Homeland Security
United States Coast Guard

Report of the International Ice Patrol in the North Atlantic

Commemorating Sixty Years of Aerial Iceberg Reconnaissance

2006 Season
Bulletin No. 92
CG-188-61

Homeland Security

United States Coast Guard

Report of the International Ice Patrol in the North Atlantic

Commemorating Sixty Years of Aerial Iceberg Reconnaissance

2006 Season
Bulletin No. 92
CG-188-61

Bulletin No. 92

Report of the International Ice Patrol in the North Atlantic

Season of 2006

CG-188-61

Forwarded herewith is Bulletin No. 92 of the International Ice Patrol (IIP), describing the Patrol's services and ice conditions during the 2006 season. The 2006 season marks only the second time in IIP's history that no icebergs were sighted or drifted south of 48° N. This Bulletin's Ice and Environmental Conditions section presents a fascinating discussion on the oceanographic and meteorological variables at play in this and other light seasons. Still, Ice Patrol personnel vigilantly monitored iceberg danger and stood ready to begin broadcasting daily limit of all known ice warnings but conditions never warranted this measure. Transatlantic shipping was the primary benefactor – saving hundreds of miles on each voyage when compared to a severe season transit. The 2006 season also marked the first operational use of an iceberg database synchronized between IIP and the Canadian Ice Service (CIS). Appendix D of this Bulletin describes the process in greater detail. This milestone underscores the strength of this international partnership and the value of the broader North American Ice Service (NAIS), which is an alliance between IIP, CIS & the U.S. National Ice Center. NAIS was created in 2003 to meet the combined ice information requirements of the U.S. and Canadian Governments. Appendix E provides more details on NAIS.

The men and women of the IIP are proud of the work that this Bulletin represents and would be delighted to address any questions you may have on the information presented within. Please read and enjoy!

M.R. Hicks

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

International Ice Patrol
2006 Annual Report

Contents

Cover photograph: CG7254 (foreground), last of the B-17 Flying Fortresses (designated PB-1G for USCG use) sits on the runway at CGAS Elizabeth City in 1960, alongside an HC-130 Hercules and an R5D-3, all used for IIP operations in the years since 1946. The 2006 ice season marked the 60th anniversary of Ice Patrol utilizing aerial reconnaissance.

Abbreviations and Acronyms

AOR	Area of Responsibility
AXBT	Air-deployed eXpendable BathyThermograph
BAPS	iceBerg Analysis and Prediction System
CAMSLANT	Communications Area Master Station atLANTic
CCG	Canadian Coast Guard
CIS	Canadian Ice Service
DDH	callsign for Hamburg Germany
DDK	callsign for Pinneberg Germany
FLAR	Forward-Looking Airborne Radar
GMES	Global Monitoring for Environment and Security
HF	High Frequency
HMCS	Her Majesty's Canadian Ship
IIP	International Ice Patrol
INMARSAT	INternational MARitime SATellite (also Inmarsat)
IRD	Ice Reconnaissance Detachment
KT	Knot
LAKI	Limit of All Known Ice
M	Meter
MB	Millibar
MCTS	Marine Communications and Traffic Service
M/V	Motor Vessel
NAO	North Atlantic Oscillation
NIC	National Ice Center
NIK	callsign for CAMSLANT
NM	Nautical Mile
NMF	callsign for USCG Communications Station Boston
NTIS	National Technical Information Service
PAL	Provincial Aerospace Limited
RADAR	Radio Detection And Ranging (also radar)
RMS	Royal Mail Steamer
SOLAS	Safety Of Life At Sea
SLAR	Side-Looking Airborne Radar
VON	callsign for MCTS St. John's
WOCE	World Ocean Circulation Experiment

Introduction

This is the 92nd annual report of the International Ice Patrol, which is under the operational control of Commander, U.S. Coast Guard Atlantic Area. The report contains information on IIP operations, environmental conditions, and iceberg conditions in the North Atlantic during 2006. Funded by 17 member nations and conducted by the U.S. Coast Guard, Ice Patrol was formed soon after RMS *Titanic* sank on 15 April 1912. Since 1913, except for periods of World War, Ice Patrol has been monitoring iceberg danger on and near the Grand Banks of Newfoundland and broadcasting the Limit of All Known Ice to mariners. The activities and responsibilities of IIP are delineated in U.S. Code, Title 46, Section 738, and the International Convention for the Safety of Life at Sea, 1974.

The International Ice Patrol conducted aerial reconnaissance from St. John's, Newfoundland, to search for icebergs in the southeastern, southern, and southwestern regions of the Grand Banks. Lighter-than-normal ice conditions in 2006 never warranted issuing daily ice warnings. Instead, IIP issued ice-chart and bulletin updates each Friday from 17 February to 1 July 2006. In addition to IIP reconnaissance data, Ice Patrol received iceberg reports from other aircraft and mariners in the North Atlantic. At the Operations Center in Groton, Connecticut, personnel analyzed iceberg and environmental data and used the BAPS computer model to predict iceberg drift and deterioration. Based on the model's prediction, IIP produced the weekly chart and text bulletin on Fridays. In addition to these routine broadcasts, IIP responded to individual requests for iceberg information.

VADM Vivien S. Crea was Commander, U. S. Coast Guard Atlantic Area until May 2006 when she was relieved by VADM D. Brian Peterman. CDR Michael R. Hicks was Commander, International Ice Patrol.

For more information about the International Ice Patrol, including iceberg bulletins and charts, visit our website at http://www.uscg.mil/lantarea/iip/home.html.

Summary of Operations

As mandated by the International Convention for the Safety of Life at Sea (SOLAS) and U.S. Code, International Ice Patrol (IIP) monitors iceberg danger near the Grand Banks of Newfoundland from 15 February to 01 July. This time period is regarded as the Ice Season because the Grand Banks are normally iceberg-free from August through January. In practice, however, IIP services will commence whenever iceberg populations pose a significant threat to the primary shipping routes between Europe and North America and continue for the duration of that threat. The severity of ice conditions dictates the frequency of IIP product distribution. Weekly products commence the first Friday following 15 February and continue until such time that the severity of the ice conditions necessitates that daily products be transmitted.

In 2006 IIP actively monitored the iceberg danger to transatlantic shipping in the region bounded by 40°N, 50°N, 39°W, and 57°W (**Figure 1**). For the 2006 Ice Season, IIP began issuing weekly products on 17 February 2006. Due to light ice conditions, daily products were not required throughout the season. IIP monitored iceberg populations, and issued weekly products through 01 July 2006. Note: All of the statistics reported in this summary are taken from data gathered during the 17 February through 01 July 2006 time frame mentioned above.

IIP's Operations Center in Groton, Connecticut analyzed 775 information reports from IRDs, merchant ships, Canadian Ice Service iceberg and sea-ice reconnaissance flights, the National Ice Center, and other sources (**Figure 2**). Of these reports, 123 contained ice information (**Figure 3**). These ice

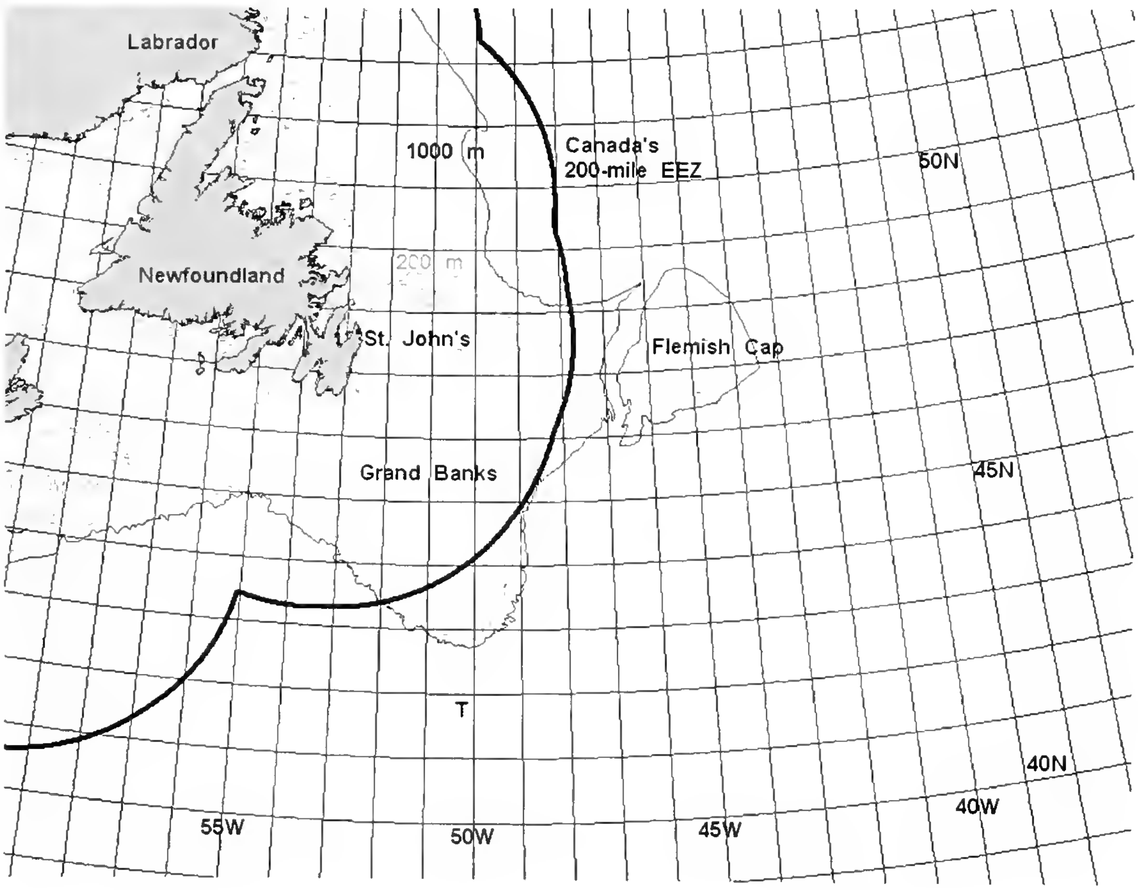


Figure 1. IIP's operating area. **T** indicates location of *Titanic*'s sinking.

reports potentially contained single or multiple iceberg sightings, stationary radar targets, and sea-ice. From these reports, 125 individual targets were merged into the Ice Patrol's modeling system (BAPS). **Figure 4** highlights the reporting source of sightings merged into BAPS.

Information Reports

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

Merchant shipping provided the vast majority of reports received by IIP. In 2006, 79 ships from 25 countries provided IIP with 675 reports (87% of the total reports received) demonstrating that the number of nations that used IIP services exceeded the 17 member nations supporting IIP under SOLAS. Furthermore, the international merchant fleet's high level of participation indicated the value placed on IIP products and services.

Ice Patrol relies heavily on the support of merchant traffic transiting through the operational area, both for reports of icebergs, and sea surface temperatures (SST) to aid in iceberg melt and deterioration predictions. In 2005, IIP initiated a program to recognize the ship or station that made the most contributions through SST or iceberg reports. Named after *Carpathia*, which came to the aid of the victims of *Titanic*, the *Carpathia* Award is presented annually to the ship that makes the most information reports. In 2006, the M/V *Mattea*, home ported in Arnold's Cove Station, Newfoundland was the recipient, with 131 reports of SST and ice. Ice Patrol salutes *Mattea* for providing the most ship reports two years in a row. Appendix B lists all of the ships that provided information reports, including weather, sea surface temperature, ice, and stationary radar target reports.

While the vast majority of information reports were received from merchant shipping, IIP received valuable information from other sources as well. For example, the Canadian Government, which includes reports from the CIS reconnaissance airplane, contract reconnaissance flights by Provincial Airlines, HMCS vessels at sea, and even coastal lighthouses, provided 62 reports (8% of the total reports received). **Figure 2** provides a thorough breakdown of the sources for all information reports handled during 2006.

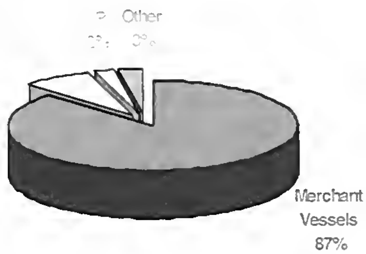


Figure 2. Reporting sources of the 775 information reports received at Ice Patrol during 2006. Information reports including ice, sea surface temperature, and weather reports.

Ice Reports

In 2006, 123 of the 775 information reports (16% of all reports) contained data on icebergs. Differing from information reports, the Canadian Government provided 51% of the iceberg reports, followed by the merchant vessel fleet with 28% and the IIP reconnaissance detachment with 14%. The remaining 7% of ice reports were received from other sources. **Figure 3** displays a breakdown of these iceberg reporting sources.

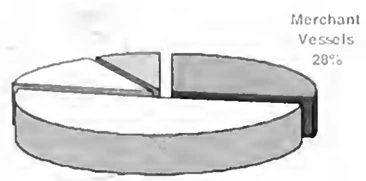


Figure 3. Reporting sources of the 123 ice reports received during 2006. Ice reports include individual iceberg sightings, and stationary radar target information.

Merged Targets

The 123 ice reports received by IIP contained 125 targets that were merged into BAPS, the drift and deterioration modeling system operated jointly between CIS and IIP. The Canadian Government reported 69% of the targets merged into the BAPS model while the merchant vessel fleet accounted for 25%, and the IIP Ice Reconnaissance flights accounted for 6% (**Figure 4**).

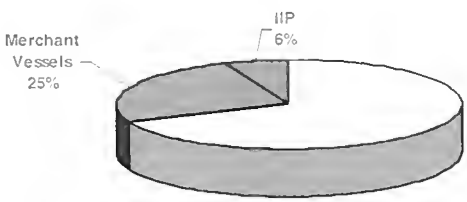


Figure 4. Reporting sources of the 125 individual targets merged into BAPS in 2006

LAKI Iceberg Sightings

SOLAS mandates that IIP guard the southeastern, southern, and southwestern regions of the Grand Banks. In doing so, IIP develops a Limit of All Known Ice (LAKI) in order to inform the mariner of the southernmost limits of the iceberg population. IIP did not create a LAKI in 2006 because there were no iceberg incursions into the shipping lanes. No bergs were sighted or drifted south of 48°N, the nominal northern extent of trans-Atlantic shipping routes. Therefore, no LAKI iceberg sightings occurred during this season.

Products and Broadcasts

IIP issued weekly ice chart and bulletin updates each Friday from 17 February to 01 July. The ice chart and bulletin were both valid for 1200Z. The ice chart was broadcast via HF Fax at 0438Z, 1600Z, and 1810Z. Both products stated that IIP was monitoring iceberg conditions, but was not issuing daily products.

Ice Patrol broadcast the weekly ice chart and bulletin updates by the same means that daily products are broadcast. U.S. Coast Guard CAMSLANT/NMF and Canadian Coast Guard Marine Communications and Traffic Service St. John's/VON were the primary radio stations that transmitted ice chart updates. The German Federal Maritime and Hydrographic Agency stations Hamburg/DDH and Pinneberg/DDK were the secondary stations for the ice chart transmission. In addition to these sources, the ice chart was also available via plain-paper facsimile, email on demand, and the World Wide Web.

Bulletin updates were delivered over the Inmarsat-C SafetyNET via the Atlantic East and West satellites. U.S. Coast Guard CAMSLANT/NMF and Canadian Coast Guard Marine Communications and Traffic Service St. Anthony/VCM transmitted bulletin updates via radio. Finally, like ice chart updates, bulletin updates were also available via the World Wide Web.

Historical Perspective

To compare ice years in a historical perspective, IIP uses two different measurements. The first is the length of time in days when daily products were issued during a given Ice Season (**Figure 5**). The second is the number of icebergs crossing south of 48°N (**Figure 6**). This measurement includes both icebergs initially detected south of 48°N and those that were originally detected north of 48°N but whose model position drifted south of 48°N. No daily products were issued in 2006 and no individual icebergs were sighted or experienced model drift south of 48°N.

Because no icebergs drifted south of 48°N in 2006, IIP never issued daily products. By all measures, 2006 was an extremely light ice year. **Table 1** lends some historical perspective to the lightness of the 2006 ice season.

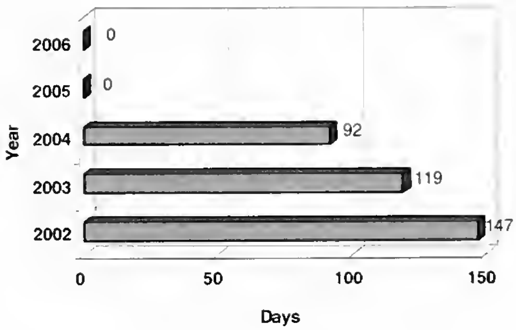


Figure 5. Length of ice season in days since 2002. The climatological (2004-2006) mean is 31 days.

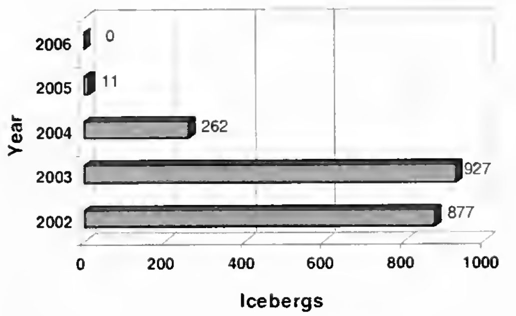


Figure 6. Count of individual icebergs (sighted and drifted) south of 48°N since 2002. The climatological (2004-2006)) mean is 91 icebergs.

Rank	Year	Bergs South of 48°N
1 (Tie)	2006	0
1 (Tie)	1966	0
3 (Tie)	1940	1
3 (Tie)	1958	1
5	1941	3
6	1951	8
7 (Tie)	1924	11
7 (Tie)	2005	11
9	1931	14
10	1952	15

Table 1. Ranking of historically light ice seasons based on cumulative number of bergs south of 48°N

Canadian Support

As they do every year, the Canadian Government generously supported IIP during 2006. The Canadian Ice Service shared its valuable reconnaissance data and ice expertise with IIP. This year marked the first time CIS & IIP operated with a synchronized database. Appendix D describes this achievement in detail. In addition, CIS provided IIP with critical support of BAPS. Finally, Provincial Aerospace Limited supplied IIP with invaluable ice data.

References

Alfultis, M. (1987). Iceberg Populations South of 48°N Since 1900. *Report of the International Ice Patrol in the North Atlantic*, Bulletin No. 73, 63-67.

Marko, S. R., Fissel, D. B., Wadhams, P., Kelly, P. M., & Brown, R. D. (1994). Iceberg Severity off Eastern North America: Its Relationship to Sea-ice Variability and Climate Change. *Journal of Climate*, 7(9), 1335-1351.

Iceberg Reconnaissance and Oceanographic Operations

Iceberg Reconnaissance

The Ice Reconnaissance Detachment (IRD) is a sub-unit under Commander, International Ice Patrol (IIP) partnered with Coast Guard Air Station Elizabeth City, which provided the aircraft platform for reconnaissance in 2006. IRDs deployed to observe and report sea-ice, icebergs, and oceanographic conditions on the Grand Banks of Newfoundland. Oceanographic observations were used for operational support and research purposes.

Ice Patrol's preseason IRD departed on 24 January 2006 to determine the early-season iceberg distribution. The iceberg distribution noted during the preseason and subsequent IRDs never warranted normal (once every two weeks) deployments to Newfoundland. Though IIP did not issue daily ice-limit products in 2006, IRDs deployed periodically between January and August to monitor iceberg conditions on the Grand Banks. Iceberg reconnaissance operations officially concluded on 24 August 2006 with the return of the postseason IRD.

Ice Reconnaissance Detachments were deployed to IIP's base of operations in St. John's, Newfoundland for 54 days during 2006 (**Table 2**). Ice Patrol flew 33 sorties, 16 of which were transit flights to and from St. John's. The 17 remaining sorties were iceberg-reconnaissance patrols to determine the extent of iceberg danger. In addition to the 33 sorties, four roundtrip logistics flights were conducted from Coast Guard Air Station Elizabeth City to maintain and repair IRD aircraft. **Figure 7** shows IIP's flight hours for 2006.

In 2006, Ice Patrol also continued support of GMES, successfully completing one ground-truth validation flight in conjunction with scheduled reconnaissance. GMES/PolarView is a project that coordinates the users and providers of satellite-gathered environmental and security information. For a fifth year, Ice Patrol participated as an end user of satellite reconnaissance through the GMES project's Polar View element, led by C-CORE, a global engineering firm specializing in remote sensing and geotechnical engineering.

IRD	Deployed Days	Iceberg Patrols	Flight Hours
Pre	11	2	44.5
1	Cancelled		
2	6	2	30.1
3	Cancelled		
4	9	2	22.0
5	6	3	27.9
6	6	3	28.2
7	Cancelled		
8	9	3	30.0
9	Cancelled		
10	4	2	19.0
Post	3	0	11.1
Total	**54**	**17**	**212.8**

Table 2. 2006 IRD summary (Flight hours include patrol, logistics, and transit hours.)

Ice Patrol used 212.8 flight hours in 2006, a 7% increase from 2005 (**Figure 8**). **Figure 9** compares flight hours with the number of icebergs south of 48°N since 1997. Iceberg population affects flight hours, but **Figure 9** demonstrates that IIP expends a fairly consistent number of flight hours independent of the highly variable number of icebergs from year to year. Ice Patrol maintains this consistency because even light years require

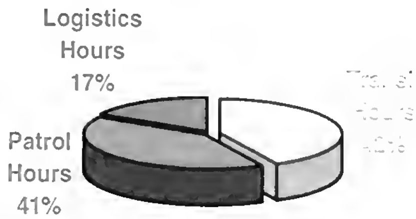


Figure 7. 2006 flight hours

flights to confidently declare the Grand Banks ice-free. Additional training requirements will necessitate a minimum number of flights in low-ice years to maintain a sufficiently qualified crew.

Coast Guard aircraft provided the primary means of detecting icebergs in the vicinity of the Grand Banks. To conduct iceberg reconnaissance, IIP used a Coast Guard HC-130H long-range aircraft equipped with the Motorola AN/APS-135 Side-Looking Airborne Radar (SLAR) and the Texas Instruments AN/APS-137 Forward-Looking Airborne Radar (FLAR). Ice Patrol began using SLAR in 1983, FLAR in 1993, and incorporated the Maritime Surveillance System 5000 with SLAR in 2000. 2006 became yet another technological milestone when the IIP began incorporating the Automatic Identification System (AIS) in the sensor package. This system is capable of tracking every equipped ship in VHF radio range, and displaying data which includes ship name, call sign, course and speed, classification, cargo, last port, destination, and other information. As a result of its ability to quickly identify ambiguous radar targets as ships, AIS has proven a valuable asset.

After a mishap involving a U.S. Forestry Service HC-130H in 2002, comprehensive inspections identified problems with the aircraft's center wing-support structure. The continued result of this mishap was significant limitations being placed on the 1500 series HC-130H aircraft, whose patrol-length maximum for IIP operations was reduced from 1,700 nm to 1,200 nm in excellent-moderate weather and 900 nm in moderate-marginal weather. These restrictions were in effect throughout the 2006 ice season. As of the date of the publication, CG 1500 and CG 1501 have passed depot-level inspection and are operating in an unrestricted capacity.

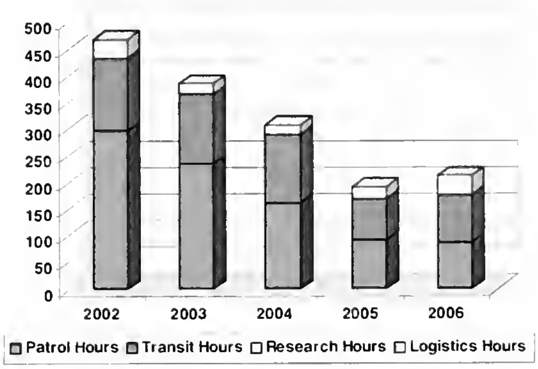


Figure 8. Breakdown of flight hours (2002-2006)

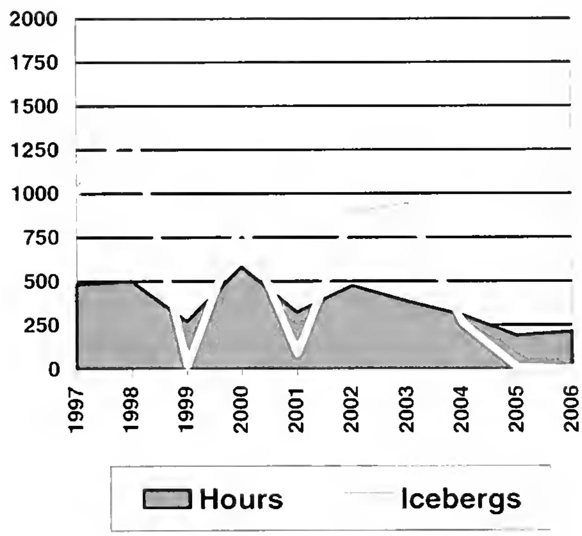


Figure 9. Flight hours versus icebergs south of 48°N (1997-2006)

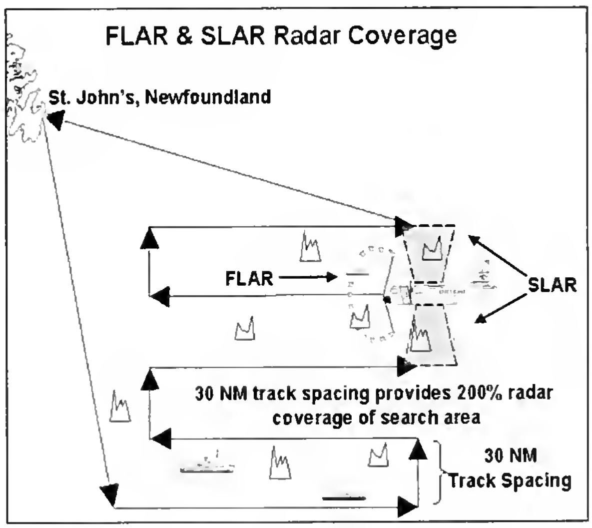


Figure 10. Radar reconnaissance plan

Environmental conditions on the Grand Banks permitted adequate visibility (≥10 nm) only 28% of the time during iceberg reconnaissance. Consequently, Ice Patrol relied heavily on its two airborne radar systems to detect and identify icebergs in cloud cover and fog. The combination of SLAR and FLAR enabled detection and identification of icebergs in pervasive low-visibility conditions, minimizing the flight hours necessary to accurately monitor the iceberg population. In addition, the SLAR-FLAR combination allowed IIP to use 30 nm track spacing and provide 200% radar coverage on each patrol despite poor visibility (**Figure 10**). A detailed description of IIP's reconnaissance strategy is provided at:
http://www.uscg.mil/lantarea/iip/FAQ/ReconnOp_10.shtml

Identifying the various types of targets on the Grand Banks is a perpetual challenge for IIP reconnaissance. Frequently, poor visibility forces the IRD to identify targets based solely on the nature of their radar image. Both SLAR and FLAR provide valuable clues to target identity, but in most cases, FLAR's superior imaging allows definitive target identification. **Figure 11** displays the number and types of targets that reconnaissance patrols detected during 2006. Reconnaissance detachments detected a total of 222 icebergs; 33% (74) were identified with radar alone (not seen visually), while the remaining 67% (148) were identified using a combination of visual and radar information or by visual means alone.

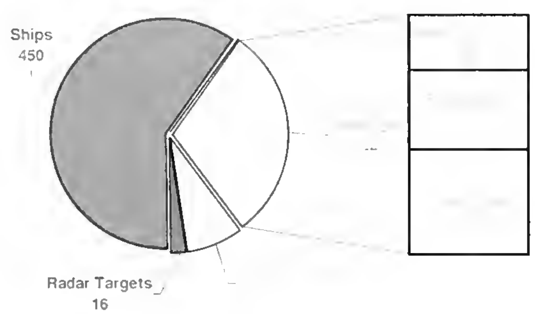


Figure 11. Breakdown of targets detected by IRDs in 2006

The Grand Banks are a productive fishing ground frequented by fishing vessels, ranging from 20 to over 70 meters in length. Determining whether an ambiguous radar contact is an iceberg or a vessel is particularly difficult with small targets. These contacts sometimes create similar radar returns and cannot easily be differentiated. Therefore, when a radar image does not present distinguishing features, Ice Patrol classifies the contact as a radar *target*.

The Grand Banks region has been rapidly developed for its oil reserves since 1997. 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. In addition to Hibernia, other drilling facilities—including Glomar Grand Banks, Terra Nova, and Henry Goodrich—are routinely on the Grand Banks. Consequently, this escalated drilling has increased air and surface traffic in IIP's area of responsibility, further complicating target identification. This difficulty is offset, however, by the information reports this traffic provides. Reports from ships, aircraft, and drilling platforms greatly aid IIP in the creation of ice limits that are as accurate and reliable as possible.

Oceanographic Operations

IIP's oceanographic operations peaked in the 1960s, when the U.S. Coast Guard dedicated substantial ship resources to collecting oceanographic data. Since that time, however, IIP's involvement in oceanographic surveys on the Grand Banks has declined. The decline is a result of numerous factors, three of which are the most significant. First, increased competition among various U.S. Coast Guard missions made it increasingly difficult for IIP to obtain the ship resources necessary to continue extensive oceanographic surveys. Second, because the capability and reliability of air-deployable oceanographic instruments has improved vastly, Ice Patrol can collect oceanographic data without the aid of ships.

Finally, the wide availability of oceanographic information now on the internet enables IIP personnel to focus on iceberg reconnaissance.

In 2006, IIP collected oceanographic data from air- and ship-deployed satellite-tracked drifting buoys. Satellite-tracked drifting WOCE buoys, drogued at a depth of fifteen or fifty meters, provided near real-time ocean-current information. Ice Patrol deployed WOCE buoys on the Grand Banks and in the offshore and inshore branches of the Labrador Current and used data from these buoys to modify the historical-current database within IIP's computer model.

During 2006, IIP deployed nine satellite-tracked drifting buoys – five from reconnaissance aircraft and four from Canadian Coast Guard ships (**Figure 12**).

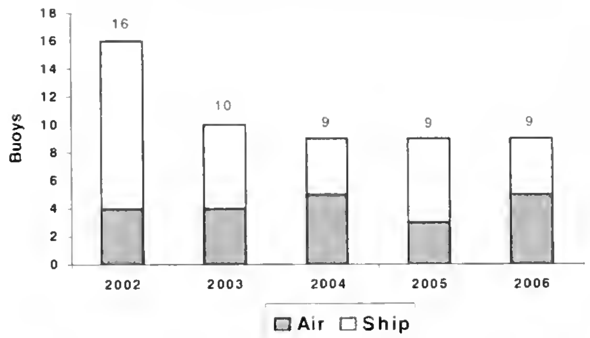


Figure 12. WOCE buoy deployments (2002-2006)

Figure 13 depicts composite drift tracks for the buoys deployed in 2006. Detailed drifter information is provided in IIP's *2006 WOCE Buoy Drift Track Atlas*, which is available upon request.

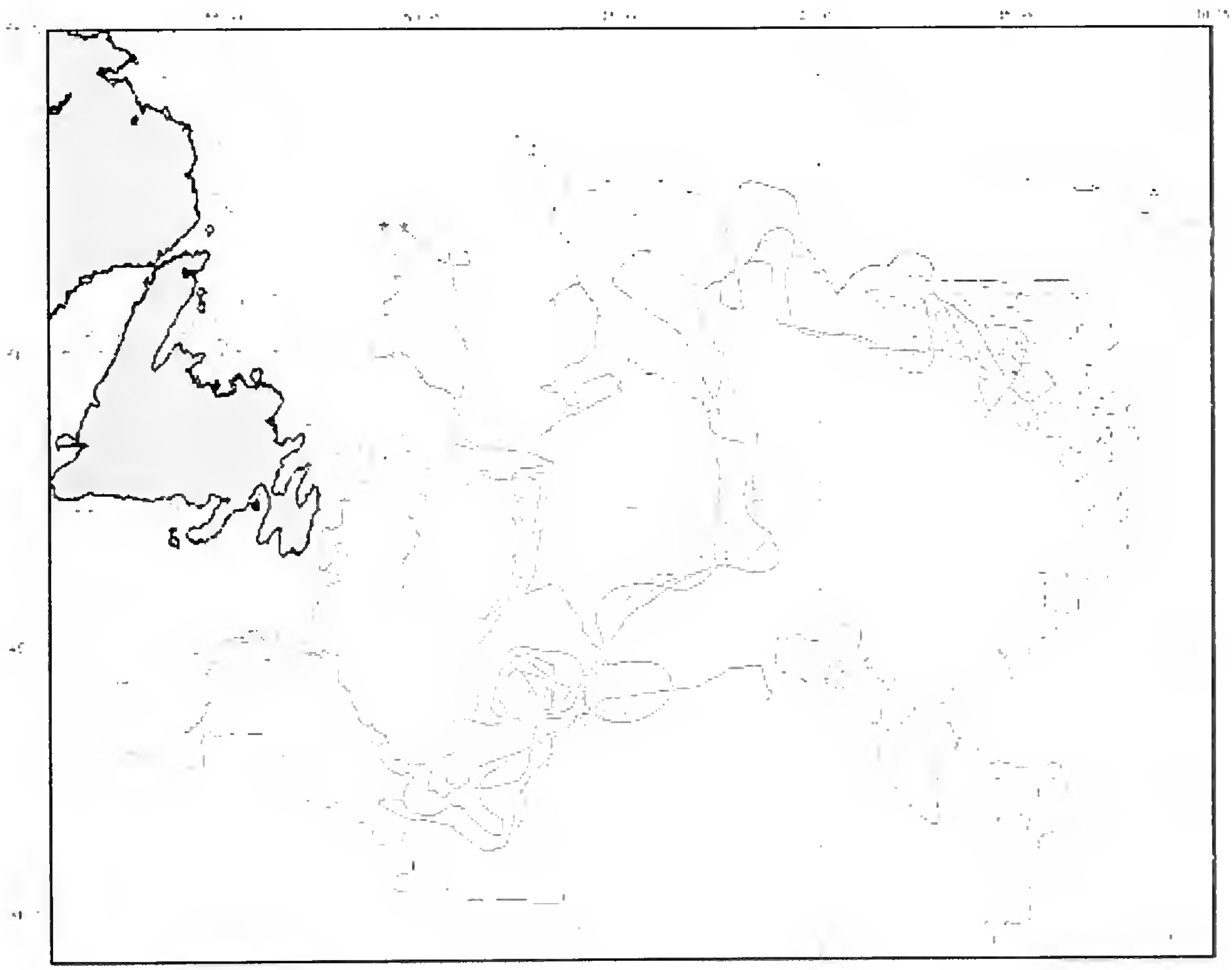


Figure 13 Composite buoy tracks. Blue stars represent drop locations of air-deployed buoys. Red stars represent ship-deployed buoys.

Ice and Environmental Conditions

Introduction

For the second time in Ice Patrol's history, no icebergs passed south of 48°N, the traditional latitude below which icebergs are considered a threat to transatlantic shipping. Thus, Ice Patrol did not provide daily warnings to mariners. During the 2006 ice year no icebergs, bergy bits or growlers passed into the shipping lanes, placing it in a tie with 1966 as the lightest year in IIP's history. This section describes the progression of the ice year and the accompanying environmental conditions.

The IIP ice year extends from October through September (not to be confused with the Ice Season, running 15 February – 01 July). The following month-by-month narrative begins as sea-ice started to form along the Labrador coast in December 2005, and concludes on 01 July 2006 when Ice Patrol stopped sending weekly ice chart and bulletin updates to mariners. The narrative draws from several sources, including the *Seasonal Summary for Eastern Canadian Waters, Winter 2005-2006* (Canadian Ice Service, 2006); sea-ice analyses provided by the Canadian Ice Service (CIS) and the U.S. National Ice Center; sea surface temperature anomaly

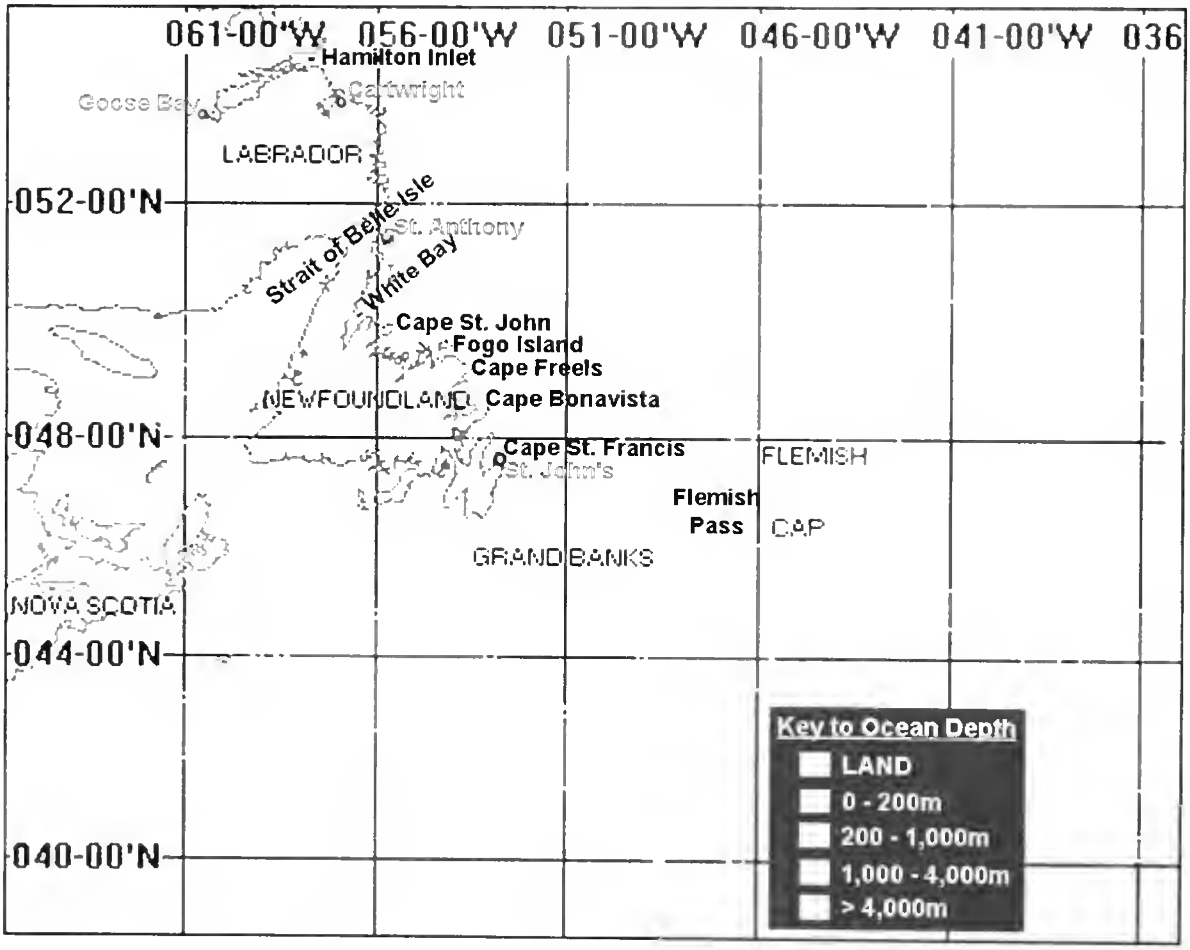


Figure 1. Grand Banks of Newfoundland

plots provided by the U.S. National Weather Service's Climate Prediction Center (National Oceanic and Atmospheric Administration [NOAA]/National Weather Service [NWS], 2007); and, finally, summaries of the iceberg data collected by Ice Patrol and CIS. Because Ice Patrol did not create daily limits of all known ice (LAKI) in 2006, the CIS iceberg analyses are used to document the extent of the iceberg population from 15 February to 01 July 2006 (pages 33-43).

The progress of the 2005-2006 ice year is compared to sea-ice and iceberg observations from the historical record. The sea-ice historical data are derived from the *Sea-ice Climatic Atlas, East Coast of Canada, 1971-2000* (Canadian Ice Service, 2001), which provides a 30-year median of ice concentration at seven-day intervals for the period from 26 November to 16 July.

The preseason sea-ice forecast (Canadian Ice Service, 2005), which was issued on 02 December, predicted:

- movement of the southern ice edge to the northern entrance of the Strait of Belle Isle (**Figure 1**) by end of December 2005, which is one to two weeks later than normal,
- during March the southern ice edge could reach as far north as Cape St. Francis, but most of the significant ice would remain north of Cape Bonavista, and
- sea-ice retreat beginning during the latter part of March and proceeding at a normal pace.

From 05-26 October 2005, CIS, with the cooperation of C-CORE, conducted a census of the iceberg population in the Davis Strait using 57 RadarSat images and one aircraft reconnaissance patrol that focused on the coastal region (Desjardins, 2005). The resulting iceberg count was 262, approximately thirty of which were in the southward-moving offshore waters. The offshore icebergs are likely to be the icebergs that arrive first at 48°N, thus are the vanguard of the iceberg season. The 2005 survey count was the lowest number of icebergs observed during the six years CIS has conducted this survey. Desjardins (2005) predicted a late February or early March opening to the 2006 iceberg season (defined as the date that IIP starts providing daily warnings to mariners).

December 2005

Labrador experienced warmer-than-normal conditions throughout December. The mean daily air temperatures at Nain, Goose Bay, and Cartwright, Labrador were 1.7°C to 2.2°C above normal for the month (Environment Canada, 2007). In addition, December's mean sea-surface temperature was about 0.5°C above normal along the northern Labrador coast. Farther offshore, the surface waters of the central Labrador Sea were up to 1.5 °C warmer than normal. As a result, the southern edge of the main ice pack reached Cape Chidley—the northernmost point in Labrador— during the last week of December, about three weeks later than normal.

January 2006

Much warmer-than-normal air temperatures prevailed in Newfoundland and Labrador during the entire month of January with daily average temperature in Goose Bay, Cartwright, and St. John's, respectively, 3.5°C, 4.2°C, and 3.3°C above normal. At fourteen Newfoundland locations new daily maximum temperature records were set during a mid–January warm period (Environment Canada Atlantic Region, 2006). Consequently, sea-ice development was well behind normal for most of the month.

The southern sea-ice edge reached the northern entrance to the Strait of Belle Isle at the end of the first week of the January, about two weeks later than normal and somewhat later than predicted in the pre-season sea-ice forecast. By mid month, it progressed southward across the strait to Cape Bauld, the northernmost point of the island of Newfoundland.

On 22-23 January an intense low pressure system (**Figure 2**) passed across Newfoundland bringing hurricane force winds (**Figure 3**) to offshore waters early on the 23rd. The very strong northwest winds had a dramatic effect on the sea-ice along the southern Labrador coast and in the Strait of Belle Isle (**Figure 4**). In some places the ice edge expanded 40 nm eastward in little more than 24 hours. The increasing ice concentrations at the entrances to the Strait of Belle Isle prompted the Canadian Coast Guard to recommend that, effective January 31, 2006, the strait not be used by transatlantic shipping.

Despite the storm-driven expansion of the sea-ice edge, at month's end the distribution of sea-ice in east Newfoundland waters was far less extensive than normal. The southern edge of the main ice pack was about 20 nm north of Cape St. John, while in a normal year it would reach Cape Freels, over 80 nm southeastward. The eastward extent of the ice edge was also well below normal. At St. Anthony, the eastern ice edge was approximately 40 nm offshore, while in a normal year it would be about 130 nm.

Under CIS sponsorship, Provincial Aerospace Ltd. (PAL) conducted two iceberg reconnaissance flights on 13 and 14 January. They were flown in good visibility along the Labrador coast south of 59°30'N. No icebergs were located over the entire area. In addition, according to the observers, the sea-ice conditions south of 57°N were well below what would normally be expected for the time of year. Based on the results of these two flights, Pip Rudkin (PAL) predicted that: "As a result of this survey we confirm a forecast for light iceberg distributions on the Grand Banks this coming season. We would expect that only the isolated berg may make the Grand Banks and there is a strong possibility of an iceberg free season."

On 26 January 2006, Ice Patrol deployed its preseason Ice Reconnaissance Detachment (IRD) to St. John's, Newfoundland. The intent of the IRD was to monitor the progress of icebergs toward the Grand Banks and help determine the start date for the 2006 season.

February

Warmer-than-normal conditions in Newfoundland and Labrador continued into February, although many places saw the mean temperatures move closer to typical conditions. The average daily temperature was about a degree warmer than normal in southern Labrador, while St. John's was 1.5°C warmer than normal. The exception to this trend toward typical temperatures was Nain, where the daily average temperature for the month was 4.3°C higher than normal.

During the first half of February most of the ice-edge expansion was eastward rather than southward. By mid-month the eastern ice edge lay 70 nm east of St. Anthony, still a fraction of the normal 200 nm eastward extent for the date.

The southern ice edge pushed southward during the second half of February, approaching to within ten nautical miles of Cape Bonavista, Newfoundland by month's end. The eastern ice edge continued to expand as well, reaching between 100 and 120 nm east of St. Anthony's by the end of February.

In February there were no icebergs near the transatlantic shipping lanes. On 3-4 February, IIP's pre-season IRD searched the sea-ice free offshore branch of the Labrador Current from 48°N northward to 55°N. They found no icebergs. Later in the month, PAL documented a substantial iceberg population but it was within the sea-ice north of 55°N.

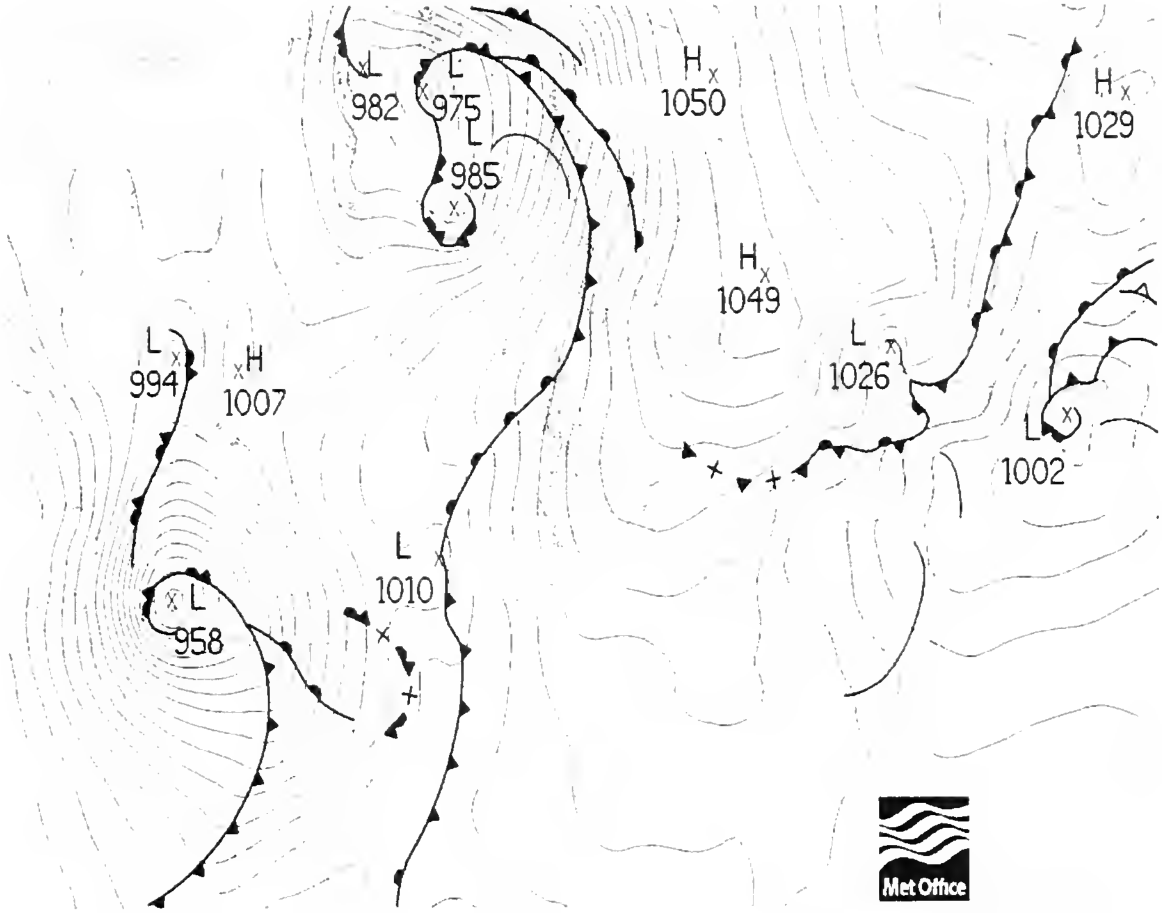


Figure 2. Sea-level pressure for 00Z 23 January 2006. (Plot courtesy of Met Office, Bracknell)

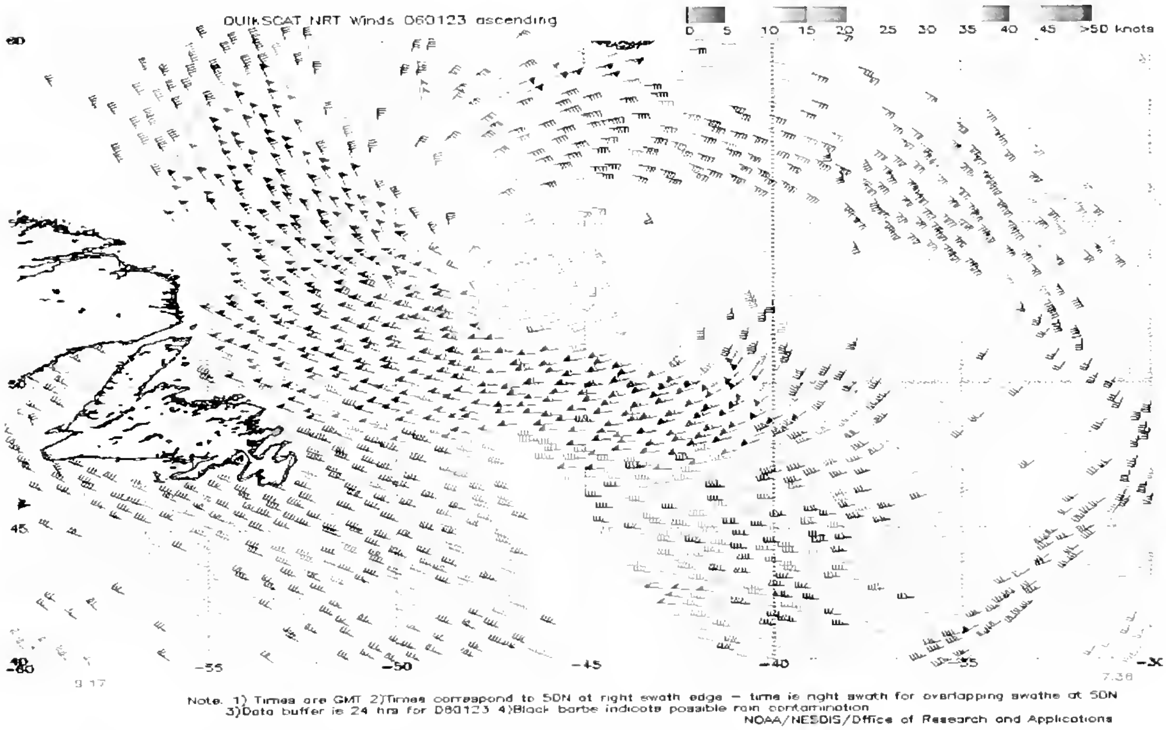


Figure 3. Surface winds for 0917Z 23 Jan 2006. (Image courtesy the National Oceanic and Atmospheric Administration / National Environmental Satellite, Data, & Information Service / Center for Satellite Applications and Research)

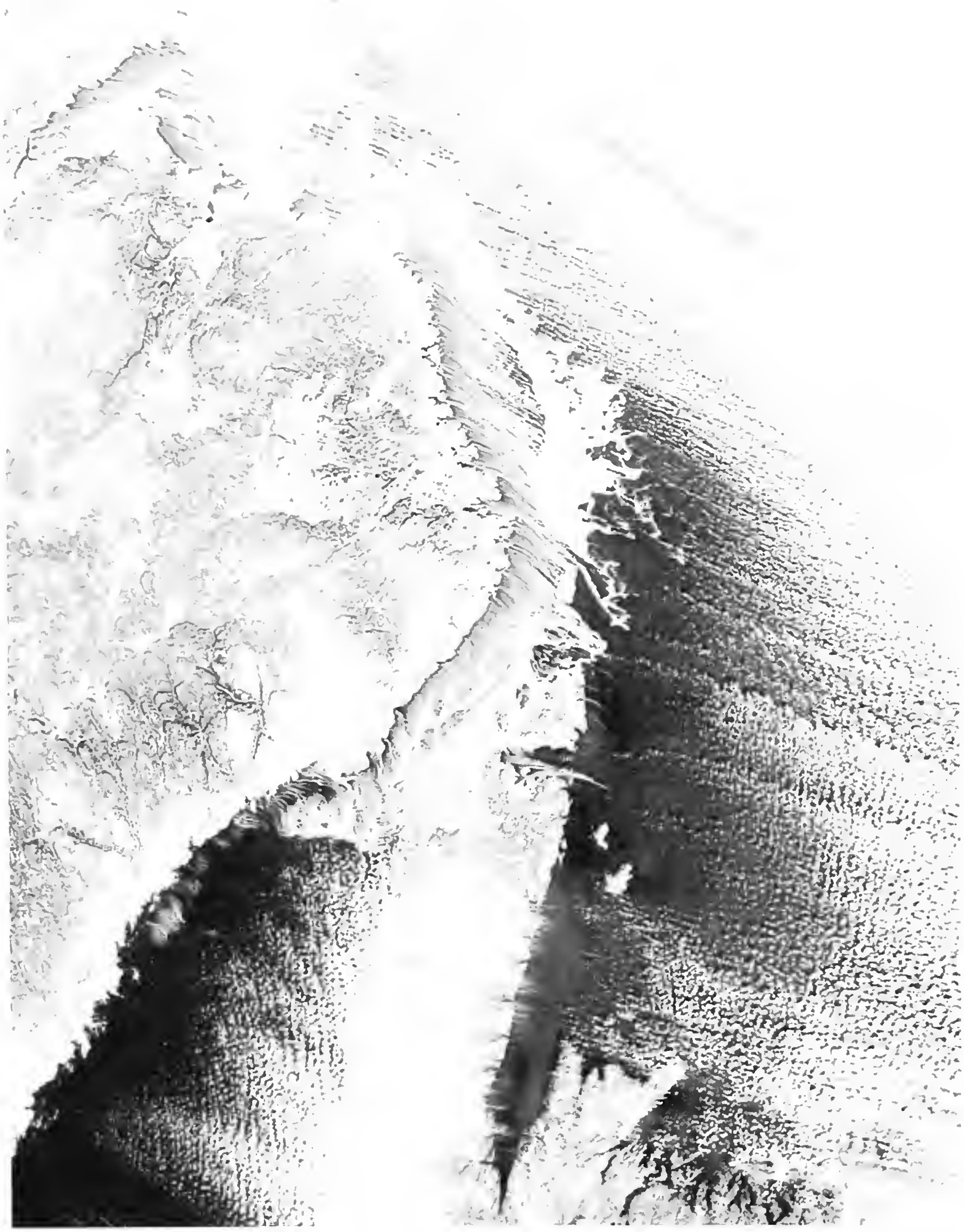


Figure 4. MODIS image (1450Z 23 January 2006) showing the rapid off-shore movement of the main ice pack under the influence of strong northwest winds along the southern Labrador coast. (Image courtesy of MODIS Rapid Response Project at the National Aeronautics and Space Administration/ Goddard Space Flight Center)

Three reconnaissance flights – two on 21 February and one on 22 February – found over 100 icebergs between 55°N and 59°N. Ice Patrol reconnaissance continued to focus on the area from 48°N to 55°N in its late February (24^{th} and 27^{th}) flights. They found 17 icebergs, all between 54°N and 55°N.

March

Unusually warm conditions continued in Newfoundland and Labrador throughout March. While St. John's was only slightly warmer than normal (0.7°C above normal), the remainder of Newfoundland was more than 2°C greater than normal. Labrador was warmer yet, with Cartwright and Nain experiencing daily mean temperatures 5.2°C and 6.8°C greater than normal, respectively.

Sea-ice reached its 2006 maximum extent during the second week of March (**Figure 5**), at which time the southern ice edge was approximately at the latitude of Cape Bonavista and the eastern ice was 120 nm offshore. In a normal year (**Figure 6**), the southern ice edge is over 70 nm farther south of this latitude and the eastern edge more than 80 nm farther offshore.

The southern ice edge remained between Cape Bonavista and Cape Freels until the last week of the March, after which it began a rapid retreat. This retreat was driven in part by a strong storm that passed just southeast of St. John's and brought vigorous onshore winds to northern Newfoundland from 28 to 30 March. The resulting ice destruction and compaction against the north coast left most of the northeast shelf ice free by the last day of March. Significant sea-ice concentrations were limited to the vicinity of White Bay, the inner part of Notre Dame Bay and along the northern peninsula of Newfoundland. At this point the sea-ice retreat was more than four weeks ahead of normal.

The diminished sea-ice extent in east Newfoundland waters and good weather aided a series of five iceberg reconnaissance flights from 23-25 March. Two patrols by IIP and three by PAL searched sea-ice free waters over the region between 48°N to 56°30'N. The flights found no icebergs in open water south of 52°N.

The easternmost and southernmost icebergs seen during the year were spotted well north of 48°N during March, the easternmost on 18 March at 49°52'N, 50°01'W and the southernmost on 28 March at 49°01'N 52°59'W. In addition, the southernmost (48°41'N and 53°06'W) estimated iceberg position for the season occurred on 30 March.

April

Exceptionally mild weather continued in April, particularly in Labrador, which experienced record-setting warm conditions (Environment Canada Atlantic Region, 2006). Both Goose Bay and Cartwright tied their previous records, set in 1953, for high monthly mean temperature. In April, the daily air temperature in Cartwright and Goose Bay averaged 4.7°C and 4.3°C above normal, respectively.

South, southwest, and west winds dominated Newfoundland for the first two weeks of April. Winds from these directions favored the offshore movement of sea-ice that had been compacted into White Bay, Notre Dame Bay, and along the northern peninsula at the end of March. As the sea-ice moved offshore, it quickly deteriorated. Overall, the sea-ice retreat continued at a pace that was over four weeks ahead of normal.

The disappearance of sea-ice from the Strait of Belle Isle led the Canadian Coast Guard to recommend its use for transatlantic voyages on April 26, 2006 – about two weeks earlier than last year.

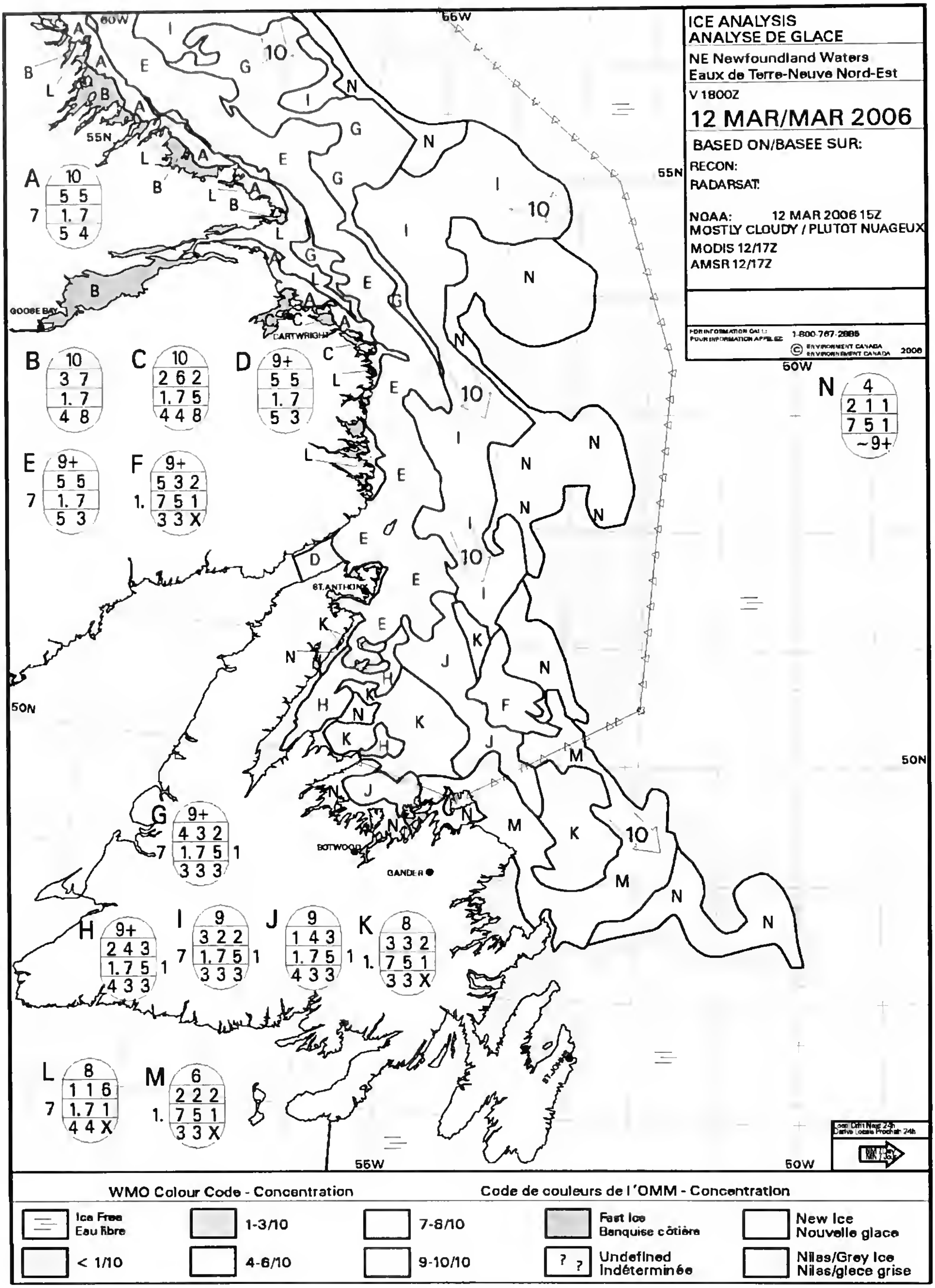


Figure 5. Sea-ice concentrations for 12 March 2006. (Map Courtesy of the Canadian Ice Service)

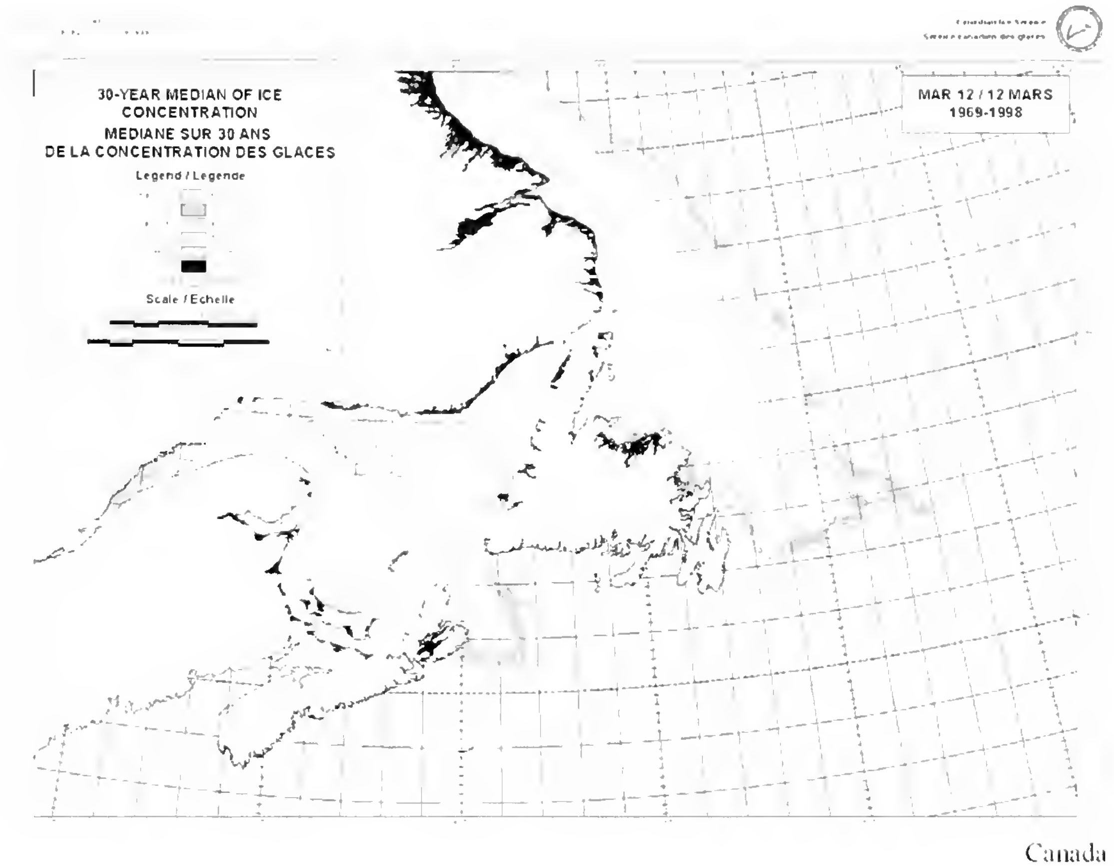


Figure 6. Median ice concentrations for 12 March. (Map Courtesy of the Canadian Ice Service)

With the exception of an isolated patch of ice near Fogo Island, the southern ice edge had retreated to the vicinity of Cartwright by month's end. A southern ice edge at this location is typical of early June.

The iceberg population in April remained well north of the shipping lanes. Three IIP flights from 23 to 25 April showed there were no icebergs or radar targets south of 49°N. On the other hand, PAL conducted intensive aerial reconnaissance with good visibility off the entire length of the Labrador coast on 28-29 April. They found an extensive iceberg population, mostly within the sea-ice (**Figure 7**).

The easternmost (51°31'N and 49°05'W) estimated iceberg position for the season occurred on 14 April.

May

The record-setting warmth continued in Labrador in May with both Goose Bay and Nain setting new records for the high monthly mean temperature.

The anomaly at Nain was nearly 5°C greater than normal while at Goose Bay it was 4.3°C above. Unusually warm air and sea temperatures fueled the rapid sea-ice retreat. The sea surface temperature anomaly was 1°C greater than normal (**Figure 8**) along the mid-Labrador coast and over 2°C in the central Labrador Sea near the location of Ocean Station B (56°30'N 52°30'W).

By the end of May there was no sea-ice south of Hamilton Inlet, a condition more typical of June 25th, about four weeks ahead of normal. A large population of icebergs in the approaches to the Strait of Belle Isle and northward along the Labrador coast was documented by several PAL flights in May and many reports from the increased transatlantic shipping using the strait after it cleared of sea-ice. No icebergs passed south of 48°N during May.

June and July

In Newfoundland and Labrador the record-setting warmth continued in June, with 33 temperature records set or tied (Environment Canada Atlantic Region, 2006). The pace of the sea-ice retreat slowed somewhat in June, but the northward movement of the ice edge still remained ahead of normal. By the first week of July – about two weeks earlier than normal – sea-ice departed Labrador's coast.

Throughout June and into early July, a large iceberg population persisted from the Strait of Belle Isle northward along the Labrador coast. Vessels using the Strait of Belle Isle reported numerous icebergs within and on the Atlantic Ocean approaches to the strait. In addition, reconnaissance, primarily by PAL, as well as Canadian ice breakers CCGS *Terry Fox* and CCGS *Pierre Radisson*, reported large numbers of icebergs off the Labrador coast during June. On its 30 June iceberg-analysis plot CIS was carrying 681 icebergs and radar targets between 50°N and 56°N.

After verifying that there were no icebergs threatening the transatlantic shipping lanes, Ice Patrol's last 2006 ice reconnaissance detachment returned from Newfoundland on 20 June.

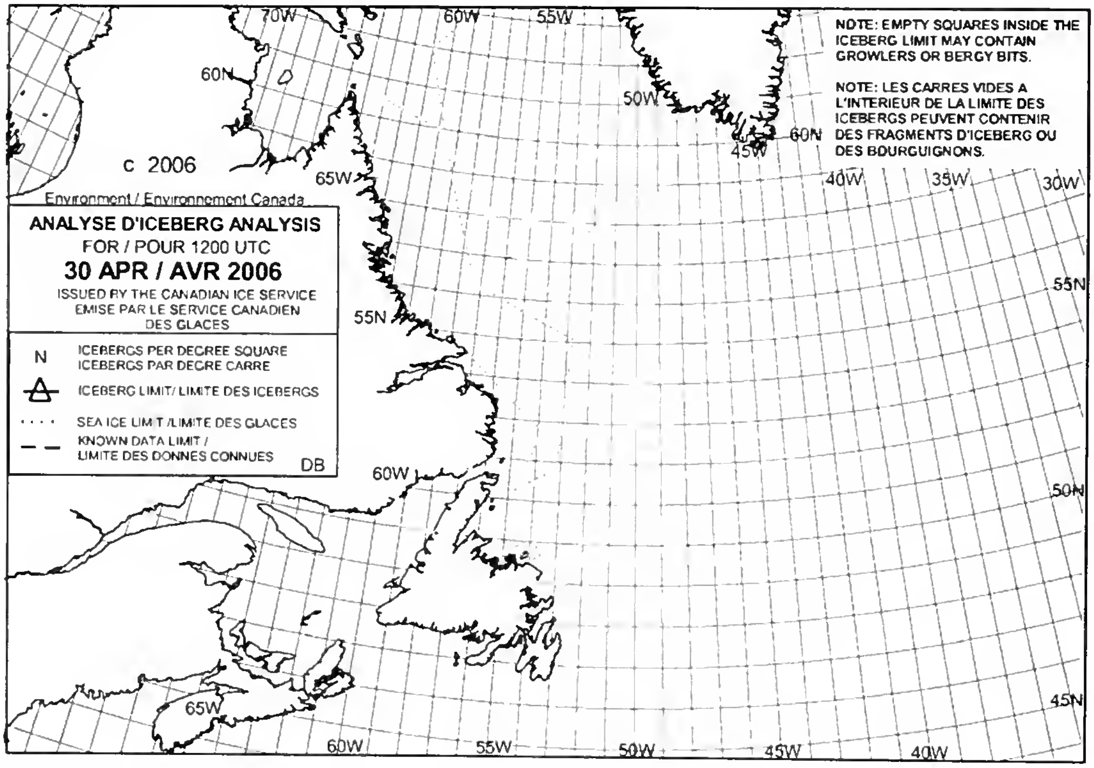


Figure 7. Iceberg Distribution on 30 April 2006. There are 443 icebergs and radar targets north of 52°N (Map Courtesy of the Canadian Ice Service)

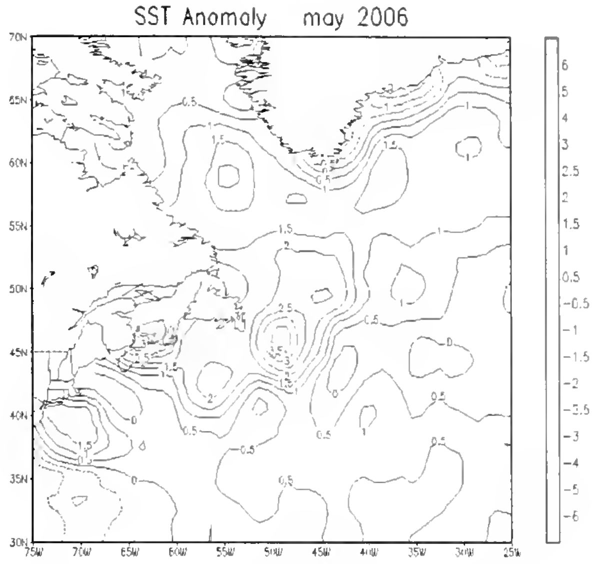


Figure 8. Sea surface temperature anomaly for May 2006 in degrees C. (Plot courtesy of National Oceanic and Atmospheric Administration / National Weather Survey)

Discussion

No icebergs passed south of 48°N in 2006 placing it in a tie with 1966 – "the year with no icebergs". In some respects, 2006 was a less severe iceberg year than 1966, in some not. For example, in 1966 many growlers drifted southward amidst pack ice to 47°30'N, 52°30'W and several growlers moved as far south as 46°55'N, 52°15'W (International Ice Patrol, 1966). In 2006 the southernmost position of glacial ice was an iceberg seen on 28 March at 49°01'N, 52°59'W – over 120 nm farther north. On the other hand, the early summer iceberg population along the Labrador coast was greater in 2006 than it was in 1966. The 1966 population south of Cape Chidley (about 60°30'N) was 297 on 7 June, while in 2006 there were over twice that number south of 56°N at the end of June. This suggests that more icebergs reached the Labrador coast in 2006 than in 1966.

There are more similarities than differences between the two record-setting iceberg years, particularly in the accompanying environmental conditions. In both years:

- Newfoundland and Labrador experienced much-warmer-than normal air temperatures. In the case of 2006, numerous records were set for warmth in Labrador.
- The pack ice arrived late, departed early, and was less extensive than normal.
- The sea surface temperatures were warmer than normal in the region, particularly in the central Labrador Sea.
- Several storms brought strong on-shore winds to the Labrador coast in the preceding December and January.

These common factors are consistent with many of the previous light iceberg years (Murphy, 1999). They are also consistent with the negative phase of the North Atlantic Oscillation (NAO). The winter 2006 (December 2005 through March 2006) NAO Index (NAOI) was -1.09 (Hurrell, 2007), which was calculated using the difference of normalized sea level pressure between Lisbon, Portugal and Stykkisholmur/ Reykjavik, Iceland.

The NAO, the dominant mode of winter atmospheric variability in the North Atlantic, fluctuates between positive and negative phases. The positive phase is associated with meteorological conditions that favor the movement of icebergs into the shipping lanes. These include strong and persistent northwest winds along the Labrador coast, which bring colder-than-normal air temperatures and greater-than-normal sea-ice extent. In addition, the persistent northwest winds promote southward iceberg movement. Warmer-than-normal conditions and less extensive sea-ice off the Labrador coast are associated with the negative NAO phase. The -1.09 NAOI value in 2006 was strongly negative, which is consistent with the

RANK	YEAR	NAO I	ICEBERGS SOUTH OF 48°N
1 (Tie)	2006	-1.09	0
1 (Tie)	1966	-1.69	0
3 (Tie)	1940	-2.86	1
3 (Tie)	1958	-1.02	1
5	1941	-2.31	3
6	1951	-1.26	8
7 (Tie)	2005	0.12	11
7 (Tie)	1924	-1.13	11
9	1931	-0.16	14
10	1952	0.83	15

Table 1. Years with the lowest number of icebergs estimated to have drifted south of 48° N and North Atlantic Oscillation Index. Note: The iceberg-count data reflects the current definition of the ice year. In 1940 and 1941 the ice year was the calendar year. In both years it was reported in IIP's annual reports that two icebergs passed south of 48° N during the year. One of these icebergs passed south of 48° N in November 1940 and was originally counted as a 1940 observation. It is now counted as a 1941 observation. Thus, in 1940 there is one iceberg listed, and in 1941, three.

extremely light iceberg season that followed. Seven of the ten lightest iceberg years in Ice Patrol's record (**Table 1**) had a strongly negative NAOI. Two years (1931 and 2005) had a neutral NAOI and one (1952) was moderately positive.

While **Table 1** shows encouraging agreement between NAOI and low iceberg-count years, there are dramatic inconsistencies in some years. For example, in 1996 the NAOI was -3.78, the sixth lowest NAOI in Hurrell's (2007) 142-year record; however, 611 icebergs passed south of 48°N making it a very active iceberg year. As a result, comparisons between NAOI and iceberg counts should be interpreted with the caution that, although the overall relationship is good, individual years can be entirely incompatible.

By the end of January 2006 Ice Patrol recognized that 2006 was going to be extraordinary. The antecedent environmental conditions, pre-season surveys, and forecasts collectively pointed to the likelihood of a very light year. The October 2005 CIS survey of the Davis Strait area (Desjardins, 2005), although limited in scope, found the fewest number of icebergs in the six years the survey had been conducted.

January 2006 pre-season iceberg surveys by PAL and IIP showed a small iceberg population along the Labrador coast, which led to the anticipation that few, if any icebergs, would reach the Grand Banks. Finally, based on the slow early sea-ice growth, Peterson's long-range iceberg forecast system (Peterson, 2004) predicted sparse population of icebergs throughout the ice year (Peterson, personal communication).

An ice year like 2006 renews the awareness of the impressive variability of Ice Patrol's iceberg counts. This appreciation is not recent. Edward H. "Iceberg" Smith (1926) said: "The amount of ice drifting out of the north into the open Atlantic is subject to great annual variations, for instance, in 1912 there were approximately 1,200 bergs counted south of Newfoundland while in 1924 there were only a total of 11."

It is remarkable that 2006, a second year without icebergs, followed a year with only 11. Having two consecutive years with exceptionally low iceberg counts is unusual, but not unprecedented. This has happened three additional times in Ice Patrol's history: 1940-1941, 1951-1952 and 1965-1966. The combined iceberg count for 1940 and 1941 was four. [During these two early World War II years mariners were reluctant to break radio silence to make iceberg reports and reveal their location, so there may have been isolated icebergs that were not reported. In both years the USCG cutter *General Greene* conducted oceanographic surveys of the region, focusing their attention on the offshore branch of the Labrador Current and the southern Grand Banks. They found that the usual iceberg population was absent.] In 1951-1952 a total of 23 icebergs passed south of 48°N and in 1965-1966, 76.

For many decades Ice Patrol and others have struggled to understand what causes the variability in the iceberg counts. Most attention has focused on ocean and atmospheric forcing (Davidson et al., 1986) with special emphasis on the role of sea-ice (Smith, 1931, Marko et al., 1994 and Peterson et al., 2000). The number of icebergs passing south of 48°N is well correlated with sea-ice extent near Newfoundland (Peterson et al., 2000). This good correlation is not surprising because extensive sea-ice protects icebergs from destruction as they move southward. Extensive sea-ice along the Labrador coast may also inhibit icebergs from being driven into shallow waters and grounded during winter storms.

The problem of understanding the variability of the iceberg counts might be getting more complicated. Thus far, most studies have not considered the variability of iceberg production at the Greenland glaciers for two reasons. First, few detailed iceberg-production data were available. Second, the iceberg population arriving along the Labrador and Newfoundland coasts is a small fraction of the calf ice produced at the Greenland glacial fronts. This leads to the implicit assumption that the glaciers were producing a more-or-less constant and extensive supply of icebergs to Baffin Bay and the observed variability in Ice Patrol's iceberg counts was due primarily to the transport and deterioration processes farther to the south.

Recent research shows significant changes are occurring in many of Greenland's outlet glaciers. Mayer and Herzfeld (2006) reported that in 1999 the Jakobshavns Isbrae in West Greenland entered a phase of rapid retreat and the production of icebergs increased. This is one of the fastest flowing ice streams in the world and a major iceberg producer in West Greenland.

Moon and Joughin (2006) used satellite images to study over 150 Greenland outlet glaciers in 1992, 2000, and 2005 and found an overall trend of retreat, with more rapid retreat in 2000-2005. Finally, Rignot and Kanagaratnam (2006) used satellite radar measurements to document an enormous increase in ice discharge from Greenland's glaciers, with Jakobshavn Isbrae alone increasing from 24 km^3/yr in 1996 to 46 km^3 ice/yr in 2005. These studies make it clear that more, not fewer, icebergs are being produced by Greenland's glaciers.

References

Bancroft, George P., (2006). Marine Weather Review – North Atlantic Area, January to April 2006. Mariners Weather Log, Vol. 50(2), August 2006.

Canadian Ice Service, (2000). Sea-ice Climatic Atlas. East Coast of Canada, 1971-2000. Canadian Ice Service, 373 Sussex Drive Block E-3, LaSalle Academy, Ottawa, ON, Canada K1A 0H3, 151 p.

Canadian Ice Service, (2005). Seasonal Outlook, Gulf of St. Lawrence and East Newfoundland Waters, Winter 2005-2006. Unpublished Manuscript, Canadian Ice Service, 373 Sussex Drive, E-3, Ottawa, ON, Canada K1A 0H3, 13 p.

Canadian Ice Service, (2006). Seasonal Summary for Eastern Canadian Waters, Winter 2005-2006. Unpublished Manuscript, Canadian Ice Service, 373 Sussex Drive, Ottawa, ON, Canada K1A 0H3, 18 p.

Desjardins, Luc, (2005). 2006 East Coast Seasonal Outlook. International Ice Patrol Annual Conference, 7 December 2005.

Environment Canada Atlantic Region, (2006). Atlantic Region Monthly Climate Summary. http://atlantic-web1.ns.ec.gc.ca (30 January 2007).

Environment Canada, (2007). National Climate Data and Information Archive. http://www.climate.weatheroffice.ec.gc.ca (29 January 2007).

Hurrell, J., (2007). Winter (Dec-Mar) Station Based NAO Index. National Center for Atmospheric Research. http://www.cgd.ucar.edu/cas/jhurrell/indices.data.html#naostatdjfm (7 February 2007).

International Ice Patrol, (1966). Bulletin No.52, Report of the International Ice Patrol Service in the North Atlantic Ocean, Season of1966, International Ice Patrol, 27 p.

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. Jour. Climate Vol. 7:1335-1351.

Moon, T. and I. Joughin, (2006). Ice Front Changes on the Greenland Ice Sheet: 1992-2005, Eos Trans. AGU, 87(52), Fall Meet. Suppl., Abstract C13B-05

Murphy, D. L., (1999). An Historical Perspective to the Mild 1999 Ice Year. Appendix C to Bulletin No. 85, Report of the International Ice Patrol in the North Atlantic, 1999 Season, International Ice Patrol, 64 p.

Mayer, H. and U. C. Herzfeld, (2006). Jakobshavns Isbrae, West Greenland: Structural Evolution During Transition from Stable Fast Flow to Rapid Retreat, Eos Trans. AGU, 87(52), Fall Meet. Suppl., Abstract C13B-07.

NOAA/NWS, (2006). National Oceanic and Atmospheric Administration Operational Model Archive Distribution System. http://nomad3.ncep.noaa.gov/ncep_data (29 Jan 2007).

Peterson I. K., S. J. Prinsenberg, and P. Langille. (2000). Sea-ice Fluctuations in the Western Labrador Sea (1963-1998). Can. Tech. Rep. Hydrogr. Ocean Sci. 208: v+51 p.

Peterson, I. K. (2004). Long-Range Forecasting of the Iceberg Population on the Grand Banks, in Proceedings of the Fourteenth (2004) International Offshore and Polar Engineering Conference Toulon, France, May 23-28, 2004, Vol. 1, pp. 831-836.

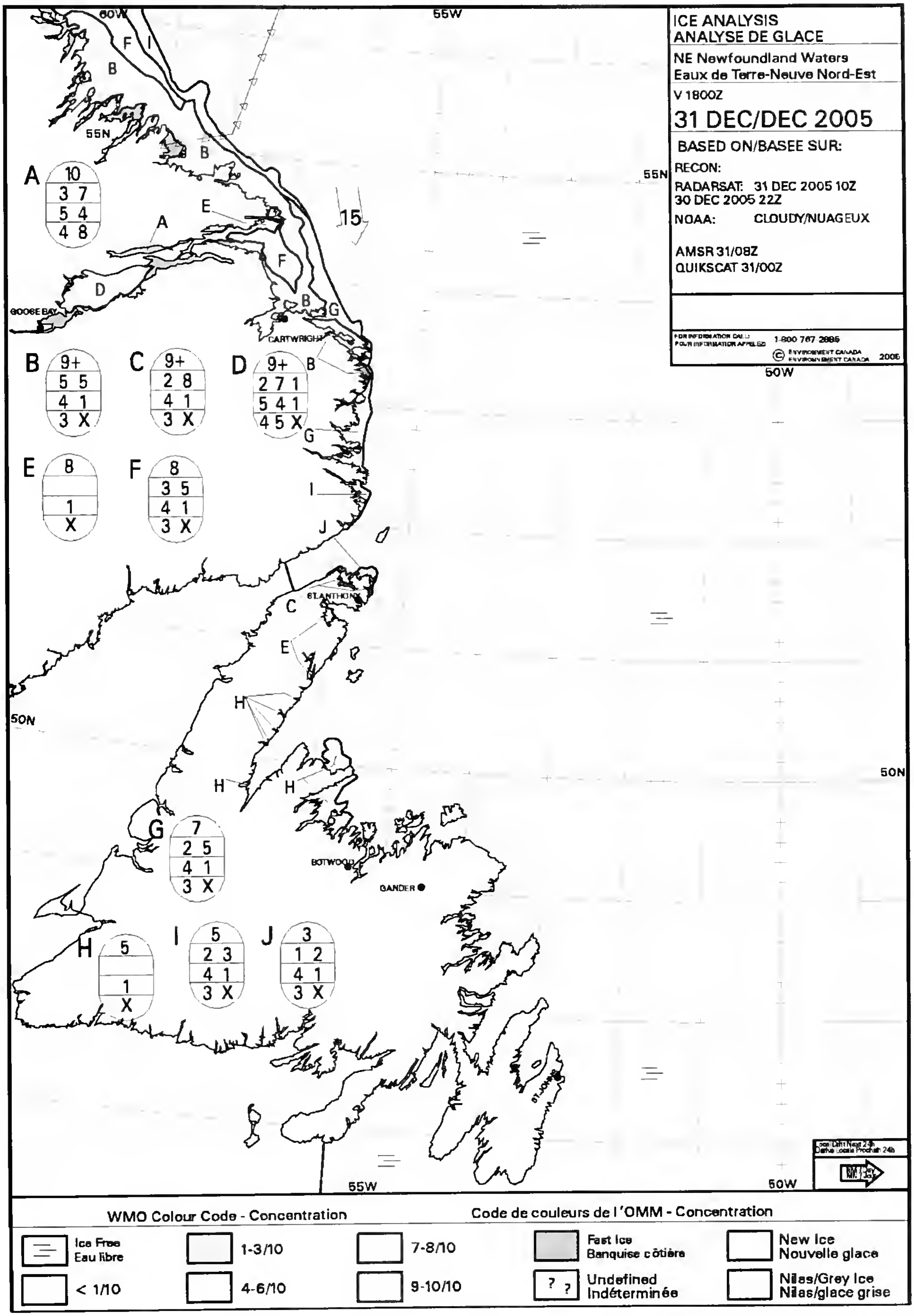
Rignot, E. and P. Kanagaratnam, (2006). Changes in the Velocity Structure of the Greenland Ice Sheet. Science, Vol. 311:986-990.

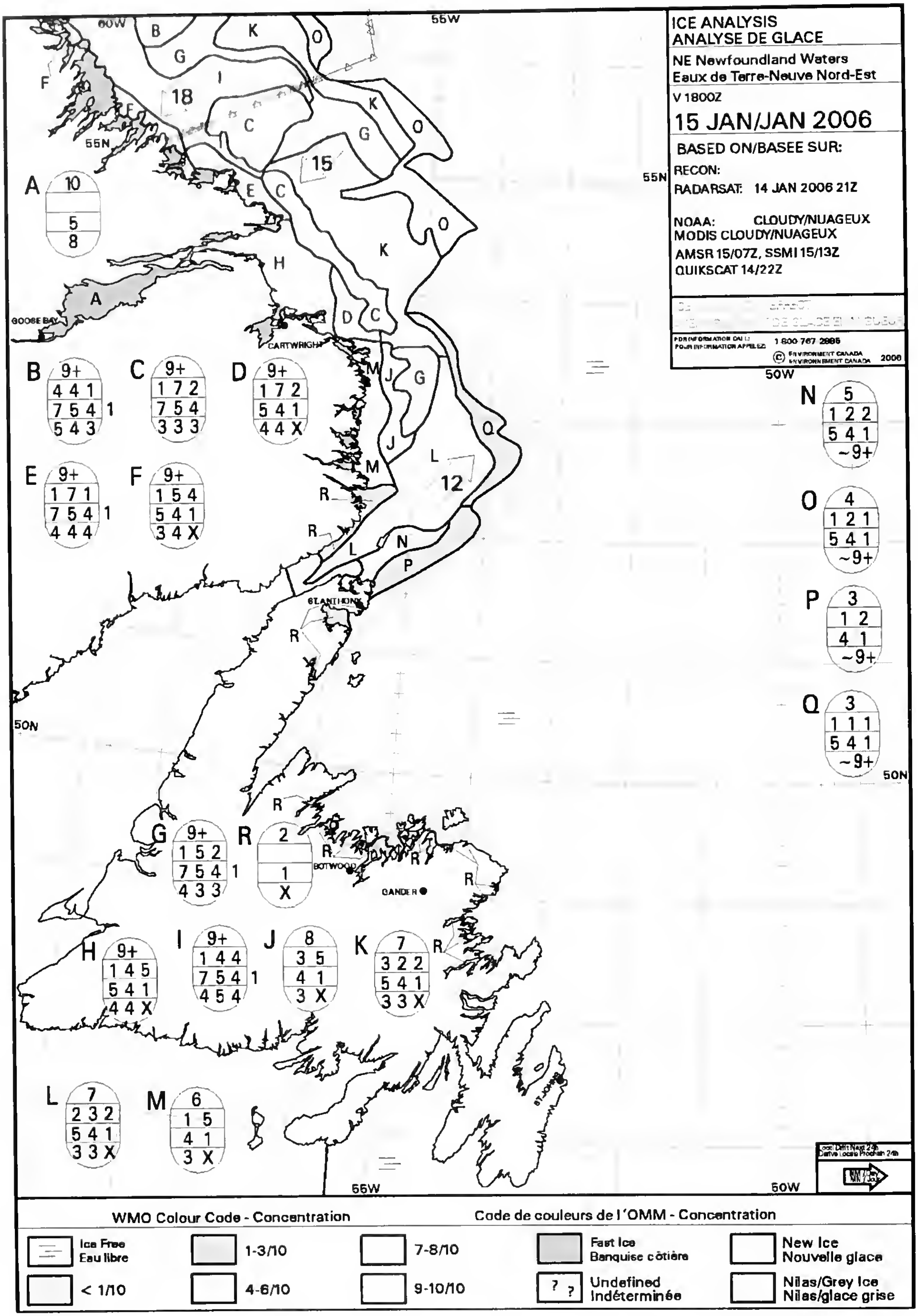
Smith, E. H. (1926). Weather-A Brief Review of the 1926 Ice Season. International Ice Observation and Ice Patrol Service in the North Atlantic Ocean, Bulletin No. 15, 31-48.

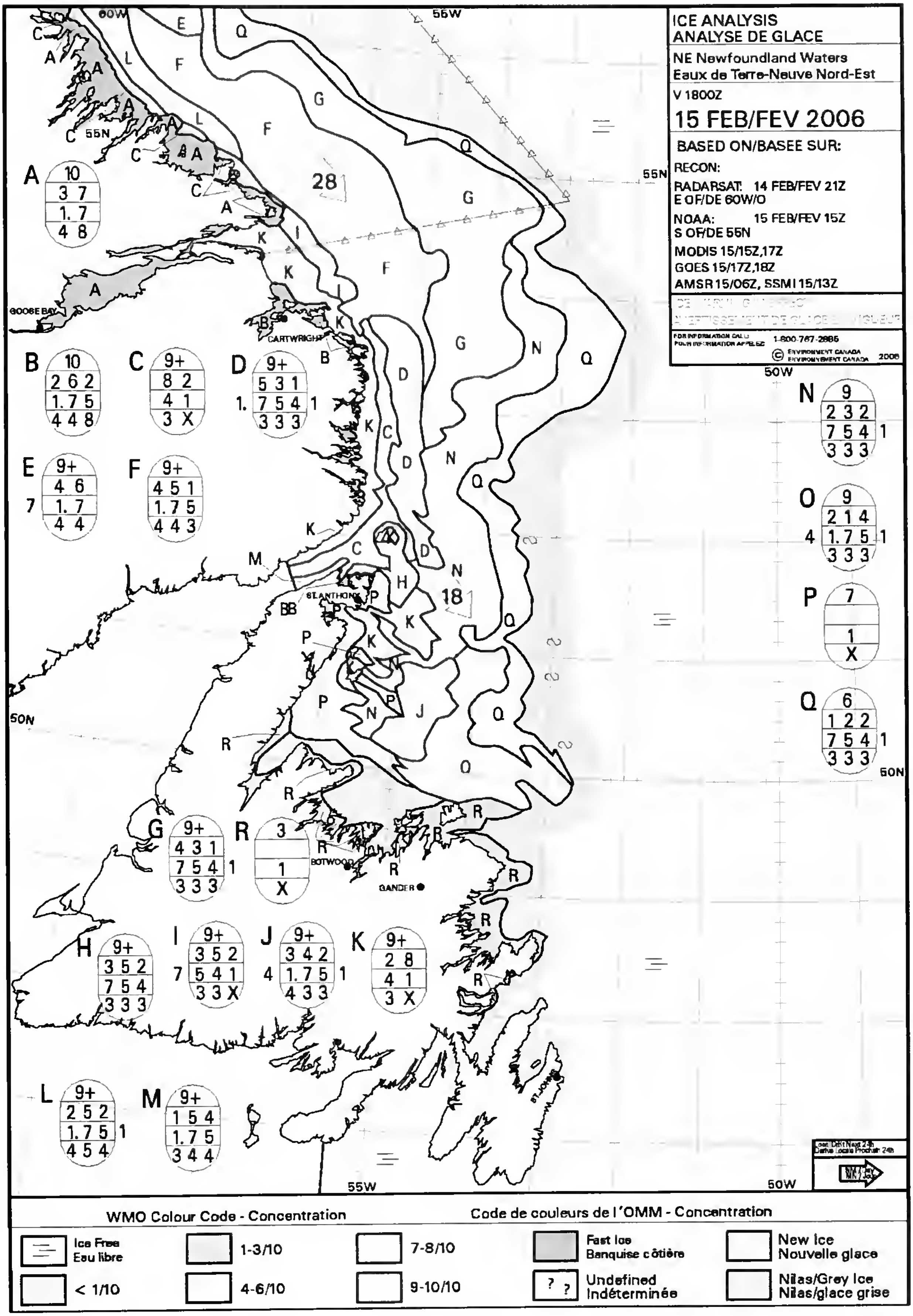
Smith, E. H. (1931). The Marion Expedition to Davis Strait and Baffin Bay, 1928. Scientific Results, Part 3, Bulletin No. 19, 221 p

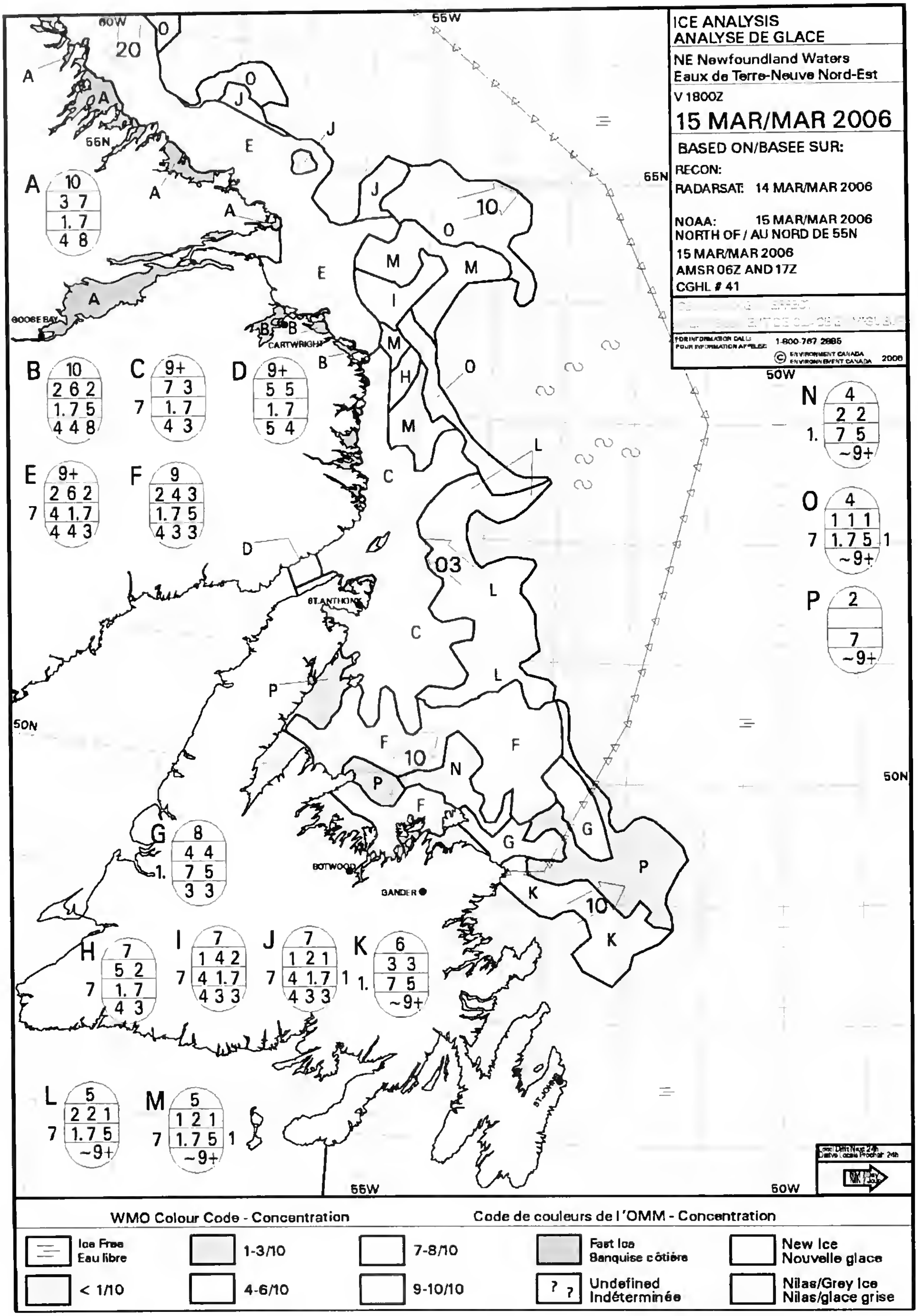
Monthly Sea-Ice Charts

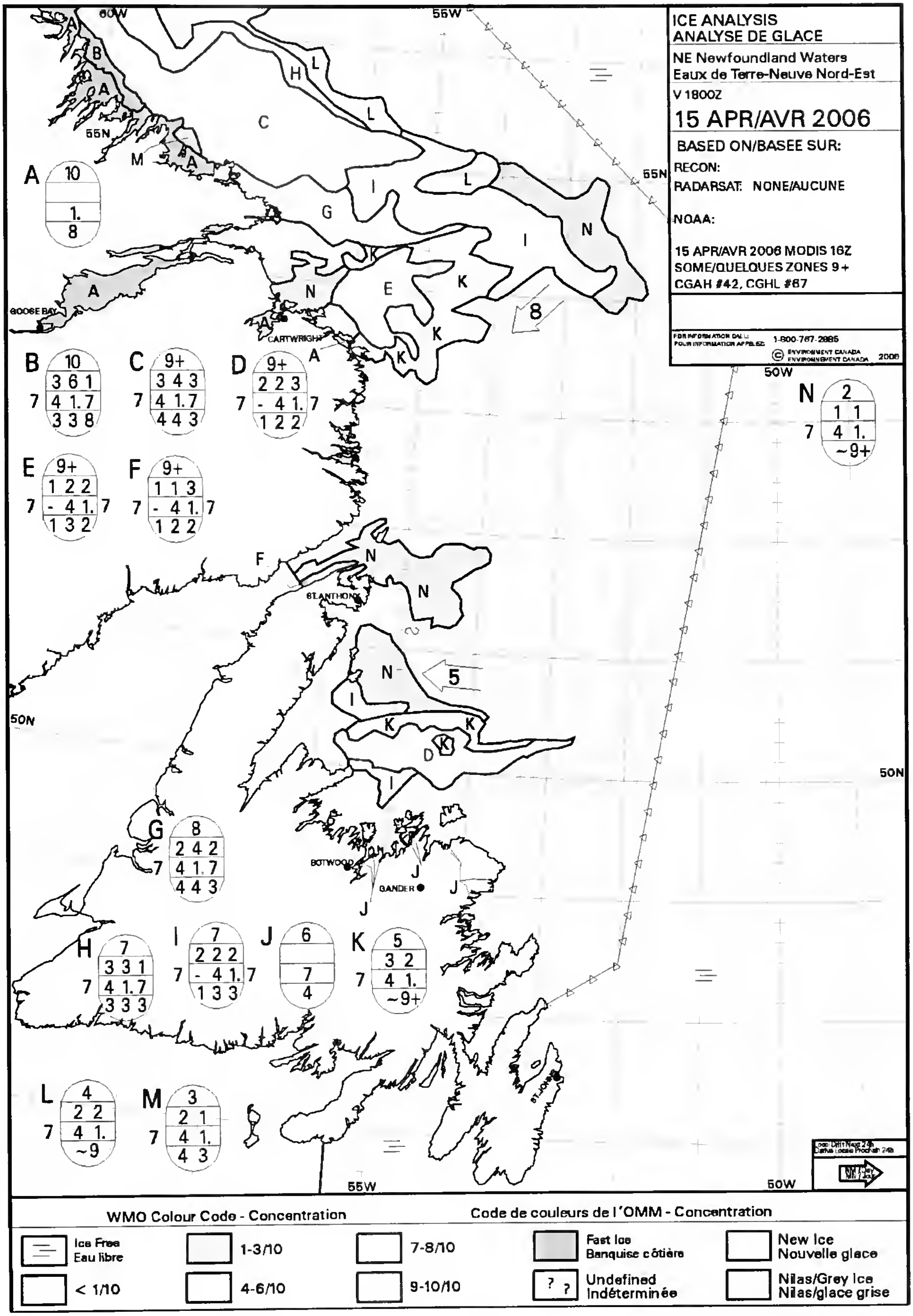
Sea-ice charts are reprinted with permission of the Canadian Ice Service.

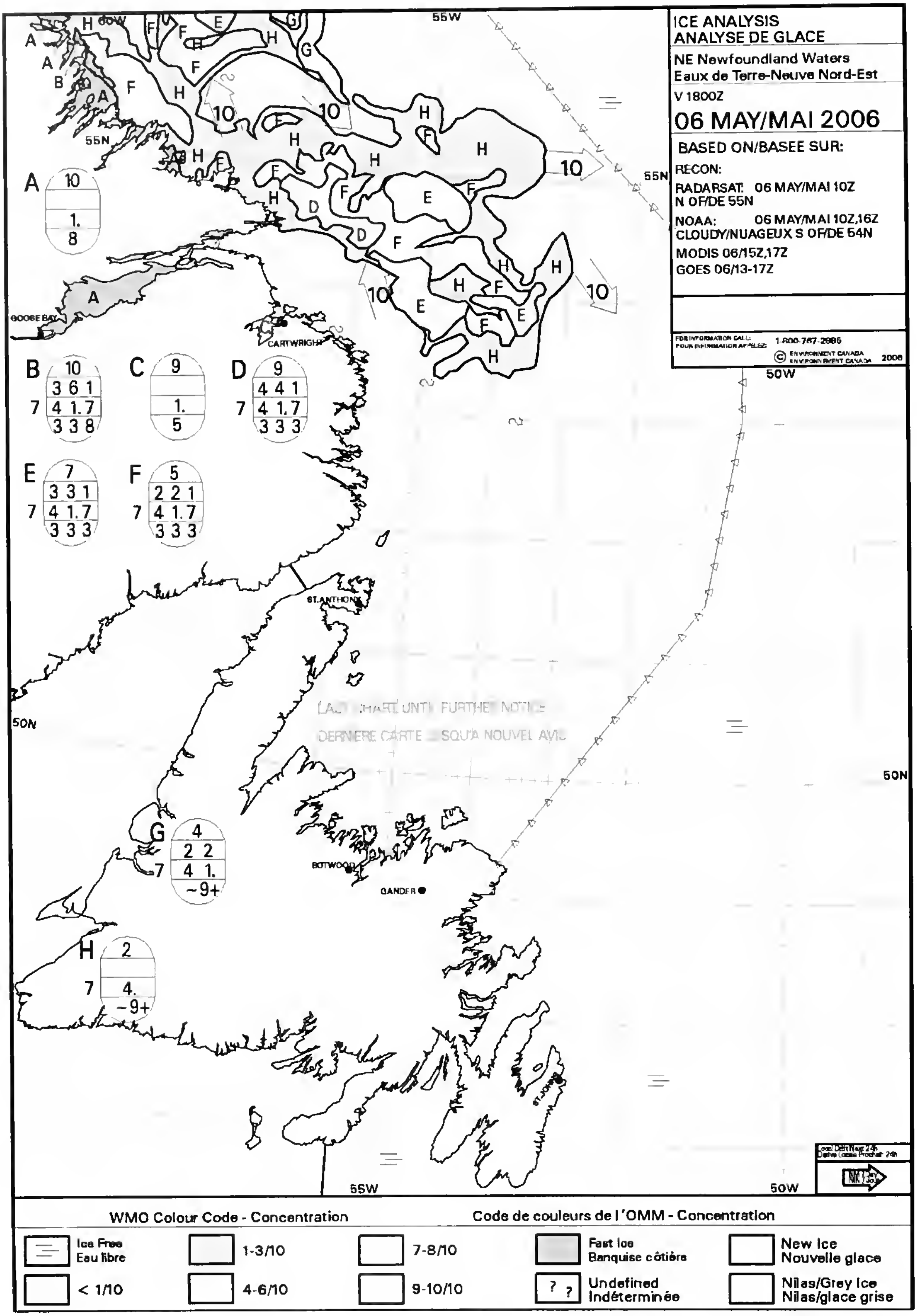

ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
31 DEC/DEC 2005
BASED ON/BASEE SUR:
RECON:
RADARSAT: 31 DEC 2005 10Z
30 DEC 2005 22Z
NOAA: CLOUDY/NUAGEUX
AMSR 31/08Z
QUIKSCAT 31/00Z
1-800 767 2885
2005
60W
55W
50W
55N
50N
GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHN'S
15
A 10 / 3 7 / 5 4 / 4 8
B 9+ / 5 5 / 4 1 / 3 X
C 9+ / 2 8 / 4 1 / 3 X
D 9+ / 2 7 1 / 5 4 1 / 4 5 X
E 8 / 1 / X
F 8 / 3 5 / 4 1 / 3 X
G 7 / 2 5 / 4 1 / 3 X
H 5 / 1 / X
I 5 / 2 3 / 4 1 / 3 X
J 3 / 1 2 / 4 1 / 3 X
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 JAN/JAN 2006
BASED ON/BASEE SUR:
RECON:
RADARSAT: 14 JAN 2006 21Z
NOAA: CLOUDY/NUAGEUX
MODIS CLOUDY/NUAGEUX
AMSR 15/07Z, SSMI 15/13Z
QUIKSCAT 14/22Z
1 800 767 2885
60W
55W
55N
50W
50N
GOOSE BAY
CARTWRIGHT
ST. ANTHONY
BOTWOOD
GANDER
ST. JOHN'S
A 10 5 8
B 9+ 4 4 1 7 5 4 1 5 4 3
C 9+ 1 7 2 7 5 4 3 3 3
D 9+ 1 7 2 5 4 1 4 4 X
E 9+ 1 7 1 7 5 4 1 4 4 4
F 9+ 1 5 4 5 4 1 3 4 X
G 9+ 1 5 2 7 5 4 1 4 3 3
R 2 1 X
H 9+ 1 4 5 5 4 1 4 4 X
I 9+ 1 4 4 7 5 4 1 4 5 4
J 8 3 5 4 1 3 X
K 7 3 2 2 5 4 1 3 3 X
L 7 2 3 2 5 4 1 3 3 X
M 6 1 5 4 1 3 X
N 5 1 2 2 5 4 1 ~9+
O 4 1 2 1 5 4 1 ~9+
P 3 1 2 4 1 ~9+
Q 3 1 1 1 5 4 1 ~9+
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
1-3/10
7-8/10
Fast Ice
Banquise côtière
New Ice
Nouvelle glace
< 1/10
4-6/10
9-10/10
Undefined
Indéterminée
Nilas/Grey Ice
Nilas/glace grise

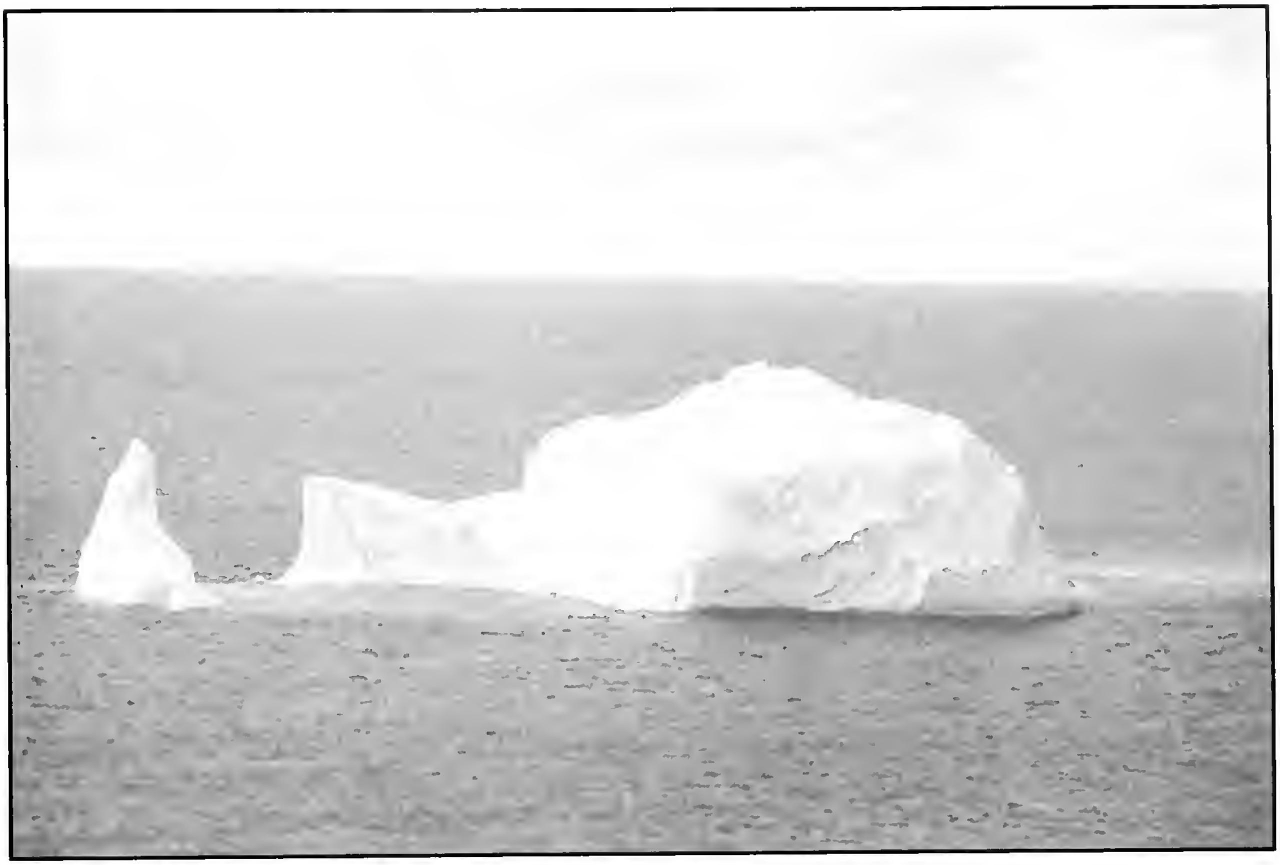

ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 FEB/FEV 2006
BASED ON/BASEE SUR:
RECON:
RADARSAT: 14 FEB/FEV 21Z
E OF/DE 60W/O
NOAA: 15 FEB/FEV 15Z
S OF/DE 55N
MODIS 15/15Z,17Z
GOES 15/17Z,18Z
AMSR 15/06Z, SSMI 15/13Z
1-800-767-2885
ENVIRONMENT CANADA
ENVIRONNEMENT CANADA
2006
60W
55W
50W
55N
50N
GOOSE BAY
CARTWRIGHT
ST ANTHONY
BOTWOOD
GANDER
ST JOHNS
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 MAR/MAR 2006
BASED ON/BASEE SUR:
RECON:
RADARSAT: 14 MAR/MAR 2006
NOAA: 15 MAR/MAR 2006
NORTH OF / AU NORD DE 55N
15 MAR/MAR 2006
AMSR 06Z AND 17Z
CGHL # 41
1-800-767-2885
ENVIRONMENT CANADA
ENVIRONNEMENT CANADA
2006
60W
55W
50W
55N
50N
GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHN'S
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

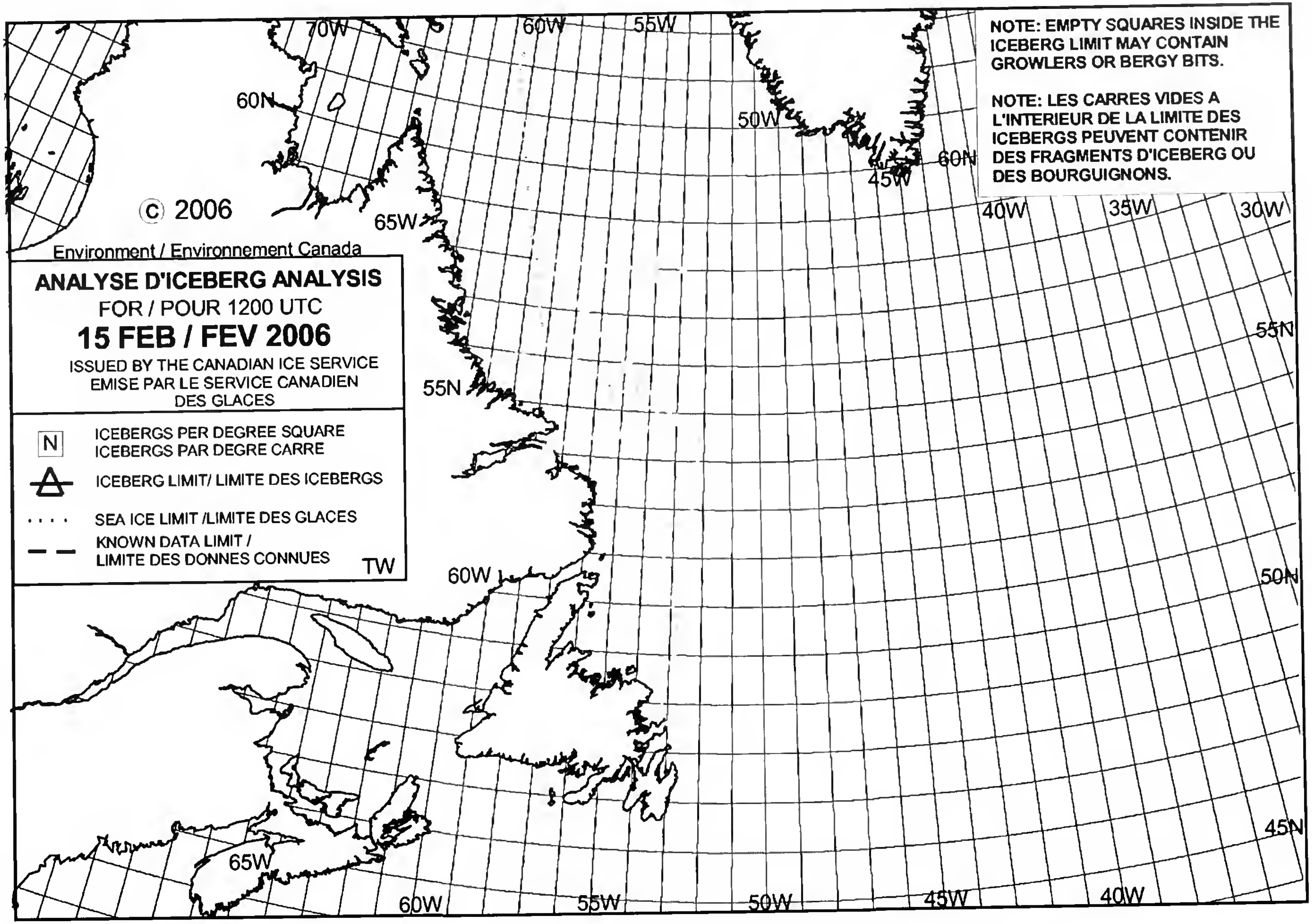

ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 APR/AVR 2006
BASED ON/BASEE SUR:
RECON:
RADARSAT: NONE/AUCUNE
NOAA:
15 APR/AVR 2006 MODIS 16Z
SOME/QUELQUES ZONES 9+
CGAH #42, CGHL #67
1-800-767-2885
ENVIRONMENT CANADA
ENVIRONNEMENT CANADA 2006
60W
55W
50W
55N
50N
GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHN'S
A 10 1. 8
B 10 3 6 1 7 4 1.7 3 3 8
C 9+ 3 4 3 7 4 1.7 4 4 3
D 9+ 2 2 3 7 - 4 1. 7 1 2 2
E 9+ 1 2 2 7 - 4 1. 7 1 3 2
F 9+ 1 1 3 7 - 4 1. 7 1 2 2
G 8 2 4 2 7 4 1.7 4 4 3
H 7 3 3 1 7 4 1.7 3 3 3
I 7 2 2 2 7 - 4 1. 7 1 3 3
J 6 7 4
K 5 3 2 7 4 1. ~9+
L 4 2 2 7 4 1. ~9
M 3 2 1 7 4 1. 4 3
N 2 1 1 7 4 1. ~9+
8
5
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

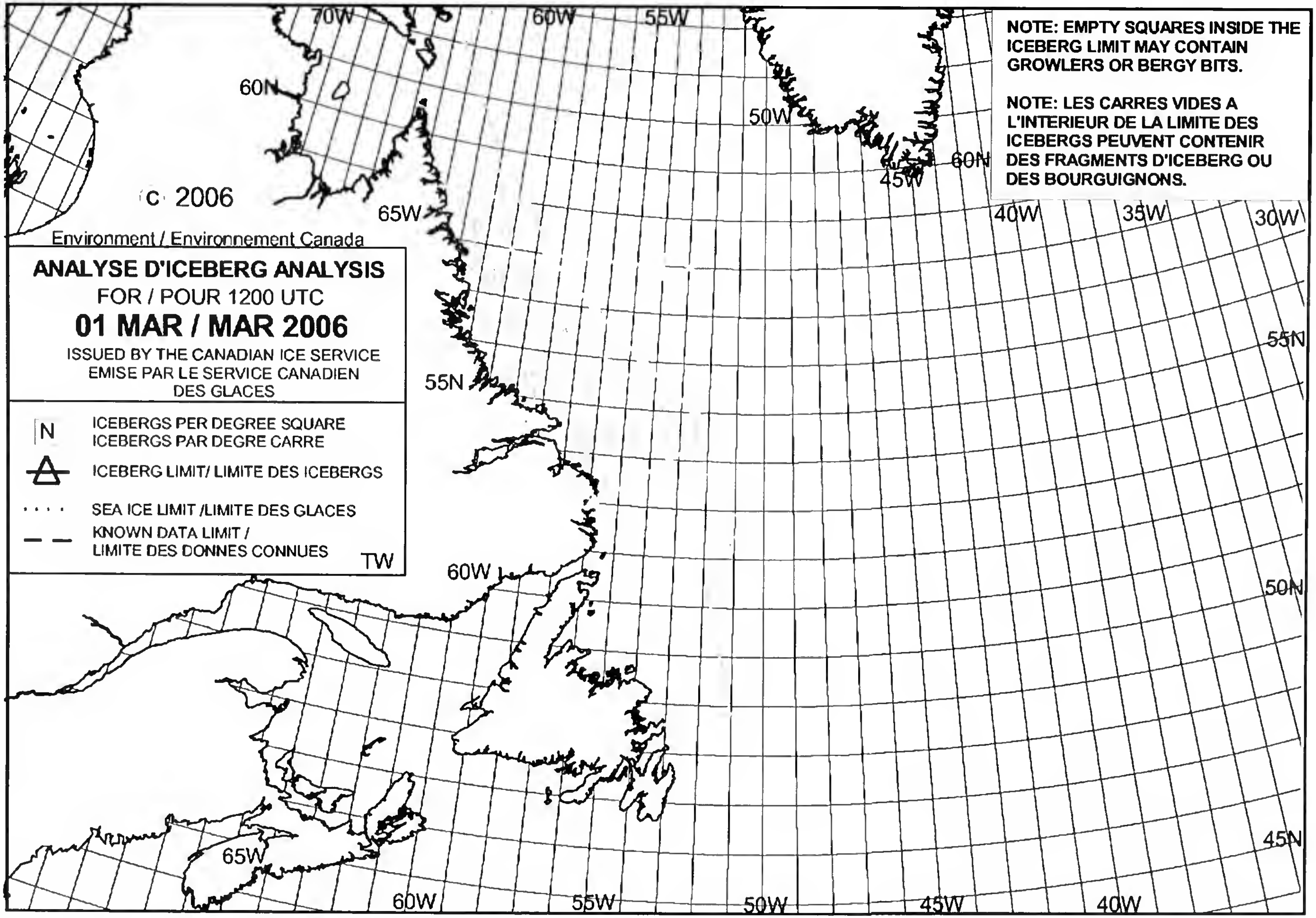

ICE ANALYSIS
ANALYSE DE GLACE
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
06 MAY/MAI 2006
BASED ON/BASEE SUR:
RECON:
RADARSAT: 06 MAY/MAI 10Z
N OF/DE 55N
NOAA: 06 MAY/MAI 10Z,16Z
CLOUDY/NUAGEUX S OF/DE 54N
MODIS 06/15Z,17Z
GOES 06/13-17Z
1-800-767-2885
ENVIRONMENT CANADA
ENVIRONNEMENT CANADA 2006
LAST CHART UNTIL FURTHER NOTICE
DERNIERE CARTE JUSQU'A NOUVEL AVIS
GOOSE BAY
CARTWRIGHT
ST. ANTHONY
BOTWOOD
GANDER
55W
50W
55N
50N
60W
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Biweekly Iceberg Charts

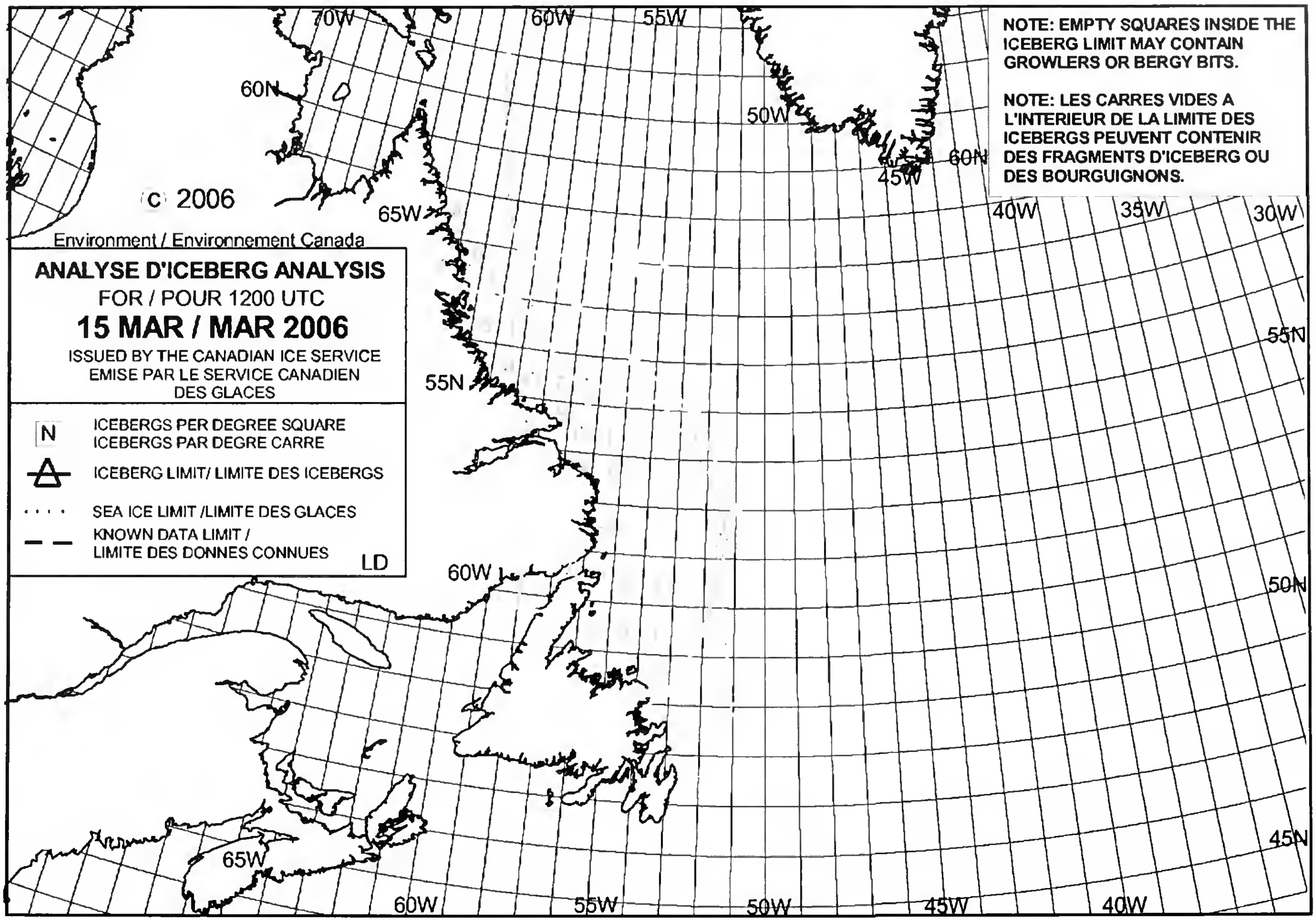


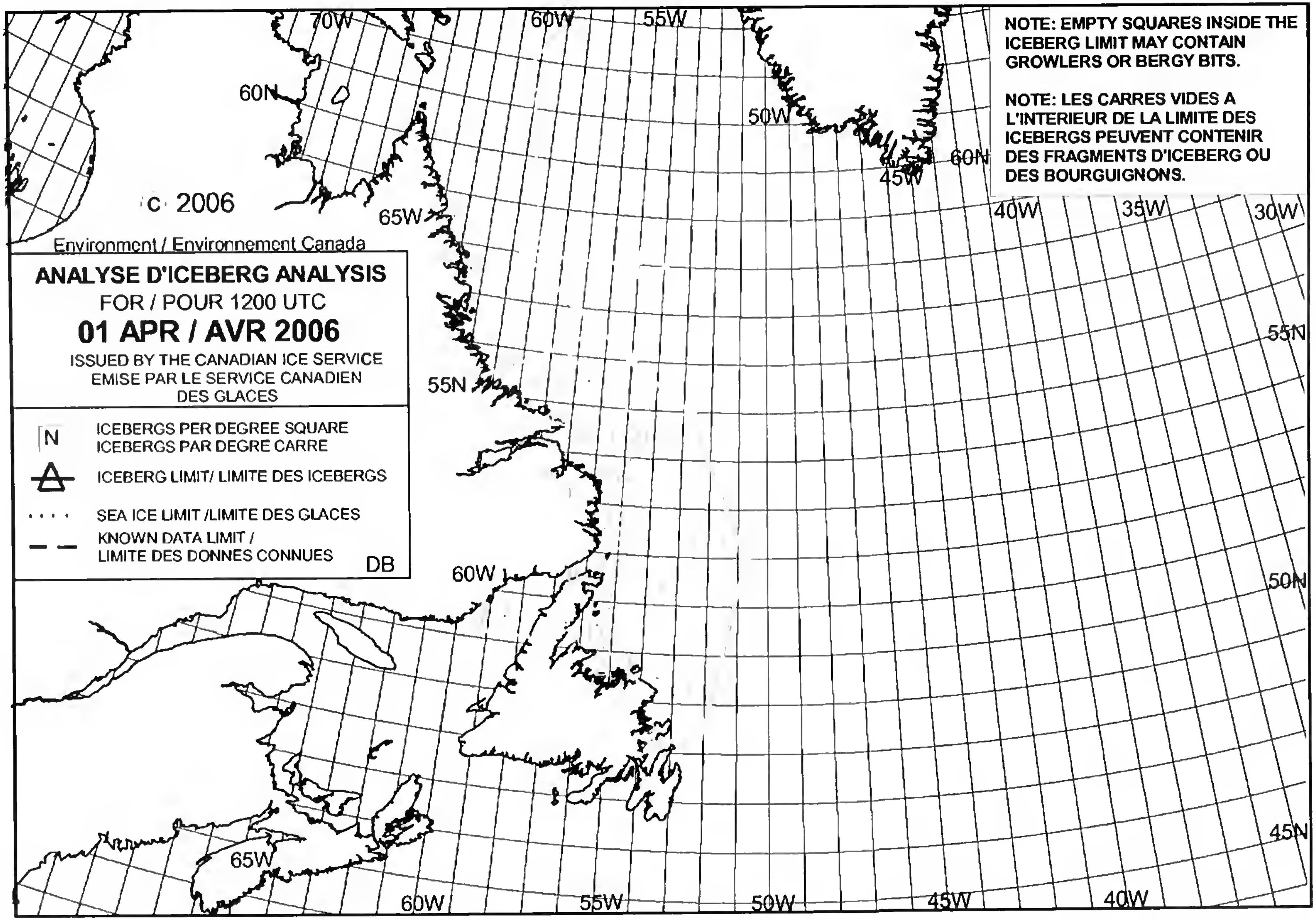
Iceberg charts are reprinted with permission of the Canadian Ice Service.

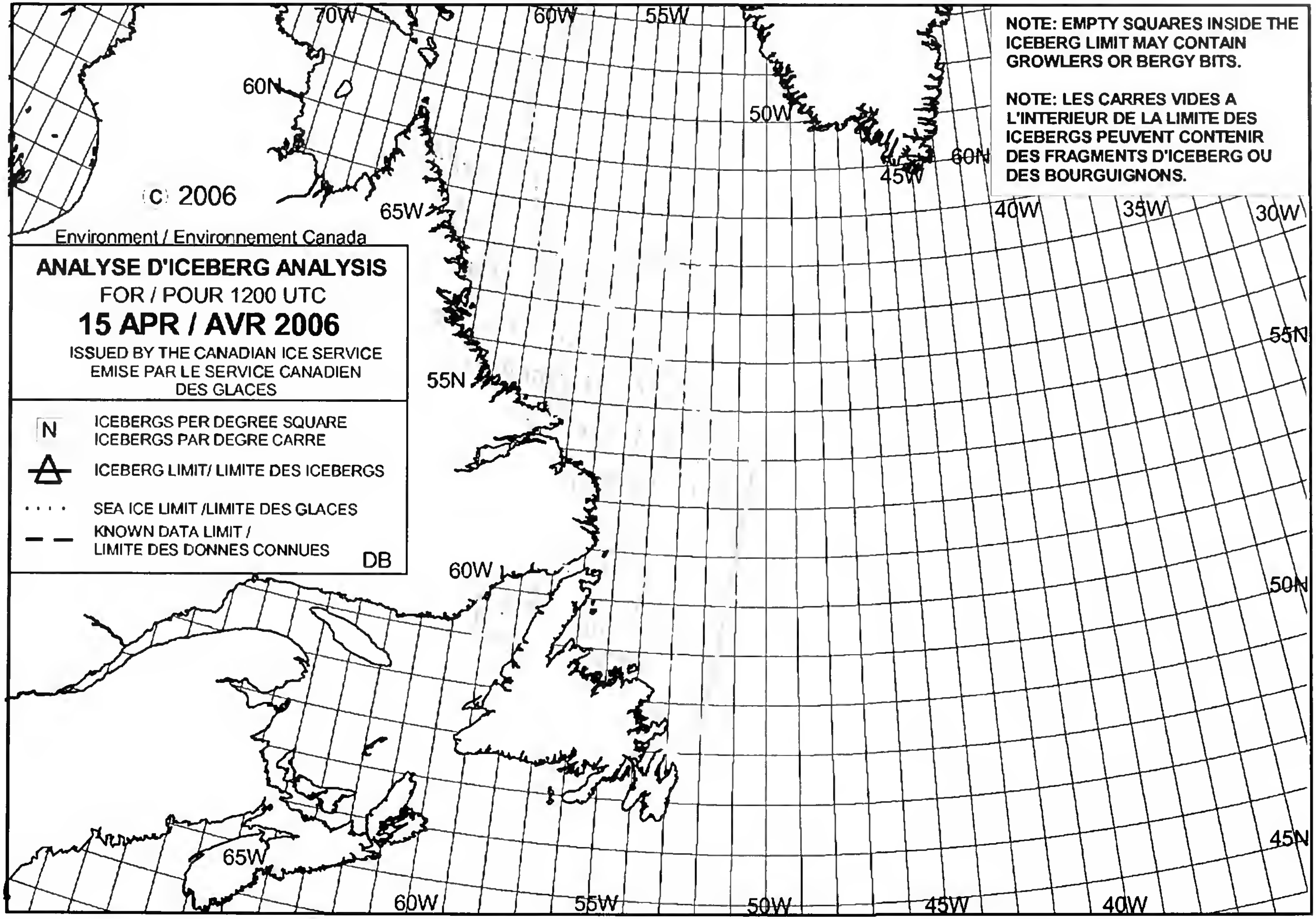

NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
© 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
15 FEB / FEV 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
TW
70W
60W
55W
60N
50W
60N
45W
65W
40W
35W
30W
55N
55N
60W
50N
65W
45N
60W
55W
50W
45W
40W



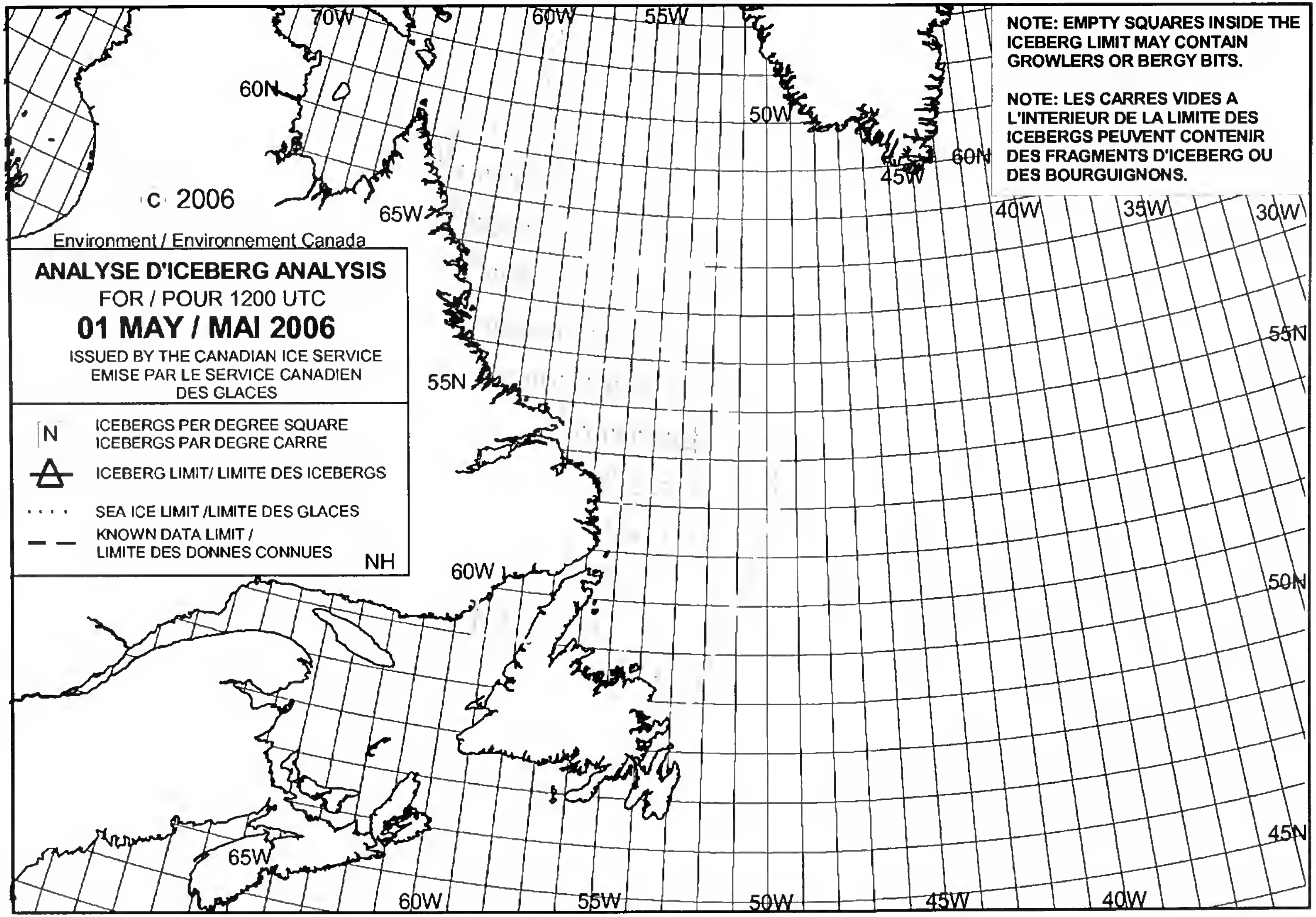
70W
60W
55W
60N
50W
60N
45W
65W
40W
35W
30W
(c) 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
01 MAR / MAR 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
TW
NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
55N
60W
50N
45N
65W
60W
55W
50W
45W
40W

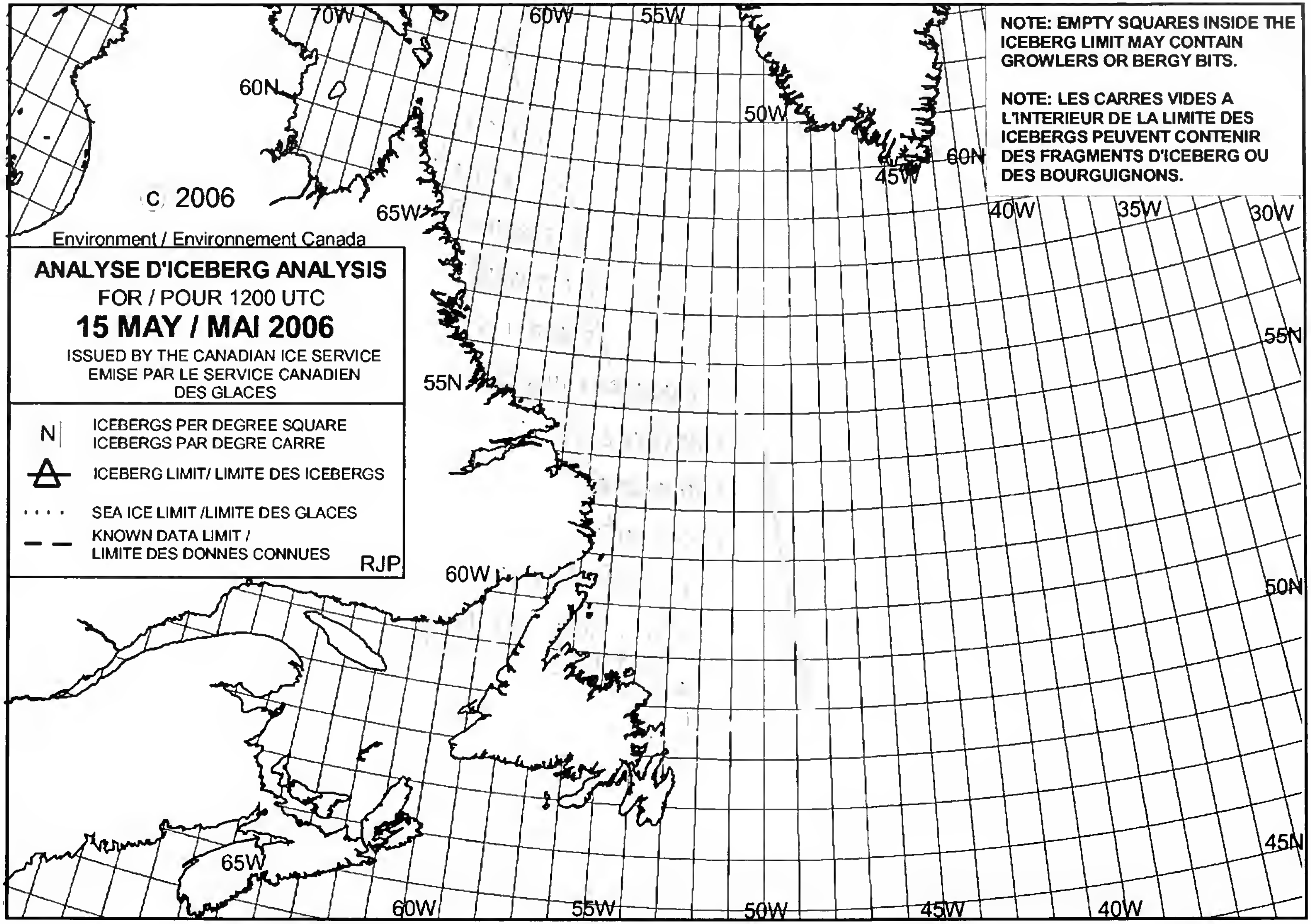

NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
(c) 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
15 MAR / MAR 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
LD
70W
60W
55W
50W
45W
40W
35W
30W
65W
60N
55N
50N
45N

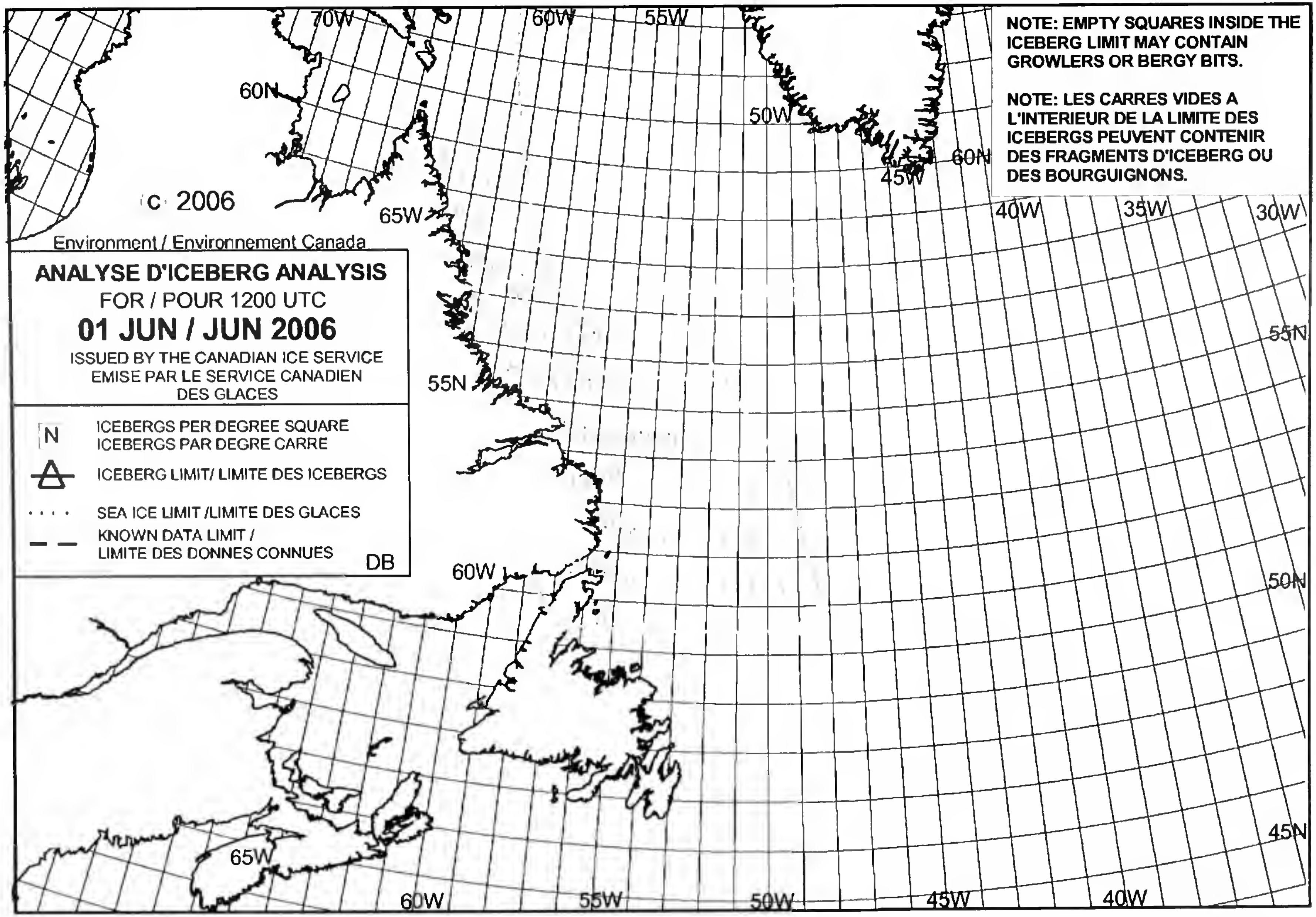

NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
c 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
01 APR / AVR 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
DB
70W
60W
55W
50W
45W
60N
65W
55N
60W
50N
45N
40W
35W
30W
65W
60W
55W
50W
45W
40W
60N



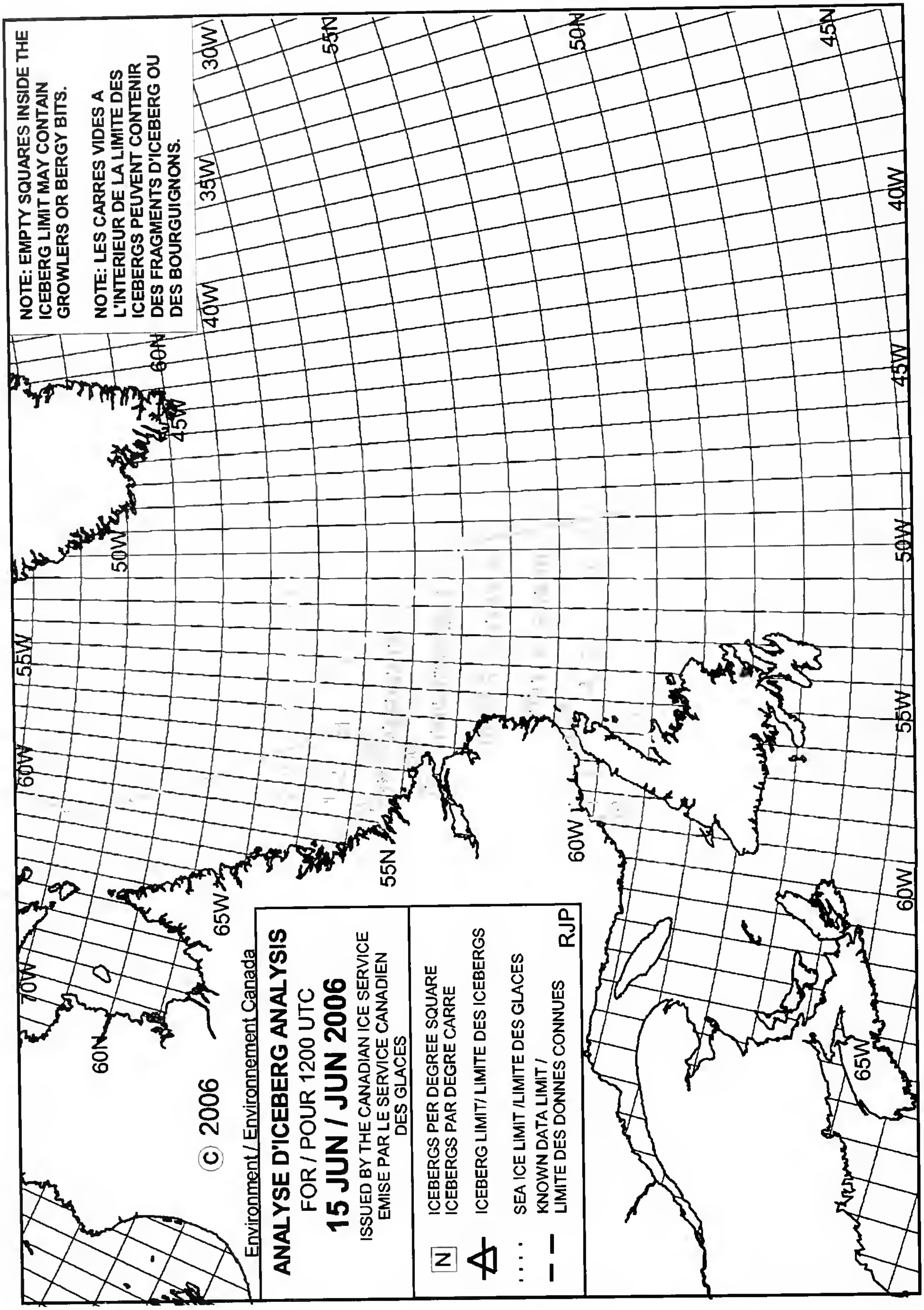
NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
(c) 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
15 APR / AVR 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
DB
70W
60W
55W
50W
45W
40W
35W
30W
65W
60N
55N
50N
45N

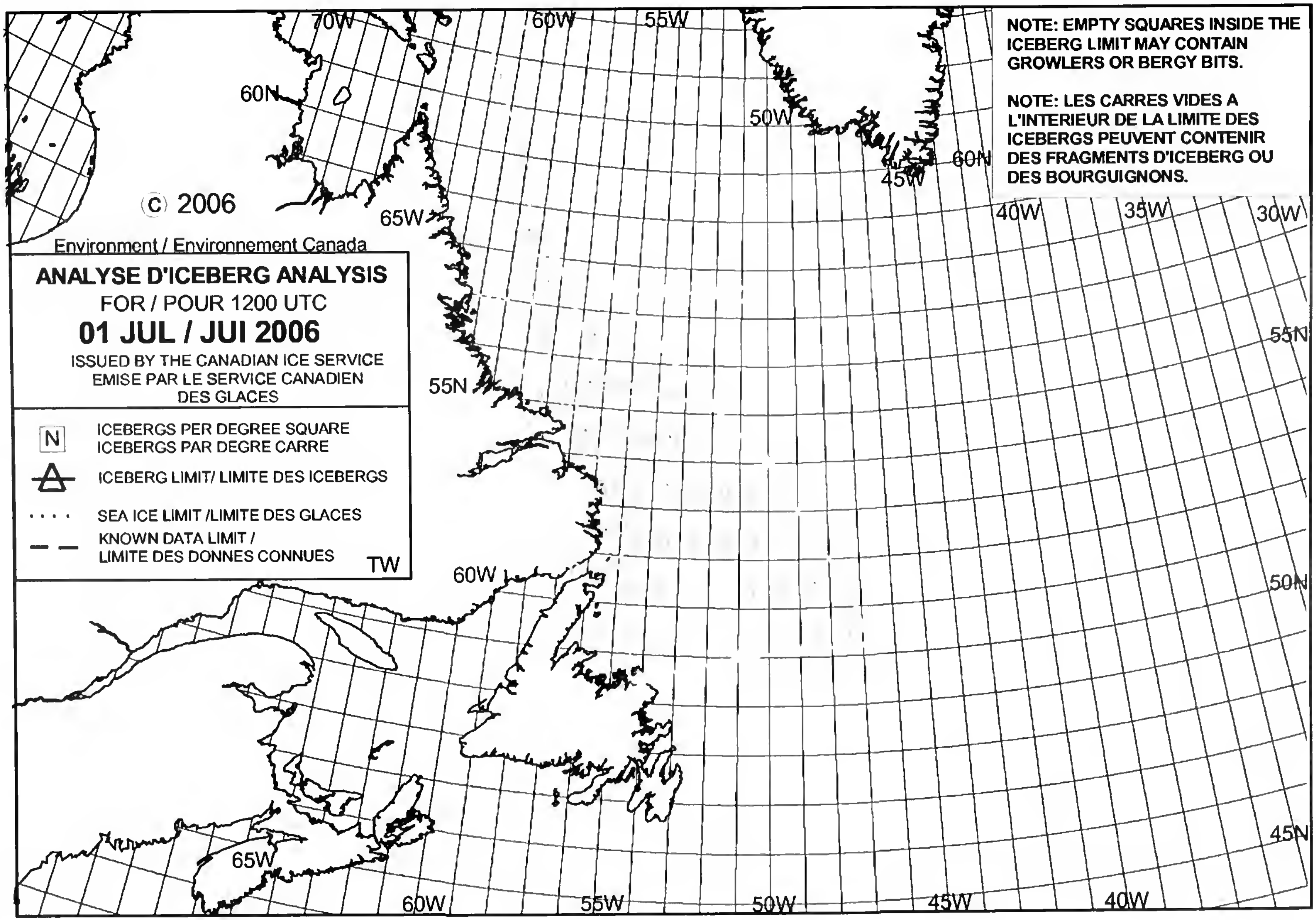

NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
c 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
01 MAY / MAI 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N
ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
NH
70W
60W
55W
50W
45W
40W
35W
30W
65W
60N
55N
50N
45N


NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
c 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
15 MAY / MAI 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
RJP
70W
60W
55W
50W
45W
40W
35W
30W
65W
60N
55N
50N
45N



NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
(c) 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
01 JUN / JUN 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
DB
70W
60W
55W
50W
45W
40W
35W
30W
65W
60N
55N
50N
45N


NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
© 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
15 JUN / JUN 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT / LIMITE DES DONNES CONNUES
RJP
30W
35W
40W
45W
50W
55W
60W
65W
70W
45N
50N
55N
60N


NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN GROWLERS OR BERGY BITS.
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D'ICEBERG OU DES BOURGUIGNONS.
© 2006
Environment / Environnement Canada
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
01 JUL / JUI 2006
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN DES GLACES
N
ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
TW
70W
60W
55W
50W
45W
60N
40W
35W
30W
65W
55N
50N
45N
60N
55N
60W
65W
60W
55W
50W
45W
40W

Acknowledgements

Commander, International Ice Patrol acknowledges the following for providing information and assistance:

C-CORE
Canadian Coast Guard
Canadian Forces
Canadian Ice Service
Canadian Maritime Atlantic Command Meteorological and Oceanographic Center
Department of Fisheries and Oceans Canada
German Federal Maritime and Hydrographic Agency
National Geospatial-Intelligence Agency
National Ice Center
National Weather Service
Nav Canada Flight Services
Provincial Aerospace Limited
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 assigned to the International Ice Patrol during the 2006 Ice Season:

CDR M. R. Hicks
LCDR B. D. Willeford
Dr. D. L. Murphy
Mr. G. F. Wright
LT N. A. Jarboe
LT W. C. Woityra
MSTCS J. M. Stengel
MST1 T. M. Davan
MST1 A. J. Alonso
MST1 H. L. Brittle
YN1 D. C. Phillips
MST2 A. L. Rodgers
MST2 J. P. Buehner
MST2 W. P. Tootle
MST2 S. B. McClellan
MST2 J. N. Sherrill
MST3 N. G. Myers
MST3 S. J. Weitkamp
MST3 S. A. Baumgartner

International Ice Patrol staff produced this report using Microsoft® Word 2003 and Excel 2003.

Appendix A

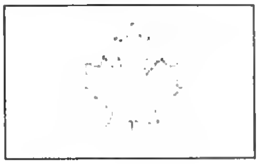
Nations Currently Supporting International Ice Patrol

Belgium

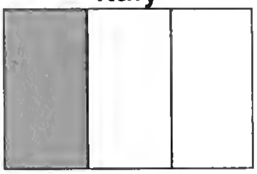
Greece

Poland

Canada

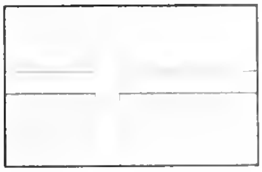


Italy

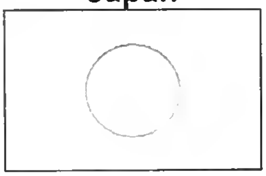


Spain

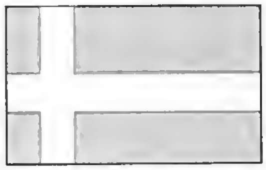
Denmark



Japan



Sweden

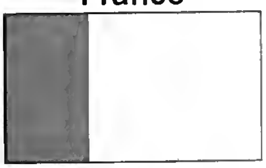


Finland

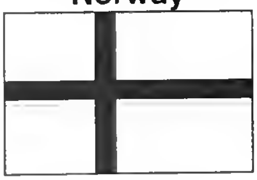
Netherlands

United Kingdom

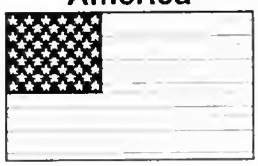
France



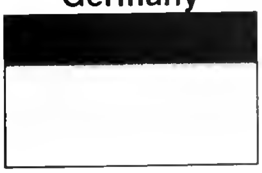
Norway



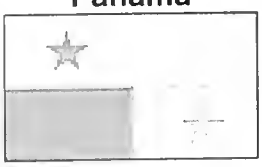
United States of America



Germany



Panama



Appendix B

Ship Reports

Ships Reporting By Flag	Reports
ANTIGUA & BARBUDA	
BRUARFOSS	3
BAHAMAS	
ATLANTIC CARTIER	26
EVEREST SPIRIT	10
JAEGER ARROW	3
MAUD	1
BERMUDA	
GLORY	3
TRIUMPH	1
ZETLAND	51
CANADA	
ANN HARVEY	2
ARCTIC	2
ATLANTIC AIRWAYS	6
CCG HELICOPTER	1
CICERO	1
GARTH HILTZ	1
GEORGE R. PEARKES	12
HENRY LARSON	1
HUDSON	1
INUSUK I	1
[illegible]	[illegible]
OOCL BELGIUM	2
PIERRE RADISSON	7
PROVINCIAL AIRWAYS	27
TERRY FOX	3
TWILLINGATE LIGHTHOUSE	2
WESTERN TUG	3
CAYMAN ISLANDS	
ICE STAR	16

Ships Reporting By Flag	Reports
CROATIA	
JARDRAN	9
CYPRUS	
IRYDA	18
ISADORA	14
FINLAND	
NESTE	1
TERVI	3
GERMANY	
FLOTBEK	1
REINBEK	2
GIBRALTAR	
KENT NAVIGATOR	9
SANDON	13
GREECE	
CAP DIAMANT	17
CAP LAURENT	13
MINERVA ALICE	15
HONG KONG	
FEDERAL OSHIMA	1
FEDERAL VENTURE	1
OOCL FORTUNE	29
OOCL MONTREAL	1
LIBERIA	
HC DALIA	1
HEDWIG OLDENDORFF	1
MAERSK PERTH	2
SERENITY	1
SWIFT-FAVOR	1

Ships Reporting By Flag	Reports
LIBERIA cont.	
ZIEMIA CIESZYNSKA	17
ZIEMIA GORNOSLASKA	19
ZIEMIA LODZKA	5
LITHUANIA	
KAPITONAS A. LUCKA	4
MALTA	
ARTEMIS II	1
OTTAVIA	3
SUN LIGHT	9
MARSHALL ISLANDS	
ROTORUA	1
NETHERLANDS	
SLUISGRACHT	1
NORWAY	
BERGE ARCTIC	4
BERGE NORD	46
ISADORA	2
MENOMINEE	2
ONEGO VOYAGER	10
PANAMA	
BRUNO SALAMON	3
CHALLENGE PROSPECT	1

Ships Reporting By Flag	Reports
PANAMA cont.	
CMA CGM HUDSON	1
GULF PACIFIC	4
MSC SABRINA	2
ORANGE TIARA	1
SARDEGNA	1
SINGAPORE	
BARENTS SEA	1
MAERSK WILLOW	1
STAR SIRANGER	8
SWEDEN	
ATLANTIC COMPANION	1
FINNFIGHTER	1
FINNWOOD	4
UNITED KINGDOM	
BRITISH ENGINEER	8
BRITISH HOLLY	1
BRITISH TRANQUILLITY	2
HUNTESTERN	22
UNITED STATES OF AMERICA	
GEYSIR	36
UNKNOWN	?
ANY SHIP	66

*DENOTES VESSEL PARTICIPATION AWARD WINNER

Appendix C

International Ice Patrol Iceberg Size Classification

MST2 Sheridan B. McClellan
International Ice Patrol

Background

It was recently discovered that there existed a slight difference between the iceberg size classifications listed on the IIP website and in chapter 4 of the MANICE manual. The tables below are taken directly from the IIP website and from the MANICE manual:

61-122
123-213
Over 213

Table 1: (IIP Website)

61-120m
121-200m
>200m

Table 2: (MANICE Code)

As seen above in the highlighted areas, the differences are small but cannot be accounted for as rounding errors in the conversion from feet to meters. In addition, no distinction in iceberg shape is made in either table. For consistency, IIP has decided to adopt the MANICE size descriptions for all future use. Prior to making this decision, the following information was gathered regarding IIP's legacy iceberg sizing chart.

Methodology:

IIP Annual Reports proved to be the best resource in establishing the origin of IIP's iceberg sizing conventions. This research commenced with the first Annual Report from 1914 and worked forward to the present. The following annual reports contained some information regarding size classification of icebergs:

1914 – Icebergs are classified as either growlers or icebergs on the charts in the Annual Report but no mention is made on the measurements used to classify them. The charts and ship's logs were the only sources of iceberg information.

1920 – Report makes no distinction on the size of the icebergs on the enclosed chart.

1921 – The first in-depth look that expands on iceberg size. Report mentions large and small in the text, but no specific delineation is cited.

1923 – Report classifies icebergs as either growlers or icebergs on enclosed charts. The written sighting reports make some distinctions between large and small icebergs.

1925 – First written individual sighting reports and first use of different sizes (small, medium, large and very large); no growlers are mentioned in the report, still no size measurements.

1926 – Written individual report now includes growlers as well.

1929 – First icebergs with measurements mentioned on the individual sighting reports, however icebergs with measurements are just mentioned as bergs with no specific size given.

1958 – Last report with written individual sighting reports of icebergs by size.

1964 – A deterioration table mentions sizes and measurements (R.E. Lenezyk, page 98).
Reproduced below is **Table IX** as seen in the report:

Table IX. Deterioration Time in Days for Bergs (from Lenezyk)

Although the table is focused on deterioration, it is clear that the height and length of the various iceberg sizes were well established at that time. No distinction is made between tabular and non-tabular icebergs.

1965 – First use of a table that summarizes iceberg data according to size classification (small, medium, large and unclassified), (page 29).

1968 – In May, J.E. Murray publishes a report written for an Ice Seminar in Calgary, Alberta sponsored by the Petroleum Society of CIM called "The Drift, Deterioration and Distribution of Icebergs in the North Atlantic Ocean". **Table 3** (below) reproduces the table shown in that report and **Table 4** is the same table but converted into meters without rounding.

Table 3: from Murray(1968)

Table 4: metric conversion of Murray(1968)

As seen in the above tables, Murray did not list growlers or bergy bits, however the conversion from feet to meters shows that the values provided for non-tabular bergs are similar to the size measurements found on the legacy IIP iceberg sizing chart. These iceberg measurements show only a meter difference for the medium, large and very large category. Also, Murray differentiates between tabular and non-tabular icebergs.

1974 – First and only use of a Berg Sizing Table (mentioned in an evaluation report of possible satellite use by LTJG S.R. Osmer, USCG) (**Table 5**). There is no reference to the source of the measurements.

Two of the key differences between **Table 5** and the legacy IIP iceberg sizing chart are the actual berg lengths and the differing measures for tabular and non-tabular bergs. The legacy IIP iceberg sizing chart uses only a general size without differentiating between tabular and non-tabular bergs. **Table 5** also includes the first size descriptions for growlers and bergy bits.

Table 5: from Osmer(1974)

1976 – In Appendix A (p. 58), tabular and non-tabular iceberg measurements are mentioned in a report by R.Q. Robe called "Size Frequency and Distribution of Grand Banks Icebergs", citing Murray's 1968 report.

1983 – Appendix C of this report details the characteristic lengths of icebergs used in the IIP iceberg deterioration model in use at that time (Anderson, 1983). **Table C-1** is reproduced below. Anderson specifically indicates that the berg lengths are those used by IIP to classify icebergs, except for the large, which "was chosen arbitrarily."

Table C-1: Reproduced from Anderson(1983)

No new information, including size tables, charts or references, was found from 1984 to present. The years not mentioned in the findings had no references to sizes or were no different from the previous year.

In the course of research, an 1890 report written by ENS Hugh Rodman, USN, was discovered to list some measurements for an average iceberg in the Arctic (by today's standard the berg would be considered very large). The report mentions these measurements: "from 60 to 100ft to the top of its walls, whose spires or pinnacles may reach from 200 to 250ft in height and from 300 to 500 yards in length, is considered an average size berg in the Artic." [sic]

Conclusion

The detailed description of the size categories has changed over IIP's history. It is not clear from the annual reports exactly when the original categories were defined. In early reports only a general distinction was made between growlers and icebergs. By the mid-1920's, small, medium, large and very large icebergs were listed, but no specific measurements were recorded. It is likely that there were specific definitions for each of the various size classes at that time, but they were not recorded in the reports. It is also reasonable to assume that the definitions were listed in feet and originated with those that Murray used in 1968. It is clear from Murray(1968) and Osmer(1974) that IIP has long distinguished between tabular and non-tabular icebergs.

Sometime after 1976, IIP decided to define a single size classification based on the earlier size characteristics of a non-tabular iceberg. These also appear to be based on the sizes given by Murray(1968). When IIP and the Canadian Ice Service (CIS) cooperated to develop the MANICE code in the mid-1980's, the definitions of the size classes were expressed solely in meters, and rounded to the nearest ten meters for simplicity.

The degree of uncertainty in iceberg size observations vastly exceeds the minor differences between the MANICE and legacy IIP iceberg sizes. There is no sensor or detection method available to us today that is capable of making a measurement of that resolution. Accordingly, beginning with the 2007 ice season, IIP will adopt the MANICE code classifications, as presented in **Table 2**.

References

Anderson, I. (1983). Iceberg Deterioration Model. Appendix C to *Report of the International Ice Patrol in the North Atlantic Ocean*. Bulletin No. 69.

Canadian Ice Service. (2002). *Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE)*, 9th Edition.

Iceberg Size Classification. (2007). Retrieved March 7th 2007 from: http://www.uscg.mil/lantarea/iip/FAQ/Icebergs_5.shtml

International Ice Patrol. (1914-1983). *Report of the International Ice Patrol Service in the North Atlantic Ocean.*

Murray, J.E. (1968). *The Drift, Deterioration and Distribution of Icebergs in the North Atlantic Ocean*; Ice Seminar: A conference convened by the Petroleum Society of CIM, Calgary, Alberta, May 1968.

Rodman, H. (1890). Ice and Ice Movements in the North Atlantic Ocean. *U.S. Navy Hydrography Report 1890.*

The author wishes to acknowledge the following people for their assistance:
Dr. Donald Murray, International Ice Patrol
Mrs. Claudette Cloutier, Manager, Gallagher Library
Mrs. Ellen Levy, Librarian, Woods Hole Oceanographic Institution

Appendix D

Synchronization of the IIP and CIS Iceberg Sighting Databases

Donald L. Murphy
International Ice Patrol

Introduction

In 2006 International Ice Patrol (IIP) and Canadian Ice Service (CIS) operationally tested a shared database of the iceberg population near the Grand Banks of Newfoundland and along the Labrador coast. Previously, the two organizations maintained separate, although connected, databases to produce ice warnings for their specific customers.

CIS and IIP have a long record of close cooperation for mutual benefit. Although serving different customers and different areas of responsibility, their products are based on the same iceberg population. IIP, which operates under International Convention for the Safety of Life at Sea (SOLAS) focuses on the transatlantic shipping lanes east and south of Newfoundland. CIS, a branch of the Meteorological Service of Canada (MSC), is the leading authority for information about ice in Canada's navigable waters. Since 1993 IIP and CIS have used very similar iceberg drift and deterioration models to estimate the location of icebergs and create products. The major difference between the models was the input environmental parameters (wind, waves, and sea surface temperature) that drove them. Otherwise, the models, which form the basis for the operational products, used the same equations, solution techniques, etc. Once an iceberg is entered into the model, the database maintains a record of its location and size, shape, etc.

Prior to 2006 CIS and IIP divided their data entry responsibilities at 52°N. During the part of the year IIP produced daily warnings to transatlantic mariners (generally February through June), CIS entered iceberg observations north of 52°N into their database. They also assumed primary tracking responsibility. Once an iceberg moved south of 52°N it was handed off to IIP's database where it was treated as a newly sighted berg. Icebergs south of 52°N were IIP's responsibility to enter and track, as this information was used to create the limit of all known ice (LAKI). CIS was required to monitor the iceberg population south of 52°N as well, so they could generate products specific to Canadian waters. This resulted in an awkward situation for CIS and IIP watch personnel who were forced into frequent communication to ensure no iceberg observations were missed and the iceberg positions in the two databases were consistent.

There were obvious benefits to having a single database to track the iceberg population and create products:

- sharing the data-entry burden
- minimizing the opportunity for errors
- creating an off-site back-up database in the event of a major computer failure or other interruption of operations at either operation center

The synchronization of the two databases has an important side effect. It will substantially change the data that IIP provides to the archive centers each year because all the CIS data entries will be included. There are advantages and disadvantages to this change. For the first time, there will be a single database that contains all the iceberg reports in the western North Atlantic Ocean, thus creating a comprehensive picture of the iceberg distribution. On the other hand, the database provided to the archive centers will no longer be created by a single operations center, which may make it difficult to maintain a database that is entirely homogeneous. For example, IIP and CIS have different guidelines on merging some radar targets. Despite the best efforts there will be unavoidable inconsistencies.

This appendix summarizes the working agreements between CIS and IIP and explores the impact on the iceberg sighting database IIP provides to archiving centers. It is not intended to be a comprehensive analysis of the iceberg sightings in the western North Atlantic.

Achieving Database Synchronization

The first step in the synchronization process was to align the CIS and IIP drift and deterioration models by agreeing on a single suite of environmental input parameters (wind speed and direction, wave period and height, and sea surface temperature). IIP and CIS settled on a combination of products from U.S. Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC) and Meteorological Service of Canada (MSC).

Icebergs can populate an enormous area of the western North Atlantic Ocean, sometimes in great numbers. Each year the two operations centers receive and process reports of many thousands of icebergs and unidentified radar targets. The watch standers must evaluate each report to determine if the information refers to a target that has already been reported or a new one. The appropriate information is then entered into the database, thus it was prudent to divide the responsibility of entering reported iceberg information according to the primary area of each organization's interest (**Figure 1**). IIP merges all iceberg reports south of 50°N and east of 55°W because these are the icebergs that are most likely to enter the transatlantic shipping lanes. CIS evaluates the iceberg reports north and west of those lines, including the Gulf of St. Lawrence. Choosing 50°N as the northern boundary of IIP's area of responsibility is a small change from the previous line at 52°N. Prior to 2006, IIP rarely entered into their database icebergs close to the Newfoundland's northern peninsula because those icebergs had little chance of moving close to the shipping lanes. Typically, they became trapped or grounded in the bays and would deteriorate in place. If they did escape, coastal shipping would detect them and report their position. The choice of a north-south boundary at 50° N is the result of CIS' desire to maintain detailed information on the iceberg population near Newfoundland's northern peninsula, in the Strait of Belle Isle and in the Gulf of St. Lawrence.

Two copies of the shared database are maintained, one at each operations center. Regardless of which operations center enters or updates iceberg information, the other's database is automatically updated to reflect the change. This arrangement has the added advantage of creating a live back-up database should a computer failure destroy one copy.

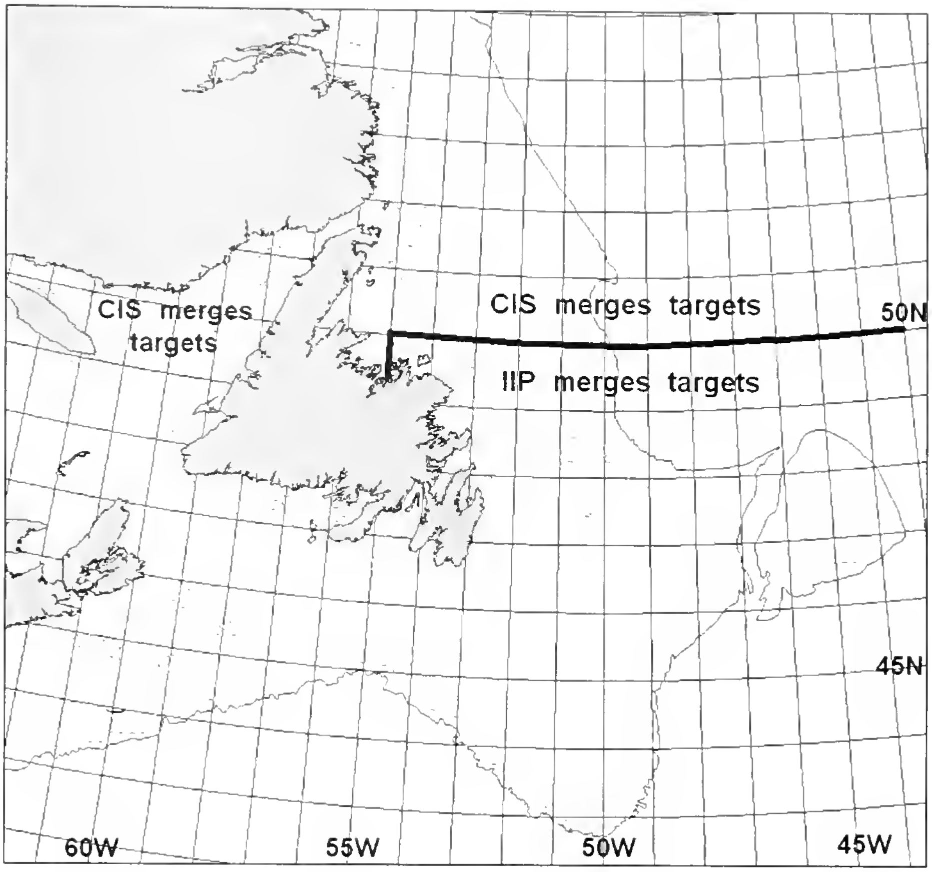


Figure 1. Areas of responsibility for entering targets into the synchronized iceberg database.

Archived IIP Iceberg Observations

IIP has been observing icebergs in the western North Atlantic Ocean since it began regular patrols in 1913. Throughout its early history Ice Patrol documented iceberg sightings in its yearly bulletins. In 1993, Anderson used original paper records of iceberg reports from 1960-1982 to create a digital record of all iceberg sightings for the period. Each year after 1982 IIP has produced a digital record of all iceberg-sighting reports. Anderson's original file and each yearly record are sent to the National Snow and Ice Data Center (NSIDC). NSIDC is part of the University of Colorado Cooperative Institute for Research in Environmental Sciences, and is affiliated with the National Oceanic and Atmospheric Administration National Geophysical Data Center through a cooperative agreement. NSIDC makes IIP's iceberg sighting data available online at http://nsidc.org/data/g00807.html (NSIDC, 1995).

The iceberg data provided by IIP constitute a major part of the comprehensive iceberg-sighting database described by Verbit et al. (2006), which is sponsored by the Canadian Program of Energy Research and Development (PERD). The PERD iceberg-sighting database also includes observations from the oil industry drilling sites, various field surveys, etc. All the data are subjected to a rigorous data-verification process before being placed the database. It is available on line at:

http://www.chc.nrc.ca/English/Cold%20Regions/Reports/PERD/grandbanks_e.htm

Finally, IIP's data and documentation are also provided for long-term preservation to the National Archives and Records Administration in accordance with U. S. Government requirements.

Comparisons

Tables 1 and **2** summarize the iceberg observations from the IIP archives for the five-year period 2002-2006, with 2006 the only year in which the databases were synchronized. The size and shape categories in **Tables 1** and **2** follow the traditional classification scheme described in *Manual of Standard Procedures for Observing and Reporting Ice Conditions* (CIS, 2005), also known as the MANICE code. The iceberg portion of the MANICE code was developed jointly by CIS and IIP. (http://ice-glaces.ec.gc.ca/content_contenu/ice_codes/manice/CHAPTER4.pdf)

As described earlier in this report, 2006 was an extraordinarily light ice year. No icebergs were estimated to have passed south of 48°N. As such, it is not a very good year to make detailed comparisons of the impact of the synchronization (or even to conduct a comprehensive operational evaluation). For example, it is not useful to parse out the sightings south of 50°N or 52°N to compare with previous years because there were so few icebergs.

The most noteworthy change in the 2006 database is the large increase in the number of radar targets entered. As indicated by both tables, approximately one-quarter of the included observations were detected only by radar. This is a large departure from the previous four years when the percentages were less than ten. It is appropriate to include a stationary radar target reported by a ship because the mariner is generally able to determine whether a target is drifting slowly rather than moving in a determined way. In most cases IIP doesn't include radar targets provided by aircraft unless corroborated by visual observation because typical aircraft-based radars have difficulty distinguishing between vessels and icebergs. This is a particular concern in high ship-traffic areas, but less of a concern north of 52° N where there is less maritime traffic. IIP enters radar targets reported by aircraft if the radar is capable of distinguishing between a vessel and an iceberg (such as the AN/APS-137 on the IIP reconnaissance aircraft.)

YEAR	GROWLER	BERGY BIT	SMALL	MEDIUM	LARGE	VERY LARGE	GENERAL	RADAR (Ship & Aircraft)	RADAR (Satellite)	OBS
2002	9.5%	3.0%	28.5%	22.5%	9.7%	1.1%	19.9%	5.8%	0.0%	4735
2003	3.4%	5.9%	29.0%	23.3%	15.4%	1.8%	19.7%	1.5%	0.0%	4874
2004	1.3%	2.3%	14.3%	16.2%	3.8%	1.1%	59.4%	1.4%	0.0%	4097
2005	11.8%	9.6%	33.1%	26.4%	5.1%	4.5%	3.9%	5.6%	0.0%	178
2006	2.1%	4.6%	17.5%	25.3%	7.4%	0.5%	12.4%	23.2%	7.0%	5165
TOTAL	4.2%	4.1%	22.6%	22.2%	9.2%	1.2%	26.1%	8.5%	1.9%	19049

Table 1. Size of the targets entered into the iceberg drift model from 2002 through 2006.

YEAR	BLOCKY	DRYDOCK	DOMED	ICE ISLAND	NON-TABULAR	PINNACLE	TABULAR	WEDGE	GENERAL	RADAR ICEBERGS	OBS
2002	3.0%	18.0%	4.1%	0.3%	16.3%	3.7%	9.9%	2.2%	33.1%	9.4%	4735
2003	1.3%	9.2%	3.8%	0.2%	27.4%	3.4%	25.2%	1.9%	23.9%	3.7%	4874
2004	2.0%	4.8%	2.7%	0.1%	12.3%	2.5%	4.5%	1.9%	63.8%	5.4%	4097
2005	0.6%	38.8%	4.5%	0.0%	11.8%	1.7%	1.7%	3.4%	30.9%	6.7%	178
2006	5.5%	13.4%	5.4%	0.0%	7.6%	6.1%	8.2%	4.1%	23.9%	25.7%	5165
TOTAL	3.0%	11.8%	4.1%	0.1%	15.9%	4.0%	12.1%	2.6%	34.8%	11.5%	19049

Table 2. Distribution of the shape of the observations entered into the iceberg drift model from 2002 through 2006.

New Data Sources

In 2006 CIS included in the database 362 satellite radar targets into the database north of 50° N. CIS and IIP are participating as end users in the Polar View Program, which is supported by the European Space Agency and the European Commission with participation by the Canadian Space Agency. C-CORE, the team's prime contractor, provides iceberg-sighting information determined from satellite-based radar images. Although 362 targets comprise only a small fraction of the number of observations in 2006, it is clearly a category that will grow as the technology improves. IIP has not started to enter reports from the radar satellites into the database.

Conclusions

The following are the major changes due to the synchronization:

1. Area of Coverage: The synchronized database encompasses a much larger area than in previous years.
2. Iceberg Population: The database will be a better representation of the iceberg population near Newfoundland's northern peninsula and the Strait of Belle Isle because it provides more detail.
3. Radar Targets: The area between 50° N and 52° N will have more radar targets because of CIS' policy of entering them into the model.
4. Satellite Usage: CIS has begun to enter into the database targets detected by satellites, while IIP has not. This is a practice that will become more common as satellite radar observations become more reliable.
5. Iceberg Pedigree: Synchronization of the database allows IIP to maintain a pedigree of an iceberg regardless of where it was seen. In previous years, icebergs entered into the model by CIS north of 52°N were entered into the IIP database with the source labeled only as a target produced by the CIS database. The original information on the reporting source and the iceberg's size and shape was not carried into IIP's database.

References

Anderson, I., (1993). International Ice Patrol's Iceberg Sighting DataBase 1960-1991. Appendix D in: Report of the International Ice Patrol in the North Atlantic, Bulletin No. 79, 1993 Season, CG-188-48, Washington, D. C.

Canadian Ice Service, (2005). *Manual of Standard Procedures for Observing and Reporting Ice Conditions*, Unpublished Manuscript, Canadian Ice Service, 373 Sussex Drive, Ottawa, ON, Canada K1A 0H3.

National Snow and Ice Data Center, (1995). *International Ice Patrol (IIP) iceberg sightings database*. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media http://nsidc.org/data/g00807.html, February 25, 2007.

Verbit, S., G. Comfort and G. Timco, (2006). Development of a Database for Iceberg Sightings off Canada's East Coast. Proc. 18th International Symposium on Ice, IAHR '06, Vol. 2, pp 89-96.

Appendix E

The North American Ice Service

CDR Michael R. Hicks
International Ice Patrol

Introduction

The concept of the North American Ice Service (NAIS) evolved from the long relationship that the Canadian Ice Service (CIS), the National Ice Center (NIC) and the International Ice Patrol (IIP) have enjoyed in the US-Canada Joint Ice Working Group (JIWG). The JIWG was established in 1986 to improve information exchange and enhance coordination among the centers. The centers have taken advantage of these cooperative efforts in data exchange, terminology and standards, systems development, mutual backup, training, and research and development. NAIS was developed to extend and strengthen the working relationships among the three centers. It was formalized in 2003 through an Annex to a Memorandum of Understanding between the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Meteorological Service (MSC) of Environment Canada. The NAIS leadership is composed of two co-chairs, one from NOAA and the other from MSC, and the directors of the three services. There are no legal or financial obligations among the three organizations.

NAIS was established with the expectation that the cooperation among both countries' ice services could result in further efficiencies in the provision of ice information. Further, we believe a collaborative North American ice service can provide clients and sponsors with superior ice information to meet their requirements. NAIS may be the best way to meet the challenges presented by changing ice regimes in the Polar Regions and the associated increase in activity and interest expected throughout the rest of this century. The first four years of NAIS have shown that to fully realize these benefits, further integration of services within a new organizational model should be explored.

During the NAIS meetings in the fall 2005 and spring 2006, it became apparent to NAIS directors and co-chairs that an increasing level of ambiguity in the scope and future direction of NAIS had resulted in growing concern among the staff. Individual NAIS committees continually hit upon seemingly insurmountable barriers such as disparate information technology systems and the absence of a link between individual organizational budgets/funding and NAIS priorities. As a result, a team of NAIS leaders (the NAIS 'Tiger Team') with senior representatives from CIS, NIC & IIP met during the spring of 2006 in an effort to clarify the scope, mission, vision and strategic objectives that will allow NAIS to better serve ice information customers and clients. The Tiger Team unanimously agreed that products and services resulting from the combined efforts of all three organizations would be superior to each center's independent contributions. This key fact was seized upon to be clearly articulated and demonstrated – both internally (to gain buy-in from NAIS membership), as well as externally (to justify any further integration to parent services and governments).

The Tiger Team strategy focused on creating two key documents to promote NAIS concepts and explore possible governance options. The first document, Vision and Scope of the North American Ice Service, was intended to create a powerful message to inspire members and stakeholders alike to embrace the NAIS concept. The main points are summarized in the following Executive Summary:

Executive Summary
to the Vision and Scope of the
North American Ice Service

Today, the Canadian Ice Service, the U.S. National Ice Center and the International Ice Patrol all provide sea ice, lake ice and iceberg information that permit mariners to operate safely and efficiently year round in North American and global waters. Wintertime economies in North America are dependent on the reliable and efficient movement of goods and materials through ice-encumbered coastal waters. The ice services of Canada and the United States enable this by providing timely and accurate strategic and tactical ice information to the marine community. In doing so, these agencies also reduce the risk of loss of life, property and environmental damage from ice-related accidents and disasters. Military operations in the Polar Regions (land and sea patrols) depend on regular ice information to enhance their domain awareness and to plan their operations under, through and on top of sea ice.

Dramatic shifts in global ice regimes are occurring now and are anticipated to last throughout this century. Transportation routes and natural resources, once encumbered by the presence of sea ice, are now more viable and likely in the wake of shrinking ice conditions. As such, northern requirements for security and maritime domain awareness are expected to approach those of North America's east and west coast. Importantly, monitoring and understanding this reduction in ice is the basis to sound national policy decisions around the mitigation of, and adaptation to, this environmental change. In the face of this change, the need for ice information is growing rapidly and broadening beyond those of traditional users as activities and interest in the Polar Regions escalates. Under the current structure, the ice services will not be able to adequately respond to the increased future demands.

One integrated *North American Ice Service* capable of delivering a broad-based mission is considered to be the best way to ensure Canada and the United States have the ice information required to secure borders, expand economies and ensure citizens are in a position to meet and adapt to the challenges of rapidly changing sea ice, lake ice and iceberg conditions.

The intent of the North American Ice Service is to:

- Facilitate the growing public, commercial and government activities in ice affected waters around the world through the provision of accurate and timely ice information.
- Enhance the Maritime Domain Awareness of North America for national security by developing and disseminating geospatially-enabled ice products tailored to the environmental intelligence needs of defense and other government security agencies.
- Improve the accuracy of civilian and military numerical weather, ocean and environmental models by providing enhanced and timely observations of ice conditions.
- Help ensure that climate change research and the development of government policies and regulations is based on the best knowledge of past, present and future ice conditions.
- Meet North American requirements for ice information more effectively and efficiently through the development and assumption of a new organizational framework.

Despite some early successes, it is now apparent that the organizational and service model as defined in the current agreement is not adequate to realize the full promise of an integrated ice service.

Five organizational models capable of meeting the aforementioned NAIS goals were developed and analyzed, each representing an integration of current NIC, CIS and IIP operations and an enhanced level of collaboration. While all five models could meet the NAIS requirements, there were clear differences in the cost and complexity of organizational migration and in their respective organizational efficiencies.

The five options proposed by the NAIS Tiger Team were:

1. Enhanced Business Integration
2. Consolidated Authority
3. Pooled Budget With Legal Personality (Civilian or Military)
4. Independent Government Organization
5. Independent Non-Government Organization

These models were presented at the North American Ice Service 4th Annual Meeting that was hosted by the International Ice Patrol at the US Coast Guard Academy, New London CT 28-31 August 2006. From a pure efficiency perspective, it was generally agreed that an integrated NAIS with the "Pooled Budget with Legal Personality" (either civilian or military) would be preferred. It was clear from the discussion, however, that the complexity of implementing such a model would be both complicated and time consuming. Options 4 and 5 (an Independent Government Organization and an Independent Non-Government Organization) were also considered too complex to pursue. Option 1 (Enhanced Business Integration) and Option 2 (Consolidated Authority) were considered natural steps progressing toward the preferred governance model. Consequently, the NAIS leadership decided to pursue the desired option by implementing an enhanced joint leadership model. This enhanced joint leadership model would strive to implement as many of the attributes of Option 3 in as timely a manner as possible. This implementation would advance as far as possible until such time as an obstacle for which they did not have the appropriate legal instruments to resolve was encountered. At that point, the appropriate authority to continue the advancement would be sought.

NAIS Goals, Strategies and Expected Outcomes

An important outcome of the work of the NAIS Tiger Team was to develop a set of Goals, Strategies to meet those goals, and expected Outcomes. These are presented in **Table 1**.

GOALS	STRATEGIES	OUTCOMES
Support safe and efficient maritime operations in and around ice	• Provide timely and accurate products • Engage all levels of customers • Educate customers and stakeholders	• Increased use and effectiveness of ice products • Reduced risk of ship damage due to ice • Reduced risk of environmental harm due to ice-induced ship damage • Reduced risks to indigenous users and tourists • Viability of marine activity in ice-affected waters
Enhance maritime domain awareness(MDA) for national security	• Create and deliver geospatial products tailored to environmental intelligence needs of government security agencies • Increase engagement of security agencies	• Improved common operational picture used by defense forces • Improved characterization of ice environment in MDA products • Affect standards development for ice data • Improved use of other surveillance assets through better knowledge of environmental factors
Provide ice information to support for national numerical weather, ocean and other environmental prediction	• Create and deliver specific ice products to support civilian, military meteorological and oceanographic prediction • Promote and support development of coupled ice models	• Improved weather, ocean and environmental predictions • Improved ice forecast capability
Provide a knowledge foundation of the ice environment for national decision-making	• Create and ensure the preservation of a scientifically-valid archive • Maintain and promote expert analysis capability	• Ice information available to all levels of government policy makers • National policy based on sound science • Engineering and environmental assessment based on sound science
Support climate change research by creating and providing relevant ice information products.	• Create and deliver specific ice products to support climate change research • Create and ensure the preservation of a scientifically-valid ice archive	• Improved society's ability to understand, assess and adapt to climate change
Improve, through partnership in NAIS, the quality and efficiency of meeting national ice information requirements	• Transform NAIS from a working level partnership to a unified organization • Realign work and business practices for maximum effectiveness • Grow international leadership and influence	• Improved quality of products and services • Reduced cost through sharing resources and non-duplication • International standards and policies favor NAIS interests

Table 1: NAIS Goals, Strategies, and Objectives

Conclusion

As a small, 17 person organization responsible for monitoring 500,000 square nautical miles of ocean, the International Ice Patrol has long relied on partnerships in the spirit of international cooperation. IIP has identified several critical strategic challenges that compel our staff to seek more efficient and effective means to conduct business. Among others, these include: (1) increasing competition for Coast Guard C-130 resources; (2) emerging information technology – to include the use of satellite-borne synthetic aperture radar; (3) potentially changing requirements for IIP customers in the face of an ice-reduced Arctic. Now more than ever, IIP must continue to partner with organizations like CIS and NIC or risk technical and managerial obsolescence. In fact, Appendix D of this report, Iceberg Database Synchronization, offers a concrete, tangible result from our close cooperation with CIS and paves the way for continued work efficiencies while improving the readiness of both organizations. Continued involvement in the North American Ice Service provides a potential pathway for IIP to move even closer to its vision of eliminating the risk of iceberg collision. As IIP moves along this path, our focus will not stray from the transatlantic mariner, our primary customers, or our international treaty obligations under Regulation 6 of the Safety of Life at Sea (SOLAS) convention.

This page left blank

U.S. DEPARTMENT OF COMMERCE
TECHNOLOGY ADMINISTRATION
NATIONAL TECHNICAL INFORMATION SERVICE

ORDER FORM

NTIS

NTIS Web Site — http://www.ntis.gov

SHIP TO ADDRESS (please print or type)

CUSTOMER MASTER NUMBER (IF KNOWN) | DATE

ATTENTION/NAME

ORGANIZATION | DIVISION / ROOM NUMBER

STREET ADDRESS

CITY | STATE | ZIP CODE

PROVINCE / TERRITORY | INTERNATIONAL POSTAL CODE

COUNTRY

PHONE NUMBER ( ) | FAX NUMBER ( )

CONTACT NAME | INTERNET E-MAIL ADDRESS

METHOD OF PAYMENT (please print or type)

❑ VISA ❑ MasterCard ❑ American Express ❑ Discover

CREDIT CARD NUMBER | EXPIRATION DATE

CARDHOLDER'S NAME

❑ NTIS Deposit Account Number:

❑ Check / Money Order enclosed for $

ORDER BY PHONE

CUSTOMER SERVICE

ORDER BY FAX – (703) 605-6900

ORDER BY MAIL

RUSH SERVICE

ORDER VIA E-MAIL –

BILL ME

SATISFACTION GUARANTEED – NTIS strives to provide quality products, reliable service, and fast delivery. Please contact us for a replacement within 30 days if the item you receive is defective or if we have made an error in filling your order.

- E-mail: info@ntis.gov
- Phone: 1-888-584-8332 or (703)605-6050

PRODUCT SELECTION (please print or type)

Most of the documents available from NTIS are reproduced on demand from our electronic archive and are not original stock.

NTIS PRODUCT NUMBER	INTERNAL CUSTOMER ROUTING (OPTIONAL)	UNIT PRICE	QUANTITY: PAPER COPY	MICROFICHE	MAGNETIC TAPE *	DISKETTE	CD-ROM	OTHER	INTERNATIONAL AIRMAIL FEES	TOTAL PRICE
		$							$	$
		$							$	$
		$							$	$
		$							$	$
		$							$	$
		$							$	$

* CIRCLE REQUIREMENTS	3480 CARTRIDGE	6250 BPI	LABELING: STANDARD	NONLABELED	FORMAT: EBCDIC	ASCII

TOTAL	$
HANDLING FEE PER TOTAL ORDER	$ 5.00
Outside North America–$10.00	$
GRAND TOTAL	$

PLEASE NOTE

Out-Of-Print Surcharge

International Airmail Fees

Thank you for your order!

2002-01

This page left blank

To Order International Ice Patrol Annual Reports from NTIS (National Technical Information Service)

1. The *Report of the International Ice Patrol in the North Atlantic,* for each season from 1990 to 2005, may be ordered through the NTIS website (http://www.ntis.gov/index.asp) by entering the appropriate NTIS Accession Number into the "Search Now!" text box.

2. The *Report of the International Ice Patrol in the North Atlantic,* for each season from 1953 to 2005, may be ordered by telephone, fax, or mail.

For orders by telephone, call 1-800-553-6847 Monday through Friday between the hours of 8:00 A.M. and 6:00 P.M. Eastern Time.

Orders by fax may be placed using the NTIS Order Form (previous page, which is also available on the NTIS website). Fax NTIS Order Forms to 1-703-605-6900. Include Accession Number in "NTIS PRODUCT NUMBER" box.

Orders by mail may be placed using the NTIS Order Form (previous page, which is also available on the NTIS website). Include Accession Number in "NTIS PRODUCT NUMBER" box. Send order form to:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Please contact NTIS for pricing and shipping information.

U.S. Department of Commerce
Technology Administration
National Technical Information Service
Springfield, Virginia 22161
(703) 605-6000

Year	NTIS Accession #
1953	AD780 850/4
1954	AD780 851/2
1955	AD780 852/0
1956	AD780 853/8
1957	*Unavailable*
1958	AD780 854/6
1959	AD780 855/3
1960	AD777 945/7
1961	AD777 950/7
1962	AD777 951/5
1963	AD777 952/3
1964	AD774 510/2
1965	AD774 511/0
1966	AD692 936
1967	AD774 504/5
1968	AD774 505/2
1969	AD718 504
1970	AD736 981

Year	NTIS Accession #
1971	AD778 013/3
1972	AD780 537/7
1973	ADA020 336/4
1974	ADA055 267/9
1975	ADA058 898/8
1976	ADA066 081/1
1977	ADA075 246/9
1978	ADA079 474/3
1979	ADA093 073/5
1980	ADA113 555/7
1981	ADA134 791/3
1982	ADA149 595/1
1983	ADA259815/9
1984	ADA261408/9
1985	ADA259656/7
1986	ADA259816/7
1987	ADA259817/5
1988	ADA261407/1

Year	NTIS Accession #
1989	ADA259818/3
1990	ADA256161
1991	ADA256162
1992	PB2002100029
1993	PB2002100028
1994	PB2002100030
1995	PB2002100023
1996	PB2002100025
1997	PB2002100024
1998	PB2002100022
1999	PB2002100514
2000	PB2003100304
2001	PB2003101111
2002	PB2003107684
2003	PB2004106733
2004	PB2006106452
2005	PB2007108145