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Review of Surface Ship Fleets

Ice-Classed Ships

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PSPC Contract Number: W7714-156105/001-SV Task #50
Technical Authority: Benoit Arbour, Defence Scientist
Contractor's date of publication: March 2018

Defence Research and Development Canada

Contract Report
DRDC-RDDC-2018-C083
May 2018

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Canada

Review of Surface Ship Fleets
(Ice-Classed Ships)

This project delivers a global overview of all ships classed for ice operations and suitable for operating in polar waters

ISR Report 6114-01-01
Version 2.0
30 March 2018

Presented to:

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QUALITY ASSURANCE AND VERSION TRACKING

Authorization

Title	Review of Surface Ship Fleets (Ice-classed ships)	
Report number	W7714-156105/001/SV	
Version	2.0	Signature
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Approved for Corporate Release by	M. McCall	M McCall

Version Tracking

Ver.	Action	By	Date
1.0	Release to Client	McCall	26-Mar-2018
2.0	Release to Client	McCall	30-Mar-2018

Abstract

This project attempts to characterize and quantify the global fleet of ice-capable ships. It does this through a brief review of the history of polar navigation and the processes of classifying ships for safe operation in ice, arriving at a notional scale of equivalence for different current and historic classification schemes. Using search terms related to different levels of ice-capability, the project extracted from the Seaweb Ships Online (SW) database of over 200,000 ships some 11,000 ships that are characterized as “ice-capable.” This list was reconciled with various other available global lists of icebreakers. The noted ice-classification of each ship was related to the Canadian scale of ice-capability under the Arctic Shipping Safety Pollution Prevention Regulations to give a common point of reference for ships that can legally and safely go “into the ice". Some brief analysis of the list and the recent record of Northwest Passage voyages was conducted to qualify the coverage in terms of ice-capable ships missing from the list and ships/yachts that may choose to transit the NWP under Zone-Date regulations with no ice-class at all. The report concludes that while the list can be used as a guide to ships that can operate in heavier ice conditions of the Canadian Arctic (i.e. Thick First year Ice and heavier), it is not altogether predictive as many ships with lower ice classes will not have reason to depart their normal areas of operation (e.g. Ice-classed Baltic ferries) and, conversely, many non-ice-classed vessels may attempt transit in the brief opportunities provided by Zone-Date windows and climate change.

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1. INTRODUCTION

1.1 Background of polar voyaging

Stories of polar navigation have been alive almost as long as man has been recording his ocean voyages. The Greek voyager Pytheas, in the 4th century BC, was reputed to have discovered and circumnavigated Britain, and sailed north of there as far as the Arctic Circle and drifting sea ice. Later, it was largely whalers and fishermen who pioneered the routes to the Northwest Passage, pursuing the profusion of whales and fish reported in northern latitudes. This led eventually to a different class of arctic voyagers, those interested not only in skirting the ice but penetrating it to find a way through to the un-natural riches of the Orient.

Ships of these early voyagers were originally lightly modified standard ships. Sheathing of special hardwoods was added to the hull around the waterline to take the additional abrasion of the ice. Ships especially strengthened for their original use were re-purposed as polar exploration ships. In the case of the Royal Navy after the Napoleonic Wars, heavily built “bomb ketches” were the ship of choice, among whom were the famous ships of Franklin and others, HMS Erebus, Terror and many others of the same type. These ships, with decks and internal structures built to take the shock of heavy mortars fired from their decks, were retrofitted with auxiliary steam engines of about 30 horsepower to permit wind-less passage through the ice.

Increasingly, after this, ships were designed and built to incorporate the best features of successful polar vessels. The experience of whalers and sealers contributed to ships that were shorter and beamier, with cross-sections and internal structure calculated to resist pressure and lift the ship free of crushing forces. The prime example of this approach was Fidjof Nansen’s Fram, the first ship built with the express purpose of staying in the ice long enough to circumnavigate the Pole.

In more modern times, the range of vessels pressed into Arctic service has ranged the full spectrum from purpose-built nuclear-powered icebreakers to rigid-hulled inflatable boats and even Hobie-cat sailing catamarans, lending ever greater possibilities to the question of who may choose to navigate the north.

1.2 Historical trend and nature of traffic in Canada’s north

The anticipation of Arctic intrusions is a question of special relevance to Canada. The ceding of the Arctic islands to Canada by Britain in the 1880’s established territorial claims that are largely uncontested. This has not been so in the maritime domain, in which the distinctions between internal waters (or territorial seas) and international straits has made for differences of opinion between Canada and others, notably the US. The historical record and ongoing practice of Arctic navigation is thus of key importance to Canada.

The Canadian Arctic was an area of great interest but sparse presence for other than Inuit in the past century. The early 20th century succession of explorers, hydrographers, government agents and Royal Canadian Mounted Police (RCMP) sought to further establish claims of ownership by mapping and occupying the white spaces on the chart.

This was abetted by the forced relocation of Inuit from Hudson's Bay to the High Arctic in the 1950's, resulting in the increasing requirement for seasonal resupply voyages by both government and Hudson's Bay Company (HBC) ships. The creation of "Canada's Arctic Port" [1] at Churchill on Hudson's Bay in 1917 enhanced the HBC's centuries-long traditional reach into the Canadian west to provide an outlet for Canadian wheat. Following the Second World War, combined Cdn-US shipping provide the materials for the building of the Distant Early Warning (DEW) Line of air-defence radar sites from Labrador to Alaska. Many of these ships were war-surplus general cargo vessels, but increasingly the use of true icebreakers, such as the US Wind-Class ships, was required to escort such vessels. Still, the nature and volume of traffic in the north was fairly specialized and thin.

A wave of resource extraction excitement in the late '60's to mid-'80's brought additional enthusiasm to arctic navigation. The discovery of oil in the Beaufort Sea and the Alaska Slope stimulated the ultimately abandoned attempt of Humble Oil to pioneer a route to Europe through M'Clure Strait in 1969-70. Nonetheless, offshore drilling and oil development boomed in the Beaufort Sea through the mid-'80's. The opening of the Polaris (Little Cornwallis Is) and Nanisivik (Baffin Is) lead and zinc mines in the early '70's fuelled an expansion in ice-navigation technologies. Fednav's MV Arctic was designed and built in 1978 to service both these mines as an ice-breaking cargo ship without icebreaker escort. Other developments such as spoon-shaped bows and water-lubrication systems were tried out in such designs as the Canmar Kigoriak (1979), which also incorporated new ideas for winterization of ships in the Arctic.

Despite these developments, traffic through the Canadian Arctic remains sparse. While traffic into the north has tripled from 2005-2014, up to 302 trips, the greatest part of this growth has been in fishing vessels (from 20 to 119). Cargo barges, general cargo, tanker and bulk carrier traffic all generally increased between 50-100% over this period. Cruise ship traffic increased from 2005 to 2008 and then has wavered between 10 and18 per year since. Most of this is destination traffic; the number of through-transits of the Northwest Passage (NWP) was much less at only 6-30 per year. Of these, the majority in every year 2008-2014 were pleasure craft (between 7 and 22 each year).[2][3][4] A complete list of NWP transits maintained by the Scott Polar Research Institute demonstrates the increasing prevalence of yachts of less than 25m Length overall (LOA) among the transiting vessels.[5]

Arctic tourism, in both small and well-found ships, is expected to continue to increase, although with wide variations from season to season. [6] Much of this traffic has little or no "Ice Class", and is lured by the expectation of diminishing ice cover in the NWP. A key example of the trend was the passage of the MV Crystal Serenity in 2016; this was the largest cruise ship to transit the NWP at 68,870 GT and over 1700 passengers and crew. While the transit was repeated in 2017, Crystal Cruises appears to favouring exclusivity rather than volume with the launch of a 25,000 GT "Polar Mega-yacht" that is ice-classed as PC6.[7]

1.3 Environmental and political concerns/responses

Well before public understanding of climate change generated a surge of eco-tourism in the north, Canada was becoming concerned about recognition of her sovereign claims to the Arctic islands and waterways.[8][9] The natural resources boom of the 1970's stimulated these fears, which were exemplified by the passage of the SS Manhattan in 1969. The intended cargo of this ship suggested potential for environmental disaster with the then-recent memory of the Torrey Canyon oil spill in the English Channel. Accordingly the Arctic Waters Pollution Prevention Act (AWPPA) was passed in January 1970, in time for the Manhattan's second voyage to the NWP.

The AWPPA set the framework for a series of related regulations, principally the Arctic Shipping Pollution Prevention Regulations (ASPPR[1])[10], which governs the conditions under which vessels of greater than 100 GT may navigate in the Canadian Arctic. While the regulations are oriented toward safety of shipping (and through that, environmental protection), they also provide the means by which Canada asserts sovereignty over the north. This is important because the Third UN Convention on Law of the Sea (UNCLOS III, 1985), while recognizing the right of coastal or oceanic states to claim archipelagic responsibility, provided for the right of passage through "International Straits" connecting portions of the high seas. Certain states, notably the US, claim this right for the NWP, disputing Canada's declaration of straight baselines and "Internal Waters" status for these waters. Nonetheless, no-one dispute's Canada's right to protect the environment, so the ASPPR provide effective mechanisms for enforcing safety standards, ship emissions and access to the north.

Key among the provisions of the ASPPR is a table of accessible dates, by area and ship type, for different zones of the Arctic. This is the fundamental screen on entry to the north, assembled by historical records of successful voyages, ship damage experiences, scientific study and climatology. Ships must report to the Maritime Communications and Traffic Services (MCTS) system of the Canadian Coast Guard ("NORDREG" in the Arctic) before entering Canada's Exclusive Economic Zone north of 60N, to verify that they have an Arctic Waters Pollution Prevention Certificate and that their intended voyage conforms to the Zone and Date access permitted for their assigned ice-class. Under the "Zone-Date System" (ZDS), a narrow window exists in the late summer when ships of very low or no ice class are also permitted passage, but this does not mean that the NWP is always clear of ice at this time.

Vessels wishing greater flexibility in accessing the NWP may voyage outside of their ZD limits, if they carry a Transport Canada-recognized Ice Navigator (IN). The IN is trained in identification of different ice types, assessment of risk and familiarity with Canadian Regulations in order to advise the ship's master of preferred routing to remain within ice regimes compatible with the ship's capabilities. The methodology for achieving this is detailed in Canada's Arctic Ice Regime Shipping System (AIRSS), of which more detail is provided at Section 2.5 below. With the adoption of the International Maritime Organization (IMO) Polar Code in 2017, Canada has agreed that a comparable system, the IMO's Polar Operational Limit Assessment Risk Indexing System (POLARIS) shall be acceptable for determining passage outside the ZDS dates. The IMO stipulates qualification experience for IN equivalent to that demanded by Canada, and the Nautical Institute (NI) of London has instituted a scheme that provides internationally-recognized certification of such qualification.

Multiple instruments and processes are therefore in place to regulate the passage of vessels (at least those greater than 100 GT) through the Canadian Arctic. The principal

[1] Reissued in 2018 as the Arctic Shipping Safety and Pollution Prevention Regulations (ASSPPR), incorporating elements of the IMO's Polar Code

deciding factor in the decision to voyage north and the choice of dates to attempt passage, however, is the strength and capability ("Ice-Class") of the ship.

1.4 Objectives of the study

The principal task of this study is to "characterize ice-capable surface vessels" while demonstrating a deep understanding of the role of classification societies in developing and assigning "ice-class". This is particularly to include the International Association of Classification Societies' (IACS) Polar Classification and its relation to other classification schemes.[11]

The background of the Statement of Work indicates that the project is related to the Associate Deputy Minister – Science and Technology's (ADM(S&T)) All Domain Situational Awareness – Threat, Requirements, Gaps project (ADSA). This project thus aims to enable ADSA to understand which ships can navigate, when and where, in the Canadian Arctic.

The main product of the project is a spreadsheet listing all known "ice-capable" surface vessels. However, "ice-capable" is a loose term which covers everything from the least ice-strengthened harbour tugs to the largest, all-season, globally deployable nuclear icebreakers. Accordingly, the authors of this report attempt to add value in further characterizing ships, not only as those "capable" of working in ice, but also those "likely" to venture into or through Canada's Arctic waters.

1.5 Qualifications of the contractors

The authors and researchers for this project bring a significant range of pertinent experience to this task. The lead author, RAdm Nigel Greenwood is a 37-year surface warfare officer of the Royal Canadian Navy (RCN), whose last jobs included responsibility for maritime defence of western Canada and Search And Rescue (SAR) for BC and the Yukon. He is a currently licensed Master Mariner and a qualified ice-navigator, having completed four voyages in the Northwest Passage in the last four years, the last of which onboard the Chinese icebreaker XUE LONG. Captain Duke Snider is a 30-year veteran of the Canadian Coast Guard (CCG) whose business, Martech Polar Consulting Ltd (http://martechpolar.com), is in the forefront of providing ice-navigators to vessels wishing to enter Canadian waters under the Arctic Ice Regime Shipping System (AIRSS). He has personally completed numerous transits of the NWP, including both the earliest and latest seasonal transits on record, onboard the Finnish multi-role support vessels FENNICA and NORDICA. As the current President of the London-based Nautical Institute, he has recently led NI's support of IMO's Polar Code and the NI's implementation of a certification scheme for ice-navigators. Captain Gary Paulson is a 35-year veteran of the RCN who has commanded five different ships. For the past ten years he was the VP Operations and Harbour Master at the Port of Prince Rupert, responsible for port operations and security.

2. ICE CLASSIFICATION

2.1 Evolution of Ice-Classification

Design and construction to a formal classification standard for operating in ice covered waters is generally considered to date back to late 1800s and early 1900s for ships operating in the Baltic. Ice Classification refers to the additional design criteria required by national administrations or classification societies for vessels to safely operate in ice covered waters. These standards may include such elements as heavier scantlings, additional framing, power and equipment requirements above those required for non-ice going vessels. As experience was gained over decades of operation in ice, rules evolved becoming more complex due primarily hard won trial and error. The first combined rules developed to standardize among differing agencies are believed to be the pre-1965 Finnish-Swedish (Baltic) rules, elements of which were often the basis of external classification society rules.

By their nature, ship design and construction rules are evolutionary rather than revolutionary. As such, they are ever changing as new experience, technology and science changes. Individual society or flag state administration rules therefore often have evolved independently and though many basic elements are shared, specific limitations, allowances and notations describing the divisions and sub-divisions of ice class can vary significantly. Owners have been able to select whichever classification society or flag state rules best suited their own operations. This pick and choose method of selecting ice class however, and the wide range of differing ice-classes become problematic when coastal state regulations are in place that require adherence for vessels operating within national waters regardless of a classification society ice class. The Finnish-Swedish rules (First year ice only, updated in 1971, 2002, 2010) and Canada's Arctic Shipping Pollution Prevention Regulations (ASPPR) 1972 (updated in 1989 and 1995 and recently modified in 2017 to incorporate IMO's Polar Code) are examples. The result has been the development of numerous tables of equivalency that nominally provide guidance for compliance to coastal state requirements (see Section 2.4 "Equivalencies") or across classification standards.

Canada's ASPPR requirements for design and construction and Russian Register/Northern Sea Route Administration (MRS/NSR) are considered the first ice class rules with a particular focus on polar waters. Both flag states recognized the far more onerous ice conditions prevalent in Arctic waters encumbered by multi-year sea ice and glacial ice and icebergs. Much heavier construction and horsepower requirements were necessary to be defined that would permit vessels to safely transit these heavier ice regimes. A gradual divergence between polar and subpolar ice classes had developed, in addition to the classification differences that already existed.

During the 1990's IMO unsuccessfully attempted to address the broad divergence of standards in design, construction and operation of ships in Polar Waters with the development of a stand-alone convention for Polar Shipping. The result of several years of work was only a "guideline" document that was not mandatory, and at the time applied only to Arctic shipping. The IMO Guidelines for Ships Operating in Arctic Ice Covered Waters (2002) made very little mention of specific ice-classification or construction standards. After a series of newsworthy incidents involving vessels in ice covered

Antarctic waters, the Antarctic Treaty Organization requested IMO's guidelines be expanded and the original guidelines were amended and re-issued as the IMO Guidelines for Ships Operating in Polar Ice Covered Waters (2010). Very little change in the substance of the guidelines was effected, however the geographic scope was extended to cover the Antarctic.

2.2 Classification Societies

National administration ice regulations are often focused on controlling traffic in territorial waters by requiring vessels to meet specific standards within those waters. Environmental and safety requirements in national waters are the primary drivers. Outside of territorial waters, owners and insurers turn to non-profit, non-governmental classification societies for ice class guidance. Classification societies banded together as members of the International Association of Classification Societies seek to ensure international harmonization through agreements in class such as the Unified Rules for Polar Class Vessels. To date, though some similarity does exist in nomenclature and notification exists between classification societies, much divergence in specific classification ice class requirements still exists. The first truly unified classification society rules for ice construction are the Unified Rules for Polar Class Construction. Though these rules exist, some variance between classification societies may still exist. Broad differences still exist in sub-polar ice classes across the classification societies.

In the absence of detailed unified standard of polar design and construction standards and IMO guidance, the International Association of Classification Societies (IACS) developed and released the Unified Rules for Polar Class Construction in 2012. These detailed classification standards for polar class vessels are now further enhanced by more general goal based technical standards now outlined in the Polar Code to form an overarching international standard. Taken together with sub-polar ice classes such as the Finnish-Swedish rules and other classification society ice-classes, a complete range of ice classes now exists. These include, among other classes:

- Canadian Arctic Shipping Pollution Regulations (9 classes)
- Russian MRS/NSR (9 classes, 4 icebreaker)
- Finnish Swedish Ice Class Regulations (first year ice only) (5 classes)
- Lloyds Register LR (5 Polar, 5 Baltic classes)
- Det Norske Veritas/Germanischer Lloyd DNV-GL (3 icebreaker, 3 Polar, 5 Baltic classes)
- American Bureau of Shipping ABS (5 Polar, 5 Baltic classes)

2.3 Elements of Ice Classification

"Ice Classification" is a grade assigned to a ship to indicate a particular Classification Society's determination and endorsement of a vessel's suitability to operate in polar waters. Key among the considerations for such endorsement are:

a. Performance. Many classification societies spell out the expected capability in terms of a ship's ability to move through a certain thickness of compact ice, or in terms of limiting concentrations and thickness of different types of ice (e.g.: multi-year hard ice or first-year ice). Other schemes, for instance the Russian Ice

Passport approach, indicate the range of safe operations by speed regimes for each vessel in different kinds/thicknesses of ice.

b. Hull strength. Performance is a function of many factors, primarily hull strength which depends on structure and plating. Higher ice-classed ships have a special “ice-belt” around the waterline area to sustain the wear of constant ice interaction.
c. Steel quality/resilience. Steel must be specially formatted with low-temperature resilience so as not to fracture from brittleness in contact with ice.
d. Power. The ship must have sufficient power to push through ice commensurate with the strength of the hull. This depends in turn on the propulsion mechanism and also the form of the hull for effective use of the ship’s power.
e. Manoeuverability. The ability of a ship to manoeuvre in ice will depend on propulsion mechanism (e.g.: twin azipods are becoming more popular in icebreaking ships as giving a great facility of clearing ice astern and course alternations in ice) and on the ship’s hull form. Ships that are relatively “short and fat” without long parallel mid-body sections are more manoeuverable.
f. Winterization factors. Ships’ systems must be configured for operation in waters that are at or close to freezing temperatures. This means that sea-suctions must be lower in the hull and provided with means of ensuring that sea-chests do not freeze-up or become clogged with slush.
g. Self-sufficiency. Ships must be provided with ample reserves of fuel and food and spares to be self-sufficient for extended periods in case they get stick in the ice. Generally speaking, polar ships will be capable of un-supported operations for periods of months and distances of thousands of nautical miles.
h. Safety/Survival Equipment. Standards of ice classification extend to immersion suits, enclosed lifeboats and other means of survival in a cold climate away from the ship.

2.4 Equivalencies

Not all ice classes are created equal. For many reasons, individual administrations and classification societies have taken different routes to determine components and requirements of ice class. Nomenclature differs across classification societies and administrations. Specific requirements for scantlings, frame spacing and equipment can vary minutely between ice-class, even if the class notation appears similar.

Tables of equivalencies are at best approximations and maintain relevancy only as long as the reviewed ice-classes remain unchanged and thus are only suitable as “rule of thumb guidelines”. In practice, comparisons must be made on a case by case basis. For example, a vessel operator wishing to operate within Canadian Arctic Shipping Safety Control Zones using the AIRSS “route” as opposed to Zone/Date restrictions, must submit design and construction criteria for ships classed outside Transport Canada’s ice-class for approval and equivalency. Most classification societies are delegated to do this on behalf of Transport Canada, however, each case must be applied for individually and detailed design comparison made based on current specific rules of design and construction.

The table at in Annex A presents a table of notional Ice Class Equivalencies. This table must be carefully caveated by the recognition that different ice classes do not in all cases form a one-to-one correspondence. There are overlaps of different degrees between different schemes, and not all classification societies provide a full scheme of classification from highest “icebreaking” classes to lowest “ice-strengthened” endorsements. Nonetheless, for the purposes of this study, the table is sufficient to relate current and also legacy ice-classes of all sources to current standards. This table was compiled by merging multiple tables of ice-class equivalence and also by correlating the descriptive performance criteria of several classifications.

The principal common standard to which all vessels’ ice-classes are reduced is the Canadian ASPPR scheme of 9 levels. This provides the most direct relation to ability to operate (practically and legally) in the Canadian Arctic.

2.5 Ice Classification and Risk Management in Ice

Bridge officers experienced in ice operations must always take into consideration the ice classification of their vessel in combination with present or expected ice conditions in their intended area of operation in order to adequately manage risk. Understanding both the limitations and capabilities of different ice classes relative to a prevalent ice regime is key.

Experienced Ice Navigators will always take into consideration the ice classification of the vessel that provides the foundation understanding of the vessel’s capability in ice. Understanding the manoeuverability, structural limitations and vulnerabilities is necessary to determine what ice regimes a vessel can safely enter and negotiate or to avoid completely. In short, higher ice class denotes greater strengthening and capability and the ability to negotiate more onerous ice conditions. Lower ice class may require avoidance of any ice other than the thinnest and least concentrated.

Simply having a ship with a high ice class does not ensure safety. Understanding the ship’s capability within a constantly changing ice environment, and a thorough understanding of that ice environment is necessary for effective risk management. In-experienced bridge teams have often been the cause of serious incidents in ice due to poor decisions. Modern decision-making aids such as Canada’s AIRSS (described below) and IACS/IMO Polar Operational Limit Assessment Risk Indexing System (POLARIS – also described below) still require that those making inputs fully understand ice development, degradation and movement to be meaningful risk analysis tools.

2.6 Ice Navigation in the Canadian Arctic under ASSPPR

The recently reissued Arctic Shipping Safety and Pollution Prevention Regulations (ASSPPR) provide three methods of determining GO/NO-GO for ships operating in Canadian Arctic territorial waters and EEZ. The first system known as “Zone Date” originates from the original Canadian Arctic Waters Pollution Prevention Act and associated Canadian Arctic Shipping Pollution Prevention Regulations (ASPPR) and Shipping Safety Control Zones Regulations (SSCZ). The second system is the Arctic Ice Regime Shipping System (AIRSS) which produces a positive or negative (GO/NO-GO) Ice Numeral as a product of the ship’s ice class and actual concentrations of different types of ice. The third system is the IMO POLARIS scheme which, while similar in methodology to AIRSS, provides greater flexibility of operational response to actual ice conditions.

2.6.1 Shipping Safety Control Zones and Zone Date System (SSCZ/ZDS)

The Shipping Safety Control Zones (SSCZ) divides Canadian Arctic territorial waters into 16 zones based on historical ice cover. Generally speaking, from Zone 1 to Zone 16, each zone decreases in relative severity based on assumed ice conditions. Thus, Zone 16 is assumed to exhibit the least onerous ice conditions, with Zone 1 the most onerous.

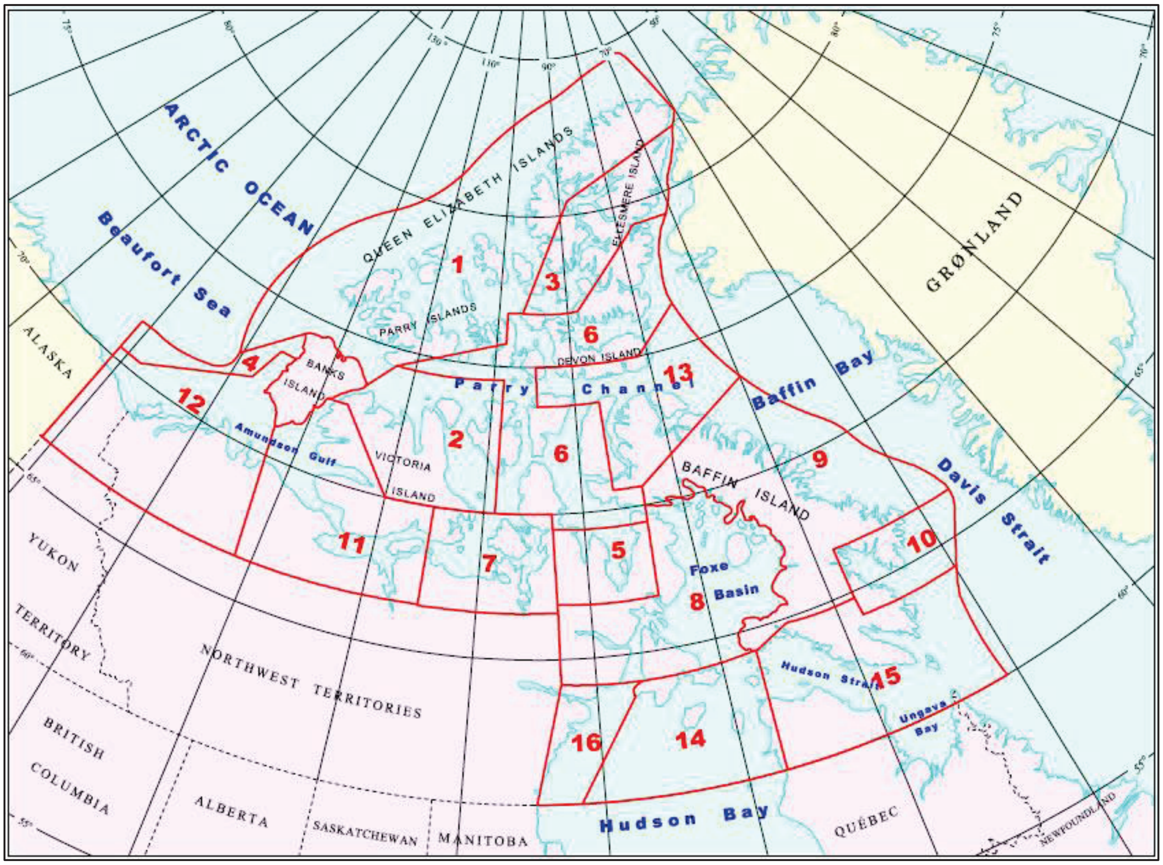


Figure 1: Arctic Shipping Safety Control Zones [12]

Within the ASPPR, these zones are then related to a table that describes safe dates of earliest entry and latest departure for each of the ASPPR ice classes. Operators enter the table on the left with the vessel's Canadian Ice Class and from the top with the SSCZ Zone number to find the date that the vessel is permitted to operate within that zone. Since the 1970s, the arbitrary date restrictions have been found to be invalid as ice conditions can often be heavier or lighter than historical average. It can be readily surmised that such an arbitrary restriction based on historical dates could preclude safe operation of a vessel in a zone in which conditions were would in fact permit safe passage.

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17
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, CAC 1	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, CAC 2	Jul. 1 to Oct. 15.	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
3	Arctic Class 7	Aug. 1 to Sept. 30	Aug. 1 to Nov. 30	Jul. 1 to Dec. 31	Jul. 1 to Dec. 15	Jul. 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, CAC 3	Aug. 15 to Sept. 15	Aug. 1 to Oct. 31	Jul. 15 to Nov. 30	Jul. 15 to Nov. 30	Aug. 1 to Oct. 15	Jul. 15 to Feb. 28	Jul. 1 to Mar. 31	Jul. 1 to Mar. 31	All year	All year	Jul. 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	Jul. 15 to Oct. 31	Jul. 15 to Nov. 15	Aug. 15 to Sept. 30	Jul. 20 to Dec. 31	Jul. 15 to Jan. 15	Jul. 15 to Jan. 15	Jul. 10 to Mar. 31	Jul. 10 to Feb. 28	Jul. 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, CAC 4	Aug. 20 to Sept. 15	Aug. 20 to Sept. 30	Jul. 25 to Oct. 15	Jul. 20 to Nov. 5	Aug. 20 to Sept. 25	Aug. 1 to Nov. 30	Jul. 20 to Dec. 15	Jul. 20 to Dec. 31	Jul. 20 to Jan. 20	Jul. 15 to Jan. 25	Jul. 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	Jul. 25 to Dec. 20	Jul. 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	Jul. 15 to Nov. 10	Jul. 1 to Nov. 10	Jul. 15 to Oct. 31	Jul. 1 to Nov. 30	Jul. 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	15 juil. au 20 oct.	Jul. 1 to Oct. 31	Jul. 15 to Oct. 15	Jul. 1 to Nov. 30	Jul. 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	Jul. 25 to Nov. 20	Jul. 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	Jul. 15 to Oct. 20	Jul. 1 to Oct. 25	Jul. 15 to Oct. 15	Jul. 1 to Nov. 30.	Jul. 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	Jul. 15 to Oct. 15	Jul. 1 to Oct. 25	Jul. 15 to Oct. 10	Jul. 1 to Nov. 25	Jul. 1 to Nov. 25	June 25 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	Jul. 15 to Oct. 10	Jul. 1 to Oct. 20	Jul. 30 to Sept. 30	Jul. 10 to Nov. 10	Jul. 5 to Nov. 10	Jul. 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	Jul. 15 to Sept. 30	Jul. 1 to Oct. 20	Aug. 15 to Sept. 20	Jul. 20 to Oct. 31	Jul. 20 to Nov. 5	Jul. 1 to Oct. 31

Table 1: Zone-Date Access by SSCZ and Ice Class [10]

By entering the tables it can be seen that, a Type B ice strengthened vessel is not permitted to enter SSCZ Zone 1, 2 or 5 at any time, but can enters Zone 3 between 20 August to 05 September, or Zone 10 from 01 August to 31 October. A Type A vessel is not permitted to enter Zones 1, 2 or 5 but can enter Zone 10 from 25 July to 20 November.

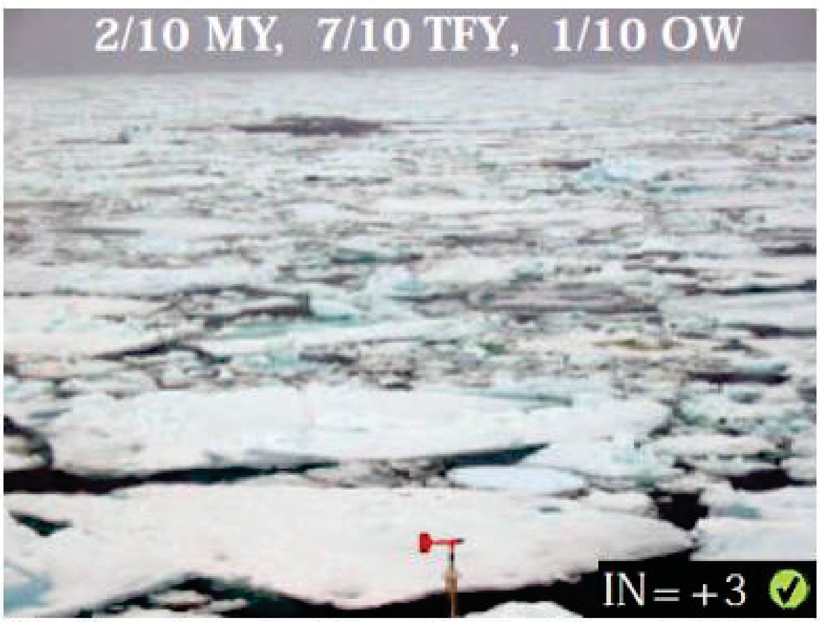
2.6.2 Arctic Ice Regime Shipping System

Transport Canada developed the AIRSS in the mid 1990's to provide more accurate and practical go-no go decision process. The arbitrary nature of the Zone Date system was found to often preclude operation in zones that were in fact ice free beyond the risk dates laid out in the tables.

AIRSS utilizes a heavily field-tested algorithm that considers the ice class of the vessel against actual ice conditions along an intended route. An experienced Ice Navigator identifies and categories ice by stage of development and surface concentration or ice chart "ice eggs" may be used to determine ice stage and concentration. The algorithm data entry results in an Ice Numeral. A positive Ice Numeral indicates it is safe to proceed, a negative Ice Numeral indicates it is not safe to proceed.

Ice Multipliers for each Vessel Class							
	Type Vessels					CAC	
Ice Types	E	D	C	B	A	4	3
MY 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 stage 1 30 -50 cm	 -1 -1	 -1 -1	 -1 1	 1 1	 2 2	 2 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 N New Ice < 10 cm Brash (ice fragments) Bergy Water Open Water	2 " " " "	2 " " " "	2 " " " "	2 " " " "	2 " " " "	2 " " " "	2 " " " "

Table 2: Ice Multipliers for different ice classes (TP 14044E) [14]



$$IN = [C_{MY} \times IM_{MY}] + [C_{TFY} \times IM_{TFY}] + [C_{OW} \times IM_{OW}]$$
$$= [2 \times -3] + [7 \times 1] + [1 \times 2]$$
$$= +3$$

Figure 2: Example of IN Calculation (TP 14044E) [14]

Most vessels operating in Canadian Arctic territorial waters may opt to use either the Zone Date System or AIRSS. Passenger vessels and tankers must use AIRSS. If using AIRSS, an Ice Navigator as defined within ASPPR must be onboard the vessel. If a vessel first opts for Zone Date then switches to AIRSS the vessel must continue using AIRSS for the duration of the operation within Canadian waters and cannot revert to

Zone Date. A choice to switch from Zone Date to AIRSS might be advantageous when the vessel would be denied entry into a Zone by virtue of its ice class and exclusion dates, however the zone was found to be ice free and passage would be permitted under AIRSS. Once a vessel opts to operate under AIRSS it must continue under AIRSS and cannot revert to Zone Date.

2.7 IMO Polar Code

2.7.1 Polar Operational Limit Assessment Risk Indexing System

Canada's Arctic shipping related regulations have recently been revised in order to more closely adhere to Polar Code Requirements. Under these changes the Zone Date and AIRSS systems will be retained for current vessels and vessels on cabotage trade, but ASSPPR also allows IMO Polar Code procedures for vessels built to Polar Class or on international voyages.

Using AIRSS as the foundation, IACS has developed Polar Operational Limit Assessment Risk Indexing System (POLARIS) alongside the development and implementation of the Polar Code. IMO document MSC.1 CIRC 1519 "Guidance on methodologies of assessing operational capabilities and limitations in ice" [15] points to AIRSS, the Russian Ice Certificate (or "Ice Passport") and POLARIS as tools to consider. POLARIS takes into consideration the vessel's ice class, actual ice conditions (including a separate table for decayed ice conditions) and also considers whether the vessel is operating independently or under escort of an icebreaker. IACS Polar Classes and Finnish Swedish Ice Classes are used for the ice class entry value.

The methodology for POLARIS is similar to AIRSS. However, unlike a clear GO/NO-GO that results with AIRSS, POLARIS offers the more subjective options of "Normal Operation", "Elevated Risk", or "Operations Subject to Special Consideration", with additional operational safeguards as follows:

a. Normal Operation – not explicitly defined.
b. Elevated Risk – Vessels are cautioned to reduce speed to values associated with each class (PC1 11kts; PC2 8kts; PC3 to PC5 5kts; and Below PC5 3kts), and advised to take additional measures suggesting that the operation should be avoided.
c. Operations Subject to Special Consideration – Vessels are cautioned to exercise extreme caution and should consider "course alteration/re-routing, further speed reductions and other special measures."

While AIRSS and POLARIS detail prudent risk management for ships venturing into polar regions, it remains possible that vessels may enter the Canadian Arctic at certain times without either an ice class or following these procedures (especially ships of less than 100 GT).

3. METHODOLOGY

3.1 Sources of information, references

The main source of information for this project was the IHS Markit Maritime Portal and the associated "Seaweb Ships" online database (https://maritime.ihs.com). This is a subscription service, permitting one researcher at a time to access a database of more than 200,000 ships. Given that the annual Equasis statistical report on the world fleet for the European Maritime Safety Agency (EMSA) [16] gives the size of the fleet (of over 100 Gross Tons (GT)) as 89,804, the Seaweb gives high confidence that all relevant ships are accessible from this source. The Seaweb in fact captures many ships not reported in the Equasis – those under 100 GT, and also a number of governmental and non-merchant ships. In both cases, however, most military and para-military ships are not included. The implications of this on the project results will be covered later.

A search of the Seaweb database, employing terms such as "icebreaking', "ice-strengthened", "ice-capable", as well as specific terms relating to recognized Ice Classification under Finnish-Swedish Rules, returned lists totalling over 16,000 ships. This number includes a large number of duplications as the terms are not exclusive. Employing the terms judiciously in combination yielded over 11,000 ships, of which there is high confidence that this relates to unique ships. As the project progressed, a number of ships appeared or disappeared from the search list, the result of ships being sold and renamed, or broken up. Correlations with the unique and permanent International Maritime Organization identification (IMO) Number for each ship permitted these differences to be resolved. However, due to the ever-changing nature of the database, such changes were not pursued after 5 Feb 18 when the consolidation of the most significant part of the list was completed.

In addition to the search of Seaweb for ice-classed ships, we examined the following lists of "icebreakers" and "Polar Ships" (numbers of ships in each list in brackets):

a. Wikipedia's "List of Icebreakers" (301) [17]
b. The US Coast Guard's list "Major Icebreakers of the World" (116) [18]
c. Aker Arctic's "List of Operational Icebreakers" (119) [19]
d. The European Unions' "Database of Existing Icebreakers in the World" (136) [20]
e. The World Antarctic Program's (WAP) "Polar Ships Book 2007" (149) [21]
f. The "World Wide Icebreakers" list of Baltic Icebreaker Management (BIM) (92) [22]

These lists were used as a check and verification of the lists generated from Seaweb. The reconciliation of duplicates among these lists yielded a list of 475 unique ships. Of these lists, the Wikipedia and the WAP list included the greatest number of ships either unsearchable, laid up or broken up, or inactive as museum ships. Once these were eliminated there were 78 ships to be added to the consolidated list. These were then reconciled with the Seaweb lists and the duplications eliminated.

One further source of ice-capable ships was examined: the online database of Jane's Fighting Ships. [23] It was hoped that this source would provide a list of icebreaking military and paramilitary ships. The database was not searchable in the same way as

Seaweb, however, and different searches only turned up 17 ships of evident ice-capability. This is considered to be insignificant compared to the number of marginally ice-capable naval and coast guard ships that must exist. In the author's experience, naval ships as small as frigates can be operated carefully in 0.25m of new ice, however the main concern is with freezing of the seawater intakes. It was not considered feasible in terms of time required, nor useful in terms of this low ice-capability, to further pursue the ice-capabilities of military ships and this remains a significant unknown quantity in this study.

3.2 Process of compilation of required data

The largest part of the data for the tables was extracted in separate searches from the Seaweb database. The database only permitted the extraction of 2500 records of 12 columns at a time, so the search was divided by ice-class, and then by length overall (LOA) to limit the size of output files. The data export for each group was duplicated with different output criteria (fields), and then the files were recombined off-line to achieve the breadth of required data fields.

The basic scheme of search proceeded by these ice-characterizations (numbers of ships in brackets):

- "Icebreaking" – a descriptive term in the Construction details of each ship record (236)
- "FS Ice Class IA Super" – the highest degree of Baltic Ice Class under the Finnish-Swedish Ice Rules (287)
- "FS Ice Class IA" (2336)
- "FS Ice Class IB" (1015)
- "FS Ice Class IC" (2895), and
- "FS Ice Class II" (4274)

There was some overlap between the first list with its descriptive search term and the following lists with their unique assigned ice-class. This was resolved by correlating the ships and highlighting duplications through the unique identifying IMO Number. Where the record showed the ships as "dead ships" or "broken up", these were eliminated from the list. Where the ships were "laid up" or "no longer meet ihsf criteria"[2], the ships were retained on the list as representative of ships that could be brought back to service.

The lists were finally assembled through a progressive process of data validation, supplemental data addition, recombination and reconciliation (disambiguation).

3.3 Additional Data

While much data was extracted directly and easily from the Seaweb database, some data was not recorded consistently (neither in form nor regularity), and some information was available through Seaweb but not accessible as an "exportable" data field. A prime example of this is the IACS Polar Ice Class (PCx). Some ships included this equivalence in their construction details but it was not a searchable quantity like "FS Ice Class IA Super". Another example is aviation capability; this was available in the individual ships'

[2] This term means that they are no longer sea-going, but this term encompasses a number of operating ice-breakers on the Russian northern river systems.

records but not exportable.

This omission of data led us to examine each list in turn to verify certain data (especially to look for ice-class designation other than FS Rules) and to add details that were considered important to the independent ice-capability of the ship. Principal among the latter category were the details of propulsion system (i.e., twin azimuthing controllable-pitch propellors (CPP) with thrusters, or single fixed-pitch (FPP) without thrusters, etc., which denote considerable differences in the ship's ability to manoeuvre and extricate itself from ice). Regarding aviation capability, the notation of "helo facility" did not in all cases mean a capability to house and maintain a helo, but sometimes only a heli-deck. Verification of this difference required inspection of the ship's photos.

This process was very time-consuming, especially for the longer lists. Accordingly, this detailed review of the data was pursued only for the first four data lists (down to include FS Ice Class IB).

4. TABLE OF SHIPS

4.1 Elements of the Table

The client requested a table of the following fields [11]:

A. Ship Name.
B. Ship Class.
C. Country of Registration.
D. Country of Owner.
E. Home port.
F. Ice class.
G. Polar class.
H. Northern point.
I. Southern point.
J. Ship category. Each column will contain the ship's purpose with headings from the following list. If a column contains a ship purpose, this column should have an 'X', and be left blank otherwise:
    i. Icebreaker. The ship is a dedicated icebreaker.
    ii. Military. The ship is owned by the military.
    iii. Search and Rescue. The ship is a dedicated search and rescue resource.
    iv. Intelligence gathering. The ship is an intelligence gathering vessel.
    v. Research. The ship is a research vessel, state owned or otherwise.
    vi. Cargo. The ship is a cargo ship.
    vii. Tanker. The ship is a tanker, military or commercial.
    viii. Utility. The ship is a utility ship such as a barge, tug, etc.
    ix. Fishing. The ship is a fishing vessel.
    x. Cruise Liner. The ship is a cruise liner.
    xi. Other. Other type of ship, not part of the list above. Note that the Contractor may suggest new purposes, to be agreed upon by the Technical Authority (TA), during the contract to categorize ships that research has shown to not fall within categories i-x.
U. Ship length.
V. Ship beam.
W. Ship draught.
X. Ship displacement.
Y. Ship propulsion.
Z. Max speed.
AA. Max range speed.
AB. Range. Ship range.
AC. Complement.
AD. URL. Secondary references

In some cases, the information could not be extracted as a data-dump according to search parameters in Seaweb and the information had to be sought manually. This was exceptionally time consuming and could not be pursued beyond the top 4000 ice-classed ships. Even then, some of the information was inconsistently available.

Otherwise, there were a number of fields that were proposed by the contractors as being important information. These included:

1. IMO #
2. Classification Society
3. Canadian CAC/Type Equivalency
4. Gross Tonnage (GT)
5. Propulsion type (i.e.: type/number of propellors)
6. Propulsion power
7. Thrusters (indicative of dynamic positioning)
8. Bunkers
9. Consumption
10. Passengers (to distinguish from crew, where possible)
11. Aviation capability

Following discussion with the client, particularly once the full scale of the project was determined, the fields of the table were established as follows (listed by column, with explanation of some omissions/inconsistencies of data):

1. (blank; saved for additional annotations or flags)
2. IMO # (a unique identifier that stays with the ship through sales and renaming)
3. Ship Name (sometimes ambiguous or variously spelt, especially Russian names)
4. Class (not always possible or worth noting, as in large classes of identical merchant ships)
5. Flag State (i.e.: nominal national ownership, responsibility)
6. Built (year-month of construction; note that ships are registered in construction and so some of these are noted for ships not yet afloat)
7. Registered Owner (sometimes a holding company or corporation, not an identified single owner)
8. Port of Registry (the client asked for “home port” but this is not distinguished from port of registry, and in any case has very little relevance to merchant ships)
9. Noted Ice Class (this was as taken from the Seaweb database, either as data-extraction or from inspection)
10. Classification Society (this was added as necessary to make sense out of the Ice Class)
11. Noted or Equivalent IMO Polar Class (this was as noted in Seaweb or as sourced independently, and as recorded in class abbreviations– see the equivalence table at 0)
12. Canadian CAC/Type Equivalencies (unless noted directly in sources, this was as qualified by us in accordance with Annex A)
13. Northern Point (of previous voyages)
14. Southern Point (these two fields could not be determined with any confidence; where the information was known to us, we included this, but in most cases this could not be determined nor was it useful in indicating the capability of the ship, as in the case of Baltic icebreakers)
15. Ship Type (this was as extracted from Seaweb; this was consistent and detailed but did not correspond exactly to the ship-types defined by the client)
16. Ship Type – Primary (this was a primary sort to the types defined by the client; a three level characterization to this list was attempted but soon became too time consuming without additional value and so was discontinued after the first 4000 ships)

17. Ship Type – Secondary
18. Ship Type – Tertiary
19. Length (in metres)
20. Beam (in metres)
21. Draft (in metres)
22. Displacement (in metric tonnes; this measure of ship size is more common of military vessels than merchant ships which traditionally use “gross or net tonnage”)
23. Gross Tonnage (GT, in “tons” measurement according to International Tonnage Convention)
24. Machinery Type (the means of producing motive power, e.g.: steam turbine-electric, or “oil engines, electric drive” (diesel-electric), etc.)
25. Propulsion Type (the means of converting power to speed through the water, e.g.: 2 controllable pitch propellers (2 x CPP), etc.)
26. Propulsion Power (in kilowatts; the power that is available to the propellers, i.e.: apart from domestic electrical generating capability of the ship)
27. Thrusters (propulsion units, usually athwartships, independent of main propulsion units)
28. Maximum Speed (in knots)
29. Economical Speed (in knots; usually only one figure is given for merchant ships, equating to “Service Speed” which is within a couple knots of maximum and economical speed)
30. Bunkers (in cubic metres; this figure was extracted automatically from the Seaweb database in order to calculate range; in some cases this is clearly not a good figure as it gives too low a range and this may be a consequence of having two types of fuel onboard, both of which were not captured in the data extraction)
31. Consumption (in cubic metres per day; in many cases this figure was not available; the fact that this had to be extracted manually resulted in terminating this after the first couple data extracts.)
32. Range (in nautical miles; in some cases this was extracted directly; in many more it had to be calculated as [(Bunkers/Consump) x Economical Speed x 24] but the result is sometime suspect as indicated above)
33. Complement (persons; this was as extracted from Seaweb and represents total onboard, except in cases where there is clearly a separate passenger load indicated)
34. Passengers (persons)
35. Aviation Capability (this had to be verified by inspection of the database and photos and so is only done for the top 3800 ships; where there is none it is indicated with a “N”, otherwise “helideck” for a landing pad or “helo facility” for hangar and support capability, and just greyed-out if this is not clear.)
36. Key Reference (this was in all cases Seaweb; even where the ship name was first found in other lists, the majority of detailed data was extracted from Seaweb.)
37. Secondary Reference (the intent was to indicate the next most significant source of information on each ship; time and volume precluded a complete treatment in this respect although some additional references, keyed to the References Tab in the table, are noted.)
38. Special Notes (a few elaborating notes are made; this could not be continued beyond the first list)
39. (through 44) SW Source (this indicates which data-extraction and search terms yielded the ship name; in some cases ships popped up on both the first list

["icebreaking"] and the list corresponding to the ice class [e.g.: "FS IA S"] and these were resolved to the appropriate ice class in eliminating redundancies.)

4.2 Scanty or Incomplete Data

The reliability of the data is as presented from the Seaweb database. In a few random cases this was checked with other sources such as MarineTraffic.com and Vesselfinder.com as means of verifying the configuration of the ship. In these few cases the information was similar if not identical. Where data was not available, the cell is shaded grey. Also, where the information is derived, rather than extracted directly from the database (as in the case of ice class equivalencies), or obtained other than from Seaweb, the cell is also greyed.

5. SUMMARY OF ICE-CLASSED SHIPS

5.1 Analysis

The list of ice-classed ships captures with a high degree of confidence all the ships in the world merchant fleet that are ice-classed. There are two notable caveats to this statement: (1) many of the world's service ships (coast and border guard cutters, naval ships, etc.) are not registered with classification societies and do not show up on this database; and (2) many yachts, even large well-found private ships, may have some rudimentary ice-class but for one reason or another are not categorized as "ice-strengthened" and were not turned up in the data search.

With respect to the first category, the database lists only 195 "naval/naval auxiliary" ships (surely a gross under-reporting), of which only 36 have any kind of ice notation. These are mostly civilian-pattern ships such as cargo, replenishment and tanker ships, as well as a few landing ships. This is not a surprise, as warships are generally not "registered" for ownership and flag state affiliation as are merchant ships, nor are they built to civilian standards and thus "classified" by classification societies. Exceptions to this common practice exist, where naval ships are built to merchant standards and registered by the construction yard for the sake of sea trials prior to hand-over to the navy. This is apparently the case of the Harry DeWolf class of Arctic Offshore Patrol Ships being built for the RCN, of which some appear in the Seaweb database. For the most part, however, warships do not figure in merchant ship registries.

An example of the second category is MY EQUANIMITY, IMO #1012086. She is of 2627 tons displacement and 91.5m LOA, and transited the Northwest Passage in 2015. She is classed by Lloyd's as ice class 1E (lower part of FS II or Cdn Type E equivalence), but was not annotated "ice strengthened" in order to be returned in the Seaweb search.[3] Seaweb lists 2841 ship as "yachts" and none of these are annotated with ice capability in a way that is searchable. There is no way of verifying the ice class of these ships aside from a line-by-line examination of the whole list.

It will be seen therefore that the list of ice ships does not capture all ships that are classified for or capable of operations in ice. In so far as ships of nil or marginal ice classification may also attempt polar voyages, even if complete with respect to ice-classed ships the list might not be a perfect predictor of vessels likely to be found in the Arctic. However, analysis of the list does suggest which countries have the expertise and capability for sustained operations in polar regions.

[3] The author participated in part of this transit. This ship is used here as a known example of a ship that shows an ice class in the database details but is not captured by the data-extraction due to the manner of reflecting that information in the database. In other ways it may not be a good example: Lloyds ice class 1E was meant for European river application only and thus is not formally equivalent with FS Ice Class II. This may be why EQUANIMITY's ice class did not translate as FS II and get caught by the data extraction for that class but neither did she get caught by the term "ice-strengthened".

5.2 Numbers, types, distribution of ice-classes

This project has identified 11,067 ships of recognized ice capability, belonging to 145 Flag States[4]. Of these 94 ships (0.85%) were of apparent low-moderate ice capability (by appearance or purpose) but no formal ice classification could be determined. In 23 cases (all lowest ice-class ships) the Flag State was unknown. Of the total, 10,556 ships (95.38%) were of the lowest four classes of ice capability, while 417 ships (3.77%) were of ice class “Type A” (equivalent to FS Ice Class IA Super, or Polar Class 6) or higher. These latter ships, more capable of independent operation in ice, belong to 69 different Flag States.

The distribution of ice-ships by Flags State shows 24 states with more than 100 ships each. China tops the list at 1192 although these are overwhelmingly (90%) the lowest Type E ice-classed cargo ships. Russian stands next with 1032, of which 126 (12.21%) are Type A or higher. The top ten states owning vessels of Type A or higher are Russia, Finland, Canada, Cyprus, Sweden, Bahamas, Denmark, Netherlands, Malta and Italy.

Ice Class	CAC1	CAC2	CAC3	CAC4	Type A	Type B	Type C	Type D	Type E	Unkn	Grand Total
Numbers of Ships	6	10	36	44	321	2342	1028	2899	4287	94	11067
Flags States (incl UNKN)	1	5	7	10	47	95	96	119	120	32	147
Percentage of Ships	0.05%	0.09%	0.33%	0.40%	2.90%	21.16%	9.29%	26.19%	38.74%	0.85%	100.00%
Percentage of Flag States	0.68%	3.40%	4.76%	6.80%	31.97%	64.63%	65.31%	80.95%	81.63%	21.77%	

Table 3: Ice-ships by Equivalence to Canadian ASSPPR Ice Classifications

Seaweb’s database lists ships defined by 125 different specific types. Of these, three types of ship (General Cargo, Container, Chemical/Products Tanker) account for 48.82% of the total of ice-ships. Sixteen types of ships account individually for 1% or more and collectively 85.12% of the total. Icebreakers are not among this group.

Of the ships ice-classed Type A and above, 49.64% are represented by 5 types of ship: Icebreakers, Ro-Ro Cargo ships, Passenger/Ro-Ro ships (i.e. Baltic ferries), Tugs, and General Cargo ships. Those types of ships individually representing 1% or more of the fleet are of 18 types totalling 89.69% as shown in Table 4.

[4] Note that Russia and USSR are both listed in the database as flag states, although only once for the latter. In these figures, they are considered together.

Ship Type	CAC1	CAC2	CAC3	CAC4	Type A	Type B	Type C	Type D	Type E	Unkn	Grand Total	Type A+	% Type A+
Icebreaker	5	7	13	22	11	3			1	8	70	58	13.91%
Ro-Ro Cargo Ship					45	68	11	28	27		179	45	10.79%
Passenger/Ro-Ro Ship (Vehicles)					36	70	39	65	65		275	36	8.63%
Tug				4	31	82	56	158	107	44	482	35	8.39%
General Cargo Ship			1		32	911	264	476	1180	3	2867	33	7.91%
Chemical/Products Tanker					27	423	177	230	251		1108	27	6.47%
Container Ship (Fully Cellular)					25	317	7	65	1014		1428	25	6.00%
Research Survey Vessel				2	15	27	20	110	71	8	253	17	4.08%
Products Tanker					16	64	41	47	166	1	335	16	3.84%
LNG Tanker			15			13	2	14	11		55	15	3.60%
Icebreaker/Research		1	1	3	5						10	10	2.40%
Anchor Handling Tug Supply			2	2	5	25	23	135	54		246	9	2.16%
Offshore Tug/Supply Ship		1	1	2	5	5	10	39	93	2	158	9	2.16%
Passenger/Cruise	1	1	1		7	8	4	40	13	6	81	10	2.40%
Buoy Tender					9	5	6	3	4	1	28	9	2.16%
Patrol Vessel				1	7	1	6	15	12	2	44	8	1.92%
Salvage Ship				2	5		8	2	3	1	21	7	1.68%
Fishing Vessel					5	16	90	420	59	1	591	5	1.20%
Total	6	10	34	38	286	2038	764	1847	3131	77	8231	374	89.69%

Table 4: Ice-ships by Type (>1% by combined Type A and higher ice-class)

Of the ships classed CAC4 equivalence or higher (96 ships), the greatest majority (48.96%) are Icebreakers with another 5.21% being “Icebreaker-Research” ships. Ships typed as “Anchor-Handling Tug Supply” and “Offshore Tug/Supply Ship”, often ships designed explicitly for oil and gas work in polar regions, make up another 8.33%. Liquefied Natural Gas (LNG) Tankers make up 15.63% of ships classed CAC4 and above, largely due to polar hydrocarbon exploitation north of Russia. Passenger and Passenger/Cruise vessels include 4 highly ice-classed ships; these are largely icebreakers re-purposed for eco-tourism in polar regions.

Shiptype	CAC1	CAC2	CAC3	CAC4	Type A	Type B	Type C	Type D	Type E	Unkn	Grand Total	Type CAC4+	% Type CAC4+
Icebreaker	5	7	13	22	11	3			1	8	70	47	48.96%
LNG Tanker			15			13	2	14	11		55	15	15.63%
Icebreaker/Research		1	1	3	5						10	5	5.21%
Tug				4	31	82	56	158	107	44	482	4	4.17%
Anchor Handling Tug Supply			2	2	5	25	23	135	54		246	4	4.17%
Offshore Tug/Supply Ship		1	1	2	5	5	10	39	93	2	158	4	4.17%
Passenger/Cruise	1	1	1		7	8	4	40	13	6	81	3	3.13%
Search & Rescue Vessel				3	1	5	13		8		30	3	3.13%
Standby Safety Vessel				3			14	22	12		51	3	3.13%
Research Survey Vessel				2	15	27	20	110	71	8	253	2	2.08%
Salvage Ship				2	5		8	2	3	1	21	2	2.08%
General Cargo Ship			1		32	911	264	476	1180	3	2867	1	1.04%
Patrol Vessel				1	7	1	6	15	12	2	44	1	1.04%
Heavy Load Carrier			1		1	6	1	1	12		22	1	1.04%
Passenger Ship			1			3	5	6	44	2	61	1	1.04%
Total	6	10	36	44	125	1089	426	1018	1621	76	4451	96	100.00%

Table 5: Ice-ships by Type (>1% by combined CAC4 and higher ice-class)

The list was examined from the perspective of what ships can, or are likely, to venture through the Northwest passage. Given that the more direct, deep-water routes through M’Clure Strait and Prince of Wales Strait are more heavily encumbered by ice and not usually accessible to any but the highest ice-classed vessels, the fundamental limitation is the limiting draft on the more southerly routes. The route of Amundsen in 1903-06 through James Ross, Rae and Simpsons Straits is only suitable to small vessels or those with local knowledge, and in any case no more than 8m draft. For larger ocean going vessels, the limiting draft on the key southern route through Cache Point Channel is about 13.5m. Using 13.5m as a filter on draft and excluding (commercial) vessels of less than 100 GT or having no listed tonnage, the list still shows 10,609 ships capable of transiting the Northwest passage by the most common route. The point is that even these constraints do not substantially refine the list. In reality, almost anything of any size and any (or no) ice class can transit the NWP if they pick their time carefully.

A further attempt to refine the list of probable transit vessels, by excluding special purpose vessels likely to be engaged in specific areas (e.g.: RO-RO ferries), or harbour precincts (e.g.: tugs and harbour utility craft such as crane barges, dredges and fire-fighting vessels) only limits the list to 9518 vessels. Many of these vessels would have no good reason to venture into the Arctic for their particular trade but could do so during the limited window available to lower ice-classes. This demonstrates that the compilation of the list by ice-class, by draft and by type (purpose) is not a significantly limiting method of identifying how many vessels may enter the Canadian Arctic, unless this is matched with particular dates in which the higher ice-classes would begin to dominate.

5.3 Vessels Absent From the List

Of the two major types of ship not reliably captured by this project, yachts are perhaps the hardest to quantify. There are 29 ships listed as “yachts”, ranging from 15,850 GT and maximum LOA of 162.5m down to 145 GT and 28m, covering ice classes Type B to Type E. One is a former Soviet icebreaker of indeterminate class. However, only one of these ships is among those on a website advertising “expedition yachts”.[24] As mentioned earlier, other large yachts known to have traversed the NWP are not on the list either. Furthermore, the Scott Polar Research Institute list of transits in 2017 includes vessels as small as a 6.3m catamaran. Of the 33 vessels to transit the NWP in 2017, 20 were of less than 20m; such vessels are not required to participate in the NORDREG Vessel Traffic Services zone, and are not likely to be registered (i.e. included in the global database of ships) even if they are required to be licensed in their home countries. On the basis of this statistic alone, a list of registered ships of noted ice classes could have a no better than 1/3rd chance of predicting potential arctic voyagers.

Warships and government vessels not included in merchant ship lists are also difficult to quantify. The website “Global Firepower” lists 9249 warships worldwide, of which 413 are frigates, 536 are submarines and 3448 are patrol craft.[25] Wikipedia lists global figures of 23 Aircraft Carriers, 86 Amphibious Warfare ships, 29 Cruisers, 218 Destroyers, 368 Frigates, 262 Corvettes, 146 Nuclear Submarines and 363 non-nuclear Submarines, for a total of 1495 warships.[26][5] This smaller total may not include the myriad smaller patrol ships and auxiliaries included in the Global Firepower list.

This cursory examination suggests that naval lists may yield something like 1500 ships that have sea-going capabilities that could conceivably permit Arctic operations in ice-free waters, or in waters of thin new ice. This will not be attractive to high-value vessels such as carriers or amphibious ships, but smaller warships such as frigates and patrol

[5] Note that more authoritative lists may be obtained from subscription services such as the International Institute of Strategic Studies, https://www.iiss.org/en/publications/military-s-balance/militarybalanceplus.

vessels, and even non-nuclear submarines have been deployed in Arctic waters regularly by the RCN in recent years. Of note, the "Kingston-class" Mine and Coastal Defence Vessels (MCDV) were designed to operate in up to 40cm of first year ice (equivalent capability to ASSPPR Type D).[27] These ships were designed to civilian standards. Generally, however, warships are not built to classification standards and thus have no ice-class rating.

Of all these vessels, Nuclear Submarines have by far the greatest Arctic capability in being able to evade ice by transiting beneath it. This submerged mode of operation could only be permitted by prior arrangements with the RCN or justified by invoking "International Straits Passage" which would be disputed by Canada. Only the smallest of these vessels could transit the Northwest Passage by the southern route, and they would be draft-limited to do this in a surfaced mode for key portions of the transit. Surface transit of the NWP by foreign warships would be under the exercise of "Innocent Passage" but is unlikely without prior notification of Canada. Notably, government or foreign state-owned vessels are expected to conform to Canada's shipping safety and pollution prevention regulations but are not formally obligated to the ASSPPR.[10]

5.4 Building, development trends

While this project has sought to list and categorize all operating ice-capable ships in the world, this continues to be a "moving target." The demand for eco-tourism is providing incentive for projects such as Crystal Cruise's PC6 megayacht "Endeavour" and the more ambitious "Ponant Icebreaker." The latter ship will be a PC2, LNG-powered diesel-electric luxury yacht of 30,000 GT and 270 passengers, designed specifically for polar voyages in summer and winter. The advertised objective of the Ponant company is a voyage to the North Pole before Christmas 2021. The ship will be designed by Aker Arctic to be double acting: forward in open seas and light ice, and stern-first in more severe ice conditions.[28][29]

There have been many innovations in ice-breaking technology over the years.[30] Aker Arctic is a world-leader in icebreaker design and has been perfecting stern-acting azipod cargo ships for the Russian LNG trade in the Yamal gas-fields since 2011.[31] This design concept is oriented toward the best balance of open-water and ice operations and was first developed by the Finnish for Baltic operations. The NORILSKIY NICKEL and her sister ships are general cargo ships classed as Arc7 (CAC3 equivalent) which are capable of breaking 1.5m of ice either ahead or astern.

The United States Coast Guard List of Major Icebreakers (1 May 2017)[18] shows 16 ships under construction with delivery dates 2017-2021, with another 17 ships planned with delivery dates 2020-2026. This represents a considerable replacement and in many cases an upgrade in the overall capability of the global icebreaker fleet of about 95 "icebreakers". The fact that there is this level of rebuilding among this group, and over 400 ships of Type A and above indicates a strong and growing interest in Arctic operations.

6. CONCLUSION

6.1 Confidence in Coverage of the List

It is difficult to put a firm confidence level on the quality and completeness of this list of ice-ships. It has been compiled with all reasonable care and attention to the distinctions of ice-class and other vessel characteristics. The volume of the list does not admit a line-by-line verification. A number of corrections and amendments have been made in the process of writing this report, as additional information was encountered. However, the list cannot be verified as completely up to date, given the fluid nature of the global shipping database.

It is confidently asserted however that this is the largest and most complete and most current list of ice ships encompassing all 9 levels of the Canadian ASSPPR and equivalent scales of ice-classification of ships.

6.2 Predictive Value of the List

The utility of this list for Maritime Domain Awareness prediction in the north has to be heavily caveated by the following factors:

a. The list does not include many small yachts and adventurers that are an increasing component of both destination and through-traffic in the Canadian Arctic;
b. There are also many not-so-small mega-yachts and cruise ships that are being designed explicitly for polar eco-tourism that may not show up in the list due to lower ice-classes not reflected in the searchable fields of the database;
c. The list does not include the many warships and government vessels that could venture into the Arctic, although it is considered unlikely that many countries would be inclined to deliberately challenge Canadian sovereignty in this fashion;
d. The vast majority of ships on this list, even those with substantial ice classes such as Baltic Ferries, are not at all likely to have cause (or economic incentive) to voyage into the Canadian Arctic; and
e. There are a vast number of ships that within strict Zone-Date limits may venture legally into the Arctic with no ice-class whatsoever.

This being said, the fact that so many ships are being constructed with recognized ice-classes indicates the interest in ship-operations in ice-infested waters. While much of this is due to winter traffic in the Baltic, increasingly the Russian, Canadian, and US Arctic and the Antarctic are influencing this trend.

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ANNEX A. ICE CLASSIFICATION EQUIVALENCIES

0	Consolidated RMRS Criteria IB, Arc & UL	AIRSS Criteria	Consolidated BV Criteria IB & POLAR (Equiv w/CAC,AC)	BV POLAR Criteria (independent ops in >6/0 concentration)	ABS	BV	CA	CCS	DNV	FSICR	GL	IACS	KR	LR	NKK	Poland	RIN	RMRS
1	IB arctic coastal up to 4.0m winter-spring; continuous in unbroken >2.0m; power NLT 48 MW		Without restrictions summer-fall, winter MY 3.0m, ramming 12kt			Ice-breaker 1						PC1						Ice-breaker 9, LL1, LL9
2	Ice-strengthened for indep ops in close ice up to 3.5m winter-spring, 4.0m summer-fall; up to 12 kt in compact MY	Unrestricted Date and Zone	Year-round operation, >3.0m	Year-round SY with MY inclusions 2.0m		POLAR CLASS 1	CAC1, 10					PC1						Arc9, LU9
3	IB arctic coastal up to 3.0m winter-spring; continuous in unbroken 2.0m; power NLT 22 MW		Summer-fall MY 3.0, winter SY 2.5m, ramming 9kt			Ice-breaker 2	9		POLAR-30			PC2						Ice-breaker 8, LL2, LL8
4	Non-IB arctic navigation up to 3.5m winter-spring, 4.0 summer-fall; up to 10kt in close SY	Unrestricted Zone, Date & Ice Condition sensitive	Year-round operation, MY 3.0m	Year-round TFY with old ice inclusions 1.5m	A4	POLAR CLASS 2	CAC2, 8		POLAR-20		Arc3	PC2		AC2				Arc8, LU8
5	IB arctic coastal up to 2.5m summer-fall; continuous in unbroken 1.5m; power NLT 11 MW		Summer-fall SY 2.5m, winter TFY 1.8m, ramming 7kt			Ice-breaker 3	7		POLAR-20			PC3						Ice-breaker 7, LL3, LL7
6	Non-IB arctic navigation in TFY up to 1.8m winter-spring, SY (>2.0m) summer-fall; 6-8kt in close FY	Unrestricted SY Ice, occasional MY	Year-round operation, SY with old ice inclusions, 2.5m	Year-round MFY with old ice inclusions 1.2m	A3	POLAR CLASS 3	CAC3 ,6		POLAR-15		Arc2	PC3		AC1.5				Arc7, LU7
7	IB ops in hbr up to 1.5m; continuous in unborken 1m		Summer-fall TFY 1.8m, winter Med FY 1.2m, ramming 5.5kt			Ice-breaker 4	5,4		POLAR-10			PC4						Ice-breaker 6, LL4, LL6
8	Non-IB arctic navigation in MFY (<1.2m) winter-spring, TFY up to 1.5m summer-fall; continuous 6-8kt in open FY 1.1-1.3m winter-summer	Unrestricted TFY, occasional MY	Year-round operation TFY with old ice inclusions, >1.2m	Year-round MFY with old ice inclusions 1.0m	A2	POLAR CLASS 4	CAC4, 3		POLAR-10, ICE-15		Arc1	PC4		AC1				Arc6, LU6
9	Ice-strengthened for indep ops up to 1.1m winter-spring, 1.3m summer-fall	Medium FY, old ice inclusions	Summer-fall MFY 1.2m, winter MFY 1.0m, ramming 5.5kt			Ice-breaker 5	2					PC5						
10	Non-IB arctic navigation in MFY up to 0.8m winter-spring, MFY (<1.2m) summer-fall; continuous 6-8kt in open FY 0.8-1.0m winter-summer	Summer/Autumn MFY with old ice inclusions	Year-round operation in MFY with old ice inclusions, 0.7-1.2m	Summer-fall MFY with old ice inclusions 0.6-0.8m	A1, 1AA	POLAR CLASS 5/6, IA Super	Type A, A, 1A, 1	B1*	ICE-1A*, ICE-10	FS IAS	100 A5 E4, E4	PC6	ISS	1AS, 1SS	IA Super	KM L1A, KM YLA, KM YL	IAS	Arc5, LU5, ULA, KM*YA, KM*Y
11	IB ops in hbr and non-Arctic freezing seas, compact ice up to 1.0m, power <11MW		Summer-fall MFY 1.0m, winter MFY 0.8m, ramming 4.5kt			Ice-breaker 6				FS IAS								
12	Non-IB arctic navigation <0.7m winter-spring, MFY up to 0.9m summer-fall; continuous 6-8kt open FY 0.6-0.8m winter-summer	Summer/Autumn Thin FY with old ice inclusions	Summer-fall operation in Thin FY with old ice inclusions, 0.7m	Summer-fall Thin FY 0.4m	A0, 1A	POLAR CLASS 7, IA	Type B, B	B1	ICE-IA, ICE-05, ICE-A	FS IA	100 A5 E3, E3	PC7	IS1	1A	IA	KM L1	IA	Arc4, LU4, L1, UL, KM*1
13			Summer-fall MFY 0.8m, winter Thin FY 0.6m, ramming 4.5kt			Ice-breaker 7				FS IA								
14	Independent 5kt in open ice up to 0.7m; escorted at 3kt in compact ice up to 0.65m	Thin FY 0.5-0.6m	FY ice, 0.5m		1B	IB	Type C, C	B2	ICE-IB, ICE-B	FS IB	100 A5 E2, E2		IS2	1B	IB	KM L2	IB	Ice3, LU3, L2, KM*2
15																		
16	Independent 5kt in open ice up to 0.55m; escorted at 3kt in compact ice up to 0.5m	Grey-white 0.3-0.4m	FY ice, 0.4m		1C	IC	Type D, D	B3	ICE-IC, ICE-C	FS IC	100 A5 E1, E1		IS3	1C	IC	KM L3, KM L4	IC	Ice2, LU2, L3, KM*3
17																		
18	Independent 5kt in open ice up to 0.4m; escorted at 3kt in compact ice up to 0.35m	Grey ice <0.15m			D0	ID	Type E, E	B	ICE-IC	FS II	100 A5, E		IS4	1D, 1E	ID	KM	ID	Ice1, LU1, L4, KM*
Ref	1	7	8,9	8	2.2, 3	3,8,9	2.2, 3, 5, 6	2.2, 3	2.2, 3, 4, 5	2.1, 2.2, 3	2.2, 3, 4	2.1, 2.2, 4	2.2, 3	2.2, 3, 5	3	4	3	1,2.2, 3, 4, 5

Ref #	Source	Title	Website	Accessed
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2.1	Prof Claude Daley, MUN	Brief on Ice Class Rules (Equivalency Table)	http://www.engr.mun.ca/~cdaley/8074/Ice%20Class%20Rules_CD.pdf	11-Feb-18
2.2	Prof Claude Daley, MUN	Brief on Ice Class Rules (CNIIMF Table)	http://www.engr.mun.ca/~cdaley/8074/Ice%20Class%20Rules_CD.pdf	11-Feb-18
3	Baltic Sea Ice Services	Table of Ice Classes	http://www.bsis-ice.de/material/table_iceclasses.pdf	11-Feb-18
4	Finnish Maritime Safety Regulation	TRAFI/31299/03.04.01.00/2010	https://www.trafi.fi/filebank/a/1328278814/39cb4a062bcb70efb122d4de971ef7cf/9148-36442-Vastaavuusluettelomaaraykset_TRAFI_31299_03_04_01_00_2010_EN_corr_20_Dec_2010.pdf	11-Feb-18
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7	Ship Ice Classes	(source unknown)	(lost link)	
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10	RMRS, 2003	Symbols and Abbreviations	http://globalocean.ru/KM_L2.htm	11-Feb-18
11	Codan Marine	Ice Classes in brief	http://www.codanmarine.com/repository/com/Files/Seminar/Ice%20Navigation/Ice%20classes%20in%20brief.pdf	11-Feb-18
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ANNEX B. LIST OF ICE SHIPS

(Provided in electronic form B. CORA 050 - Consolidated Clean List v1-0.xlsx)

ANNEX C. ACRONYMS

A

ADM(S&T)
Associate Deputy Minister – Science and Technology 8
ADSA
All Domain Situational Awareness 8
AIRSS
Arctic Ice Regime Shipping System 7
ASPPR
Arctic Shipping Pollution Prevention Regulations 7
ASSPPR
Arctic Shipping Safety and Pollution Prevention Regulations 12
AWPPA
Arctic Waters Pollution Prevention Act 7

C

CCG
Canadian Coast Guard 8
CPP
Controllable-pitch propellors 19

D

DEW
Distant Early Warning 6

H

HBC
Hudson’s Bay Company 6

I

IACS
International Association of Classification Societies 8
IMO
International Maritime Organization 7
IN
Ice Navigator 7

L

LNG
Liquefied Natural Gas 26
LOA
Length overall 6

M

MCDV
Mine and Coastal Defence Vessels ... 28
MCTS
the Maritime Communications and Traffic Services ... 7

N

NI
Nautical Institute ... 7
NSR
Northern Sea Route ... 9
NWP
Northwest Passage ... 6

P

POLARIS
Polar Operational Limit Assessment Risk Indexing System ... 7

R

RCMP
Royal Canadian Mounted Police ... 5
RCN
Royal Canadian Navy ... 8

S

SAR
Search And Rescue ... 8
SSCZ
Shipping Safety Control Zones ... 12

U

UNCLOS
UN Convention on Law of the Sea ... 7

W

WAP
World Antarctic Program's ... 17

Z

ZDS
Zone-Date System ... 7

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3. TITLE (The document title and sub-title as indicated on the title page.)

Review of Surface Ship Fleets: Ice-Classed Ships

4. AUTHORS (Last name, followed by initials – ranks, titles, etc., not to be used)

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5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total pages, including Annexes, excluding DCD, covering and verso pages.)	6b. NO. OF REFS (Total references cited.)
May 2018	37	31

7. DOCUMENT CATEGORY (e.g., Scientific Report, Contract Report, Scientific Letter.)

Contract Report

8. SPONSORING CENTRE (The name and address of the department project office or laboratory sponsoring the research and development.)

DRDC - Centre for Operational Research and Analysis
Defence Research and Development Canada
Carling Campus
60 Moodie Drive, building 7
Kanata ON K2H 8E9
Canada

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
99ac - Threat, Requirements, and Gap (TRG) Analysis	

10a. DRDC PUBLICATION NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.)	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)
DRDC-RDDC-2018-C083	W7714-156105/001-SV Task #50

11a. FUTURE DISTRIBUTION WITHIN CANADA (Approval for further dissemination of the document. Security classification must also be considered.)

Public release

11b. FUTURE DISTRIBUTION OUTSIDE CANADA (Approval for further dissemination of the document. Security classification must also be considered.)

12. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Use semi-colon as a delimiter.)

ADSA; Maritime Surface; Ice capable vessels; Commercial fleet review

13. ABSTRACT/RÉSUMÉ (When available in the document, the French version of the abstract must be included here.)

This project attempts to characterize and quantify the global fleet of ice-capable ships. It does this through a brief review of the history of polar navigation and the processes of classifying ships for safe operation in ice, arriving at a notional scale of equivalence for different current and historic classification schemes. Using search terms related to different levels of ice-capability, the project extracted from the Seaweb Ships Online (SW) database of over 200,000 ships some 11,000 ships that are characterized as "ice-capable." This list was reconciled with various other available global lists of icebreakers. The noted iceclassification of each ship was related to the Canadian scale of ice-capability under the Arctic Shipping Safety Pollution Prevention Regulations to give a common point of reference for ships that can legally and safely go "into the ice". Some brief analysis of the list and the recent record of Northwest Passage voyages was conducted to qualify the coverage in terms of ice-capable ships missing from the list and ships/yachts that may choose to transit the NWP under Zone-Date regulations with no ice-class at all. The report concludes that while the list can be used as a guide to ships that can operate in heavier ice conditions of the Canadian Arctic (i.e. Thick First year Ice and heavier), it is not altogether predictive as many ships with lower ice classes will not have reason to depart their normal areas of operation (e.g. Ice-classed Baltic ferries) and, conversely, many non-ice-classed vessels may attempt transit in the brief opportunities provided by Zone-Date windows and climate change.

Ce projet tente de caractériser et de quantifier la flotte mondiale de navires capables de naviguer dans la glace. L'étude comporte une brève revue de l'histoire de la navigation polaire, ainsi qu'une analyse des processus de classification des navires capables de naviguer en toute sécurité dans la glace. Cette analyse a abouti à une échelle d'équivalence entre différents modèles de classification actuels et historiques. En utilisant des mots clés liés à différents niveaux de classe polaire, plus de 200 000 navires ont été extraits de la base de données Seaweb Ships Online (SW), parmi lesquels, près de 11 000 navires ont été qualifiés de «résistants aux glaces». La liste a été réconciliée avec divers autres recensements mondiaux de brise-glaces. En outre, la classe polaire de chaque navire a été liée à l'échelle canadienne de classe polaire en vertu du Règlement sur la sécurité de la navigation et la prévention de la pollution dans l'Arctique dans le but de fournir un point de référence pour les navires pouvant entrer légalement et en toute sécurité « dans la glace ». Enfin, une brève comparaison entre la liste et l'historique récent des voyages à travers le Passage du Nord-Ouest a été effectuée afin d'identifier les navires et yachts qui pourraient choisir de transiter par le passage du Nord-Ouest sous la réglementation zones/dates, mais qui ne seraient dotés d'aucune classe polaire. Le rapport conclut que même si la liste peut servir de guide pour identifier les navires capables de se déplacer dans des conditions de glace extrêmes de l'Arctique canadien (à travers la glace épaisse de première année par exemple), ses prédictions ne sont pas infaillibles étant donné que beaucoup de navires avec une basse classe polaire n'ont pas de raison de quitter leurs zones d'exploitation normales (par exemple, les ferries baltes détenant une classe polaire). Inversement, de nombreux navires sans classe polaire pourraient tenter de traverser dès que le climat et le système de zones et de dates le permettent.