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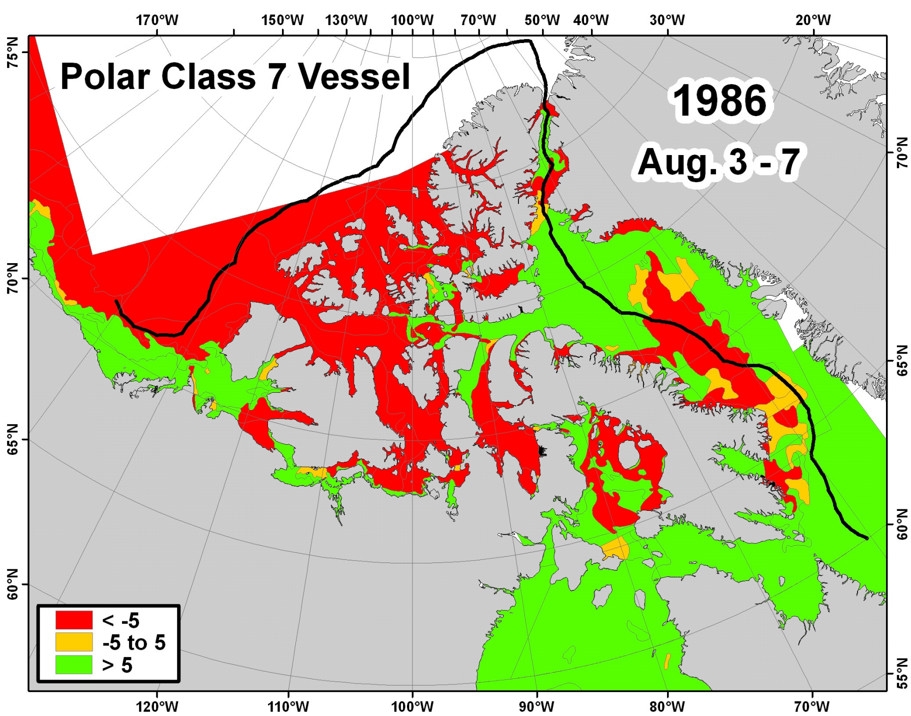

Technical Report CHC-TR-045

March 2007

CHC CANADIAN HYDRAULICS CENTRE
CENTRE D'HYDRAULIQUE CANADIEN

TP 14732E

Discussion Paper

Regulatory Update for Shipping in Canada's Arctic Waters: Options for an Ice Regime System

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ABSTRACT

The two ice-related systems that are used in the Arctic Pollution Prevention Regulations are briefly described and the research to establish their scientific basis is summarized. It is shown that neither system has a strong scientific basis. This fact, along with the new international initiatives for classifying the structural capability of Arctic vessels suggests that a review and updating of the Arctic regulations are in order. Four options are suggested for doing this: Modified Ice Regime System, Regimes Ice Chart System, Hybrid System, and the Arctic Certificate System. The general approach for each is described and the advantages and disadvantages are outlined. The report is intended to initiate a dialogue amongst all stakeholders of the shipping regulatory system in the Arctic.

RÉSUMÉ

Dans ce rapport, on présente une brève description des deux systèmes utilisés par la réglementation sur la prévention de la pollution dans l'Arctique, et on résume les études effectuées pour évaluer la validité de ces systèmes. On constate ainsi que le fondement scientifique de l’un comme de l’autre laisse à désirer. Cet état de chose, allié aux nouvelles initiatives internationales pour la classification des navires arctiques, démontre la pertinence de revoir et de mettre à jour les règlements s'appliquant à l'Arctique. On suggère quatre approches pour arriver à cette fin : la modification du système des régimes de glaces; la mise en place d’un système de cartes des régimes de glaces; un système hybride; et un système de certificat arctique. On présente une description générale de chacune de ces approches, ainsi que leurs avantages et inconvénients. Le but de ce rapport est d’initier un dialogue entre tous les principaux intervenants du système de réglementation sur le transport maritime dans l’Arctique.

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1.0 INTRODUCTION

The Canadian Hydraulics Centre (CHC) of the National Research Council of Canada has been investigating the scientific basis for the Transport Canada Arctic Pollution Prevention Regulations. These are based on two completely different approaches: the Zone-Date System and the Ice Regime System.

The results of this research show that neither system is based on strong science. This suggests that a different system that can build on their strengths could provide a better method for the Arctic. Moreover, the International Association of Classification Societies (IACS) has recently agreed to harmonize their classifications for Arctic vessels and have developed standards for seven Polar Classes. These are not taken into account in the current Canadian Regulations. All of these factors suggest that this is a suitable time to revisit the Arctic Regulations. This report briefly summarizes the existing regulatory approaches and discusses their limitations. Further, it outlines four different approaches, which would include Polar Class vessels, and which may prove to be a more suitable means of pollution prevention in Canada's Arctic waters. These approaches are put forward in a discussion forum and it is intended that feedback from stakeholders will provide added input.

The report is structured in the following format:

- Section 2.0 provides a brief overview of the Zone-Date System and its characteristics as a regulatory means for the Arctic.
- Section 3.0 provides a brief overview of the Ice Regime System and its characteristics as a regulatory means for the Arctic.
- Section 4.0 presents four different options for possible regulatory approaches. These are:
    - 4.1 Modified Ice Regime System
    - 4.2 Regimes Ice Chart System
    - 4.3 Hybrid System
    - 4.4 Arctic Certificate System
- Section 5.0 presents a short discussion of the way forward.

It should be noted that the discussions in this report will be brief but they will be supported by citations to appropriate references where full details can be found. This approach was done to ensure that the salient features of the four approaches are the main focus of the report.

2.0 THE ZONE-DATE SYSTEM

In 1972, the Canadian Government drafted the Arctic Shipping Pollution Prevention Regulations (ASPPR) to regulate navigation in Canadian waters north of 60°N latitude. These regulations include the Shipping Safety Control **Zones** (Figure 1), and the **Date** Table (Table 1), 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. In this system, the ship types and classes, in descending order of ice capability are:

Arctic Class:	10, 8, 7, 6, 4, 3, 2, 1A, 1
Type Ships:	A, B, C, D, E

The Arctic Class was normally but not accurately described as the thickness in feet of level ice that the vessel would have the power and strength to break. The Type ships represent the Classifications Societies' designation of ice-capable ships that are in turn equivalent to the Baltic Rules. The "Zone-Date System" is based on the premise that nature consistently follows a regular pattern year after year. It is a rigid system with little room for exceptions.

Figure 1: Map showing the regions of the Zones in the Zone-Date System.

Table 1: Zone-Date Table

Item	Category	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Zone 12	Zone 13	Zone 14	Zone 15	Zone 16
1.	Arctic Class 10	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year
2.	Arctic Class 8	July 1 to	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Oct. 15
3.	Arctic Class 7	Aug. 1 to Sept. 30	Aug. 1 to Nov. 30	July 1 to Dec. 31	July 1 to Dec. 15	July 1 to Dec. 15	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year	All Year
4.	Arctic Class 6	Aug. 15 to Sept. 15	Aug. 1 to Oct. 31	July 15 to Nov. 30	July 15 to Nov. 30	Aug. 1 to Oct. 15	July 15 to Feb. 28	July 1 to Mar. 31	July 1 to Mar. 31	All Year	All Year	July 1 to Mar. 31	All Year	All Year	All Year	All Year	All Year
5.	Arctic Class 4	Aug. 15 to Sept. 15	Aug. 15 to Oct. 15	July 15 to Oct. 31	July 15 to Nov. 15	Aug. 15 to Sept. 30	July 20 to Dec. 31	July 15 to Jan. 15	July 15 to Jan. 15	July 10 to Mar. 31	July 10 to Feb. 28	July 5 to Jan. 15	June 1 to Jan. 31	June 1 to Feb. 15	June 15 to Feb. 15	June 15 to Mar. 15	June 1 to Feb. 15
6.	Arctic Class 3	Aug. 20 to Sept. 15	Aug. 20 to Sept. 30	July 25 to Oct. 15	July 20 to Nov. 5	Aug. 20 to Sept. 25	Aug. 1 to Nov. 30	July 20 to Dec. 15	July 20 to Dec. 31	July 20 to Jan. 20	July 15 to Jan. 25	July 5 to Dec. 15	June 10 to Dec. 31	June 10 to Dec. 31	June 20 to Jan. 10	June 20 to Jan. 31	June 5 to Jan. 10
7.	Arctic Class 2	No Entry	No Entry	Aug. 15 to Sept. 30	Aug. 1 to Oct. 31	No Entry	Aug. 15 to Nov. 20	Aug. 1 to Nov. 20	Aug. 1 to Nov. 30	Aug. 1 to Dec. 20	July 25 to Dec. 20	July 10 to Nov. 20	June 15 to Dec. 5	June 25 to Nov. 22	June 25 to Dec. 10	June 25 to Dec. 20	June 10 to Dec. 10
8.	Arctic Class 1A	No Entry	No Entry	Aug. 20 to Sept. 15	Aug. 20 to Sept. 30	No Entry	Aug. 25 to Oct. 31	Aug. 10 to Nov. 5	Aug. 10 to Nov. 20	Aug. 10 to Dec. 10	Aug. 1 to Dec. 10	July 15 to Nov. 10	July 1 to Nov. 10	July 15 to Oct. 31	July 1 to Nov. 30	July 1 to Dec. 10	June 20 to Nov. 30
9.	Arctic Class 1	No Entry	No Entry	No Entry	No Entry	No Entry	Aug. 25 to Sept. 30	Aug. 10 to Oct. 15	Aug. 10 to Oct. 31	Aug. 10 to Oct. 31	Aug. 1 to Oct. 31	July 15 to Oct. 20	July 1 to Oct. 31	July 15 to Oct. 15	July 1 to Nov. 30	July 1 to Nov. 30	June 20 to Nov. 15
10.	Type A	No Entry	No Entry	Aug. 20 to Sept. 10	Aug. 20 to Sept. 20	No Entry	Aug. 15 to Oct. 15	Aug. 1 to Oct. 25	Aug. 1 to Nov. 10	Aug. 1 to Nov. 20	July 25 to Nov. 20	July 10 to Oct. 31	June 15 to Nov. 10	June 25 to Oct. 22	June 25 to Nov. 30	June 25 to Dec. 5	June 20 to Nov. 20
11.	Type B	No Entry	No Entry	Aug. 20 to Sept. 5	Aug. 20 to Sept. 15	No Entry	Aug. 25 to Sept. 30	Aug. 10 to Oct. 15	Aug. 10 to Oct. 31	Aug. 10 to Oct. 31	Aug. 1 to Oct. 31	July 15 to Oct. 20	July 1 to Oct. 25	July 15 to Oct. 15	July 1 to Nov. 30	July 1 to Nov. 30	June 20 to Nov. 10
12.	Type C	No Entry	No Entry	No Entry	No Entry	No Entry	Aug. 25 to Sept. 25	Aug. 10 to Oct. 10	Aug. 10 to Oct. 25	Aug. 10 to Oct. 25	Aug. 1 to Oct. 25	July 15 to Oct. 15	July 1 to Oct. 25	July 15 to Oct. 10	July 1 to Nov. 25	July 1 to Nov. 25	June 20 to Nov. 10
13.	Type D	No Entry	No Entry	No Entry	No Entry	No Entry	No Entry	Aug. 10 to Oct. 5	Aug. 15 to Oct. 20	Aug. 15 to Oct. 20	Aug. 5 to Oct. 20	July 15 to Oct. 10	July 1 to Oct. 20	July 30 to Sept. 30	July 10 to Nov. 10	July 5 to Nov. 10	July 1 to Oct. 31
14.	Type E	No Entry	No Entry	No Entry	No Entry	No Entry	No Entry	Aug. 10 to Sept. 30	Aug. 20 to Oct. 20	Aug. 20 to Oct. 15	Aug. 10 to Oct. 20	July 15 to Sept. 30	July 1 to Oct. 20	Aug. 15 to Sept. 20	July 20 to Oct. 31	July 20 to Nov. 5	July 1 to Oct. 31

Although the Zone-Date System has been used for many years, it does have a number of shortcomings:

1. The permission to proceed into a region and the regulatory control for not allowing entry into a region is based solely on historical ice data for any given vessel. It does not take into account the ice conditions at the time that the vessel wants to enter the region;
2. There has not been a recent update on the ice information in the Zone-Date System so the defined zones are not based on the more recent and complete ice information;
3. Even if the ice conditions are not hazardous outside the Zone-Date for a particular vessel, it is not straightforward for the vessel to get permission to enter the zone;
4. The Arctic Class classification of vessels currently in regulations is out of date with several existing vessels still in operation. The Equivalent Standards for the Construction of Arctic Class Ships (1995) and the new IACS polar standards (Kendrick, 1999; IMO, 2002; Santos-Pedro, 2003; IACS, 2007) have the more up-to-date classification for structural integrity. An essential pollution prevention measure for safe ship operation in ice-covered waters requires knowledge of the structural capability of the vessel in different ice conditions.

Recently, the Canadian Hydraulics Centre of the National Research Council of Canada (NRC-CHC) has been investigating the veracity of the Zone-Date System (Kubat et al. 2005, 2006a, 2006b) for Transport Canada. They have found that there are very large variations in the ice conditions from year-to-year. An examination of several years of data has shown that the Zone-Date System allows vessels into ice regimes which have a high potential to damage the vessel and it often restricts vessels from entering regions where the ice conditions are favourable for a safe passage. The large annual variations are not taken into account by this system - it has fixed (rigid) entry dates that often do not reflect the severity of the ice.

As an example, Figure 2 and Figure 3 show the range of Ice Numerals [see Equation 1] in Zone 11 for a cold and warm year, respectively. The circles represent the Ice Numerals calculated from the CIS ice charts. Positive Ice Numerals indicate that passage is allowed whereas a negative Ice Numeral indicates that there is a high potential for damage to the vessel. The Regional Ice Charts for the Canadian Arctic are issued monthly in winter/spring season and weekly in summer/fall season. The lowest values and the highest values of the Ice Numerals are connected by individual lines to highlight the range of Ice Numerals throughout the whole year. The bold solid rectangle represents the Zone-Date shipping season for a Type B vessel in Zone 11. Bold dashed rectangle indicates the "corrected" Zone-Date window, modified to reflect the actual ice conditions in the NorthWest Passage shipping route in Zone 11 for that year. The modified window basically covers the period with only positive values of Ice Numerals indicating that the vessel is allowed to proceed through the ice regime. Note that in Figure 2, there are a large number of negative Ice Numerals in the first half of the allowable dates for entry into the Zone. Thus, there is still a high potential for damage at that time. On the other hand, for a warmer year (Figure 3), there are still several weeks of positive Ice Numerals through the month of November where shipping could be allowed. However this is restricted by the Zone-Date System. These examples highlight the potential inadequacies of the Zone-Date System as a regulatory mechanism for Canada's Arctic waters.

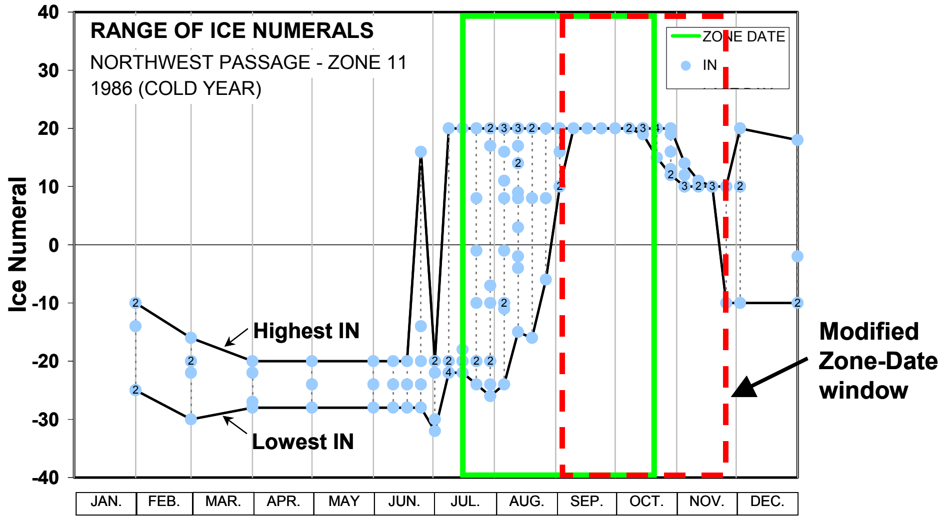

Figure 2 Range of Ice Numerals calculated from CIS ice charts for the NorthWest Passage shipping route in Zone 11, throughout year 1986 (colder than normal in period 1968-2004). The solid bold box shows the allowed dates for this region according to the ZDS. The bold dashed rectangle indicates the "corrected" Zone-Date window, modified to reflect the actual ice conditions in the Passage shipping route in Zone 11. Passage is not allowed in negative Ice Numerals.

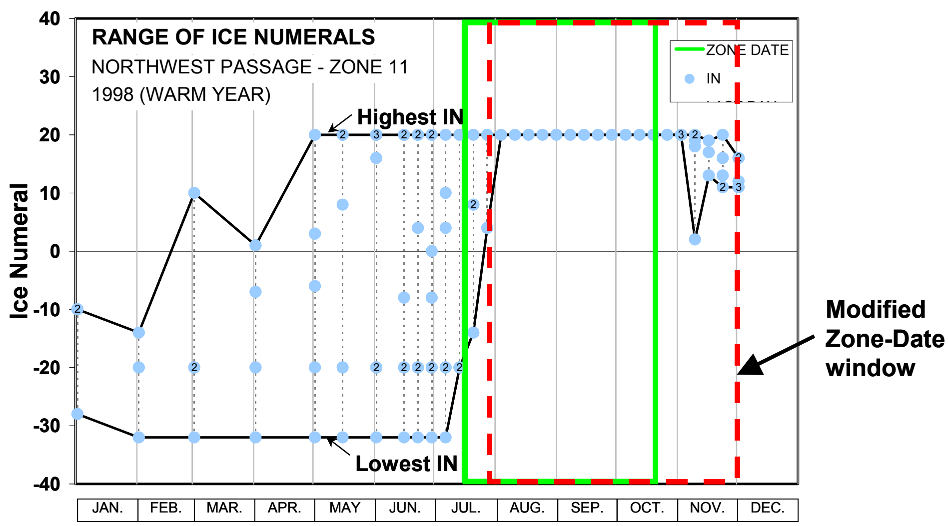

Figure 3 Range of Ice Numerals calculated from CIS ice charts for the NWP shipping route in Zone 11, throughout year 1998 (warmer than normal in period 1968-2004). Bold dashed rectangle indicates the "corrected" Zone-Date window, modified to reflect the actual ice conditions in the NorthWest Passage shipping route in Zone 11. Passage is not allowed in negative Ice Numerals.

3.0 THE ICE REGIME SYSTEM

Transport Canada, in consultation with stakeholders, made extensive revisions to the Arctic Regulations through the introduction of the Ice Regime System (ASPPR 1989; Canadian Gazette 1996; Equivalent Standards 1995; AIRSS 1996). The changes were 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 ship-owners by making use of actual ice conditions, as seen by the Master to determine transit.

In this 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 through that ice regime. The Ice Numeral (IN) is based on the quantity of hazardous ice with respect to the ASPPR classification of the vessel (see Table 2). The Ice Numeral is calculated from

$$IN = [C_a \, x \, IM_a] \quad + \quad [C_b \, x \, IM_b] \quad + ... \qquad [1]$$

where

IN = Ice Numeral
C_a = Concentration in tenths of ice type "*a*"
IM_a = **Ice Multiplier** for ice type "*a*" and Ship Category (from Table 2)

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 2). The Ice Numeral is therefore unique to the particular ice regime and ship operating within its boundaries.

The vessel class is defined in terms of vessels that are designed to operate in severe ice conditions for both transit and icebreaking (Canadian Arctic Class - **CAC**) as well as vessels designed to operate in more moderate first-year ice conditions (**Type** ships). The classes were developed based on a "nominal" ice type, which were correlated to the World Meteorological Organization (WMO) classification for sea ice as given in Table 3 (ASPPR 1989). In this system, the ship types and classes, in descending order of ice capability are:

Canadian Arctic Class:	CAC1, CAC2, CAC3, CAC4
Type Ships:	A, B, C, D, E

The Ice Regime System determines whether or not 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 a qualified Ice Navigator (ASPPR, 1989) 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.

At the present time, there is only partial application of the Ice Regime System, exclusively outside of the Zone-Date System. That is, vessel traffic is regulated by the Zone-Date System, but is allowed to proceed into a (normally) restricted zone if the ice conditions are such that the Ice Regime System gives a positive Ice Numeral. For this, the vessel must have a qualified Ice Navigator onboard and initially send an *Ice Regime Routing Message* to the CCG-NORDREG office indicating a positive ice regime. Following the voyage, an *After Action Report* must be submitted to Transport Canada. Full details are found in the applicable regulatory standards and guidelines.

Table 2: Table of the Ice Multipliers (IM) for the Ice Regime System

Ice Types			Ice Multipliers						
			Type Vessels					CAC	
			E	D	C	B	A	4	3
MY	Old / Multi-Year Ice		- 4	- 4	- 4	- 4	- 4	- 3	- 1
SY	Second Year Ice		- 4	- 4	- 4	- 4	- 3	- 2	1
TFY	Thick First Year Ice	> 120 cm	- 3	- 3	- 3	- 2	- 1	1	2
MFY	Medium First Year Ice	70-120 cm	- 2	- 2	- 2	- 1	1	2	2
FY	Thin First Year Ice:								
	stage 2	50-70 cm	- 1	- 1	- 1	1	2	2	2
	stage 1	30-50 cm	- 1	- 1	1	1	2	2	2
GW	Grey-White Ice	15-30 cm	- 1	1	1	1	2	2	2
G	Grey Ice	10-15 cm	1	2	2	2	2	2	2
NI	Nilas, Ice Rind	< 10 cm	2	2	2	2	2	2	2
N	New Ice	< 10 cm	"	"	"	"	"	"	"
	Brash (ice fragments < 2 m across)		"	"	"	"	"	"	"
	Bergy Water		"	"	"	"	"	"	"
	Open Water		"	"	"	"	"	"	"

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.

Table 3: Vessel Class for the Ice Regime System

CATEGORY	OPERATING ROLE	ICE TYPE
CAC 1	Unrestricted	Multiyear Ice
CAC 2	Transit or controlled icebreaking	Multiyear Ice
CAC 3	Transit or controlled icebreaking	Second Year Ice
CAC 4	Transit or controlled icebreaking	Thick First Year Ice
Type A	Transit	Medium First Year Ice
Type B	Transit	Thin First Year Ice - 2nd Stage
Type C	Transit	Thin First Year Ice - 1st Stage
Type D	Transit	Grey-White Ice
Type E	Transit	Grey Ice

Transport Canada also produced a Users Assistance Package (TC-UAP 1998), which provides information and a video on the Ice Regime System, and they sponsored the NRC-CHC to develop a Pictorial Guide to the Artic Ice Regime Shipping System (Timco and Johnston, 2003a).

Transport Canada sponsored the NRC-CHC to perform a considerable amount of research to investigate the scientific veracity of the Ice Regime System. This included developing an overall plan (Timco and Frederking, 1996; Timco et al. (1997). This plan identified seven "Tasks" to evaluate the system. Research was carried out to determine vessel damage caused by ice (Timco and Morin, 1997, 1998a; Kubat and Timco, 2003), the strength and decay of both first-year ice and Old ice (Johnston, 2004; Johnston et al., 2001, 2002a, 2002b, 2003a, 2003b; Johnston and Frederking, 2000, 2001a, 2001b; Johnston and Timco, 2002; Timco and Johnston, 2002). This research led to recommendations for revising the approach used to incorporate decay into the Ice Regime system (Timco et al., 2001; Timco and Johnston 2003b). The NRC-CHC research also included collaboration with the Canadian Ice Service to investigate the accuracy of Ice Charts (Kubat and Timco, 2001) and to develop the technology for producing an Ice Strength Chart (Gauthier et al., 2002: Langlois et al. 2003; Johnston and Timco, 2003, 2004, 2005). Data collection programs were also carried out onboard both commercial vessels, as well as Canadian Coast Guard icebreakers (Timco et al., 2003a; 2003b; 2004a, 2005). The research was summarized in a series of update reports (Timco et al., 1999, Timco and Morin, 1998b; Timco and Kubat, 2000, 2001a, 2001b). The results were presented to stakeholders at numerous meetings. Based on the research results and discussions with these stakeholders, a Discussion Paper was produced (Timco and Kubat, 2002). This led to a Workshop of Stakeholders in Montreal with the final outcome of a suggested modified Ice Regime System that better fit the empirical data (Timco et al., 2004b).

It is instructive to look at an example of both the shortcomings in the current Ice Regime System as well as the improvements that could be achieved using a modified approach. For this example, data collected onboard several commercial vessels were examined. The data from 1997 to 2002 were analyzed using both the existing AIRSS approach and the CHC-modified approach (as discussed in Timco et al., 2004b) for calculating the Ice Numeral. A total of 435 non-damage events were identified for Type B vessels from the dataset.

Figure 4 shows a pie chart comparison of the data analyzed using the existing AIRSS definition for the Ice Numeral and that calculated using the CHC-modified approach. Since these were all non-damage events, the Ice Numerals should be positive and the pie chart should only show positive Ice Numerals (i.e. all green). For the AIRSS approach, 13% of the events had a negative numeral even though there was no damage to the vessels. On the other hand, only 5% of the events had a negative numeral using the CHC-modified approach. There is a clear improvement. It illustrates that the existing Ice Regime System would have been too restrictive in this case but the modified approach would be more representative of the actual conditions for transit.

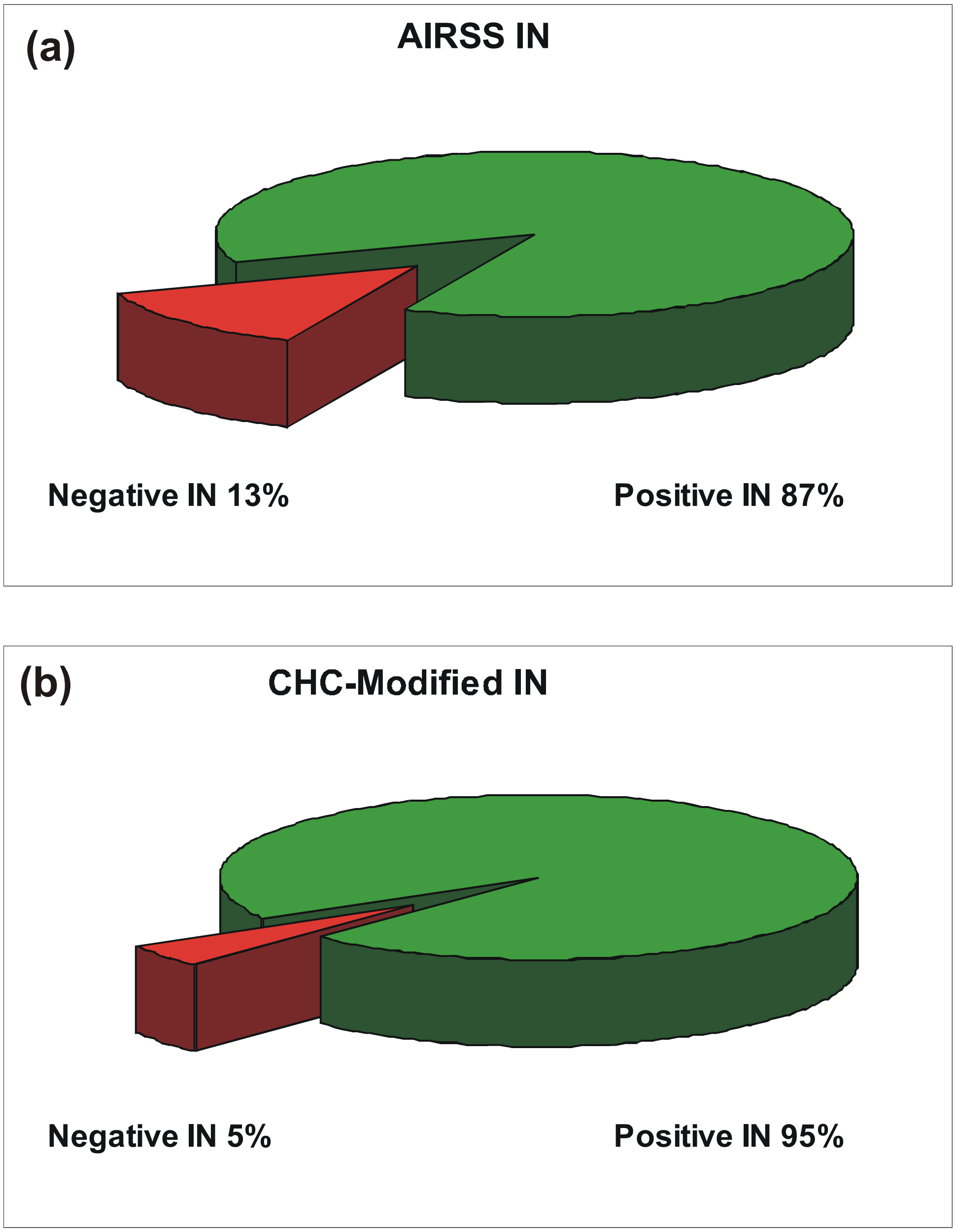

Figure 4: Pie chart comparison of the data for Type B vessels from 1997 to 2002. The data represents 435 events with no damage. Since these were all non-damage events, all the IN data should be green. The comparison illustrates the deficiencies of the existing Ice Regime System and shows the clear improvement using the CHC-modified approach.

4.0 FOUR APPROACHES

The inadequacies of the Zone-Date System and the existing Ice Regime System combined with the new changes in international harmonization of Polar Classes indicates that changes to the Arctic Regulations for Canada's Arctic are required. However, it is not clear which is the best approach to do this. The Regulations would have to have the following features:

1. Have a strong scientific basis (i.e. not be based on *ad hoc* approach)
2. Allow the operators sufficient opportunity to operate safely in the Arctic
3. Facilitate a means for operators to manage risk in a systematic way.
4. Develop a quantifiable system that will allow improvements and innovation in rule making.

Four different approaches are presented in the following sections. They are intended for discussion purposes with all the key stakeholders. The approaches that are presented are:

1. Modified Ice Regime System
2. Regimes Ice Chart System
3. Hybrid System
4. Arctic Certificate System

Each approach is discussed in the following sections along with some of their advantages and disadvantages.

4.1 Modified Ice Regime System

This approach would base the regulations strictly in terms of an Ice Regime System. It would have the same format as the existing Ice Regime System but would be updated to include the Canadian Hydraulics Centre's recommendations for modifying it (Timco et al., 2004b). Figure 5 illustrates the overall approach and lists the factors that would have to be developed to implement this system. Basically decisions would have to be made on the definition of suitable navigation experience and ice information technology, and the IACS Polar Class vessels would have to be integrated into the system (Kendrick, 2005). There are several advantages to this approach since most operators are familiar with it and it uses real-time ice information.

4.2 Regimes Ice Chart System

This approach would be based on the Ice Charts issued by the Canadian Ice Service. They would use the Daily Ice Chart to calculate the regions of go/no go based on the (modified) Ice Regime System. Figure 6 shows the overall approach. The CIS would issue "Regime Ice Charts" that show these regions for each vessel class. This system would be very visual and would reflect essentially real-time actual ice conditions. Figure 7 shows an example (based on a past Ice Chart). This approach would require more work load for the CIS since they would have to produce and send several more charts. This however could be relatively easily automated once the Ice Chart was produced.

Modified Ice Regime System

Approach:
The regulations would be based on an Ice Regime System that would evaluate the vessel capability to safely traverse the actual ice conditions during the voyage. It would be similar in format to the existing Ice Regime System but it would be modified to account for factors identified in the NRC-CHC evaluation.

Implementation Details:
The existing IRS would be modified to account for:
- Reward for summer (ice strength), experience, ice information
- Combine multi-year ice and second-year ice into Old Ice category
- Base Ice characteristics on actual thickness, not WMO nomenclature
- Re-define October 1 as start date for Second-year ice
- Requires a System that includes Arctic Class and Polar Class vessels
- Consider removing CAC vessels
- Review Type vessels to include Baltic classes only
- Applies to all seasons

Advantages:
- Operators familiar with this system
- Verified by numerous empirical data
- Relatively easy to implement and use
- Emphasizes increased safety through better knowledge of ice and operations in ice throughout all seasons
- Decision-making close to operators

Disadvantages
- Decisions required regarding definitions of suitable experience, equipment, etc.
- Could be difficult for Regulators to enforce
- Modifications to the existing IRS would require suitable scientific basis (mostly done)

Figure 5: Overview of the Modified Ice Regime System

Regimes Ice Chart System

Approach:
The Canadian Ice Service would calculate the regions of go/no go based on the daily Ice Chart and the Ice Regime System. They would issue "Regime Charts" that show these regions for each vessel class.

Implementation Details:
Since this would be based on the Ice Regime System, the modifications required for scientific agreement would be required. It would also take many more resources (and dollars) for the CIS to implement. The technology to produce these Regime Charts is readily available.

Advantages
- Very well defined areas of access for vessels
- A visual system which is easy to use
- Based on empirical data and best available ice information
- Easy for the Regulators to assess whether a vessel should be allowed in a specific region

Disadvantages
- Costly to implement and maintain
- Could be confusing since there would be many charts produced (depending upon vessel class and summer bonus)
- Requires the modifications to the Ice Regime System to use the modified approach
- Requires good ice forecasting technology
- Decision-making away from the operational level

Figure 6: Overview of the Regimes Ice Chart System

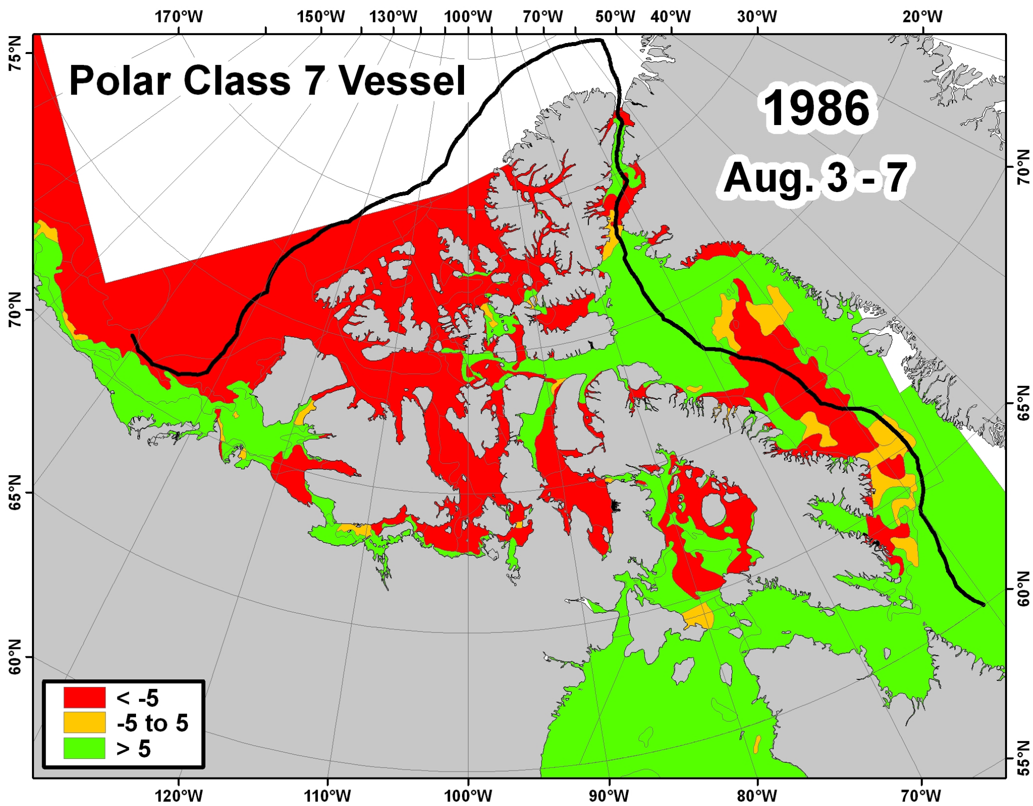

Figure 7: Regimes-Based Ice Chart showing the regions that would be allowed for a Polar Class 7 vessel (used here as an example to illustrate the output of this approach). The green regions would be allowable areas for the vessel (IN > 5). The yellow regions would require extra care in proceeding (-5 < IN < 5) and the red areas would be restricted areas for the vessel (IN < -5).

4.3 Hybrid System

A third option is the Hybrid System which would make use of both the Zone-Date System and the (modified) Ice Regime System in a direct manner. In this case, the existing Zones and Dates would be re-evaluated and updated based on the historical data from the last twenty years. This would provide a framework for allowable entries into the zones. Based on the research of Kubat et al. (2005, 2006a, 2006b), it is expected that this re-evaluation would result in longer entry times within the zones. However with the Hybrid System, vessels would be required to use the modified Ice Regime System at all times. Thus, the operators would have potentially more times to operate in the Arctic but they would be required to use the Ice Regimes System to define areas of allowable entry within the Zone. Figure 8 provides details of the step necessary for implementation and the advantages and disadvantages of this approach.

Hybrid System

Approach:
The existing Zones and Dates would be re-evaluated and updated based on the historical ice data from the last twenty years. This would provide a framework for allowable entries into the zones. The modified Ice Regime System would be used within the zones to define areas of allowable entry.

Implementation Details:
The existing Zones and Dates would be evaluated and new zone boundaries and dates would be defined for the whole Arctic region. The modifications to the existing Ice Regime System would have to be done to ensure that it is based on best available data.

Advantages
- Similar to the existing Zone-Date System so it can be used for general planning purposes by the Operators
- Makes use of best available information (both historical and actual) for implementation.

Disadvantages
- Requires the most effort to implement since both the Zone-Date System and the Ice Regime System would have to be updated
- Still no guarantee that the ice conditions, especially with climate change, will follow the zone-dates year-to-year

Figure 8: Overview of the Hybrid System

4.4 Arctic Certificate System

The Arctic Certificate System would be very similar to the Hybrid System except that owners/operators could calculate the ice-related capability of their vessel and apply to Transport Canada for an "Arctic Certificate". If the vessel and crew meet suitable, defined standards, the vessel would be assigned an "Arctic Certificate" to operate in certain ice conditions. These standards would include suitable experience of the Master or Ice Navigator and appropriate equipment for evaluating the ice conditions both on a regional and local scale. Vessels with an Arctic Certificate would not have to formally use the Ice Regime System within the allowable zone-date windows of the vessel. Further, the vessel could operate outside the allowable zone-date window by using the Ice Regime System (with follow-up reports to NORDREG). Thus there is an incentive for promoting safer vessels with this system since owners/operators with well staffed and equipped vessels would have more flexibility in operating in the Arctic. Figure 9 provides further details of this system including the step necessary for implementation and the advantages and disadvantages of this approach.

Arctic Certificate

Approach:
The Zones and Dates would be updated based on the past twenty years of historical ice data and new boundaries would be defined. Owners/operators would apply with suitable calculations to be evaluated with respect to the vessel structural integrity, experience of the crew, and ice information systems. If they meet suitable, defined standards, the vessel would be assigned an “Arctic Certificate” to operate in certain ice conditions in the Arctic. The vessel would not have to formally use the Ice Regime System within the allowable zone-date windows of the vessel. Further, the vessel could operate outside the allowable zone-date window by using the Ice Regime System (with follow-up reports to NORDREG)

Implementation Details:
The historical ice data would have to be evaluated to update the zones and dates for entry. Each vessel would have to be evaluated along with its available ice information technology and the experience of the crew to operate in the Arctic.

Advantages
- Very flexible system for the Operators
- Encourages safety through structurally sound vessels, good crews and good ice information
- Easy to use and possibly easy to regulate

Disadvantages
- Very costly to implement and maintain since work required to update the Zones and Dates, and to evaluate each vessel.
- The calculations and considerations to implement an “Arctic Certificate” pose various challenges
- It is a hybrid system of Zone-Date and Ice Regime System plus an Arctic Certificate System

Figure 9: Overview of the Arctic Certificate System

5.0 THE WAY FORWARD

There is a need to have an updated ice regime regulatory system in place for the Arctic to protect the environment and allow commercial shipping to operate safely. The best approach for doing this is not straightforward and will require input from all interested parties. Figure 10 shows a suggested approach to achieve this goal. The NRC-CHC will distribute this report to all key stakeholders and during the year, have a series of consultation meetings with them to discuss it and get their feedback. This will be followed by a Stakeholders Workshop. The outcome of the Workshop should provide a path forward.

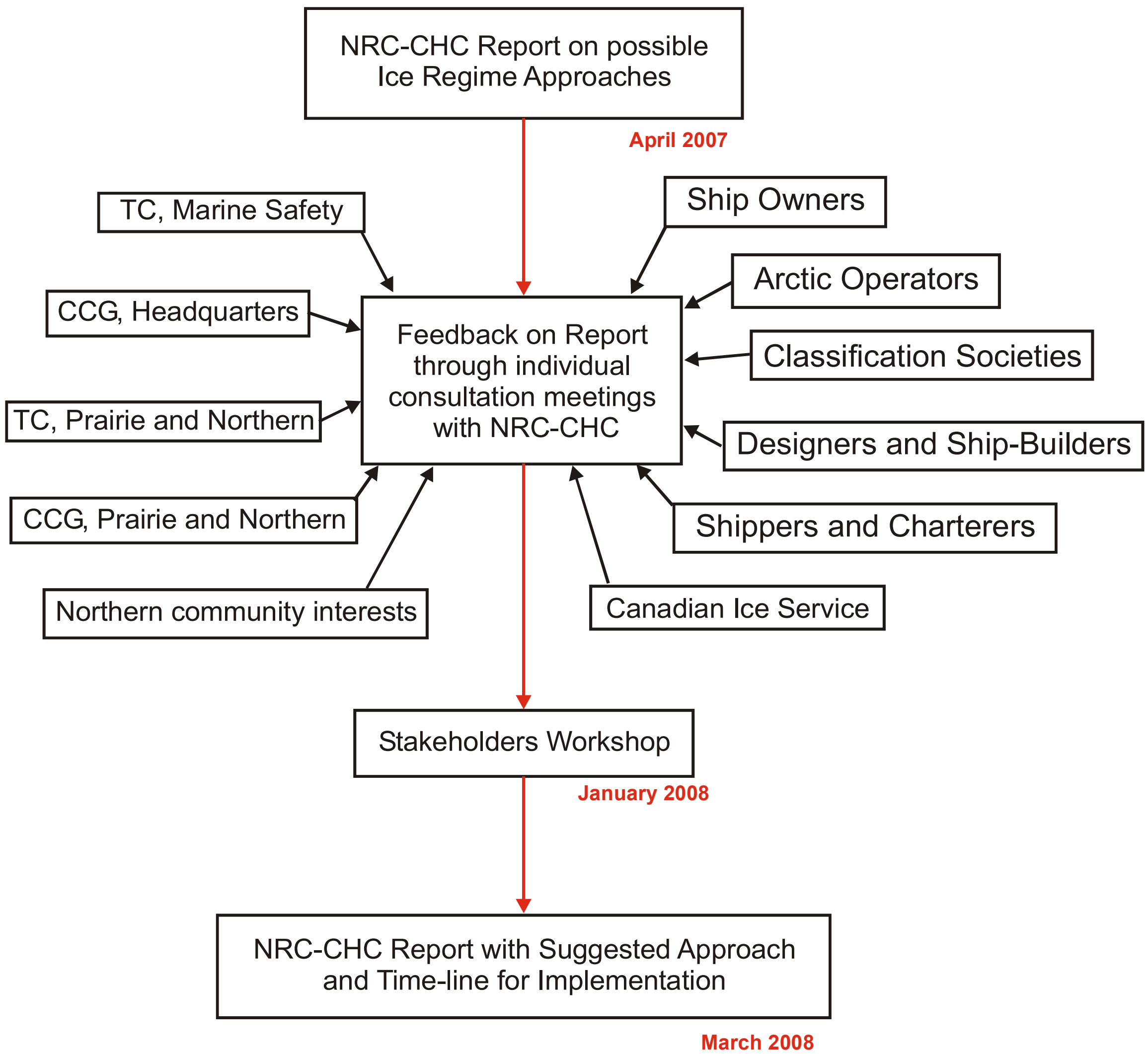

Figure 10: Schematic time-line of the Consultation Process

6.0 SUMMARY AND CONCLUSIONS

This report has summarized the two ice-related regulatory systems that are used in the Canadian Arctic as part of the Pollution Prevention Regulations. It was shown through several years of scientific research that neither system has a strong scientific basis. This fact, along with new international initiatives on classifying the structural capability of Arctic vessels, suggests that a review and updating of the regulations is required. The report presents four different potential approaches for this. A plan was proposed to get key input from stakeholders to develop a system that would allow the required flexibility for the owners/operators to manage risk in a systematic manner, as well as meet the necessary objectives of a regulatory framework that promotes safe and environmentally sound practices.

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