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RADARSAT REPORT 82-12
Canadian Coast Guard Captain
Interviews - Final Report
PHILIP A. LAPP LTD.

TASK 1
of the Extension to the
Radarsat Ice and Ocean
User Requirement Study
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1. INTRODUCTION

This report summarizes the findings on the task to interview the Canadian Coast Guard captains and officers on the role of ice information in making routing decisions for icebreaker operations. In addition, a number of interviews were held with commercial shipping operators to obtain their point of view. The interviews were held in Halifax/Dartmouth, Sidney, St. John's, Quebec City, Ottawa and Toronto. The interviews were conducted in two sessions, the latter half of June just prior to the beginning of Coast Guard summer operations while the second set were completed in early December, 1982.

1.1 Background

The interviews with the Coast Guard captains were considered to be a key element in the ongoing process to determine user needs for ice and ocean information. The active captains and officers involved with icebreaking operations have the largest accumulated experience in operating ships in ice covered waters. Accordingly, it was crucial to obtain their views to provide insight into the needs, uses and the relative contribution of ice information in operational decision-making for icebreaking ships.

The task is an extension to the original Radarsat Ice and Ocean User Requirement Study conducted by Philip A. Lapp Ltd.

for the project office which was completed in April of 1982. It was originally intended to interview the captains as part of the survey of user requirements; however, approval from the Coast Guard came too late for the task to be implemented.

An interim report (1) based on the June interviews was submitted to the project office in September 1982 to coincide with the conclusion of the Phase A studies so that at least some input from this important group was immediately available. The final report incorporates the results of the later interviews with other CCG captains missed on the first series and interviews with some commercial ship captains to obtain their point of view.

1.2 Methodology

The interviews were based around discussion of several related topics of concern to the Radarsat project:

(1) Brief the captain and/or officers on the Radarsat project.

(2) Discussion of the present ice information system and the services and products provided by the AES Ice Branch.

(3) Review the proposed information products presented in Radarsat report 82-9 for their views on format and usefulness as well as any anticipated problems in their use.

(4) How the captain uses ice information to make operational decisions regarding the routing and conduct of his vessel.

(5) Other issues or points of interest raised by the captains and officers.

A total of 24 interviews were conducted with various personnel including:

- 14 active and former Coast Guard icebreaker captains
- 2 CCG icebreaker chief officers
- 3 active and former commercial ship captains
- 2 people in the CCG Ice Operations Center
- 4 marine superintendants for Arctic and Gulf oil tanker operations

Table 1 lists the names of the captains and officers and their positions who were interviewed.

TABLE 1

INTERVIEW LIST OF INDIVIDUALS AND THEIR POSITIONS

Dartmouth, N.S.

Canadian Coast Guard

1. Captain W. Dancer - former captain Louis St. Laurent and Labrador
2. Captain V. Barry - relief captain on major icebreakers
3. J. McKenna - chief officer Louis St. Laurent
   B. Frampton - chief officer Tupper
4. Captain S. Gomes - captain Louis St. Laurent
   John A. MacDonald
5. Captain W. Tanner - captain Louis St. Laurent
6. Mr. S. Gillis - routing adviser Ice Operations Center
7. Captain I. Green - director CG Halifax Regional HQ (now retired)
   - former captain Labrador, John A. MacDonald, Sir Humphrey Gilbert
8. Captain Toomey - captain Pierre Radisson
9. Captain P. Whitehead - Head, Ice Operations Center
10. Captain C. Greene - captain John A. MacDonald

Esso Marine Division

1. Captain E. Coates - marine superintendant

Halifax, N.S.

Federal Commerce and Navigation

1. Captain B. Acorn - captain Federal Pioneer
2. Captain K. Raseback - Marine Superintendant

Sydney, N.S.

CN Marine

1. Captain F. Petite - captain CN ferry BOND
2. Captain Williams - captain CN ferry FREDERICK CARTER

St. John's, Nfld.

Canadian Coast Guard

1. Captain Rodeneiser - captain Grenfell (search and rescue)
2. Captain Dernford - captain Jackman (search and rescue)
3. Captain Piercy - captain Sir John Franklin
4. Captain McGarvie - ice operation officer
   - former captain Cabot
   - relief captain on St. John's icebreakers

Quebec City

Canadian Coast Guard

1. Captain Guimont - captain Alexander Henry
2. Captain St. Pierre - captain Des Groseilliers

Ottawa

Canadian Coast Guard

1. Captain R. Pierce - captain Sir Humphrey Gilbert

Toronto

Gulf Canada

1. Captain A. McIntyre - Marine Superintendant

Shell Canada

1. Captain J. MacDonald - Marine Superintendant

None of these individuals had ever heard of the Radarsat project with the exception of two former CG captains now in shore positions in Dartmouth who had been briefed and interviewed during the original user survey. Thus it was necessary to spend some time on explaining the various aspects of the project. The discussion of their use of ice information for routing decisions centered on the topics of the present ice reconnaissance/forecasting system, the proposed information products and the captains' strategies in sea ice conditions.

Examples of the proposed information products which included two SEASAT images were shown to the captains for their views. Following the first round of interviews which provided a considerable number of opinions on the products and a Radarsat Information Standards Commitee meeting held in October 1982, some of the products were changed in their format and presentation. New versions of the ice ridge distribution and iceberg distribution charts were created and the forecast products altered slightly to improve their appearance. These latest forms of the products are in Appendix A of this report. Both the new and old versions of the products were shown to the captains in the second set of interviews.

1.3 Report Organization

The report is presented under headings related to the primary objective of the task to determine the role of the present and proposed information products in ship routing decisions. Section 2 summarizes the comments made by the captains on the various proposed ice and ocean information products with subheadings by product type. A brief summary of the deliberations of the Radarsat Information Standards Committee (RISC) meeting on the products is also included. Overall preferences and general issues of concern about the products complete the chapter. Section 3 describes the use of ice information in operational decision making discussing the criteria used by the captains. Section 4 lists the conclusions and impressions of the writers in assessing the statements by the captains to the context of the Radarsat project. Section 5 outlines two recommendations to the project office to meet the concerns of these important end users.

2. REVIEW OF INFORMATION PRODUCTS

During each interview the captain was shown examples of the proposed information products as presented in Radarsat report 82-9, "Information Products Required for Ice and Ocean Operations". This report discussed the form and characterictics of information products needed by the collective ice and ocean user community. A total of 11 products were proposed as follows:

(1) Ice imagery and interpretive chart
(2) Current ice analysis chart
(3) Ice ridge distribution chart
(4) Forecast ice concentration/thickness chart
(5) Forecast ice drift/pressure chart
(6) Iceberg distribution charts - nowcast and forecast
(7) Vessel location map
(8) Wave data charts - nowcast and forecast
(9) Sea surface temperature chart
(10) Ocean features analysis chart
(11) Ice accretion chart

Examples of products 1-6 and 8 were shown to the captains for their review and comment. Products 7, 9 and 10 were of minimal operational interest while product 11 was discussed in concept only, since no example was available. As mentioned earlier, new versions of products 3-6 were created and shown along with the older products in RPO report 82-9.

Comments on the products from each captain could be classified under one of four responses:

(1) Product was desired for operational use.

(2) The product was desired but the effort to produce it to be useful and timely was not worth it or there was skepticism on its validity.

(3) The product was either unnecessary, a duplicate of another product or it is or would not be used.

(4) No comment on the product.

Table 2 shows the breakdown of responses for each product from the 24 interviews. The new formats for products 3-6 did not affect the response on whether a product was wanted or not. It is interesting to note that the imagery and interpretive charts as well as the current ice analysis chart were unanimously desired. The two negative responses to the imagery came from one Coast Guard captain and one tanker marine superintendant. The CG captain commanded a search and rescue vessel, and believed his vessel would not get the necessary receiving equipment for the imagery. The marine superintendant, while expressing his admiration on the quality of the imagery, felt its availability to the captain would result in less consideration of all other factors in making his operational decisions.

The response to the current ice analysis chart was not surprising since all are familiar with it and have used the chart operationally for some time.

Opinion on the remaining products, once the no comment figures are discounted, is divided on their usefulness and desirability. After the first set of interviews, the totals showed almost an even split between wanting and not wanting the products. The revised totals show more divergence in opinion on the individual products. In general, there was less support for most of the additional charts with the exception of the ice drift/pressure chart, which showed increased popularity when the additional opinions from the second set of interviews were included. Virtually all the individuals said the accuracy of the forecasts will have to be proven before much use is made of these products.

TABLE 2

SUMMARY OF RESPONSES TO PROPOSED INFORMATION PRODUCTS

INFORMATION PRODUCT	DESIRED	DESIRED BUT EFFORT NOT WORTHWHILE OR SKEPTICAL AND VALIDITY	UNNECESSARY OR REDUNDANT	NO COMMENT
ICE IMAGERY/ INTERPRETIVE CHART	22	2	0	0
CURRENT ICE ANALYSIS CHART	24	0	0	0
ICE RIDGE DISTRIBUTION CHART	8	6	5	5
FORECAST ICE CONCENTRATION/ THICKNESS CHART	10	10	2	2
FORECAST ICE DRIFT/PRESSURE CHART	13	7	2	2
ICEBERG DISTRIBUTION CHART	10	2	8	4
WAVE NOWCAST AND FORECAST CHART	5	3	9	7

It was suggested by the Ice Operations Center and by a few other captains that the forecast products be put into the egg code to maintain consistency with the current chart. Essentially the forecast chart would be a carbon copy of the current chart except that it is a projection 24 hours into the future. Such a proposal would have several benefits:

(1) No new codes would have to be learned. With the proposed new forecast products, there would be new additional codes to be assimiliated which may cause confusion.

(2) The similar presentation would permit the captain to more easily assess the anticipated changes in ice conditions from the current chart.

(3) It would reduce the number of forecast information products by one which is important in the context of using information sources for ship operating decisions.

Such a proposal would perhaps be more difficult to implement into Ice Branch functions, because it would introduce an additional step of transcribing predictions of particular ice parameters into the egg code as well as integrating the various pieces of information into the one presentation.

The Ice Operations Center made the point that changes in public ice information products should not contravene the internationally agreed to egg code.

Another reason for the lower popularity of the new chart products was that many of the later interviews were with commercial captains and marine superintendants, all of whom expressed the need to keep the number of products they receive to a minimum. Reluctance to support the new products was also due to a general satisfaction with the present ice information service. The individuals in the Ice Operations

Center of the Canadian Coast Guard which is responsible for ship routing expressed the view that there were probably too many products for the end user, but that they would wish to receive all the charts.

Information on ice ridging was desired by some captains, but others questioned the level of effort to produce the product and keep it current. The ultimate use of the numerical ridge information by a ship captain was questionable, since individual ridge encounters were specific to the ship and were an almost inevitable feature of normal icebreaking operations. Opinion was evenly divided on the usefulness of an iceberg distribution to ship operations. Some captains thought such a product would be most useful for offshore drilling operations and for archival data bases.

As mentioned previously, the new formats proposed for products 3-6 did not affect the response on the principle of the product. Most of the captains when asked solely to comment on whether the new formats were an improvement over the old ones said yes.

Wave nowcast and forecast charts were acknowledged to be important by a few captains, but the majority had little to say about them. In fact, many of the captains during the second set of interviews said they receive the charts but do not use them.

The following subsections detail specific comments on each product.

2.1 Ice Imagery and Interpretive Chart

When the SEASAT imagery examples were shown to the captains, all were impressed with the quality and the available detail. If such a product could be delivered to the ship with comparable quality and timeliness, it would be very much wanted. There was unanimous agreement on providing a latitude/longitude grid system to help them determine their position on the imagery. There was more interest from the later interviews in having the capability to focus on specific areas in the imagery implying a zoom and roam capability. A few captains also wanted to have a scale indicator. Some captains went so far as to say they would prefer the imagery over the charts as long as they could understand what the image means and if it was delivered in the proposed turnaround time of 3 hours.

A majority of the captains wanted the interpretive chart with the imagery albeit for differing reasons. Some would like to have the chart in case the imagery was blurred on reception. Others wanted the chart so that they would not have to interpret the imagery themselves. The provision of an ice interpretive chart would reduce the time to integrate the information into their planning. The interpretation should be put into the egg code.

In time, the demand for the interpretive chart will probably decline because the captain and his officers will become used to the imagery and be able to understand what it means. The interpretive chart will take further time to produce and turnaround in addition the imagery turnaround. In many cases the image may be sufficient to meet their operational needs.

2.2 Current Ice Analysis Chart

This product generated the most comments mainly because it is presently the primary product of the ice information system. All of the people interviewed wanted to receive the chart. Most made the point that the present turnaround of information (in the neighbourhood of 24 hours) must be improved. Because of the long turnaround, the charts have been found to be less accurate because the ice situation has changed. The poor turnaround also makes detailed maps of ice conditions less useful. If the turnaround time cannot be reduced, then there should be much less emphasis on detail.

The current ice analysis chart as shown in RPO report 82-9 depicts the ice conditions using the old standard code. Since that time, a new international code describing ice conditions known as the egg code has been introduced into the ice information service. An example of a chart with the new code is shown in Appendix A. The new code allows for a much more detailed description of ice conditions shown within an egg-shaped figure. The code was implemented in the spring of 1982 by the AES Ice Branch. Most of the captains did not like the code but thought they would get used to it. Many expressed the opinion that the code would unnecessarily clutter the chart, and, if the reception was blurred which it is sometimes, the chart would be far less useful. One suggestion was to place the eggs around the sides of the chart with arrows pointing to the respective areas where the code applies.

Five suggestions were made to provide additional or different information on the chart:

(1) Specific locations of multi-year bits and floes especially in areas in which such occurrences are unexpected.

(2) Better indication of specific floe sizes, especially in the channels of the Arctic Archipelago where the ships must decide in advance whether to go through the floes or negotiate around them.

(3) Better indication of the location and persistence of leads, especially in nearshore areas.

(4) Information on ridging of a similar form to that provided in the old code (i.e. tenths of ridged ice).

(5) Gross ice movement arrows and magnitudes, also similar to what was shown with the old code and was in the current chart example in RPO report 82-9.

2.3 Ice Ridge Distribution Chart

A major problem many captains had with this chart was that it would require a large effort to produce and that the information would age rapidly given the dynamics of the ice. A few of the captains said ridge encounters were inevitable and the product would not provide sufficient detail for individual encounters. Another view was that enough ridging detail was provided in the current ice chart (old code) and that the proposed product would be an unnecessary duplication.

Those captains that supported the idea of a ridge distribution chart suggested some changes in format and presentation. Most wanted the product to be more pictorial than a series of numbers as shown in RPO 82-9. Numbers must be read and interpreted. Ridging density represented by contours or enclosed areas of high, medium and low ridging was suggested.

A more pictorial presentation would be easier to use if the received chart was blurred. One captain suggested the chart should include an indication of active versus old ridging areas.

As a result of those comments, new presentation formats for the ridge information were proposed and are shown in Appendix A. When the two formats were compared (RPO 82-9 versus the new ones) the more pictorial format was unanimously preferred.

The Ice Operations Center (IOC) suggested that such a product should probably not be sent out generally but instead it should be received by the intermediate centres such as IOC who have the strategic planning function for which such general information would be helpful in routing.

2.4 Forecast Ice Thickness/Concentration Chart

Those captains who did not agree with the idea of such a product were skeptical of forecasts in general. They were not confident in the ability of the ice service to provide accurate forecasts. Acceptance of the product by supporting individuals was dependant on its accuracy being proven. One suggestion was to put the ice concentrations into the egg code format as mentioned previously. This would ensure continuity and consistency with the present coding system.

Forecast duration should be 24 hours for the Gulf of St. Lawrence and up to 48 hours in the Arctic. In the Gulf, icebreakers are supplied assignments every 24 hours so that planning of their routes and activities is geared to that schedule. Missions are generally longer in the Arctic and the captains exercise a greater degree of their own routing control.

Forecasts of ice concentration should be updated every 12 hours according to some of the captains who support the product. Most of them liked the hatched format but felt the numbers depicting thickness should be eliminated.

There was considerable support for combining this chart somehow with the other forecast product and code the information in the egg code to make the format similar to the current ice chart.

2.5 Forecast Ice Drift/Pressure Chart

Most of the same captains and individuals who were against the forecast concentration chart were of the same opinion for this product. Almost all agreed the parameters were extremely important to know for a ship operator, but the means to predict pressure events and dangerous ice movements was better determined by assessing the on-site conditions and drawing upon past experiences.

Those captains who wanted the chart thought it would be a very important product for their operations, if it was accurate. Of all the proposed new charts, this one was the most desired type of information and presentation that the captains now do not have.

The product would most certainly be viewed with caution at first because misleading information on this chart would have more serious consequences to ship operations than a wrong forecast of ice concentration. Pressure was found to be the primary concern of almost all the people interviewed. Pressured ice can stop the advance of even the largest icebreakers.

In some cases operations have to be temporarily discontinued until the pressure subsides. Often ships can be trapped in harbours unable to break out because of pressured ice at the mouth.

The presentation of pressure as high, medium and low was an acceptable way of maintaining simplicity for this parameter. Opinion was divided on the drift vectors. Some of the captains thought a few gross movement vectors perhaps with magnitudes would be sufficient. The gridded vector patterns as now proposed do not have much meaning to them. Others felt the gridded vector pattern was helpful in that they could interpret to some extent the high and low pressure areas based on the pattern.

There was some comment of combining this information with the forecast ice concentration/thickness chart in the egg code format, especially the drift information. However this suggestion does not solve the pressure paramemter which is vitally important to the captains.

2.6 Iceberg Distribution Chart

There was a wide cross section of opinion regarding the usefulness and presentation of iceberg information. As Table 2 showed, there was an even division between wanting and not wanting the proposed product.

The problem with the original chart format as proposed in RPO report 82-9 was that it would be difficult to interpret without considerable study. The numbers could become blurred with poor reception rendering the chart useless. Some captains would not trust the line delineating zero icebergs, one captain suggested there should also be a limit of visibility line accompanying the presumed zero line boundary.

In response to the concerns regarding the format, the iceberg chart was considerably simplified. The revised version appears in Appendix A. When shown the two examples most of the captains agreed the simpler format was an improvement since the information could be more easily interpreted. As well, the status of present chart communications means the simpler format would still be useful should reception be blurred.

Captains opposed to the product claim the turnaround and its usefulness will be marginal since the icebergs will have moved. Like the ridge product, the work required to collect and process the information would not be worth the effort since it ages so rapidly. Icebergs are a hazard to be dealt with on an individual rather than collective basis. Close vigil and ship's radar would minimize collisions more effectively than a dated strategic overview of all icebergs.

The iceberg product was the only one which showed a clear difference in opinion between commercial and icebreaker captains. When only the latter are considered, a majority of captains support the idea of such a product. However, virtually all commercial captains voiced reservations or rejected the idea of the product. Their concerns were similar to those noted above, but also the fact of simply having another piece of paper which provides marginal information at best was not worth the effort. More useful to their operations are the regular radio iceberg reports. One captain stated that the turnaround of iceberg information on the radio can be as low as 20 minutes.

He found this to be the case from his own ship which had reported positions of some icebergs which were then broadcast generally within 20 minutes. Such timely information is more current than could ever be achieved by an iceberg chart.

Some captains thought the product would be useful for drillship captains and/or drilling operation planners more than for ships.

2.7 Wave Data Charts

Only a few of the captains mentioned the METOC wave charts in the conduct of their operations. In some cases, such as for search and rescue vessels whose operations are within 50-100 miles of the coastline, there is no need for such information because their area of operation is so limited. In general, most of the ships including commercial ones receive the charts but apparently make little use of them. Some captains said their ships are designed for icebreaking rather than open water so they steer for the ice as much as possible.

Everyone was satisfied with the format and information content in the chart. One captain wanted forecast information on heavy swells which he would avoid since the icebreaker is optimized to transit in ice.

The surprise with this product was its low utilization in present shipping operations within Canadian waters. It would appear that its main use would be for trans-Atlantic crossings, an observation noted by several of the captains who do not use the product.

2.8 Overall Issues of Concern

The provision of information products for an ice and ocean information system as proposed raised a number of concerns including:

1) The number of information products
2) The transmission and reception of the products on the ship
3) Timeliness

The major issue of concern raised by most of the captains was the number of information products and the added paper burden versus benefit. There are probably too many products to be able to use them all effectively. The time to receive charts by facsimile at present is about 18 minutes. If five or six products were to be received, the reception would take 90 minutes or more out of the operating day which would hamper their activities. One solution might be to receive the charts earlier in the day, but this would require overtime for the CCG radio operator, and, given budgetary restrictions, this may not be possible to implement. It would appear that the number of charts and images should be traded off against communication limitations.

Another point made especially by the commercial captains was the ability of the captain and/or his assistants in assimilating the various charts into one overall picture. The number of information sources should be more restricted with perhaps the ice service doing the integration rather than the captain. The essential question is - how much information can be assimilated?

The Ice Operations Center expressed the viewpoint that perhaps the end user, or user processor should not receive all the products but that an intermediate processor like the IOC would. In their scenario, the number of products to the end user would be kept to a minimum, perhaps two or three (e.g. imagery plus current chart) while the IOC would receive the more specialized products which are useful for overall route planning purposes, but are not so useful for more site-specific applications.

It may well turn out that if the ship captain were to receive all the proposed products only 2 or 3 would really get used.

A second difficulty related to the number of products is the variable chart quality of the ship receiving end. Some of the broadcast current charts arrive blurred and fuzzy so as to make them virtually unreadable and useless. Sometimes the current chart is not received at all. It has been found that voice transmissions from the ship cannot occur at the same time a chart is being received, otherwise a large black line appears. With the time required to receive the chart, having a large number of products received on a daily basis would impose a major constraint on their radio contact activities.

The last overall concern related to the turnaround of the information products commented upon earlier in this report. Faster turnaround is vital to keep the information accurate.

2.9 RISC Product Review

The Radarsat Information Standards Committee (RISC) met in Calgary in late October 1982 in part to discuss the results of the first set of interviews of CCG captains and their comments on the products. The concern raised in the interim report (RPO 82-12) over the number of information products led to the committee considering which products could be eliminated. It was agreed that the ice ridge distribution chart was the lowest priority product yet one of the most difficult to obtain such information on and to keep current. A few of the captains had felt the ridge product was a duplication of the ridging information on the current chart (with the old code). It was agreed to drop the ridging chart as a proposed information product to be included as information on the current chart.

The concept of an ice accretion chart was difficult to imagine since icing conditions are largely dependant on the individual vessel and its speed. The prediction of icing should probably remain as a voice message instead of creating a chart.

Discussion also centered on the imagery presentation. Two identically placed SEASAT images were displayed for visual inspection. One image was a full 25 m resolution while the other was reduced to 100 m resolution by averaging the pixels, a worst case approach. Committee members concluded there was little visual difference and that the captains would probably not know the difference nor care. With such evidence, the conclusion was made that transmission of lower resolution and perhaps reduced grey scale imagery to vessels was probably sufficient for their needs. This would make communication of the imagery to the end user much simpler because the data rates could be significantly reduced.

3. USE OF ICE INFORMATION IN OPERATIONAL DECISION-MAKING

As one captain said, "The use of ice information by a ship captain does not lend itself to categorical statements. Much depends on the skill, experience and common sense of the commanding officer".

When the writers attempted to probe the captains on how they make use of the provided ice information, the answers were almost as numerous as the number of captains. Each has his own unique style of operation and importance he places on various information sources at his disposal. For icebreaker operations, there are few set procedures primarily because every on-site operation condition is unique. Thus ultimate discretion is left to the captains.

3.1 Ice Operations Center (IOC)

Central to the discussion of the uses of ice information by Coast Guard and commercial vessels is the ice operations center, located in Halifax in winter and Frobisher Bay in summer. The IOC has responsibility for providing routing advice to icebreakers and commercial vessels. It is also responsible for deploying the available icebreaker resources along the recommended routes. In the Gulf of St. Lawrence shipping and icebreaker operations are fully controlled by the IOC.

Ships are provided recommended routings determined by the IOC from information supplied by Ice Reconnaissance and Ice Forecasting. While following the routes is not mandatory for commercial vessels, any deviation from the recommended track which results in the ship getting stuck will get a lower priority in terms of icebreaker assistance than stuck ships following the routes. Icebreakers as well are quite controlled in their activities in the Gulf of St. Lawrence because they must be available within a limited operating area to provide escort or icebreaking service should a commercial vessel require assistance. The IOC routes about 80% of the ships in the Gulf while the other 20% requires icebreaker escort. Good ice information is thus of paramount importance to this facility. If a large proportion of ships had to be escorted by icebreakers, the Coast Guard could not cope because of its limited resources.

The IOC receives ice and weather information from the AES Ice Branch which it then uses to make its own forecast of ice conditions. Based on these projections the IOC will adjust the routes as necessary to take advantage of favourable conditions, provided they will persist. In the Gulf, it takes about 48 hours to redeploy the icebreakers to new routes, so the center tries to stick with a route as long as possible to minimize disruptions. Routing selections in the Gulf are based on prevailing winds, ice concentrations and past experience. Operations from previous years have determined for the most part standard routes through different times of the year. One example would be whether to steer a ship to the north or south side of Anticosti Island.

Routing strategies and icebreaker deployment in the Gulf are decided in such a way that a ship can be quickly reached by a CCG icebreaker if the ship gets into trouble. In certain locations such as the ferry terminal at Sydney, an icebreaker will be nearby to render assistance. This particular area is known to have bad ice conditions at times especially when there is a NE wind which pushes ice into the harbour and causes difficulties for the ferries.

Ship routing in the Arctic is much less controlled, and discretion is left to the individual captains. The center, when located in Frobisher Bay, provides routing advice to commercial vessels unescorted by an icebreaker. However, if an icebreaker is escorting commercial ships, routing decisions are then deferred to the icebreaker captain. The tendency has been to provide icebreaker escort service to ships in the early spring and late fall since there are not too many other ships up there at those times. The IOC asserts that there is more routing of ships in the Arctic (i.e. under control of IOC) than many people realize. Distances in the Arctic are much greater than in the Gulf so information must be obtained over a wider geographic area and projections must be made over a longer timeframe. This is balanced by slower progress of ships in the Arctic since ice conditions are more difficult. Such is the case for the heavier icebreakers which engage the more difficult ice conditions.

While the present shipping levels in the Arctic permit the routing and escorting of ships on an individual basis, future expansion of oil and gas shipping will almost certainly result in a similar form of routing control in the Arctic as there is in the Gulf, according to the IOC. Routing will already be somewhat controlled by biological and sociological factors as well as the bathymetry. However to intelligently deploy icebreakers to provide assistance and control may necessitate a form of control similar to the Gulf of St. Lawrence. This issue has not as yet been resolved and probably will not be until oil and gas transportation plans and timetables become more firm.

In terms of ice parameters which affect routing decisions made by the IOC, prevailing winds and ice concentrations determine high pressure and probable heavy ridging areas which are to be avoided. In general, the routes are selected to minimize ridge encouters. If a choice is to be made between heavy ridging and heavy ice the route will steer towards the latter. Heavier icebreakers are deployed in areas of more difficult conditions and escort ships while lighter icebreakers will perform less difficult functions such as breaking out harbours.

Routing in the Arctic is dependent upon the ship capability in ice as well as the availability of an icebreaker. The route considers not only the ship itself but also the ease for an icebreaker to affect a rescue should it become necessary.

During the information product review, the IOC made the point that many of the products should probably not be sent to the ships because of the paper burden and the general nature of the information. Because IOC's function is to determine strategic routings, they should be the ones to receive the more specialized products which would assist them in route planning. Since IOC is responsible for 80% of ship routing in the Gulf and a substantial proportion of present Arctic shipping it would appear that the major client for the products is the IOC not the end user. The IOC fears that the provision of too much information to the shipper will result in a loss of routing control in that ships will try to select their own routes. Should the ship become stuck in an unexpected location, rescue by an icebreaker may take considerably longer.

In the writer's view, it is the IOC or other intermediate processors (IP's) who are the major clients for the information products other than the imagery and current chart.

3.2 Factors Used by the Captains

The mission or assignment of the ship is the first factor to be considered by a ship captain. If it is a Coast Guard icebreaker, this mission and the corresponding degree of control of the captain to decide where and how to route his vessel is dependent on the geographic location. In the Gulf the icebreaker is at the disposal of the IOC while in the Arctic the captain makes the decisions. If the ship is a commercial one such as a tanker the planning process is a continuous one since most commercial tankers run a 24 hour operation while CCG operates only during the day. The commercial captain is also driven by a schedule of deliveries and/or pickups while the icebreaker has no such constraint. This important distinction between the two leads to different approaches to the problems of ice to shipping as will be discussed on a subsequent section.

The mission of the icebreaker captain will often govern how the vessel is operated and the route it will take. If the function is to escort another vessel, the captain must know its ice capability, available power and the captain's familiarity with local conditions and procedures. One captain said the stopping capabilities of the escorted vessel were important because the icebreakers can quickly stop. An escorted ship must follow the icebreaker far enough away to be able to stop to avoid collision, but the forward progress must be slow enough to ensure the escorted vessel benefits from the broken ice track. If the ice is pressured, the track may close quickly so the escorted vessel must closely follow the icebreakers. Another situation noted by some of the commercial tanker captains was that these ships are quite long and have limited turning capability while the shorter icebreakers are very manoeuvrable. Quick changes in routing which might be considered by the icebreaker were she on her own could not be enacted if there was a tanker being escorted. One captain said that if he was transporting a load of drums on the ship's deck during Arctic resupply he would steer a course to go through the ice rather than around it. The ice, although slowing the forward progress, serves as a brake to the ship and prevents it from rolling too much which it would do in unfavourable open water conditions.

Whether the escorted ship is foreign or domestic is also important. Foreign vessels are usually less knowledgeable about environmental conditions and have less capability in ice while domestic ships are better equipped and the masters are more familiar with conditions in the area.

The icebreaker master and the commercial captain should his ship be unescorted must then consider the capabilities of their ship:

(1) available horsepower
(2) hull strengthening
(3) type of propulsion system
(4) maximum speed

Available horsepower and hull strengthening are two key factors in assessing icebreaker and ship capability to deal with ice. For example, the captain of the Pierre Radisson, a river class icebreaker, would consider breaking through large second year floes but would steer around equivalent sized multi-year floes, chiefly because of the icebreaking capability. Smaller icebreakers and ships obviously take fewer chances and cannot handle heavier ice conditions, so their deployment and function are more limited.

Once the factors of the type of mission or assignment and the capabilities of the ship have been considered, the captain then consults the available environmental information. There are essentially five sources of information at his disposal:

(1) ice charts
(2) weather charts and forecasts
(3) helicopter reconnaissance
(4) information from other ships
(5) captain's experience and knowledge of local conditions.

The degree to which each is used is highly dependant on the captain. Some information sources such as helicopter reconnaissance are only available on the larger icebreakers. Most captains consider the ice charts to provide an overview of the ice conditions and think that excessive detail is not necessary for its intended purpose. One captain gets the ice observer to colour code the ice chart according to expected degrees of difficulty. Difficult areas are coloured blue while easier areas are yellow. The captain then plans his route to avoid blue areas and steer into yellow areas whenever it is possible. In essence, the captain is simplifying the information and putting into a form which he can use practically.

Some of the charts transmitted from the aircraft during a tactical support mission can be used for detailed routing because the information is recent and of sufficient detail.

Routing decisions require a prediction of incoming weather conditions, since many dangerous ice situations are created by unfavourable winds. Most of the captains considered weather information to be very important, some thought it to be of equal importance to ice information. The parameters of greatest interest are the location of high and low pressures to determine expected wind direction as much as speed. Despite having such overview information, most captains will combine it with the local wind conditions to judge in their own minds what will occur.

On the larger icebreakers all the captains rely on helicopter reconnaissance when one is available and flying conditions are suitable. Usually the ice observer and the chief officer go on the helicopter to determine the detailed, mile-by-mile routing. The function of the ice observer ranges from confirming ice observations made by the chief officer (who could also recommend routing) to actually suggesting the ship route. Most of the captains see additional benefit in sending the chief officer to get experience in examining the ice and recommending routes as well as observing the ultimate routing decisions made by the captain.

Radio communication between ships and between ships and shore stations is an important source of ice information. One smaller icebreaker captain estimated last year he saved 1½ day's sailing by communicating ahead to another icebreaker who had just been through the area. Icebergs sighted by ships and oil rigs are radioed to shore stations who then rebroadcast information on their position on public broadcasting frequencies. The ferry operators between Sydney and Port-aux-Besques rely extensively on ship-to-ship communications to find easier paths through the ice. Three ferries service the route and they are scheduled so that the ships can break tracks through the ice for the vessel coming from the opposite direction to make passage easier, and also provide each other with detailed information and routing advice for the respective areas they are going through. Oil tanker operations in the Gulf of St. Lawrence and the Arctic use information from other tankers and ships as a primary source. Tankers entering areas where other tankers and ships have recently been find the information to be most reliable and current. Clearly, ship-to-ship communication is and will continue to be an important source of ice information.

Virtually all the captains said that the information provided to them must be weighed against their experiences, plain common sense and prior knowledge of the area. For example, if there is a nearshore lead with an onshore wind, it is highly likely the ice field will close the lead in a short time. The ship would then steer a course further away from the shore to go into the ice field so that if and when it moves towards shore, the ship will have sufficient bathymetry to avoid grounding. Prior knowledge of what to expect in terms of ice movement and distribution is an important element to many of the captains in deciding what to do. One captain has had 26 trips to the Arctic so he feels he knows what are the range of possibilities. Most of the individuals interviewed had a large number of year's experience guiding ships, tankers or icebreakers through ice. Such experience compliments the ice information currently being provided.

3.3 Dangerous Ice Situations

Most captains agreed that the most dangerous situation for ships operating in ice-frequented waters was when concentrations of ice are two to three tenths and lower. There is the greatest potential for ship damage to occur in these conditions because of the desire and tendency for ships to increase their speed. Should a ship impact with an ice floe or growler at high speed, serious damage is likely. One captain estimated that an ordinary ship travelling at only 4 knots in open water would have a hole punched in it on impact with an ice floe. The greatest threat to the ship from ice is thus caused by speed rather than power. The same captain said he slows down his icebreaker in lower ice concentrations to reduce the chances of damage.

All captains acknowledged the hazard of icebergs and growlers to the ship's safety. The danger is analagous to low ice concentrations in that a ship colliding with an iceberg could sustain heavy damage. When an icebreaker or commercial vessel is in an area known to have icebergs, a visual watch is instituted and the ship's radar watched closely. In general, ship speed is reduced in accordance with prevailing weather conditions and nighttime operations. In poorer conditions, the ship will slow down to the limits of visibility and its stopping distance. If the ship were outside of the line of zero icebergs as shown on the iceberg distribution chart, the captains would still maintain a constant vigil but continue with normal open water operations. In general, strategic ship routes would not be changed in relation to the number of icebergs in an area unless the concentrations were quite high. Encounters with icebergs and growlers are to be dealt with on a close tactical basis.

3.4 Commercial Shipping vs Icebreaker Objectives

During the first set of interviews, several Coast Guard captains remarked that commercial ship captains view ice information and routing differently. The commercial operator is tied to a schedule for his ship while an icebreaker does not have one. The Coast Guard captain's role is to ensure the safe passage of escorted vessels and to minimize any ice damage to his icebreaker or any other ship. For these reasons the captain has a need to obtain proper ice information to help him meet this goal. The primary goal of a commercial ship operator is to get the cargo or pick it up from a destination within an allowable time period. According to one CG captain, escorted ships often lose time in continuous ice cover conditions which they try to make up by increasing soeed in areas of more open water and lower ice concentrations. In essence, the implied conclusion was that the skills and common sense of the commercial ship captain and his use of ice information may be secondary in making the effort to meet a tight schedule.

It was alleged that the commercial operator may also accept the incidence of ice damage to the ship as a cost in meeting the schedule. The commercial captain may be tempted to sacrifice some basic mariner's principles to meet the schedule because if he doesn't do so, the company may replace him with someone who will.

As a result of these observations by some of the Coast Guard captains, the second set of interviews emphasized talking to commercial interests to explore these observations.

Oil tanker operators (Esso, Shell and Gulf) and commercial shippers (Federal Commerce and Navigation) were interviewed. Esso, Shell and Fed Com operate ships in the Arctic and the Gulf of St. Lawrence while Gulf only operates in the latter. All the companies are supplied routing recommendations by the IOC but use the recommendations in different ways. Esso follows the routes to the letter while Shell and Gulf may or may not use them.

Esso is more cautious about ice than perhaps most. Their Arctic resupply is always well within the established operating windows and they preach respect for the ice to their captains. They try to avoid ice completely whenever possible. Operations preside over business aspects and the skipper is never overruled. As the marine superintendent said, "A good skipper is a guy who won't budge from his decisions". Their scheduling always takes ice into account by adding about 30% to the estimated open water time to cover the distance. The schedule comes second in bad conditions and they take the view that each ice year varies and if it is a bad one, the slack can be made up with extra chartered vessels. Within the last two years facsimiles have been added to the tankers to receive the charts and the captains have said the machines had paid for themselves in one trip from the value of the supplied information.

Gulf have had facsimile machines on their vessels for the past 4-5 years and receive charts from the aircraft sometimes as well. Ice charts and radio contact with other ships constitute the information sources they use for routing. In general Gulf does not necessarily follow the recommended route of the IOC except in tricky places such as around Charlottetown.

All things being equal, the schedule is secondary to the ice conditions. If the tanker is near the ice edge, it will stay within it so as to not build up too much speed and increase the possibility of damage.

Shell Canada services the Hudson Strait and Hudson Bay areas as well as the Gulf of St. Lawrence. They use and follow the ice routes from the IOC and get their ice information over the radio. Planning for the Arctic operations is more extensive than for the Gulf and is primarily based on the weekly composite ice charts. All decisions are left to the captain and with constant communication between larger tankers and the smaller delivery ships adjustments are made to the schedule as the problems arise.

FedCom are involved in Arctic resupply and the interviewed captain operated a ship betwen Frobisher and Resolute last year. The company draws up a schedule which takes into account delays because of ice. Most of the ships can meet the schedule unless it is a heavy ice year and this is recognized as a fact of operations.

The captain consults the recommended routing and may or may not follow it depending on the local conditions. If there are better conditions away from the track the ship will steer for them. The captain noted the ship always tries to minimize ice damage because the time to repair costs money not only on the repair but also the availability of the ship to generate revenue. The captain tends to balance his routing and operating decisions between the schedule and ice conditions. The ship would still attempt to transit through an area even if conditions were not predicted to be very good; however, the degree of trying would be dependant on the nearby availability of an icebreaker.

4. CONCLUSIONS

1. The greatest beneficiary for improved ice information as provided by Radarsat will be the Ice Operations Center of the Canadian Coast Guard. They have responsibility for a wide geographic area and their function is more strategic in nature. Such a role requires the type of information which will be provided by the ice information center. This would also apply to a Calgary central should one be created for oil and gas transportation. In essence, it is these intermediate processors in the system which have the greatest need to know the overall picture.

   It is thus concluded that the proposed information products would be of greatest use to the IP's and that the number of products to the end user such as a ship be kept to a minimum. Distribution of the proposed products should thus be more limited. The IP's have more time to assimilate the information while the ship captain cannot take the time and effort to study many different products to gain an understanding of the situation and make a decision.

2. The provision of better quality and more timely information to mariners should not overshadow the importance of mariner's skills, common sense and experience in making routing and operational decisions. The ship master will never solely rely on such information and forecasts to arrive at a decision. However, it will hopefully help him make better decisions.

3. Communication between vessels is and will be an important, supplemental ice information source. The information will

likely be more current than the coverage of a strategic ice information system and it will be explained in the language and objectives of the mariner - that is captain to captain.

4. The role strategic ice information plays in the operation of individual ships and icebreakers is perhaps overestimated by outside observers. Use of the current ice chart varies considerably between captains and is primarily dependant on his experience. Many of the captains have worked on and commanded icebreakers and ships for many years so they know what changes in the nature of the ice cover can occur under a given set of ice conditions. However, many of these captains are approaching the end of their careers and will be replaced by younger, much less experienced individuals. Without an equivalent base of experience, it is probable that the new captains will rely more on ice information products for their routing and operational decisions.

5. There is some dichotomy in objectives between captains of commercial and Coast Guard ships but the division is not as large as first perceived. The commercial vessels respond to the routes recommended to them by the IOC in different ways according to the nature and geographical extent of their operations. Some follow the routes exactly while others disregard them. All the commercial shipping interests interviewed operate to a schedule which accounts for ice conditions, but in the final analysis discretion is left to the captain. The "business" side thus defers to the operational side whenever such scheduling problems occur. The CCG vessels operate under no schedule except as directed by the IOC.

6. The extent of use of ice information by commercial and CCG captains varies with each one and does not lend itself to definitive states. However, the elements employed by the captains can be grouped under the following headings:

   a) Ship horsepower and icebreaking capability
   b) Type of mission or assignment
   c) Captain's experience and prior knowledge of an area
   d) Common sense
   e) Ice information - strategic and tactical
   f) Geographic location
   g) Weather information
   h) Ship itinerary and destination(s)
   i) Commercial vs government vessel

Each of these factors has a different weighting between captains. It can be seen that ice information of the kind which can be supplied by Radarsat and the ice information system is one of many factors, albeit a very important one. Weightings of these factors to make routing and operational decisions will likely shift towards ice information with less experienced captains, commercial or government.

5. RECOMMENDATIONS

1. The number of information products to end users should be kept to a minimum number so as to not load the captain with excessive quantities of information which cannot be satisfactorily used in their decision-making processes.

   It is recommended that the ship receive the imagery in somewhat reduced resolution and gray scale mode as well as the current chart and perhaps a forecast chart in a similar format to the current one.

2. A major effort should be made at examining the communication, reception and display needs of the end user for imagery and charts. The ice information system as a whole including Radarsat will be judged for its effectiveness solely on the basis of the products received at the user end.

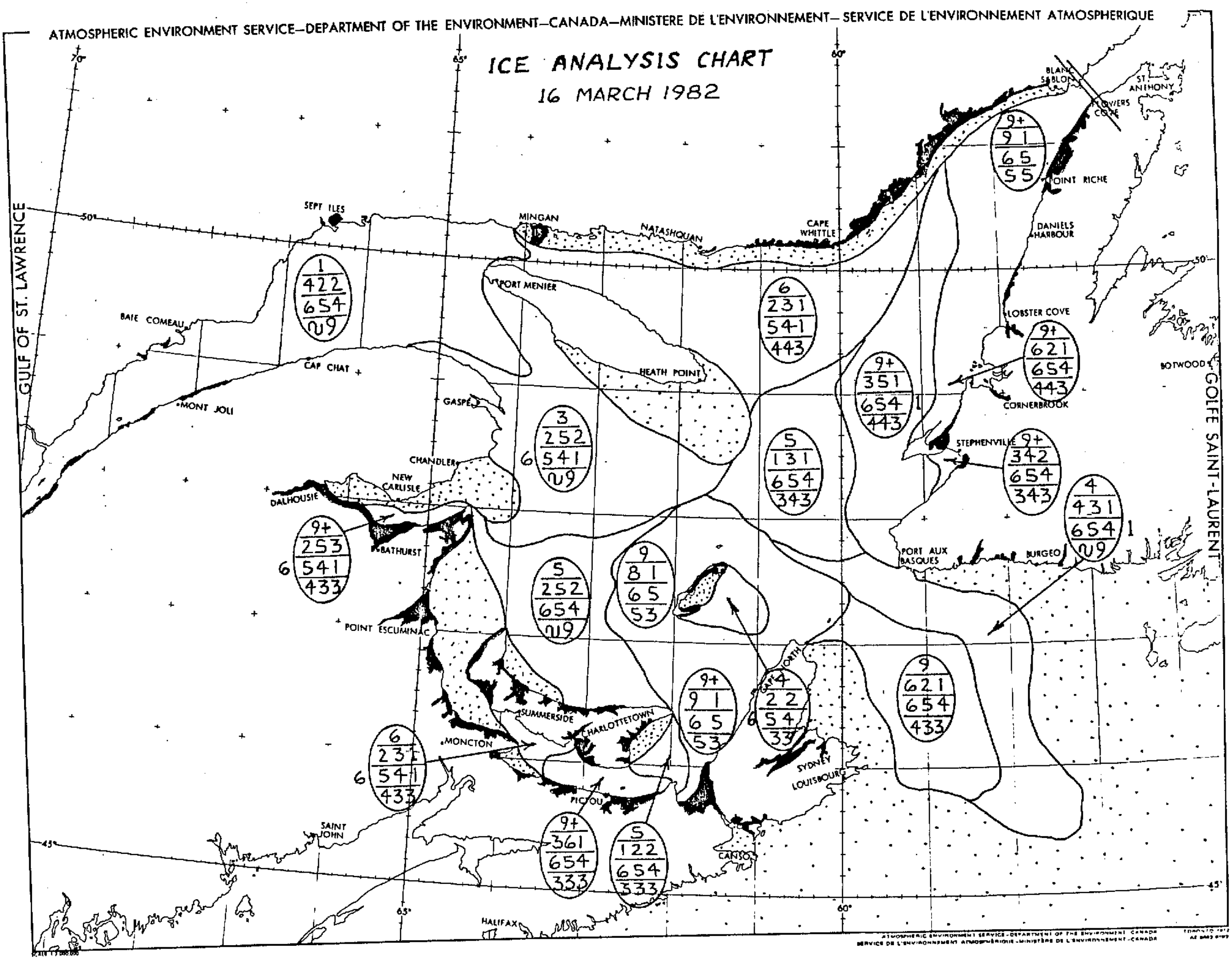
6. REFERENCES

1. Radarsat Project Office (1982), "Canadian Coast Guard Captain Interviews in Interim Report", Radarsat Project Report 82-12, Philip A. Lapp Ltd., September, 1982.

2. Radarsat Project Office (1982), "Information Products Required for Ice and Ocean Operations," Radarsat Project Report 82-9, Philip A. Lapp Ltd., May, 1982.

APPENDIX A

REVISED ICE INFORMATION PRODUCT EXAMPLES



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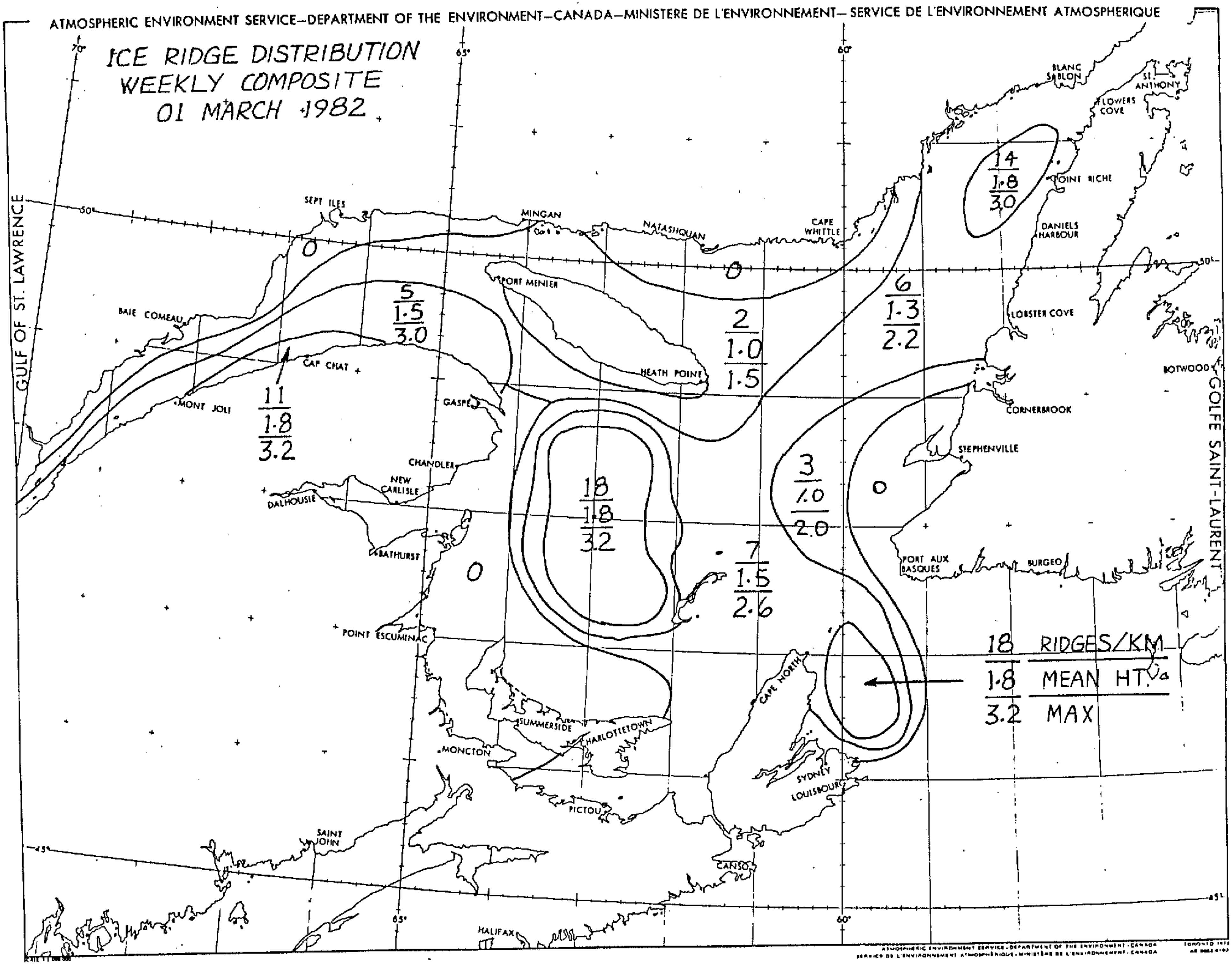
ICE ANALYSIS CHART
16 MARCH 1982
GULF OF ST. LAWRENCE
GOLFE SAINT-LAURENT
SEPT ILES
MINGAN
NATASHQUAN
CAPE WHITTLE
BLANC SABLON
ST. ANTHONY
FLOWERS COVE
POINT RICHE
DANIELS HARBOUR
LOBSTER COVE
BOTWOOD
CORNERBROOK
STEPHENVILLE
PORT AUX BASQUES
BURGEO
PORT MENIER
HEATH POINT
BAIE COMEAU
CAP CHAT
MONT JOLI
GASPE
CHANDLER
NEW CARLISLE
DALHOUSIE
BATHURST
POINT ESCUMINAC
SUMMERSIDE
CHARLOTTETOWN
MONCTON
PICTOU
SAINT JOHN
HALIFAX
CANSO
SYDNEY
LOUISBOURG
CAPE NORTH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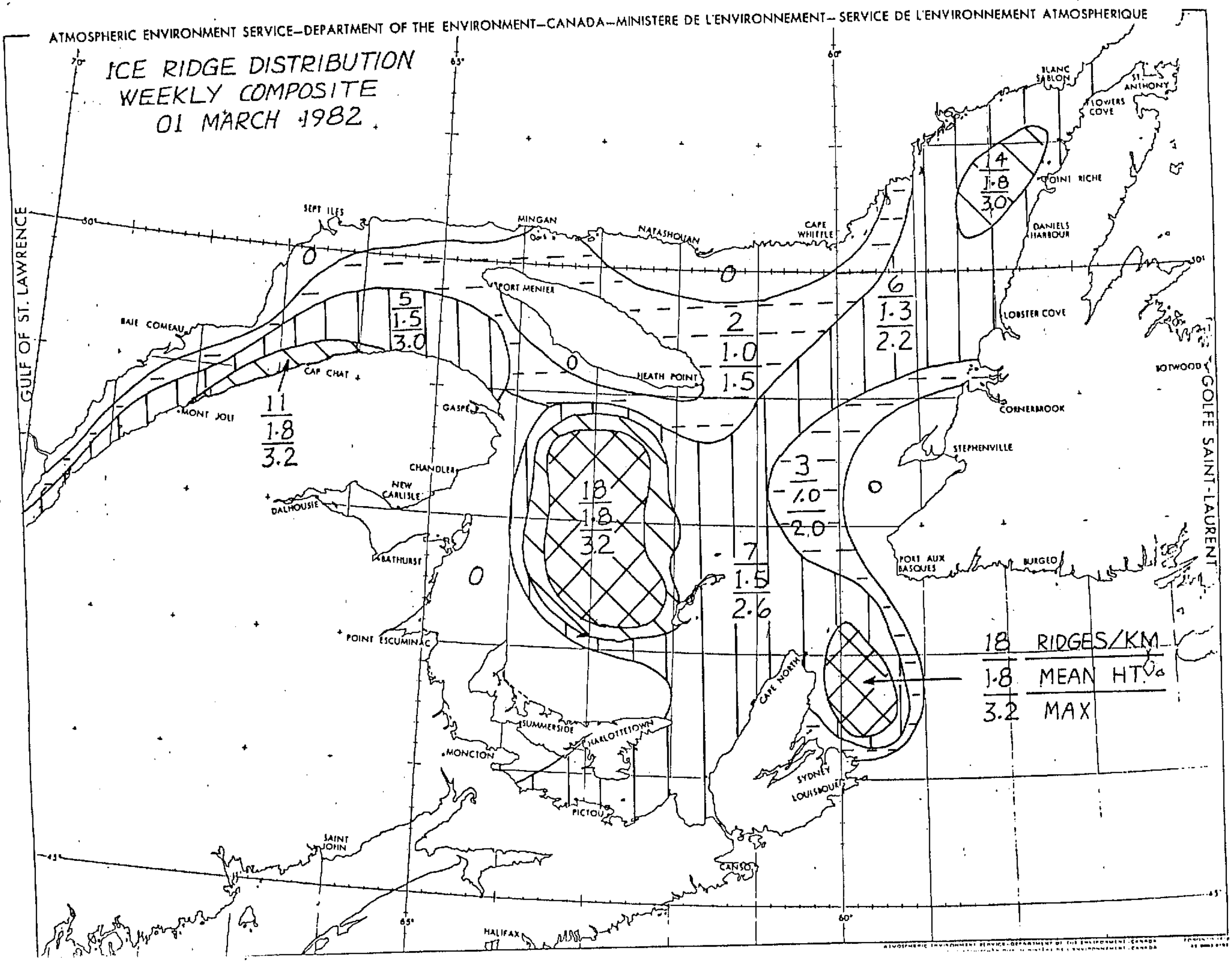
ICE RIDGE DISTRIBUTION
WEEKLY COMPOSITE
01 MARCH 1982
GULF OF ST. LAWRENCE
GOLFE SAINT-LAURENT
18 RIDGES/KM
1.8 MEAN HT.
3.2 MAX
14 / 1.8 / 3.0
5 / 1.5 / 3.0
11 / 1.8 / 3.2
2 / 1.0 / 1.5
6 / 1.3 / 2.2
18 / 1.8 / 3.2
3 / 1.0 / 2.0
7 / 1.5 / 2.6
0
BLANC SABLON
ST. ANTHONY
FLOWERS COVE
POINT RICHE
DANIELS HARBOUR
SEPT ILES
MINGAN
NATASHQUAN
CAPE WHITTLE
PORT MENIER
HEATH POINT
BAIE COMEAU
CAP CHAT
MONT JOLI
GASPE
LOBSTER COVE
BOTWOOD
CORNERBROOK
STEPHENVILLE
CHANDLER
NEW CARLISLE
DALHOUSIE
BATHURST
PORT AUX BASQUES
BURGEO
POINT ESCUMINAC
CAPE NORTH
SUMMERSIDE
CHARLOTTETOWN
MONCTON
SYDNEY
LOUISBOURG
PICTOU
SAINT JOHN
CANSO
HALIFAX
70°
65°
60°
50°
45°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ICE RIDGE DISTRIBUTION
WEEKLY COMPOSITE
01 MARCH 1982
GULF OF ST. LAWRENCE
GOLFE SAINT-LAURENT
18 RIDGES/KM
1.8 MEAN HT.
3.2 MAX
5 / 1.5 / 3.0
11 / 1.8 / 3.2
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18 / 1.8 / 3.2
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SEPT ILES
MINGAN
NATASHQUAN
CAPE WHITTLE
BLANC SABLON
ST. ANTHONY
FLOWERS COVE
POINT RICHE
DANIELS HARBOUR
LOBSTER COVE
BOTWOOD
CORNERBROOK
STEPHENVILLE
PORT AUX BASQUES
BURGEO
BAIE COMEAU
PORT MENIER
HEATH POINT
CAP CHAT
MONT JOLI
GASPE
CHANDLER
NEW CARLISLE
DALHOUSIE
BATHURST
POINT ESCUMINAC
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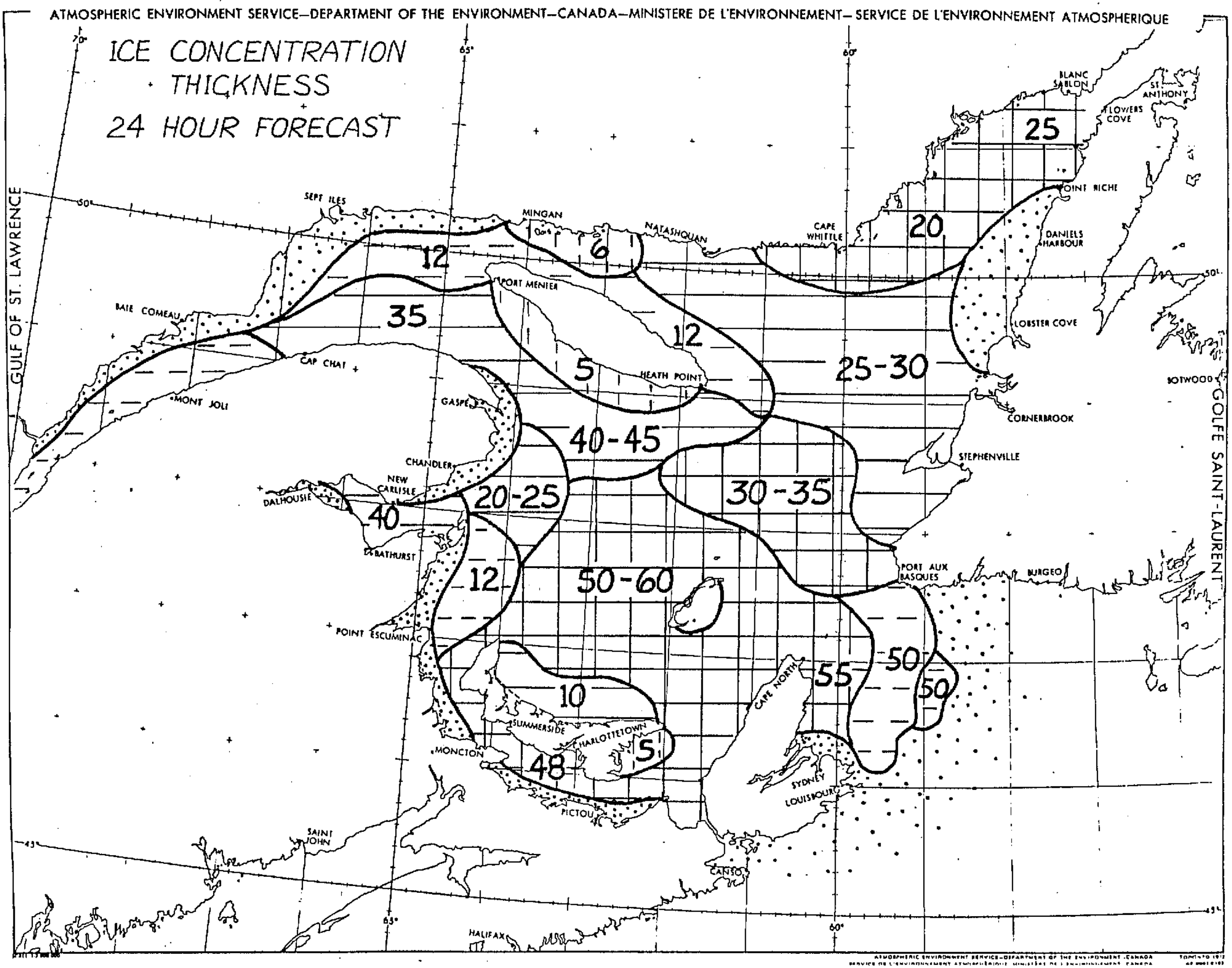
MONCTON
PICTOU
SYDNEY
LOUISBOURG
SAINT JOHN
CANSO
HALIFAX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ICE CONCENTRATION
THICKNESS
24 HOUR FORECAST
GULF OF ST. LAWRENCE
GOLFE SAINT-LAURENT
SEPT ILES
MINGAN
NATASHQUAN
CAPE WHITTLE
BLANC SABLON
ST. ANTHONY
FLOWERS COVE
POINT RICHE
DANIELS HARBOUR
LOBSTER COVE
BOTWOOD
CORNERBROOK
STEPHENVILLE
PORT AUX BASQUES
BURGEO
BAIE COMEAU
PORT MENIER
HEATH POINT
CAP CHAT
MONT JOLI
GASPE
CHANDLER
NEW CARLISLE
DALHOUSIE
BATHURST
POINT ESCUMINAC
SUMMERSIDE
CHARLOTTETOWN
MONCTON
PICTOU
CAPE NORTH
SYDNEY
LOUISBOURG
CANSO
SAINT JOHN
HALIFAX
12
6
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55
50
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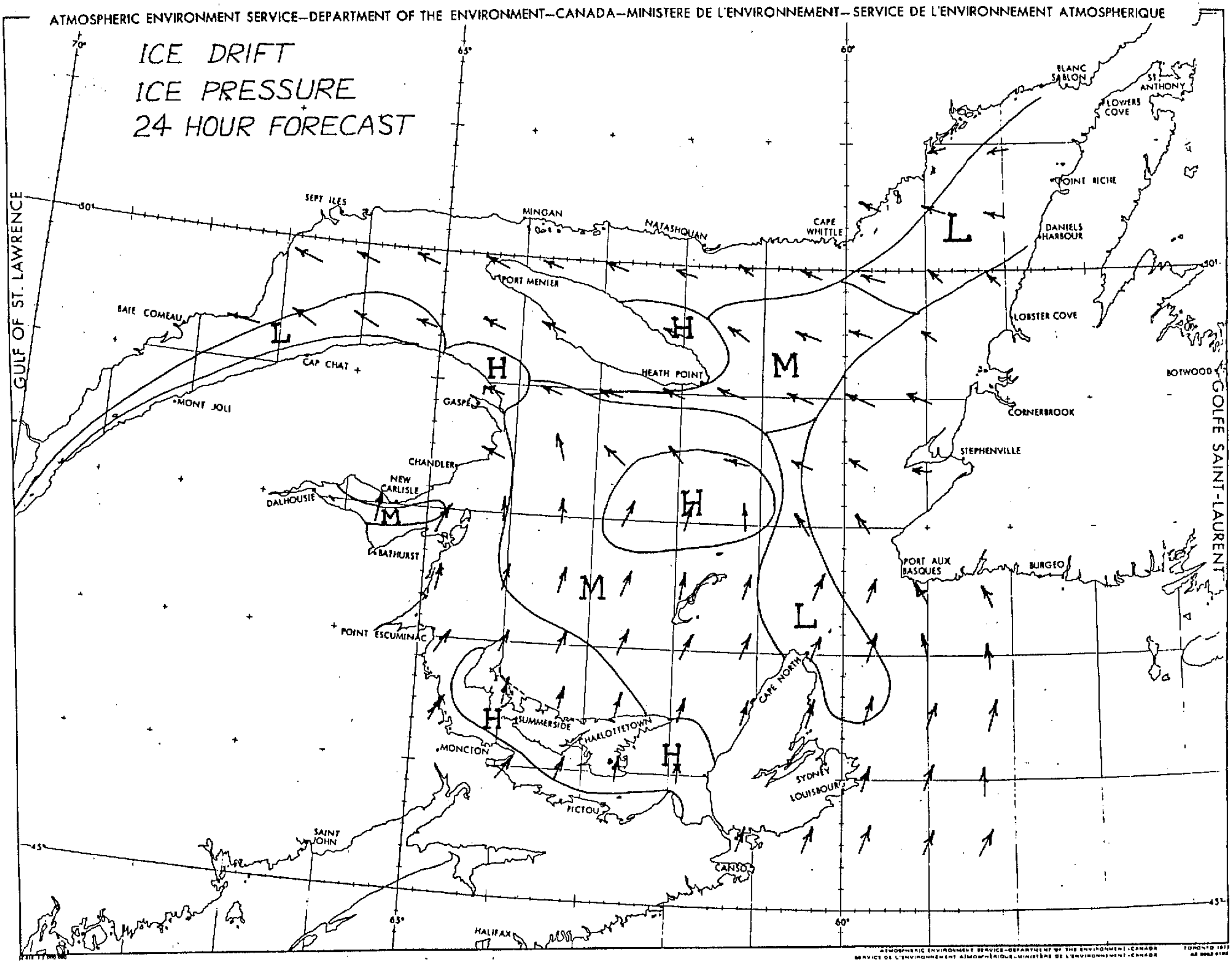
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ICE DRIFT
ICE PRESSURE
24 HOUR FORECAST
GULF OF ST. LAWRENCE
GOLFE SAINT-LAURENT
70°
65°
60°
50°
45°
BLANC SABLON
ST ANTHONY
LOWERS COVE
POINT RICHE
DANIELS HARBOUR
LOBSTER COVE
BOTWOOD
CORNERBROOK
STEPHENVILLE
PORT AUX BASQUES
BURGEO
SEPT ILES
MINGAN
NATASHQUAN
CAPE WHITTLE
PORT MENIER
HEATH POINT
BAIE COMEAU
CAP CHAT
MONT JOLI
GASPE
CHANDLER
NEW CARLISLE
DALHOUSIE
BATHURST
POINT ESCUMINAC
SUMMERSIDE
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HALIFAX
H
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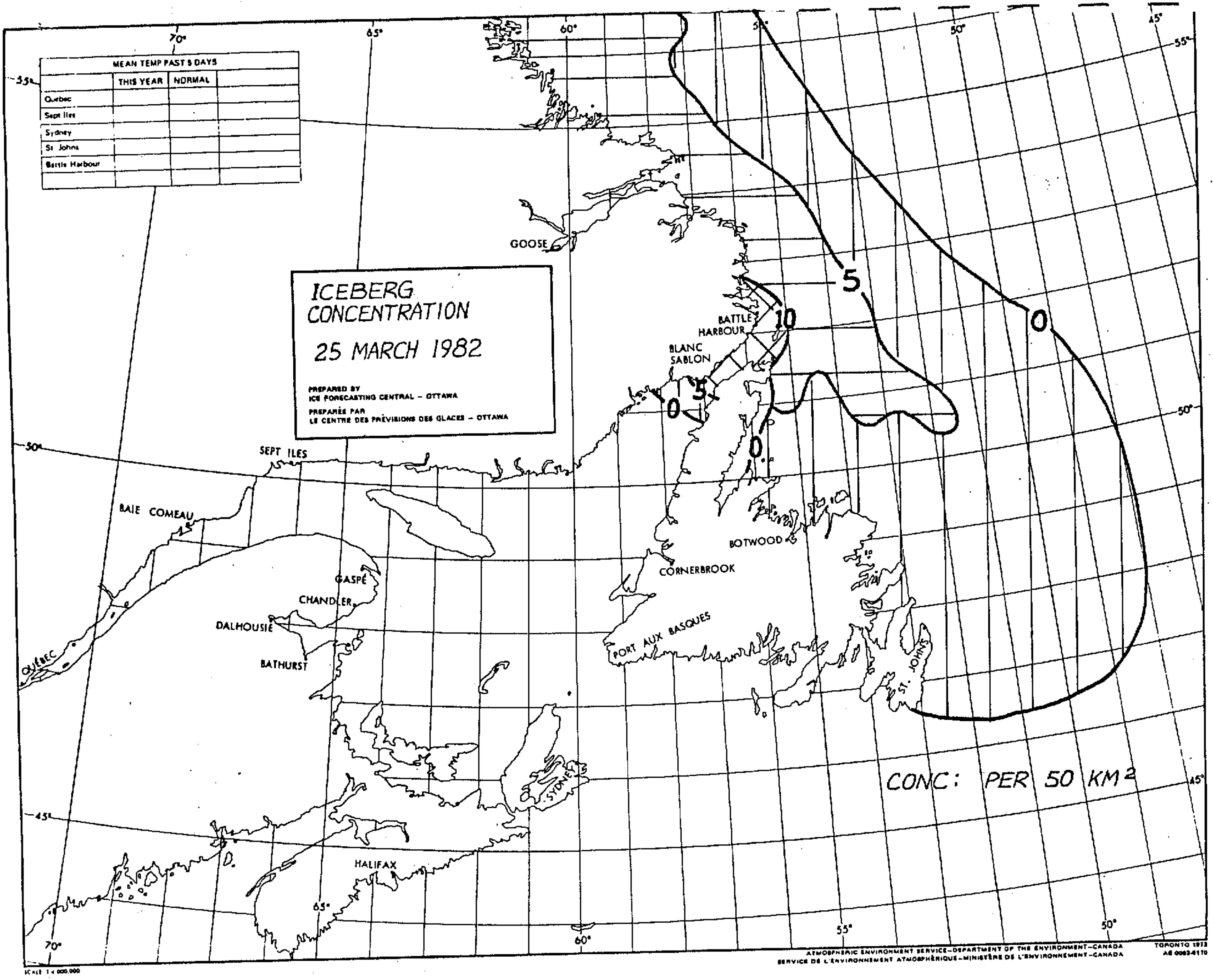
ICEBERG CONCENTRATION
25 MARCH 1982
PREPARED BY
ICE FORECASTING CENTRAL - OTTAWA
PRÉPARÉE PAR
LE CENTRE DES PRÉVISIONS DES GLACES - OTTAWA
CONC: PER 50 KM²
MEAN TEMP PAST 5 DAYS
THIS YEAR
NORMAL
Quebec
Sept Iles
Sydney
St Johns
Battle Harbour
GOOSE
BATTLE HARBOUR
BLANC SABLON
SEPT ILES
BAIE COMEAU
GASPÉ
CHANDLER
DALHOUSIE
BATHURST
QUEBEC
BOTWOOD
CORNERBROOK
PORT AUX BASQUES
ST. JOHNS
SYDNEY
HALIFAX
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ATMOSPHERIC ENVIRONMENT SERVICE—DEPARTMENT OF THE ENVIRONMENT—CANADA
SERVICE DE L'ENVIRONNEMENT ATMOSPHÉRIQUE—MINISTÈRE DE L'ENVIRONNEMENT—CANADA
TORONTO 1973
SCALE 1:4 000 000

APPENDIX B

INTERNATIONAL SEA ICE SYMBOLS

USED ON CURRENT ICE CHART

International Sea Ice Symbols

used on

ICE CHARTS

prepared and disseminated by

ICE BRANCH

of

ATMOSPHERIC ENVIRONMENT SERVICE

Environment Canada
A.E.S.
Ice Forecasting Central
Ottawa, Canada
November 1981

INTERNATIONAL SEA ICE SYMBOLS

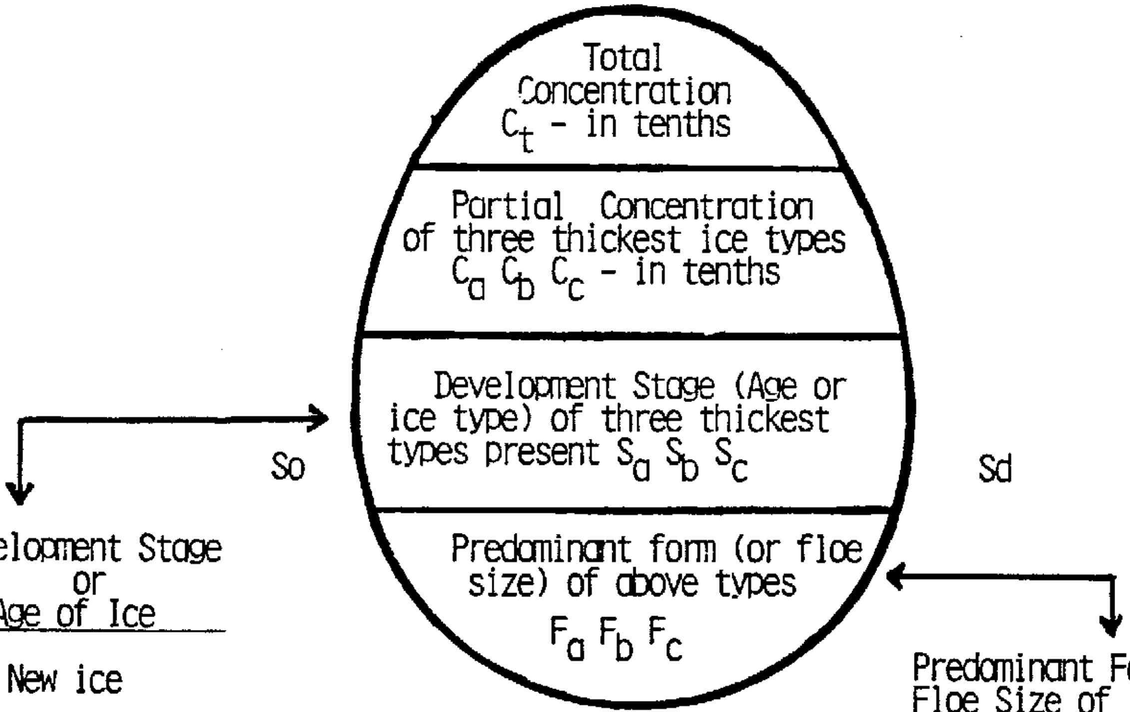
1. INTRODUCTION

Because of the increasing use of radio facsimile by commercial ships the World Meteorological Organization (WMO), which had approved the International Sea Ice Nomemclature in 1968, has now approved a new set of symbols for use on ice charts. The intent of the symbols is to permit most ice data to be shown in numerical or symbolic form, eliminating the language barrier from international ice data exchange and from use on broadcast ice charts by ships of all nations.

The countries of the northern hemisphere which operate significant ice information programs will use these International Sea Ice Symbols beginning this winter. Canada will begin using these symbols on all observed and generated ice charts from the beginning of the ice season along the eastern seaboard in December 1981.

The basic data on ice concentration, ice types, and ice floe sizes are enclosed in a simple oval - the egg - and are described herein, together with the appropriate code tables, optional hatching pattern, and examples of coded ice data.

The Basic Symbol - The Egg



Development Stage or Age of Ice

1 - New ice
2 - Nilas
   3 - Young ice
4 - Grey ice
5 - Grey white ice
   6 - First year ice
7 - Thin first year ice
1• - Medium first year ice
4• - Thick first year ice
7• - Old ice
   8• - Second year ice
   9• - Multi year ice
   ▲• - Icebergs

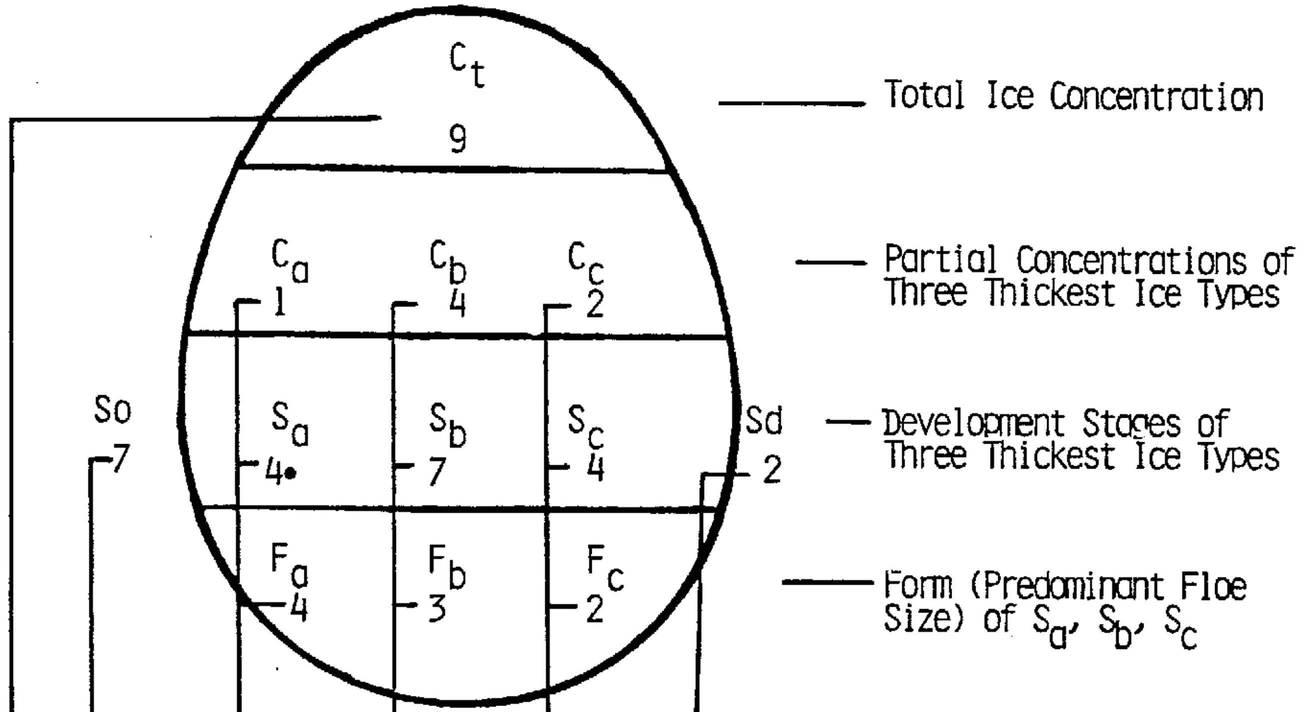
The indented number codes will be used infrequently in the Gulf and Newfoundland areas.

Predominant Form or Floe Size of Ice

0 - Pancake
1 - Brash
2 - Ice cake
3 - Small floe
4 - Medium floe
5 - Big floe
6 - Vast floe
7 - Giant floe
8 - Fast ice
9 - Icebergs
X - Unknown

See pages 4 and 5 for use of So and Sd

How To Decode The Egg



Sd
2 - Remaining ice cover (9-(1+4+2)) is 2 tenths Nilas and New ice with Nilas predominant.

C_c S_c F_c
2 4 2 - 2 tenths ice, type 4 (grey ice) floe size 2 (ice cakes).

C_b S_b F_b
4 7 3 - 4 tenths ice, type 7 (thin first year) predominant floe size 3 (small floes).

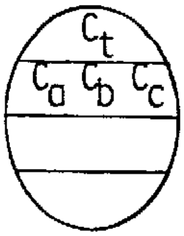
C_a S_a F_a
1 4• 4 - 1 tenth ice, type 4• (thick first year) predominant floe size 4 (medium floes).

So
7 - less than 1 tenth ice, type 7• (old ice - see note 7 on page 5). Floe size is not shown.

C_t
9 - Total Ice Concentration in the area is 9 tenths.

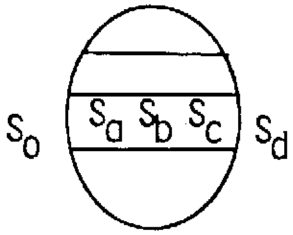
2. MAIN SYMBOL

The basic data concerning concentration, stage of development (age) with partial concentrations of up to three ice types, and form of ice (floe size) are contained in a simple oval form - the egg (see Appendix 2 for examples).

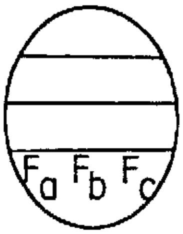


2.1 C_t - Total concentration of ice in the area, reported in tenths

C_a C_b C_c - Partial concentration, in tenths, of thickest (C_a), second thickest (C_b), and third thickest (C_c) ice types. See notes below.



2.2 S_a S_b S_c - Stage of development (age) of thickest (S_a), second thickest (S_b), and third thickest (S_c) ice of which concentrations are reported by C_a, C_b, C_c respectively. See notes below.



2.3 F_a F_b F_c - Form of ice (floe size) corresponding to S_a, S_b, and S_c respectively. See note 8 below.

Notes:

1. Partial concentration (C_a, C_b, C_c) <u>less than</u> 1 tenth is not shown.
2. S_a , S_b, and S_c shall have concentrations of 1 tenth or more.
3. If, after coding S_a, S_b, S_c, <u>more than one type of ice remains</u>, Sd shall be coded to indicate the remaining ice type with the greatest concentration. (Example 7 in Appendix 2)
4. S_o shall indicate an ice type thicker than S_a but whose concentration is <u>less than</u> 1 tenth.

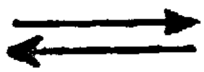
5. If total concentration is 10 tenths of one ice type, the partial concentration need not be shown because the full description is given by C_t, S_a, and F_a. (Example 4 in Appendix 2)

6. Concentration is not reported for Sd. Knowing the total concentration (C_t) and the combined partial concentrations (C_a, C_b, C_c) the concentration of ice type Sd will be less than or equal to this difference, and the thickness range will be less than that of S_c. (Example 7 in Appendix 2)

7. The decimal (•) which is an integral part of the code for medium first year and thicker ice types appears only <u>once</u> in the symbolic form. Ice thickness ranges increase from S_c to S_b to S_a and S_o, therefore all ice types to the left of the decimal (•) are understood to have this mark as part of the symbol and it is not repeated for each one.

8. Absence of information on form (floe size) of ice corresponding to S_a, S_b, S_c shall be indicated by an "x" in the appropriate position of F_a, F_b, F_c. (Example 1 in Appendix 2)

3. <u>Symbols for dynamic processes</u>

Compacting	
Diverging	
Shearing	
Drift	

Supplementary procedures (optional):

Compacting: ⟶ (degree) ⟵

degree: 1 - compacting slight
2 - compacting moderate
3 - compacting strong

Drift: (in tenths of knots) ⟶ (e.g. 15 = 1.5 knots)

4. Symbols for water openings

Crack  (symbol indicating presence of cracks in the area)

Crack  (symbol for a crack at a specific location)

Lead  or 

Frozen lead  (the orientation of the crosslines may be varied to distinguish them from other hatching lines)

Supplementary procedures (optional):

Lead  (width) (width of lead in metres or kilometres, e.g. 100-300m)

5. Symbols for topography features

Ridges/hummocks F  $\bar{h}/h_x$
C

Concentration (areal coverage) C in tenths
Frequency f in numbers per nautical mile (f is an alternative for C)
Mean height $\bar{h}$ and maximum height h_x are expressed in decimetres.

Note: The data for C or f, $\bar{h}$ and h_x are added <u>where known</u>.

Rafting 
C

Concentration C as above to be added where known.

6. Symbol for ice thickness

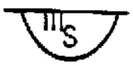
Thickness measured [t_E] (t_E in centimetres)

Thickness estimated [t_E] (example: [35])

When more than one measurement has been taken, both mean and maximum thickness are reported as shown:

[30/40]

7. Symbol for stage of melting

Stage of melting  (see code table for m_S in appendix 1)

8. Symbol for surface features

Snow cover: 

C - concentration (areal coverage) in tenths

s - snow depth, (see code table in Appendix 1).

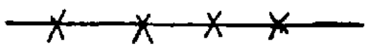
The orientation of the symbol will show the direction of sastrugi, as follows:

9. Symbols for limits or boundaries

Undercast 

Limit of visual observations 

Limit of radar observations 

Ice edge by radar 

Observed edge or boundary (Visual or satellite)

Estimated edge or boundary

10. <u>Symbol for strips and patches</u>

Strips and patches ∾ C

C - concentration in tenths of ice within the area of strips and patches (Optional addition).

The symbol ∾ C is placed within the main "oval" symbol in the section reserved for "Form of ice" (see example in Appendix 2).

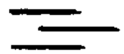
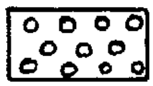
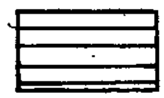
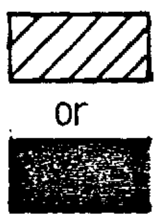
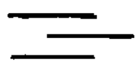
11. <u>Supplementary procedures for indicating total concentration</u>

In order to facilitate readability of the chart, ice-covered areas may be hatched according to total ice concentration. Hatching may be applied to all areas of ice concentration or only to some of them. Whenever hatching is applied, the hatching symbols shown in Appendix 1 shall be used. Generally Canadian ice charts will not be hatched.

APPENDIX 1

CODE TABLES

Concentration Symbols for C_t, C_a, C_b, C_c

Concentration	Symbol	Optional Hatching Pattern
Ice free		
< 1/10	0	 open water
1/10	1	 very open pack (1–3)
2/10	2	
3/10	3	
4/10	4	 open pack (4–6)
5/10	5	
6/10	6	
7/10	7	 close pack (7–9)
8/10	8	
9/10	9	
> 9/10 but less than 10/10	9+	 very close pack or consolidated (9+, 10)
10/10	10	
		 land fast ice
		 Δ bergy water

Stage of development and thickness range

(S_o S_a S_b S_c S_d)

ELEMENT	SYMBOL	THICKNESS RANGE
No stage of development	0	No ice
New ice	1	-
Nilas, ice rind	2	<10 cm (4 in.)
Young ice	3	10-30 cm (4-12 in.)
Grey ice	4	10-15 cm (4-6 in.)
Grey white ice	5	15-30 cm (6-12 in.)
First year ice	6	>30 cm (>12 in.)
Thin first year ice	7	30-70 cm (12-28 in.)
Medium first year ice	1•	70-120 cm (28-48 in.)
Thick first year ice	4•	>120 cm (>48 in.)
Old ice	7•	
Second year ice	8•	
Multi year ice	9•	
Icebergs	▲•	

Note: Codes 3 and 6 are general age categories and are intended for use only in satellite imagery interpretation. Codes 8• and 9• will be used primarily in Arctic areas from October to December; at other times 7• (old ice) will be used. (Codes 8 and 9 are specifically for Baltic area and will not be used in Canada.)

Stage of Melting

(M_s)

Element	Symbol
0 No Melt	0
Few Puddles	1
Many Puddles	2
Flooded Ice	3
Few Thaw Holes	4
Many thaw Holes	5
Dried Ice	6
Rotten Ice	7
Few Frozen Puddles	8
All Puddles Frozen	9
Undetermined or Unknown	x

Snow Cover Depth

(S)

Element	Symbol
No snow	0
Up to 2 cm	1
Up to 5 cm	2
Up to 10 cm	3
Up to 15 cm	4
Up to 25 cm	5
Up to 50 cm	6
Up to 1 m	7
Up to 2 m	8
Over 2 m	9
Undetermined or Unknown	x

Form of Ice

(F_a F_b F_c)

Element	Symbol
Pancake ice	0
Small ice cake; brash ice	1
Ice cake	2
Small floe	3
Medium floe	4
Big floe	5
Vast floe	6
Giant floe	7
Fast ice	8
Iceberg	9
Undetermined or unknown	x

Symbols for Ice of Land Origin

n = number from WMO Code 2877

yy = day of month berg sighted

- Growler and/or bergy bit
- Iceberg (size unspecified)
- Iceberg, small
- Iceberg, medium
- Iceberg, large
- Iceberg, very large
- Tabular berg indicated by adding a horizontal line through any of the above
- Ice island
- Radar target (suspected berg)

Note: The right-hand column of symbols may be used when many bergs are present but actual numbers are not known.

Symbol for Ice of Sea Origin

Floeberg 

Specification of Icebergs

(as established by the International Ice Patrol Service)

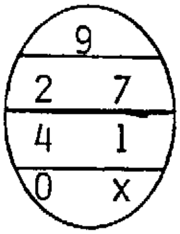
SIZE	HEIGHT (m)	LENGTH (m)
Growler & Bergy Bit	Up to 5	Less than 15
Iceberg, small	6-15	16-60
Iceberg, medium	16-45	61-122
Iceberg, large	46-75	123-213

NOTE: Sizes refer to the above water portion only. If height and length of a berg fall into different size classification, use the larger size. Dimensions (in km's) of a tabular berg or ice island may be indicated beneath the symbol.

Appendix 2

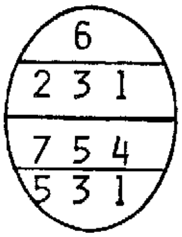
EXAMPLES OF USE OF THE "OVAL" SYMBOL

Example 1



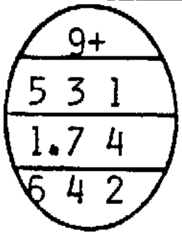
9 tenths of ice; 2 tenths of grey ice and 7 tenths of new ice; floe size of grey ice is pancake and that of the new ice is not determined.

Example 2



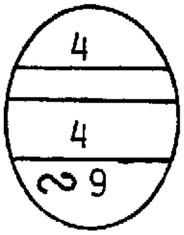
6 tenths of ice; 2 tenths of thin first year ice, 3 tenths of grey white ice, and 1 tenth of grey ice; predominant floe size of the thin first year ice is big floes, of the grey white ice is small floes, and of the grey ice is brash.

Example 3



over 9 tenths of ice; 5 tenths of medium first year ice (floe size is vast), 3 tenths of thin first year ice (floe size is medium), and 1 tenth of grey ice (floe size is ice cakes). There is 1-2/10 of ice thinner than grey ice (9+ - (5+3+1)) - no floe size is indicated.

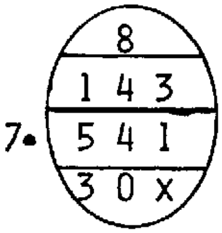
Example 4



general ice cover is 4 tenths; ice is all grey ice in strips and patches, with concentration 9 tenths in the strips and patches.

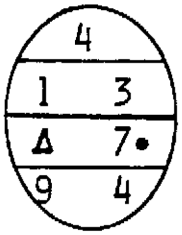
Note: with only one stage of development shown partial concentration is not needed.

Example 5



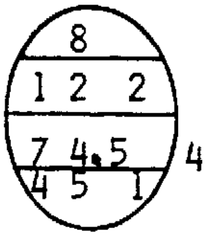
8 tenths of ice; 1 tenth grey white ice of predominantly small floes, 4 tenths grey ice in pancakes, and 3 tenths of new ice with no determinable floe forms. There is less than 1 tenth of old ice present in the area.

Example 6



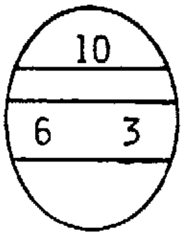
4 tenths ice cover; 1 tenth of icebergs and 3 tenths of old ice in predominantly medium floe size.

Example 7



8 tenths ice cover; 1 tenth old ice in predominantly medium floe size, 2 tenths thick first year ice with big floes predominating, 2 tenths grey white ice in brash form. Of the remaining 3 tenths of ice, grey ice (4) is present in the highest concentration (must be 2 tenths) with 1 tenth of nilas or new ice also in the area.

Example 8



Complete ice cover - 10 tenths, first year and young ice are indicated with no breakdown by partial concentration or information on floe sizes available. This type of report might be used in analyzing satellite data where these elements could not be determined.