to the west when they passed south of Cape Race, they never strayed very far from Newfoundland. The mid-May iceberg limits were between the minimum and the 75th percentile for eastern limits. While the southern LAKI was at the median for the period, it was due to a single, isolated iceberg east of the Tail of the Bank. By the end of the month, the southern LAKI had retreated to the 75th percentile and the eastern LAKI moved close to the minimum value. An estimated 19 icebergs drifted south of 48°N in May, while the average for the month is 147. In the 101-year average, May is the busiest month of the year for Ice Patrol in terms of number of icebergs passing south of 48°N. In 2001, March and April tied as the months with the most icebergs passing south of 48°N for the year.

On 14 May, the southernmost iceberg seen during the 2001 ice season was a small iceberg located by an Ice Patrol reconnaissance flight at 43°-24'N and 48°-13.2'W. The southernmost estimated iceberg position for the year was at 43°-04.8'N and 48°-18'W on the same date.

June

The Strait of Belle Isle was opened (recommended) for transatlantic vessels on 1 June 2001. IIP's last reconnaissance patrol returned from Newfoundland on 13 June.

The extent of the iceberg threat continued its rapid decline throughout the month of June. Both the southern and eastern LAKI were at the 75th percentile in mid-month. On 29 June, the day Ice Patrol closed the 2001 iceberg season, the eastern LAKI was at the minimum and the southern limit was nearing minimum extent. In June, Ice Patrol estimated that four icebergs passed south of 48°N. The average for the month is 87.

Although icebergs had departed the North Atlantic shipping lanes for the 2001 ice season, there remained a substantial iceberg population farther to the north. A series of six CIS ice reconnaissance flights at the end of June and beginning of July and reports from the Canadian icebreaker CCGS *Pierre Radisson* documented an extensive population of icebergs from the Strait of Belle Isle to Cape Chidley, the northernmost point of Labrador. Over 1000 icebergs were observed.

July

By early July, sea ice had disappeared from the Labrador coast. Throughout the month, the number of icebergs north of Newfoundland declined sharply, and by month's end there were only scattered icebergs south of Hamilton Inlet. No icebergs passed south of 48°N during the month.

Summary

Classifying the severity of the 2001 season is straightforward. With the 93-day season length and 89 icebergs estimated to have passed south of 48°N, the season falls solidly in the short and light categories defined by Trivers (1994). Furthermore, the extent of the iceberg distribution rarely exceeded the 75th percentile during the season, again pointing to a very light iceberg year.

Neither the air temperatures nor the sea surface temperatures in east Newfoundland waters appeared to be dominant factors in the development of the ice season. Sea ice arrived late in east Newfoundland waters and its development was hindered greatly by frequent storms traveling south of the island. Although the southern extent of the sea ice was near normal, even exceeding it at times, the eastern extent was dramatically less than normal most of the year, owing to the persistent storminess. By the end of March, the time when the sea ice normally begins its slow northward retreat, it was packed tightly against the coast. The pre-season sea ice forecast proved to be accurate for the early part of the season, including the progress of the ice edge to Cape Bonavista. After that, the impact of the storms dominated the sea ice distribution.

The severity of the 2001 iceberg season was consistent with both the early season predictions based on pre-season reconnaissance and the observed strong negative NAO phase. Though limited in scope, the reconnaissance in January and February showed a sparse iceberg population along the Labrador coast in position to move into the shipping lanes during the early part of the season. Late in the season, many icebergs were seen along the Labrador coast, but seasonal warming of the ocean waters lead to their destruction before they could move to east Newfoundland waters. From December 2000 through March 2001 there was a strong negative phase of the NAO (Wagner, 2001), which is characterized by abnormally high atmospheric pressure at high latitudes and a North Atlantic storm track that is displaced southward. The winter (December through March) North Atlantic Oscillation Index was –1.89 (Hurrell, 2001). The location of the storm track and the frequent storms that traveled along it dominated the environmental conditions east of Newfoundland in 2001.

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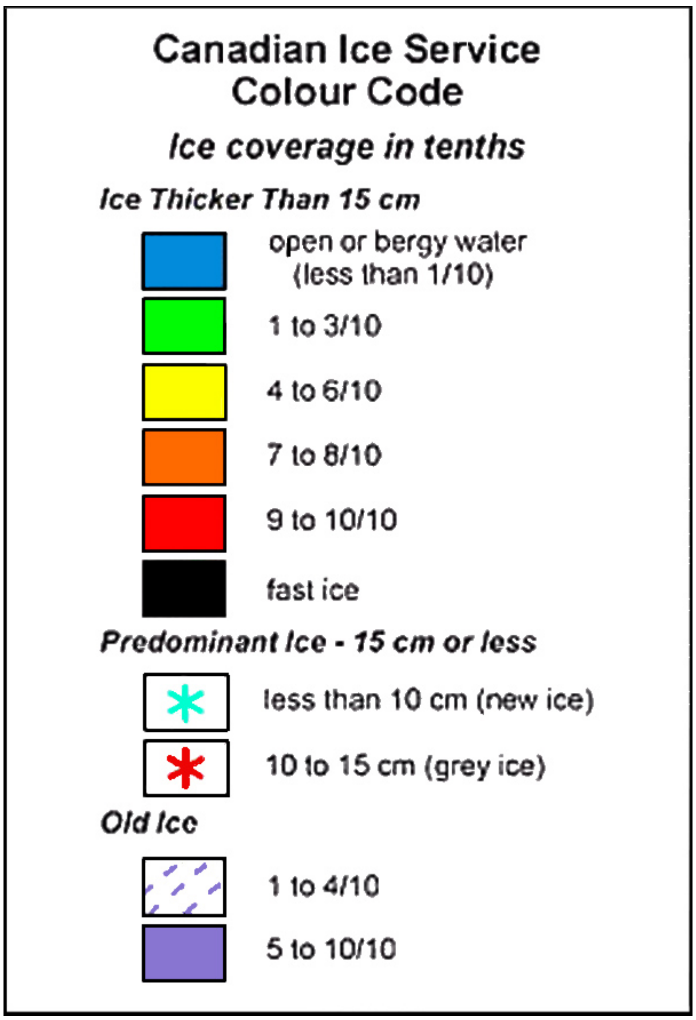
Monthly Sea Ice Charts



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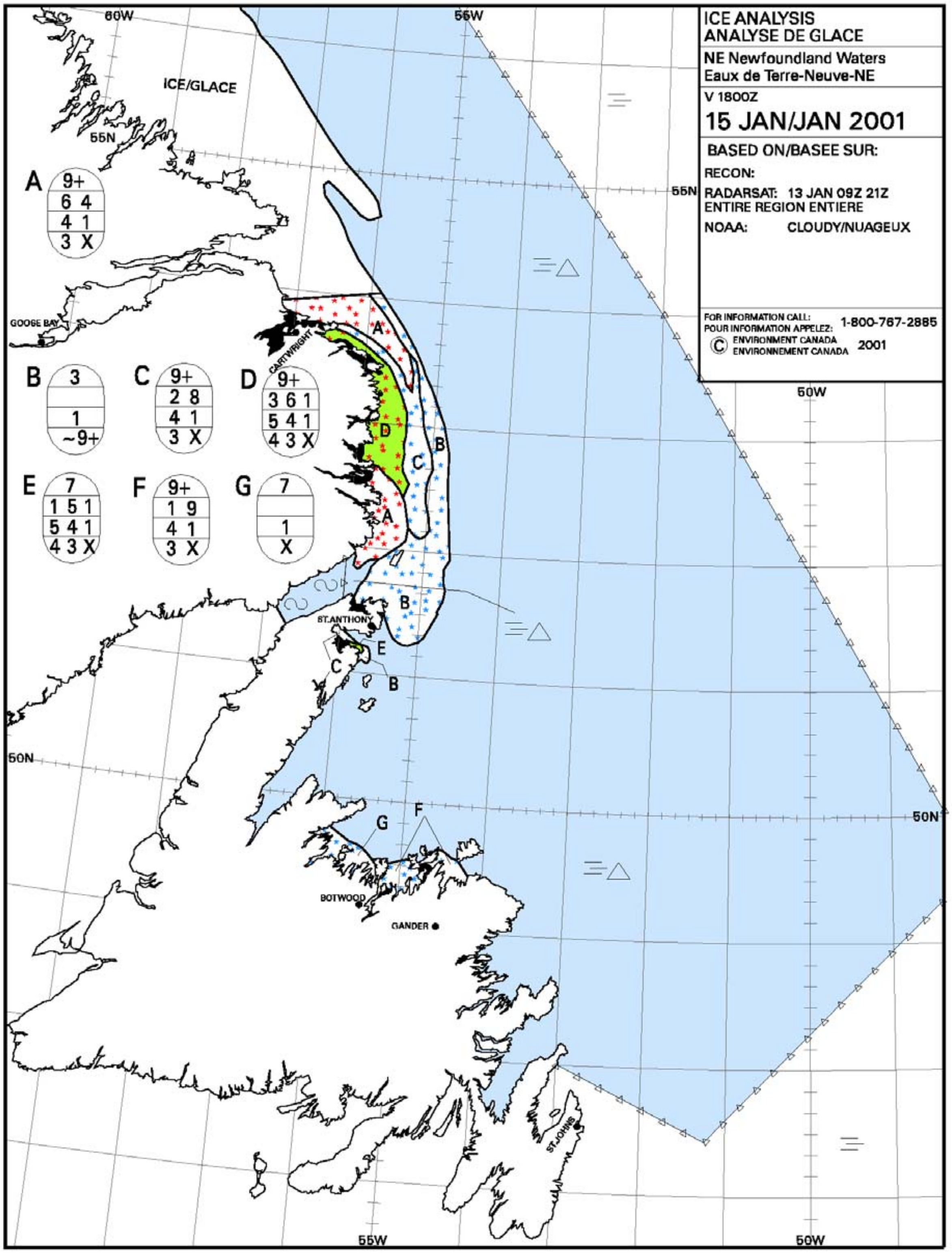

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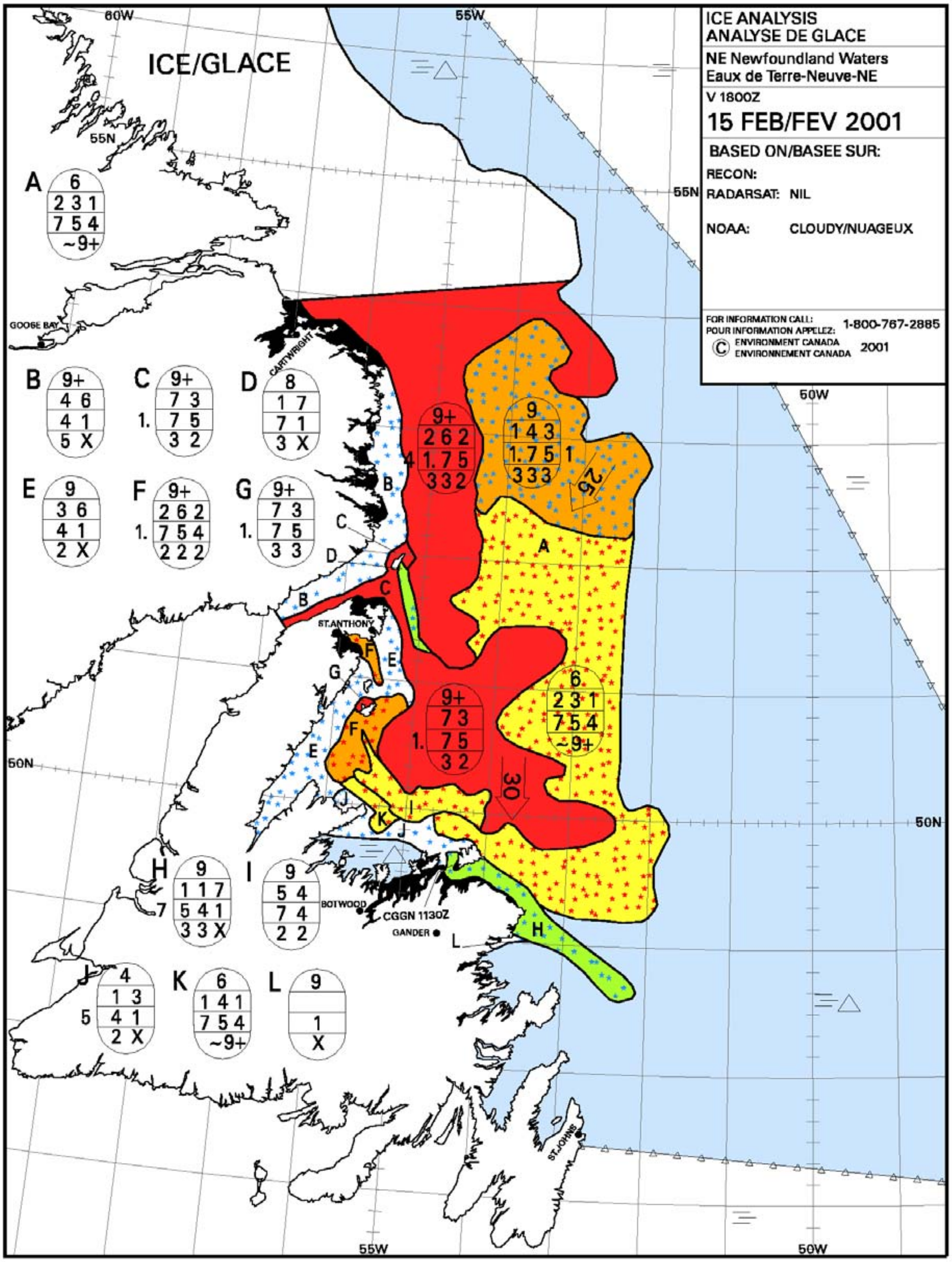
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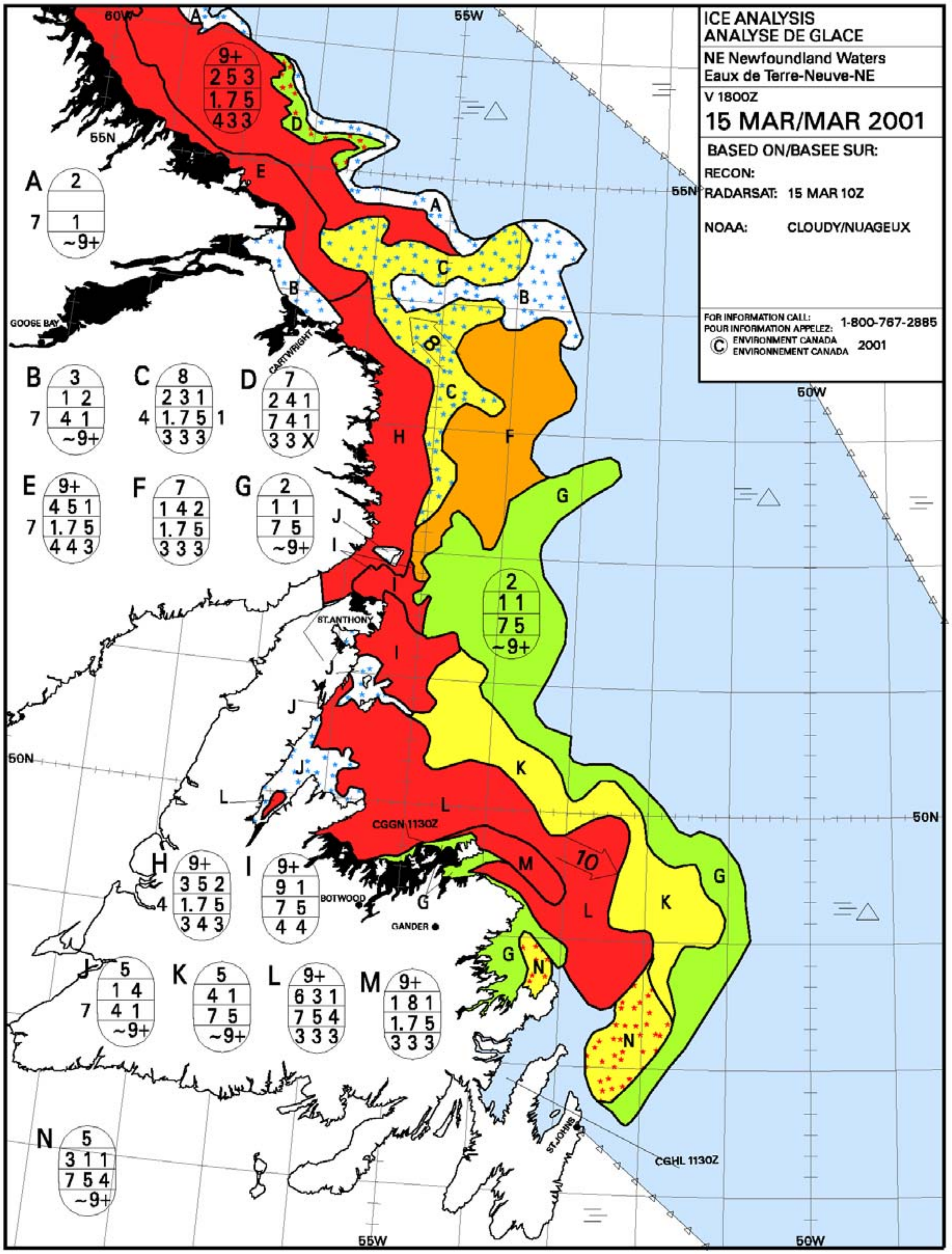
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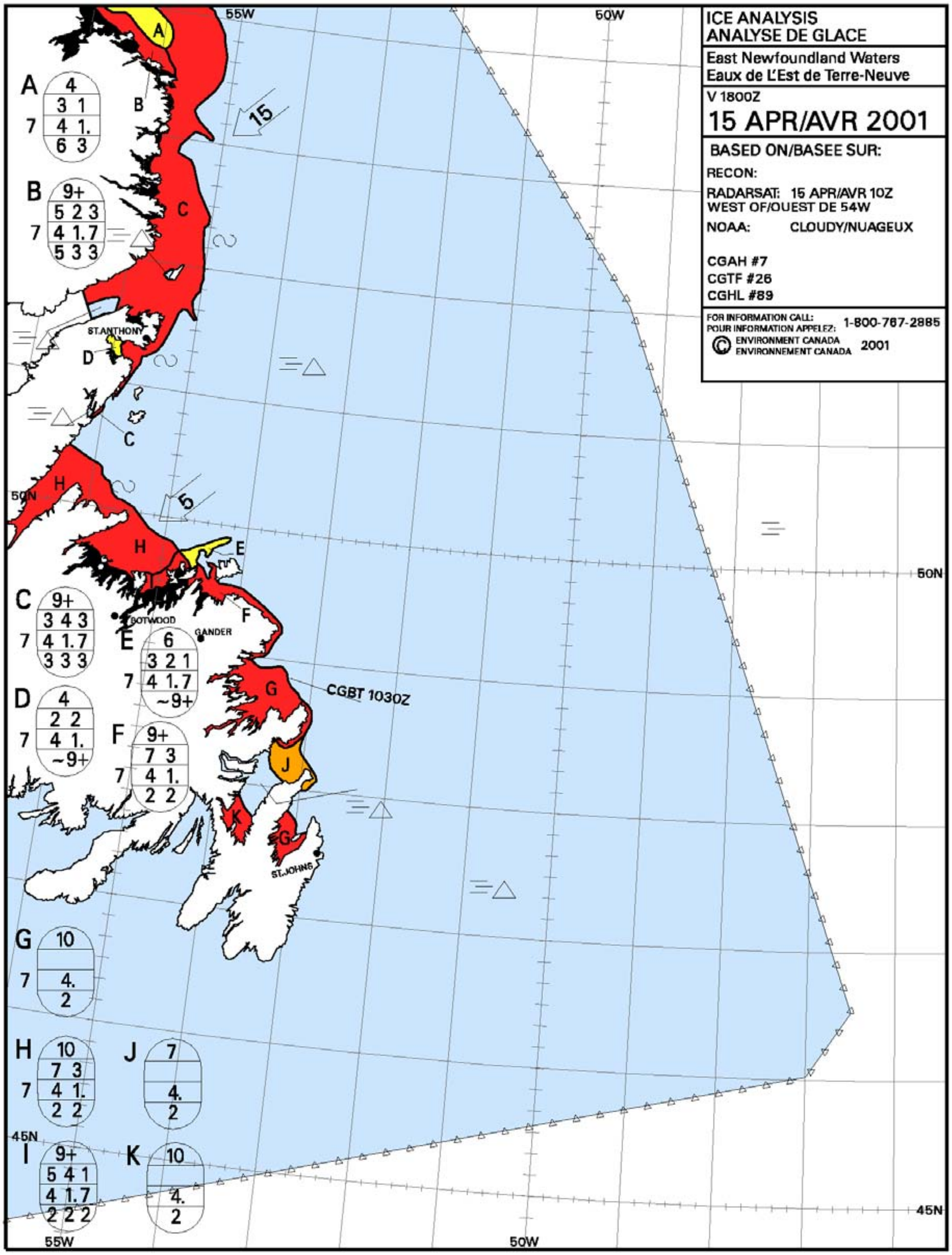
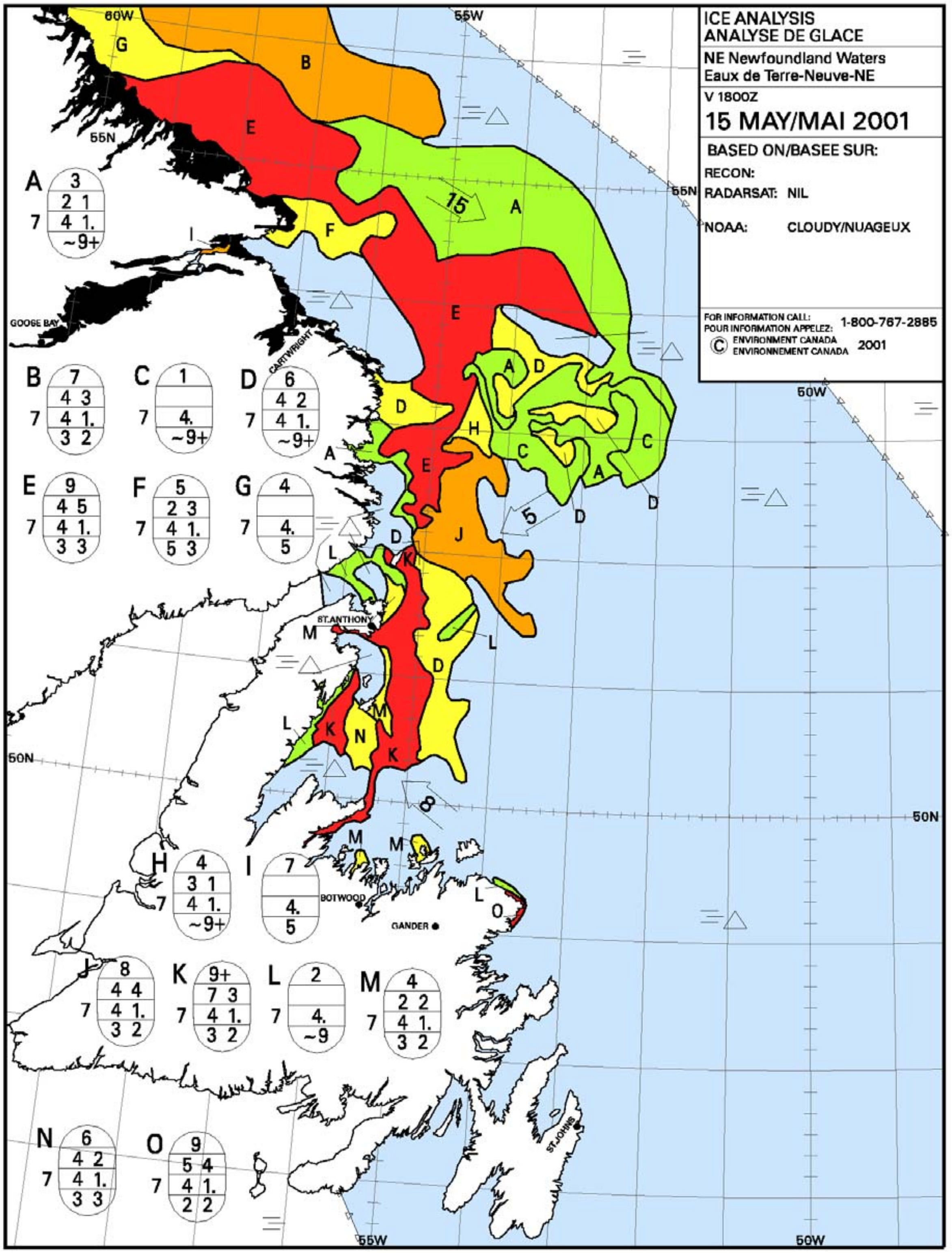


NOTE: CIS did not produce an ice chart for NE Newfoundland waters on this date.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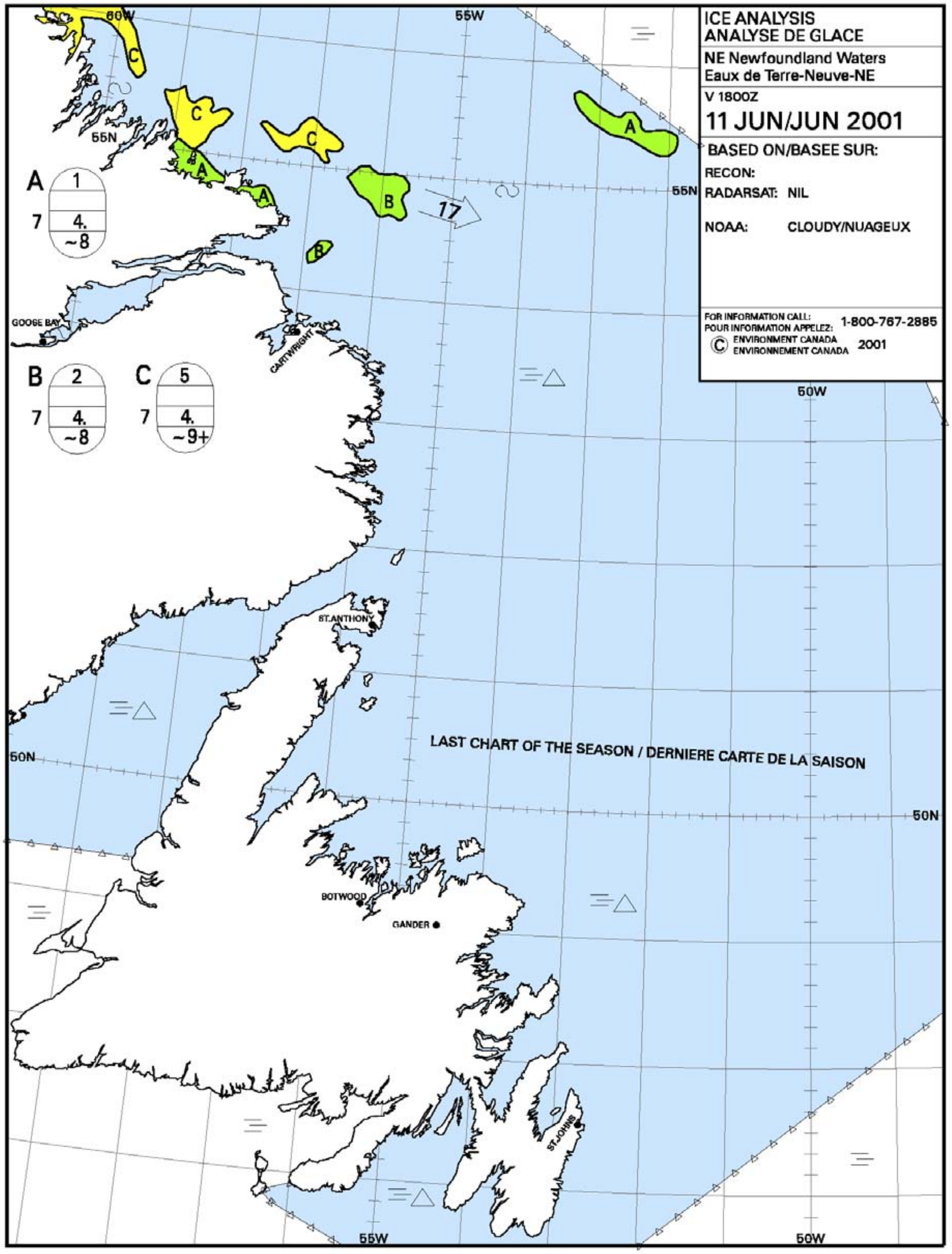

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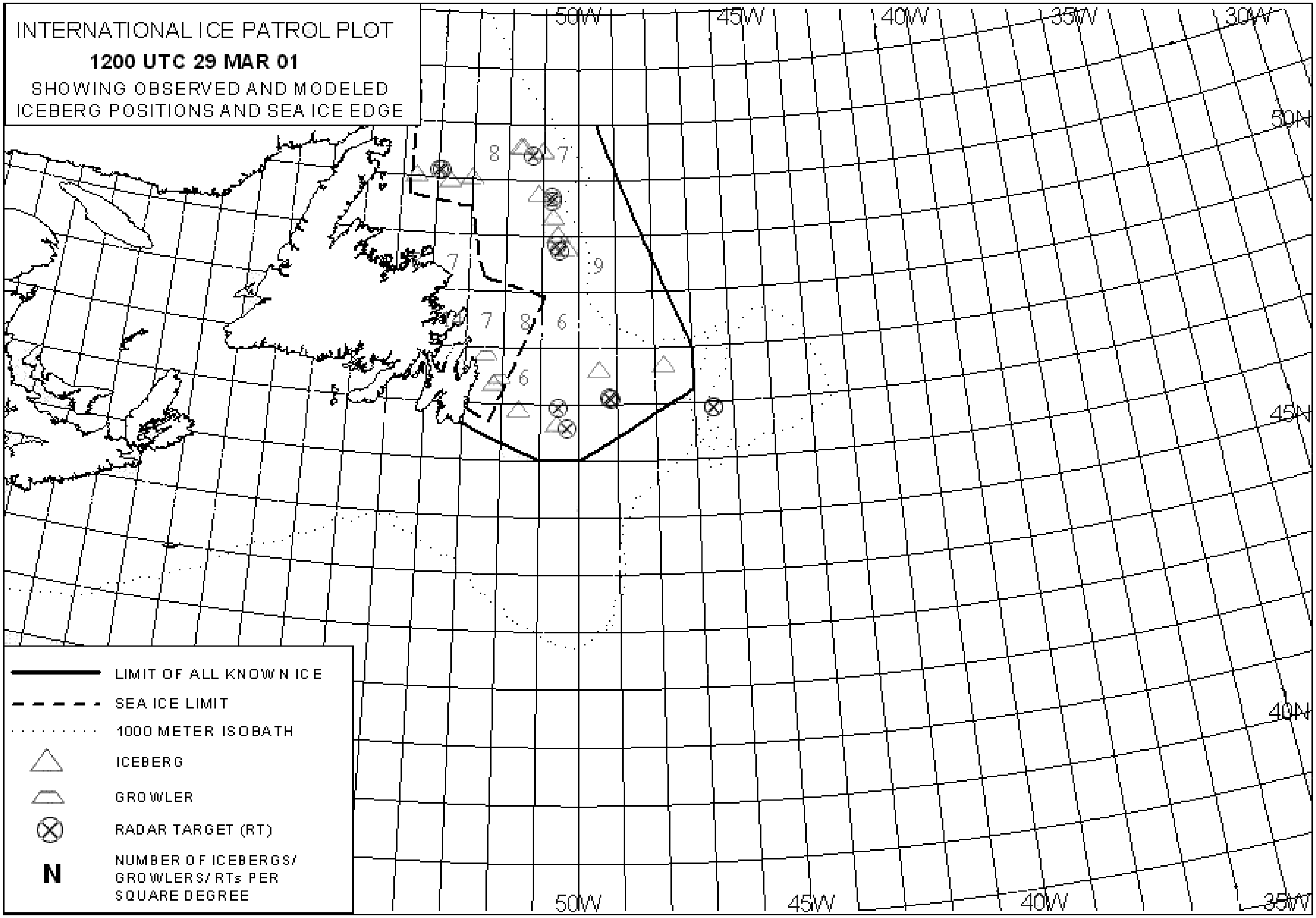
Biweekly Iceberg Charts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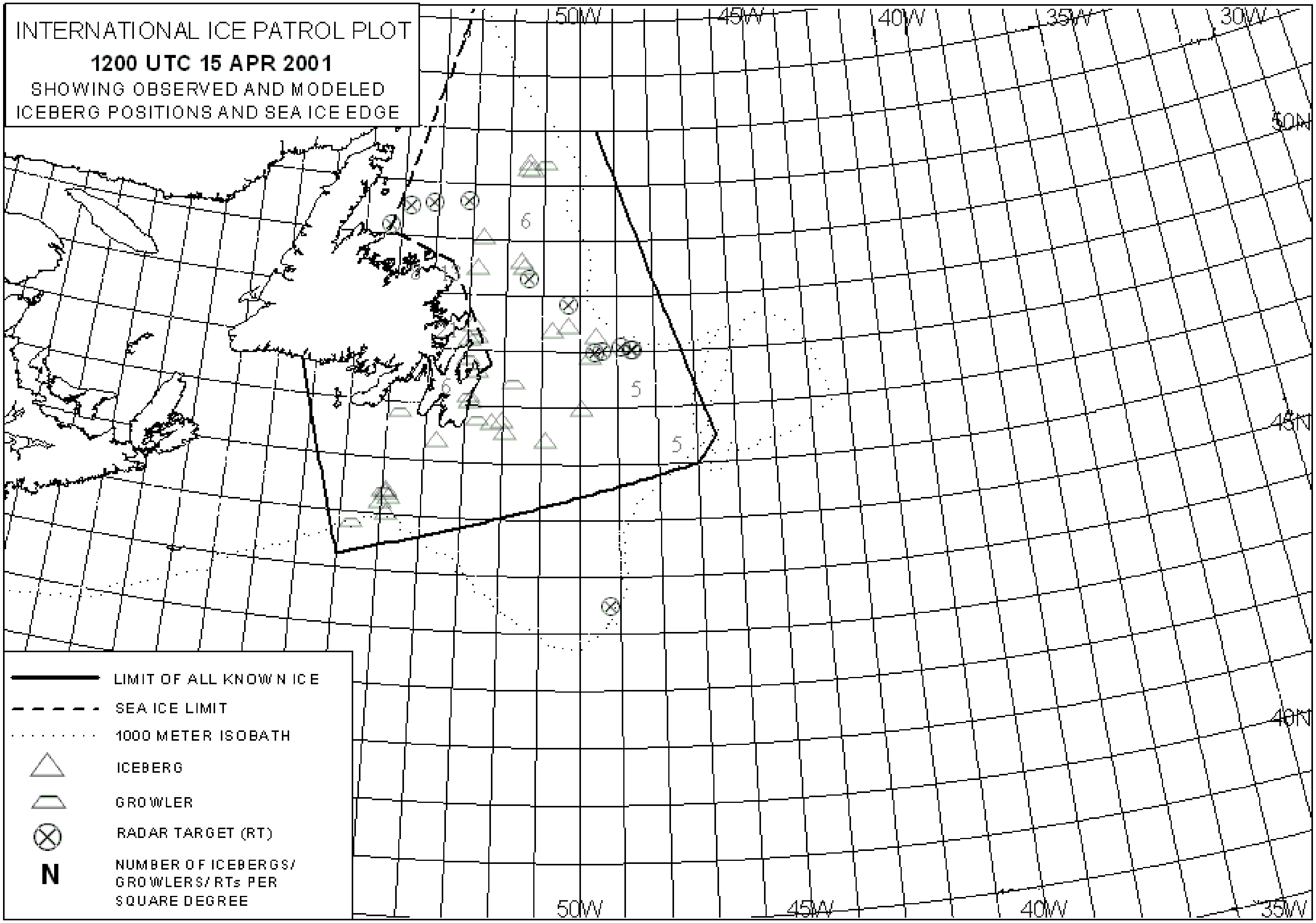
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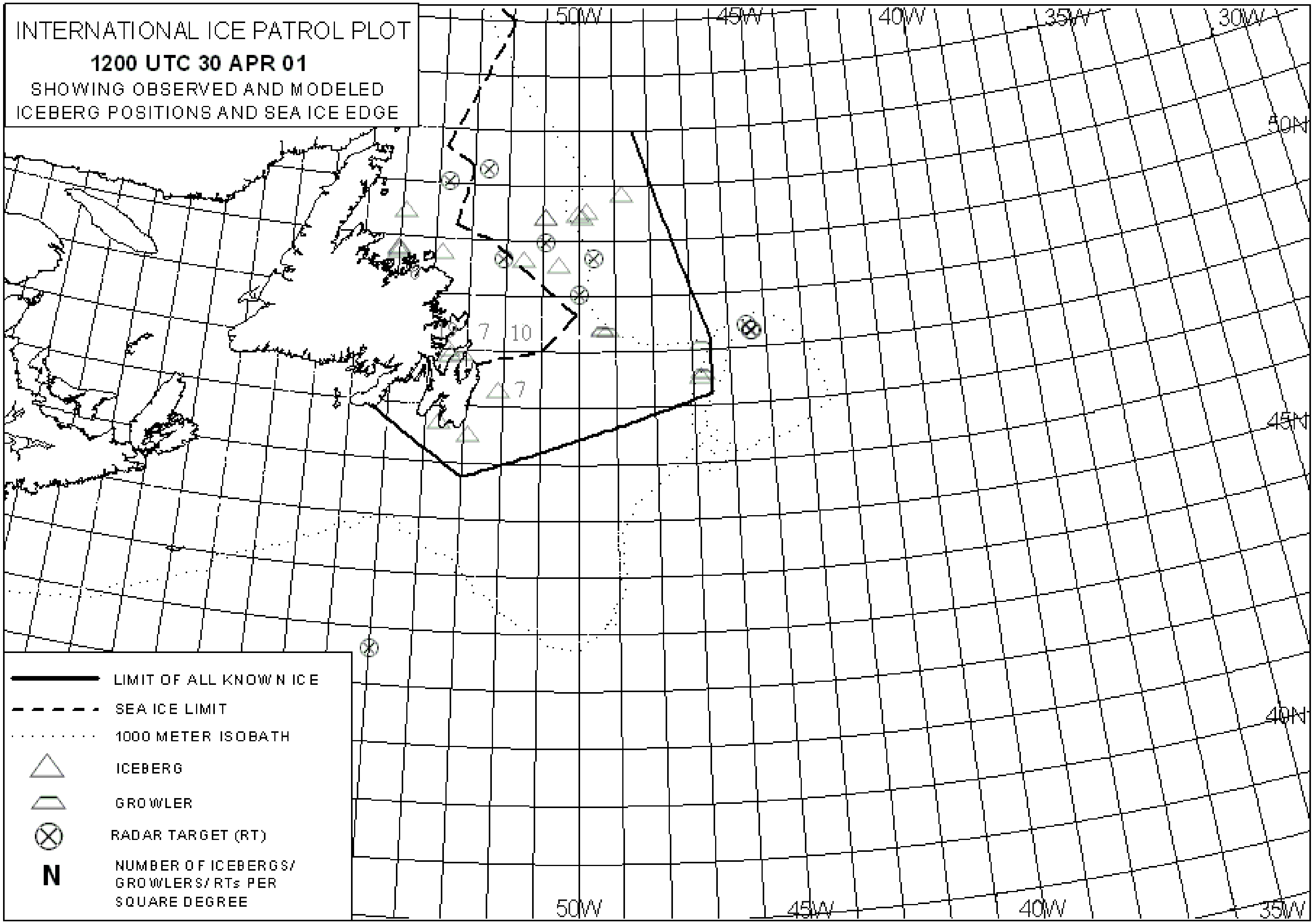
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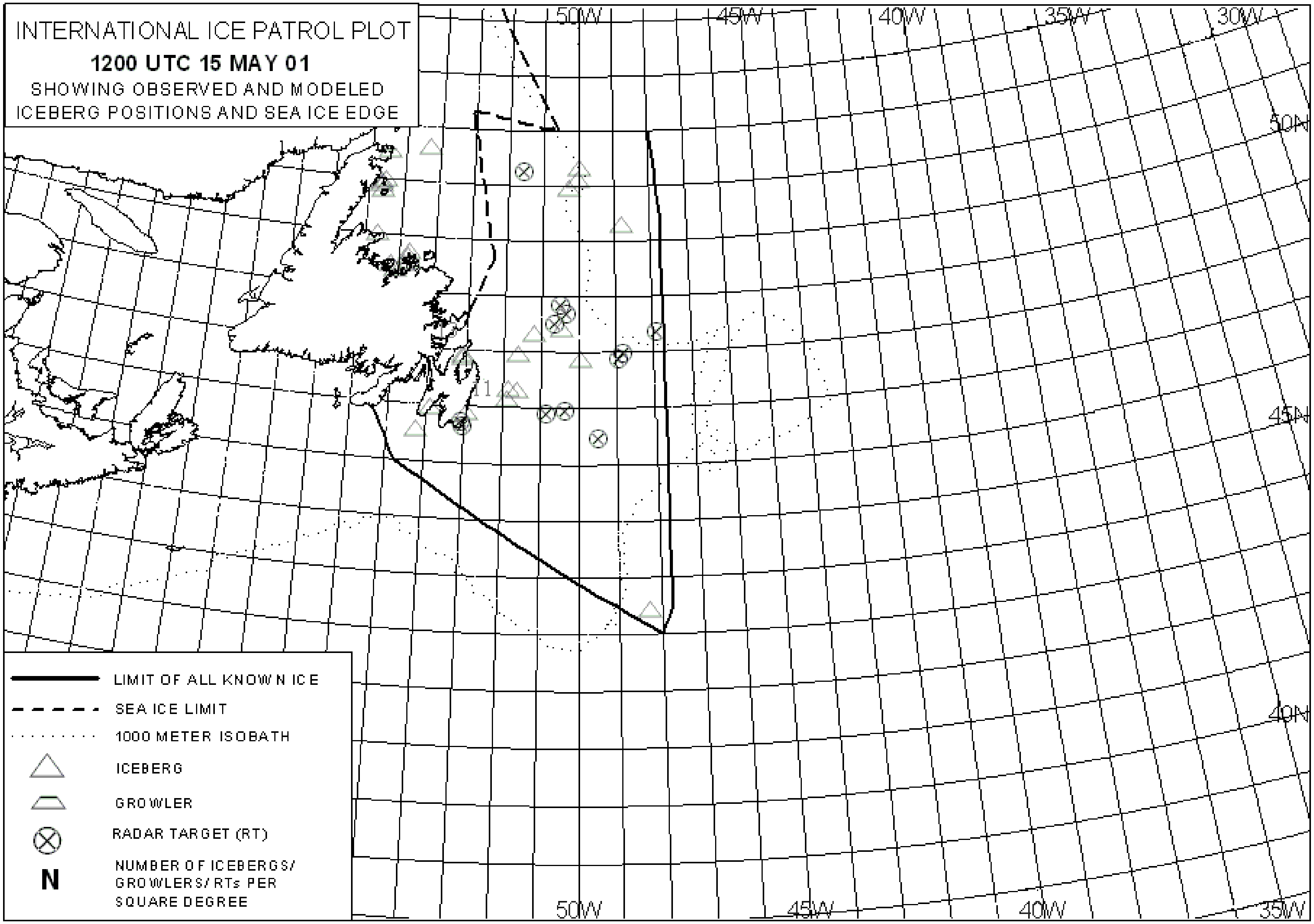

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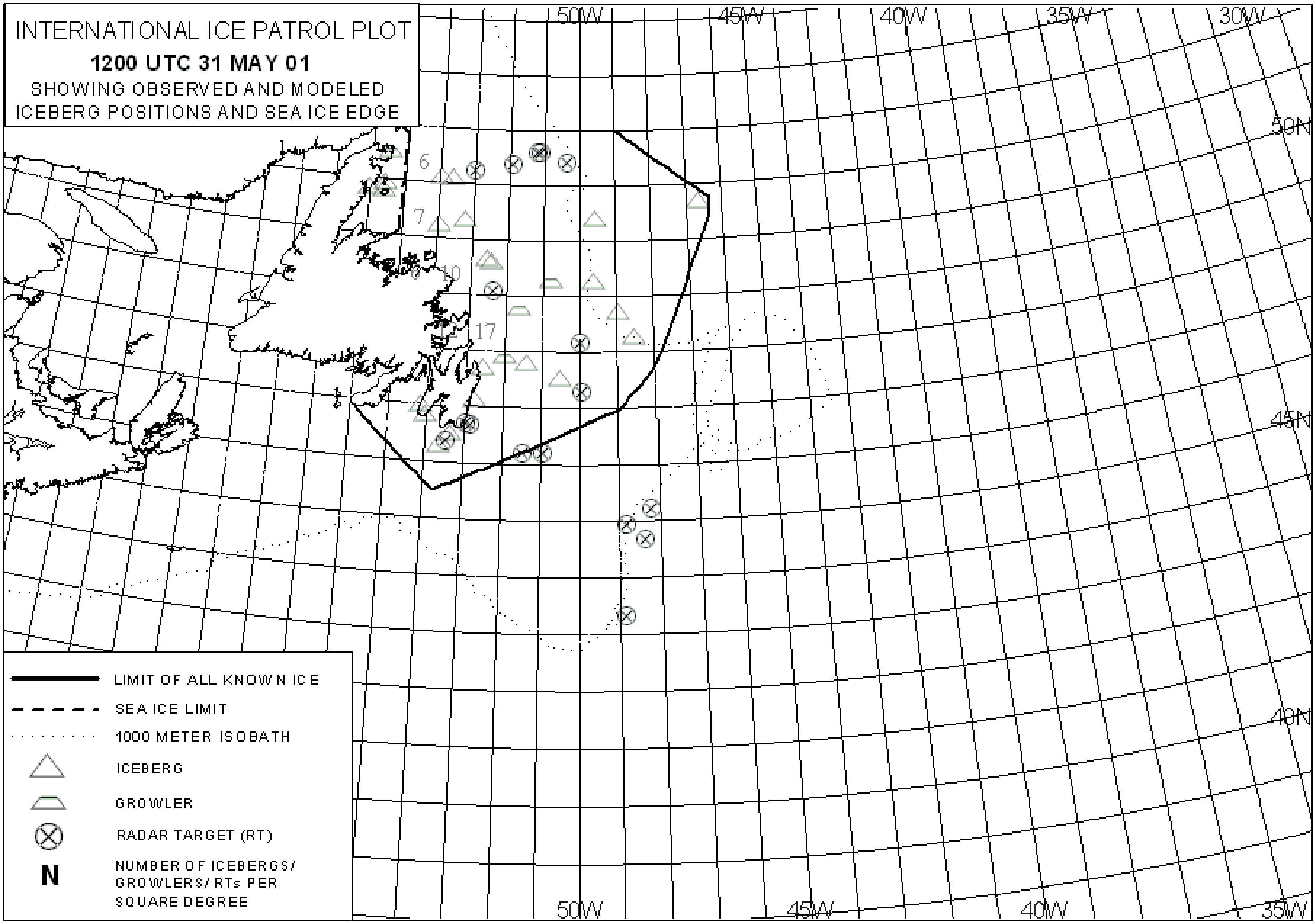
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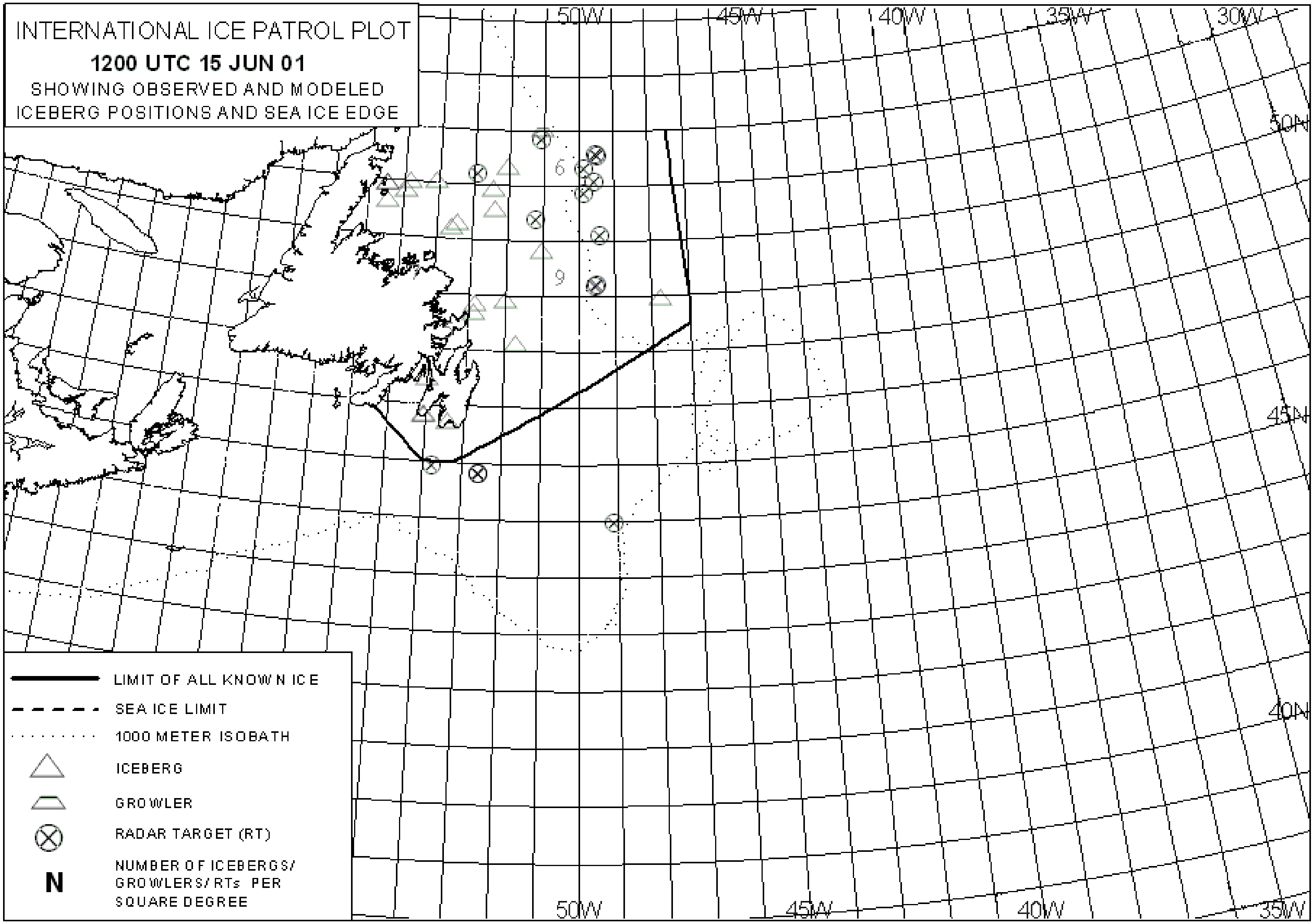
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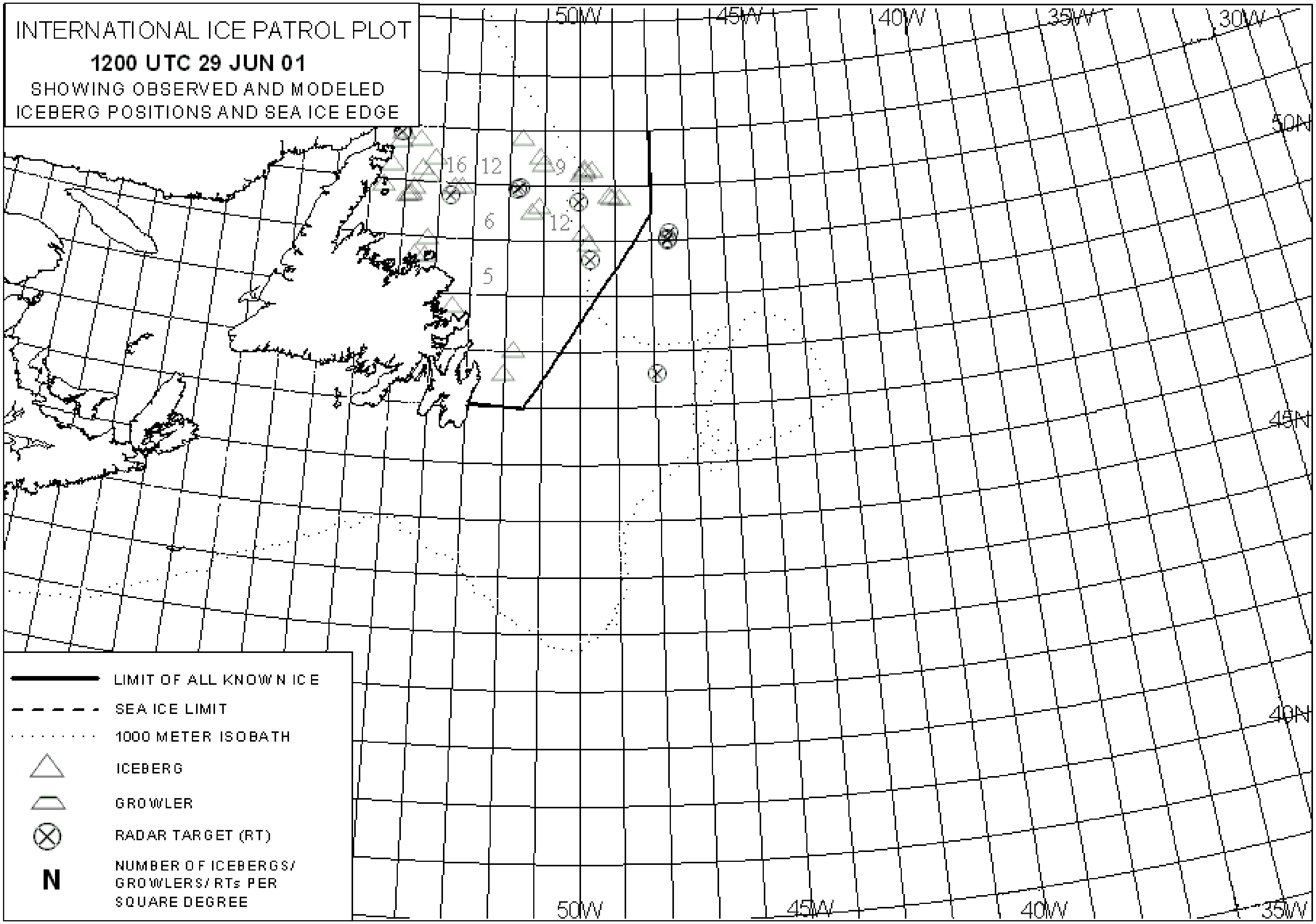
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Acknowledgements

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

Canadian Coast Guard
Canadian Forces
Canadian Ice Service
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
LCDR T. P. Wojahn
LCDR S. D. Rogerson
Dr. D. L. Murphy
Mr. G. F. Wright
LT L. K. Mack
LT C. A. Strong
MSTC V. L. Fogt
YNC G. J. McCarthy
MST1 D. L. Alexander
MST1 S. R. Houle
YN1 T. J. DeVall
MST2 T. T. Krein
MST2 P. J. Jenicek
MST2 E. W. Thompson
MST3 D. A. Jolly
MST3 R. J. Kenward
MST3 J. Dale
MST3 B. H. Grebe
MST3 J. P. Carew

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Appendix A

Nations Currently Supporting International Ice Patrol

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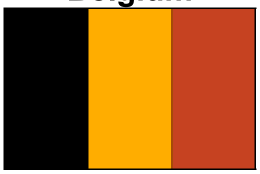

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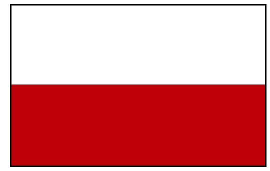

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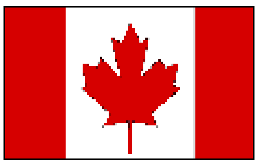

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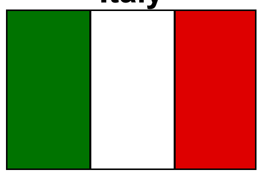
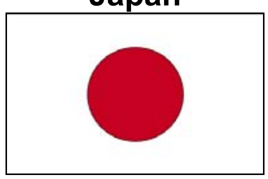


Spain

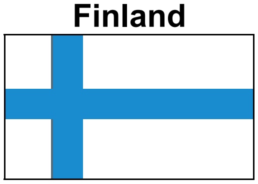
Denmark

Japan



Sweden

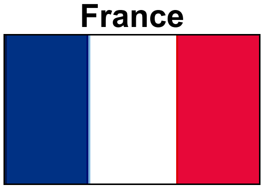
Finland



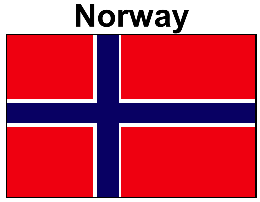
Netherlands

United Kingdom

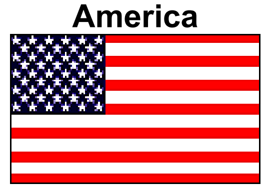
France



Norway

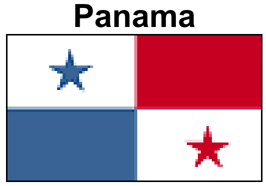


United States of America



Germany

Panama



Appendix B

Ship Reports

Ships Reporting By Flag	Reports
ANTIGUA & BARBUDA	
LAGARFOSS	1
MALTE B	9
OSTKAP	3
BAHAMAS	
ATLANTIC CARTIER	35
BLACK SWAN	8
CHIQUITA BELGIE	33
CRANE ARROW	12
GIMO ONE	14
GOTLAND SPIRIT	6
HAWK ARROW	5
NORBAY	2
VICTORIA SPIRIT	1
BARBADOS	
FEDERAL BAFFIN	1
BERMUDA	
CANMAR PRIDE	1
CANADA	
ANN HARVEY	4
ATLANTIC CLAIRE	1
BRITTANY & SHANNON	1
CAPE ROGER	2
CATHERINE DESGAGNES	1
CICERO	1
DES GROSEILLIERS	2
GRAND BARON	1
GREENWHICH MAERSK	6
J.E. BERNIER	1
MATTEA	36
NORDIK EXPRESS	1
OOCL BELGIUM	1
PARIZEAU	1

Ships Reporting By Flag	Reports
CANADA continued	
PIERRE RADISSON	3
SIBIL W	1
CAYMAN ISLANDS	
MAGIC	5
MILLENIUM EAGLE	3
CHINA, TAIWAN	
CAPE OCEANIA	7
CROATIA	
ORSULA	6
PELJESAC	4
CYPRUS	
AQUA SIERRA	11
DORINE	5
INDEPENDENT VENTURE	1
ISA	14
ISADORA	14
ISOLDA	7
MIDEN AGAIN/MAERSK TORONTO	39
NOGAT	4
NORDISLE	1
FINLAND	
CAMILLA	2
DEGERO	2
FRENCH ANTARCTIC TERRITORY	
MES BRO CECILE	4
GREECE	
ARCADIA	1
ATHENIAN FREEDOM	1
CAP ROMUALD	16
HOBBY	18

Ships Reporting By Flag	Reports
HONG KONG	
FEDERAL HUDSON	1
FEDERAL RIDEAU	1
OOCL CANADA	1
ICELAND	
SUNNA	1
ITALY	
MIMMO IEVOLI	1
LIBERIA	
KNOCK SALLIE	11
OCEAN KMIR	6
SANTA MONICA I	5
ST. PETERSBURG SENATOR	8
STOLT ASPIRATION	5
LITHUANIA	
KAPITONAS A. LUCKA	2
MALTA	
ALEKSANDR SIBIRYAKOV	10
MARSHALL ISLANDS	
LAKE ERIE	10
LEOPARDI	1
NEW CONCORD	6
MYANMAR	
GREAT LAKER	10
NETHERLANDS	
JO SYPRESS	4
NORWAY	
BERGE NORD*	77
BRUNTO	8
SIBONAWCY	3
STAR SKOGANGER	16
TEEKAY FOUNTAIN	8
NORWEGIAN INT. REGISTER	
CONCORD	30
EMMA	1
GREEN BERGEN	11
NEVA TRADER	13

Ships Reporting By Flag	Reports
PANAMA	
CO-OP PHOENIX	5
FEDERAL MACKENZIE	1
GLENBUCK	3
LOWLANDS YARRA	4
PANDORA	1
PHILIPPINES	
AURORA TOPAZ	6
STAR SAVANNAH	7
RUSSIA	
PAVEL VAVILOV	1
SINGAPORE	
FIDELITY	6
FRONT VIEWER	6
IKAN SEPAT	11
MAERSK ELEO	6
MAERSK ESTELLE	1
MAERSK WAVE	5
STAR IKEBANA	12
ST. VINCENT	
RHONE	7
SWEDEN	
ATLANTIC COMPASS	1
INGRID GORTHON	3
TANZANIA	
AGIP DAR	1
UNITED KINGDOM	
GRASMERE MAERSK	1
JOHANNA C	14
UNITED STATES OF AMERICA	
SHIP (NAME UNKNOWN)	3

*DENOTES VESSEL PARTICIPATION AWARD WINNER

Appendix C

Safety of Life at Sea (SOLAS) Excerpt on Ice Patrol Services

International Maritime Organization
International Convention for the Safety of Life at Sea
Chapter V, Safety of Navigation

Regulation 6

Ice Patrol Service

1 The Ice Patrol contributes to safety of life at sea, safety and efficiency of navigation and protection of the marine environment in the North Atlantic. Ships transiting the region of icebergs guarded by the Ice Patrol during the ice season are required to make use of the services provided by the Ice Patrol.

2 The Contracting Governments undertake to continue an ice patrol and a service for study and observation of ice conditions in the North Atlantic. During the whole of the ice season, i.e. for the period from February 15th through July 1st of each year, the south-eastern, southern and south-western limits of the region of icebergs in the vicinity of the Grand Banks of Newfoundland shall be guarded for the purpose of informing passing ships of the extent of this dangerous region; for the study of ice conditions in general; and for the purpose of affording assistance to ships and crews requiring aid within the limits of operation of the patrol ships and aircraft. During the rest of the year the study and observation of ice conditions shall be maintained as advisable.

3 Ships and aircraft used for the ice patrol service and the study and observation of ice conditions may be assigned other duties provided that such other duties do not interfere with the primary purpose or increase the cost of the service.

4 The Government of the United States of America agrees to continue the overall management of the ice patrol service and the study and observation of ice conditions, including dissemination of information therefrom.

5 The terms and conditions governing the management, operation and financing of the Ice Patrol are set forth in the Rules for the management, operation and financing of the North Atlantic Ice Patrol appended to this chapter which shall form an integral part of this chapter.

6 If, at any time, the United States and/or Canadian Governments should desire to discontinue providing these services, it may do so and the Contracting Governments shall settle the question of continuing these services in accordance with their mutual interests. The United States and/or Canadian Governments shall provide 18 months written notice to all Contracting Governments whose ships entitled to fly their flag and whose ships registered in territories to which

those Contracting Governments have extended this regulation benefit from these services before discontinuing providing these services.

APPENDIX TO CHAPTER V

RULES FOR THE MANAGEMENT, OPERATION AND FINANCING OF THE NORTH ATLANTIC ICE PATROL

1 In these Rules:

.1 *Ice season* means the annual period between February 15 and July 1.

.2 *Region of icebergs guarded by the ice patrol* means the south-eastern, southern and south-western limits of the region of icebergs in the vicinity of the Grand Banks of Newfoundland.

.3 *Routes passing through regions of icebergs guarded by the Ice Patrol* means:

.3.1 routes between Atlantic Coast ports of Canada (including inland ports approached from the North Atlantic through the Gut of Canso and Cabot Straits) and ports of Europe, Asia or Africa approached from the North Atlantic through or north of the Straits of Gibraltar (except routes which pass south of the extreme limits of ice of all types).

.3.2 routes via Cape Race, Newfoundland between Atlantic Coast ports of Canada (including inland ports approached from the North Atlantic through the Gut of Canso and Cabot Straits) west of Cape Race, Newfoundland and Atlantic Coast ports of Canada north of Cape Race, Newfoundland.

.3.3 routes between Atlantic and Gulf Coast ports of the United States of America (including inland ports approached from the North Atlantic through the Gut of Canso and Cabot Straits) and ports of Europe, Asia or Africa approached from the North Atlantic through or north of the Straits of Gibraltar (except routes which pass south of the extreme limits of ice of all types).

.3.4 routes via Cape Race, Newfoundland between Atlantic and Gulf Coast ports of the United States of America (including inland ports approached from the North Atlantic through the Gut of Canso and Cabot Straits) and Atlantic Coast ports of Canada north of Cape Race, Newfoundland.

.4 *Extreme limits of ice of all types* in the North Atlantic Ocean is defined by a line connecting the following points:

A - 42° 23'.00N, 59° 25'.00W	J - 39° 49'.00N, 41° 00'.00W
B - 41° 23'.00N, 57° 00'.00W	K - 40° 39'.00N, 39° 00'.00W
C - 40° 47'.00N, 55° 00'.00W	L - 41° 19'.00N, 38° 00'.00W
D - 40° 07'.00N, 53° 00'.00W	M - 43° 00'.00N, 37° 27'.00W
E - 39° 18'.00N, 49° 39'.00W	N - 44° 00'.00N, 37° 29'.00W
F - 38° 00'.00N, 47° 35'.00W	O - 46° 00'.00N, 37° 55'.00W
G - 37° 41'.00N, 46° 40'.00W	P - 48° 00'.00N, 38° 28'.00W
H - 38° 00'.00N, 45° 33'.00W	Q - 50° 00'.00N, 39° 07'.00W
I - 39° 05'.00N, 43° 00'.00W	R - 51° 25'.00N, 39° 45'.00W

.5 *Managing and operating* means maintaining, administering and operating the Ice Patrol, including the dissemination of information received therefrom.

.6 *Contributing Government* means a Contracting Government undertaking to contribute to the costs of the ice patrol service pursuant to these Rules.

2 Each Contracting Government specially interested in these services whose ships pass through the region of icebergs during the ice season undertakes to contribute to the Government of the United States of America its proportionate share of the costs for the management and operation of the ice patrol service. The contribution to the Government of the United States of America shall be based on the ratio which the average annual gross tonnage of that contributing Government's ships passing through the region of icebergs guarded by the Ice Patrol during the previous three ice seasons bears to the combined average annual gross tonnage of all ships that passed through the region of icebergs guarded by the Ice Patrol during the previous three ice seasons.

3 All contributions shall be calculated by multiplying the ratio described in paragraph 2 by the average actual annual cost incurred by the Governments of the United States of America and Canada of managing and operating ice patrol services during the previous three years. This ratio shall be computed annually, and shall be expressed in terms of a lump sum per-annum fee.

4 Each of the contributing Governments has the right to alter or discontinue its contribution, and other interested Governments may undertake to contribute to the expense. The contributing Government which avails itself of this right will continue to be responsible for its current contribution up to 1 September following the date of giving notice of intentions to alter or discontinue its contribution. To take advantage of the said right it must give notice to the managing Government at least six months before the said 1 September.

5 Each contributing Government shall notify the Secretary-General of its undertaking pursuant to paragraph 2, who shall notify all Contracting Governments.

6 The Government of the United States of America shall furnish annually to each contributing Government a statement of the total cost incurred by the Governments of the United States of America and Canada of managing and operating the Ice Patrol for

that year and the average percentage share for the past three years of each contributing Government.

7 The managing government shall publish annual accounts including a statement of cost incurred by the governments providing the services for the past three years and the total gross tonnage using the service for the past three years. The accounts shall be publicly available. Within three months after having received the cost statement, contributing Governments may request more detailed information regarding the costs incurred in managing and operating the Ice Patrol.

8 These Rules shall be operative beginning with the ice season of 2002.

Appendix D

RADM Edward H. "Iceberg" Smith Biography

The following is a press release issued by the U. S. Coast Guard's Public Information Division shortly after the death of Rear Admiral Edward H. "Iceberg" Smith. It is produced as written, with the exception of corrections to minor typographical errors.

Public Information Division
U. S. Coast Guard Headquarters
Washington 25, D. C.

RADM EDWARD H. "ICEBERG" SMITH,
U. S. COAST GUARD (RET) DIES

Rear Admiral Edward H. Smith, U. S. Coast Guard, retired, internationally recognized figure in scientific and maritime circles for his knowledge of the Arctic and oceanography, died on his birthday, Sunday, October 29, 1961, of cerebral vascular assident at his home 437 Sippewissett Road , Quisset, Massachusetts. He was 72, and had been critically ill for the past several months.

Rear Admiral Smith was born in 1889 at Vineyard Haven, Massachusetts, a descendent of a long line of Martha's Vineyard whalemen. His parents were Edward J. and Sarah Elizabeth (Pease) Smith. After attending Vineyard Haven High School and New Bedford High School, he spent a year studying at the Massachusetts Institute of Technology.

Appointed a cadet on May 4, 1910, he entered the U. S. Coast Guard Academy when it was known as the U. S. Revenue Cutter Service School of Instruction and classes were held aboard the Revenue Practice Cutter ITASCA at Arundel Cove, Maryland. He was graduated and commissioned an Ensign on May 17, 1913, and subsequently advanced in rank as follows:

Lieutenant (jg), June 7, 1918; Lieutenant, January 12, 1923; Lieutenant Commander, April 21, 1924; Commander, October 1, 1934 Captain, December 1, 1941; Rear Admiral, June 30, 1942 (permanent rank as of January 1, 1948).

EARLY ASSIGNMENTS:

He served his first assignment as junior engineer and line officer aboard the Cutter SEMINOLE, based at Wilmington, North Carolina. From February to November of 1915, he served aboard the Cutter ACUSHNET out of Woods Hole, Massachusetts, then reported to the Cutter APACHE at Baltimore, Maryland. In January 1916, he was reassigned to the Cutter SEMINOLE.

From August 1917 to January 1919, during World War I he was navigator of the Cutter MANNING in the Atlantic Patrol Force which performed convoy escort duty between England and Gibraltar. He received the World War I Victory Medal for that period. His next tour of duty lasted six months with the Cutter TALLAPOOSA of Boston, after which he was assigned briefly as navigator of the Cutter ANTIGONE of the Newport News Division Transport Force.

In November 1919, he was assigned to the Coast Guard Cutter SENECA, and in the spring of 1920 when that cutter was ordered to conduct the International Ice Patrol he was detailed with her as scientific observer and navigator. From this point on, the main part of his career was devoted to specializing in research and work in the Arctic and in the field of oceanography. As a result of his intensive early work in International Ice Patrol, his associates nick-named him "Iceberg" Smith and others conferred upon him honors for contributing greatly to man's present knowledge of the Arctic and in the science of oceanography.

He continued carrying on the duties of observer with the Ice Patrol until August 1924. During off-seasons he studied at Harvard University and annually prepared for publication the Coast Guard bulletins on the work of the Ice Patrol. In recognition of his work on the Ice Patrol, Harvard University awarded him the Master of Arts Degree in 1924. At this time he was also awarded a Fellowship in Oceanography by the American-Scandinavian Foundation, by which he studied oceanography at the Geo-Physical Institute at Bergen, Norway, from August 1924 to August 1925. From there he spent three months with the British Meteorological Office in London obtaining scientific data and information of value to the Coast Guard in its work of conducting the Ice Patrol.

Returning to the United States, he resumed working with the Ice Patrol throughout the seasons 1926 to 1928. During that time he reorganized the scientific programs for the International Ice Patrol and introduced the modern methods of dynamic oceanography predicting and tracing the movements of the dangerous icebergs. He also began a service of iceberg forecasting whereby the number of bergs annually drifting south of Newfoundland are predicted. During off-seasons he continued research work at Harvard University and in 1926 gave lectures on oceanography and Arctic ice at Clark University.

Between January 1928 and June 1936, he was commanding officer of various vessels of the Destroyer Force which the Coast Guard operated during that period in suppression of smuggling. But he was absent from those duties much of the time to perform work in connection with the Ice Patrol, and other special assignments. His commands at that time, however, included the destroyers HENLEY, DOWNES, SHAH, TUCKER, GEORGE E. BADGER, and also command of Base 18 at Woods Hole.

One of his special assignments occurred in the summer of 1928, when he was leader of the Coast Guard Cutter MARION expedition, which made thorough oceanographic surveys in the Labrador Sea, Davis Strait, and Baffin Bay, visiting some of the most important iceberg producing glaciers in West Greenland. This was the most comprehensive oceanographic survey ever made by the United States, from which RADM Smith prepared a report for publication.

In July 1929, he was recommended by Harvard University, the American Geographic Society, and the National Academy of Science as a scientific member of the Graf Zeppelin polar flight proposed by the Central Office of Aeroarctic in Berlin. He was the only American invited by the sponsors of the expedition. The flight was made from July 24 to August 1, 1931, with RADM Smith, then a Lieutenant Commander, acting as observer and navigator of the dirigible. It was the longest non-stop flight ever made by the Graf Zeppelin, constituting a cruise of six days and coverage of 8,000 miles in the area of the Arctic Circle for the purpose of collecting data on terrestrial magnetism, atmospheric electricity, and aerogeodesy. From this expedition, he gathered much information which was of importance to the Ice Patrol.

Prior to that trip, on June 19, 1930, he was awarded the Degree of

Doctor of Philosophy in geologic and oceanographic physics by Harvard University as a result of original work and extensive thesis.

By June 1936, he was in command of the Cutter TAHOE, and in February 1937, took command of the newly built Cutter JOHN C. SPENCER, both of which were assigned duties in Alaskan waters. While with the latter he was cited by the Navy Department for his rescue of the crew of the USS SWALLOW from Kanaga Island in February 1938.

In October 1938, he became Commanding Officer of the Cutter CHELAN of Boston. He then was designated Commander, International Ice Patrol for the seasons of 1939 and 1940.

WORLD WAR II:

On June 1940, he was assigned as commanding officer of the Cutter NORTHLAND and as Commander of the Greenland Patrol. This patrol consisted mainly of Coast Guard cutters which assisted the Army and Navy in establishing the military defense of Greenland. In its earliest days, the Patrol's mission consisted of surveying the area and estimating the probable actions of the Nazis. At that time RADM Smith prepared and placed into effect a plan for defenses which involved the evacuation of Danish and Norwegian civilians scattered over the territory, and the organization of these trappers into a Greenland government operated sledge patrol. As a direct result of this administration, the first violation of the United States-Greenland agreement was foiled when in September 1941, a German agent and secret codes were captured in Northeast Greenland by the Greenland Patrol. Enemy forces were repeatedly prevented from establishing a foothold in Greenland during the ensuing war years.

He remained in command of the Greenland Patrol until November 1943, during World War II, during which he advanced to Captain then to Rear Admiral. He then served as Commander, Task Force 24, U. S. Atlantic Fleet until the end of the war. Rear Admiral Smith was the first Coast Guardsman awarded the Distinguished Service Medal for World War II service, for which he was cited as follows:

> "For exceptionally meritorious service to the Government of the United States in a duty of great responsibility as Commander of the Greenland Patrol and later as Commander of a Task Force in the Atlantic Fleet from December 1941 to November 1944. During the critical years of 1942 and 1943, Rear Admiral Smith planned, built, organized and efficiently administered the naval bases and stations in Greenland and in the Arctic for the support of the Army in those areas and the Naval control of the North Atlantic. Under extremely difficult conditions, the forces of his command successfully operated patrol and escorts, maintained a system of weather stations and provided full logistic and tactical support for the Army. As Commander of a Task Force in these strategic waters, he skillfully directed vital weather, patrol and escort services which were of inestimable assistance in connection with the ferrying of aircraft and the operation of transport planes to and from the European theaters of war and effectively protected valuable convoys. In all his negotiations and contacts, Rear Admiral Smith distinguished himself by his splendid diplomacy, sound judgment and intelligent planning and consistently maintained excellent relations with other United States forces and those of the Allied Nations. His superior tactical knowledge and steadfast devotion to duty throughout these important years were in keeping with the highest traditions of the United States Naval Service."

/s/ JAMES FORRESTAL

His other service campaign medals and ribbons included the American Defense Service with Sea Clasp, European-African-Middle Eastern Area, World War II Victory. He also received the Cross of the Commander of the Order of Danneberg First Class from the King of Denmark for services in Greenland.

In August 1945, Rear Admiral Smith was assigned as Commander, Third Coast Guard District, New York, and later (in May 1946) was designated the additional post of Commander, Eastern Area. He was also Captain-of-the-Port of New York, having supervision of all activities in this respect in the states within the Third District boundaries. In addition to these duties he served on the Staff of Applied Physics Laboratory of the John Hopkins University from 1946 to 1949. He was also Project Leader, Weapons System Evaluation Group, Office of the Secretary of Defense from 1949 to 1951. He retired from his New York post on June 30, 1950, with more than 40 years of Coast Guard service. At that time he accepted the position of Director of the internationally famous Oceanographic Institution at Woods Hole, Massachusetts, of which he had been a trustee for several years, and where he remained until 1956. He was appointed to the Naval Research Advisory Committee, Department of the Navy, on February 15, 1953. From the first of his retirement on, he continued to be active in promoting the Coast Guard's safety program with shipping and with aircraft flying over water areas.

Rear Admiral Smith was a member of the American Geophysical Union, the Arctic Institute of North America, the Aero-Arctic Society, and the Propeller Club of New York. He held an unlimited master's license in the American Merchant Marine. He also lectured at the University of Washington. Rear Admiral Smith leaves his wife, Mrs. Isabel B. Smith, formerly Miss Brier of Malden, Massachusetts, and three children, Porter Hulsart, Stuart Edward, and Jermiah.

The remains of Rear Admiral Smith are being shipped to Boston for cremation, after which services will be held at the Church of Messiah, Woods Hole, Massachusetts, at 2:00 p.m., Wednesday, November 1, 1961. Burial will be conducted at Martha’s Vineyard, Massachusetts, on Thursday November 2.

31 October 1961

EXTRA DATA ON RADM EDWARD H. "ICEBERG" SMITH, USCG (RETIRED/DECEASED)

Rear Admiral Smith wrote a number of articles on Arctic ice and ocean currents which were published. Among his early works which earned him a Ph.D. Degree from Harvard were the following:

1922 - Some Meteorological Aspects of the Ice Patrol Work in the North Atlantic. The Monthly Review, Volume 10, No. 12, Washington.

Report of Physical Observations. International Ice Observation and Ice Patrol Service in the North Atlantic Ocean. Season of 1921. U. S. Coast Guard Bulletin No.9, pp 49-60, Charts D-H, Washington.

1923 - Oceanographer's Report. Discussion of Profiles 1-14. Oceanographic Summary. Season of 1922. Ibid. Bulletin No. 10, pp 44-56 and 84-97, 12 charts. Washington.

1924 - Oceanographer's Reports. Discussion of Profiles 1-15. Oceanographic Summary. Oceanographic Cruise, October 11-26, 1923. Summary of Oceanographic Cruise, October 21-26, 1-23, Ibid. Bulletin No. 11, pp 70-160, 8 charts Washington.

Oceanographer's report. Discussion of the Sub-Surface Investigation, oceanographic Summary. Season of 1924. Ibid. Bulletin No. 12, pp 63-147, sketches and figures, charts A-M. Washington.

1925 - The International Ice Patrol. The Meteorological Magazine. The Meteorological Committee, Air Ministry, Vol. 60, No. 713, London.

1926 - A Practical Method for Determining Ocean Currents. United States Coast Guard Bulletin No.14, p. 50, with illustrations, Washington.

Oceanography for the Ice Patrol. Bulletin of the National Research Council, Volume ll, Part 2, No.56, pp 106-112. Washington.

1927 - Weather. Ice Observation. Oceanography. International Ice Observation and Ice Patrol Service in the North Atlantic Ocean. Season of 1926. U. S. Coast Guard Bulletin No.15, pp 31-80, 53-124. Washington.

The Drift of Ice in the North Atlantic. Pilot Chart of the

North Atlantic Ocean for March. U. S. Hydrographic Office, Washington.

Weather, Ice Observation. Oceanography. International Ice Observation and Ice Patrol Service in the North Atlantic Ocean. Season of 1927, U. S. Coast Guard Bulletin No. 16, pp 33-50,52-119. Washington.

Oceanographic Investigations of the International Ice Patrol. Bulletin of the National Research Council, No. 61, pp 212-217 Washington.

1929 - The North Atlantic Ice Menace and the Work of Protection Conducted by the U. S. Coast Guard. United States Naval Institute Proceedings, Volume 53, No. 315, pp 393-400 Annapolis.

Appendix E

Integration and Operational Evaluation of the Maritime Surveillance System 5000 with Side-Looking Airborne Radar for Iceberg Reconnaissance

Lisa K. Mack and Donald L. Murphy

Introduction

Since 1983, International Ice Patrol has used the Motorola AN/APS-135 Side-Looking Airborne Radar (SLAR) as its primary iceberg detection sensor (Table 1). Robe et al. (1985), Rossiter et al. (1985) and Alfultis and Osmer (1990) document the iceberg detection capability of the SLAR under a variety of environmental conditions. Though it uses dated technology, the SLAR is fundamentally sound and has several more years of useful service. However, the image display system, that used dry process photographic film, was difficult to maintain and no longer met Ice Patrol's needs. Prior to the 2001 ice season, the U.S. Coast Guard integrated Swedish Space Corporation's (SSC) Maritime Surveillance System (MSS) 5000 with the SLAR to provide real-time digital data acquisition, display and archiving.

Real Aperture Radar (Motorola)
Frequency: X-Band
Peak Power: 200 kilowatts
Polarization: VV
Range Resolution: ~30 meters
Azimuth Resolution: 0.5°

Table 1. Summary of the specifications of the AN/APS-135 SLAR.

This report describes a series of iceberg detection tests conducted prior to, and in the early part of the 2001 ice season to document the system's performance. Since no fundamental changes were made to the SLAR, the tests focused on the use of the MSS 5000 display to detect icebergs. Ice Patrol's objective was to ensure that MSS 5000 allowed operators to detect icebergs at least as well as the film recorder and to expand Ice Patrol's knowledge of the capability of the SLAR. The tests also provided an opportunity for the operators to gain experience using the new system, which provides a vastly improved, but more complex, user interface. From January through May 2001, Ice Patrol conducted three evaluation flights in conjunction with routine airborne reconnaissance using icebergs off the Labrador and Newfoundland coasts as test targets. The objectives of the evaluation flights were to compare iceberg detection by MSS 5000 with SLAR film and to evaluate the ability of MSS 5000 to detect small icebergs (< 60 meters in length), the iceberg size on which Ice Patrol bases its reconnaissance strategy. In addition, the test flights provided the operators an opportunity to determine optimum gain and sea state settings for iceberg detection under various sea conditions.

Figure 1. MSS 5000 system installed at right operator station of aircraft pallet.

MSS 5000 Description

The Maritime Surveillance System was developed by SSC for the Swedish Coast Guard's ocean pollution surveillance and has been in operation in Sweden for over 20 years. The U.S. Coast Guard integrated the current version of the system, MSS 5000, with its existing Motorola AN/APS-135 SLAR to modernize and extend the life of the radar. MSS 5000 hardware includes the sensor data processor (SDP) for acquiring and processing raw data, a data server that manages the local area network (LAN) onboard the airplane and has redundant hard drives for recording data, a mission management unit for displaying data, and a display station. There are also several ground-based display stations for analyzing data and conducting operator training.

MSS 5000 digitizes data from SLAR at a rate that corresponds to 30 meters of flight track, with a resulting pixel size of 30 meters by 30 meters. MSS 5000 also acquires navigational data from the aircraft's global positioning system (GPS) to determine target position. The geometric correction of slant range to ground range is calculated in the SDP before the image is released to the LAN for display and recording. For purposes of database management, MSS 5000 records the full SLAR range all of the time, regardless of the range scale being used by the operator.

The following summarizes the major improvements achieved by integrating MSS 5000 and SLAR:

- Real-time display of SLAR data (The film recorder had a five-minute delay due to the developing process, making it difficult for operators to correlate SLAR targets with information from other sensors).
- Real-time geo-correction of all sensor data with GPS accuracy.
- Digital data acquisition and archiving.
- Flexible image display system with the capability to zoom on targets, freeze the display and annotate SLAR images.
- Full sensor range recorded independent of operator’s display.
- Capability to plot aircraft flight tracks and SLAR images on digital chart and export data to geographic information systems.
- Digital SLAR data provides the opportunity to implement image enhancement and automatic detection software.

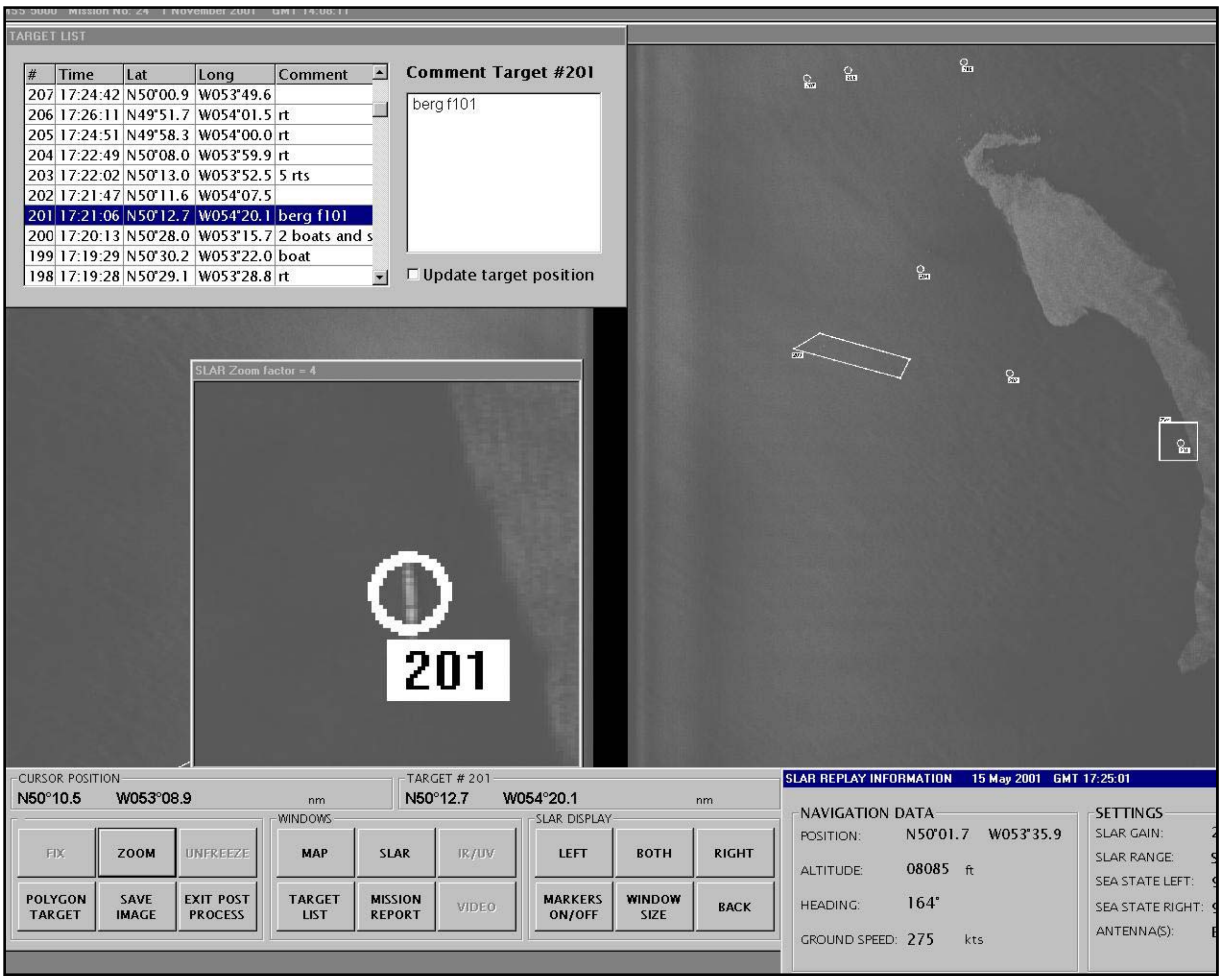


Figure 2. MSS 5000 system display including normal operator display overlaid with target list and zoom window. Target #201 was identified as an iceberg near sea ice.

Iceberg Detection Experiments

Results of three separate test flights (January 30, April 29 and May 2, 2001) are reported here.

January 30, 2001

Due to high seas and severely weathered iceberg targets, the first test flight provided the most challenging iceberg detection environment of the three test flights. The goals were simple: determine if MSS 5000 displayed the same iceberg targets as the film and determine how reliably the iceberg targets could be detected using MSS 5000.

Description of the Experiment. The test used five icebergs as targets, four of which were originally detected by the AN/APS-137 Forward-Looking Airborne Radar (FLAR) operator, who identified them as icebergs. When the aircraft descended to photograph the icebergs and obtain size estimates before conducting the MSS 5000 test, another iceberg was detected visually. This iceberg, the smallest (#4), was never detected on FLAR. Because of low light conditions, the photographs were poor quality, but the ice observer in the window was able to estimate iceberg sizes (Table 2) with a binocular reticule. The wave height at the time of low-level visual survey was estimated to be 5 meters and there were many whitecaps on the ocean surface.

A parallel search with 10 NM track spacing (Figure 3), was conducted from 6400 feet, a typical IIP reconnaissance altitude. The search pattern was designed to obtain iceberg detection opportunities at various ranges up to 50 NM using both the left and right radar antennas. A detection opportunity is defined simply as the target passing through the radar's swath. The orientation of the search legs was chosen without regard to the direction of the wind and waves.

ICEBERG #	*LATITUDE*	*LONGITUDE*	*SIZE CLASS*	*LENGTH (m)*	*SHAPE*
1	50-06 N	51-18 W	Medium	64	Blocky
2	50-10 N	51-21 W	Small	28	Non-tabular
3	50-12 N	51-21 W	Small	41	Non-tabular
4	50-15 N	51-27 W	Small	18	Non-tabular
5	50-15 N	51-30 W	Medium	55	Non-tabular

Table 2. List of iceberg targets for the January 30, 2001 evaluation.

Note: The size class was determined by the iceberg's length. Iceberg #5 was on the borderline between small and medium and therefore, according to IIP's standard practice, is classified as a medium iceberg. All the icebergs were in an advanced stage of deterioration and did not extend more than 5 to 10 meters above the ocean surface. In fact, none of the icebergs met the minimum height requirement to be classified as a medium iceberg (16 meters above the water).

The search was conducted twice, once with the SLAR set at high Pulse Repetition Frequency (PRF) and a second time at low PRF. The reason two PRF settings were used was to provide detection opportunities at ranges greater than 27 NM, a radar range setting that requires the lower PRF. After completing the northernmost leg of the search pattern (60 NM from original line) the track was reversed, the radar was set to low PRF and the search pattern reversed. Gain and sea state adjustments were set at 35% and 9, respectively, and were not changed during the test.

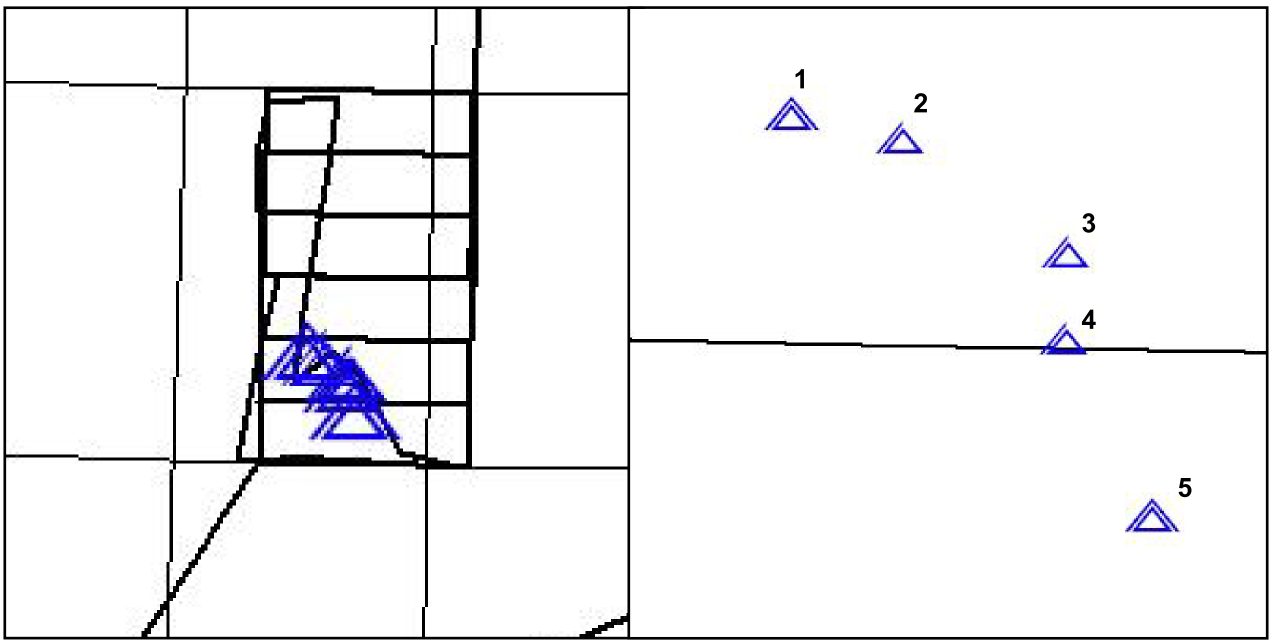


Figure 3. Test pattern and iceberg distribution for the January 30, 2001 evaluation.

Results. The following results are based on post-flight analysis of the film and MSS 5000 data.

Comparisons between film and MSS 5000 display. Due to the poor quality of the film recorder images when the radar was set to low PRF, direct comparison between the MSS 5000 images and the film was possible for only one leg of the search. On this leg, the icebergs ranged from 16 to 25 NM from the aircraft. The film clearly showed four of the icebergs, three visible with the unaided eye, and one with the aid of a loupe (magnifying glass). The smallest iceberg (#4) was not seen on the film. Locating the icebergs on the MSS 5000 display depended on the range setting of the display. The greater the data compression required to show the image on the MSS 5000 display station, the less likely the targets could be seen. Although the four icebergs could be seen using 2X2 data compression, full resolution (no data compression) provided a superior image that was comparable and, perhaps, slightly better than the film. The MSS 5000 display did not show iceberg #4 on the leg for which the comparisons were made.

Review of the MSS 5000 data. MSS 5000 data were reviewed using a replay station to determine how many times the known icebergs were seen during the test flight. This test of the ability to locate an iceberg using the MSS 5000 is certainly not the same as an un-alerted radar operator flying over the North Atlantic. The analyst knew where the targets were and simply determined whether there was an image of a target at that location. Therefore, the results of this test are not appropriate for determining the probability of detection. Furthermore, there were not enough detection opportunities at the various ranges to segment the data according to the iceberg's range from the aircraft. Nonetheless, the results (Table 3) are useful in understanding the performance of the SLAR with the MSS 5000 system.

ICEBERG #	***SIZE CLASS***	***LENGTH (m)***	***DETECTION OPPORTUNITIES***	***DETECTIONS***
1	Medium	64	12	12
2	Small	28	8	7
3	Small	41	11	10
4	Small	18	13	1
5	Medium	55	12	11

Table 3. Summary of detection results for the January 30, 2001 evaluation.

The two medium icebergs were detected in 23 of 24 opportunities, with the smaller iceberg accounting for the only missed opportunity. The three small icebergs were detected in 18 of 32 opportunities, with the smallest iceberg accounting for 12 of the 14 missed opportunities.

Figure 4. Low-profile iceberg from the January 30, 2001 evaluation.

April 29, 2001

Description of the Experiment. The goal of the test conducted on April 29, 2001 was to determine the effect of varying the gain setting on the ability of the MSS 5000 to display icebergs. Wind and sea height were approximately 25 KT and 1.5 meters, respectively. The ice targets included one 34 meter-long iceberg (small, non-tabular) and two nearby growlers (< 15 meters). The search pattern was simply a series of boxes flown at an altitude between 6000 and 8000 feet around the targets at ranges varying from 5 NM to 15 NM from the icebergs, with most of the detection opportunities occurring at a distance of about 10 NM.

Results. Although the target image quality (target brightness and definition) was best at high gain settings, the small iceberg was detected on 19 of 19 opportunities, without regard to the gain setting. The two growlers were detected on 27 of 38 opportunities (71%). Most of the missed detection opportunities (7 of 11) were on east-west legs, where the radar was looking across wave trains, which can obscure small targets. The remainder of the missed detection opportunities for the growlers (4 of 11) were at the longest range (15 NM) or lowest gain setting (5%).

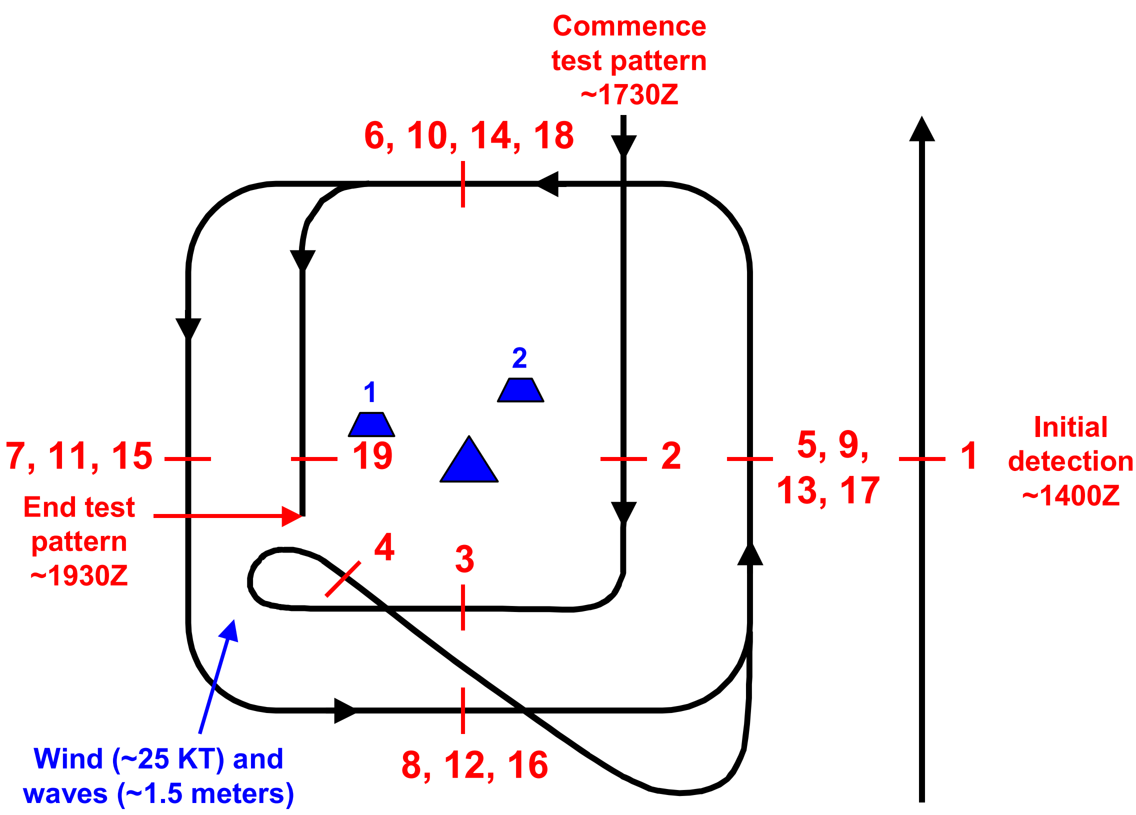


Figure 5. Test pattern and iceberg distribution for the April 29, 2001 evaluation. Numbers in red indicate detection opportunity.

May 2, 2001

Description of the Experiment. The May 2, 2001 test had the same goal as that on April 29: determine the best gain setting, this time with slightly higher wind conditions (~35 KT) and sea height (~2 meters). Again, the ice targets included one small iceberg (37 meter-long non-tabular) and two growlers. The box search pattern flown at an altitude between 6000 and 8000 feet was repeated with the addition of three parallel legs to obtain detection opportunities at longer ranges (20 NM and 25 NM). However, most of the detection opportunities were at the 10 NM range.

Results. As in the April 29 test, the target image quality (targets brightness and definition) was best at high gain settings. The small iceberg was detected on 23 of 25 opportunities (92%) at all gain settings and all ranges. Both iceberg misses were on the northbound leg with aircraft turning into wind and taking longer to get on course. The two growlers were sighted visually and not detected on FLAR or SLAR on any of the search legs.

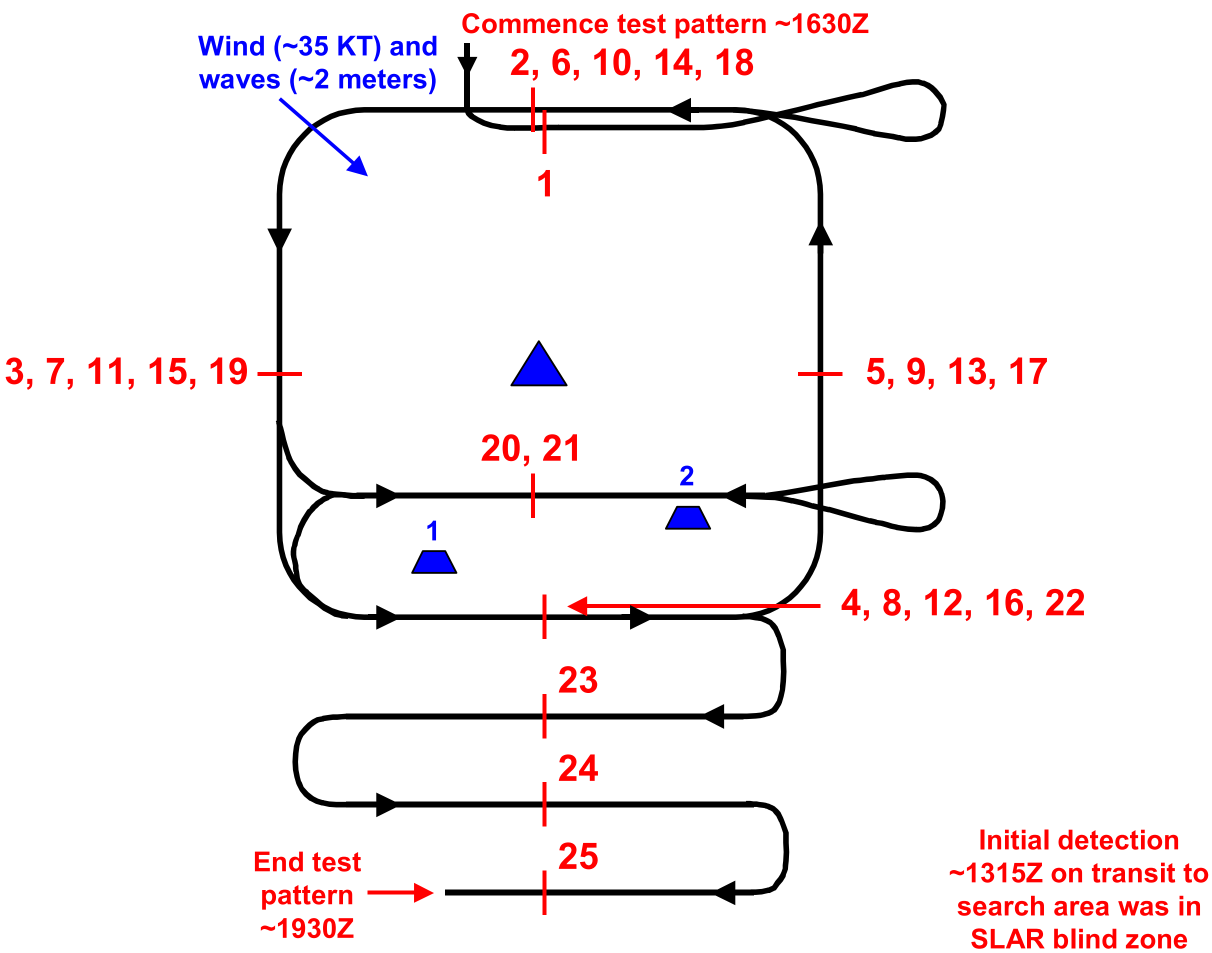


Figure 6. Test pattern and iceberg distribution for the May 2, 2001 evaluation. Numbers in red indicate detection opportunity.

Conclusions

Based on limited data from the evaluation flight of January 30, we conclude that MSS 5000 has the same detection capability as the film. The operator's choice of the range of the display is critical to the operator's ability to locate a target on the image shown on the screen. The data compression required for the primary display used by the operator should not exceed two by two pixels. Displaying the data at full resolution is preferable.

More important is the performance of the MSS 5000 in detecting the five icebergs during the flight. Of the 24 detection opportunities against medium icebergs, there were 23 detections (96%). The two medium icebergs used for the test were on the low end of the medium scale according to length and neither fit the medium size criterion for height. Thus, these were particularly difficult targets given the high sea state on the test date.

The performance against small icebergs was not nearly as good, with 18 detections in 32 detection opportunities (56%). The smallest iceberg (18 meters) accounted for 12 of the 14 detection misses. This iceberg was barely in the small size range (15 to 60 meters) according to length, hence was a particularly challenging target in high states.

When the results from April 29 and May 2 are combined, the tests showed good detection performance against small icebergs (42 of 44 opportunities) in relatively low seas (~1.5 meters). The detection performance against growlers was mixed. On the first day, there were 27 detections in 38 opportunities. The detection failures seemed to be related to long range, low gain settings, or the fact that the growlers were obscured by waves. On the second date, with only a minor increase in wave height, from 1.5 to 2 meters, there were no detections by either the SLAR or the FLAR.

Based on field testing, Ice Patrol found that the MSS 5000 display system meets its operational iceberg reconnaissance needs. When the SLAR images are displayed at full resolution, the MSS 5000 has the same or slightly better iceberg detection capability than the film. During the tests, many recommendations were developed to refine the user interface.

The system was evaluated and used operationally on 29 iceberg reconnaissance patrols during the 2001 season. Due to a light iceberg season fewer than 100 icebergs were detected with the new system. However, the detection of over 1000 ships allowed operators to gain experience operating the system in various environmental conditions. Subsequent opportunities for iceberg detection are expected to increase operator experience with the system.

References

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