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http://dx.doi.org/10.4224/12340960

CHC CANADIAN HYDRAULICS CENTRE
CENTRE D'HYDRAULIQUE CANADIEN

TP 14097 E

Data Collection Program on Ice Regimes Onboard the CCG Icebreakers - 2003

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Technical Report
CHC-TR-021

March 2004

ABSTRACT

A field program was designed and carried out onboard six Canadian Coast Guard icebreakers during the summer of 2003. Information was collected on the ice conditions (ice regimes) and the stage of melting (decay) of the ice. In total, 57 ice regimes were documented and photographed. Based on this information, the severity of the ice regimes were evaluated in terms of the Canadian Arctic Ice Regime Shipping System. This report provides a description of the data collection program and an overview of the results.

RÉSUMÉ

Un programme de collecte de données sur le terrain à bord de six brise-glaces de la Garde côtière canadienne a été conçu et exécuté pendant l'été de 2003. On a recueilli de l'information sur l'état des glaces (régimes de glaces) et le stade de fonte (décroissance). Au total, 57 régimes de glaces ont été documentés et photographiés. D'après l'information recueillie, la rigueur des régimes de glaces a été évaluée en terme du Système des régimes de glaces pour la navigation dans l'Arctique. Ce rapport présente une description du programme de collecte de données et une vue d'ensemble des résultats.

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1.0 INTRODUCTION

The Arctic Shipping Pollution Prevention Regulations (ASPPR) regulates navigation in Canadian waters north of 60°N latitude. These regulations include the date Table in Schedule VIII and the Shipping Safety Control Zones Order, made under the Arctic Waters Pollution Prevention Act. Both of these are combined to form the “Zone/Date System” matrix that gives entry and exit dates for various ship types and classes. It is a rigid system with little room for exceptions. It is based on the premise that nature consistently follows a regular pattern year after year.

Transport Canada, in consultation with stakeholders, has made extensive revisions to the Arctic Shipping Pollution Prevention Regulations (ASPPR 1989; AIRSS 1996). The changes are designed to reduce the risk of structural damage in ships which could lead to the release of pollution into the environment, yet provide the necessary flexibility to shipowners by making use of actual ice conditions, as seen by the Master. In this new system, an "Ice Regime", which is a region of generally consistent ice conditions, is defined at the time the vessel enters that specific geographic region, or it is defined in advance for planning and design purposes. The Arctic Ice Regime Shipping System (AIRSS) is based on a simple arithmetic calculation that produces an “Ice Numeral” that combines the ice regime and the vessel’s ability to navigate safely in that region. The Ice Numeral (IN) is based on the quantity of hazardous ice with respect to the ASPPR classification of the vessel (see Table 1). The Ice Numeral is calculated from

$$IN = [C_a \ x \ IM_a] \quad + \quad [C_b \ x \ IM_b] \quad + ... \qquad \textbf{(1)}$$

where
IN = Ice Numeral
C_a = Concentration in tenths of ice type “a”
IM_a = Ice Multiplier for ice type “a” (from Table 1)

The term on the right hand side of the equation (a, b, c, etc.) is repeated for as many ice types as may be present, including open water. The values of the Ice Multipliers are adjusted to take into account the decay or ridging of the ice by adding or subtracting a correction of 1 to the multiplier, respectively (see Table 1). The Ice Numeral is therefore unique to the particular ice regime and ship operating within its boundaries. At the present time, there is only partial application of the ice regime system, exclusively outside of the “zone-date” system.

Table 1: Table of Ice Multipliers

Ice Types		Vessel Class						
		Type					CAC	
		E	D	C	B	A	4	3
Old / Multi-Year Ice	MY	-4	-4	-4	-4	-4	-3	-1
Second-Year Ice	SY	-4	-4	-4	-4	-3	-2	1
Thick First-Year Ice	TFY	-3	-3	-3	-2	-1	1	2
Medium First-Year Ice	MFY	-2	-2	-2	-1	1	2	2
Thin First-Year Ice - 2nd Stage	FY	-1	-1	-1	1	2	2	2
Thin First-Year Ice - 1st Stage	FY	-1	-1	1	1	2	2	2
Grey-White Ice	GW	-1	1	1	1	2	2	2
Grey Ice	G	1	2	2	2	2	2	2
Nilas, Ice Rind	N	2	2	2	2	2	2	2
New Ice	N	2	2	2	2	2	2	2
Brash		2	2	2	2	2	2	2
Open Water	OW	2	2	2	2	2	2	2

Ice Decay : If MY, SY, TFY or MFY ice has Thaw Holes or is Rotten, add 1 to the IM for that ice type
Ice Roughness : If the total ice concentration is 6/10s or greater and more than one-third of an ice type is deformed, subtract 1 from the IM for the deformed ice type.

The ASPPR deals with vessels that are designed to operate in severe ice conditions for transit and icebreaking (CAC class) as well as vessels designed to operate in more moderate first-year ice conditions (Type vessels). The System determines whether a given vessel should proceed through that particular ice regime. If the Ice Numeral is negative, the ship is not allowed to proceed. However, if the Ice Numeral is zero or positive, the ship is allowed to proceed into the ice regime. Responsibility to plan the route, identify the ice, and carry out this numeric calculation rests with the Ice Navigator who could be the Master or Officer of the Watch. Due care and attention of the mariner, including avoidance of hazards, is vital to the successful application of the Ice Regime System. Authority by the Regulator (Pollution Prevention Officer) to direct ships in danger, or during an emergency, remains unchanged.

Credibility of the new system has wide implications, not only for ship safety and pollution prevention, but also in lowering ship insurance rates and predicting ship performance. Therefore, the Canadian Hydraulics Centre (CHC) of the National Research Council of Canada in Ottawa has worked with Transport Canada to assist them in developing a methodology for establishing a scientific basis for AIRSS (see e.g. Timco and Kubat 2002; Timco et al. 2004). As part of this work, the CHC worked with the Canadian Ice Service (CIS) and the Canadian Coast Guard (CCG) to collect information onboard the CCG Icebreakers during the summer of 2003. This was a continuation of the data collection program that was started in the summer of 2002 (Timco et al., 2003a, 2003b).

The objectives of the work were:

1. Collect detailed information on the range of ice regimes encountered in the Canadian Arctic;
2. Obtain an evaluation of the potential damage severity of the ice regimes from the Commanding Officer or Officer of the Watch;

3. Obtain field data to evaluate the decay bonus that is part of the Regulatory Standards for the Ice Regime System;
4. Assist the CCG in understanding and using the Ice Regime System.

This data collection program was carried out on-board the six icebreakers that were in the Arctic in the summer of 2003. This was arranged through Gary Sidock and Jean Ouellet at the CCG Central and Arctic Region Offices in Sarnia. The icebreakers that were involved with this data collection program were:

- LOUIS S. ST- LAURENT
- TERRY FOX
- HENRY LARSEN
- DES GROSEILLIERS
- PIERRE RADISSON
- SIR WILFRID LAURIER

Field Books were developed and given to the Ice Service Specialists (ISS) of the Canadian Ice Service. The ISS personnel were onboard six Canadian Coast Guard Icebreakers throughout the summer navigation season in the Canadian Arctic. They used these Field Books and digital cameras to collect information on the ice regimes and the surface appearance of the ice. The information on the ice regimes was used in conjunction with input from the Commanding Officers of the icebreakers to assess the likelihood of damage to the vessels while in different ice conditions. In addition, the results from this program were used to validate a prototype product developed by the CIS to provide quantitative and qualitative information on the strength of first-year level ice in the Arctic (Gauthier et al., 2002; Langlois et al, 2003). This report discusses the procedure and results of this data collection program. Further, it compares the results of the 2003 field data to that collected during 2002 on the CCG icebreakers.

2.0 FIELD BOOKS

Field books were developed to allow the collection of key information in a systematic format. Figure 1 shows a page from the Field Book for the CCGS Louis S. St-Laurent.

The books were subdivided as follows:
General Information – This section was used to collect general information on the observation including: Observation Number, Date, Time, Latitude, Longitude, Geographic Location, Vessel Speed, Visibility, Ice Roughness, Floe Size.
Digital Photographs – The ISS were supplied with digital cameras and asked to photograph the observed ice regimes.
Stage of Melt – The surface conditions were noted according to the following format: No Snow Melt, Snow Melt, Ponding, Drainage, or Rotten/Decayed.
Ice Regime – Information on the ice regime was collected by noting the concentration of each Ice Type based on the World Meteorological Organization (WMO) definitions. The ISS were asked to define the ice regime as "the ice that the vessel will likely encounter".
Ice Numeral – The Ice Numeral was calculated based on the observed ice conditions and the Ice Multipliers that were supplied in the Field Books.
Comments from the Officer of the Watch – A number of questions were asked of the Officer of the Watch to correlate the ice conditions to the potential for damage by the ice to the ship. These questions were as follows[1]:

1. How would you rank the severity (damage potential) of this ice regime for your icebreaker?

   - high potential to damage the (icebreaker name)
   - potential to damage the (icebreaker name)
   - not likely to damage the (icebreaker name)
   - highly unlikely to damage the (icebreaker name)

2. Do you think that the Ice Numeral reflects the degree of severity of the ice conditions?

   Yes No If no, why does it not reflect the severity of the ice regime?

3. Did you alter your mode of operation with this ice regime?

   Yes No If Yes, how was it changed?

General Comments – Space was left for any comments from either the ISS personnel or Officer of the Watch.

[1] The changes from the 2002 field books are highlighted in blue. The changes were made since there was some confusion regarding the evaluation in 2002. In some cases, the evaluation was made for a vessel under escort, and not for the icebreaker. Therefore, this was clarified to emphasize that the evaluation was to be made on the CCG vessel's potential to be damaged by the ice regime.

These Field Books were deployed on six Canadian Coast Guard icebreakers. It should be noted that the CCG vessels are not assigned a Vessel Class. Therefore, it was necessary to assign to them a nominal Vessel Class in order to calculate the Ice Numeral. The Vessel Classes that were used were suggested by Andrew Kendrick of BMT Fleet Technology Ltd. based upon preliminary analysis of the vessels. *It is important to understand that the Vessel Class used here is not necessarily the Vessel Class that would be assigned by Transport Canada for these types of vessels.* This assignment would require a more thorough analysis. It should be noted that in 2002, the Sir Wilfrid Laurier was classified as a Type A vessel. However, there were a number of highly negative Ice Numerals for it with no damage. For the 2003 season, the Laurier was assigned Ice Multipliers appropriate for a CAC4 vessel.

General information pertaining to the vessels, their Commanding Officers and the ISS personnel onboard for this study is given in Table 2. There were a total of 57 ice regimes identified for this project and 93 photographs taken of the ice regimes. This is substantially lower than the 201 ice regimes recorded last year. In 2003, there were a number of field books returned with only open water entries. In general, it was reported that the ice conditions were much lighter in 2003 than in 2002.

Table 2: Information on the CCG Vessels for 2003

Vessel Name	Data Collection		Commanding Officers	Ice Service Specialists	Number of Observations	Number of Photographs	Assigned Vessel Class
	Start	End					
LOUIS S. ST-LAURENT	22-Jul-03	27-Sep-03	M. Marsden S. Klebert ??	S. Leger S. Payment ??	6	3	CAC3
TERRY FOX	10-Jul-03	25-Aug-03	G. Barry M. Champagne	?? R. Morrow	11	29	CAC3
HENRY LARSEN	7-Jul-03	4-Sep-03	J. Broderick J. Vanthiel	C. Stock L. Theriault	8	16	CAC3
DES GROSEILLIERS	2-Jul-03	11-Jul-03	R. Dubois	E. Vaillant	3	8	CAC4
PIERRE RADISSON							
SIR WILFRID LAURIER	20-Jul-03	4-Oct-03	N. Thomas M. Taylor N. Thomas	R. Hilchie C. Daigle B. Simard	29	37	CAC4

General Information	
Observation #	Location:
Date:	Vessel Speed (knots):
Time:	Visibility (n.mi):
Latitude:	Ice Roughness (please circle): Low Medium High
Longitude:	Floe Size (m):
Digital Photo File Name:	

Stage of Melt (please circle)				
Snow Cover	Snow melt	Ponding	Drainage	Rotten

use Decay Ice Multiplier if the Stage of Melt is Drainage or Rotten

Ice Regime

Ice Type	Concentration		Ice Multiplier (IM)				Ice Type Contribution
			(please circle)				
	C		Normal	Decay*	Ridged**		C x IM
MY		x	-1	0	-2	=	
SY		x	1	2	0	=	
TFY		x	2	3	1	=	
MFY		x	2	3	1	=	
FY		x	2	2	1	=	
GW		x	2	2	1	=	
G		x	2	2	1	=	
N		x	2	2	1	=	
OW		x	2	2	2	=	
Sum =			Ice Numeral =				

*use Decay Ice Multiplier if the **Stage of Melt** is Drainage or Rotten
use Ridged Ice Multiplier if **Ice Type is more than 30% ridged

Comments from the Officer of the Watch

How would you rank the severity (damage potential) of this ice regime for your icebreaker?

- ☐ high potential to damage the Louis S. St-Laurent
- ☐ potential to damage the Louis S. St-Laurent
- ☐ not likely to damage the Louis S. St-Laurent
- ☐ highly unlikely to damage the Louis S. St-Laurent

Does the Ice Numeral reflect the degree of severity of the ice conditions? ☐Yes ☐No

If no, why does it not reflect the severity of the ice regime?

Did you alter your mode of operation with this ice regime?

☐Yes ☐No

If yes, how was it changed?

General Comments and Work Area

CO ____________ OOW ____________ ISS ____________

Figure 1: Page from the Field Book for the CCGS Louis S. St-Laurent

The vessels sailed in different parts of the Canadian Arctic. Figure 2 shows the vicinity in which data were collected by each of the six vessels.

In the following sections, the results for each vessel are described. For this data, the Ice Numeral was calculated using the decay bonus as described in the AIRSS Regulatory Standards. For this, a bonus of +1 was applied to the Ice Multipliers for Multi-year ice, Second-year ice, Thick First-year ice and Medium First-year ice if the ice had thaw holes (i.e. drainage) or if the ice was rotten/decayed.

2.1 Data Analysis

After the field program, the data books were collected by the CIS and sent to the CHC. Since there was a considerable amount of data to analyze, the CHC developed a database to organize the data. When a Field Book was received at the CHC, the data contained in the books were extracted and entered into the database.

In the analysis, the data were analyzed independently for each vessel. The following information was investigated:

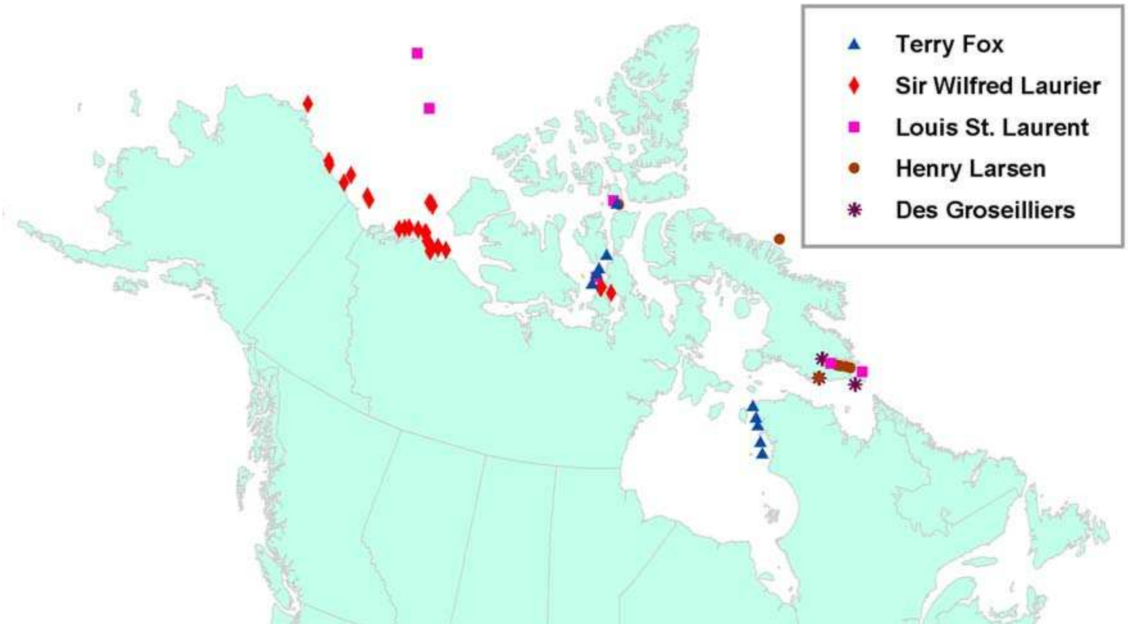

Figure 2: Location of the data collection for each of the icebreakers in the summer of 2003.

1. The *Ice Numeral* was compared to the *Damage Potential* to see if there was a correlation. For these plots, a “Damage Potential Number” was defined to reflect the four conditions specified in the Field Book as given in Table 3.
2. The *Damage Potential* was plotted versus the *speed* of the vessel. It is realized that the speed listed for the vessel would not necessarily be the maximum speed that the vessel could transit in the particular ice regimes since it could be escorting another vessel or there could be other factors to reduce the speed (operational requirements, poor visibility, etc.). Nevertheless, this plot should illustrate that the vessel was travelling slower in lower Ice Numerals.
3. In a similar manner, the *Ice Numeral* was plotted versus the *speed* of the vessel.

Table 3: Definition of the Damage Potential Number

Damage Potential Number	Description
1	high potential for damage
2	potential for damage
3	not likely to damage vessel
4	highly unlikely to damage vessel

3.0 CCGS LOUIS S. ST- LAURENT

The LOUIS S. ST- LAURENT is designated as a Heavy Gulf Icebreaker. It was built in 1969 in Montreal. Some salient details of this icebreaker are given in Table 4. Capts. M. Marsden and S. Klebert were the Commanding Officers. S. Leger and S. Payment were the ISS personnel onboard. Data were collected from July 22 to August 31. Figure 2 shows the location of the vessel during the data collection timeframe. This vessel collected information across a wide area of Arctic. Observations were made in the Entrance of Frobisher Bay, Cape Vanderbilt, Larsen Sound, Western Arctic, North Beaufort and Resolute. Six ice regime observations were reported and they are summarized in Table 5.

Table 4: Information on the CCGS LOUIS S. ST.-LAURENT

CCGS	LOUIS S. ST- LAURENT
Official No:	328095
Type:	Heavy Gulf Icebreaker
Port of Registry:	Ottawa
Region:	Maritimes
Home Port:	Dartmouth, N.S.
Call Sign:	CGBN
When Built:	1969
Builder:	Canadian Vickers, Montreal, Qué.
Modernized:	1988 - 1993 - Halifax Shipyard

Certificates		Complement	
Class of Voyage:	Home Trade I	Officers:	13
Ice Class:	100 A	Crew:	33
MARPOL:	Yes	Total:	46
IMO:	6705937	Crewing Regime:	Lay Day
		Available Berths:	53

Field Book	Start Date	End Date	Commanding Officer	ISS Personnel	# of Events	# of Photos	Comments
1	22-Jul	23-Jul	M. Masden	S. Leger	2	3	
1	6-Aug	31-Aug	S. Klebert	S. Payment	3		3 photos not received
2	27-Sep	27-Sep			1		1 photo not received, Data included in the St. Laurent 2 book
3	-	-					

Table 5: Summary of the Ice Regimes for the Louis S. St-Laurent

Ice Concentration								Decay			Ridged			Speed	Ice	DP#	CCG Comments
N	G	GW	FY	MFY	TFY	SY	MY	FY	SY	MY	FY	SY	MY	Knots	Numeral		
0	0	0	2	5	3	0	0	Y	-	-	-	-	-	10	28	4	
0	0	0	0	0	0	0	10	-	-	-	-	-	-	0	-10	3	We have encountered this type of ice predominantly in the western arctic. This is an area that is historically 90% old ice. A lot of the ice we have seen is only 1-1.5 mtr thick and we have managed to maintain 10 kts, if required. (Avoiding the ridges).
0	0	0	0	0	10	0	0	-	-	-	-	-	-	0	20	3	7 holes were drilled in this floe ranging from 1.1 to 2.0 mtrs at the thickest spots. We are in an area of the permanent multi-year ice pack but have encountered very easy conditions for navigation.
0	4	0	0	0	2	0	4	-	-	-	-	-	Y	3	4	4	Egg diagram with total concentration = 10, Stage of development = 4., conc. = 2, Flow size = 4. Stage of development = 9., conc. = 2, Flow size = 3. Stage of development = 9., conc. = 2, Flow size = 4. Stage of development =4, conc. = 4, Flow size = x. Ice regime is consolidated 10/10 at the shore-line.
0	0	0	0	0	3	0	1	Y	-	-	-	-	-	7	20	4	1 Narrow band of (4/13/94·/~7). 1 narrow band approx 3-4 nm wide (SL) Decayed TFY ice having a higher positive value than OW or Bergy water? (SL)
0	0	0	0	0	4	0	4	Y	-	-	-	-	-	10	12	3	Ice organized in a varing narrrow band through navigating area (SL)

Figure 3 shows the Damage Potential versus the Ice Numeral using the data from the Louis S. St-Laurent. For the ice regimes listed in Table 5, there were no ice regimes identified that would have the potential to damage the icebreaker. One ice regime had an Ice Numeral of -10, yet the comments indicated that the regime had little potential to damage the vessel. Figure 4 shows the Damage Potential versus the speed of the vessel. The vessel speed for the negative Ice Numeral was discussed in the comments for the ice regime. Although the ice was multi-year ice, the ice thickness was only 1 to 1.5 m thick and the vessel could navigate with speeds up to 10 knots. Figure 5 shows the Ice Numeral versus the speed of the vessel. The numbers on the graph indicate the damage severity number for the ice regime. Figure 6 shows a comparison of the 2002 and 2003 data from the Louis S. St-Laurent. There were substantially less ice regime information collected in 2003.

Samples of ice regimes identified on the Louis S. St-Laurent are given in Figure 7 and Figure 8.

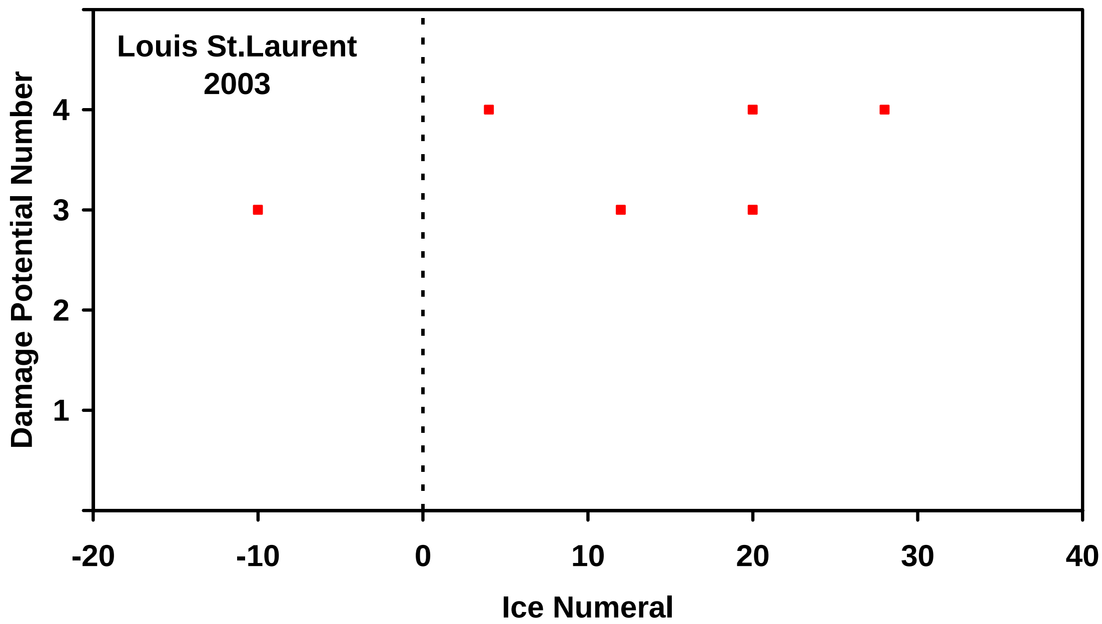

Figure 3: Damage Potential versus the Ice Numeral for the Louis S. St-Laurent

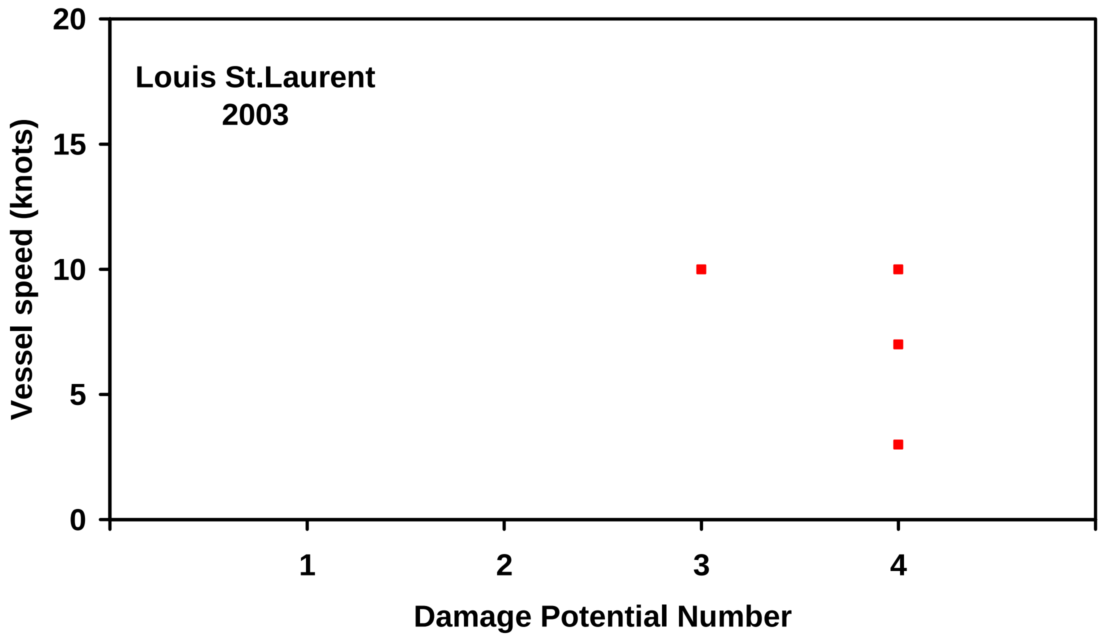

Figure 4: Vessel speed versus the damage potential for the Louis S. St-Laurent.

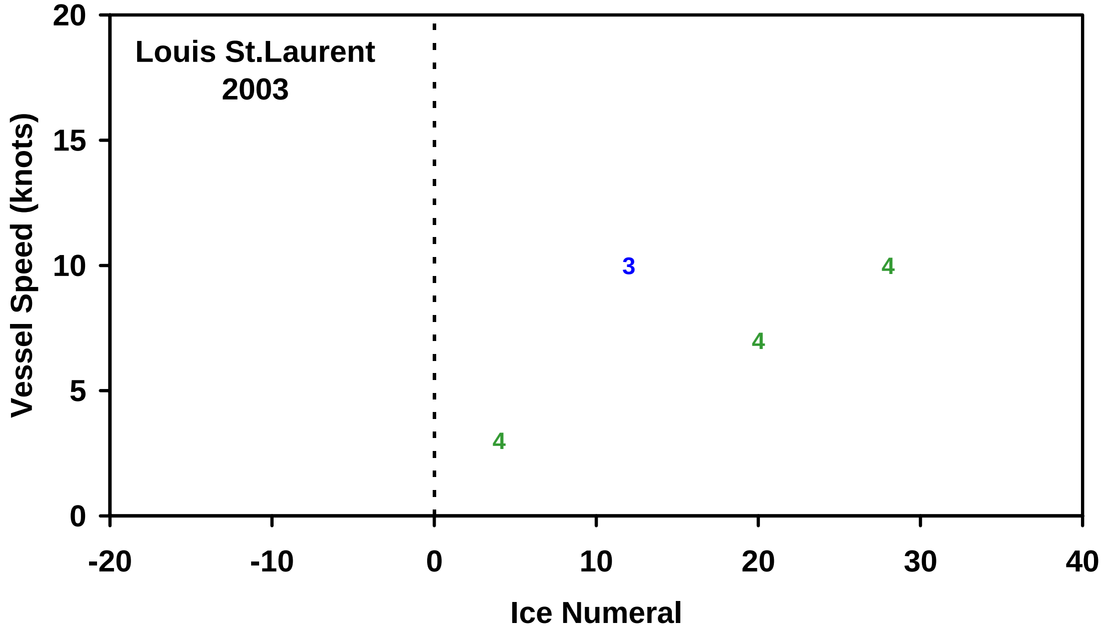

Figure 5: Vessel speed versus the Ice Numeral for the Louis S. St-Laurent.

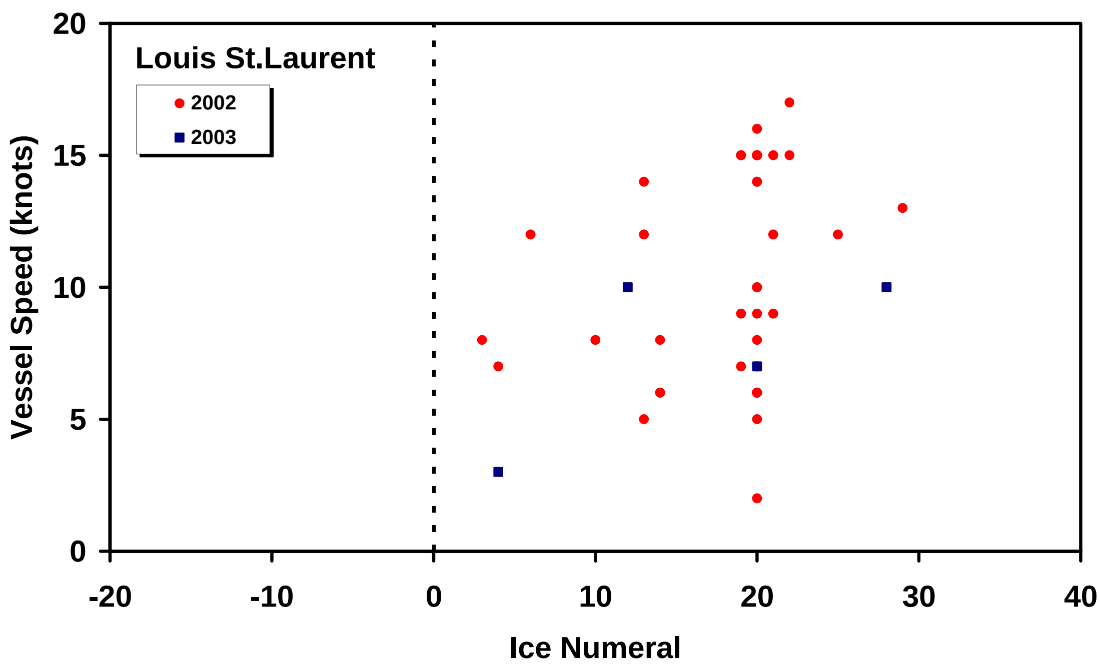

Figure 6: Comparison of data from 2002 with 2003 for the Louis S. St-Laurent

Figure 7: Ice regime with 3/10 TFY, 1/10 MY ice observed from the Louis S. St.-Laurent.

Figure 8: Ice regime with 4/10 TFY, 4/10 MY ice observed from the Louis S. St.-Laurent

4.0 CCGS TERRY FOX

The TERRY FOX was built in 1983 and is designated as a Heavy Gulf Icebreaker. Some salient details of this icebreaker are given in Table 6. Capts. G. Barry and M. Champagne were the Commanding Officers. R. Morrow was one of the ISS personnel onboard. The other ISS person did not identify him/herself. Data were collected from July 10 to August 25 but only the data from August 15 to August 25 were used in this analysis. Figure 2 shows the location of the vessel during the data collection timeframe. Data used in this analysis were collected in Peel Sound, Franklin Strait, Larsen Sound and Resolute. Although 11 ice regimes were identified, only five were used in this analysis. Table 7 provides a summary of the events.

Table 6: Information on the CCGS TERRY FOX

CCGS	TERRY FOX
Official No:	803579
Type:	Heavy Gulf Icebreaker / Suppy Tug
Port of Registry:	Ottawa
Region:	Maritimes
Home Port:	Dartmouth, N.S.
Call Sign:	CGTF
When Built:	1983
Builder:	Burrard Yarrows Corporation, Vancouver, B.C.
Modernized:	

Certificates

Class of Voyage:	Home Trade I
Ice Class:	Arctic Class 4
MARPOL:	Yes
IMO:	8127799

Complement

Officers:	10
Crew:	14
Total:	24
Crewing Regime:	Lay Day
Available Berths:	10

Field Book	Start Date	End Date	Commanding Officer	ISS Personnel	# of Events	# of Photos	Comments
1	10-Jul	24-Jul	G. Barry	Not identified	6	6	
2	15-Aug	25-Aug	M. Champagne	R. Morrow	5	23	
3							Open water - no data
4							Open water - no data

Table 7: Summary of the Ice Regimes for the Terry Fox

Ice Concentration								Decay			Ridged			Speed	Ice	DP #	CCG Comments
N	G	GW	FY	MFY	TFY	SY	MY	FY	SY	MY	FY	SY	MY	Knots	Numeral		
0	0	0	0	2	8	0	0	Y	-	-	-	-	-	4	30	4	
0	0	0	0	0	6	0	4	Y	-	Y	-	-	-	3	18		
0	0	0	1	2	4	3	0	Y	Y	-	-	-	-	3	26	4	M/V Bremen under escort. Ice Numeral not reflective. (CG)
0	0	0	0	0	6	4	0	Y	Y	-	-	-	-	3	26	3	M/V Bremen under escort, south bound peel sound
0	0	0	2	2	5	0	0	Y	-	-	-	-	-	7	27	4	M/V Bremen under escort, south bound Franklin Strait.

During the first data collection for the first field book on the Terry Fox, there were six ice regimes identified. The regimes were mostly 5/10s first-year ice. These regimes were evaluated to have potential to damage the Terry Fox. This is quite surprising to the authors since the Terry Fox is a heavy icebreaker that has operated extensively in multi-year ice with little or no damage. The ISS personnel who collected the data indicated that he/she did not want to be associated with this ice collection program. Therefore, this data was not included in the analysis.

Figure 9 shows the Damage Potential versus the Ice Numeral using data from the Terry Fox. All of the ice regimes were rated as having little potential to damage the vessel. Figure 10 shows the Damage Potential versus the speed of the vessel. There are few data points and all speeds were relatively low. Figure 11 shows the Ice Numeral versus the speed of the vessel. Figure 12 shows a comparison of the data from 2002 and 2003. There were considerably more data points from the data collection program in 2002.

Figure 13 to Figure 15 show some of the ice regimes observed from the Terry Fox.

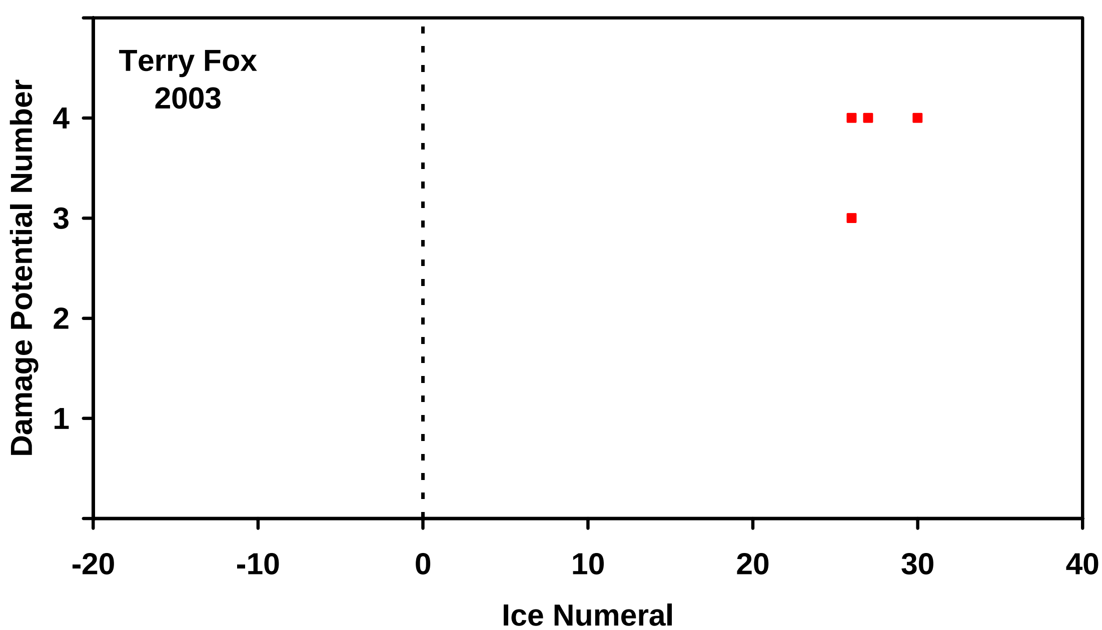

Figure 9: Damage potential number versus the Ice Numeral for the Terry Fox.

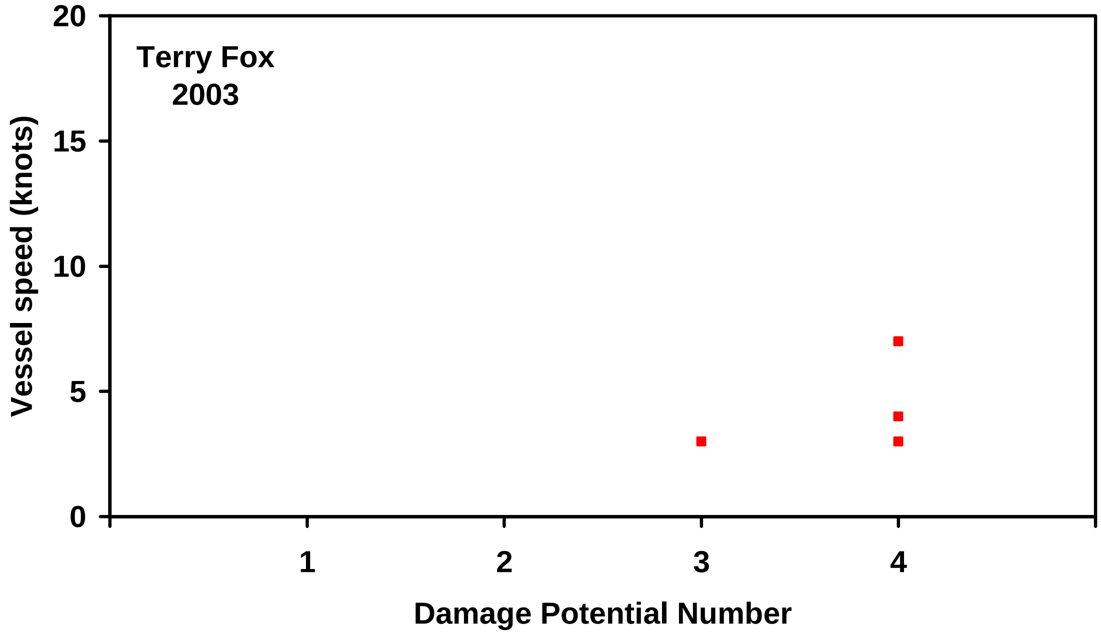

Figure 10: Vessel speed versus the damage potential for the Terry Fox.

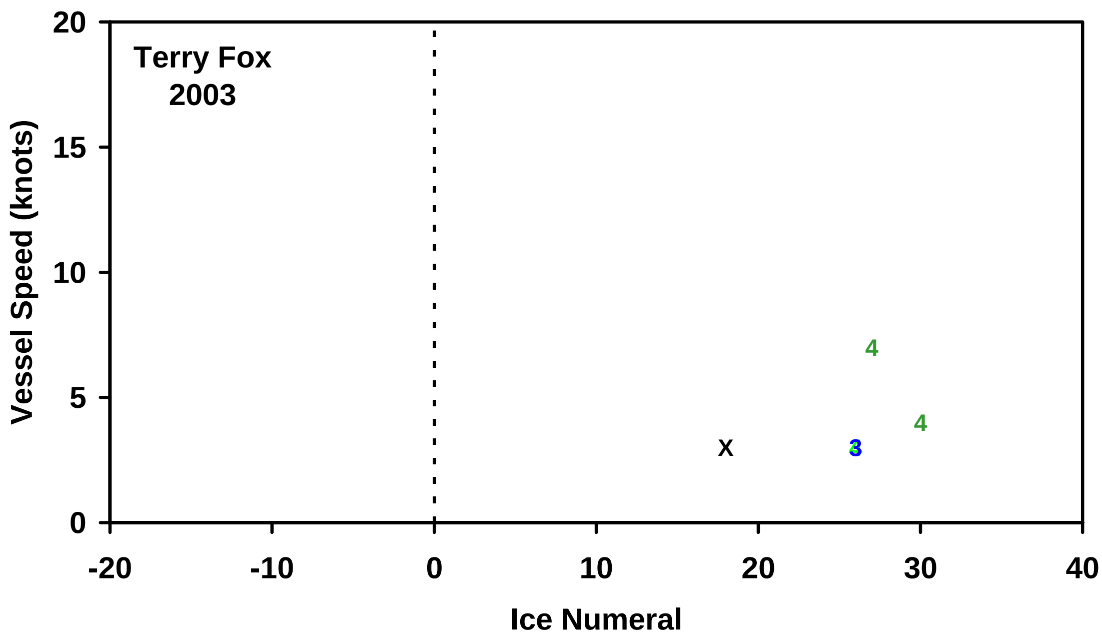

Figure 11: Vessel speed versus the Ice Numeral for the Terry Fox.

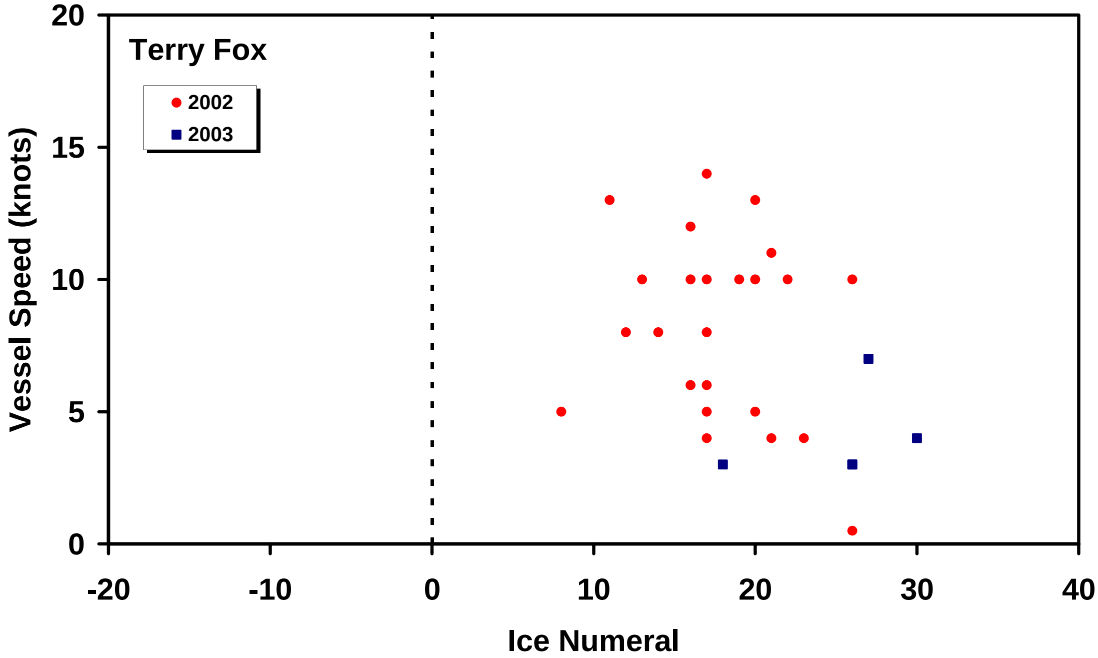

Figure 12: Comparison of data from 2002 with 2003 for the Terry Fox.

Figure 13: Ice regime with 6/10 TFY, 4/10 SY ice observed from the Terry Fox.

Figure 14: Ice regime with 1/10 FY, 2/10 MFY, 4/10 TFY, 3/10 SY ice observed from the Terry Fox.

Figure 15: Ice regime with 2/10 MFY, 8/10 TFY ice observed from the Terry Fox.

5.0 CCGS HENRY LARSEN

The HENRY LARSEN was built in 1987 and is designated as a Medium Gulf Icebreaker. Some salient details of this icebreaker are given in Table 8. Capts. J. Broderick and J. Vanthiel were the Commanding Officers. C. Stock and L. Theriault were the ISS personnel onboard. Data were collected from July 7 to September 4. Figure 2 shows the location of the vessel during the data collection timeframe. Observations were made in Frobisher Bay, North Bay (Hudson Strait), Cape Christian and Resolute. Eight ice regime observations were reported as summarized in Table 9.

Table 8: Information on the CCGS HENRY LARSEN

CCGS	HENRY LARSEN
Official No:	808731
Type:	Medium Gulf - River Icebreaker
Port of Registry:	Ottawa
Region:	Newfoundland
Home Port:	St. John's, Nfld.
Call Sign:	CGHL
When Built:	1987
Builder:	Versatile Pacific Shipyards Inc., Vancouver, B.C.
Modernized:	

Certificates		Complement	
Class of Voyage:	Home Trade I	Officers:	11
Ice Class:	Arctic Class 4	Crew:	20
MARPOL:	Yes	Total:	31
IMO:	8409329	Crewing Regime:	Lay Day
		Available Berths:	40

Field Book	Start Date	End Date	Commanding Officer	ISS Personnel	# of Events	# of Photos	Comments
1	7-Jul	3-Aug	J. Broderick	C. Stock	7	14	
2	4-Sep	4-Sep	J. Vanthiel	L. Theriault	1	2	Data included in the Larsen 1 book
3	-	-					no data received by CHC

Table 9: Summary of the Ice Regimes for the Henry Larsen

Ice Concentration								Decay			Ridged			Speed	Ice	DP #	CCG Comments
N	G	GW	FY	MFY	TFY	SY	MY	FY	SY	MY	FY	SY	MY	Knots	Numeral		
0	0	0	0	0	4	1	2	-	-	-	-	-	-	7	13	2	- Continued transit NW' wards into Frobisher Bay. - Ice assessed as 7/2113/9844./3232. CN 2/10 ridging / hummocking and many puddles.
0	0	0	0	0	6	2	1	-	-	-	-	-	-	7	15	2	
0	0	0	0	0	4	0	3	-	-	-	-	-	-	5.3	11	2	- Escorting M/V 'UMIAVUT' outbound - Mean ice conc 7/124/994./322
0	0	0	0	0	4	1	1	Y	-	-	-	-	-	7.2	20		- Escorting M/V UMIAVUT through North Bay into the approaches to Lake Harbour - Normal IM used for old ice, decay IM used for FY concs, due some rot + thaw holes in FY vs normal ponding on old ice.
0	0	0	0	0	3	0	1	-	-	-	-	-	-	10.4	17	2	- Escorting cruise ship 'BREMEN' westwards towards Clyde River - Avg concentration asssessed as 4/121/944./332 (large + vast floes northwards)
0	0	0	0	0	6	0	3	-	-	-	-	-	-	5	11	2	- Transit into Frobisher Bay to assist shipping. - Narrow band of ice assessed as 9/126/994./322. - 2/10 ridging, many puddles; - Normal early summer melt pattern.
0	0	0	0	0	2	0	2	-	-	-	-	-	-	5.4	14	2	- Concentrations vrbl btwn 2 and 4/10
0	0	0	0	0	3	0	1	Y	-	Y	-	-	-	6.3	21	4	- Escorting M/V IMUIVAQ to Resolute

Figure 16 shows the Damage Potential versus the Ice Numeral using data from the Henry Larsen. There are a number of ice regimes that were rated as having the potential to cause damage to the vessel. These ice regimes consisted of a mixture of thick first-year ice and old ice. Figure 17 shows the Damage Potential versus the speed of the vessel. There is no trend in the data, with speeds in the range of 5 to 10 knots. Figure 18 shows the Ice Numeral versus the speed of the vessel. No negative Ice Numerals were calculated for this vessel. Figure 19 shows a comparison of the ice regimes events collected in 2002 and 2003 on the Henry Larsen.

Figure 20 to Figure 26 show some examples of the ice regimes observed from the Henry Larsen.

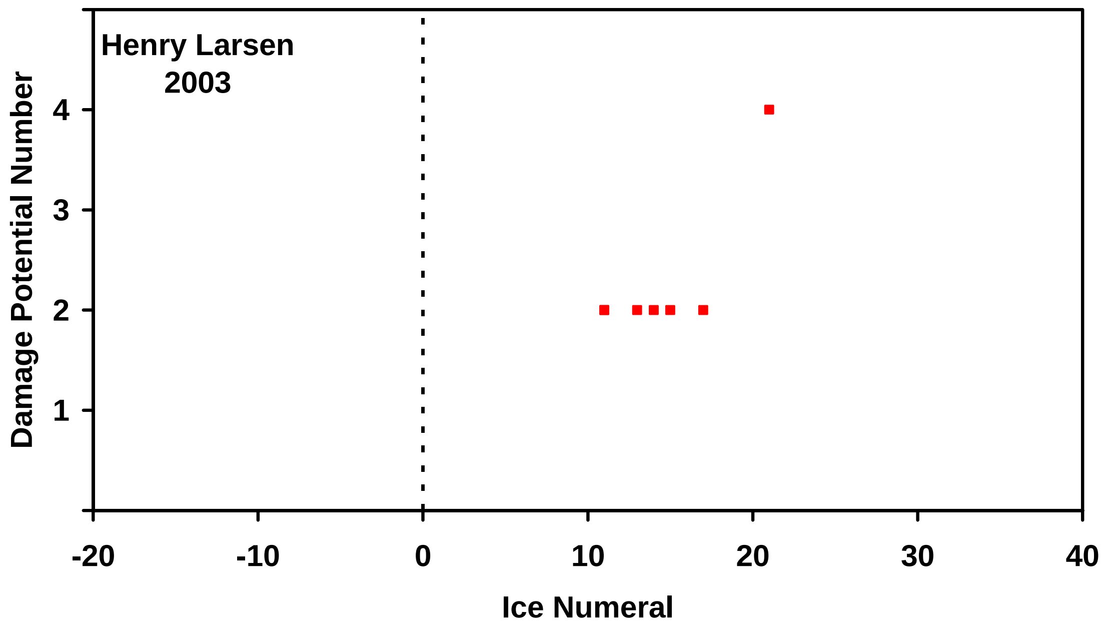

Figure 16: Damage Potential Number versus the Ice Numeral for the Henry Larsen.

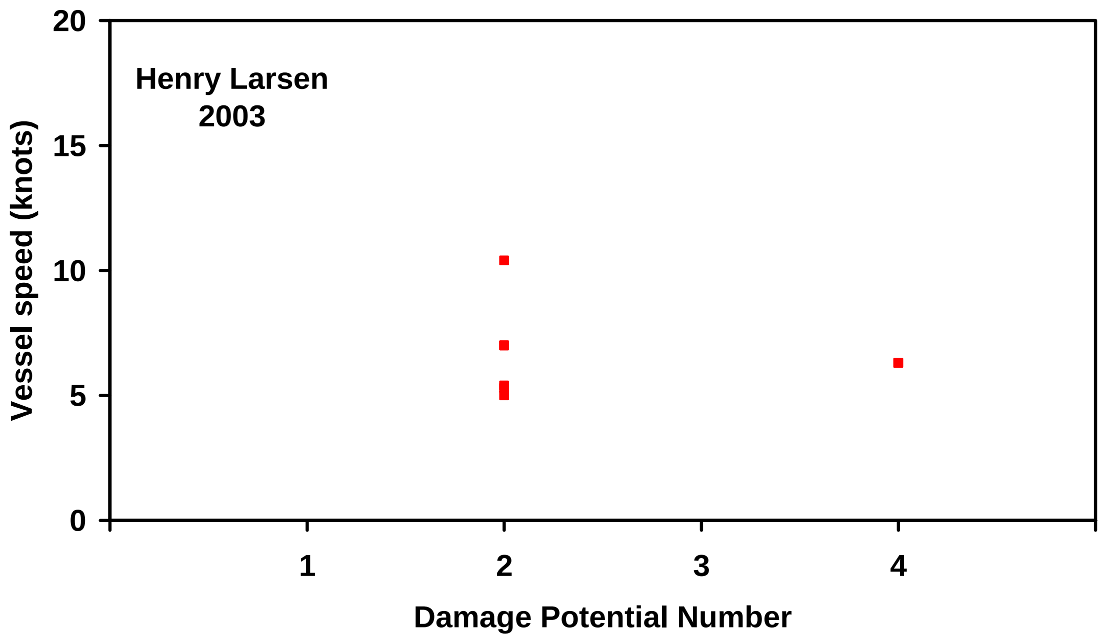

Figure 17: Vessel speed versus the Damage Potential Number for the Henry Larsen.

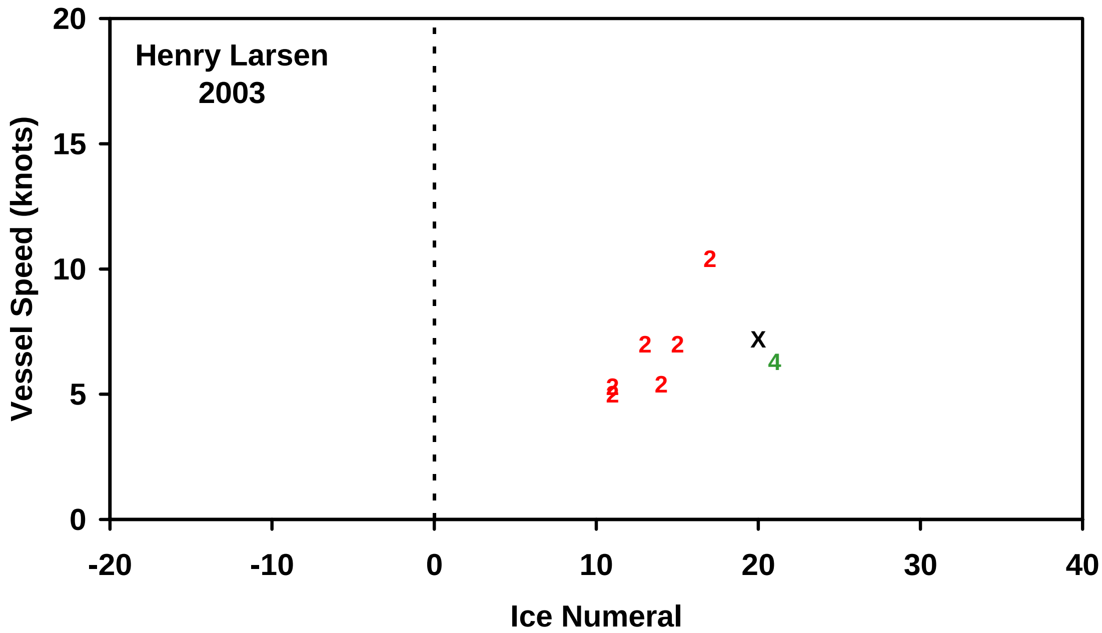

Figure 18: Vessel speed versus the Ice Numeral for the Henry Larsen.

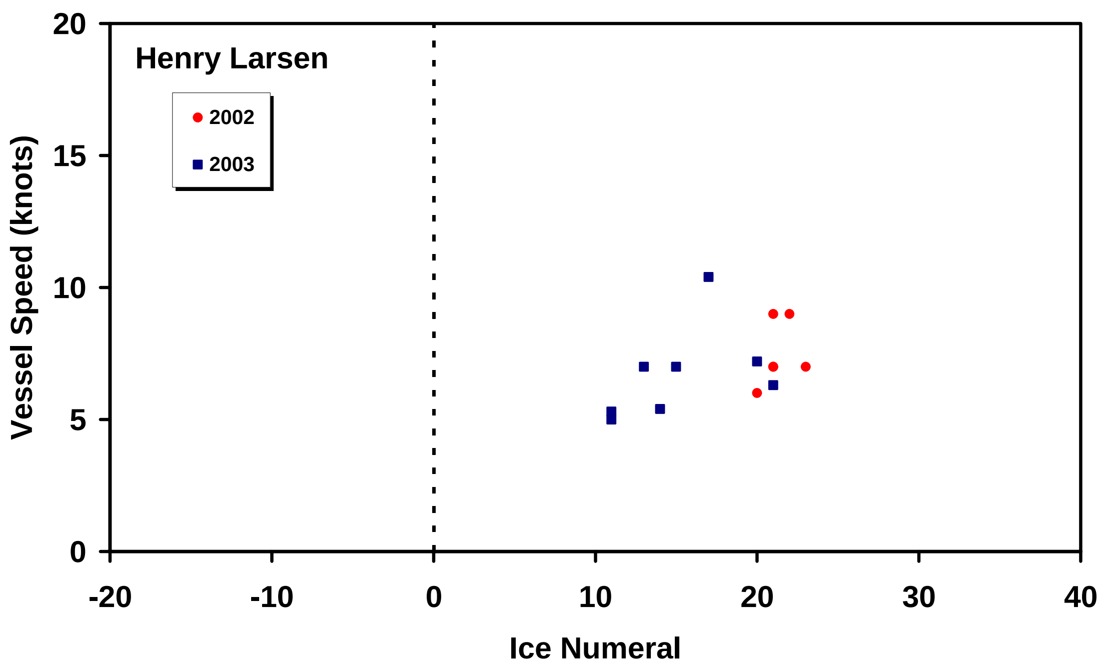

Figure 19: Comparison of the data from 2002 and 2003 for the Henry Larsen.

Figure 20: Ice regime with 6/10 TFY, 3/10 MY ice observed from the Henry Larsen.

Figure 21: Ice regime with 2/10 TFY, 2/10 MY ice observed from the Henry Larsen.

Figure 22: Ice regime with 4/10 TFY, 1/10 SY, 2/10 MY ice observed from the Henry Larsen.

Figure 23: Ice regime with 6/10 TFY, 2/10 SY, 1/10 MY ice observed from the Henry Larsen.

Figure 24: Ice regime with 4/10 TFY, 3/10 MY ice observed from the Henry Larsen.

Figure 25: Ice regime with 4/10 TFY, 1/10 SY, 1/10 MY ice observed from the Henry Larsen.

Figure 26: Ice regime with 3/10 TFY, 1/10 MY ice observed from the Henry Larsen.

6.0 CCGS DES GROSEILLIERS

The DES GROSEILLIERS was built in 1982 and is designated as a Medium Gulf Icebreaker. Some salient details of this icebreaker are given in Table 10. Data was only collected with one crew since there was open water listed for the other field books. Capt. R. Dubois was the Commanding Officer, and E. Vaillant was the ISS personnel onboard. Data were collected from July 2 to July 11. Figure 2 shows the route for the vessel during the data collection timeframe. Three ice regime observations were made in East and West Frobisher Bay and Kimmirut. They are summarized in Table 11.

Table 10: Information on the CCGS DES GROSEILLIERS

CCGS	DES GROSEILLIERS
Official No:	802160
Type:	Medium Gulf - River Icebreaker
Port of Registry:	Ottawa
Region:	Laurentian
Home Port:	Québec, Qué.
Call Sign:	CGDX
When Built:	1982
Builder:	Port Weller Dockyard, St. Catherines, Ont.
Modernized:	

Certificates

Class of Voyage:	Home Trade I
Ice Class:	
MARPOL:	
IMO:	

Complement

Officers:	12
Crew:	26
Total:	38
Crewing Regime:	Conventional
Available Berths:	26

Field Book	Start Date	End Date	Commanding Officer	ISS Personnel	# of Events	# of Photos	Comments
1	2-Jul	11-Jul	R. Dubois	E. Vaillant	3	8	
2	-	-					Open water - no data
3	-	-					Open water - no data

Table 11: Summary of the Ice Regimes for the Des Groseilliers.

Ice Concentration								Decay			Ridged			Speed	Ice	DP #	CCG Comments
N	G	GW	FY	MFY	TFY	SY	MY	FY	SY	MY	FY	SY	MY	Knots	Numeral		
0	0	0	0	2	5	0	1	-	-	-	-	-	-	7.5	10	3	
0	0	0	0	0	10	0	0	Y	-	-	-	-	-	13	20	4	
0	0	0	0	0	3	0	1	-	-	-	Y	-	Y	8	8	3	

Figure 27 shows the Damage Potential versus the Ice Numeral using the data from the Des Groseilliers. None of the three ice regimes were identified to have a potential to damage this vessel. Figure 28 shows the Damage Potential versus the speed of the vessel for the Des Groseilliers. Vessel speed ranged from 7 to 13 knots. Figure 29 shows the Ice Numeral versus the speed of the vessel. Figure 30 shows a comparison of the data collected in the 2002 and 2003 data collection programs.

Figure 31 to Figure 33 show some of the ice regimes observed from the Des Groseilliers.

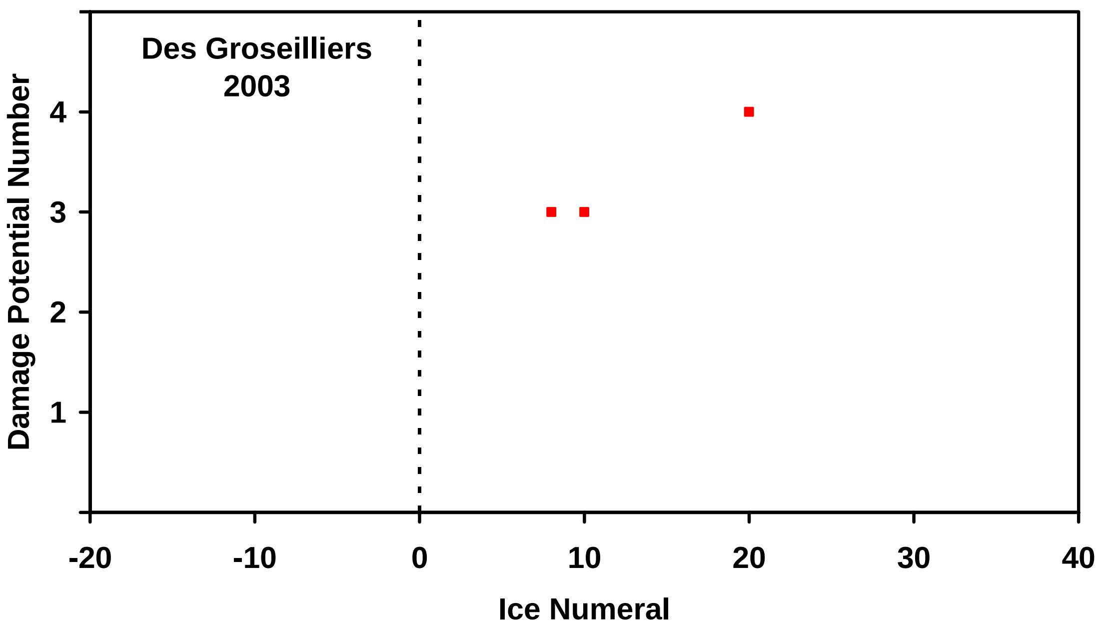

Figure 27: Damage Potential Number versus the Ice Numeral for the Des Groseilliers.

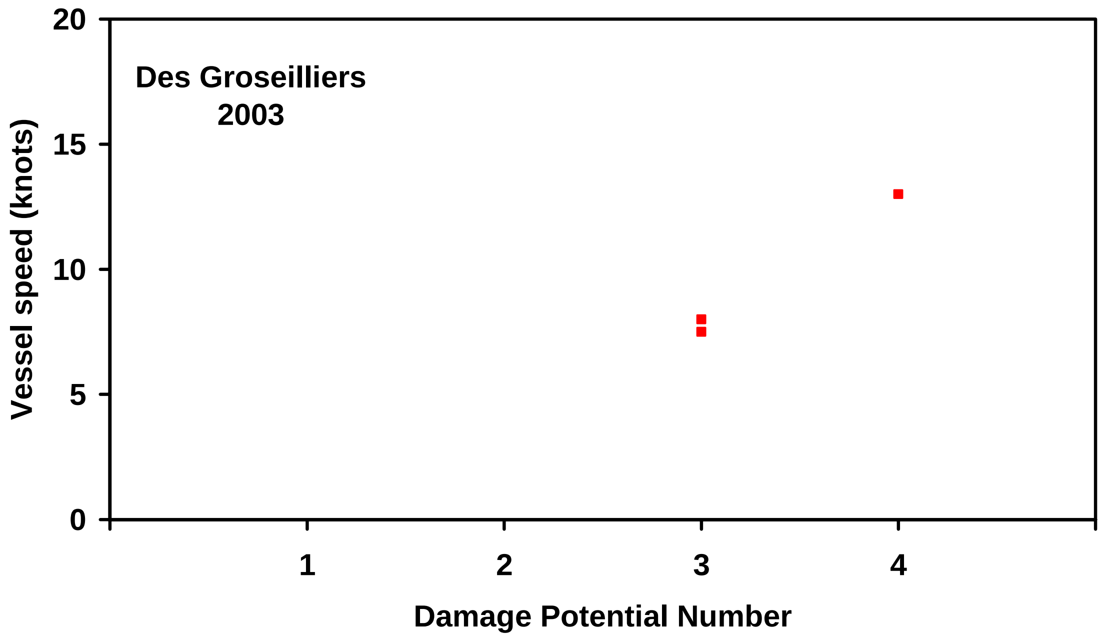

Figure 28: Vessel speed versus the Damage Potential Number for the Des Groseilliers.

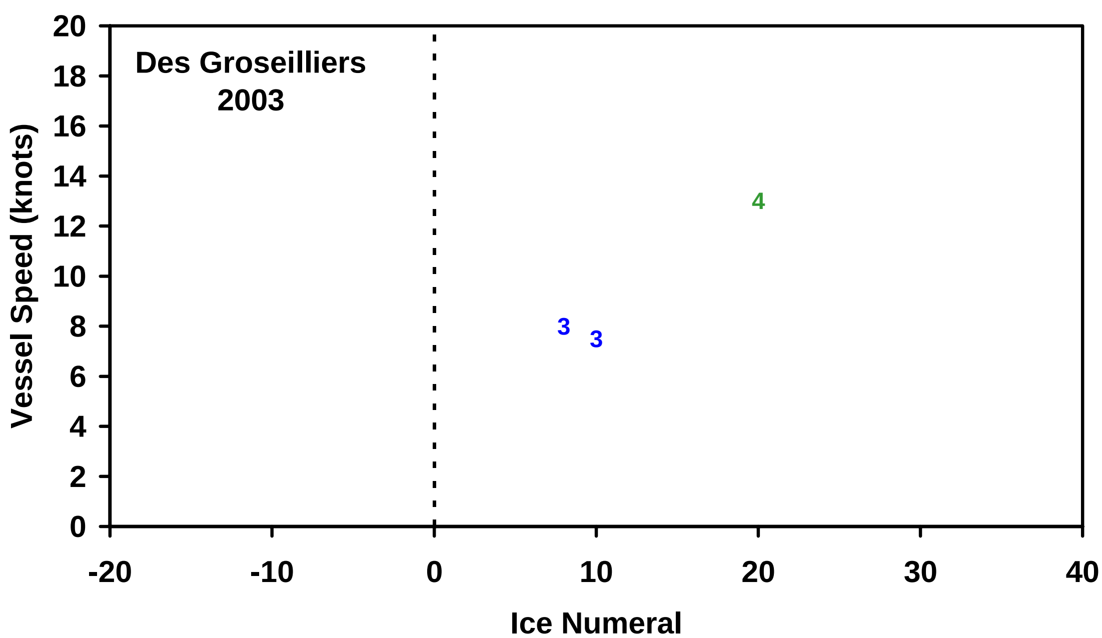

Figure 29: Vessel speed versus the Ice Numeral for the Des Groseilliers.

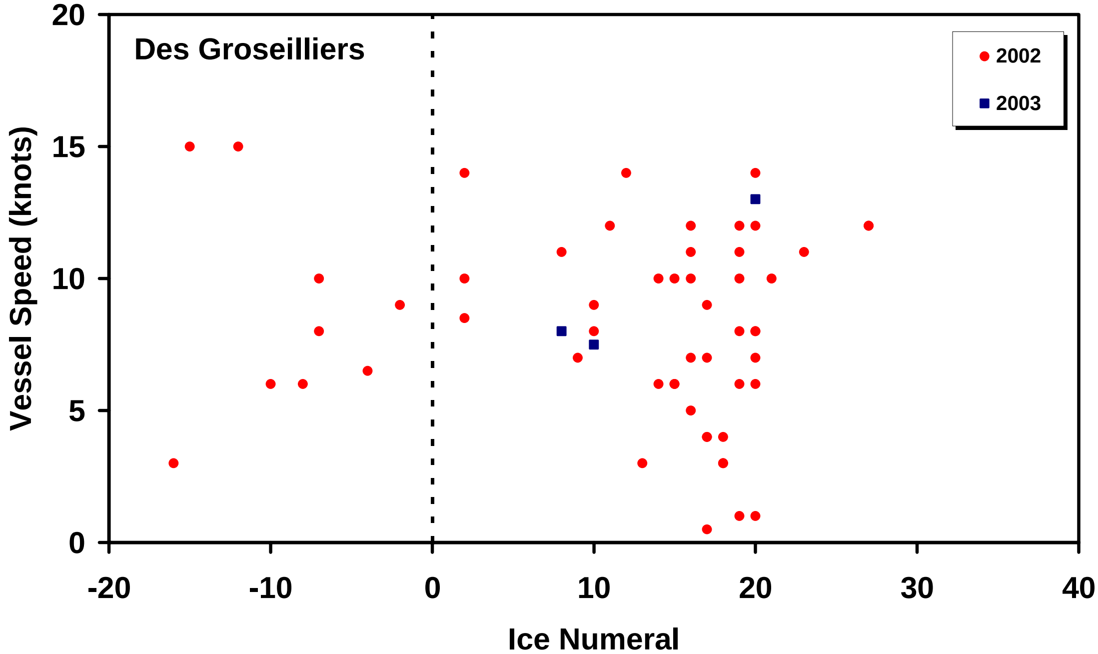

Figure 30: Comparison of the 2002 and 2003 data events from the Des Groseilliers.

Figure 31: Ice regime with 10/10 TFY ice observed from the Des Groseilliers.

Figure 32: Ice regime with 2/10 MFY, 5/10 TFY, 1/10 MY ice observed from the Des Groseilliers.

Figure 33: Ice regime with 3/10 TFY, 1/10 MY ice observed from the Des Groseilliers.

7.0 CCGS PIERRE RADISSON

The PIERRE RADISSON was built in 1978 and is designated as a Medium Gulf Icebreaker. Some salient details of this icebreaker are given in Table 12. No information on the ice regimes was submitted for this vessel for year 2003.

Table 12: Information on the CCGS PIERRE RADISSON

CCGS	PIERRE RADISSON
Official No:	383326
Type:	Medium Gulf - River Icebreaker
Port of Registry:	Ottawa
Region:	Laurentian
Home Port:	Québec, Qué.
Call Sign:	CGSB
When Built:	1978
Builder:	Burrard Dry Dock Co. Ltd, North Vancouver, B.C.
Modernized:	1995, 1996, & 1997

Certificates		Complement	
Class of Voyage:	Home Trade I	Officers:	12
Ice Class:	100 A	Crew:	26
MARPOL:	Yes	Total:	38
IMO:	7510834	Crewing Regime:	Conventional
		Available Berths:	26

Field Book	Start Date	End Date	Commanding Officer	ISS Personnel	# of Events	# of Photos	Comments
1							no data received by CHC
2							no data received by CHC
3							no data received by CHC

8.0 CCGS SIR WILFRID LAURIER

The SIR WILFRID LAURIER was built in 1986 and is designated as a Light Icebreaker. Some salient details of this icebreaker are given in Table 13. Capts. N. Thomas and M. Taylor and were the Commanding Officers. R. Hilchie, C. Daigle and B. Simard were the ISS personnel onboard. Data were collected from July 20 to October 4. Figure 2 shows the location for the vessel during the data collection timeframe. Observations were made off Pte. Barrow, Prudhoe Bay, Barter Island, Horton River, Franklin Bay, Wise Bay, Cape Lyon, James Ross Strait, Southern Larsen Sound, Beaufort Sea, Baillie Islands, Mackenzie Bay and Alaskan North Shore.. Twenty-nine ice regime observations were reported and these are summarized in Table 14.

Table 13: Information on the CCGS SIR WILFRID LAURIER

CCGS	SIR WILFRID LAURIER
Official No:	807038
Type:	Light Icebreaker - Major Navaids Tender
Port of Registry:	Ottawa
Region:	Pacific
Home Port:	Victoria, B.C.
Call Sign:	CGJK
When Built:	1986
Builder:	Canadian Shipbuilding, Collingwood, Ont.
Modernized:	

Certificates		Complement	
Class of Voyage:	Home Trade I	Officers:	10
Ice Class:	Arctic Class 2	Crew:	16
MARPOL:	Yes	Total:	26
IMO:	8320456	Crewing Regime:	Lay Day
		Available Berths:	25

Field Book	Start Date	End Date	Commanding Officer	ISS Personnel	# of Events	# of Photos	Comments
1	20-Jul	9-Aug	N. Thomas	R. Hilchie	12	20	1 photo not received, 1 "Test Run" ignored
2	21-Aug	5-Sep	M. Taylor	C. Daigle	6	3	1 photo corrupted, 2 example sheets
3	29-Sep	4-Oct	N. Thomas	B. Simard	11	14	

Table 14: Summary of the Ice Regimes for the Sir Wilfrid Laurier.

Ice Concentration								Decay			Ridged			Speed	Ice	DP #	CCG Comments
N	G	GW	FY	MFY	TFY	SY	MY	FY	SY	MY	FY	SY	MY	Knots	Numeral		
0	0	0	0	0	2	0	0	-	-	-	-	-	-	0	18	3	
0	0	0	0	0	0	1	0	-	-	-	-	-	-	6	16	4	
5	0	0	0	0	0	2	2	-	-	-	-	-	-	3	2	3	Because we are now October 1st. the change in the numeral is dramatic (Benoit Simard)
0	0	0	0	0	0	2	0	-	-	-	-	-	-	9	12	3	
0	0	0	0	6	3	0	0	Y	-	-	-	-	-	5	26	4	
0	0	0	0	0	2	2	5	Y	-	-	-	-	-		-13	2	Example of ice conditions encountered for brief distance before route alteration
0	0	0	0	0	3	0	6	Y	-	-	-	-	-		-10	2	Continued from 'Does Ice Numeral reflect the degree of severity of the ice conditions?' notes: AIRRS does not take into account ice floe size and V/L maneoverability. Example of ice conditions observed from helicopter recco. ship did not transit through
0	0	0	0	2	7	0	0	Y	-	-	-	-	-	3.7	22	4	
0	0	0	0	0	2	0	0	-	-	-	-	-	-	14	18	4	
0	0	0	0	0	7	0	2	Y	-	-	-	-	-	4	10	3	
0	0	0	0	0	9	0	0	Y	-	-	-	-	-	4.5	20	3	
0	0	0	0	0	3	0	1	-	-	-	-	-	-	5	12	3	
0	0	0	0	0	7	0	2	Y	-	Y	-	-	-	5.5	12	3	
0	0	0	0	1	6	0	0	Y	-	-	Y	-	-	5	14	3	Moderate conditions
0	0	0	0	0	0	3	2	-	-	-	-	-	-	5.1	-2	3	
0	0	0	0	0	0	1	0	-	-	-	-	-	-	7	16	4	
1	0	0	0	0	0	2	3	-	-	-	-	-	-	0	-3	4	
0	0	0	0	0	0	3	4	-	-	-	-	-	-	4	-12	2	
0	0	0	0	0	0	2	3	-	-	-	-	-	-	5	-3	3	
0	0	0	0	2	4	0	0	Y	-	-	Y	-	-	2	16	3	
0	0	0	0	1	6	0	0	Y	-	-	Y	-	-	2	14	3	
0	0	0	0	0	0	0	1	-	-	-	-	-	Y	6.5	14	4	Past comments re ship numeral re L/B ratio, # of shafts should be taken into account for ship multiplier not just ice class assigned.
0	0	0	0	0	3	0	6	Y	-	Y	-	-	-	3.75	-4	3	3 to 4.5 kn on 2 M.E., vessel did not work really hard except for a few ridges. (Did not need 3 M.E. to maintain speed)
0	0	0	0	0	1	0	3	Y	-	-	-	-	Y	6	2	4	Need multiplier for under close pack conditions?
0	0	0	0	0	2	0	8	Y	-	Y	-	-	-	2	-12	2	CAC 4 does give a better numeral than type A though.
0	0	0	0	2	2	0	6	Y	-	Y	-	-	-	2	-2	3	Very little open water to move (tug)? into, track for tug closed quickly - some pressure, small bits of 1st year jammed progress, esp for tug.
0	0	0	0	0	1	0	8	Y	-	Y	-	-	-	3.5	-12	3	Made 3 kn with tug & barge escort, unlike 1 1/2 km in obs 10 with tug alone.
0	0	0	0	0	2	0	8	Y	-	Y	-	-	-	2	-12	3	
0	0	0	0	2	3	0	5	Y	-	Y	-	-	-	4	2	4	

Figure 34 shows the Damage Potential versus the Ice Numeral using the data from the Sir Wilfrid Laurier. Although there were a number of ice regimes with a negative Ice Numeral, there were only a few of those that were identified as having potential for damaging the icebreaker. These regimes typically had 4/10s to 6/10s multi-year ice in them. Figure 35 shows the Damage Potential versus the speed of the vessel. There is a trend of lower speeds in ice regimes that are identified as having a high damage potential. Figure 36 shows the Ice Numeral versus the speed of the vessel. Lower speeds (below 5 knots) were always used in the ice regimes that had negative Ice Numerals. In general, the data from the Sir Wilfrid Laurier were quite consistent. Figure 37 shows a comparison of the 2002 and 2003 data collection programs. There were more data collected in 2003 than in 2002.

Figure 38 to Figure 44 show some of the ice regimes observed from the Sir Wilfrid Laurier.

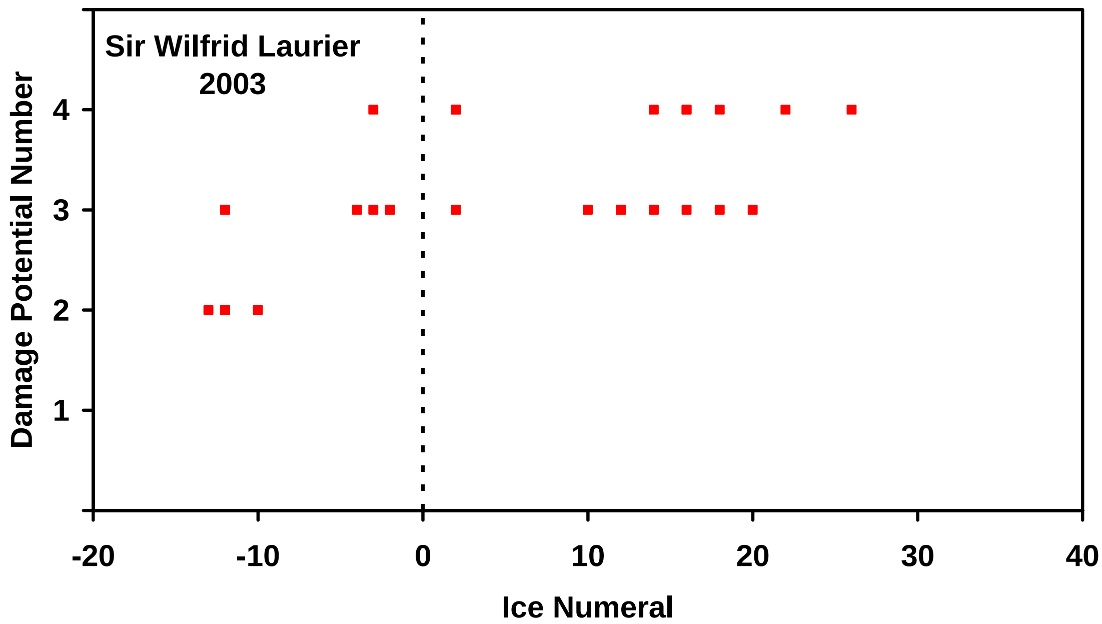

Figure 34: Damage Potential Number versus the Ice Numeral for the Sir Wilfrid Laurier.

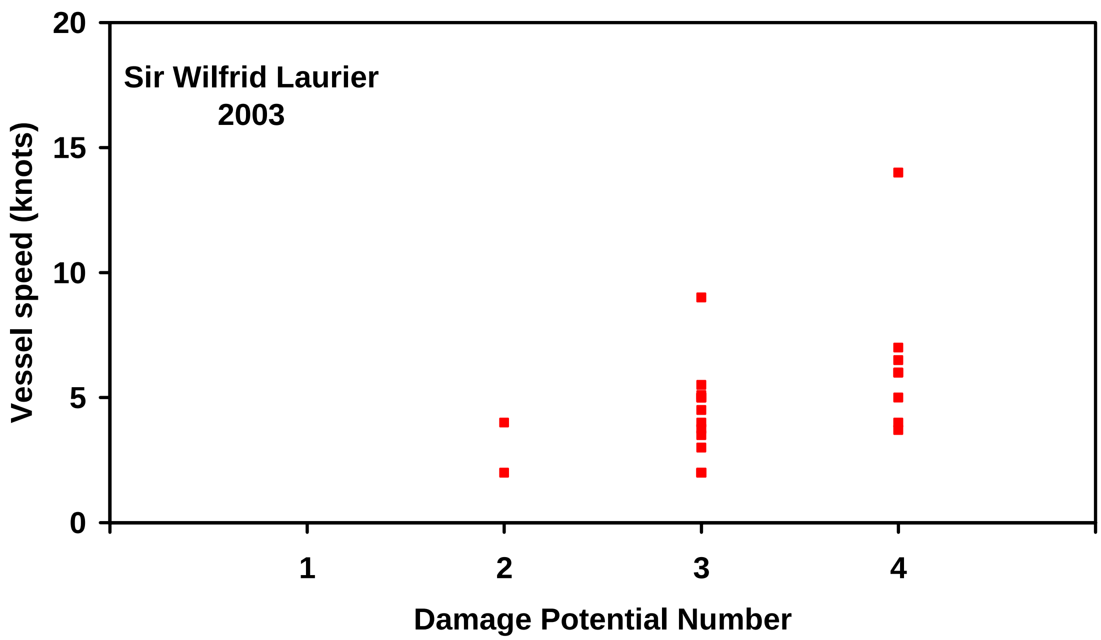

Figure 35: Vessel speed versus the Damage Potential Number for the Sir Wilfrid Laurier.

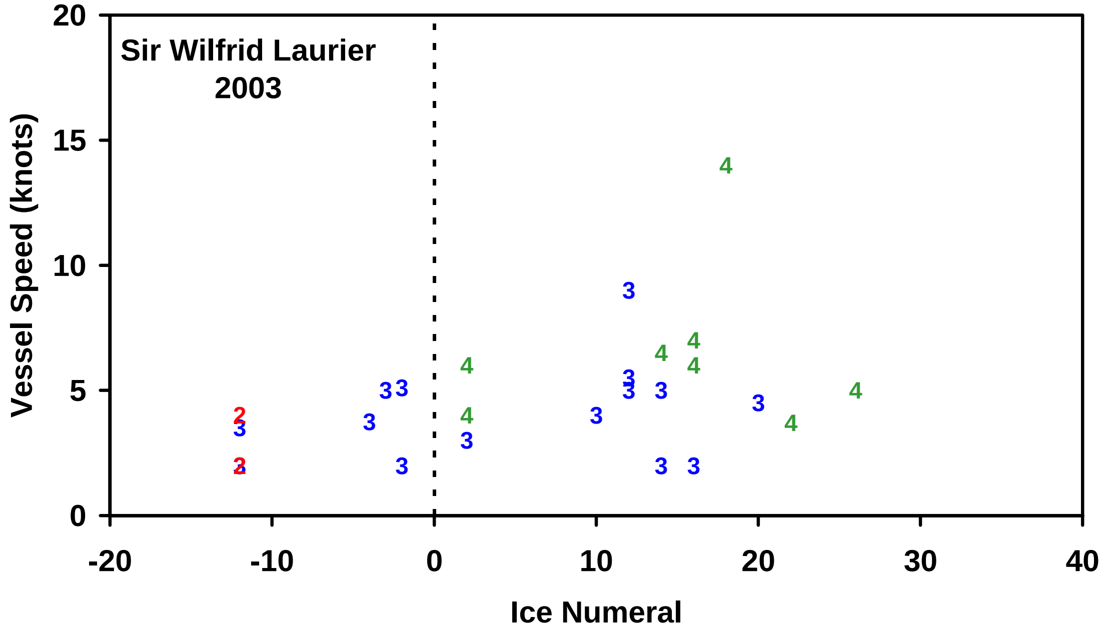

Figure 36: Vessel speed versus the Ice Numeral for the Sir Wilfrid Laurier.

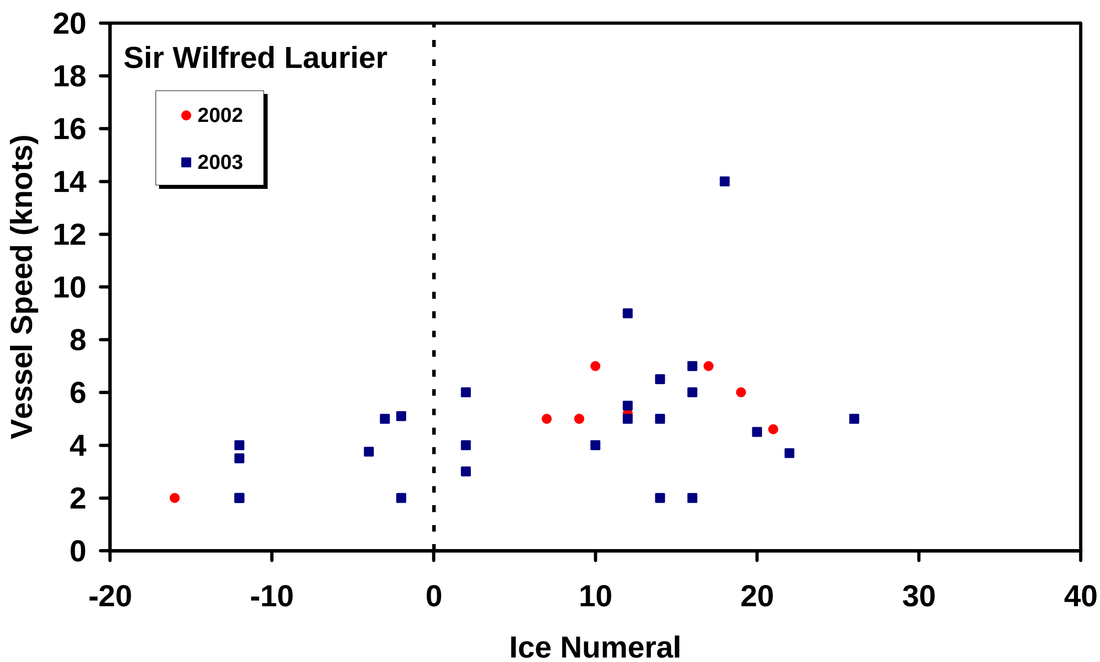

Figure 37: Comparison of the ice regime events for 2002 and 2003 on the Sir Wilfrid Laurier.

Figure 38: Ice regime with 6/10 MFY, 3/10 TFY ice observed from the Sir Wilfrid Laurier.

Figure 39: Ice regime with 1/10 MFY, 6/10 TFY ice observed from the Sir Wilfrid Laurier.

Figure 40: Ice regime with 3/10 TFY, 6/10 MY ice observed from the Sir Wilfrid Laurier.

Figure 41: Ice regime with 1/10 MY ice observed from the Sir Wilfrid Laurier.

Figure 42: Ice regime with 2/10 TFY, 8/10 MY ice observed from the Sir Wilfrid Laurier.

Figure 43: Ice regime with 2/10 MFY, 3/10 TFY, 5/10 MY ice observed from the Sir Wilfrid Laurier.

Figure 44: Ice regime with 3/10 TFY, 1/10 MY ice observed from the Sir Wilfrid Laurier.

9.0 GENERAL ANALYSIS

The data obtained from this study can be used to investigate several aspects of the Ice Regime System. An analysis of the data is provided in the following sections.

9.1 Calculating the Ice Numeral

The data collection project showed that defining ice regimes and calculating the Ice Numeral was not a problem. Figure 45 shows the overall breakdown of the calculated Ice Numeral for the 201 events. In 80% of the cases, the Ice Numeral was calculated correctly based upon the observed ice regime. This is better than in 2002 when the Ice Numeral was calculated correctly 72% of the time. In 2003, three different types of mistakes were made:

- The Open Water was not included in the ice regime in 16% of the cases. This is same percentage as 2002. Since the Open Water Ice Multiplier is +2 for all vessels, this led to an overly negative Ice Numeral for those ice regimes. This was done consistently by a few of the ISS personnel, and this skews the data towards a larger number of incorrect Ice Numerals.
- For one event, the wrong Ice Multiplier was used. In this case, the ice regime was not identified as having decayed ice, but the decay bonus of +1 was applied to the Ice Multiplier.
- In 2% of the cases, mistakes were made summing the contributions from each ice type when determining the Ice Numeral (i.e. arithmetic errors).

These results are encouraging despite the errors in determining the Ice Numeral in about one-quarter of the observations. The program shows that determining the Ice Numeral is relatively straightforward once the ice regime has been defined. The mistakes of neglecting the Open Water and incorrect summing can be corrected by taking a more careful approach. The mistake of choosing the incorrect Ice Multiplier would be remedied with more experience with the Ice Regime System.

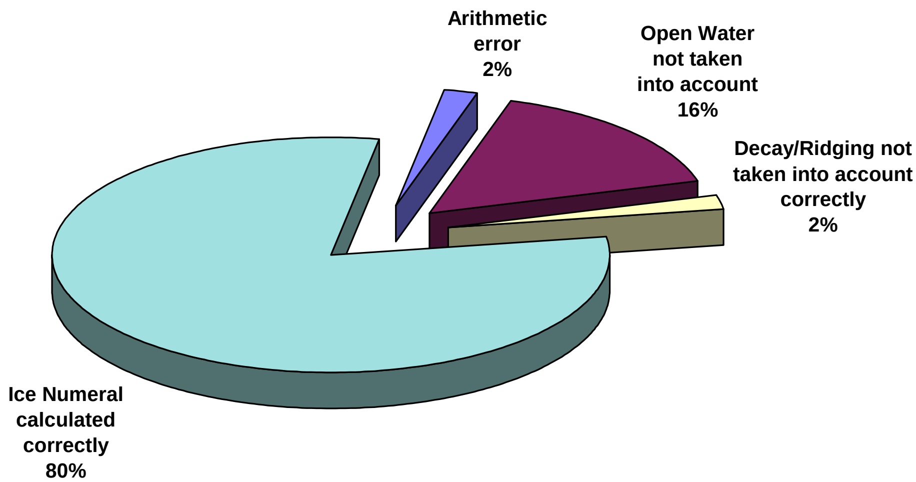

Figure 45: Pie chart showing the breakdown of the calculated Ice Numeral.

9.2 CCG Comments on the Ice Numeral

The CCG Officer of the Watch (OOW) was asked to comment on the ability of the Ice Numeral to reflect the damage potential of the ice regime. There were a significant number of events where the OOW did not feel that the Ice Numeral adequately reflected the severity of the ice regime. Table 15 lists the conditions and the reasons given why the OOW felt that the Ice Numeral was not representative of the damage severity. In some cases, the fact that floe size and the ability of the vessel to manoeuvre through the ice should be taken into account in the Ice Regime System. Some comments were made on the difficulty of estimating the decay of the ice and whether the decay bonus should be used. Some comments were made with respect to the vessels ability to operate in the ice regime despite the low Ice Numeral for the ice regime. In the authors view, this might reflect some misunderstanding of the Ice Regime System. AIRSS has been developed for ship safety, not operation in different ice regimes. In AIRSS, if the Ice Numeral is positive, the vessel would be allowed to proceed using due care and diligence. The actual numerical value reflects the severity of the system, but it is not a linear scale. Some of the confusion could be remedied if the Ice Numeral is viewed in terms of vessel safety and not operations.

9.3 Ice Numeral and Vessel Speed

Figure 46 shows a plot of vessel speed versus the Ice Numeral for all vessels. There is no evident trend. This, however, is not surprising since the vessel speed is not necessarily the highest speed that the vessel could travel in the ice regime. In many cases, the CCG vessels were engaged in activities that would limit their speed (e.g. escorting another vessel). It is interesting to note that the Sir Wilfrid Laurier is the only vessel with negative Ice Numerals on this plot. This, in spite of the fact that the vessel was rated as a CAC4 vessel for the 2003 test program (compared to the rating of Type A in 2002).

Table 15: CCG Comments on the Suitability of the Ice Numeral

Ice Concentration								Decay			Ridged			Speed	IN	DP #	Why Ice Numeral Not Representative
N	G	GW	FY	MFY	TFY	SY	MY	FY	SY	MY	FY	SY	MY	Knots			
0	0	0	0	0	2	2	5	Y	-	-	-	-	-		-13	2	1/10 OW, & 2/10 rotted TFY allowed room to maneuver ship in "softer areas". Risk of damage is in view of possibility of bouncing off 1 floe & laterally into a M.Y. floe on the cheeks of the V/L.
5	0	0	0	0	0	2	2	-	-	-	-	-	-	3	2	3	Does not impede ops at all - artificial low number means nothing
0	0	0	0	0	10	0	0	-	-	-	-	-	-	0	20	3	Had to enter floe very slowly to avoid cracking or splitting it. Egg with total concentration = 10, Stage of development = 4. with trace of 9. and Flow size = 7. Crescent moon on top of egg with 10 in it. At bottom two black triangles with slash under
0	0	0	0	0	0	1	0	-	-	-	-	-	-	7	16	4	High number. Was escorting tugs & barges at the time 5 - 7 knots.
0	0	0	2	2	5	0	0	Y	-	-	-	-	-	7	27	4	Ice numeral does not consider floe size which in this instance is small making it easier to transit the ice.
0	0	0	0	2	4	0	0	Y	-	-	Y	-	-	2	16	3	Ice rotten - mostly ridges - soft
0	0	0	1	2	4	3	0	Y	Y	-	-	-	-	3	26	4	In comparison to last ops. ice condition value only increased by 1 but progress is considerably slower. Might be better if ice numeral would differentiate between drainage and rotten.
0	0	0	0	0	0	3	2	-	-	-	-	-	-	5.1	-2	3	Low number mean nothing as to ice conditions. Was escorting 2 tugs & 8 barges (no ice class) at the time
1	0	0	0	0	0	2	3	-	-	-	-	-	-	0	-3	4	Low number means nothing as to ice severity. Was escorting 2 tugs & 8 barges at the time at 5.5 knots!
0	0	0	0	0	0	0	1	-	-	-	-	-	Y	6.5	14	4	Made good speed, no chance of damage
0	0	0	0	0	3	0	6	Y	-	Y	-	-	-	3.75	-4	3	Major decay in many areas between the larger floes.
0	0	0	0	0	0	2	0	-	-	-	-	-	-	9	12	3	No - was escorting 2 tugs & 8 barges (no ice class) at the time.
0	0	0	0	0	1	0	8	Y	-	Y	-	-	-	3.5	-12	3	No small 1st year bits clogging track for tug - made better progress than obs 10 though ice floes larger (M.Y.)
0	0	0	0	1	6	0	0	Y	-	-	Y	-	-	2	14	3	Not enough weighting for ridging wrong wt for melt/decay.
0	0	0	0	1	6	0	0	Y	-	-	Y	-	-	5	14	3	Not near operational limit of vessel
0	0	0	0	0	0	2	3	-	-	-	-	-	-	5	-3	3	Numbers too low - means nothing
0	0	0	0	0	6	4	0	Y	Y	-	-	-	-	3	26	3	Numeral is appropriate relative to the Terry Fox, but is not reflective of MV Bremen which became beset in the track several times
0	0	0	0	2	3	0	5	Y	-	Y	-	-	-	4	2	4	Rotten ice except for some old floes sp 3 - 5.5 kn. average 5 kn.
0	0	0	0	0	0	3	4	-	-	-	-	-	-	4	-12	2	Silly low number for the actual ice conditions
0	0	0	0	0	7	0	2	Y	-	-	-	-	-	4	10	3	TFY ice was definitely somewhat decayed, but not to the extent that the "decay" bonus could be "legally" used. Slight damage potential @ higher speeds if MY was hit in a lateral blow on shoulders.
0	0	0	0	0	0	0	10	-	-	-	-	-	-	0	-10	3	The ice is weak and porous yet shows no visible sign of decay on the surface. This type of ice has been penetrated using 3 of 5 engines and only 50% power on the starboard shaft.
0	0	0	0	0	1	0	3	Y	-	-	-	-	Y	6	2	4	V/L speed 8-10 knots, 2 M.E.
0	0	0	0	0	2	0	8	Y	-	Y	-	-	-	2	-12	2	Was workable at 5 kn, were able to break & maneuver
0	0	0	0	0	3	0	6	Y	-	-	-	-	-		-10	2	When compared to previous example, major change is floe size. This ice numeral (-10) indicates less severe conditions than the (-13) & yet because of Laurier's ability to navigate around smaller floes, the -13 is easier than the -10 regime. (see below)
0	0	0	0	0	2	0	8	Y	-	Y	-	-	-	2	-12	3	While Laurier able to make 5 kn + (?), tug Korts nozzles plugged with 1st yr bits of ice, progress slow.
0	0	0	0	0	6	0	4	Y	-	Y	-	-	-	3	18		Would be more reflective if it considered ridging which slowed progress a few times in this case.
0	0	0	0	2	8	0	0	Y	-	-	-	-	-	4	30	4	Yes for the Terry Fox. No for the MV Bremen which was still having trouble pushing thick floes in the track out of the way.

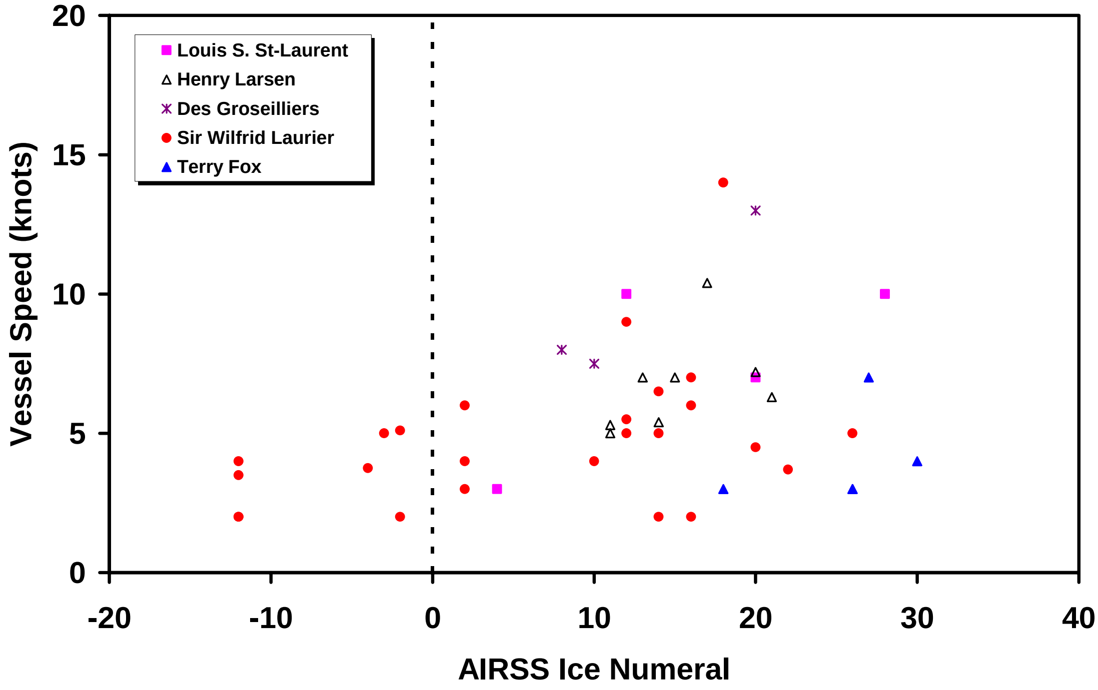

Figure 46: Vessel speed versus the AIRSS Ice Numeral for all vessels in the 2003 data collection program.

10.0 SUMMARY AND RECOMMENDATIONS

The second year of data collection of ice regimes onboard the Canadian Coast Guard icebreaking vessels provided very useful information. This, in spite of the fact that there were significantly fewer data events recorded in 2003. The data have been used to evaluate the ease of application of the Ice Regime System, to provide ground-truthed ice conditions for the Canadian Ice Service and to apply the experience of the CCG Commanding Officers to the Ice Regime System.

The comments provided by the CCG and ISS were very helpful, both in terms of factors that should be considered and the ease of understanding and using the Ice Regime System. In some cases, there still appears to be confusion on the intent of the system, especially as it relates to the safety and structural integrity of the vessel in different ice conditions. It would be very worthwhile to have a general discussion (Workshop) of the Ice Regime System with the CCG, and more focused data collection programs onboard the vessels.

11.0 ACKNOWLEDGEMENTS

The CHC would like to acknowledge the financial support of Transport Canada. They would also like to thank the Commanding Officers of the Coast Guard icebreakers, Darlene Langlois and Bob Zacharuk and the Ice Service Specialists of the CIS, Gary Sidock and Jean Ouellet of the CCG, and Victor Santos-Pedro of Transport Canada for his support of this work.

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