The Economic Development of Arctic Navigation: A Systematic Literature Review

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The Arctic has recently become one of the most intriguing regions of the globe. The USGS report of 2008 put an emphasis on the enormous potential energy reserves in the region. The Arctic Marine Shipping Assessment (AMSA) of 2009 gave hope of an ice-free Arctic far sooner than expected. This resulted in an ever-increasing focus on the Arctic's economic potential. (Howard, 2009) Traditional Arctic players were thus not alone anymore. Many countries (e.g. China) and enterprises increased their activities in the region. Navigation is one of the two main economic sectors with incredible potential for decades to come. The other one is obviously the energy sector. Numerous authors have discussed Arctic economic development during the last decade. So how has it evolved since 2007? And what is the state of knowledge today? To answer these questions, this review focuses on the literature of Arctic navigation in order to find gaps. As research is rapidly growing and evolving, the purpose of this literature review is to assess the state of the literature and its current gaps.

Introduction

Over the past decade or so, the Arctic has become one of the most intriguing regions on the planet. First, in 2007-2008, the International Polar Year (IPY) drew global attention and awareness to the Arctic region (Comba, 2011). Second, the USGS report of 2008 highlighted the enormous potential energy reserves of the region. Their projections were that 30 percent of gas reserves and 13 percent of oil reserves worldwide were in the Arctic. These resources could potentially translate into 90 billion barrels of oil and forty-four of gas (USGS, 2008). Third, 2008 represented a turning point for Arctic geopolitics with an important increase in military activity in Western Arctic states and Russia (Brutschin & Schubert, 2016: 154). The Arctic Marine Shipping Assessment (AMSA) of 2009 gave hope of an ice-free Arctic far quicker than expected, as soon as 2015 (AMSA, 2009). This resulted in an ever-increasing focus on the Arctic's economic potential.

These developments caught the attention of media around the globe, fueling beliefs that the Arctic was developing as a new el dorado and a region with a high level of potential conflict for natural resources (e.g., Borgerson, 2008; Howard, 2009; Unger, 2014). However, the rush for resources never materialized (e.g. Ash, 2016; Mayer, 2013) and the arms race was downplayed

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(e.g. Baev, 2015; Heininen, 2016: 6; Lasserre et al., 2012; Hilde, 2014: 160). At the same time, the new developments attracted new non-state actors to the region such as transnational corporations (TNCs), and Asian states such as China and Japan who were accepted as observer states at the Arctic Council in 2013 (Arctic Council, 2017; Myers, 2013). Some of these state actors had been involved for years in scientific research before all these developments began to attract global attention (e.g. Sun, 2014; The Arctic Institute, 2017)

The Arctic region has two main potential avenues for major economic development and impacts: the energy sector (see USGS, 2008) and marine transportation (Buixadé Farré, 2014; Meng et al., 2016). The latter is the first of two broad potential economic developments that must be addressed because no energy investment would be viable without it (AMSA, 2009, 120). The Arctic transportation routes need to be viable in comparison to traditional sea routes such as the one linking East Asia to Europe through Malacca and Suez. However, due to the harsh conditions and to the actual regional situation, Arctic shipping is for now mostly limited to destinational traffic, and experts agree that it will be the case for the foreseeable future (e.g., Buixadé Farré et al., 2014)

The purpose of this article is to assess the rapidly growing and evolving research in the field of maritime shipping. This is necessary to draw the web of knowledge throughout the field and identify trends and gaps (Knudsen, 2013: 282) Indeed, only one other systematic comprehensive review has been published on Arctic navigation (Meng et al., 2017), and its focus was on the models and scenarios proposed in the literature.

The larger goal of this review is to provide new insights for future research. The following review explores the literature from the last ten years (2007-2017). The paper is organized as follows. Firstly, the methodology and the challenges of this research are discussed. Secondly, the research opportunities identified in AMSA on different components of Arctic maritime navigation are used to study the literature of the last ten years. Thirdly, a title analysis of the 2016 and early 2017 literature is conducted. Fourth, and finally, findings and existing gaps in the literature are discussed.

Methodology

A literature review is methodologically demanding, and many potential problems can arise. The first one is how to guarantee a satisfying level of rigor. In order to address this very basic but important issue, most search manipulations have been done at least twice. For example, the search for potential titles has been conducted in three different ways. Furthermore, feedback was deemed essential from the start of this project, and this external perspective has been helpful.

Pickering and Byrne (2014), and Pickering et al. (2015), who focus on systematic reviews, provided the structural framework for the research. Systematic reviews are best suited for reviews that look at the number of articles coded and the transparent retrieving method, which is this paper's approach.

Inclusion Criteria

The inclusion criterion is a crucial part of any review. It was essential to be very careful in its definition. After a few rounds of restricting and subsequently relaxing the criterion, it was relaxed

to be as inclusive as possible, while remaining centered primarily on Arctic navigation. It then became easily definable:

1. The publications had to be peer-reviewed.
2. The papers had to be published in 2007 or later.
3. At least two of the chosen keywords had to appear either in the title or in the keywords.
4. The publications had to discuss Arctic navigation.

The decision to use the broadest criterion possible, criterion 1, is related to the initial choice of focusing exclusively on peer-reviewed material, which is often more rigorous than non-peer reviewed publications. This considerably reduced the pool of resources available for the review. It eliminated institutional reports, such as the Arctic Marine Shipping Assessment (AMSA) or Arctic Council publications. This was later confirmed as a non-issue since almost all of the articles already quote them, and integrate them into their analysis.

Criterion 3, which was expected to be incredibly beneficial, was unfortunately not as useful as it initially appeared because many, if not most, of the articles did not have any keywords. In those instances, the title and the abstract were the replacements to assess whether the articles should be part of this research or not.

Criterion four was the most obvious for the research. It has been the most helpful because it excluded a lot of articles either on Arctic governance or on the changing Arctic environment, for example.

Coding Guide & Scope

Regarding the actual coding process, it took some time to get to a clear and easily usable guide. At first, there were way too many elements (up to more than sixty). Therefore, after quite some time and with feedback, the decision was made to use the 2009 AMSA report as the coding framework. AMSA has been a central publication for Arctic shipping and regional governance, and contains many findings and research recommendations that are unique to this report. This is incredibly helpful because the evolution of the Arctic shipping literature will clearly appear from the gaps that remain and new conclusions that have arisen since the publication of the AMSA. This resulted in a more solid coding guide and a considerable reduction in the number of coding elements.

Other elements were later added in the coding framework to account for specific subthemes. One of the major challenges in conducting this research has been limiting the scope of articles included. As stated earlier, the aim was to be as inclusive as possible while remaining focused primarily on the core subject to this study, the development of Arctic navigation. Economic models and other papers discussing the costs and numerous factors influencing the viability of Arctic shipping were obviously in the scope of this paper. The inclusion criterion and its consequences for non-core articles were difficult because of the diversity and volume of papers. The most representative examples are articles on Arctic and marine governance. The volume of papers in these two fields is immense. This part of the literature could have easily overpowered the core articles identified during the first step of this research. For the case of marine governance, six coding elements were added to the original coding tree: three about UNCLOS; three surrounding the International Maritime Organization (IMO) and its conventions. The

forty-two elements composing the guide give us extensive coverage without being so large that it becomes unusable, as shown in Annex C.

To be as transparent and exhaustive as possible, the peripheral subjects given consideration are listed below:

- The decline of sea-ice and the future navigating conditions in the circumpolar region.
- The territorial claims and the CLCS.
- The actions and strategy of the two most prominent countries in the Arctic: Canada and Russia.
- The developments and actions related to Arctic populations, Indigenous or non-Indigenous.
- The governance of navigation: UNCLOS and IMO.
- The governance of the Arctic: The Arctic Council.
- The Arctic environment from the risk of oil pollution to noise pollution.

The reason these subthemes were included is because they all have a direct or indirect impact on Arctic navigation. Domestic developments and regulations or military actions could have been added, but these two examples were too far from the core interest of this paper. Still, others may disagree, and this might represent a limit to this research.

Bibliographic Search & Retrieval

Before coding and analyzing the results, the first step was to retrieve bibliographical sources, and the focus was solely on peer-reviewed articles. The potential of personal bias was high since the field of Arctic navigation is a particular interest of mine. The preliminary list contained all resources already available at hand before conducting the bibliographical search. More than 400 articles were retrieved in the first attempt, and the list was later reduced to 98. Then, 20 articles were selected and coded line-by-line inductively.

After this initial step, a more sophisticated method to explore databases was introduced to produce replicable and transparent results. This process led to new search results with pertinent articles for the review. Table 1 below shows the five categories of keywords used during the bibliographical search.

Table 1. Guide for exploring databases

Keywords	Combinations
A. Region: Arctic – NSR – NWP **B. Economic: Economic – Potential – Investment – Insurance – Risks – Costs – Limits** **C. Navigation: Icebreakers – Ships – Maritime - Navigation** **D. Climate: Thawing – Ice - Climate change** **E. Legal and national: UNCLOS - Polar Code – IMO – SOLAS and MARPOL - SAR Agreement - Arctic Council**	A + B (1) A + C (2) A + B + C (3) A + B + D (4) A + E (5)

The categories were then combined for more precision. Therefore, a twenty-four item research index was created, presented in Annex A. Among these twenty-four queries, twenty included variations for each keyword of category A (e.g. Arctic, NSR, NWP). In the end, for each database explored, sixty-four queries were conducted.

Regarding database selection, a convenience sample was the best suited for this review, because of the lack of access to all existing databases. Although it was a limitation, because some published material could be inaccessible for many reasons, the choice of databases available guaranteed an extensive coverage. To facilitate the bibliographical search, when the hits were superior to 250, their volume was reduced by using abstract searches. This appears on the document in Annex A. After database searches and 'snowballing', 503 references were found. This number was reduced quite considerably to 305, with articles from 155 different journals. The ones with six articles or more appear in the table below.

The full list of references is available here:

https://docs.google.com/document/d/12TzlcxBDmsWWvrhCd88E5kJFsC02TioyvVJrd8oSqLk/edit?usp=sharing.

Table 2. Journals with more than six articles

Arctic Yearbook	**Journal of Maritime Law and Commerce**	**Marine Policy**	**Ocean Development & International Law**
16	14	11	9
Polar Geography	**The Polar Journal**	**Journal of Transport Geography**	**Polar Record**
7	7	6	6

With the exception of the years 2013-2014, the number of articles has increased continuously from 2007-2017. The final grouping by year of publication is represented in the table below.

Table 3. Bibliographic search results (per year)

Year	**2007**	**2008**	**2009**	**2010**	**2011**
Number of articles (Proportion of all articles N=305)	6(.020)	11(.036)	22(.072)	20(.066)	28(.092)
2012	**2013**	**2014**	**2015**	**2016**	**2017**
41(.134)	38(.125)	30(.098)	52(.170)	48(.157)	9(.030)

Preliminary Phase: Line by Line Coding

The twenty articles were coded thematically and inductively using Nvivo, a qualitative data analysis software. Despite few adjustments during this process, the tree map, a visualization tool of the software, was quite helpful. It provided an indication of the most prominent themes. By extension, the result, presented in a weighted representation in Annex B, is a tree with 20 articles coded line-by-line, which gave preliminary indications on what to look for during the next stages of this review.

Coding Based on the Arctic Marine Shipping Assessment (AMSA)

The inductive coding tree was supposed to provide an indication, or even the actual foundation, of the coding themes for the whole list of articles. In the end, it served as the base of comparison with the tree later created from the AMSA's research opportunities. The AMSA appears in 21.3% of articles, which is surprisingly low given its prominence in policy-making. The results are as they appear in the following table:

Table 4. Coding results (Number of hits and percentage)

Arctic Shipping Lanes					
Northern Sea Route	***Northwest Passage***	***Distance Reduction***	***Comparison to traditional sea routes***	***Future Scenarios and Costs***	***AMSA***
153(50.16)	**115(37.70)**	**98(32.13)**	**92(30.16)**	**19(6.23)**	**65(21.31)**
Prominent factors					
Investment on ships and Winterization	***Ice Classes***	***Speed and travel duration***	***Fuel Costs***	***Reliability Problems***	***Energy***
62(20.33)	**50(16.39)**	**69(22.62)**	**39(12.79)**	**27(8.85)**	**137(44.92)**
Risks and Insurance	***Security***	***Infrastructure and Hubs***	***Need for skilled seamen***	***Requirements (Fee, papers, pilot)***	
75(24.59)	**20(6.56)**	**76(24.92)**	**18(5.90)**	**50(16.39)**	
Governance					
Art. 234 UNCLOS	***Art. 76 UNCLOS***	***UNCLOS (Other articles)***	***CLCS and Claims***	***Arctic Council***	***2011 SAR Agreement***
60(19.67)	**38(12.46)**	**115(37.70)**	**102(33.44)**	**91(29.84)**	**38(12.46)**
IMO Guidelines	***MARPOL and SOLAS***	***Polar Code***	***Canada's Actions and Strategy***	***Russia's Actions and Strategy***	***SAR Monitoring and National Capacities***
46(15.08)	**64(20.98)**	**69(22.62)**	**79(25.90)**	**85(27.87)**	**82(26.89)**
Arctic Populations					

65(21.31)					
Changing Arctic Environment					
Sea Ice Decreasing	***Arctic change models***	***Future conditions remain uncertain***	***Hydrographics and Charts***	***Weather forecasting***	***History and INSROP***
147(48.20)	**19(6.23)**	**57(18.69)**	**33(10.82)**	**33(11.48)**	**76(24.92)**
Risks for the Arctic Region and Environment					
Accidents	***Arctic ecosystems***	***Noise Pollution***	***Atmospheric emissions***	***Invasive Species***	***Oil Pollution and Spills***
33(10.82)	**52(17.05)**	**16(5.25)**	**36(11.80)**	**17(5.57)**	**55(18.03)**

The Northern Sea Route (NSR) is by far the most recurrent theme, with 153 hits, appearing in more than 50% of all articles. As a means of comparison, the Northwest Passage (NWP) produced 115 hits and is discussed in 37.7% of articles. Unsurprisingly, energy comes second with 137 hits (44.92%). This is a standard result because energy and shipping are the two sectors with the most potential in the Arctic.

Conversely, some elements with not so many hits are surprising. For example, most of the direct risks for the Arctic region and ecosystems range from 5.25% up to precisely 18.03%. Another example is the need for skilled seamen, which appears in only 18 articles (5.90%). In the end, the differences between elements are for most of them rather small. This indicates that the literature does cover extensively the various themes that constitute Arctic shipping. Some missing and less talked about pieces still remain, however.

2016 & Early-2017 Literature

In this section, the focus shifts to the study of titles and keywords from the most recent literature. The goal for these examinations is to compare their results to the gaps identified within the literature of the last decade. Are there dissimilarities? Or is the recent literature still weighted the same way the literature of the past ten years was?

Of all retrieved articles, 107 have been published in either 2016 or 2017, and 57 of them are included in the final bibliography. To look for trends and possible new themes that would have appeared during the last few years, the initial plan was to deepen the analysis by examining keywords, but the fact that many articles do not have this feature made this proposal irrelevant.

Title Query

In order to strike the right balance between coverage and purposefulness, parameters were identified. To that end, multiple queries were run, and the most fruitful had the following parameters. It sought synonyms (e.g. Sea: Ocean(s), Sea(s)) and produced the twenty most frequent words. When fewer words or more restrictive links between words were used (e.g. exact terms), the results were too broken up to be beneficial. When the parameters were relaxed, the richness in the results were lost. The one chosen, in the end, provided a good balance between

the two. The word cloud immediately below is from this particular query. Unfortunately, the query provides only a minimal result on its own. Nevertheless, when compared to the same examination of the titles from the 2007 and 2008 literature, the exercise appeared much more fruitful. As Figure 2 below indicates, the focus has changed to some extent, from projections and hypothetical arguments to actual examinations of what can be done in the circumpolar region.

Figure 1. Word cloud from the 2016-17 title query

Figure 2. Word cloud from the titles of the 2007-08 literature

Where are the Gaps?

After completing the coding process, and the rest of the search manipulations, the overall results were analyzed. The gaps identified either appear minimally in the literature, or do not seem to have yet been discussed significantly. To date, most of the literature is oriented towards what the future of Arctic shipping might be. The most practical implications of Arctic shipping have not been a significant feature of peer-reviewed papers. These constitute the first group of gaps:

- The role of the pilots, their expertise, and their qualifications.
- The role of skilled mariners, their expertise, and their qualifications.
- Analysis of actual SAR operations and capacities in the Arctic waters.
- The administrators of Arctic routes, particularly for the NSR, and their relationship with ship owners.
- An immersive case study of real navigation.

Another avenue for further research is Arctic governance. Institutions and legal regimes have been a major point of discussion during the past 10 years. However, the governance architecture changed tremendously during that same period. Thus, there is a constant need for new research and a deepening of the existing knowledge. This is the second group of gaps:

- The role of the Arctic Economic Council.
- The role of the IMO in developing Arctic economic opportunities.
- The role of sub-regional cooperation, forum, and institutions.

On the economic side of shipping, some cost components have yet to be explored in-depth. This is the third group of gaps:

- The actual cost of building modern ships.
- The insurance cost of Arctic shipping.
- The technological evolution and the cost of fuel for Arctic navigation.

Finally, few articles discussed the environmental impacts of Arctic economic development. Sustainability and ecological efforts, or the lack thereof, could be the subject of in-depth research. While there is research on shipping and the environment, the literature remains thin to nonexistent on the types of efforts made by ship owners and other actors (i.e., sustainable shipping). This is the fourth and final group of gaps:

- Efforts, or lack thereof, for greener, more durable ships.
- Efforts, or lack thereof, for greener, more durable fuel.
- Efforts, or lack thereof, for greener, more durable navigation.

Discussion

One of the main goals of this systematic review on Arctic navigation was to identify gaps in knowledge. Although an exhaustive coverage of a ten year period was the initial aim of this research, it has been rendered impossible because of the lack of access to some parts of the literature, which is the most significant limit to this review. There were some articles that could have been included in the search, but were not for various reasons: lack of access; error in

judgment when the list of articles was compiled; or even the plain lack of knowledge that particular publications existed.

However, this does not mean that this research was unsuccessful. The goal was to identify gaps for future research, not offer advanced statistics on what the literature says. This review includes 305 peer-reviewed articles, which still represents an extensive coverage on the existing literature. With so many articles read and coded, the gaps identified in this paper appear to have solid foundations.

Methodologically, this review was based on a strict and rigorous process. Transparency underlined every step taken during the bibliographical retrieval period and its analysis, and all manipulations have been explained. It was designed as a systematic review from its inception, and the methods employed stem directly from these types of reviews. The demanding methodology bore innovative results: the gaps. The ones identified in this review are telling for many reasons. At the top of the list is the richness of the Arctic literature. In a decade, 2007-2017, the terms and subjects have evolved considerably. This appears to be linked to the rapid evolution of the circumpolar region itself, from climate change, to shipping, to energy and governance.

Regarding practical Arctic shipping, there is still a lack of knowledge about many factors. A portion of the literature acknowledges the need for experienced mariners, but little is published about the actuals benefits of having an experienced crew and pilot. The literature is scarce on the resolution of actual shipping problems in the Arctic. The situation is similar regarding the actual costs of circumpolar shipping. Numerous models (e.g., Meng et al., 2016) have been published, but these surely do not account for all factors. Navigating in the Arctic is still risky and incredibly difficult. Technological innovations (e.g. The Baltika example) (RT, 2014; Schuler, 2016) and international governance (e.g., the creation of a permanent Secretariat for the Arctic Council and the creation of the Arctic Economic Council) is evolving rapidly. Overall, there is a clear need to keep researching Arctic shipping and to deepen the analysis on the subject.

Annex A: Bibliographic databases search results

	Searches	Wiley Interscience	Science Direct	Érudit	JSTOR	Persée
	Arctic	**38455**	**25718**	**382**	**12197**	**29**
	Arctic AND Navigation	**1633**	**902**	**42**	**394**	**10**
1	Arctic/NSR/NWP economic potential	5666[13](1)-166[1](7)-285[0](0)	3782[25](10)-91(37)	89(1)-43(0)-51(1)	1661[13](1)-59(2)-61(3)	1(1)-0-0
	Arctic/NSR/NWP economic investment	1706[2](0)-82(6)-63(3)	1117[6](3)-141[2](1)-133[1](0)	24(0)-15(0)-14(0)	526[0](4)-23(0)-18(0)	0-0-0
	Arctic/NSR/NWP economic risks	[7](1)-132(4)-2933[1](1)	2428[20](8)-210[3](2)-242[0](0)	38(2)-16(0)-17(0)	1038[2](1)-39(1)-42(3)	0-0-0
	Arctic/NSR/NWP economic limits	5685[4](0)-162(5)-3477[0](0)	3675[19](5)-323[1](1)-400[2](1)	37(0)-16(0)-27(0)	997[0]-28(1)-32(1)	0-0-0
	NSR/NWP potential	673[7](1)-2142[43](1)	1711[38](4)-1500[31](0)	60(0)-71(1)	149(11)-140(15)	1(1)-1(1)
2	Arctic/NSR/NWP maritime navigation	400[3](2)-9(6)-20(3)	256[6](4)-39(25)-21(12)	22(3)-12(2)-10(2)	118(16)-2(2)-7(3)	9(2)-0-1(1)
	Arctic/NSR/NWP icebreakers	354[14](1)-11(6)-5(3)	456[18](4)-29(23)-17(13)	5(1)-2(0)-2(0)	47(14)-2(1)-2(2)	0-0-0
	Arctic/NSR/NWP ships navigation	1823[4](2)-58[1](1)-65[0](2)	443[16](11)-45(27)-28(15)	17(0)-7(0)-7(0)	155(16)-3(2)-7(3)	0-0-0
3	Arctic/NSR/NWP economic navigation potential	857[1](6)-49(7)-29(4)	264[2](2)-35(21)-29(14)	17(2)-10(0)-6(0)	151(15)-17(7)-40(8)	1(1)-0-1(1)
	Arctic/NSR/NWP ships investment	1041[1](1)-53(6)-18(3)	449[5](4)-47(19)-34(10)	8(0)-6(0)-1(0)	241(3)-6(3)-40(3)	0-0-0

4	Arctic/NSR/ NWP icebreaker investment	31(9)-10(7)-3(3)	46(14)-16(15)-10(9)	0-0-0	11(3)-3(2)-4(1)	0-0-0
	Arctic/NSR/ NWP insurance ships	587[0](0)-30(5)-11(2)	135[0](15)-29(16)-14(9)	0-0-1(0)	120(2)-4(2)-23(2)	0-0-0
	Arctic/NSR/ NWP insurance icebreakers	16(8)-5(4)-2(2)	28(18)-17(14)-10(8)	0-0-0	2(1)-1(1)-1(1)	0-0-0
	Arctic/NSR/ NWP navigation economic limits	551[1](0)-30(8)-17(4)	259[2](2)-33(17)-29(12)	9(2)-4(0)-3(0)	104(5)-12(4)-25(5)	4(1)-0-1(1)
	Arctic/NSR/ NWP thawing navigation potential	92[0](0)-5(2)-2(1)	46(1)-3(0)-1(0)	1(0)-1(0)-1(0)	15(5)-5(4)-8(5)	0-0-0
	Arctic/NSR/ NWP ice navigation potential	706[2](0)-23(7)-44(5)	388[0](0)-60(24)-25(13)	18(3)-9(1)-7(1)	154(10)-20(9)-35(9)	4(2)-0-1(1)
	Arctic/NSR/ NWP ice navigation risks	460[2](0)-22(6)-20(4)	244[75](27)-61(24)-21(13)	9(2)-2(0)-2(0)	65(6)-11(5)-15(6)	0-0-0
	Arctic/NSR/ NWP Climate Change	25566[1076]-151[0](0)-1867[9](0)	12535[869]-224[3](3)-764[15](0)	2(0)-32(1)-31(1)	4691(15)-37(10)-101(14)	17(2)-0-1(1)
	Arctic/NSR/ NWP climate change economic potential	4202[7](1)-62(8)-191[0](0)	2268[13](6)-101[2](2)-209[0](0)	48(1)-16(0)-15(0)	1067(15)-24(9)-58(10)	1(1)-0-1(1)
	Arctic/NSR/ NWP ice economic potential	2510[2](1)-43(8)-95[0](0)	1604[12](8)-63(25)-497[0](0)	61(2)-23(0)-19(0)	823(15)-30(10)-76(14)	1(1)-0-1(1)

5	Arctic Polar Code/Arctic Council/IMO /SAR/ UNCLOS	3495[2](0)-10230[10](2)-139[1](1)-1086[15](1)-87[1](1)	1532[3](1)-5827[24](3)-224[5](4)-759[24](3)-110[3](2)	18(0)-117(0)-0-2(0)-1(1)	13(1)-120(9)-79(5)-63(9)-61(9)

This table represents the number of results for each database query.

The first number indicates the total number of results.

The number between brackets is the total number for abstract queries

The number between parentheses is the number of articles retrieved from each particular query.

Annex B: Core articles coding tree (line-by-line coding)

The tree indicates the occurrence of themes and subthemes by representing them proportionally. The larger the space for a theme, the larger the number of occurrences in the literature. As it is already complex, only the first two coding levels are included in this representation.

Annex C: Coding Guide

B **AMSA 2009**	**C** **DISTANCE REDUCTION**	**D** **COMPARISON TRADITIONAL ROUTES**	**E** **ENERGY**
F **NSR DEFINITION, USE AND REGULATIONS**	**G** **NWP DEFINITION, USE AND REGULATIONS**	**H** **SEA ICE DECREASING**	**I** **MODELS ARCTIC CHANGE**
J **FUTURE CONDITIONS REMAIN UNCERTAIN**	**K** **HISTORY AND INSROP**	**L** **TERRITORIAL CLAIMS AND CLCS**	**M** **UNCLOS (OTHER ARTICLES)**
N **ART. 234 UNCLOS**	**O** **ART. 76 UNCLOS**	**P** **CANADA'S ACTIONS AND STRATEGY**	**Q** **RUSSIA'S ACTIONS AND STRATEGY**
R **ARCTIC POPULATIONS**	**S** **MARPOL AND SOLAS**	**T** **IMO'S POLAR CODE**	**U** **IMO 2009 GUIDELINES**
V **ARCTIC COUNCIL**	**W** **2011 SAR AGREEMENT**	**X** **SAR MONITORING AND NATIONAL CAPACITIES**	**Y** **REQUIREMENTS (FEE, PAPERS, PILOT)**
Z **INFRASTRUCTURE AND HUBS**	**AA** **INVESTMENT ON SHIPS AND WINTERIZATION**	**AB** **ICE CLASSES**	**AC** **RELIABILITY PROBLEMS**
AD **SPEED AND TRAVEL DURATION**	**AE** **NEED FOR SKILLED SEAMEN**	**AF** **FUEL COSTS**	**AG** **SECURITY**
AH **ACCIDENTS**	**AI** **RISKS AND INSURANCE**	**AJ** **HYDROGRAPHICS AND CHARTS**	**AK** **WEATHER FORECASTING**
AL **RISKS TO ARCTIC ECOSYSTEMS**	**AM** **EMISSIONS**	**AN** **INVASIVE SPECIES**	**AO** **SOUND POLLUTION**
AP **RISK OF OIL POLLUTION**	**AQ** **FUTURE SCENARIOS AND COSTS**		

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The full list of articles reviewed is available here:
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