CHAPTER 5

ICE ANALYSIS CHARTS

- ❑ Daily Ice Analysis Charts
  - ❑ Description
  - ❑ Method of Production
  - ❑ Dissemination of Charts
  - ❑ Symbols Used on Charts
  - ❑ Colour Coding the Charts
- ❑ Regional Ice Analysis Charts
  - ❑ Description
  - ❑ Method of Production
  - ❑ Dissemination of Charts
  - ❑ Symbols Used on Charts
- ❑ Image Analysis Charts
  - ❑ Description
  - ❑ Method of Production
  - ❑ Dissemination of Charts
  - ❑ Symbols Used on Charts
- ❑ Examples of the Use of the Egg Code

This chapter deals with basic procedures for preparing and transmitting various chart products from the Canadian Ice Service (CIS), operations division. These charts are of importance to a variety of users for many purposes such as strategic planning, climate studies and or tactical vessel management. These products use different variations of the egg code described in Chapter 3. In some cases, scale and map area restrict and limit the use of the complete code.

5.1 Daily Ice Analysis Charts

5.1.1 Description

These charts are of importance to icebreaker captains, commercial shipping interests and fishing vessels, to assist them in finding the easiest passage through the ice or to avoid the ice when feasible to do so. The charts are meant to provide ice information for strategic planning for their activities during the next 24 hours.

Please note that there are significant differences between daily ice analysis charts and observed/image analysis charts:

- **Frequency**

  Daily ice analysis charts are done on a daily basis during the season, whereas image analysis charts are done when images arrive for a particular operational area. Observed charts are generated whenever ice conditions are encountered either from ships, helicopters or aircraft.

- **Detail**

  The other significant difference resides in the amount of detail on each chart. Observed and image analysis charts have more latitude regarding the amount of detail and information that can be placed on the product. Daily ice analysis charts will have less detail pertaining to ice areas and egg definitions. Consequently, daily ice analysis charts have a more generalized look compared to observed/ image analysis charts.

5.1.2 Method of Production

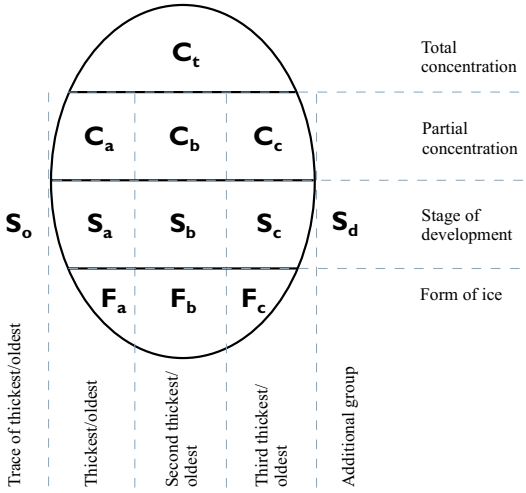
Daily ice analysis charts are computer-generated with the use of mapping and image analysis software. The system allows the forecaster to draw lines and place eggs, symbols, drift arrows, and ship positions.

The forecaster will use a variety of data sources such as NOAA AVHRR, GOES, ERS and particularly RADARSAT, as well as the image analysis charts from these data. The field observation charts from ships, helicopter and aircraft provide ground truthing (See Figure 5.16). However on days when no data is available, or when the image analysis does not coincide with the valid time of the daily ice analysis chart (1800 UTC), the ice model from CIS can be used to advance ice to the valid time.

The Egg Code

There are some limitations on the use of the egg code for daily analysis charts. Later in this chapter, we will specifically outline the significant differences. For a complete version of the egg code, please see Chapter 3.

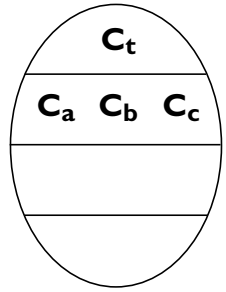
Figure 5.1: Elements of the Egg Code Used for Daily Ice Analysis Charts



Note: The symbols C_a C_b C_c and F_a F_b F_c correspond to S_a S_b S_c respectively.

Figure 5.2: Concentration (C)

Total concentration (C_t) of ice in the area indicated in tenths and partial concentrations of thickest (C_a), second thickest (C_b) and third thickest (C_c). Note that C_d which appears on observation/SAR image analysis charts, will not be indicated on daily ice analysis charts from the Canadian Ice Service.



Notes:

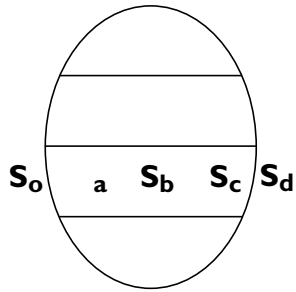
1. Less than 1/10 (i.e. traces) shall not be indicated within the egg.
2. When only one ice type is present, the partial concentration shall not be indicated (see Example 1).

3. When one ice type is present with a trace of a thinner type, only total concentration of the major ice type shall be indicated (see Example 2).

4. When two or more ice types are present, each ice type will have a corresponding partial concentration (see Example 3).

Figure 5.3: Stage of Development (S)

Stage of development of thickest (S_o), second thickest (S_a), third thickest (S_b) and fourth thickest (S_c) ice and the thinner ice type S_d, of which the concentrations are reported by C_a C_b C_c respectively.



Notes:

1. Reference to thicker ice should be understood to mean older ice and conversely, thinner ice to mean younger ice types.

2. Ice is designated Sea, Lake or River depending on where it forms. In Canada, the practice is to use the Lake Ice code to report ice in the Great Lakes and the St. Lawrence Seaway. Elsewhere, including the St. Lawrence River east of Montreal, sea ice coding is used for stages of development.

3. Reporting of S_a S_b and S_c should generally be restricted to a maximum of three significant classes. In exceptional cases further classes may be reported as follows:

   S_o - stage of ice development thicker than S_a, but having a concentration less than 1/10 (see Example 4).

   S_d - stage of development of the thickest remaining ice types. It is the fourth stage present after S_a, S_b and S_c. Partial concentration must be at least 1/10 (see Example 4), except during the freeze-up period when a trace of new ice may be present (see Example 2).

   S_e - this stage of development will not appear on a daily ice analysis chart.

Table 5.1: Coding for Sea-Ice Stages of Development (S_o S_a S_b S_c S_d)

DESCRIPTION	THICKNESS	CODE
New ice	<10 cm	1
Grey ice	10-15 cm	4
Grey-white ice	15-30 cm	5
First Year ice	> 30 cm	6
Thin first-year ice	30-70 cm	7
Medium first-year ice	70-120 cm	1•
Thick first-year ice	> 120 cm	4•
Old ice		7•
Second-year ice		8•
Multi-year ice		9•
Ice of land origin		▲•
Brash		-

Table 5.2: Coding for Lake Ice Stages of Development (S_o S_a S_b S_c S_d)

DESCRIPTION	THICKNESS	CODE
New lake ice	<5 cm	1
Thin lake ice	5-15 cm	4
Medium lake ice	15-30 cm	5
Thick lake ice	30-70 cm	7
Very thick lake ice	>70 cm	1•

Notes for Tables 5.1 and 5.2:

1. Code 2, 3, 8, 9, and **X** will not be used on daily ice analysis charts from CIS.
2. On the horizontal line giving $\mathbf{S_oS_aS_bS_cS_d}$ only one dot (•) shall be placed to indicate the distinction between classes of ice. Every coded figure to the left of the (•) is understood to have the (•) as part of its code (see Examples 4 and 5).
3. The symbol ▲• shall only be used within the egg when the concentration of ice of land origin is 1/10 or more (see Example 12).
4. Code 8• and 9• shall normally appear on CIS daily ice analysis charts from 01 October to 31 December.
5. Brash ice (-), when present, will always appear as $\mathbf{S_a}$ (see Example 11).

Figure 5.4: **Form of Ice (F)**

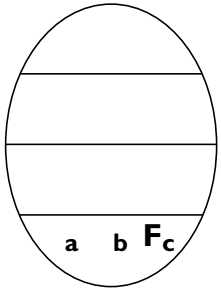


Table 5.3: Coding for Form of Ice (F_a F_b F_c)

DESCRIPTION	WIDTH	CODE
Small ice cake, brash ice	<2 m	
Ice cake	2-20 m	
Small Floe	20-100 m	
Medium floe	100-500 m	
Big floe	500-2000 m	
Vast floe	2 -10 km	
Giant floe	> 10 km	
Fast ice		
Icebergs		
No form		X

Notes for Table 5.3:

1. Width refers to the maximum horizontal extent.
2. At least one code 8 must be used for fast or consolidated ice. When significant ice types are present and it is important to maintain their floe size, the younger ice type will be coded as fast ice (see Example 5).
3. Occasionally the stage of development of fast ice cannot be determined. The area shall be blackened-in to denote fast ice. Also when the area in question is very small or difficult to place a label, it can be blackened-in. For areas with a trace of old, second or multi-year ice embedded in fast ice, the area will be shaded-in in grey with an attached label or egg.
4. New sea ice does not have a definite form, therefore, when this stage of development occurs as S_a S_b or S_c the symbol **X** shall be used to designate floe size (See Example 1).
5. When an area of ice has one particular ice type but varying floe sizes, the basic rule will be to represent the ice type that has the predominant concentration and use the corresponding floe size (see Example 6). An exception would be when there are a few giant old floes in a field of medium old floes (see Example 7).
6. Pancake floe size (code 0) will not appear on CIS charts. Since pancake ice floes implies new ice, the standard floe size when dealing with new ice at CIS is always **X**.

Coding and Symbology for Strips and Patches

ᔓ C

The symbol ᔓ, placed at the bottom of the egg in Form of Ice section, indicates that the ice is in strips and patches and that the concentration within the strips and patches is represented by **C** (see Example 8).

In an area in which the ice is arranged in strips and patches and the ice floes are medium (code 4) or greater, the floe size shall be indicated by using two eggs. The floe sizes are indicated as normal in the first egg with the ᔓ symbol placed between the first and second eggs. The ᔓ symbol is repeated in the second egg beside the total concentration of the strips and patches (see Example 9).

In an area of ice in which some first-year or thicker ice type(s) is/are embedded as strips and patches, the strips and patches shall be indicated by the use of two eggs. The overall partial concentrations of the ice types are indicated in the first egg and the concentration within the strips and patches are indicated in the second egg. The ᔓ symbol shall be placed between the two eggs and along with the total concentration in the second egg (see Example 10). Double eggs will be indicted with a leader line to the polygon in question.

Where there are isolated strips and patches of ice, of less than 1/10 concentration, located outside the main ice areas, the strip (ᔓ) symbol will be placed in the area of these strips. Usually these symbols are used to indicate ice in the final stage of melt.

5.1.2.1 Defining Polygons

The parsing of ice areas can be done in one of two ways:

1) By various ice types;
2) By concentration.

Note that only solid lines will be used to separate areas of different ice type/concentration (no dash lines).

1) Ice Type

Mandatory boundaries are required between new, grey, grey-white, first-year and old ice.

Please note that ice codes 2 (nilas ice, ice rind), 3 (young ice), 8 (first stage thin first-year ice) and 9 (second stage thin first-year ice) and **X** (undetermined or unknown) will not appear on any daily ice analysis charts from CIS.

For old ice, (7•, 8• and 9•) boundaries are required between areas with concentrations of:

- No old ice
- Trace of old ice
- 1 - 3/10
- 4 - 6/10
- 7 - 8/10
- 9 - 9+/10
- old ice (7•, 8• and 9•) with a concentration of 4 tenths or more will be considered predominant.

When two ice types are present in equal concentration, the older/thicker type is considered predominant.

When three or more types are present in equal concentrations, the second oldest is considered predominant.

2) Total Concentration

In the case of total concentration, mandatory boundaries, shown as solid lines are required between areas of:

Open water/bergy water:	< 1 tenth
Very open drift:	1 to 3 tenths
Open drift:	4 to 6 tenths
Close pack:	7 to 8 tenths
Very close pack:	9 to 9+ tenths
Compact or consolidated:	10 tenths

The total concentration is the first determining factor in defining ice boundaries. Partial concentrations of new ice are ignored when first-year or thicker ice is present.

5.1.2.2 Floe Size

Mandatory boundaries must also be placed between areas of predominantly medium floes or larger (code 4) and areas of predominantly small floes or smaller (code 3) when 6 tenths of thin first-year or thicker/older ice are present.

5.1.2.3 Discretionary boundary

In addition to the guidelines for mandatory boundaries, discretionary boundaries can also be used when sufficient data or knowledge of the ice regime has been verified by up-to-date reconnaissance flight, reports or satellite information. These boundaries are to be maintained on subsequent charts only if there is sufficient knowledge of the location, as provided by these data sources.

Discretionary boundaries should only be used in operationally sensitive areas, namely:

Great Lakes:	shipping routes
Gulf of St. Lawrence:	shipping routes
Newfoundland:	coastal waterway to Botwood
Arctic:	shipping routes

Ice type to consider:

When considering the use of a discretionary boundary, only first-year and old ice are considered, provided there is sufficient knowledge to supply this additional detail. The exception would be in the Great Lakes, where thick or very thick lake ice and areas of ridging should be considered for discretionary boundaries.

Ice Concentration of ice to consider:

Total ice concentration must be at least "close pack" (7 or 8 tenths of ice). New ice, as usual, is ignored when evaluating the total concentration.

Variance of the concentration to consider:

A discretionary boundary may be used if the partial concentration of the first-year or thicker (thick or very thick lake ice) ice varies by at least 3 tenths in a definable area within a mandatory polygon (see Examples 13 and 14).

5.1.2.4 Valid Time

Normally every daily analysis chart generated at the Canadian Ice Service has a valid time of 1800 UTC. The chart thus represents ice conditions at 1800 UTC.

5.1.2.5 Corrections and Amendments

When a correction or amendment is made to the chart, the abbreviation COR or AMD will appear next to "Ice analysis/Analyse des glaces" at the top of the legend.

- A correction is required if an error appears on a chart (examples: C_t indicated 5/10, but should have read 8/10; the ice drift is missing; wrong date for an image in the legend).
- An amendment is warranted when a significant change in ice conditions in a certain area occurs (examples: C_t was put as 5/10 but a report indicated that the concentration was 9+/10; ice is reported in an area shown as open water).

For an example of a corrected/amended chart, please see Figure 5.10, page 5-19.

5.1.2.6 Chart Legend

Used on daily ice analysis charts to detail the region, valid time and date, and other ancillary data. In the legend of the chart itself, other ancillary data can be indicated such as reconnaissance flight, RADARSAT or NOAA imagery. At the bottom of the legend, other types of information can be indicated such as the latest chart received from a particular coast guard ship.

With regards to RADARSAT and NOAA, the usual information indicated for these fields would include the date. On the line just below these sensors would have the time of the image used as well as a description of the area the imagery covered. Note that for NOAA, clouds can hide ice information therefore, the portion of the image which was used for the daily ice analysis will be indicated by using terms such as: south of 5600N/West of 7500W, etc. Sometimes, the entire area will be cloud covered. In these cases, it will be indicated as: Cloudy/Too Cloudy or terms to this effect.

Figure 5.5
Example of Chart Legend

5.1.2.7 Deadlines

Deadlines may vary from chart to chart, and from season to season.

- **Transmission**

  As a general rule, at least one chart should be made ready for transmission from CIS at 1600 Eastern Standard Time (or Daylight Saving Time). However, in consultation with the CCG Ice Operations Centre(s), priorities regarding which chart to send out first will be determined on a daily basis, to ensure that the most operationally sensitive chart is first selected for transmission.

- **Data reception and integration**

  For information received from outside sources (CFR charts, CCG ship reports, etc.), a minimum of 2.5 hours before the transmission deadline is required to integrate it into the daily ice analysis chart. In most cases when the information arrives late, the forecaster will endeavour to integrate the information, especially if it is operationally sensitive. However, this may cause a delay in the delivery of the chart. The decision to process the information or not, for use in the chart, will be at the discretion of the forecaster in consultation with CCG ice operations office.

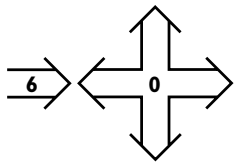
5.1.3 Dissemination of Charts

Upon completion of the analyses, daily ice analysis ice charts are disseminated electronically via a product delivery system. Clients will receive products via e-mail, fax or the internet. ISS and CCG clients have a special customised delivery system set up.

5.1.4 Symbols Used on Daily Ice Analysis Charts

Symbols for Dynamic Process

Drift

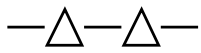


Indicates the direction and drift speed (in nautical miles per day) in the general area for the next 24 hours from the valid time of the daily ice analysis chart

Symbols for Defining Limits

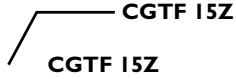
Analysed edge or boundary

Bergy water boundary



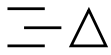
Other Symbols Used

Ship reports



Used to indicate the latest position and time of a Coast Guard ship.

Bergy water

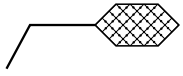


Symbol used to indicate bergy water conditions.

Ice-free

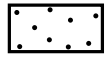
Symbol used to indicate ice-free conditions.

Ice island or
Ice island fragment



Symbol used to indicate ice island or fragments.

Open water



Stipple pattern used to indicate open water areas.

Fast ice

Blackened area representing fast ice.

Strips and patches

Symbol used to indicate strips and patches of ice outside the ice edge.

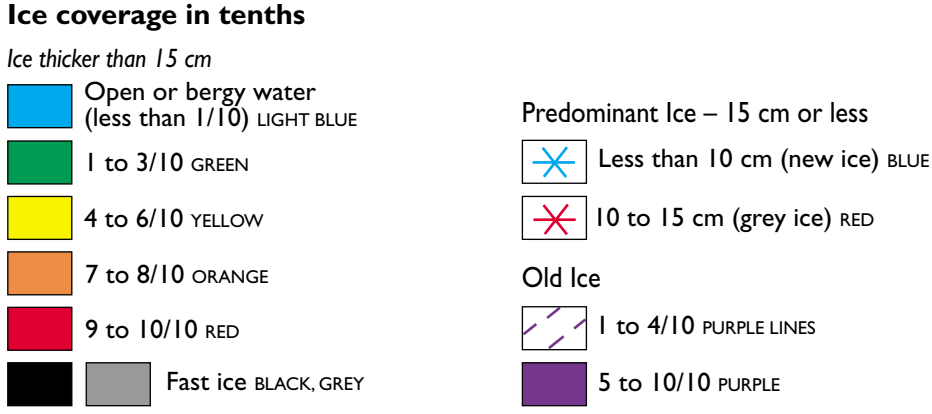
5.1.5 Colour Coding Ice Charts

CIS Colour Code

Colours are used to enhance ice charts for presentations and briefings. They also allow users to make a quick assessment of general ice conditions. The colour code available to CIS clients represents the severity of the ice conditions, and is somewhat similar to a traffic light:

- *Blue* and *green* represent relatively easily conditions for navigation;
- *Yellow* and *orange* indicate more difficult conditions;
- *Red* indicates the most severe conditions.

Figure 5.6: Standard CIS Colour Code



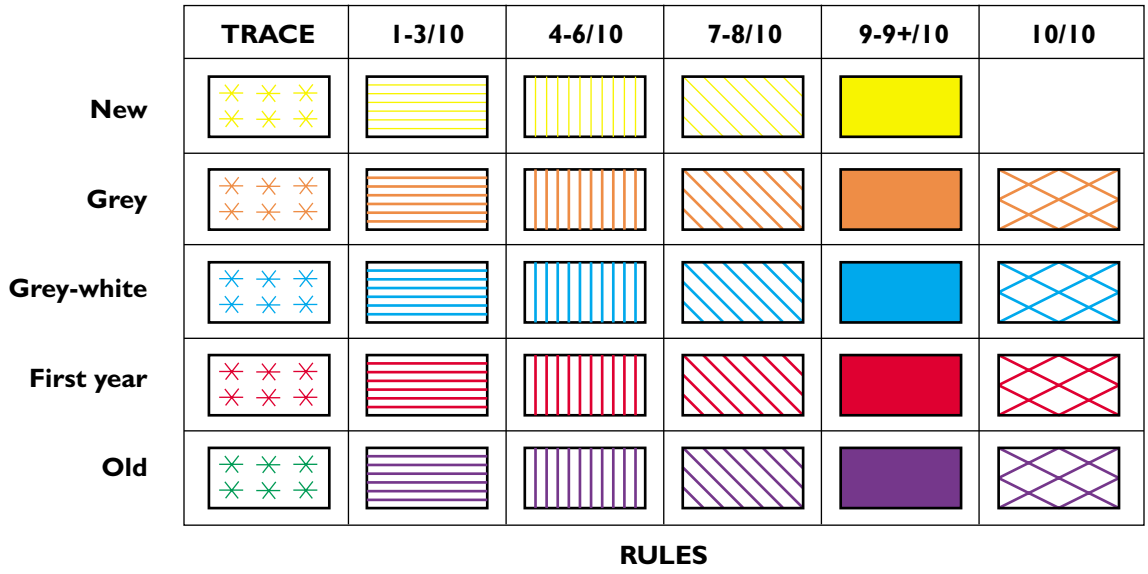
Internal Colour Code and Hatching Scheme for Quality Assurance

There is also an internal colour code and hatching scheme used at the CIS to verify the quality and consistency of the chart. These specific hatching and shading patterns help to identify problem areas, such as incorrect ice types in a polygon (colour) or incorrect concentrations (hatching).

Please note that the internal colour code and hatching scheme is not used for publication purposes.

The Canadian Ice Service QA colour code uses patterns and colour to depict ice conditions on Daily and Regional Ice Charts. This code allows forecasters/analysts to visually follow trends in ice growth and to ensure that ice chart products are consistent with the climatological regime of the region. It is loosely based on the W.M.O. code and describes the ice conditions in a given polygon based on total ice concentration and stage of development. Colour is used to identify different stages of ice development from new to old ice. Patterns are used to identify ice concentration from a trace to consolidated ice.

Figure 5.7 **Canadian Ice Service QA Colour Code for Ice Charts**



Concentration (Pattern)

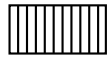
Decide on the primary pattern by determining total concentration.

Trace | 1-3/10 | 4-6/10 | 7-8/10 | 9-9+ | 10/10 Fast

Total concentration is the sum of all the partial concentrations in the ice egg.

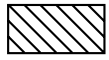
One exception is in the case of an ice polygon which has new ice and ice thicker than first year. In this case the partial concentration of the new ice is disregarded when calculating the total amount of ice.

Examples:

9+/64/71/5x	the total concentration is 6/10^{ths} therefore the primary pattern is	
8/116/7.51/34x	the total concentration is 2/10^{ths}	
9+/73/75/44	the total concentration is 9+/10^{ths}	

Decide on the second thickest ice type in the polygon and select the appropriate secondary hatching pattern that corresponds to its partial concentration.

Example:

8/53/7.4./55	the total concentration is 8/10^{ths} the partial concentration of the second most predominant ice is 3/10^{ths} therefore the polygon would be hatched as:	

Ice Type (colour)

The colour of the primary hatching is determined by the **predominant ice type**. The colour of the secondary hatching corresponds to the next thickest ice type in the polygon.

When 2 ice types are present in equal concentrations the older/thicker ice type is considered predominant.

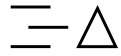
When 3 ice types are present in equal concentrations the second oldest is considered predominant

When old ice is present with a concentration of 4/10^{ths} or more it will be considered predominant.

These are the corresponding ice type / colour match ups. **Note:** the coloured output on some printers may vary slightly.

New | Grey | Grey-white | First-year | Old

Open water (less than 1/10 sea ice, no ice of land origin)

Bergy water (less than 1/10 sea ice may be present and total ice concentration is less than 1/10) 

Ice free (no ice present) 

Figure 5.8: **Black and White Daily Ice Chart**

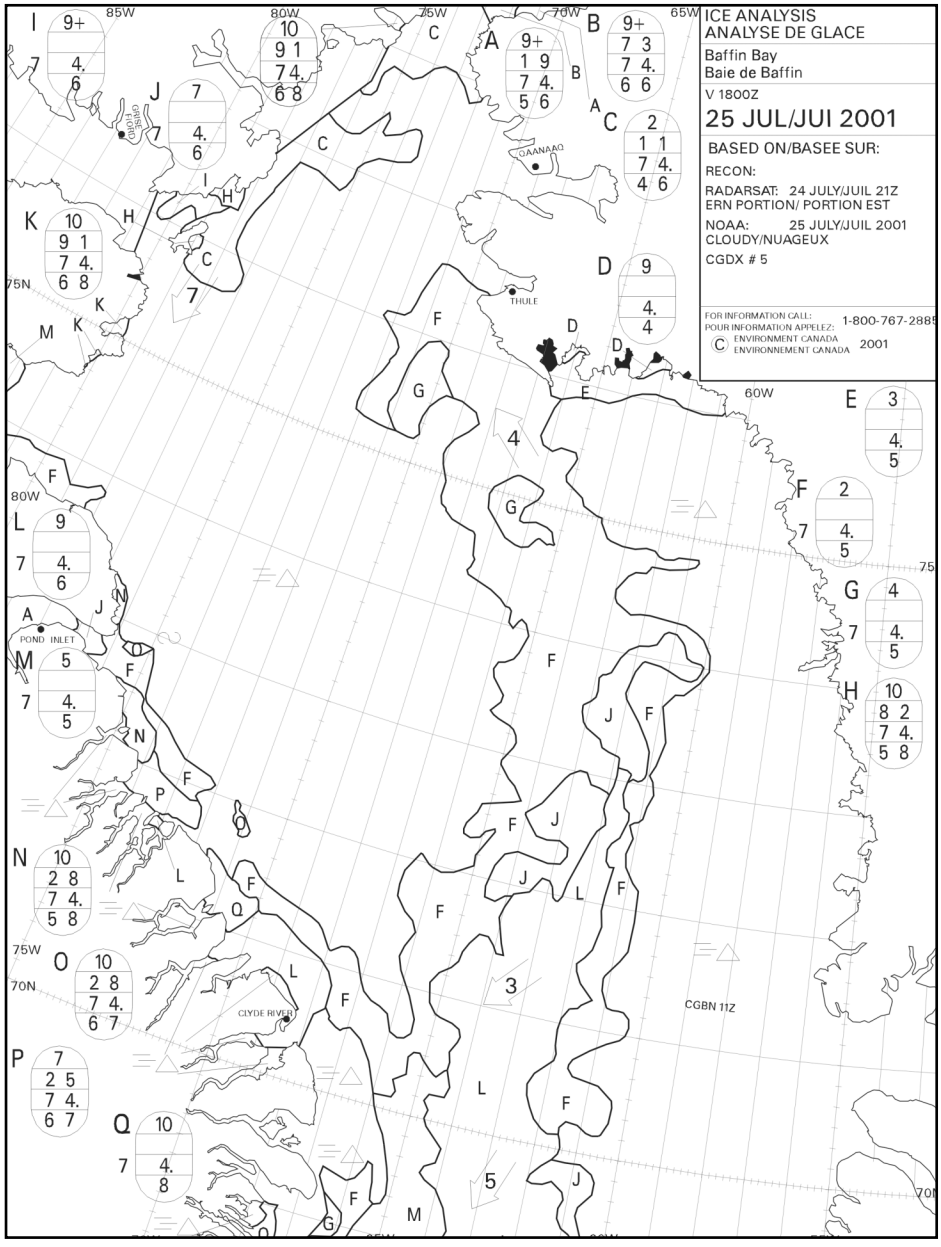


Figure 5.9: **ISS Colour-Coded Daily Ice Chart**

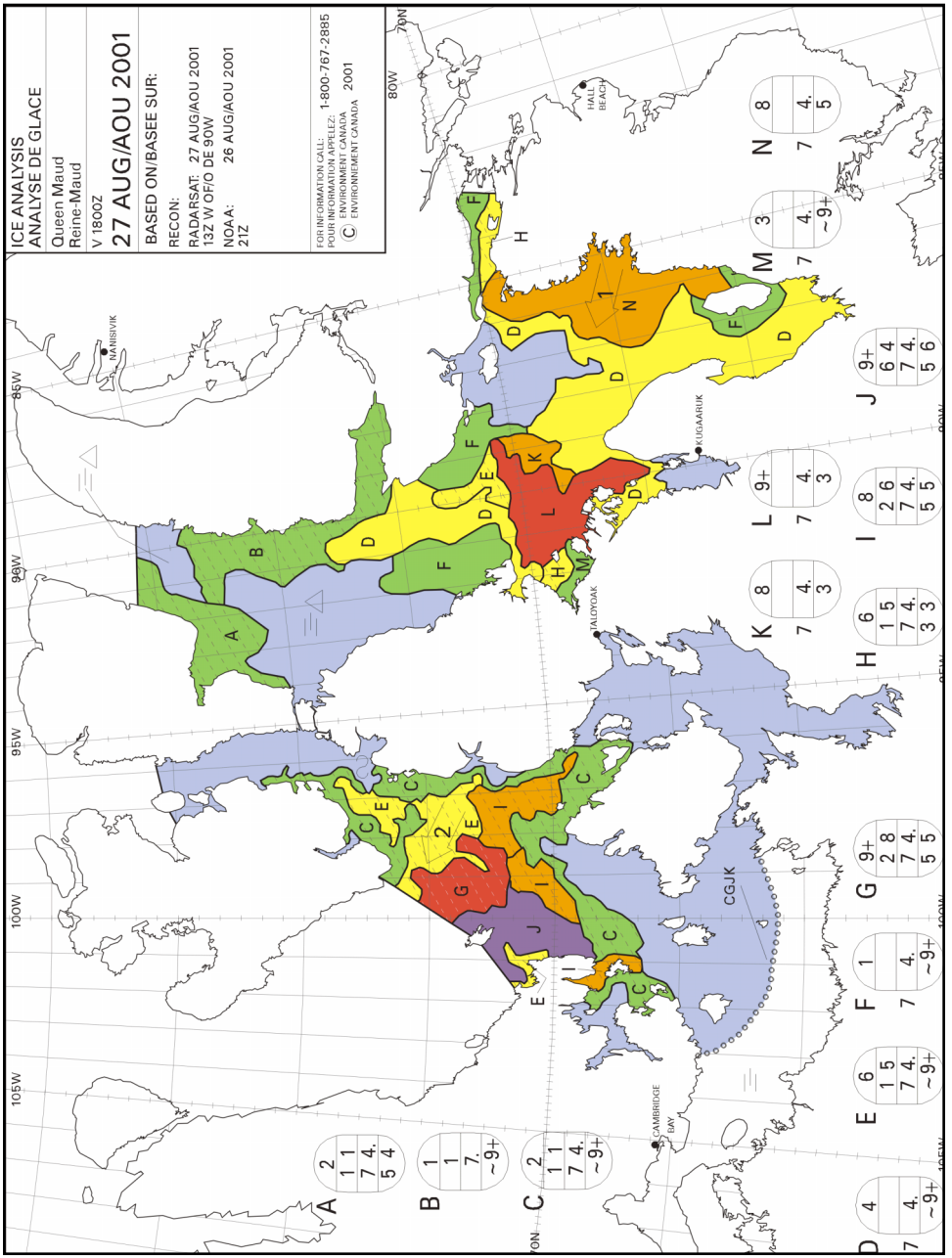
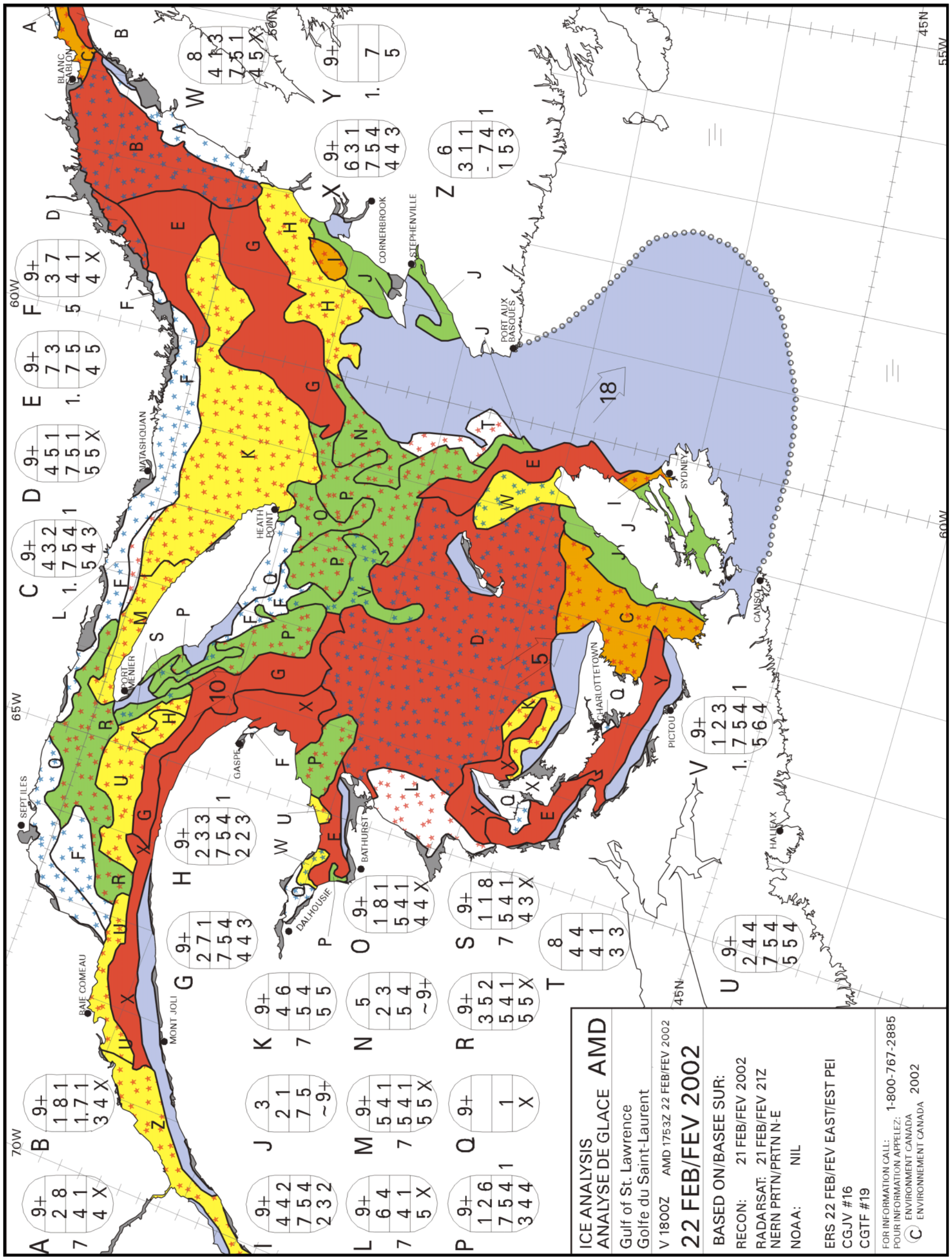


Figure 5.10: Example of Corrected/Amended Chart



5.2 Regional Ice Charts

5.2.1 Description

Regional ice analysis charts are considered to represent ice conditions on a specific date. They are prepared weekly, bimonthly or monthly, depending on the season and the region. They provide information on ice conditions for planning marine activities up to several weeks ahead.

Regional ice charts are produced for:

- ❑ the Canadian Arctic (Eastern, Western and Hudson Bay),
- ❑ the Great Lakes, and
- ❑ the East Coast of Canada.

Regional ice charts are the main climatological product issued by CIS, and are part of the national archives. Data from the charts is also used by the Canadian Meteorological Centre (CMC) in its meteorological models.

5.2.2 Method of production

These charts are meant to show generalized ice conditions; they incorporate all available data, usually within three days of the valid date. The main data sources are RADARSAT and NOAA satellite imagery. The daily ice analysis chart will be referenced; however, using all the detail would make the chart too cluttered, so small areas may be merged.

Defining Polygons

Mandatory boundaries are drawn:

- ❑ **Concentration:**
  - where the total concentration varies from the following categories:
    - open water or bergy water
    - 1 to 3 tenths
    - 4 to 6 tenths
    - 7 to 8 tenths
    - 9 to 9+ tenths
    - 10/10 or consolidated

- **Stage of Development:**
  - where the stage of development of the predominant ice type varies from new ice, grey ice, grey-white ice, first-year ice, and old ice (see Table 5.1):
    - when two ice types have the same concentration, the oldest/thickest is considered predominant;
    - when three or more types have same concentration, the second oldest is considered predominant;
  - where the concentration of old ice varies from the following categories:
    - no old ice
    - trace of old ice
    - 1 to 3 tenths
    - 4 to 6 tenths
    - 7 to 8 tenths
    - 9 to 9+ tenths
    - 10/10 or consolidated
- **Form of ice:**
  - between predominant floe size 3 or smaller and size 4 or greater, where there are 6 tenths or more of first-year ice or thicker.

Discretionary boundaries may be used for:

- **Concentration:**
  - If there is any first-year ice or thicker in an area of 7 tenths or more total concentration (ignoring new ice), may separate areas of first-year ice or thicker that vary by 3 tenths or more.

❑ **Stage of Development:**

- Second-year 8• and multi-year 9• will be used from October 1 to December 31; however, these ice types may be carried throughout the winter when established, especially for consolidated ice in the high Arctic.
- Brash may be used.
- S_d is generally not used except:
  - during freeze-up when a trace of new ice is present;
  - when remaining ice type concentration is 1/10 or more.
- S_o used only when the trace of ice is significant (usually first-year or thicker).
- Only small areas of fast ice should be shaded. As the ice area grows, the shading should be replace with an egg to show ice thickness and stage of development.
- New ice of various concentrations may be grouped together.

❑ **Form of ice:**

- Normally each ice type will have only one predominate floe size; however, more than one floe size may be used if the ice is significant (first-year ice or thicker). For example, a few giant floes in a field of medium floes.
- When significant ice types are present within fast ice it is important to maintain their floe sizes, report floe size for the significant ice (usually old ice) and younger forms of ice as code 8.
- When overall concentration of ice in a polygon is 1 to 6 tenths and ice is not evenly distributed, the strip symbol may be used in the form of ice area.

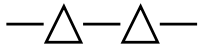
5.2.3 Dissemination of Charts

Regional ice charts are disseminated electronically via a product delivery system. Clients can receive charts via e-mail or though the Internet.

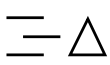
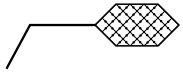
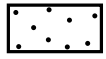
5.2.4 Symbols Used on Regional Ice Charts

Symbols for Defining Limits

Analysed edge or boundary 

Bergy water boundary 

Other Symbols Used

Bergy water		Symbol used to indicate bergy water conditions.
Ice-free		Symbol used to indicate ice-free conditions.
Ice island or Ice island fragment		Symbol used to indicate ice island or fragments.
Open water		Stipple pattern used to indicate open water areas.
Fast ice		Black or grey area representing fast ice.

Note: Strips and patches (∞) will not be used.

Figure 5.11: Eastern Arctic Regional Chart

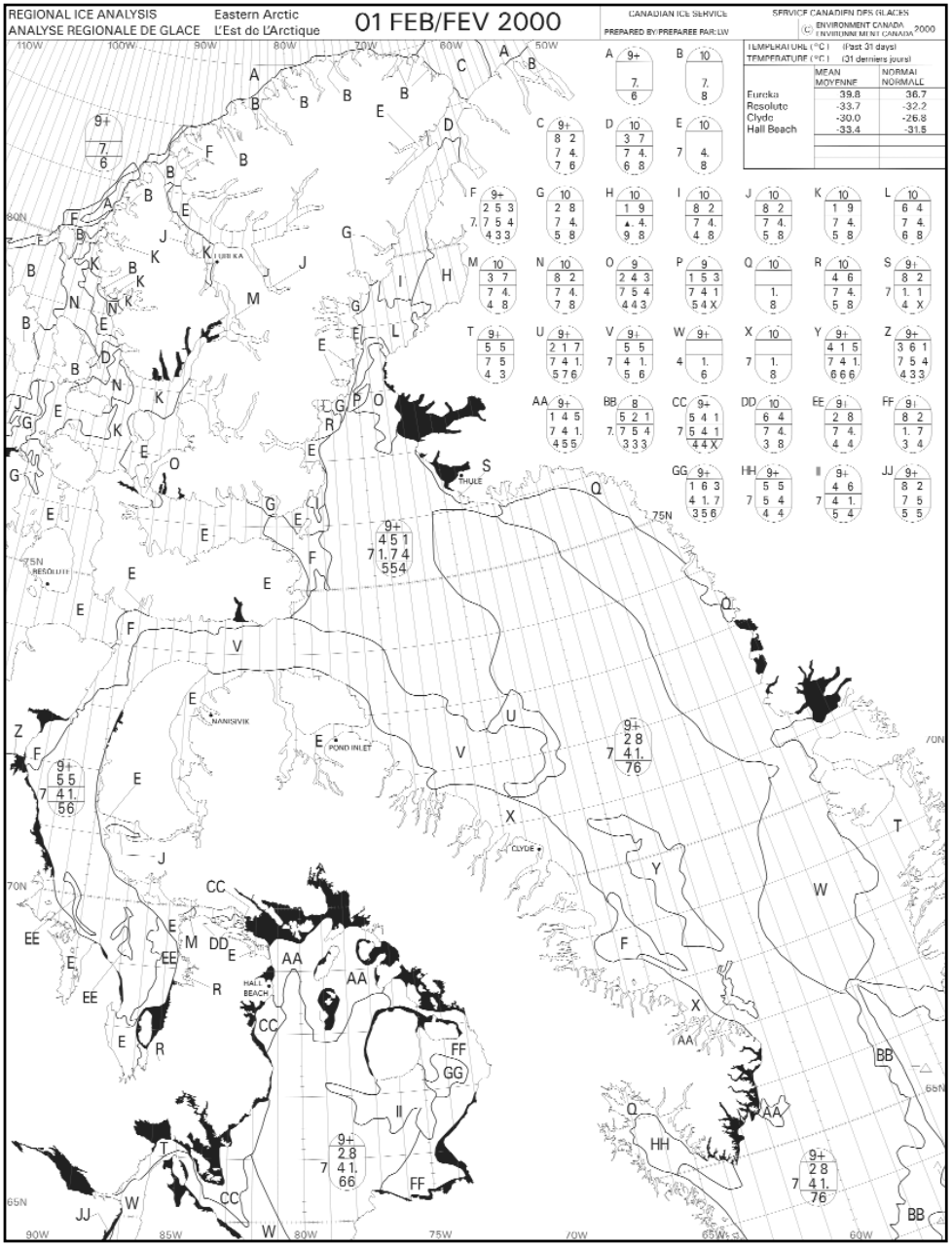
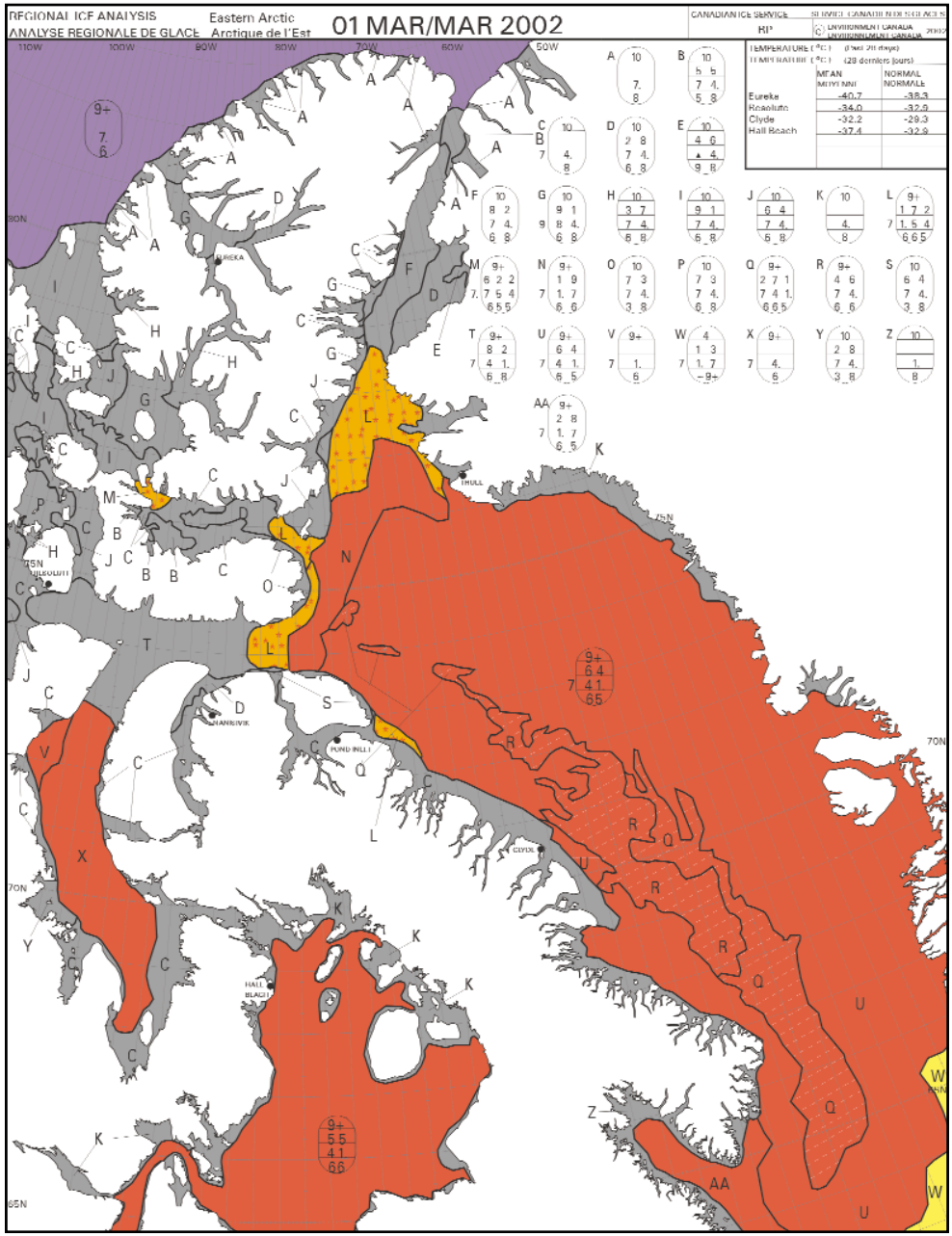


Figure 5.12: **Eastern Arctic Regional Chart with Q/A colour code**



5.3 Image Analysis Charts

5.3.1 Description

Image analysis charts are tailored sea-ice chart products that provide a visual interpretation of the ice conditions from synthetic aperture radar (SAR) imagery and, to a lesser extent, AVHRR images. The radar imagery may come from a variety of platforms such as on the ERS, RADARSAT or ENVISAT satellites or from an aircraft SAR. The Canadian Ice Service (CIS) receives approximately 3,600 RADARSAT images and 12,000 NOAA AVHRR images a year. Operationally significant images are analyzed and the image analysis chart is issued in near-real time (within 4 hours) of data reception at CIS. The international standard for coding ice information, the egg code, is used with some minor modifications. The modifications will be dealt with in the method of production section below, a complete description of the egg code can be found in Chapter 3.

This product is primarily intended for the Canadian Coast Guard ice offices and icebreakers to assist them with decision making on ship routings and escorts. The product is used as well by Ice Forecasters to supplement the daily ice analysis and regional analysis charts. Grid-point ice data from the analysis is provided to the Canadian Meteorological Centre weather models, and to ice models at the Canadian Ice Service (CIS) and the Maurice Lamontagne Institute.

The accuracy of an analysis is affected by the spatial resolution of the source data and the processing quality. Here are a few examples:

- ERS2 – pixel resolution is 25 m;
- RADARSAT ScanSAR Wide – pixel resolution is 100 m;
- ScanSAR Narrow – pixel resolution is 50 m;
- NOAA resolution is approximately 1 km at nadir.

In addition to being able to resolve different ice features, the absolute positional accuracy of the data (geo-coding) will be affected by the accuracy of the satellite orbit information. The Canadian Space Agency estimates that the geometric accuracy of a feature such as an ice edge will be within 630 m for 100 m resolution imagery.

5.3.2 Method of Production

This chart is a visual interpretation of the SAR imagery by an experienced analyst using a digital image display and vector-drawing tools. The analysis of the ice regime seen on the SAR image is actually a composite of ice signature recognition and support data. Support data sources include the prevailing environmental conditions, ice climatology and coincident ice reconnaissance charts from ships, aircraft or helicopters. SAR analysis charts are tailored to meet the user's requirements. The scale of the chart is not fixed. It will be tailored to the client's geographic area of interest, constrained by the footprint and resolution of the sensor and the need to ensure that the information presented using the egg code is clear, and readable and is issued in a timely fashion. Image analysis charts are issued and archived in digital format, in near-real time, usually within 4 hours of data reception at CIS.

Defining Polygons

Analysts extract ice concentration, ice type and ice topography from the images, based on tone, texture and spatial context of the ice features (resolution). The extraction of accurate information requires an understanding of ice forms and remote-sensing signatures, as well as access to the meteorological conditions and historic patterns of ice in a specific region. Accuracy may be diminished by poorly processed imagery, artefacts within the imagery or by the effects of moisture on/in the ice.

Areas of different ice conditions are described using elements of the egg code as shown in Figure 5.12, on a variable scaled chart. Principally, this code describes the ice in terms of:

- $\mathbf{C_t}$ the total ice concentration expressed to the nearest tenth
- $\mathbf{C_a}$, $\mathbf{C_b}$, $\mathbf{C_c}$ the partial concentrations of up to four main ice types present, to the nearest tenth plus a trace amount. $\mathbf{C_d}$ is not used but its value is apparent from the total concentration values.
- $\mathbf{S_o}$, $\mathbf{S_a}$, $\mathbf{S_b}$, $\mathbf{S_c}$, $\mathbf{S_d}$ the stage of development of sea ice and lake ice. See Table 3.1 and 3.2

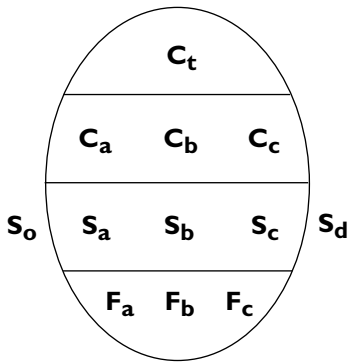
  Note: $\mathbf{S_e}$ is not used. **X** may be coded when ice type is undeterminable.

- **F_a, F_b, F_c** the form of the three main ice types present (pancake, brash, small, medium, big, vast, giant floes, strips and patches, or **X**-indeterminable) depending on the image resolution. See Table 3.3.

  Note: F_d and **F_e** are not used.

- **Brash ice** is not coded using the observed VKMT standard. Brash is coded only when there are coincident visual reports to support the signature analysis. If brash is present it will always be **C_a**. If present **S_a** will always be a dash (-) and **F_a**=1.

Figure 5.13: The Egg Code



Mandatory Boundaries (solid lines) are drawn when:

- **Concentration:**
  - where the total concentration varies from the following categories:
    - open water or bergy water
    - 1 to 3 tenths
    - 4 to 6 tenths
    - 7 to 8 tenths
    - 9 to 9+ tenths
    - 10/10 or consolidated

- **Stage of development:**
  - the stage of development of the predominant type of ice present changes in any way;
  - when old ice is predominant (4 tenths or more) mandatory boundaries are required between 6/10 and 7/10ths and between 8/10ths and 9/10ths of old ice.
- **Form of ice:**
  - the form of the predominant type of ice present changes in any way

Discretionary Boundary lines are drawn for any changes within the egg code which could impact on tactical ice operations. For example an area of heavily ridged ice may be separated from level ice.

Estimated Ice Edge Boundaries are used when the analyst may be in doubt about the positional accuracy of the edge because of poor image quality or signature ambiguity. See symbology below.

5.3.3 Dissemination

The image analysis chart product is available for distribution in near-real time or from the archive in raster or grid point format. Delivery methods include the Internet at the CIS Web site and by subscription service via ftp, email or fax.

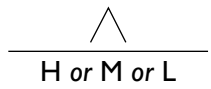
5.3.4 Symbols Used

Topographical Features

The resolution and imaging mode of the sensor directly affects the analysts ability to detect surface features. Not all topographical features are analyzed. Below is an accounting of the topographical symbology presently in use.

Relative Roughness

Light	up to 1/10	L
Medium	2/10 - 3/10	M
Heavy	4/10 - 10/10	H

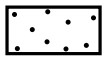


In operational areas, relative roughness will be indicated when there are coincident visual reports to support the signature analysis.

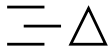
Symbols In Use On Image Analysis Charts

Fast ice

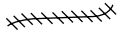
Open water
(less than 1/10 sea ice, no ice of land origin)



Bergy water
(less than 1/10 sea ice may be present and total ice concentration is less than 1/10)



Crack
(symbol indicating presence of crack at a specific location)



Strips

Ice island

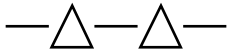
Ice-free (no ice present)

Symbols for Defining Limits

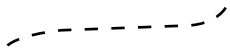
Limit of radar observation

Limit of undercast for AVHRR

Limit of bergy water



Estimated ice edge



Ice edge boundary

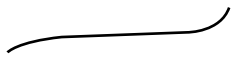


Figure 5.14: **RADARSAT Image Analysis Chart**

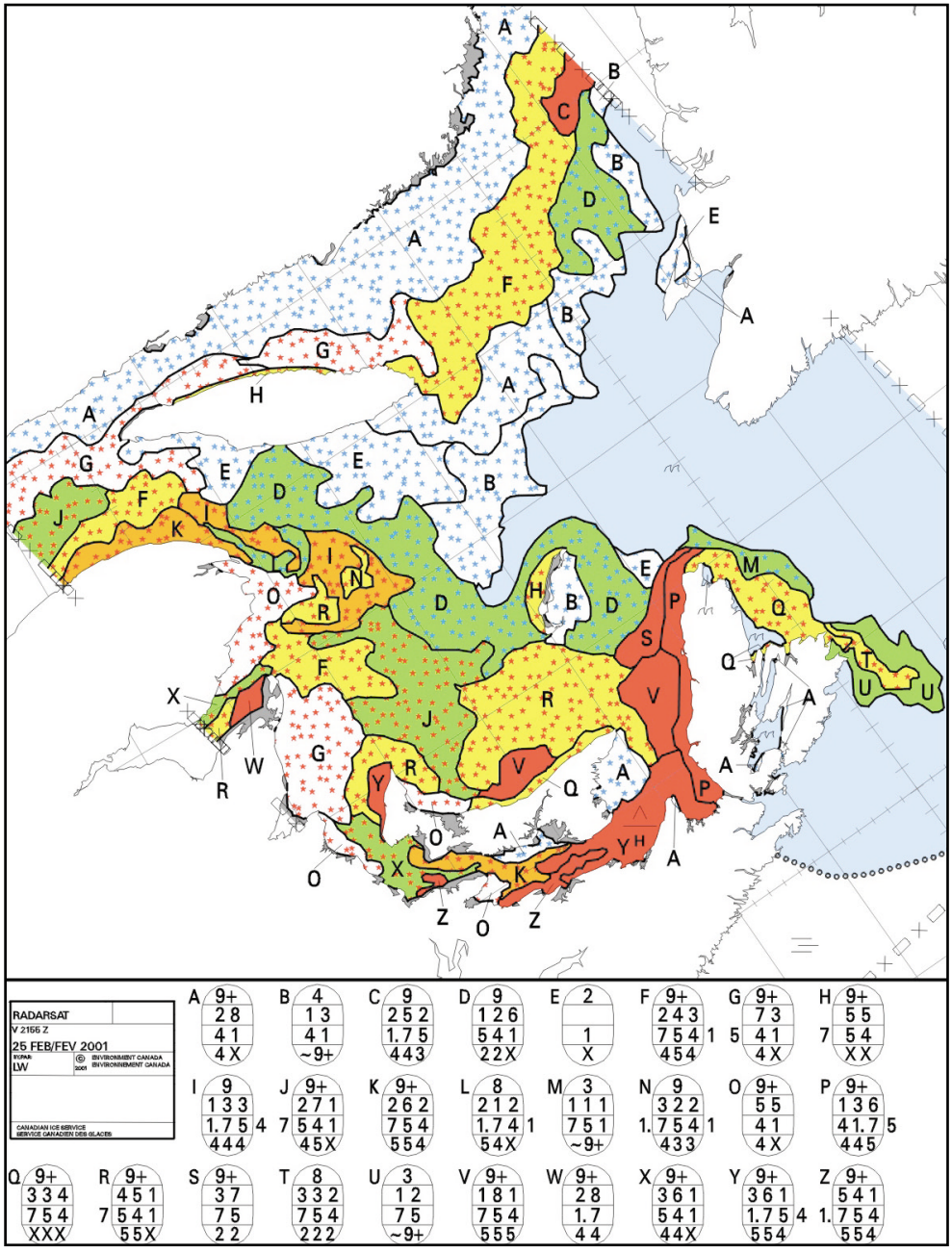


Figure 5.15: **RADARSAT Image**

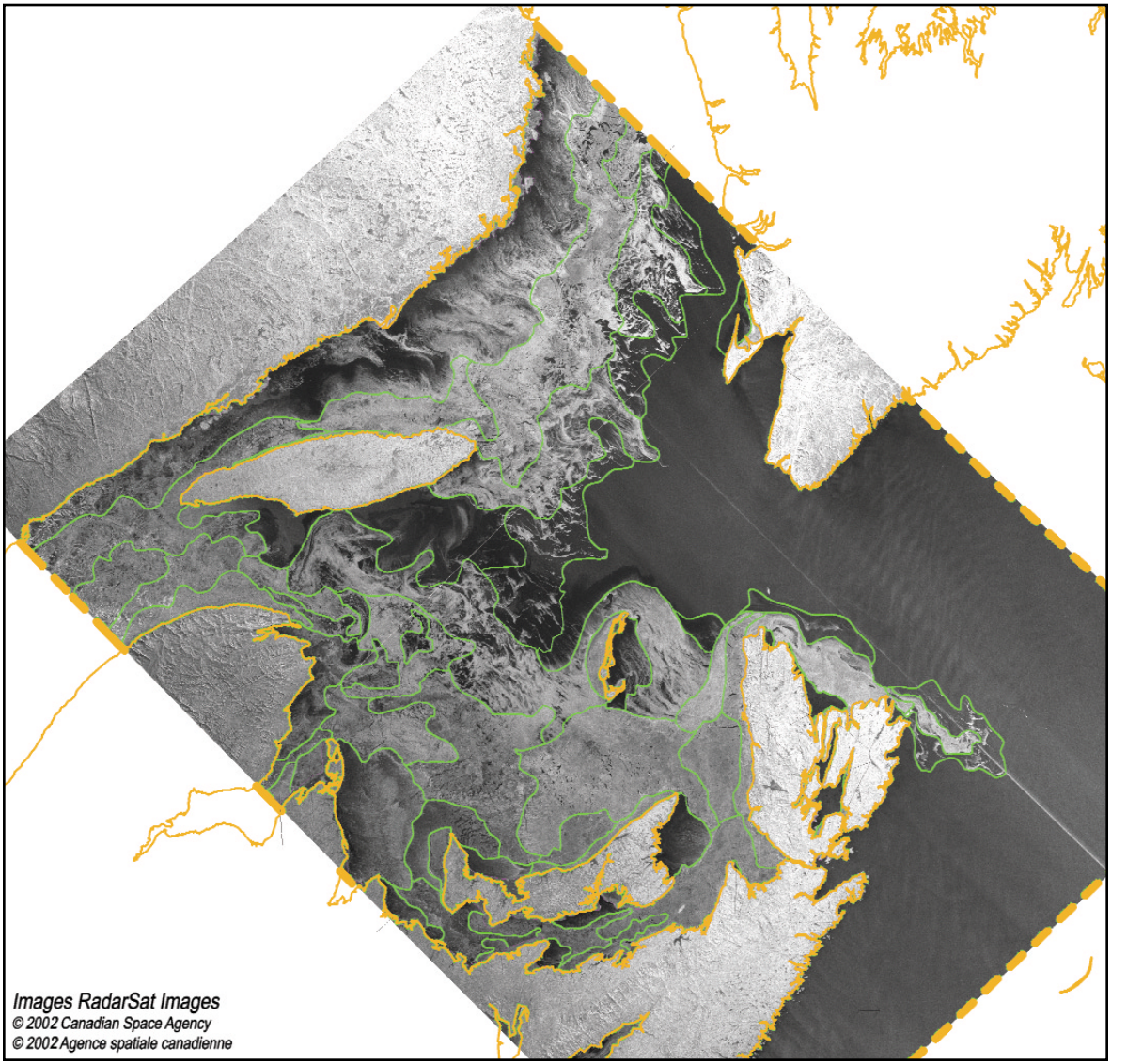
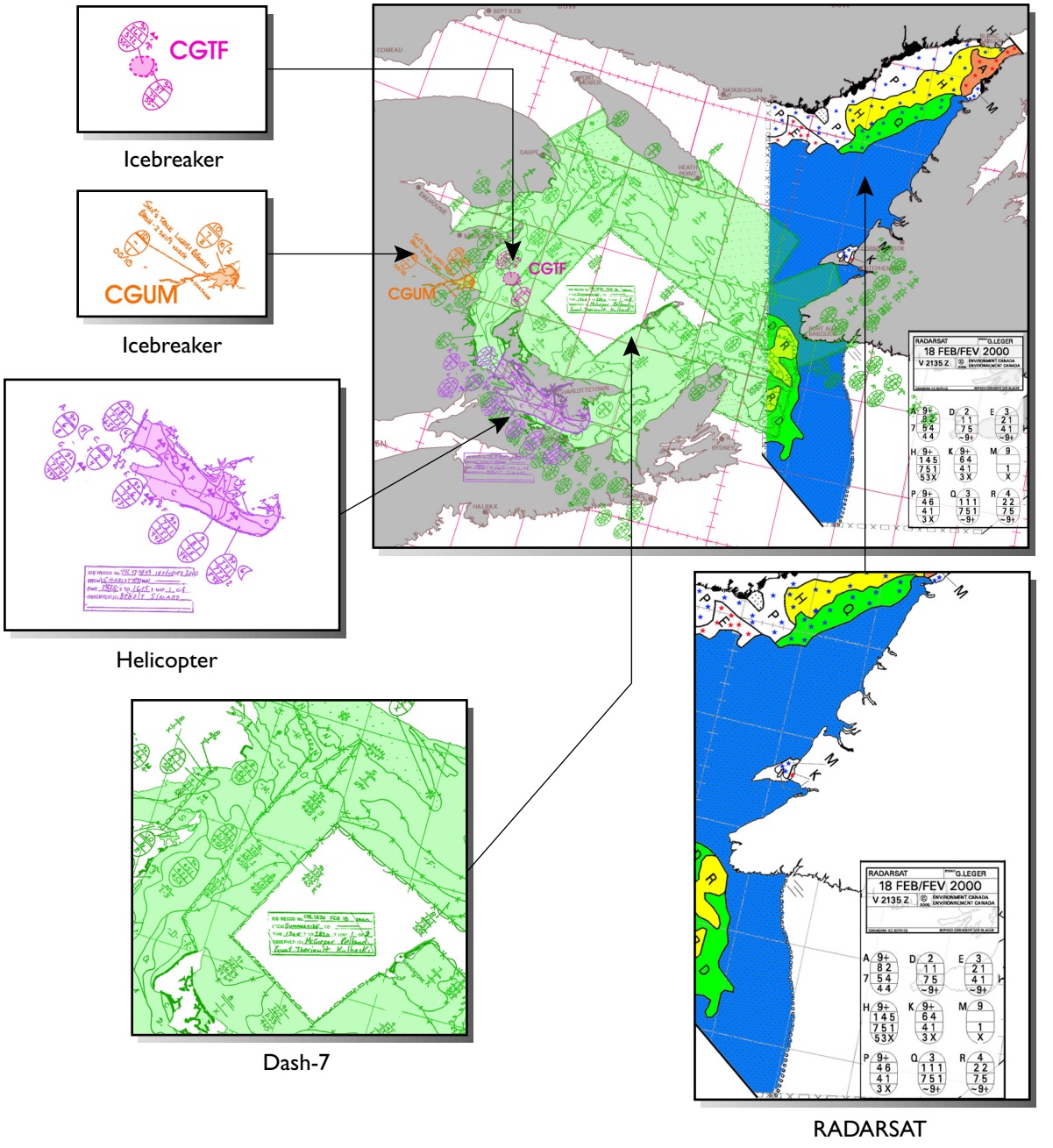


Figure 5.16: DATA SOURCES

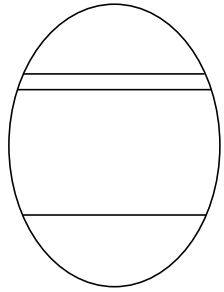


5.4 Examples of the Use of the Egg Code

Various Ice Type and Concentration Combinations

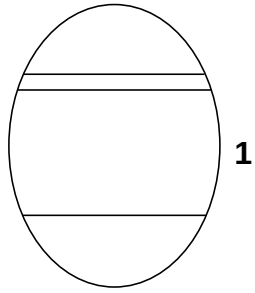
Example 1

6/10 of new ice with no form. Note that there is no partial concentration when only one ice type is represented in the egg.



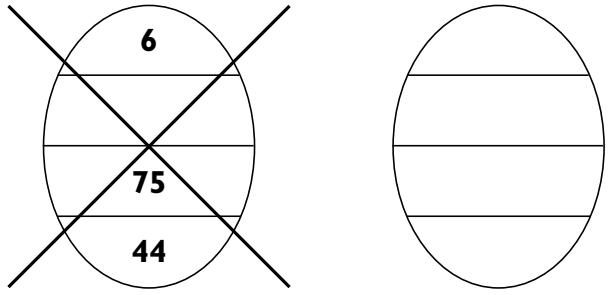
Example 2

4/10 of old ice in medium floes. New ice is also present with a concentration of less than 1/10.



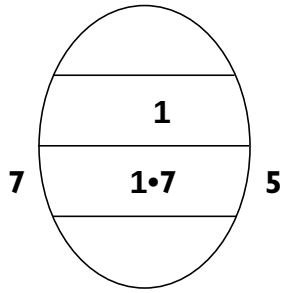
Example 3

6/10 total ice concentration. 2/10 thin first-year ice and 4/10 grey-white ice in medium floes. If more than one ice type is present, the partial concentration of each ice type must be indicated.



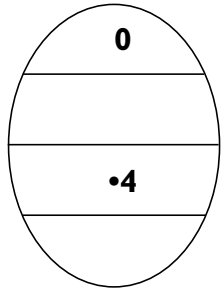
Example 4

7/10 total ice concentration. 3/10 thick first-year ice, 2/10 medium first-year ice and 1/10 thin first-year ice. All in small floes. Old ice with a concentration of less than 1/10 and 1/10 grey-white ice are also present.



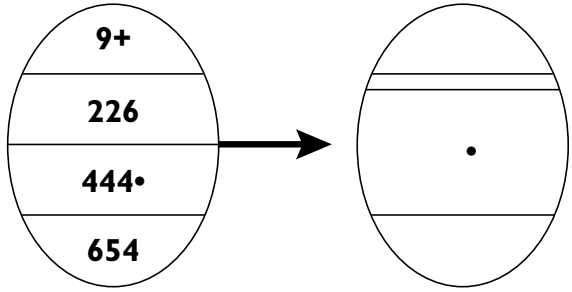
Example 5

Fast grey ice with 3/10 multi-year ice in small floes embedded.



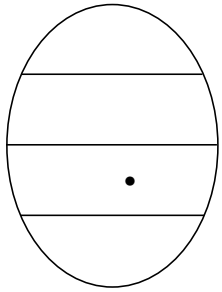
Example 6

9+/10 total ice concentration. 2/10 thick first-year ice of vast floes, 2/10 thick first-year ice in big floes and 6/10 thick first-year ice of medium floes. Since 6/10 of the thick first-year ice has medium size floes, it represents the predominate floe size and will be indicated as such in the egg on the CIS chart.



Example 7

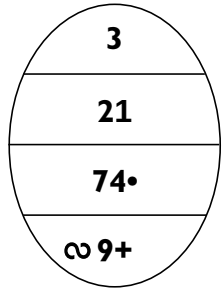
9+/10 total ice concentration. 3/10 old ice of giant floes and 7/10 old ice of medium floes.



Strips and Patches

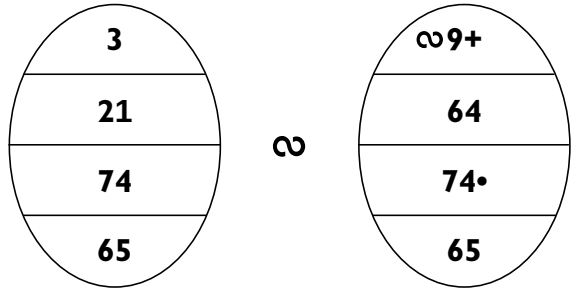
Example 8

3/10 total ice concentration. 2/10 old ice and 1/10 thick first-year ice. All ice is concentrated in strips and patches of 9+/10. Floe sizes are code 3 or less .



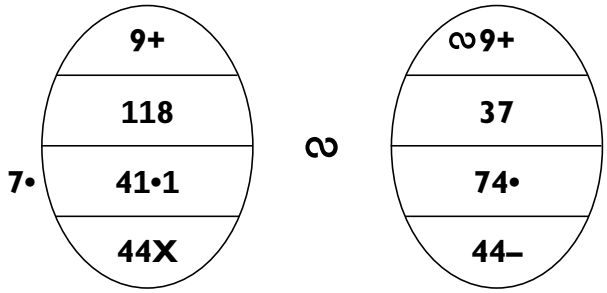
Example 9

3/10 total ice concentration in strips and patches of 9+/10. 6/10 old ice in vast floes and 4/10 thick first-year ice in big floes. These floe sizes are significant and warrant the use of two ovals.



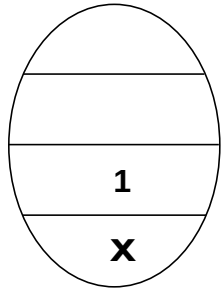
Example 10

9+/10 total ice concentration comprised of 1/10 thick first-year ice, 1/10 medium first-year ice, 8/10 new ice and old ice with a concentration of less than 1/10. The old and thick first-year ice are distributed throughout the area in strips and patches made up of 3/10 old and 7/10 thick first-year ice. All ice types in the second oval must be included in the first oval.



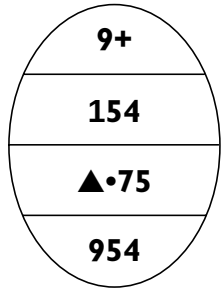
Example 11

6/10 total ice concentration. 4/10 brash and 2/10 new ice with no form.

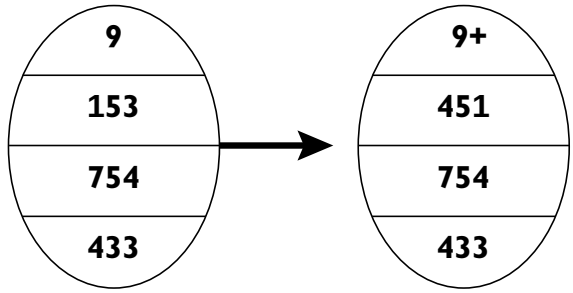


Example 12

9+/10 total ice concentration. 1/10 of ice of land origin (▲•) with floe size of 9 (icebergs). 5/10 thin first-year ice in big floes and 4/10 grey-white ice in medium floes.



Example 13



Example 14