Canadian Marine Pilots' Association

Marine Pilotage in Canada: A Cost Benefit Analysis

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Executive Summary

Introduction

In 2014, Canada's four not-for-profit regional pilotage authorities collected approximately $208 million in pilotage fees, a figure which effectively represents the total annual cost for the provision of pilotage services. The benefit received in return for this expenditure has always been clear in the qualitative sense of promoting safety and efficiency in marine navigation. What has been more elusive is placing a quantitative value on this benefit that can be compared directly to its cost. For the first time since the *Pilotage Act* was enacted in 1972, this study provides such a cost-benefit analysis of pilotage services in Canada.

Methodology

The methodology used in this study is based on the standard, generally-accepted approach used by economists when determining cost benefit ratios, not only in the transportation sector but in the economy as a whole. What is unusual about this study is the effort and rigour that has gone into quantifying benefit, both in terms of safety and efficiency.

To determine safety benefits, the impact of pilotage on accident occurrence was measured. One of the reasons why this study is ground-breaking is that, typically, the impact on accidents cannot be measured quantitatively, and instead is ascribed a hypothetical, qualitative value. The reason for this is that, generally, there is an absence of reliable comparative data showing the behaviour of marine traffic in the same waters with and without pilotage. In this study, this impediment has been overcome thanks to scientifically-collected data from vessel traffic in the Great Belt of Denmark that allows for an empirically valid statistical analysis.

In respect of efficiency, eight specific situations were selected for measurement of benefit, rather than attempting a system-wide assessment. The reason for this was strictly that the scope of a system-wide assessment of efficiency benefits would have been so massive as to be impractical. As a consequence, the result is understated, given that the analysis provides only a partial snapshot of the system-wide efficiency benefits generated.

Just as efficiency benefits are understated, the assumptions used in quantifying safety benefits are of the most conservative nature. For example, the actual occurrence rate reported by Denmark that a non-piloted vessel will ground is 9.4%. Rather than using this rate, which sits in the middle of a range starting at 0.3% and going up to 18.5%, the study uses the lowest statistical rate of probability derived from this data i.e., 0.3%, 30 times smaller than the average rate reported. Another conservative assumption relates to the rate used for conversion of US to Canadian dollars where applicable. For the purposes of this study, the currencies were assumed to have equal value, although in the year in question, 2014, the US dollar's value was actually up to 10% greater than the Canadian dollar's value. Given that all values in the study are expressed in Canadian dollars, the consequence of assuming an equivalence between the two currencies, when in fact the American currency had a greater value than the Canadian currency, is that the benefits are actually understated.

Findings

Safety benefits

- Pilotage has a relevant and direct role in respect of all incidents in the top two vessel accident categories: collision and power grounding. It also plays an important role in respect of drift grounding accidents. When combined with the use of escort and standby tugs, there is complete and effective coverage of all drift grounding accidents. This level of safety is essential to the social license necessary for shipping operations.
- Maritime accidents are very costly. In respect of tankers, environmental clean-up costs alone have been estimated at nearly $10 billion dollars for a west coast oil tanker spill. At the other end of the scale a Puget Sound study estimated the clean-up cost of a Suezmax tanker accident to be approximately $100 million dollar. Assuming only this lower $100 million-dollar accident cost, the safety benefits of pilotage produce a 62.1 to 1 cost benefit ratio for oil tankers.
- While the costs of cargo ship accidents, particularly the environmental consequences are nowhere near as large as they are with oil tankers, they remain huge in relation to the avoidance cost of pilotage. A US Coast guard analysis puts the current cost of such an accident at $3.7 million dollars, resulting in a 3.3 to 1 cost benefit ratio.
- Overall, given the mix of tanker and cargo traffic, the contribution to safety arising from the provision of pilotage services has a cost benefit ratio of 18.9 to 1.

Productivity benefits

- Pilots are instrumental in navigation efficiency and in the development of navigational improvements, both of which contribute to the productivity of Canadian ports and shipping. Of the first importance is the benefit to the efficiency of supply chain operations and the near-certainty pilotage provides that access to, and use of, critical marine infrastructure – including ports and busy waterways – will not be compromised. Such supply chain disruptions, as documented in a Port of Saint John case study, extend considerably beyond the direct cost of vessel accidents and their cleanup.
- Pilots have developed innovative practices for navigation on the Great Lakes and St Lawrence River without lighted buoys or other normal navigation aids in the winter; thereby extending the operating seasons of both the St. Lawrence Seaway and ports on the St. Lawrence River, especially Montreal. Also, night time navigation during the winter on the St. Lawrence has been greatly enhanced in recent years by the innovative application by pilots of e-Navigation and Portable Pilot Units (PPUs).
- The positive impact of an extended navigation season in the Great Lakes Region was substantiated by a case study that demonstrated how it enhances the marine mode's competitive advantage as the most cost effective means for moving grain and other commodities
- Pilots were instrumental in developing new navigational and docking techniques at Vancouver and Halifax, enabling the ports to quickly respond to industry's larger ships, safely accommodating them at docks not designed for vessels of that size. This has enabled Canadian ports to grow their container market share against competitive U.S.

ports without potentially crippling new capital costs. The recent shift of Seattle-Tacoma container traffic to Canadian ports, is evidence of this.

- In Montreal, Quebec and Vancouver, and in other places, pilots have developed new navigation techniques, integrating real time water level measurement and predictive algorithms to maximize the use of the existing channel and allow larger, wide-beam ships to transit, resulting in productivity benefits of up to $341,000 per ship. In respect of Montreal, these innovations have been critical to the port's efficiency allowing it to continue to competitively serve much of the U.S. Upper Midwest, as well as Canadian destinations.
- The cost benefit ratio, based on only the efficiency benefits identified in the specific case studies cited above, is 2.98 to 1.

Overall cost benefit ratio

- The combined safety and efficiency benefits described above result in an overall cost benefit ratio for Canadian pilotage of 21.9 to 1. This means that the $208 million spent on Canadian pilotage buys at least $4.56 billion in economic benefit to Canada. As such, it makes a net contribution of $4.3 Billion *every year* to the economic well-being of Canada's citizens –an average of $120 per person *every year* for each of Canada's 32.6 million people.

1. Introduction

Chapter 1 of this report sets out the purpose and need for the Pilotage Cost Benefit analysis, outlining the project background, alternatives considered, and the study's goals, scope, and methodologies used.

This study provides an assessment of the Costs and Benefits of pilotage services in Canada. Safe maritime transportation in the constrained channels of Canada's ports and waterways is the overarching objective of Canada's pilotage system. It follows that the safety record of pilotage is the single most important measure by which the system's success is determined. The incident-free rate for piloted vessels has consistently stood at 99.9%. This impressive safety record has been sustained over decades, despite the increasing numbers and sizes of vessels using the waterways. Safe waterways contribute in an important way to the efficiency, cost-effectiveness and competitiveness of Canada's marine transportation system.

First and foremost, the Canadian pilotage system is intended to help ensure that maritime transportation in Canada reflects the public interest, by establishing safety as the first priority. Not only are lives at stake, but so too is the marine environment itself. Shipping accidents can drastically damage fragile marine ecosystems, compromise the supply of drinking water for millions of people and otherwise negatively impact on the quality of life of virtually all Canadians. Because of this, safety cannot be sacrificed for reasons of convenience or profits. Accidents do cost money and can have significant environmental impacts. Only a portion of the environmental costs can be quantified in financial terms, but even the readily identifiable costs are very large.

However, pilots also contribute to the efficient and coordinated operations of vessels in compulsory pilotage areas. They have worked with other stakeholders such as Transport Canada and the Canadian Coast Guard to develop improved navigational procedures for maximizing the vessel draft, for making possible the safe transit of larger vessels, and for allowing enhanced safe winter and nighttime navigation. Pilots play a key role in coordinating operations between vessels in shipping channels, including with recreational users and fishing boats. These procedures result in improved maritime productivity which translates into reduced shipping costs, for the benefit of both industry and the Canadian public.

The Canadian Marine Pilots' Association (CMPA) asked Transportation Economics & Management Systems, Inc. (TEMS) to quantify the contribution that pilotage makes to maritime safety and efficiency in Canada. As such, this analysis will focus on quantifying the impacts that pilotage has on maritime safety, and then will examine how pilotage is also contributing to the efficiency and competitiveness of maritime transportation. In this assessment, the value of pilotage will be measured in quantifiable terms using the traditional Cost Benefit criteria of Transport Canada.

1.1 Project Background

Since maritime shipping is a competitive, profit-seeking commercial enterprise, it is constantly under pressure to improve efficiency and manage costs. But because the consequences of marine accidents can be severe, the best way for maintaining the public interest as the paramount consideration is to make sure that, in high-risk areas, vessels are conducted by professional pilots with demonstrated expert knowledge of local conditions and who are able to exercise their best professional judgement without undue pressure from commercial interests.

In Canada, licensed pilots have statutory responsibility for the conduct of the ship[1] and for ensuring its safe navigation. The pilot is responsible for and controls the ship's movement at all times, including during berthing and un-berthing, while remaining responsible to the captain for safe navigation.

Although the need for maintaining the independence of pilots from commercial pressure has long been established in both British admiralty law and in Canadian jurisprudence, and is recognized by the *Pilotage Act*, it has also been supported by recent research[2] that shows a strong negative correlation between ocean freight rates and vessel accident rates. Two different reasons have been suggested to explain this correlation between marine casualty and freight rate:

- The voluntary loss theory suggests that a number of ship-owners actually intentionally prefer to demolish their ships in economic recession (freight rate downturn).
- The second one can be related to low revenue which influences ship owners to minimize the operating cost of ship management and also negatively affects their disbursements related to safety expenses on ships, and de-motivates seafarers to serve their duties.

In Canada, the independence of pilots is safeguarded by the fact that they are engaged by, and responsible to, independent federal agencies, not to the owners of the vessels contracting for their services.

Nonetheless, the notion that time costs money is as true in the maritime industry as it is elsewhere. Accordingly, the on-time delivery of pilotage service is an important factor in maintaining an efficient and cost-effective maritime transportation system. Of the thousands and thousands of pilotage assignments undertaken every year, almost all of them are on time, with on-time service rates consistently comparable to the safety record of Canadian pilotage.

Canadian pilotage tariffs are set only to recover the costs of providing service. The four regional federal agencies responsible for delivering pilotage (the Atlantic Pilotage Authority, the Laurentian Pilotage Authority, the Great Lakes Pilotage Authority, and the Pacific Pilotage Authority) are required to be financially self-sufficient and are expected to maintain surpluses only to the extent necessary to achieve this. In fact, in terms of financial performance, the 2014 annual reports of the four pilotage authorities indicate that, together, they experienced a small loss of $.8 million on pilotage charges of $208 million.

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[1] Sections 25 and 26 of the *Pilotage Act*.
[2] *Are Marine Accidents Really Accidents? Fallacy of Random Marine Accidents in Dry Cargo Fleet*, Asian Journal of Shipping and Logistics, Volume 31, Number 2, pp. 217-229. See: http://www.sciencedirect.com/science/article/pii/S2092521215000310

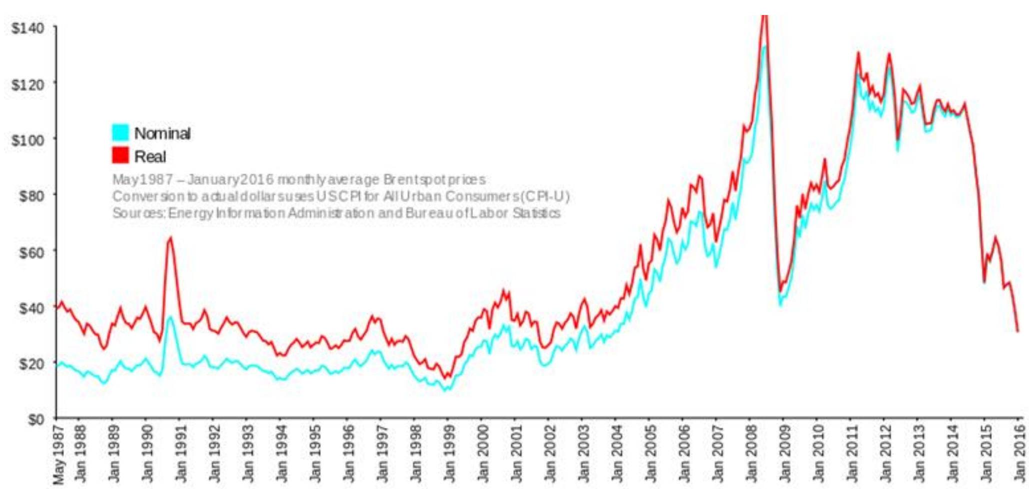
While the performance of each authority varies from year to year as a result of differing circumstances, all the authorities are financially self-sufficient. Three are debt-free, with the Great Lakes Pilotage Authority expecting to be restored to that status by 2018.

The pilotage authorities' profit margins are very tight, so for the purpose of this analysis we assume that the total revenue of the four pilotage authorities stemming from pilotage charges[3], $208 million in 2014, is the annual cost of the pilotage service. This number includes all charges paid by the shipping industry and covers the pilotage authorities' administrative costs, the costs related to maintaining and operating pilot boats, and pilot compensation. This will be used as the basis for estimating the benefit/cost ratio. If the annual benefits exceed $208 million, then the benefit/cost ratio will exceed 1.00. If the benefits are less than the actual cost of the pilotage service, then the benefit/cost ratio will be less than 1.00.

The year 2014 was selected as the representative year for this study to reflect a balanced distribution of tanker traffic on both the east and west coasts. As shown in Exhibit 1-1, from 2011 through 2013, Brent Oil prices sustained historically high levels and the domestic oil industry adjusted to the "new reality" of high energy prices. U.S. and Canadian oil producers invested heavily in Oil Shale development, only to see prices unexpectedly plummet in 2014.

During 2011-2013 while high oil prices lasted, Pacific tanker activity increased sharply while Atlantic tanker traffic plummeted. Many east coast refineries that had historically been served by ships started receiving crude oil by rail instead. After prices plummeted in 2014, Pacific tanker traffic was sharply reduced as California started receiving oil from Saudi Arabia, but Atlantic tanker traffic rebounded. 2014 itself represents a "shoulder" year of market adjustment that reflects a more balanced tanker trade on both coasts than do either 2015 or 2016. 2014 was therefore considered as more representative of likely future conditions since today's very low oil prices are not considered sustainable over the long term.

Exhibit 1-1: Brent Barrel Petroleum Spot Prices[4]



[3] The four authorities also reported approximately $.8 million in revenue from other sources (e.g., interest).
[4] In US dollars.: https://commons.wikimedia.org/wiki/File:Brent_Spot_monthly.svg *Retrieved January 13, 2017*

1.2 Discounting Technique and Time Period

Conventionally, the costs and benefits of an option are evaluated over a timeframe equivalent to the economic (useful) life of the associated facilities/assets affected by the decision. Customarily, both the benefits and costs are estimated for each year after the work of the project has begun and for a period of time at least 20 years in the future. However, a key feature of the current study is the CMPA's desire that it mirrors "facts on the ground", providing a 2014 snapshot of the impact of pilotage and of its cost benefit ratio. Because maritime traffic and, in particular, the volume of goods shipped is growing along with the Canadian economy, this approach results in a very conservative assessment[5] that likely underestimates the level of future benefits. The standard discounting formula for calculating Benefit Cost ratios is:

Present Value Costs (PV_C) = Sum of the discounted present value of all costs

$$PV_C = \sum_{i=0}^{n} C_i/(1+r)^i$$

Present Value Benefits (PV_B) = Sum of the discounted present value of all benefits

$$PV_B = \sum_{i=0}^{n} B_i/(1+r)^i$$

Where:

PV_B= the Value of Benefits over the Lifetime of the Project
B_i= the benefits of the project in year i
PV_C= the Value of Costs over the Lifetime of the Project
C_i= the costs of the project in year i
r = the discount rate
n = the number of years for which benefits are analyzed

The Benefit-Cost ratio (B/C) is: $B/C = PV_B/PV_C$

Since there is no capital investment required in this particular analysis, and it is only comparing *current operating costs* (the cost of providing pilotage services) against *current annual benefits* (measured as safety and productivity benefits), this results in a constant stream of benefits and costs going indefinitely into the future. Under these conditions, the formula will give the same Benefit/Cost result, no matter the length of the discounting period or what interest rate is used, since both the revenue and costs are the same every year. As a result, it is sufficient to simply divide current year costs into the current year benefits for calculating the Benefit/Cost ratio.

[5] TEMS will not initially prepare the typical future benefit projections based on forecasted changes in the marine industry. However, it reflects the CMPA's desire that the value of pilotage services be assessed based on current conditions – that the reported value of pilotage services not be made dependent on a potentially error prone future demand forecast, or upon the extrapolation of established trends (such as towards larger vessels, for example) which nonetheless might not continue into the future.

1.3 Approach to the Economic Evaluation

First, the study determines the safety benefits of pilotage by measuring the impact pilotage has on accident occurrence. One of the reasons why this study is ground-breaking is that, typically, the impact on accidents cannot be measured quantitatively, and instead is ascribed a hypothetical, qualitative value. The reason for this is that, generally, there is an absence of reliable comparative data showing the behaviour of marine traffic in the same waters with and without pilotage. In this study, this impediment has been overcome thanks to scientifically-collected data from vessel traffic in the Great Belt of Denmark that allows for an empirically valid statistical analysis.

In respect of efficiency, eight specific situations were selected for measurement of benefit, rather than attempting a system-wide assessment. The reason for this was strictly that the scope of a system-wide assessment of efficiency benefits would have been so massive as to be impractical. As a consequence, the result is understated, given that the analysis provides only a partial snapshot of the system-wide efficiency benefits generated.

Finally, the cost benefit ratio derived from the contribution to safety arising from the provision of pilotage services is added to the productivity cost benefit ratio that is derived from only the efficiency benefits identified in the eight specific case studies mentioned above.

Oil tanker traffic is of special importance in certain regions of Canada. Due to the environmental sensitivity of these cargoes, it is handled differently and examined in greater detail than other types of cargoes. Although the ships themselves have been dramatically improved[6], tankers still frequently make use of escort tugs not only for docking maneuvers, but also for safety through the harbours and approach channels out to the open sea. Escort tugs, whether tethered to the ships or simply on standby for call and quick activation in case of an emergency, are most often used where there are rocky bottoms or shorelines that otherwise would have significant potential for puncturing the double hull of modern oil tankers. They are also used for helping ships maneuver precisely in tight channels at low speeds. As will be shown, pilotage plays a central and fundamental role in mitigating the possibility of accidents and, combined with the use of escort and docking tugs, residual risks are practically eliminated.

Cargo ships typically only use tugs for docking maneuvers. However, for both escort and docking roles, it is the pilots who provide the experience, local expertise and the supervisory "Command and Control" structure that enables these tugs to be effectively utilized. Every ship can be different and every tugboat has different capabilities as well. The pilots are experienced in working with the local tugs and understand their capabilities and limitations. In other words, in the high-risk areas designated as pilotage areas, it is possible to have pilots without tugs, but using tugs without pilots is not an effective and appropriate risk-control strategy. In fact, due to the risks involved, tugs will typically not even attach lines to a vessel unless the pilot is on board the ship to supervise their safe handling.

In light of these considerations, the report is structured in the following manner:

[6] See: http://www.imo.org/en/OurWork/Safety/Regulations/Pages/OilTankers.aspx

- In Chapters 2 and 3, the safety analysis considers tankers separately from other vessels. Chapter 2 lays out the methodology and Chapter 3 implements the calculations.
- In Chapter 4, the productivity benefits associated with pilotage in eight specific case studies, particularly in respect of new shipping operations, are assessed. These cases do not provide a full assessment of the system-wide efficiency benefits resulting from pilotage, but provide insight on the value added by pilotage in various representative situations.
- The results from the safety and productivity analyses are combined in Chapter 5, providing an indication of the magnitude of the overall Cost Benefit assessment of pilotage in Canada.

2. The Safety Case for Pilotage: Background and Methodology

Chapter 2 documents the work of pilots, including with tugs. This Chapter takes a quantitative, statistical approach to assessing the effect of pilotage in reducing risk exposure to maritime accidents. Chapter 2 presents background and methodological issues relating to the estimation of safety benefits. The actual Cost Benefit calculations will be presented in Chapter 3.

- ***With respect to pilotage, the report develops an analysis of pilotage experience in the Great Belt of Denmark, which is one of the few places in the world where there is a high density of shipping but pilotage is not mandatory in restricted waters, because of the Copenhagen Treaty of 1857. This offers a rare opportunity to directly compare the accident rates of piloted versus unpiloted ships operating in the same area.***
- ***With respect to the particular question of the use of tugs by pilots for tankers, the experience of Puget Sound and of the Port of Vancouver is reviewed in a case study.***

Since the 1970's the safety record of oil tankers has dramatically improved, but even among maritime professionals, the reasons for this improvement have not always been well understood.

- A common error has been to attribute the safety improvement to introduction of double hulled tankers, when in fact double hulls can only protect against low-energy impacts and collisions.
- Rather, it is navigational improvements, including the development of specific pilotage practices, the greater use of escort tugs, and the extension of exclusion zones and restricted areas in which unpiloted operations are not permitted, that are directly responsible for the observed reduction in vessel accident rates.

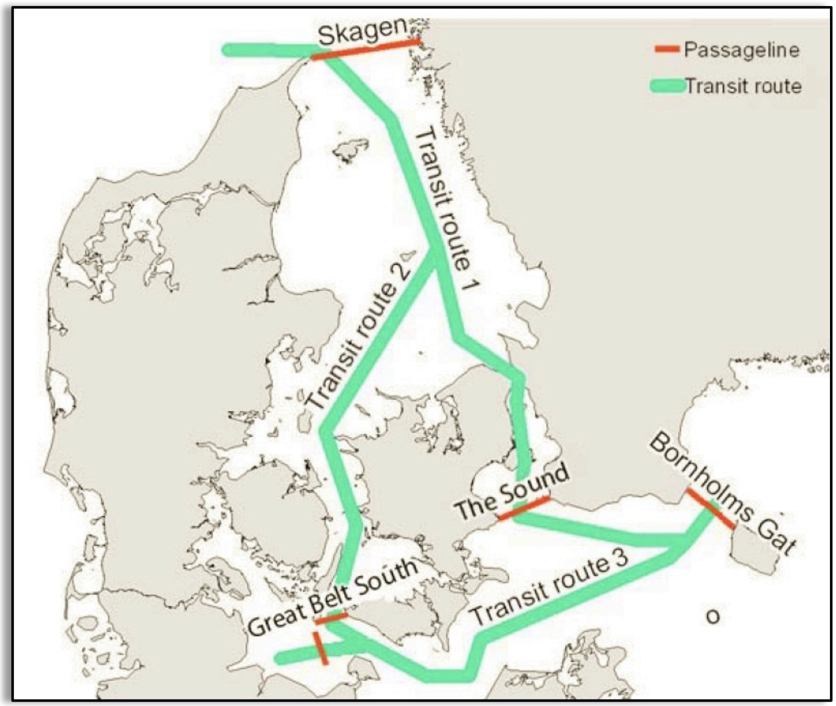
Pilots and tugs have played an essential role in reducing both the likelihood and consequences of accidents across all classes of ships, including tankers. This analysis will examine the accident reducing effect associated with the utilization of pilotage services.

2.1 The Effectiveness of Pilotage in the Great Belt of Denmark

The Baltic Sea is a sea of the Atlantic Ocean, enclosed by Scandinavia, Finland, the Baltic countries, and the North European Plain. It occupies a large basin formed by glacial erosion during the last few ice ages. It is one of the largest brackish inland seas in the world by area.

Three Danish straits, the Great Belt, the Little Belt and The Sound (Öresund), link the Baltic Sea with the Kattegat and Skagerrak strait in the North Sea[7] as shown in Exhibit 2-1.

Exhibit 2-1: Navigation Routes Linking the Baltic Sea through Denmark



It is widely acknowledged around the world that pilotage is an effective means for preventing or reducing vessel accidents, but the Great Belt is one of the few places in the world where data can be scientifically collected to empirically validate the effectiveness of pilotage, since:

> *The entrances to the Baltic Sea are international straits that follow the principle of the right to innocent passage. Furthermore, the Copenhagen Treaty from 1857 applies, which stipulates that using a pilot when passing through the Straits should be voluntary. A mandatory pilot scheme for the Great Belt and the Sound thus cannot be introduced without international acceptance.*

[7] *Baltic Sea*, https://en.wikipedia.org/wiki/Baltic_Sea retrieved on May 6, 2016. Exhibit 1 is from Stentebjerg and Engqvis, *Under Keel Clearance for Ships Carrying Dangerous Goods: A Study on Groundings and Pilotage in Danish Waters*, Figure 6 on page 12 at. http://projekter.aau.dk/projekter/files/77463025/Under_Keel_Cleareance_For_Ships_Carrying_Dangerous_Goods.pdf

> *The general pattern is that tankers in ballast come through the Sound in order to enter the Baltic Sea and when loaded they pass through the Great Belt on their way out of the Baltic Sea. The major part of tankers passing through the Great Belt are loaded tankers, although some of the passages are made by tankers in ballast.*
>
> *The Great Belt is an ancient riverbed providing just a narrow fairway for the ships to follow. However, this cannot be seen from the surface and consequently, requires thorough route planning and a high awareness during the voyage. The Great Belt is characterized by strong sea currents that sometimes have different directions at different depths. For example, the direction of the surface current might be opposite to that of the currents at a depth of 6-8 meters[8].*

According to the Danish Navy[9], over 30,000 ships pass through the Great Belt Traffic Control Area each year – this would include all three routings shown in Exhibit 2-1. Exhibit 2-2 gives the traffic distributions by vessel size and route. While the use of pilots is encouraged for all vessels, the Danish Maritime Authority especially urges any ship with a draught of 11 meters or more[10] to use pilotage service. This recommendation follows the United Nations' International Maritime Organization's (IMO) recommendation on the use of pilots in internal and external Danish territorial waters.

It should be noted that IMO's recommendation also exhorts all loaded tankers with a draught of 7 meters or more, and all loaded chemical tankers irrespective of size, to use pilots. It should also be noted that the threshold at which pilotage is made mandatory by States that are actually fully able to exercise sovereignty over their domestic waters is typically much smaller than this, in recognition not only of the intrinsic risks presented by vessels that have a lesser draft than in IMO's recommendation, but also in recognition that vessels of different sizes are in constant interaction and that it is the systemic nature of pilotage that provides for effective overall risk mitigation.

In any event, the data from Denmark provides unique insights on the effectiveness of pilotage. As can be seen in Exhibit 2-2, in 2010 vessels with a draught of 11 meters or more corresponded to a statistical population of 1,810 ships. All these larger ships must use Transit Route 2, the Great Belt passage, since the Öresund and Little Belt channels (Routes 1 and 3) are not deep enough.

[8] *Safe Shipping on the Baltic Sea*, Gdansk 2009, page 28. https://www.prs.pl/__files/parent262/safe_shipping_on_the_baltic_sea_2009.pdf
[9] *VTS Great Belt Fact Sheet,* http://forsvaret.dk/VTSSTB/eng/Facts%20on%20VTS%20Great%20Belt/Pages/default.aspx on May 6, 2016.
[10] *Great Belt FAQ*, http://us.lodstilsyn.dk/files/rules_regulation/faq/faq_the_great%20belt.pdf on May 6, 2016.

Exhibit 2-2: Vessel and Route Size Distribution Baltic Sea Traffic[11]

				Special Recommendation for Pilotage Total: 1,810 Ships				
Draught (m)	**0-7**	**7-9**	**9-11**	**11-13**	**13-15**	**>15**	**Unknown**	**Total**
Transit Route 1	8,695	2,660	0	0	0	0	144	11,499
Transit Route 2	148	2,463	2,833	686	892	232	67	7,321
Transit Route 3	9,035	3,508	540	0	0	0	121	13,204

In 2012, the Danish Maritime Authority[12] reported that 96.3% of all ships with such a draught of 11 meters or more followed the recommendation to use a licensed pilot, along with 99.9% of all relevant oil tankers. This proportion is not much different than the pilotage utilization rate in earlier years, since in 2009 it was also reported[13] that:

> *The international recommendation to use a pilot when navigating through the Great Belt and the Sound is now followed by 96-98% of the ships. Still, a few ships draw attention and concern. The challenge for the coastal state is to identify these ships by all means so proper preventive action can be taken. This relative small share of ships represents an unknown risk factor. Here the use of a pilot has proven effective, and from a Danish point of view our objective is to achieve 100%.*

The narrow Danish straits have, time and again, proven difficult to maneuver through. From January 1, 2002 to June 30, 2005 a total of 22 ships grounded[14] in the Great Belt, an average of 6.3 ships per year. **None of the grounded ships had a pilot.**

- Based on these various sources, approximately 96.3% times 1,810 or 1,743 ships take a pilot. All of these successfully transit through the Great Belt, that is, without any grounding.

- 3.7% of 1,810 ships, or 67 ships do not take a pilot. Of these, an average of 6.3 ships per year experience grounding, a rate of nearly 10%.

It appears that a 2-4% proportion of ships that do not take pilots has been consistent over the years. As well, the problem of the grounding of ships in the Baltic Sea, particularly in the Danish straits, has persisted. As shown in Exhibit 2-3, the total number of accidents in the Baltic Sea, as well as groundings in the Danish straits, has remained steady over the years. 148 ship accidents occurred in the Baltic Sea in 2012, 10 of which released pollution (6.8%). The total number of accidents in the Baltic Sea has actually been increasing, as well as the number of collisions and grounding incidents.

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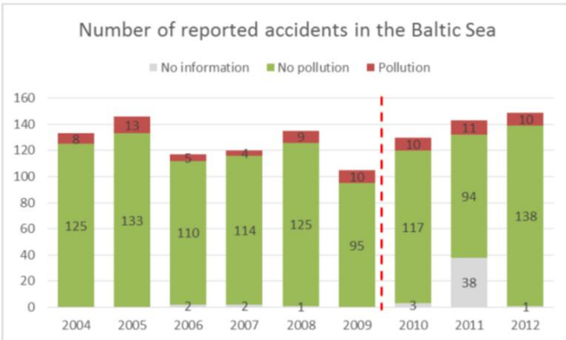
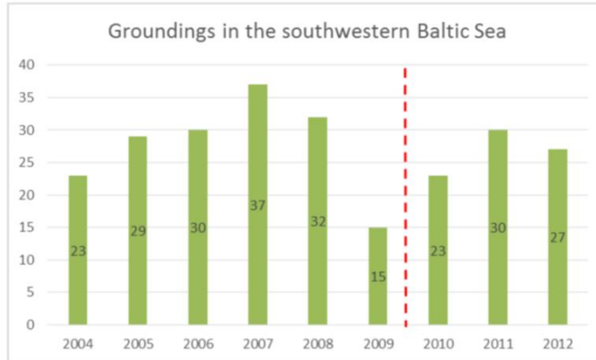
[11] *Under Keel Clearance for Ships Carrying Dangerous Goods: A Study on Groundings and Pilotage in Danish Waters*, Figure 8on page 13 at. http://projekter.aau.dk/projekter/files/77463025/Under_Keel_Cleareance_For_Ships_Carrying_Dangerous_Goods.pdf
[12] Safety 4 Sea Report, http://www.safety4sea.com/99-9-of-oil-tankers-followed-the-recommendation-on-pilotage/ on May 6, 2016.
[13] *Safe Shipping on the Baltic Sea*, Gdansk 2009, pages 31-32. https://www.prs.pl/__files/parent262/safe_shipping_on_the_baltic_sea_2009.pdf
[14] Denmark to IMO, *Consideration of the Reports and Recommendations of the Maritime Safety Committee, The advantages of taking a Pilot*, October 14, 2005. The submission by Denmark is reproduced as an annex to the present document – it is interesting to note the submission estimates that the costs incurred by one grounding surpass by 375 times the costs of taking a pilot.

Exhibit 2-3: Accident Trends in the Baltic Sea 2004-2012[15]





As frustrating as this is, the inability to enforce improvements in safety practices in international waters makes the safety record difficult to improve. The results are summarized in Exhibit 2-4.

Exhibit 2-4: Piloted vs Non-Piloted Navigation through the Great Belt

	Observed Frequencies			Row Proportions		
	Successful	Grounded	Total	Successful	Grounded	Total
Piloted Ships	1,743	0	1,743	1.000	0.000	1.000
Unpiloted Ships	60.7	6.3	67	0.906	0.094	1.000
Total	1,803.7	6.3	1,810			

A confidence interval for the difference of means can be estimated using the formula below, where Z is the parameter of the normal distribution that corresponds to the desired confidence interval[16]. For example, if Z=2.57 this corresponds to the 99% confidence level:

$$(p_1 - p_2) \pm Z\sqrt{(p_1 q_1)/n_1 + (p_2 q_2)/n_2}$$

This formula also uses the values p and q. p is probability of an accident; whereas q is the probability of no accident, thus:

$$q = 1 - p$$

The historical probability of grounding for an unpiloted ship is $p_1 = 9.4\%$ *and* $q_1 = 90.6\%$. Since no piloted ships were grounded, $p_2 = 0\%$ *and* $q_2 = 100\%$.

[15] *Annual Report on Shipping Accidents in the Baltic Sea 2012*, see Figure 7 on page 9; and Figure 26 on page 25. http://www.helcom.fi/Lists/Publications/Annual%20report%20on%20shipping%20accidents%20in%20the%20Baltic%20Sea%20area%20during%202012.pdf

[16] The formula is the standard Wald Confident Interval on the difference of means, see equation 1 on page 361 of Brown and Lee, Confidence Intervals for Two Sample Binomial Distribution, Journal of Statistical Planning and Inference 130 (2005) 359–375 http://www-stat.wharton.upenn.edu/~lbrown/Papers/2005c%20Confidence%20intervals%20for%20the%20two%20sample%20binomial%20distribution%20problem.pdf

This suggests that the 99% confidence interval for the difference in grounding probabilities (for Piloted vs Non-Piloted Operations) in the Great Belt is:

$$(0.094 - 0.0) \pm 2.57\sqrt{(.094 \cdot 0.906/67 + (0.00 \cdot 1.00)/1743}$$

$$= 0.094 \pm 2.57\sqrt{(.094 \cdot 0.906/67}$$

$$= 0.094 \pm 2.57\sqrt{.00127}$$

$$= 0.094 \pm 2.57\,(0.0356)$$

$$= 0.094 \pm 0.091$$

$$= [0.003, 0.185]$$

Since the confidence interval does not include zero, this shows that the difference in grounding probabilities is statistically significant at a 99% level of confidence.

If we consider that the two sets of observations (for piloted vs non-piloted ships) are disjoint sets then confidence intervals can be developed on the actual grounding probabilities by using the Clopper-Pearson method[17]. This is commonly referred to as the “Exact Confidence Interval.” Instead of using a Normal Approximation, the Exact CI inverts two single-tailed Binomial tests at the desired alpha. In the Clopper-Pearson formulas, the Exact CI range is p_{lb} to p_{ub}:

$$\sum_{k=0}^{k} \binom{n}{k} {p_{UB}}^{k} (1 - p_{UB})^{n-k} = \frac{\alpha}{2}$$

$$\sum_{k=x}^{n} \binom{n}{k} {p_{LB}}^{k} (1 - p_{LB})^{n-k} = \frac{\alpha}{2}$$

where:

- p_{lb} is the confidence interval lower bound
- p_{ub} is the confidence interval upper bound
- n is the number of trials
- k is the number of successes in n trials
- α is the percent chance of making a Type I error, 1-α is the confidence

[17] Mayfield, *Understanding Binomial Confidence Intervals*. http://www.sigmazone.com/binomial_confidence_interval.htm

While the population proportion falls in the range p_{lb} to p_{ub}, the actual calculation of these values is non-trivial and requires the use of a computer. Using the Clopper-Pearson formulas, 95% confidence intervals on grounding probabilities in the Great Belt have been estimated as follows:

- **Piloted**: 1743 trials, 0 groundings. 95% CI Range is [0.00000, 0.00211]
- **Non-piloted**: 67 trials, 6.3 groundings. 95% CI Range is [0.03358, 0.18480]

If for purposes of a sensitivity analysis *the upper end of the range* (0.00211) is conservatively assumed for piloted operations then the reduction in grounding probabilities associated with the use of pilots can be estimated as:

[0.00211 / 0.03358, 0.00211 / 0.18480]

[0.063, 0.011] or [1/16, 1/87]

As a result:

- The Danish data suggests that an unpiloted ship has a 3.4% to 18.5% probability of grounding. By comparison, a piloted ship has a 0.0% to 0.2% probability of grounding. Since these confidence interval ranges do not overlap, this clearly shows the statistical effectiveness of pilotage in reducing the grounding probabilities.
- As a result, a piloted ship is 16 to 87 times less likely to run aground in the Great Belt compared to a ship that has no pilot. Further, since this is based on the highest plausible estimate of grounding probability of a piloted ship (0.21%), this whole range reflects a very conservative assessment of the risk reduction associated with pilotage. The actual impact of pilotage is likely to be towards the high end of this range[18].
- The most *probable* grounding probability for an unpiloted ship is the observed rate of 9.4%, which lies near the midpoint of the 3.4% to 18.5% Clopper-Pearson range. The resulting mid-range assessment is that pilotage reduces grounding probabilities by a factor of 44.
- In the Baltic Sea, 6.8% of vessel accidents released pollution, and this is in an oceanic zone that has a soft silty bottom. In Canada because of rocky shores, the likelihood of a serious consequence to any vessel accident is likely to be higher. However, by conservatively applying this 6.8% factor to the 95% CI range of [0.03358, 0.18480] this suggests that the probability of a serious incident that releases pollution would likely fall in the [0.00228, 0.01266] range for each unpiloted vessel.

This level of risk makes sense in view of the inherently hazardous nature of constrained and congested waterways and, its reduction reflects the depth of knowledge and skill of pilots.

[18] In and of itself, the Danish data does not involve a comparison with the Canadian pilotage system; the data demonstrates the extent to which pilotage mitigates the probability of accidents in Denmark. As discussed further below, the highest plausible estimate of grounding probability of a piloted ship (0.211%) based on the Danish data is actually approximately 4 times higher than the actual rate of incidents reported by the Canadian pilotage authorities (0.056%).

2.2 The Effectiveness of Escort Tugs in Puget Sound and Vancouver

A flawless safety record for piloted oil tankers has also been demonstrated in Vancouver. This was reported in two separate publications: the first article claims a perfect safety record of 30,000 transits[19] while the second claims 20,000 transits since 1982.[20] This record is also useful to explore the role played by escort tugs in the prevention of oil tanker incidents.

Unescorted ships must sail fast enough to be able to effectively steer with their rudder. In marine environments characterized by rocky bottoms or coastlines, the speed necessary may be too fast for a double hull to provide effective protection. While pilotage is an effective risk mitigation measure in most situations, the use of escort tugs can help maneuver a vessel with a high degree of precision at lower speeds[21] which are consistent with the energy absorbing capability of the double hull. The lower speeds at which escorted ships operate ensure effective control of the vessel, even when a rudder or propulsion failure occurs. In Puget Sound, the expected failure rates for vessel steering and power were:

- **Puget Sound Actual Experience[22] (16,655 tanker transits between 1996 and 2003):**
    - P(Loss of Steering | Tanker) on a given transit = 6/16655 = 0.00036
    - P(Loss of Propulsion | Tanker) on a given transit = 8/16655 = .00048
    - Overall probability of Propulsion or Steering Failure = .00036 + .00048 = .00084

- **Based on International Data[23]:**
    - P(Loss of Steering | Tanker) on a given transit 0.00029
    - P(Loss of Propulsion | Tanker) on a given transit = 0.0011
    - Overall probability of Propulsion or Steering Failure = .00029 + .0011 = .00139

The application of these equipment failure rates to the 20,000 tanker transits reported in Vancouver since 1982 suggests there have likely been 17-28 incidents of propulsion or steering failure on tankers in the Vancouver harbour since that time. Without escort tugs, there might therefore have been up to 28 drift grounding incidents in spite of the best efforts of pilots. However, by application of the Clopper-Pearson formulas, the following is the confidence interval for actual grounding probabilities in Vancouver harbour since 1982:

- **Piloted/No Tugs**: 20,000 trials, 28 groundings. 95% CI Range is [0.00093, 0.00202]

From the Danish data, the upper end of the Piloted/No Tugs CI range was calculated as 0.00211. From the Puget Sound dataset, the upper end of the Piloted/No Tugs CI range was independently estimated as 0.00202. These two values are very close. This is very gratifying, since the two

[19] See: https://blog.transmountain.com/tugs-have-flawless-record-supporting-tanker-movements-in-port-metro-vancouver/
[20] See: http://www.vancouversun.com/news/tanker+shadow+Onboard+boat+with+video/9647997/story.html
[21] The speed of the vessel through the water must be kept as slow as possible. As the speed of the vessel increases, the kinetic energy increases, and the ability of the escort tug to affect the direction of the vessel decreases. *The Utilization of Escort Tugs in Restricted Waters*, http://www.towingsolutionsinc.com/technology-escort_restricted.html
[22] *Study of Tug Escorts in Puget Sound*, page 93 : http://www.environmental-research.com/erc_reports/ERC_report_6A.pdf
[23] *Study of Tug Escorts in Puget Sound*, page 95 : http://www.environmental-research.com/erc_reports/ERC_report_6A.pdf

results are based on completely independent data sets. The slightly more conservative value of 0.00211 will be carried forward below.

Because escort tugs are used in Vancouver, what actually happened is that there were no incidents. As a result:

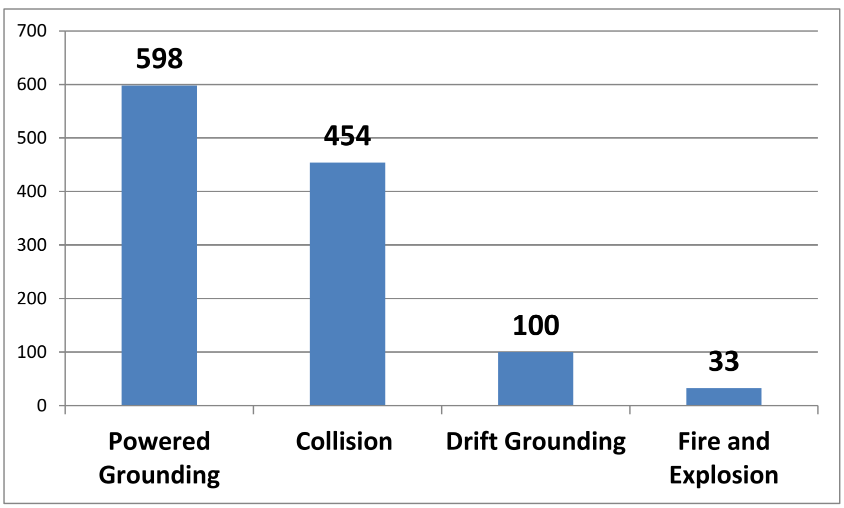
- **Pilots /Escort Tugs**: 20,000 trials, 0 groundings. 95% CI Range is [0.00000, .00018]

If piloted operations alone result in an accident probability of 0.00211, the addition of escort tugs along with pilots further reduces the accident probability to 0.00018. This is a further improvement in safety of 0.00211 / 0.00018 – or nearly a 12 times additional reduction in the risk of accidents. This practically eliminates the residual risk of drift grounding as an accident cause, leaving fire or explosion as the only significant remaining accident risk.

2.3 Summarizing the Safety Effectiveness of Pilotage

According to the international consultancy Det Norske Veritas (DNV), the two greatest risks to vessels in port or other restricted areas are powered groundings and collisions[24]. As shown in Exhibit 2-5, together these two categories account for more than 90% of all accidents likely to occur in port areas and channel approaches. Fortunately, these risk categories are the two for which pilotage directly provides the most effective mitigation.

Exhibit 2-5: Historical Accident Rates per Billion Nautical Miles (Source: DNV)



As empirical validation of the risks associated with powered groundings, note that the *Exxon Valdez*[25] and *SS Arrow*[26] accidents were both powered groundings – which resulted from navigational errors. *Exxon Valdez* remains the archetypal example of the risk associated with

[24] *Prince Rupert Marine Risk Assessment,* DNV, see http://legacy.rupertport.com/media/dnv/marine_risk_assessment_highlights.pdf Please note that the risk of Foundering is less than 1 incident per billion miles in port areas. It is mostly a risk to open ocean sailing so this risk category is not included in Exhibit 4.
[25] See: https://en.wikipedia.org/wiki/Exxon_Valdez_oil_spill
[26] See: https://en.wikipedia.org/wiki/SS_Arrow

lack of appropriate pilotage regulation[27]. Similarly, the *SS Arrow* was neither under pilotage nor escorted by tugs when it grounded on Cerberus Rock in Chedabucto Bay, Nova Scotia. The resulting spill was the largest in Canada and was still leaking in 2015, 45 years after the accident.

The largest ship-caused oil spill in history, the *Atlantic Empress*[28], was for its part the result of a collision. These cases exemplify DNV's risk exposure data and confirm that powered groundings and collisions are indeed significant risks to vessel safety.

As shown in Exhibit 2-5, drift groundings pose a lesser, but still significant risk to vessels. Drift groundings can occur if a vessel loses either propulsion or steering at a critical juncture:

- If vessel propulsion or steering fails, a pilot may not always be able to prevent drift grounding, although empirical evidence suggests that, even without tugs, pilots can still prevent many of them. Furthermore, in many cases within pilotage areas a rescue tug could reach the vessel before the wind, waves and current would ground the vessel. Established navigational procedures which are regularly updated through risk assessment processes such as the Pilotage Risk Management Methodology[29] (PRMM) process, limit vessel operations in times of exceptionally hazardous conditions when the risks may be considered too high. Following such procedures, as pilots are trained to do, will prevent sailing vessels into conditions that may make a rescue or retreat too difficult. In a worst case scenario, pilots would likely be able to at least reduce the severity of the grounding through appropriate mitigating action (e.g., speed, location)
- If escort tugs are in use, the pilot can use the tugs to maintain control of the vessel in the emergency situation, thus altogether prevent the drift grounding.

As such, and as discussed above in respect of the Vancouver and Puget Sound data, pilotage is directly effective against the overwhelming majority of all accident causes, and the use or tethered or standby escort tugs as required by practices based on risk assessments is directly effective to eliminate nearly all the residual risk.[30] Exhibit 2-6 compares the risks resulting from historical navigational accident rates (by cause) developed by DNV, as compared to the results of the Clopper-Pearson analysis of the Great Belt and Vancouver data. The results are remarkably similar. This comparison suggests that:

- Pilotage is the strongest single safety measure that can be employed to reduce the risk of maritime accidents. It reduces the accident risk by a factor of at least 44 times. Pilotage directly addresses the top two causes of vessel accidents, collision and power grounding, and in addition pilotage can help prevent or mitigate the consequences of a high

[27] At the time of the accident, harbour pilots were not mandated by the State of Alaska to be in charge of the conduct of vessels at the location where the accident happened, Bligh Reef. As a result, the pilot had disembarked from the vessel shortly before the accident. The State of Alaska changed its requirements following the accident and vessels transiting the area are now required to be under the conduct of licensed pilots. In addition, escort vessels are now also required to accompany tankers passing through Prince William Sound. Had these measures been in place at the time of the accident, the spill likely would not have occurred.
[28] See: https://en.wikipedia.org/wiki/SS_Atlantic_Empress
[29] Pilotage Risk Management Methodology, see http://publications.gc.ca/site/eng/366498/publication.html
[30] The final hazard, which is that of fire or explosion on board a vessel, is a small but statistically significant risk category, but has little directly to do with navigation or pilotage. DNV reports that most fires/explosions occur in mechanical rooms and do not necessarily have any effect on the cargo or bunker area. Bunker tanks are often located near the mechanical rooms, but are separated for safety by an empty compartment. This reduces the risk of cargo release. Double hull tankers have not only reduced the risk of hull penetration if the ship grounds, but also reduced the risk of a fire in a collision. However by reducing the frequency of groundings and collisions, it stands to reason that pilotage will also reduce the frequency of fires that may result from such accidents.

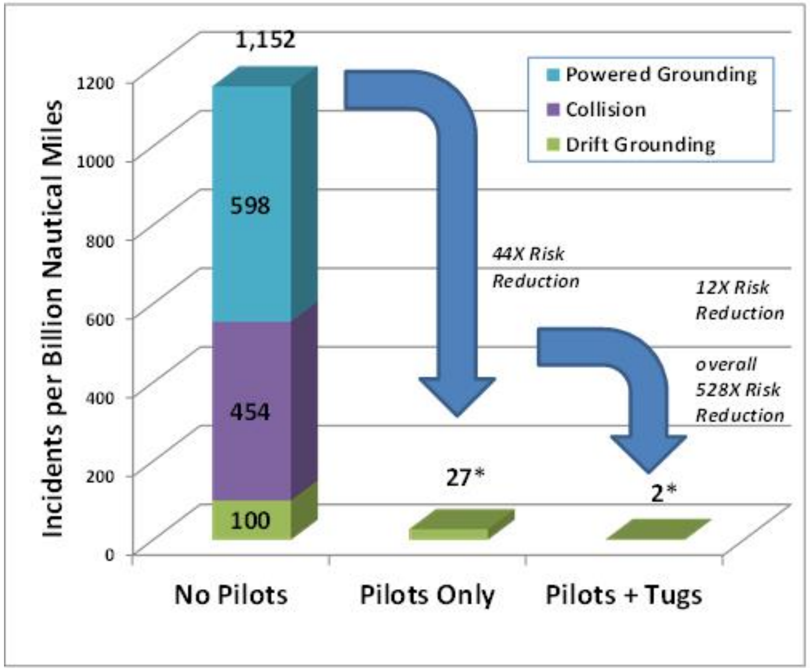
percentage of drift grounding accidents through the right intervention by a pilot. If escort tugs are additionally used, risk is reduced by an additional factor of 12, which eliminates practically all the remaining risk of drift grounding incidents.

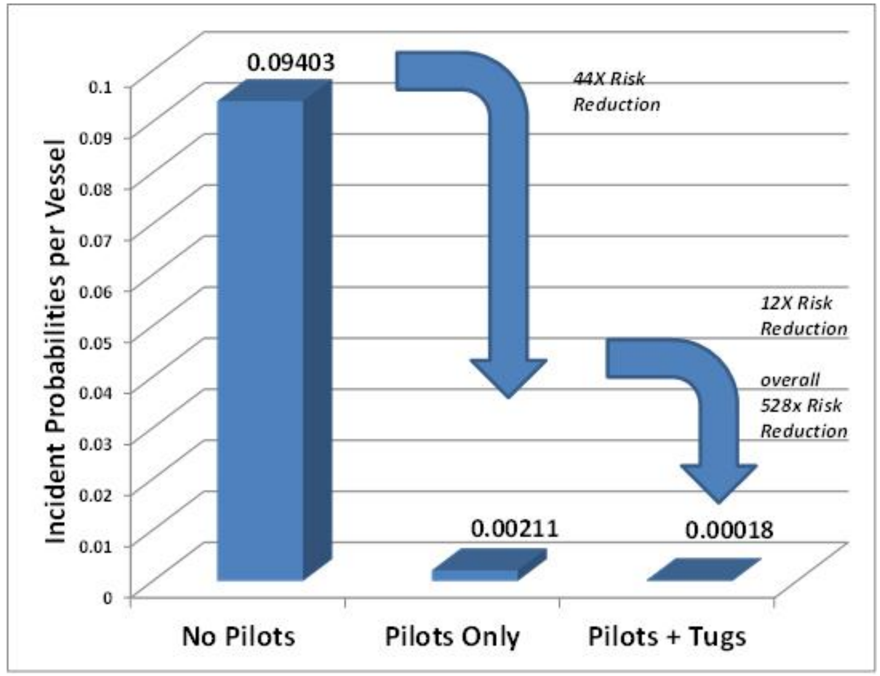
- Overall, the analysis suggests that for every 12,251 vessel movements[31] in pilotage areas -- there could be 1,152 incidents (9.4%) without pilots -- but it is extremely unlikely that there would be more than 27 incidents (0.211%) with pilots alone, or that there would be more than 2 incidents (0.018%) with pilots and the availability of tethered or standby escort tugs. Even without the use of an escort tug, pilotage has been shown to have a strong risk reducing effect and can prevent the vast majority of all incidents, or at least mitigate the impacts.
- In 2015, the four regional Canadian pilotage authorities reported 28 incidents out of 49,874 assignments, an actual rate of only 0.056%. It is gratifying to see that this falls at the low end of the predicted Confidence Interval ranges of the Danish Great Belt [0.0%, 0.211%] study and is in fact even lower than the range of incident rates suggested by the Puget Sound study on pilotage and escort tugs discussed above [0.093% , 0.202%]. This suggests that pilots were able to use tugs to reduce accident rates even lower than may be suggested by a pilots-only analysis.
- In Exhibit 2-6, it is assumed that assignments in each Canadian pilotage areas are at least equivalent in navigational difficulty to those in the Great Belt passage in Denmark. This is again a conservative assumption since many Canadian passageways, such as Vancouver harbour, the Welland Canal, the St. Lawrence River, or the Port of Saint John, present risk profiles that are certainly at least as high and significant as those present in the Great Belt. Many Canadian waterways have rocky bottoms and shoals that are much less forgiving than the silt found in the Great Belt. But, for the purpose of this analysis, generally considering that Canadian harbours and waterways are equivalent in difficulty to the Great Belt passage is sufficiently accurate to move the discussion forward.
- Because there is still some residual (very minor) probability of a navigational incident with pilots, good judgement should be exercised to manage vessel speeds in constrained channels and particularly in areas of rocky bottoms. However, the use of escort tugs means that any inadvertent impacts will be low-energy and within the design capability of the double-hulled tankers, so minor incidents happening at low speeds would not lead to major property damage, injury or loss of life, or to product or pollution in the marine environment. In port and coastal areas, these extra measures are often already in effect, and have demonstrated the safety of maritime operations even in the face of all the potential dangers that are inherent to the marine environment.
- Navigational safety has reached a point where the loading of oil in terminals, spills from pipelines at terminals, or causes such as fires or explosions on board vessels or oil drilling rigs actually pose greater environmental risks than navigational safety issues. ***Navigational safety has reached a point where the release of large quantities of pollutants from vessel accidents, particularly in ports or coastal areas, has become only a very remote and improbable outcome.***

[31] This is estimated as follows. 598 + 454 + 100 = 1,152 incidents were used as the Baseline for scaling purposes; see the DNV historical accident rates in Exhibit 5. This gives the likely relative distribution of accidents by cause, 12,251 movements without pilots * .094 = 1,152 accidents and the remaining accident estimates are also scaled according to the given incident probabilities.

- This analysis is designed to specifically measure the risk mitigating impact of pilots and tugs based on controlled comparisons, such as the Great Belt in Denmark that does allow a direct comparison of the relative risks associated with piloted versus unpiloted operations in restricted waters. On the basis of the quantitative analysis performed here, this study has identified much stronger impacts than were previously suggested by the subjective assessments carried out earlier by DNV and others. It suggests that pilots and tugs can have a much stronger risk reducing effect than was previously thought, and that the use of pilots and tugs is a very effective means for reducing the risks of vessel incidents, and in particular the risks of major oil spills. As such, pilotage becomes a key component of Canada's ability to gain the "social license" needed to develop its large natural resource base in an environmentally respectful manner.

Exhibit 2-6: Risk Reduction Effect of Pilots and Tugs





3. Safety Cost Benefit Analysis by Vessel Type

Chapter 3 separately assesses the safety costs and benefits of pilotage services to tankers and cargo vessels.

Exhibit 3-1 shows the data on the number of pilotage assignments undertaken by each of the four pilotage authorities. Only the Atlantic Pilotage Authority and the Pacific Pilotage Authority reported the number of tanker assignments apart from other ships. For the Laurentian Region, the number of tanker assignments is based on data provided by the Corporation of Lower St. Lawrence Pilots, and the Corporation of Mid St. Lawrence Pilots while for the Great Lakes Region, the number of tanker assignments was estimated based on pilotage authority data as well as the tonnage of various commodities shipped on the Great Lakes system. The Atlantic Pilotage Authority reported revenues for tankers separately from cargo ships. From this, it is seen that tankers are paying more, on average for pilotage services than are cargo ships. For example, the Atlantic Pilotage Authority earns most of its revenue from tankers even though the majority of pilotage assignments are cargo ships. It was assumed that a similar relationship would apply to the other three pilotage authorities (i.e., that the average pilotage costs for tankers were comparatively higher than the average costs for other cargo vessels). This results in the distribution of the number of pilotage assignments and estimated pilotage revenue streams as shown in Exhibit 3-1. The pilotage revenue earned by the authorities is a cost to the shipping lines, so the Benefit Cost treats it as the cost of the pilotage services.

Exhibit 3-1: 2014 Data from Canadian Pilotage Authorities

District	Tankers # of Assignments	Cargo # of Assignments	Total # of Assignments	Tanker % of Assignments	Tanker Pilotage (CDN $Mil)	Cargo Pilotage (CDN $Mil)	Total Pilotage (CDN $Mil)	Avg Tanker Revenue per Trip (CDN$)	Avg Cargo Revenue per Trip (CDN$)	Avg Total Revenue per Trip (CDN$)
Laurentian	5,383	17,003	22,386	24%	$31.90	$53.10	$85.00	$5,926	$3,123	$3,797
Pacific	1,207	11,633	12,840	9%	$10.54	$63.94	$74.49	$8,736	$5,497	$5,801
Atlantic	3,413	5,059	8,472	40%	$11.62	$10.86	$22.48	$3,405	$2,147	$2,654
Lakes	224	7,238	7,462	3%	$1.15	$25.38	$26.54	$5,149	$3,507	$3,556
TOTAL	10,227	40,933	51,160	20%	$55.22	$153.29	$208.51	$5,399	$3,745	$4,076

Exhibit 3-2 presents some further data on accident event probabilities, incident costs and the cost of tug escort services that also serve as key inputs to the analysis. The accident event probabilities for the three cases of No Pilots, Pilots Only and Pilots and Tugs are based on the analysis from Chapter 2.

- As shown in Exhibit 2-6, the Great Belt data suggests that for every 12,251 vessel movements, there may be as many as 1,152 incidents *(9.4%: the CI range is 0.3%, to 18.5%)* without pilots.
- The Great Belt and Puget Sound data suggest that this would be reduced to ***no more than*** 27 incidents *(0.211%, the CI range is 0.00% to 0.211%)* with pilots, and ***no more than*** 2 incidents *(0.018%, the CI range is 0.00% to 0.018%)* with pilots and escort tugs.

These are ***worst case*** probabilities since they reflect the upper end of the calibrated Confidence Interval (CI) ranges, except for the “No Pilots” case, which reflects the expected (average) value.

However, "worst case" probabilities are not consistent with the actual safety record of maritime services in Canada. It is obvious that the upper end of the calibrated CI range is too high to reflect expected results, since there have not, in fact, been two major oil tanker incidents per year in Canada. Therefore, the use of ***worst case*** probabilities is not appropriate for this Cost Benefit analysis. Rather, lower accident probabilities should be selected from within the CI ranges that reflect accident rates that are more consistent with actual Canadian experience.

For providing a benchmark of actual and expected accident rates, we have utilized a recent oil spill risk study by Transport Canada[32]. Table 3.5 of the Transport Canada study (reproduced below as Exhibit 3-2) estimated the probability of a major oil spill in Canada exceeding 1,000 cubic meters as 0.049 + 0.004 = 0.053 spills per year. This would imply a major oil spill occurs in Canada once every 18.9 years.

Exhibit 3-2: Overall Canadian Spill Frequency Estimates: Annual Estimate

Volume (m^3)	10 to 100	100 to 1,000	1,000 to 10,000	> 10,000
Crude	0.022	0.014	0.019	0.004
Refined Cargo	0.600*	0.100*	0.024	0.000
Fuel	1.900*	0.600*	0.006	0.000
Total	**2.522**	**0.714**	**0.049**	**0.004**

* Rates based on Canadian data; all other rates based on worldwide data.

Even this Transport Canada estimate is likely to be too high in regard to the risk associated with Canadian oil tankers:

- As shown in Exhibit 3-2, there were actually ***zero*** 1,000 to 10,000 m^3 oil spills in Canada from 2003 to 2013. The 0.049 rate was inferred by WSP Canada based on worldwide experience, and was "plugged" into the Canadian risk matrix.

- As shown in Exhibit 3-2, there were actually ***zero*** > 10,000 m^3 oil spills in Canada or anywhere in the world in "Canada-Like" countries from 2003 to 2013. This 0.004 rate was inferred by WSP Canada based on worldwide experience, and was "plugged" into the Canadian risk matrix reflecting the two spills which occurred in unregulated countries during this time. Even though the larger events occur at lower frequencies, these catastrophic events still make a considerable contribution to the total volume of oil spilled. That is why it is worth pointing out that none of these spills actually occurred either in Canada or in Canada-like countries.

- Many US tanker ships pass through Canadian waters on their way to US destinations in Puget Sound. The risks associated with these ships were also included in the Transport Canada analysis even though the cargoes neither originated nor terminated in Canada.

[32] Risk Assessment for Marine Spills in Canadian Waters: Phase 1, Oil Spills South of the 60th Parallel. WSP Canada, Inc for Transport Canada, January 2014. See: http://wcel.org/sites/default/files/file-downloads/131-17593-00_ERA_Oil-Spill-South_150116_pp1-124.pdf

The reality is that there have not been any major oil spills in Canadian coastal waters, since pilotage requirements were tightened after the 1970 ARROW disaster. Nonetheless, since an 18.9 year return rate has been established as an official Transport Canada benchmark, it will be used for calibrating the event probabilities. This does not imply endorsement of this result, since the safety of oil tankers in Canada (and "Canada Like" countries) has actually been better than Exhibit 3-2 shows, particularly in avoidance of very large spills.

For the purpose of this economic analysis, event probabilities will be chosen consistent both with the risk analysis of Chapter 2, and with Transport Canada's risk estimates. It is important to note that Transport Canada's estimates reflect the "status quo"– where tethered escort tugs are used on the West Coast and in Atlantic Canada ports.

- Tethered Tugs are used in the Pacific Region because they are needed in certain places for maneuvering; and due to the length of the escort, standby tugs are out of range for some parts of the transit. Tethered Tugs are also routinely used for laden tankers in many locations across the Atlantic Region including Placentia Bay, Saint John, Halifax, Canso.

- Tethered Tugs tend not to be used in the St Lawrence River, Seaway or Great Lakes largely because in case of unintentional grounding, much of the River has a soft/silty bottom, and there are no large ocean waves that could break up a ship, so it is typically considered that a double hull can effectively mitigate these risks.

Expanded use of escort tugs may be considered, however, as a result of risk assessments. However, since Transport Canada's study is based on current navigational practices, the benefits assessment is considered to accurately reflect today's conditions and navigational risks. This results in the following calibration of probabilities that will be used for the economic assessment:

- **For No Pilots:** ***To develop a conservative assessment, a major incident probability of 0.003358, or 0.3358% will be assumed. This assumes that one in every ten vessel incidents in Canada will be a "major" accident.*** Using this 0.3358% probability of a major accident for the "No Pilots" case is **extremely conservative** but is needed to calibrate to the accident rates from the Transport Canada report for oil spills > 1,000 m^3, as explained in the next few paragraphs. The estimated probability of 0.003358 for a major accident of an unpiloted ship falls toward the low end of the 95% CI range *of [0.00228, 0.01266]* for incidents that would release pollution, as described previously**.** As a result, the Cost Benefit calculation assumes that only 0.3358% of un-piloted ships will have an accident, rather than the 9.6% of un-piloted ships that actually grounded in the Great Belt. Since this assumption is more than 30 times lower than the percentage of ships that actually grounded in the Great Belt, it follows that the cost benefit ratio presented here will be correspondingly reduced. **If pilotage requirements were ever eliminated or reduced, *far more* accidents would most likely result than have been reflected here.**

- **For pilots alone:** ***If escort tugs are not available, the assumed accident probability is estimated as 0.0076%.*** This reflects a 44-times reduction in risk from the no-pilots case, as shown in Exhibit 2-6. This ignores the ability of escort tugs to reduce risks. However, escort tugs are in fact used in the Pacific and elsewhere are often within rescue range, so this assumption is overly conservative. It is presented as the lower range of the sensitivity analysis on the benefit of pilotage.

- **For pilots and tugs:** ***An accident probability of 0.000636%*** reflects an additional 12-times reduction in risk from the pilots-only case, as shown in Exhibit 2-6. Based on this time 10,227 tanker pilotage assignments, the estimated number of accidents is 0.065 per year, which comes close to (but is still conservatively on the high side) of Transport Canada's 0.053 annual probability of an oil release exceeding 1,000 m^3**.** This 0.000636% falls much closer to 0.000% than it does to 0.018%, but still remains within the calibrated CI Range.
    - A 0.000% accident probability would result in a "Best Case" assessment
    - The assumed 0.000636% is considered a "Most Likely" (still, very conservative) assessment of the benefits of pilotage. This is true since the 0.000636% accident rate closely (but conservatively) reflects Transport Canada's own projections.

These results:

- 0.3358% - No Pilots ("Best Case")
- 0.0076% - Worst Case with Pilots (Most Conservative)
- 0.000636% – Most Likely Case with Pilots
- 0.000000% - Hypothetical "Best Case" with Pilots

are the accident event probabilities that were used to assess the risk reducing effects of pilotage and tugs in this analysis.

The 2004 *Study of Tug Escorts in Puget Sound*[33] estimates the economic cost of 65,000 barrels (or 10,000 ton) oil spill from a Suezmax tanker in Puget Sound to be U.S.$99 Million. Most of this cost consists of environmental damage due to the spilled oil. For reference, this is about the same size as the 1970 *ARROW* oil spill in Chedabucto Bay, but this cost for cleaning up an oil spill is, if anything, on the low side. For example, the *Exxon Valdez* oil spill occurred in Prince William Sound, Alaska, on Easter Sunday, March 24, 1989, when *Exxon Valdez*, an oil tanker bound for Long Beach, California, struck Prince William Sound's Bligh Reef and spilled 11 to 38 million U.S. gallons (260,000 to 900,000 bbl.) The cleanup alone cost was in the region of U.S. $2.5 Billion and total costs (including fines, penalties and claims settlements) have, at times been estimated at as much as U.S. $7 Billion. According to CBS, Exxon spent more than U.S. $3.8 Billion in clean-up costs, fines and compensation for this single accident.[34] It has been estimated that a West Coast oil tanker spill clean-up could cost U.S. $9.6 Billion[35] and the cost of

[33] See Table 4.1 which estimates U.S. $99 million as the cost of a 65,000 barrel oil spill: http://www.environmental-research.com/erc_reports/ERC_report_6A.pdf
[34] See https://www.americanprogress.org/issues/green/news/2010/04/30/7620/oil-spills-by-the-numbers/
[35] See http://www.cbc.ca/news/canada/british-columbia/west-coast-oil-tanker-spill-clean-up-could-cost-9-6b-1.1172179

the Deepwater Horizon spill was estimated as U.S. $54 Billion.[36] The assumed U.S. $100 Million accident cost for tanker ships is very low[37] by comparison to these numbers.

It is very difficult to accurately estimate or measure the true cost of tanker accidents in economic terms. There are likely many external costs that either cannot be quantified accurately, or which may be missed, despite the best efforts of the economist. It is seen that the range of costs can easily vary from $100 million to $10,000 million: the potential error range in estimating these costs is measured in orders of magnitude. For this analysis, costs have purposely been set on the low side. This is not in any way to downplay or minimize the importance of tanker accidents. Rather, it is to intentionally promote conservatism in the economic analysis. A very round number of $100 million per accident was used, so as not to imply precision in the cost estimate. The astronomical cost of tanker accidents shows the critical importance of utilizing every possible safety measure, including pilotage as appropriate, for minimizing the risk of accidents.

The cost of accidents for Cargo Ships is significant, but not astronomical. In 1997, a U.S. Coast Guard analysis[38] estimated a U.S. $2.5 Million average cost for a cargo vessel accident. In current dollars, the inflation multiplier[39] being 1.488 brings the cost up to a current cost of U.S. $3.7 million per accident. It is important to note that, for the purpose of this report, because the 10-year history of the U.S.-CAD dollars demonstrates that the two currencies were roughly at parity for most of that period – the particular strength of the U.S. dollar being a relatively recent phenomenon – an exchange rate conversion was not performed. If anything, in the current context, this approach further exemplifies the overall intention of this report to examine the cost benefit ratio of pilotage on the basis of very conservative assumptions[40].

For comparison purposes, an approximate cost for tugs was estimated based on a cost of $1,175 per hour for a tractor tug. It is assumed that two tugs are needed for 10 hours, so the cost per escort would be $23,500. Normally only tankers are escorted although all ships use tugs for docking maneuvers. Tugs cost a lot more than pilots do, but pilots are needed for using tugs effectively. The cases with pilots assume that normal procedures are followed (e.g., including the use of tugs during berthing and unberthing operations) and the ability to use tugs as needed for emergency rescue operations.

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[36] See http://www.nytimes.com/2015/07/03/us/bp-to-pay-gulf-coast-states-18-7-billion-for-deepwater-horizon-oil-spill.html?_r=0

[37] Only 6.8% of shipping incidents in the Baltic Sea released pollution (meaning that 93.2% of incidents did not release pollution.) But, this statistic was based on incidents for *all* ships, not just tankers, and the Baltic Sea has a soft silty bottom. Tankers would likely have a higher probability of releasing pollution than general cargo ships, especially if an accident occurred in an area with a rocky bottom or coastline, as much of Canada has. Multiplying (hypothetically) the $9.6 Billion estimate for the cost of an oil spill, times the 6.8% probability of product release, the result comes to $653 million, which is still much higher than the $100 million per incident cited by the Canadian ERC report. The reason for using the very low $100 million cost estimate for an oil spill is not to downplay the result of a marine incident. Rather, even with this extremely conservative assumption, the results show that the pilots are making a tremendous contribution to improving maritime safety. The cost of pilots is truly a bargain as compared to the cost of an oil tanker incident.

[38] *The Economic Impact of Accidents on the Marine Industry*, ICF Kaiser for the U.S. Coast Guard, April 1997, table ES-1. See: http://ntl.bts.gov/lib/20000/20100/20144/PB98111420.pdf

[39] See: http://www.in2013dollars.com/2004-dollars-in-2016 :$100 in 1997 → $148.77 in 2016, retrieved on January 13, 2017. Please note also that according to https://www.ofx.com/en-us/forex-news/historical-exchange-rates/, the US and Canadian dollars have been trading at a 1:1 ratio for most of the past 10 years. Only in the past few years has the dollar strengthened to historic high levels. Since this cost reference dates back to 1997 it was considered more appropriate to use the historical 1:1 exchange rates for currency conversion than to use the current historic high rates. This is conservative since the accident costs are now lower than they would have been had a current currency rate conversion been performed.

[40] For a 10-year history of the U.S – CAD dollars, please see: http://www.ofx.com/en-us/forex-news/historical-exchange-rates/ source retrieved on January 18, 2017.

3.1 Tanker Ship Assessment

Exhibits 3-3 and 3-4 summarize the Benefit Cost results for tankers. Exhibit 3-3 shows the costs associated with the 10,227 tanker trips made each year in Canada:

- **Without Pilots** (Best Case) there would be no pilotage cost, but 34.3 accidents would cost $3.43 Billion per year

- **With Pilots** (Worst Case) there would be $55.2 Million in pilotage cost, but accidents would be reduced to $78.1 Million per year

- **With Pilots** (Expected Case) there would be $55.2 Million in cost for pilots, but by using tugs as appropriate accident costs would be conservatively reduced to $6.5 Million per year. The expected case eliminates 99.9994% of all accidents. The best case which eliminates 100% of accidents performs only slightly better than the Expected Case (in terms of Benefit to Cost Ratio).

The final row of Exhibit 3-3 sums the cost of Accidents along with Safety Prevention costs showing that total accident costs continue to decline as additional safety measures are added. As shown in Exhibit 3-4 in the Worst Case (pilots only) assessment, pilots cost only $55.2 Million per year while avoiding nearly $3.36 Billion in accident costs. This is a 60 to 1 Benefit to Cost Ratio. By using tugs in the Expected Case to further reduce the accident risk, the annual reduction in accident costs slightly improves to $3.43 Billion per year and Benefit to Cost ratio improves to a 62 to 1 ratio.

Exhibit 3-3: Oil Tanker Total Cost of Safety

District	Tanker Assignmts	No Pilots				Pilots - Worst Case				Pilots - Expected Case				Pilots - Best Case			
		Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)	Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)	Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)	Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)
Laurentian	5,383	0.003358	18.1	$1,807.61	$0.00	7.63E-05	0.41	$41.08	$31.90	0.000006	0.034	$3.42	$31.90	0.000000	0.000	$0.00	$31.90
Pacific	1,207	0.003358	4.1	$405.30	$0.00	7.63E-05	0.09	$9.21	$10.54	0.000006	0.008	$0.77	$10.54	0.000000	0.000	$0.00	$10.54
Atlantic	3,413	0.003358	11.5	$1,146.09	$0.00	7.63E-05	0.26	$26.05	$11.62	0.000006	0.022	$2.17	$11.62	0.000000	0.000	$0.00	$11.62
Lakes	224	0.003358	0.8	$75.17	$0.00	7.63E-05	0.02	$1.71	$1.15	0.000006	0.001	$0.14	$1.15	0.000000	0.000	$0.00	$1.15
Subtotal	*10,227*		*34.3*	*$3,434.17*	*$0.00*		*0.78*	*$78.05*	*$55.22*		*0.065*	*$6.50*	*$55.22*		*0.000*	*$0.00*	*$55.22*
TOTAL				$3,434.17				$133.27				$61.72				$55.22	

Exhibit 3-4: Oil Tanker Pilotage: Benefit Cost Results

District	Pilots - Worst Case			Pilots - Expected Case			Pilots - Best Case		
	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit
Laurentian	$1,766.53	$31.90	$1,734.63	$1,804.19	$31.90	$1,772.29	$1,807.61	$31.90	$1,775.71
Pacific	$396.09	$10.54	$385.54	$404.53	$10.54	$393.99	$405.30	$10.54	$394.75
Atlantic	$1,120.04	$11.62	$1,108.42	$1,143.91	$11.62	$1,132.30	$1,146.09	$11.62	$1,134.47
Lakes	$73.46	$1.15	$72.31	$75.03	$1.15	$73.88	$75.17	$1.15	$74.02
TOTAL	**$3,356.12**	**$55.22**	**$3,300.90**	**$3,427.66**	**$55.22**	**$3,372.44**	**$3,434.17**	**$55.22**	**$3,378.95**
BC Ratio		**60.78**			**62.07**			**62.19**	

3.2 Cargo Ship Assessment

Exhibits 3-5 and 3-6 summarize the Benefit Cost results for Cargo Ships. Exhibit 3-5 shows the costs associated with the 40,933 cargo ship trips made each year in Canada:

- **Without Pilots** (Best Case) there would be no pilotage cost, but 137 accidents each year would cost $508 million per year

- **With Pilots** (Worst Case) there would be $153 million in pilotage cost and the accident frequency reduced to only 3.1 per year costing $11.6 million per year

- **With Pilots** (Expected Case) there would still be $153 million in cost for pilots but by using tugs to further reduce the accident risk, accidents would be reduced to 0.26 per year and costs to less than $1 million per year. The expected case eliminates 99.9994% of all accidents. The best case which eliminates 100% of accidents performs only slightly better than the Expected Case (in terms of Benefit to Cost Ratio).

Exhibit 3-6 develops an "incremental" Cost Benefit assessment showing that pilotage is the strongest single safety measure that can be employed to reduce the risk of maritime accidents. As shown in Exhibit 3-6 in the Worst Case (pilots only) assessment, pilots cost only $153 Million per year while avoiding over $497 Million in accident costs, a 3.24 to 1 Benefit to Cost Ratio. In the Expected Case, the ratio is 3.31. Since these Ratios are based on the Best Case scenario without Pilots (please see the discussion above under "For No Pilots" in the introduction to Chapter 3 for the rationale and implications of this scenario), the overall Benefit to Cost ratio for pilots on cargo ships has therefore been estimated to be, at a minimum, in the range of 3.24 to 3.32.

Exhibit 3-5: Cargo Ship Total Cost of Safety

District	Cargo Assignmnts	No Pilots				Pilots - Worst Case				Pilots - Expected Case				Pilots - Best Case			
		Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)	Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)	Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)	Event Prob	Expected # of Accidents	Cost of Accidents (CDN $Mil)	Cost of Safety (CDN $Mil)
Laurentian	17,003	0.003358	57.1	$211.26	$0.00	7.63E-05	1.30	$4.80	$53.10	0.000006	0.108	$0.40	$53.10	0.000000	0.000	$0.00	$53.10
Pacific	11,633	0.003358	39.1	$144.54	$0.00	7.63E-05	0.89	$3.28	$63.94	0.000006	0.074	$0.27	$63.94	0.000000	0.000	$0.00	$63.94
Atlantic	5,059	0.003358	17.0	$62.86	$0.00	7.63E-05	0.39	$1.43	$10.86	0.000006	0.032	$0.12	$10.86	0.000000	0.000	$0.00	$10.86
Lakes	7,238	0.003358	24.3	$89.93	$0.00	7.63E-05	0.55	$2.04	$25.38	0.000006	0.046	$0.17	$25.38	0.000000	0.000	$0.00	$25.38
Subtotal	*40,933*		*137.5*	*$508.58*	*$0.00*		*3.12*	***$11.56***	***$153.29***		*0.260*	***$0.96***	***$153.29***		*0.000*	***$0.00***	***$153.29***
TOTAL				$508.58				$164.85				$154.25				$153.29	

Exhibit 3-6: Cargo Ship Pilotage: Benefit Cost Results

District	Pilots - Worst Case			Pilots - Expected Case			Pilots - Best Case		
	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit
Laurentian	$206.45	$53.10	$153.36	$210.86	$53.10	$157.76	$211.26	$53.10	$158.16
Pacific	$141.25	$63.94	$77.31	$144.26	$63.94	$80.32	$144.54	$63.94	$80.59
Atlantic	$61.43	$10.86	$50.56	$62.74	$10.86	$51.87	$62.86	$10.86	$51.99
Lakes	$87.89	$25.38	$62.50	$89.76	$25.38	$64.38	$89.93	$25.38	$64.55
TOTAL	**$497.02**	**$153.29**	**$343.73**	**$507.62**	**$153.29**	**$354.33**	**$508.58**	**$153.29**	**$355.29**
BC Ratio		**3.24**			**3.31**			**3.32**	

3.3 Overall Ship Safety Assessment

The overall safety benefit of Pilotage in Canada can be developed by adding together the Tanker and Cargo ship benefits. Exhibit 3-7 shows this result. Overall the pilots cost to Canada is $208 Million each year, but they prevent at least $3.8 Billion in shipping accidents. This results in an overall Benefit Cost ratio of approximately 18 to 1 – an excellent return by any assessment.

The main drivers of the benefit of pilotage are the probability of an accident (which has been assessed as high as 9.4% based on the Great Belt data) and the cost of an accident, which for tankers could possibly run into the Billions. *This assessment was purposely conservative since if the higher accident rate of 9.4% were applied (instead of the 0.36% that was actually used) along with a higher cost per incident (compared to the $100 million that was actually used): it could have been argued that pilotage has a Benefit Cost return that exceeds 300 to 1.* By any measure, the cost of pilotage is very minor compared to the direct economic and environmental costs of the accidents that pilotage prevents.

Exhibit 3-7: All Ships under Pilotage in Canada: Benefit Cost Results

District	Pilots - Worst Case			Pilots - Expected Case			Pilots - Best Case		
	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit	Accident Savings (CDN $Mil)	Safety Cost (CDN $Mil)	Net Benefit
Laurentian	$1,972.98	$85.00	$1,887.98	$2,015.04	$85.00	$1,930.04	$2,018.87	$85.00	$1,933.87
Pacific	$537.34	$74.49	$462.85	$548.79	$74.49	$474.30	$549.83	$74.49	$475.35
Atlantic	$1,181.47	$22.48	$1,158.98	$1,206.65	$22.48	$1,184.17	$1,208.94	$22.48	$1,186.46
Lakes	$161.35	$26.54	$134.81	$164.79	$26.54	$138.25	$165.10	$26.54	$138.57
TOTAL	**$3,853.14**	**$208.51**	**$3,644.63**	**$3,935.28**	**$208.51**	**$3,726.77**	**$3,942.74**	**$208.51**	**$3,734.24**
BC Ratio		**18.48**			**18.87**			**18.91**	

4. Productivity Cost Benefit Case Studies

Chapter 4 will use a Case Study approach to explore the value that pilots add to the efficiency of shipping operations, particularly through the introduction of improved navigational procedures.

In addition to providing important benefits related to safety discussed in chapters 2 and 3, pilotage also enhances the efficiency of shipping operations. Pilots minimize costly delays in vessel transits, by ensuring that such transits proceed in the most expeditious manner while maintaining safety as first consideration. This consideration relates not only to the time that each and every vessel would, by itself, otherwise need to complete a transit, but also to the fluid orchestration of traffic as a whole in any given pilotage district. The efficient timing and management of vessel meeting and overtaking in narrow approach and harbour channels is needed to ensure the optimal utilization of short tidal windows.

As market conditions and shipping technology change and the average size of ships continues to grow, it is from time to time necessary to develop new navigational procedures to enhance the economic competitiveness of Canadian ports and waterways. Pilots have played a key role in the development of innovative procedures designed to improve the efficiency and competitiveness of maritime operations, always in a manner that is consistent with safety. For example, pilots have helped develop new navigation procedures that enable Canadian ports to accept larger ships and, in areas where dredged channels or locks constrain ship size, to use the full depth and width of the channel and thereby maximize the volume of cargo carried. Pilots have also helped extend shipping operations by developing new ways for supporting winter and nighttime navigation in constrained channels, even without the assistance of buoys or other traditional navigational aids.

Information technology has been a key enabler of this innovation. Portable Pilot Units (PPUs) – an innovative tool essentially developed by pilots themselves – utilize differential GPS, and other location systems, and play a key role in navigation. PPUs are also supported by a network of real time water level and flow gauges, weather buoys and predictive algorithms. These take measurements and develop forecasts, relaying the information in real time to the PPUs, so navigation decisions can always be based on the most current and accurate information.

For example, on the lower St. Lawrence River, in the presence of strong weather systems it is not uncommon to see variations of up to 0.80 meters between predicted tidal level (from tide tables) and the actual water level. In the past, this variability in the actual vs. predicted water levels resulted in a need for maintaining an extra meter of under keel clearance to buffer the uncertainty. Today with the availability of real time measurements of actual water levels, as well as use of computer models that enable accurate forecasting of future conditions, navigation decisions can be undertaken with greater confidence.

This level of navigational precision was never possible in the past, so today's pilots are able to squeeze significant additional efficiencies out of Canada's waterways. As a result, shipping lines can send ever larger ships to Canadian ports, and the time windows during which ships can sail have expanded, reducing delays. For example, because neap tides are clustered together, in the past there was up to a 6-day window (twice a month) off Quebec City when a ship with a 15.5

meter draft could not move into port. Today, with more accurate measurements of water levels, the maximum wait for a tide has been shortened to 25 hours at most. In the past, a 15.5 meter draft ship could move into Quebec City on only 73% of the tides, but now it can move on 94% of the tides.

In the Great Lakes Region, the use of PPUs by Canadian pilots allows vessels to continue optimal operations, in terms of efficiency, for several weeks, even after all the lighted buoys are replaced. In the Laurentian region where night winter navigation was not systematically possible, vessels can now operate all winter long on the St. Lawrence River, 24 hours a day, as far as Montreal, even without the assistance of lighted buoys or other traditional navigation aids when they are replaced by spar buoys to prevent damage by the ice.

Pilots have assisted not only with channel navigation, but also in developing new berthing and docking procedures to allow Vancouver and Halifax to respond quickly to the needs for accommodating larger ships at docks that were never designed for vessels of that size. As a result, the ports were able to immediately accept the larger vessels that the shipping lines wanted to use, even while they work to obtain the required funding approvals and environmental clearances for longer term infrastructure improvements.

This chapter does not seek to provide a full assessment of the overall economic impact of pilotage. This is due to the fact that, at least in some cases, pilotage acts as the enabler of virtually all of the economic activity associated with a Port (i.e., virtually no traffic would take place otherwise), while, in other cases, it is difficult to quantify the impact that would be specific to pilotage. What this chapter does, however, is to provide insight on how pilotage has contributed to facilitate and enhance operations, as well as on the resulting value added.

4.1 Pilotage and Larger Vessels

Because of the worldwide increase in vessel sizes, Canadian pilotage practices have had to evolve to accommodate larger ships; it is interesting to examine the impact of this trend on the west and east coasts and in Central Canada:

- **West Coast ports and Halifax, NS:** both benefit from having deep water, but also have difficult navigational approaches and have had facilities (e.g., docks) that were not always designed for larger vessels; so pilotage has enabled the ports in these regions to handle nearly the largest ships afloat and, over time, to accept increasing numbers of such ships. Since large ships showed up with little advance warning, pilotage has been a critical factor in enabling ports to respond to the market need by providing the ability to accept such ships even without infrastructure improvements in respect of berthing capacities.
- **Laurentian** ports are inherently restricted by the constraints of the St. Lawrence River. The emphasis has been to expand vessel sizes to the maximum that can be possibly accommodated in restricted navigational channels, and increase the cargo capability of existing ships. Efforts to accommodate larger ships and heavier loads have relied upon new pilotage techniques and e-Navigation innovations, such as linking PPUs into a network of real time water level and flow gauges, and predictive algorithms. These will be described in the following sections.

4.1.1 Case Study 1: Pilotage and Tankers in Vancouver

In Vancouver, BC pilots and tethered tugs are used on tankers all the way out to the Juan de Fuca Strait. As described in Chapters 2 and 3, safety benefits alone provide more than enough justification for adding the pilots and tugs, but BC Coast Pilots have been instrumental, as elsewhere, in helping to optimize use of the existing shipping channel to run ships as fully loaded as possible.

Due to channel limitations, wider and longer tanker ships in Vancouver cannot be accommodated (since the length and beam guidelines have already been maximized) but tankers have been allowed to load to a deeper draft after a risk assessment process. While the actual maximum loading each day depends on real time water level measurements and tide predictions, the maximum allowable draft was increased from 12½ to 13½ meters. This increase of draft, in the same channel, was achieved in consultation with BC Coast Pilots and facilitated by the implementation of various measures including: insisting on better surveys, improved charts, improved tidal predictions, having l-time tidal information over AIS, better navigational aids, and developing and implementing customized PPUs. The economic benefit associated with this added vessel capacity has been estimated as follows:

- For an Aframax (>240m) tanker, one meter allows for a possible increase of cargo of about 10,500 cubic meters of cargo (66,038 barrels). The smaller Panamax Tanker gains 7,200 cubic meters of cargo (45,283 barrels).
- Since a Panamax tanker can normally carry 500,000 barrels[41] the increased capacity of 45,283 barrels is worth approximately a 9% increase in vessel carrying capacity.
- The tide does not allow this increase for every transit. On average the tide allows about half of this maximum increase so the benefit has been assessed on the basis of a 5% increase in cargo, resulting in a corresponding 5% reduction in the number of ships needed to carry the same cargo.
- As shown in Exhibit 4-1, 80 large tankers transited the Second Narrows in 2014; this declined to 60 tankers in 2015, so the more conservative 2015 number of 60 tankers will be carried forward. We will also make the conservative assumption that these 60 tankers are all Panamax, rather than a combination of Panamax and Aframax (for which the benefit of a 5% increase in cargo would be greater). Without the navigational improvement, three more ships would have been needed to carry the same cargo. Another way of looking at this is that approximately 1.36 million barrels moved for free, since the additional cargo only negligibly increased the operating cost of the 60 ships that did operate in 2015.
- Assuming an average shipping cost of $2 per barrel for oil by foreign flag tanker from Vancouver to California, the productivity benefit associated with the added cargo is worth approximately $2.7 million per year.
- This benefit divided over the 60 ships is $45,000 per ship.

[41] See: http://alloiltank.com/oil-tanker-ship/

Exhibit 4-1: Piloted Moves through Second Narrows MRA 2011-15

Length overall (LOA) meters	2011	2012	2013	2014	2015	Total
Bulk carriers	132	121	127	118	96	594
<190	52	26	36	30	28	172
190 - 199.9	10	13	10	28	36	97
220 – 239.9	70	82	79	60	32	323
>240	-	-	2	-	-	2
Heavy Lift 190- 219.9	-	-	2	-	-	2
Tankers	271	297	298	315	351	1532
<190	209	194	199	235	291	1128
190 – 219.9	-	4	4	8	6	22
220 – 239.9	16	50	42	36	38	182
>240m	46	49	53	36	16	200

It has been estimated that Kinder Morgan's business would expand to about 400 ships per year with approval to twin the pipeline and expand the Westridge terminal. At these increased traffic volumes, the economic benefit of the added cargo would rise from $2.7 Million to $18.1 Million per year. If Kinder Morgan starts selling more oil into Asia rather than to the United States, the benefit would rise even more due to the longer hauls needed by tanker ship.

4.1.2 Case Study 2: Larger Container Ships on the West Coast

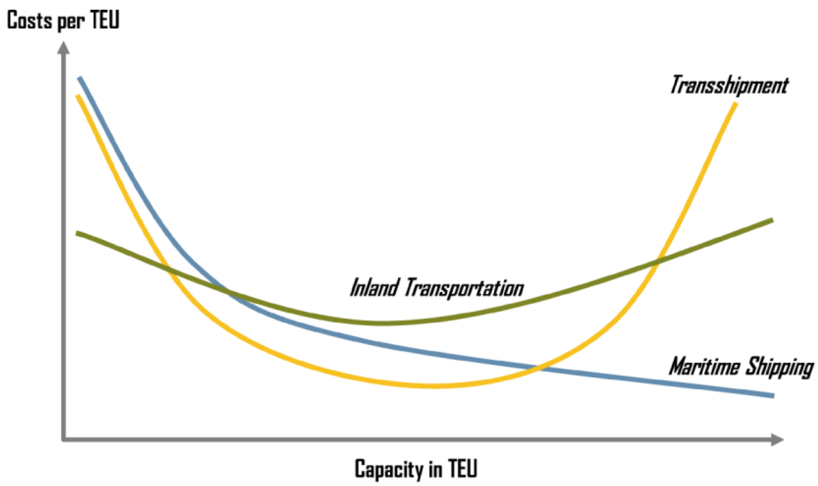
The world fleet of container ships has seen unprecedented growth in vessel size over the past few years. Whereas 80% of the existing fleet in July 2013 was of less than 5,100 TEU capacity, 23% of the ships on order at that time were of 10,000 TEU or more. As these ships are added to the fleet, it results in ever larger ships visiting ports that were originally designed for smaller vessels.

The challenge to major hub ports like Vancouver is no less than "adapt or die" since shipping lines are compelling ports to invest in the modern facilities, including development of land-side capabilities and competitive rail connections, needed to handle the high container volumes produced by mega-ships. If a port fails to invest, lines will divert their cargoes to other ports. The Port of Vancouver knows this and has been investing to improve its facilities.[42] In the meantime, pilotage has enabled the Port to accept larger ships even with its existing facilities.

Nonetheless, from an economic point of view, the move towards larger ships has not been without controversy. Classically, as shown in Exhibit 4-2, for any given port, there exists a tradeoff between vessel (line haul) and port (terminal) costs. While line haul (vessel) costs decline as ships get larger, congestion can cause port costs to rise, if the port is not designed with the capacity to handle larger ships. However, the shape of this curve can be shifted through investment. A port designed for 8,000 TEU ships functions most efficiently at the 8,000 TEU level, whereas a port designed for 14,000 TEU ships functions most efficiently at that level.

[42] *The Future of Super Ships* in http://www.vancouversun.com/future+super+ships/10982559/story.html

Exhibit 4-2: Port Congestion Can Generate Diseconomies of Scale[43] if Investments Are Not Made



Raising port productivity is essential to avoid detaining vessels for too long.[44] Shipping lines are counting on this, since it would be counterproductive to invest in big ships if they expected all the line-haul savings to be absorbed by increased terminal costs and delays. Clearly, shipping lines expect that efficiencies will not be absorbed in higher terminal costs; rather at least some of the cost savings will still remain to enhance their own competitive advantage. If this weren't true, the large ship strategy wouldn't make sense.

As such, the benefit of larger ships to Canada can be estimated based on the expected vessel line haul operating cost savings. This assumes that ports can be adapted to the new realities of shipping in large vessels. As forecasts of rising container traffic[45] continue to be realized, both ports and vessel operators will be able to recover the investments they are making to modernize their facilities and vessel fleets. The level of overcapacity in the global shipping market remains a serious concern, and launching of new high capacity ships only adds to the capacity glut. However, the economics of the new ships are so compelling[46] that they are continuing to be built even if this means mothballing or even scrapping older, less efficient ships.

The ramifications for Vancouver have been anticipated for some time. While the average length of container ships at Vancouver's key terminals is between 260-320m, with the largest so far at 371m, there is increasing pressure from the shipping lines to accept larger ships more often. This brings increased risks when berthing and unberthing, particularly considering space-compression in the available berths given the high level of capacity utilization in the port today. The increase in container ship size and the impact on the terminals is clearly just beginning.

[43] *Line Haul, Port and Total Cost Function* graph, see: https://people.hofstra.edu/geotrans/eng/ch3en/conc3en/contchipecoscale.html

[44] The ability to use more cranes and thus accelerate the loading/unloading rate is even considered a benefit of larger ships by the steamship operators. See: http://www.marinelink.com/news/container-economies358220.aspx

[45] *No Worries over Looming Container Slump Here*, http://www2.laufer.com/no-worries-over-looming-container-shipping-slump-here.html Drewry research released in late December 2015 noted that more large container ships are being deployed on the Asia-West Coast North America trade route. It said the average size of the ships on the route has risen 14% in two years and that there are now more than 50 ships with capacity to carry 10,000 or more 20-foot containers (TEU) on the route compared with 14 at the start of 2014.

[46] Putting both IFO bunker and ship operating cost savings together reveals that Maerk's 18,000 TEU ships are a massive 30% cheaper than 13,100 TEU ships on a round voyage basis – $294/TEU carried versus $418/TEU carried. This does not include Suez Canal and port costs, however, so it is not a total slot cost, but the differential in ship operating cost is clear. See: http://www.marinelink.com/news/container-economies358220.aspx

Larger ships are often less maneuverable than smaller vessels; they may need more assistance from tugboats to stay under control, and thereby depend even more on the navigational and vessel handling skills of pilots to be handled safely in the constrained waters of harbours.

Pilots have supported Vancouver's ability to accommodate larger ships:

- Pilots have developed new navigational procedures to safely handle larger container ships. In Vancouver, computer simulation is still ongoing to determine the largest ship that the First Narrows can handle which may include a cost benefit analysis on raising the First Narrows (Lions Gate) bridge, and of real-time bridge height measurement for allowing smaller air draft restrictions.
- A Container Berth Risk assessment was completed for developing procedures for docking large vessels at the existing piers in Vancouver. Now, 180,000-ton ships are safely docked at berths that were originally designed for 60,000-ton ships. Approach speeds cannot exceed 6 cm per second.

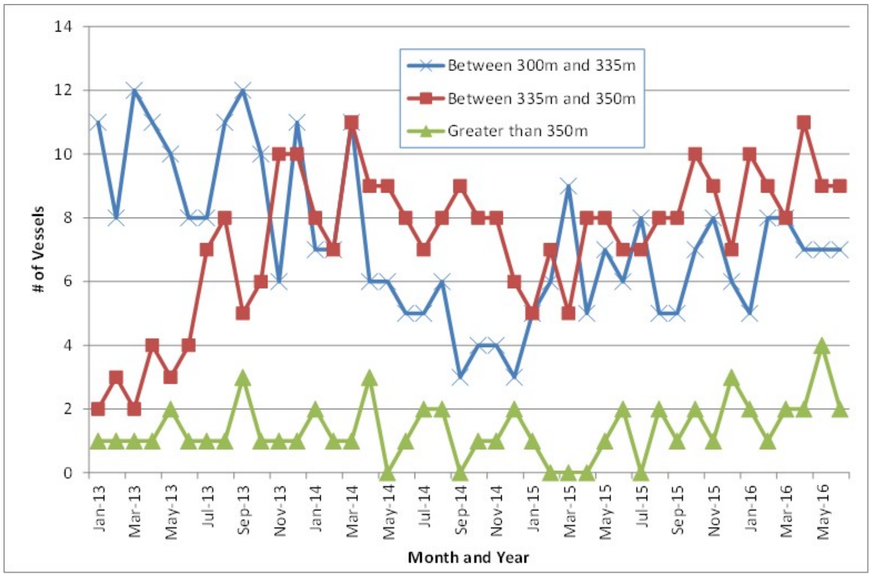
The existing standards of ship-spacing on container berths in Vancouver, combined with the capacity of the fenders on these berths, means that Vancouver will be operating at a higher degree of risk than some comparable ports. Not only is Vancouver's acceptable spacing tighter than most, but the capacity of the fenders also requires a higher degree of precision in berthing.

The additional docking risks have been largely mitigated by use of additional tugs. As ships get bigger, extra tugs will be required at lower wind speeds, and the natural variability in the environment will require pilots to operate with tighter margins of error. However, an additional tug can enhance precision in an economic manner as one of the few mitigations available as a tactical response.

The use of at least two tugs has been recommended as standard practice for ships of more than 350m. This is a small price to pay however, since it enabled the port to be responsive to the needs of the shipping lines for handling larger ships. As a result, the port has maintained and even enhanced its competitive position. The new procedures have bought the port valuable time for making strategic investments in port infrastructure. In terms of what has happened as a result, Exhibit 4-3 shows the container ship size trends in Vancouver for the most recent 3½ years.

- The size category 300m to 335m are ships that are only slightly larger than the Panamax specification (maximum length 294 meters) and are mostly in the 5,000-6,000 TEU range with an average around 5,500 TEU. The use of this size of ships has been declining; it has fallen from 11 ships per month to only 7 ships.
- The size category 335m to 350m is Post-Panamax vessels up to 10,000 TEU but averaging around 8,000 TEU. Some of these ships have been cascading out of Asia to Europe services as larger ships are introduced in those lanes, so they have been appearing more frequently on the trans-Pacific services. Their usage has risen from 2 up to 9 ships per month.
- 350m+ includes New Panamax vessels in excess of 10,000 TEU capacity. (New Panamax specification allows ships up to 366 meters) and averaging around 14,000 TEU. These very large ships are not often used in the trans-Pacific lanes, but their use has increased slightly from 1 vessel per month up to 2.

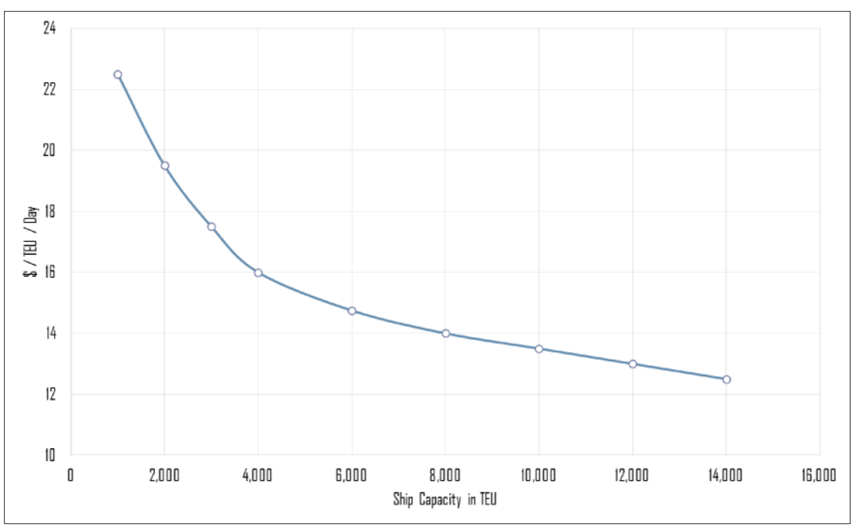
Exhibit 4-3 Large Containership Vessel Trends in Vancouver BC (January 2013-May 2016)



As shown in Exhibit 4-3, Vancouver is receiving larger ships and more vessel calls than ever before[47]. There were 14 large ships averaging 6,464 TEU and total capacity of 90,500 TEU in January 2013. In May 2016, there were 18 ships averaging 7,684 TEU and total capacity of 138,500 TEU. This is a 29% increase in the number of large containerships, an 18% increase in average vessel size and a resulting 53% increase in total vessel capacity over this 3½ year period.

For estimating the economic value of this increase in container ship size, Exhibit 4-4 shows how operating costs per TEU declines as vessel size increases.

Exhibit 4-4: Vessel Size vs. Daily Operating Cost per TEU[48]



[47] January 2013: 11*5500+ 2*8000 + 1*14000 = 14 ships; 90,500 TEU per month; average 6464 TEUs PER SHIP; as compared to May 2016: 7*5500+ 9*8000 + 2*14000 = 18 ships; 138,500 TEU per month; average 7684 TEUs PER SHIP
[48] See: https://people.hofstra.edu/geotrans/eng/ch7en/conc7en/daily_operating_costs_teu.html

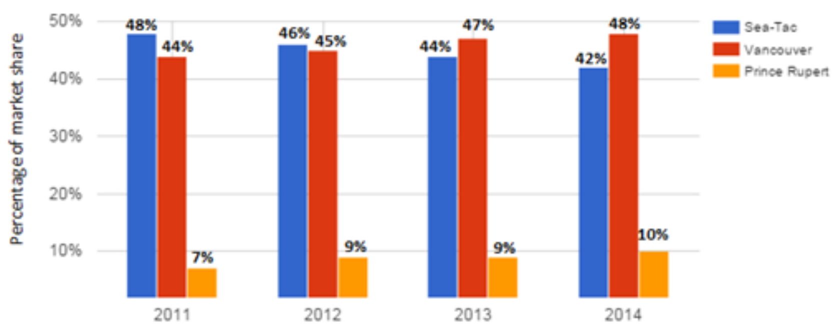
Since China is a major trading partner, Hong Kong to Vancouver has been used as a representative trading lane. From http://www.sea-distances.org/ the distance is 5,756 nautical miles; at 15.5 knots this would take 16 days. (Some services may be faster than this, but 15.5 knots is consistent with modern slow sailing[49] practice.) From Exhibit 4-4:

- The 2013 ship size of 6,464 TEU would result in a cost of $14.50 per day; times 16 days the cost would be $14.50 x 16 days = $232 per TEU
- The 2016 ship size of 7,684 TEU would result in a cost of $14.00 per day; times 16 days the cost would be $14.00 x 16 days = $224 per TEU

The savings amounts to $8 per TEU, which is very conservatively estimated relative to other benchmarks[50] for this incremental increase in vessel size. Multiplied times 3.05 million TEU per year at Vancouver[51], $24.4 Million per year would be the annual cost savings[52] generated by the larger container ships. If we divide this savings into the number of large container ships (432 per year) this suggests an average productivity benefit of $56,500 per ship.

However, this does not tell the whole story of the impact that larger container ships have had on Vancouver. As a result of the pilots' efforts, and those of their industry partners, to enable Canadian ports to accept larger ships, and because of problems at U.S. ports, Vancouver gained 4% and Prince Rupert 3% of total PNW container market share, as shown in Exhibit 4-5.

Exhibit 4-5: PNW Port Market Share[53], 2011-2015



Source: Seattle-Tacoma Alliance, Port of Vancouver, Prince Rupert Port Authority

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[49] Marine Insight says that most ships are slow sailing at 12-19 knots instead of the usual 20-24 knots, see: http://www.marineinsight.com/wp-content/uploads/2013/01/The-guide-to-slow-steaming-on-ships.pdf 15.5 knots has been assumed for this analysis, this speed was selected as the mid-point of this12-19 knots range. However Maersk, who are considered the pioneer of slow sailing, states that they are operating at just 12 knotsSee: https://www.yumpu.com/en/document/view/7803715/slow-steaming-the-full-story-maersk. As a result, the speed of 15.5 knots is likely a conservative assumption. Maersk's new big ships have smaller engines and hull forms that are optimized for lower speeds. As according to Maersk, "The lower top speed of the Triple-E vessels has a significant impact on the hull shape," naval architect Troels Posborg says. "It means we can build vessels with a larger capacity below the deck."

[50] This $12 per TEU savings is much smaller than has been estimated by some other studies. For example a recent Transport Canada study https://www.tc.gc.ca/eng/policy/report-research-ack-tp14837e-chapter8-1661.htm found that *the largest ships reduce ocean shipping costs by $180 per 40-ft. container over the smallest ones*. While this level of savings, is very impressive the Transport Canada study did not actually define what it meant by largest and smallest ships. These two articles cite overcapacity and the fact that much of the savings from new ships now comes from better engines, rather than scale economies:: https://www.bloomberg.com/view/articles/2016-06-14/ships-have-gotten-too-big and http://www.ibtimes.com/giant-container-ships-arrive-us-shores-many-ports-not-prepared-era-megaships-2246620 Exhibit 3-4 shows scale economies only, not the result of other technological improvements that also are built into new vessels. This explains why this assessment may be more conservative than some others.

[51] Vancouver's total TEUs in 2015, see http://www.portvancouver.com/wp-content/uploads/2016/02/2015-statistics-overview.pdf

[52] As previously noted, this savings is attributable to the efforts of the pilots to be able to accommodate these larger vessels at existing facilities. The larger ships showed up so quickly that there was not enough time for major port investments to be made.

[53] Source: http://www.joc.com/sites/default/files/u1117861/PNW4.PNG

It is not realistic to assume that any of this traffic growth would have been possible without the ports' ability to handle larger ships. Without the navigational improvements put in place by pilots, which enabled Vancouver to quickly adapt to large ships while Seattle and Tacoma could not, this market share shift simply would not have occurred. Combined with labor problems affecting the whole U.S. west coast, Vancouver and Prince Rupert were able to gain market share, while the U.S. Pacific Northwest and California ports both lost market share. According to Ocean Shipping Consultants[54], the reasons for Canada's success in penetrating the U.S. market are *the efficient operations of marine terminals in Vancouver and the cost-competitive intermodal services offered by the Canadian railroads. The all-in transportation cost to Chicago through Vancouver is 'considerably cheaper' than through Seattle-Tacoma.*

As a result, Vancouver's share of containerized imports moving to the U.S. expanded from 7.5 percent in 2008 to 22.9 percent in 2013. Now, Vancouver's biggest problem is capacity, which is approaching 85 percent utilization. However, the Port of Vancouver is constantly upgrading its capacity through additions to marine terminals, rail and roadway infrastructure. Also, the port and its transportation providers are expanding effective throughput capacity through more efficient business processes.

The economic impact of the shifted container traffic to Canada is significant. A recent U.S. economic study[55] concluded that the Seattle-Tacoma Seaport generates $4.3 billion of economic activity in Washington State, and that the port supported 18,886 direct jobs and a total of 48,134 direct, indirect and induced jobs. (This is a multiplier of 2.55 on the number of direct jobs.) As shown in Exhibit 4-6, over half (52%) of the directly identifiable economic impact, or 9,816 direct jobs were associated with the international container traffic in Seattle-Tacoma. Based on this 52% share of total port employment, the international container business at Seattle-Tacoma is worth 9,816 direct jobs; 25,018 indirect jobs and $2.1 billion of economic impact.

Exhibit 4-6: Sea-Tac Economic Impact by Port Activity

Port Activity	Direct Jobs
International Containers	9,816 (52%)
Domestic Containers	3,626 (19%)
Dry Bulk	393 (2%)
Autos	277 (2%)
Unallocated	4,774 (25%)
TOTAL	**18,886**

But by the first quarter of 2015, the Seattle-Tacoma Seaport saw its share of container volumes *fall* from 44 to 41 percent. Since 41 / 44 = 93%, this would be equivalent to a 7% loss of Seattle-

[54] *US importers moving more containers through Vancouver:* http://www.joc.com/port-news/us-ports/us-importers-moving-more-containers-through-vancouver_20150618.html
[55] *The Economic Impact of Marine Cargo at the Ports of Tacoma and Seattle,* September 2014, see: http://www.portoftacoma.com/sites/default/files/JointEconomicImpactStudy.pdf

Tacoma's container traffic, which was all shifted to Canada[56]. For understanding what this 7% shift means to Canada, the calculations in Exhibit 4-7 reflect just 7% of Seattle-Tacoma's total container impact as was assessed by Sea-Tac's own economic study:

Exhibit 4-7: Sea-Tac Economic Impact Shifted to Canada

Economic Gain to Canada	
Direct Jobs	**687**
Total Jobs	**1,752**
Economic Gain to Canada (Annual Basis, U.S. Dollars)	**$147 Million**

It can be seen that the economic impact associated with the shifted traffic (at $147 million per year) substantially *exceeds* the $24.4 Million per year of direct cost savings that was earlier attributed to the larger vessel sizes now being used in Vancouver. The difference reflects the ocean carriers' willingness to reward Canadian ports with extra traffic, because these two ports are responsive to their needs, whereas U.S. ports were not. The difference also reflects the effect of the economic multiplier factors as direct spending at the port ripples through the rest of the Canadian economy.

None of this economic gain to Canada could have occurred if the Canadian pilots had not played a key role in enabling the West Coast ports to respond quickly to the shipping lines desires' for larger vessel calls. For the purpose of this study, however, this economic impact resulting from shifted traffic is *not* included in the cost benefit ratios since Exhibit 4-7 shows impacts and not benefits. Only the $24,.4 Million that are admissible under Transport Canada's framework have been included.

4.1.3 Case Study 3: Larger Container Ships at Halifax

In Halifax, a real-time system is already in place for measuring the available overhead clearance of the two Halifax Harbour Bridges to optimize vessel loads and sailing times; berths have been extended and one berth equipped with stronger fenders.

On the approach to Halifax Harbour, "Dynamic Underkeel Clearance" during gale force winds and/or periods of heavy swell may become a concern due to wave response of large vessel (pitching, rolling, and heaving of the ship). A study is currently underway to better identify "go or no go" ship transits during such conditions. In addition, Full Mission simulation has been performed to ascertain optimal vessel handling procedures for ships with large windage area in high winds in confined channels. A 3-metre metocean "weather" buoy deployed in the vicinity of

[56] This shift has been documented by the Seattle-Tacoma ports themselves. See: http://kuow.org/post/tacoma-seattle-ports-join-forces-take-canada, http://kuow.org/post/notice-fewer-containers-puget-sound-ports-canada-grabbed-our-business, http://www.kiro7.com/news/small-port-big-competition-canadas-threat-seattle-/246331684

Herring Cove supports real time data collection on wave heights. Combined with predictive algorithms that can forecast wave conditions up to 36-hours on a 4-hour weather delay, a ship has the option to slow down and save up to 20% in fuel cost. The weather buoy helps with the predictability of the wave and weather conditions. Since January 1, 2015, with the coming into force of the requirement to burn Ultra Low Sulphur Fuel (ULS MGO/MDO 0.1% sulphur) in all main and auxiliary engines and boilers within the East Coast Emission Control Area, an average of 70 ships per winter would have saved a total of 800 tonnes of fuel valued between CAD $700 to $1000. per tonne, as a result of the Herring Cove Buoy.

As is the case at Vancouver and elsewhere, the challenge at Halifax is to "adapt or die". The capacity to accommodate larger container ships is crucial to the success of the port and successive waves of larger container ships have been successfully accommodated as a result of the coordinated efforts of the port, pilots and industry stakeholders.

As background, the first regular service to Halifax involving Post-Panamax ships (5,700 TEU) commenced in October of 2007. Prior to that, the largest size of containership was 4,700 TEU with the exception of 1998 when Halifax had approximately 8 transits of 6,000 TEU containerships. The next increase came in May 2015 (7,400 TEU) followed by another increase in August 2015 (with ships in the 8,400 – 9,300 TEU range.)

From 2013 to 2016, the average TEUs per container ship at Halifax increased from 3,916 up to 4,387 TEU: a 12% increase. (This takes into account the use of some small feeder ships linking Halifax to St. John's.) Exhibit 4-8 shows that from 2013 to 2016, yearly visits by "large" vessels (capacity greater than 7,500 TEU) grew by *7.5 times*, from 12 to 90 (each ship used two pilotage assignments) with the average capacity of these ships going from 7,500 TEU to 8,293. During the same period, yearly visits by "mid-sized" container ships between 3,100-7,500 TEUs also increased significantly, going from 542 in 2013 to 727 in 2016, a 34% increase, with the average capacity of these ships going from 4,157 TEU to 4,363 TEU.

Exhibit 4-8: Container Ship Size in Halfax 2013-2016

Year	TOTAL Containership Assignments	% Change in Total Containership Assignments (over previous year)	7500-9300 TEU Containership Assignments as % of Port's Containership Business	Containership Assignments 7500 – 9300 TEU (LOA 320-334m)	% Change in 7500-9300 TEU Containership Assignments (over previous year)
2016	1113	12.1%	16.2%	180	73.1%
2015	993	11.8%	10.5%	104	258.6%
2014	888	-7.6%	3.3%	29	20.8%
2013	961		2.5%	24	

Without this capacity to accommodate growing numbers of ever-larger container ships, the long-term strategy of Halifax to position itself as a deep-water hub for container ships would be significantly compromised.

Since Europe is a major trading partner, Halifax to Rotterdam has been used as a representative trading lane. The distance is 2,782 nautical miles[57]; at 15.5 knots this would take 8 days. (Some services may be faster than this, but 15.5 knots, as detailed in the Vancouver case study, is consistent with modern slow sailing practice.)

- *The 2013 average carrying capacity of 3,916 TEU per ship would result in a cost of $16.00 per day; times 12 days the cost would be $16.00 x 8 days = $128 per TEU*
- *The 2016 average carrying capacity of 4,387 TEU per ship would result in a cost of $15.25 per day; times 12 days the cost would be $15.25 x 8 days = $122 per TEU*

The savings amounts to $6 per TEU, which is very conservatively estimated relative to other benchmarks[58] for this incremental increase in average vessel size and carrying capacity. A savings of this order applies not only to the largest container ships, however, but rather is for the average of **all** the ocean-going container ships – a move up from a small to a medium sized ship would actually yield equal or greater benefit as a move from a medium size to a large ship.

Halifax is handling 480,000 TEUs per year[59] but it is appropriate to remove the short haul and domestic feeder volumes, for which vessel size increases on long-haul ships are not relevant. Oceanex's feeder service handles 100,000 TEUs per year,[60] but only 36% come out of Halifax.[61] Removing the estimated 36,000 Oceanex TEUs at Halifax, 444,000 TEUs are considered to benefit from the efficiency gains of the larger ships. As a result, $2.7 Million per year would be the annual cost savings generated by larger container ships at Halifax.

The overall economic impacts (direct, indirect and induced) of port-related activities at Halifax have been estimated at over $1.66 Billion and 11,820 full-time equivalent jobs in 2013[62]. Without a doubt, pilotage plays an important role in making this possible, and a fair part of the economic impacts of these activities would not exist were it not for the 2,800 pilotage assignments per year that take place at Halifax. The purpose of this case study, however, was not to determine how sizeable the particular part of the overall economic impacts that is attributable to pilotage might be, but simply to provide insight on the nature of the benefits provided by pilotage in respect of a specific type of shipping operations at the Port, regarding the transits of container ships.

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[57] See: http://www.sea-distances.org/

[58] This $12 per TEU savings is much smaller than has been estimated by some other studies. For example a recent Transport Canada study https://www.tc.gc.ca/eng/policy/report-research-ack-tp14837e-chapter8-1661.htm found that *the largest ships reduce ocean shipping costs by $180 per 40-ft. container over the smallest ones*. While this level of savings, is very impressive the Transport Canada study did not actually define what it meant by largest and smallest ships. These two articles cite overcapacity and the fact that much of the savings from new ships now comes from better engines, rather than scale economies:: https://www.bloomberg.com/view/articles/2016-06-14/ships-have-gotten-too-big and http://www.ibtimes.com/giant-container-ships-arrive-us-shores-many-ports-not-prepared-era-megaships-2246620 Exhibit 3-4 shows scale economies only, not the result of other technological improvements that also are built into new vessels. This explains why this assessment may be more conservative than some others.

[59] Halifax's total TEUs in 2016, see http://portofhalifax.ca/cargo/statistics/

[60] *An Overview of Eastern Terminals*, http://www.canadiansailings.ca/?p=9505

[61] From http://atlanticnortheast.com/onl/iss/i020221_150730.pdf 20,000 TEU (36%) from Halterm and 35,000 TEU (64%) from Montreal

[62] Port of Halifax, Economic Impact Study, Chris Lowe Planning and Management Group, January 2015

4.1.4 Case Study 4: Larger Ships on the St. Lawrence to Quebec and Montreal

Pilotage on the St. Lawrence River begins at Les Escoumins downstream from Quebec City. The River consists of three major sections:

- **From Les Escoumins to Quebec**, the Traverse du Nord[63], a dredged channel, is the major limitation in terms of maximum drafts for vessels bound for Quebec City[64]. The water is brackish; average tide height in the harbour at Quebec City is 4.9 m, but can exceed 6.0 m. The charted depth of the Traverse is 12.5 m. However, by using the tidal rise of the flood tide, except for neap tides, the maximum draft of vessels is currently 15.5 m.
- **From Quebec to Trois-Rivières**, it is fresh water and the River is subject to tidal influence. The tidal effect is obviously greater in Quebec (averaging, as mentioned above, 4.9 m) and diminishes approaching Trois-Rivières (30 cm). The tides induce an upstream current that opposes the general downstream current from the Great Lakes to the ocean. Depending on the height of the tide, the upstream current will flow over the downstream current. Generally, the tidal current reverses the River's flow up to Portneuf (approximately halfway between Quebec and Trois-Rivières). In this stretch, the maintained channel depth takes into account the possibility of using the rise of water level from the tide to make up for a lesser available channel depth. That is, from Quebec to about 4 NM from Batiscan, the charted depth is 10,7m. The depth is 11,0 m from that point to Batiscan, and finally 11,3m from Batiscan to Trois-Rivières.
- **From Trois Rivières to Montreal**, the St. Lawrence River is fresh water with a one-way flow. The channel depth is 11.3 m plus the water level in Montreal, which varies seasonally. It goes from -0.3 meters in the summer, to +2 meters in the spring. Tide gauges and water level predictions, coupled with very specific regional squat calculations and tables have allowed the underkeel clearance requirement to be confidently reduced to less than 1 meter.

There is a natural range of water flow on the River: the Great Lakes act as a reservoir collecting water from rainfalls and, accordingly, the River's flow varies from levels experienced on the Lakes. In winter, ice acts as a cover to prevent the water from evaporation. This allows water levels to remain higher during the winter months than they would otherwise be, and the lowest water levels usually occur in September and October.

However, there is also a daily variability of water flow attributed to weather (rainfall, wind, atmospheric pressure, etc.) and a man-made variation attributed to the possibility of releasing more or less water from the Moses Saunders and other hydroelectric dams along the River and the Seaway. The Port of Montreal and Environment Canada provide water level forecasts for one, two and three weeks in advance; the one week forecast being the most reliable. Based on these water level forecasts, container ships can be loaded in Europe to utilize the maximum expected available draft. Laurentian pilots then work to optimize the handling of the ship based on optimal tide and River levels to ensure its effective passage to Montreal.

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[63] *Water Level Forecasts and Squat Calculation for the Traverse du Nord,* see: http://vzb.baw.de/e-medien/4th-mashcon/PDF/2%20Squat/2_05.pdf

[64] Since deeper drafts are allowed to Quebec than to Montreal, the draft limitation in the Traverse du Nord would generally not affect a vessel bound for Montreal.

The water level forecast determines the timing of when heavily laden ships can move in the tidal regions. As mentioned above, from Trois-Rivières to Montreal the channel depth is consistent at 11.3 meters, but is only 10.7 meters from Trois-Rivières to Quebec. On a given day, the water level does not vary much from Montreal to Trois-Rivières, but the water level is slightly greater in Sorel than in Montreal and greater in Trois-Rivières than Sorel. Therefore, on that particular day, if a vessel leaves Montreal with a maximum draft of 10.96m, the underkeel clearance will increase as the vessel proceeds downstream to Trois-Rivières. As a rule of thumb, a vessel loaded to maximum draft in Montreal will time its departure in order to arrive in Trois-Rivières 1,5 hours before high tide in Quebec. This will provide sufficient tidal lift from Trois-Rivières to Quebec to clear all areas of shallower dredged depth of 10.7 m.

Similarly, based on the tides, ships regularly proceed through the Traverse de Nord at a draft of 15.5m to and from Quebec; but at this draft, there are only two windows each day where a ship would have sufficient underkeel clearance to traverse the entire length of the channel. The other limiting factor is available water depth at some docks in Quebec City; there may be cases where the vessel has to leave the berth on high tide, or if it arrives at the dock on high tide it must discharge enough cargo to allow for minimal available depth at low tide.

Another factor that pilots must consider is the squat[65] of the vessel. Squat is the additional sinkage of the moving vessel when it interacts with a navigation channel. As a vessel passes near the bottom of the River, there is an acceleration of the water[66] which causes the ship to sink lower in the water. The effect is more pronounced as the ship goes faster, as the ship's beam increases, or in narrow[67] and shallow channels. For squat measurements of specific type of vessels in the River, formulas were derived and tables were issued by the Canadian Coast Guard. These measurements will influence the maximum available draft of a vessel by up to a few decimeters, as well as the speed at which it will be able to transit. For example, a ship transiting at a faster speed will experience a greater squat effect which, in turn, will reduce its maximum available draft.

From Les Escoumins to Quebec, in the past, the maximum allowable draft of ships coming into Quebec was limited to 15.0 m instead of 15.5 m in winter. Because of the availability of real time tide gauges and predictions, ships can now sail to Quebec at 15.5 m draft year-around. Thus, heavily laden ships bound for Quebec (mostly tankers bound for the Valero/Ultramar refinery) have gained about 0.5 meters draft in winter.

From Quebec to Montreal, there is not a constant fixed maximum draft since this depends on the amount of water in the St. Lawrence River. However, the advent of real time water level gauges and predictions have allowed better transit times, better predictability and increased efficiency, and the tools allow vessels to have maximum drafts more often.

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[65] Here are two references on vessel squat modeling: http://omcinternational.com/wp-content/uploads/2015/02/Squat-modelling-for-operational-underkeel-clearance-systems.pdf and http://www.vliz.be/imisdocs/publications/10/251710.pdf

[66] Bernoulli's principle – the same effect that makes airplanes fly, also causes ships to sink lower as water accelerates around their hulls. See https://en.wikipedia.org/wiki/Bernoulli%27s_principle. The degree of acceleration will depend on the exact shapes of the hull and channel.

[67] As a result, pilots use two different sets of squat and required underkeel clearance tables: one for Escoumins to Quebec and a different table from Quebec to Montreal. These tables have evolved over the years to become ship type specific as the underwater form, the finer shape, of a container ship is not the same as a square bulker. The difference between the tables is due to the fact that the minimum width of the navigation channel between Quebec and Escoumins and from Quebec to Montreal is not the same.

However, a second area in which pilots have contributed to navigational improvements from Quebec to Montreal is in the area of navigating wide-beam vessels. The maximum allowable ship's beam went from a maximum of 32.2 m up to 44 m; for the same draft, the larger 5,300 TEU vessels can carry as much as 30% extra cargo compared to the older Panamax-sized ships.[68]

Tankers and container vessels are both using this new possibility. There has been a deployment of crude oil Panama size shuttle tankers between Quebec and Montreal where local pilots have been instrumental in the establishment of the service.

Since a post Panamax vessel (i.e. with a beam exceeding 32.2m) cannot meet some ships in certain parts of the channel, meeting and overtaking areas have been designated to allow vessels to get past one another. Vessel pairs with a combined beam of 65 m or greater are subject to some restrictions above Quebec City including daylight only navigation in some situations

Economic assessment of wide beam container ships into Montreal: As background, the average size of container ships sailing to Montreal has increased by a factor of eight since 1975. The largest ships calling to the port back then carried up to 750 TEUs. That number increased to 1,800 TEUs in 1981, and to 2,800 TEUs in 1996, as container ships were redesigned. In 2003, OOCL and the former CP Ships built and assigned to their Montreal routes 32.1-metre-wide Panamax-size ships capable of transporting 4,100 TEUs"[69].

While each of these successive waves of new, larger containerships provided economies of scale leading to operational efficiencies, this section will assess the potential benefit of employing "wide-beam" container ships (up to 44m) that have a larger TEU capacity than today's 32.1m beam Panamax sized ships. The possibility of seeing such wide-beam post-Panamax ships sailing to Montreal now exists following a full risk assessment study conducted jointly by the Montreal Port Authority, Transport Canada, the Canadian Coast Guard, the Laurentian Pilotage Authority and the "Corporation of Mid St. Lawrence Pilots" (*Corporation des Pilotes du Saint-Laurent Central*).

Specifically, this joint effort made it "possible for all post-Panamax-type vessels, including 6,000-TEU container ships, to reach Montreal. The Port can also now accommodate oil tankers with a cargo carrying capacity of 500,000 barrels, up from 350,000 barrels, and dry bulk ships that can transport 65,000 tonnes of cargo, up from 35,000 tonnes[70]". In respect of containerships, initial steps have now been taken towards introducing Post-Panamax wide-beam vessels, with the recent introduction of a new service by Hapag Lloyd using 37m vessels.

Since Germany is a major trading partner; Hamburg to Montreal has been used as a representative trading lane. From http://www.sea-distances.org/ the distance is 3,412 nautical miles; at 15.5 knots this would take 9 days. (Some services may be faster than this, but 15.5 knots, as detailed in the Vancouver case study, is consistent with modern slow sailing practice.) From Exhibit 3-4:

[68] By comparison, CP Ships' former 32.1-metre-wide Panamax-size ships were only capable of transporting 4,100 TEUs. See: http://www.canadiansailings.ca/?p=8285, http://www.port-montreal.com/en/post-panamax-vessels-july2013.html , http://www.port-montreal.com/en/postpanamax-year-april2014.html , https://www.port-montreal.com/en/post-panamax-en.html
[69] Canadian Sailings, April 2, 2014.
[70] *Ibid*.

- The Panamax ship size of 4,100 TEU would result in a cost of $16.00 per day; times 9 days the cost would be $16.00 x 9 days = $144 per TEU
- The Post-Panamax ship size of 5,400 TEU would result in a cost of $15.00 per day; times 9 days the cost would be $15.00 x 9 days = $135 per TEU

The savings per trip amounts to $9 per TEU, which is very conservatively estimated relative to other benchmarks[71] for this incremental increase in vessel size. Since Montreal had 1.44 million TEU[72] in 2015, if half were handled on larger "wide-beam" ships (this implies having, on average, 6 calls per month by such ships), the cost savings generated would be $6.5 Million per year (0.72 million TEU times $9 per TEU). This would grow over time as a larger percentage of Montreal's traffic is converted to Post-Panamax vessels. Dividing this savings into the assumed number of large container ships (6 per month, or 72 per year) this suggests an average potential productivity benefit of $90,300 per ship. This reflected a potential gain at the Port of Montreal which has not yet been fully attained but which will likely be achieved in the near future. But because the proposed wide-beam container ship services have not been implemented yet, this $6.5 million prospective benefit has not been included in the national assessment of Pilotage benefits.

Economic assessment of tankers into Quebec City: The Port of Quebec is the last deep-water port before the Great Lakes. 27 million tons of merchandise were handled on average over the last five years at the Port and it is estimated that it generates over 13,000 jobs and has economic impacts over $1.35 Billion[73]. The Port is also an important hub for cruise ships[74], with approximately 125 ships calling every year, bringing over 150,000 visitors.

The maximum allowable draft for tankers was recently increased from 15 to 15.5 meters in the winter (it was already 15.5 m in the summer). This was made possible following the introduction of advanced new technology that enables pilots to manage – and minimize – underkeel clearance with more precision than ever including real-time water level gauges along the River that feed information directly to pilots' Portable Pilots Units (PPUs). The economic benefit associated with this added vessel capacity has been estimated as follows:

- For an Aframax (>240m) tanker, one meter allows for a possible increase of cargo of about 10,500 cubic meters of cargo (66,038 barrels). Since the gain is ½ meter this corresponds to 33,019 barrels that can essentially move for free on each ship.
- It is assumed there is one Aframax ship per week during the winter months, for a total of 12 ships. Assuming an average shipping cost of $5 per barrel for oil by foreign flag

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[71] This $14 per TEU savings is much smaller than has been estimated by some other studies. For example a recent Transport Canada study https://www.tc.gc.ca/eng/policy/report-research-ack-tp14837e-chapter8-1661.htm found that *the largest ships reduce ocean shipping costs by $180 per 40-ft. container over the smallest ones*. While this level of savings is very impressive the Transport Canada study did not actually define what it meant by largest and smallest ships. These two articles cite over capacity and the fact that much of the savings from new ships now comes from better engines, rather than scale economies:: https://www.bloomberg.com/view/articles/2016-06-14/ships-have-gotten-too-big and http://www.ibtimes.com/giant-container-ships-arrive-us-shores-many-ports-not-prepared-era-megaships-2246620 Exhibit 4-4 shows scale economies only, not the result of other technological improvements that also are built into new vessels. This explains why this assessment may be more conservative than some others.

[72] See: http://www.port-montreal.com/PMStats/html/frontend/statistics.jsp?lang=en&context=about

[73] Port of Quebec, 2015 Annual Report

[74] Cruise ships could therefore well have been the object of a particular economic assessment but, since the Port of Quebec accounts for 17% of the crude oil involved in Canada's international trade, examining the impact of efforts made by pilots and their industry partners to come up with additional savings and benefits in respect of a commodity whose volume is such an important part of the Port's activities, was equally compelling.

tanker from the Middle East to Quebec City, the productivity benefit associated with the added cargo is worth approximately 33,019 x 12 x 5 = $2.0 Million per year.

- This benefit divided over the 12 ships is $167,000 per ship.

It is also noteworthy that the new practices put in place regarding tide management and underkeel clearance, coupled with improved communications between pilot groups and Valero's refinery, have also resulted in a sharp reduction of delays to tankers going up the River to Quebec City. In the five-year period 2004-2008, there was an average of 12 occurrences when tankers had to go to anchor for an average of 19 hours – to catch the next enabling tide – resulting in 228 hours of delays on average per year. For the period 2011-2015, however, while the average number of Suezmax vessels only marginally dropped from 72 to 69 per year, vessels had to go to anchor only 3.4 times per year, for an average of 13.75 hours, resulting in an average of 46.75 hours of delays per year, a fivefold decrease.

Again, as indicated in the case studies that examined the benefits associated with the transits of larger vessels to Vancouver, Montreal and Halifax, the purpose of this case study, is not to determine how sizeable the particular part of the overall economic impacts that is attributable to pilotage might be, but simply to provide insight on the nature of the benefits provided by pilotage in respect of a specific situation at the Port.

Economic assessment of Tanker Shuttles from Montreal to Quebec City: Over the last two years, a new service of shuttle tankers was established[75] for carrying crude oil loaded at the Port of Montreal to be refined at Valero's facility in Quebec City. This service relies on two Panamax tankers, the *Laurentia Desgagnés* and the *Espada Desgagnés*, of 228.6 m (length overall) by 32.27 m (extreme breadth) with a deadweight tonnage capacity of approximately 75,000 tonnes[76].

One of the main navigational challenges that had to be overcome in order for the service to be established had to do with the berthing and unberthing of the new, larger tankers at Section 86 in the Port of Quebec City. Prior to the new shuttle service, only much smaller tankers of up to 20,000 tonnes could berth at Section 86[77]. Since no infrastructure work was done to modify or otherwise enhance Section 86 (apart from adjusting the mooring equipment and some dredging at the berth itself to account for the possibility of tidal fluctuations during unloading operations), it is *only* because of the development and implementation of customized new pilotage practices by pilots based, among other things, on simulations they designed and conducted on state-of-the-art simulators, that the berthing and unberthing of tankers of 75,000 tonnes at Section 86 could be safely achieved.

The service runs about 300 transits per year, or 150 round trips. As a result of the draft limitations between Montreal and Quebec City, vessels cannot be loaded to the full 75,000

[75] See: http://business.financialpost.com/news/energy/valero-strikes-deal-to-ship-line-9-crude-from-montreal-to-quebec-city-by-tanker and http://www.dieselduck.info/blog/2014/06/canadas-register-to-add-two-crude/

[76] See: http://www.concordiamaritime.com/en/fleet/p-max/

[77] The increased capacity at Section 86 resulting from the new pilotage practices established for the Montreal-Quebec City shuttle tankers has also resulted in the section now being regularly used by other tankers - thereby further enhancing its year-round utilization by bigger ships with virtually no infrastructure spending. The service would not be in operation without this work and, in light of this, all the economic impact resulting from it could be traced back to pilotage, notwithstanding its role in acquiring and maintaining the "social license" to operate.

tonnes capacity, described above, but typically carry 48,000 tonnes[78], or 350,000 barrels[79] of crude oil per trip. As indicated, this is a new service and, prior to this, no crude oil was shipped on the same route although smaller tankers (of approximately 10,000 to 15,000 tonnes) were carrying refined products from Valero's facility back to Montreal.

Without the navigational improvement, at least 360 trips by smaller, 20,000 tonnes tanker would have been needed to carry the same cargo on average per year. With the larger tankers, only 150 trips per year are needed. Since each tanker carries 350,000 barrels, a total of 52 million barrels of oil are moved each year by these tanker shuttles.

- Although the number of tanker trips is reduced by more than half, because larger ships are used it is estimated that this reduction in trips reduces Valero's cost by 33%.
- Assuming an average shipping cost of $2 per barrel for oil by shuttle tanker, the cost savings would be $0.66 per barrel. Multiplied times the 52 million barrels moving every year, the productivity benefit associated with using the larger ships is worth approximately $34 million per year.
- This benefit divided over the 150 trips is $227,000 per trip.

Economic assessment of Import Tankers from Quebec City to Montreal: Suncor in Montreal has been bringing larger post-Panamax tankers directly to its refinery in Montreal. On December 6, 2013 the Port of Montreal welcomed the largest petroleum tanker[80] to have ever visited the port: the MT Overseas Portland, an Aframax vessel that sailed from St. James, Louisiana, carrying 475,000 barrels of crude oil. In late August 2014, the NS Leader, a 44 meter-wide oil tanker, had earlier visited the Port of Montreal.

As compared to the Panamax-sized vessels that Valero is using (which carry 350,000 barrels) a Post-Panamax tanker can bring 450,000 to 475,000 barrels of oil up the St. Lawrence river, an approximate 30% increase for the same draft. 11 tankers made the trip in 2014, which doubled in 2015, but the more conservative number of 11 ships will be used for this analysis. These ships are estimated to have brought approximately 5 million barrels of oil to Montreal in 2014.

- Although the number of tanker trips is reduced by 30%, because larger ships are used it is estimated that this reduction in trips reduces Valero's cost by 15%.
- Assuming an average shipping cost of $5 per barrel for oil by tanker for brining oil from Louisiana or the North Sea, the cost savings would be $0.75 per barrel. Multiplied times the 5 million barrels moving every year, the productivity benefit associated with using the larger ships is worth approximately $3.75 million per year.
- This benefit divided over the 11 trips is $341,000 per trip.

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[78] If the vessel were coming from the sea rather than from Montreal, and was therefore not subject to the draft restrictions between Quebec City and Montreal, a fullcapacity of 75,000 tonnes could have been assumed.

[79] 7.33 barrels of oil per metric ton. See: https://www.reference.com/science/many-barrels-oil-metric-ton-7385070d688eb443

[80] "A larger ship capable of carrying a higher tonnage is an attractive economic lever for us," said Kris Smith, Executive Vice-President, Refining and Marketing at Suncor. See: http://www.port-montreal.com/en/postpanamax-year-april2014.html

4.2 Winter Navigational Improvements

End-of-season navigation on the Great Lakes and St. Lawrence Seaway, and winter navigation on the St. Lawrence River are both especially challenging and, perhaps even more than at any other time, safe navigation relies heavily on the expert local knowledge of pilots. Hazards related to winter navigation include diminished aids to navigation[81], rapidly changing weather conditions that impact visibility, diminished daytime, along with difficult navigational conditions, for example as a result of the presence of ice. Winter conditions can also damage ships and bring about suction problems, main engine failures due to ice obstructed engine cooling water intake and the icing of anchors. The reliability of winter spars, which may be invisible or displaced, is also diminished, and radars are less efficient notably because the large amount of ice attached to the River's shores ("shore-fast ice") deform their shapes. These various factors make the positioning of vessels in the navigation channel more difficult and, as a result, the need for assistance in piloting is enhanced, leading to a requirement to have two pilots on board transiting vessels.

4.2.1 Case Study 5: Night-time Winter Navigation on the St Lawrence River

The history of winter navigation on the St. Lawrence River dates back to 1962, when the federal government decided to use icebreakers to keep the channel open between Montreal and Quebec City during the winter. This was done first and foremost as an environmental measure to protect riverside communities from spring floods caused by ice jams. Year-round navigation to and from the Port of Montreal began in 1964. At first, however, winter navigation was restricted to daytime hours. Due to the northern latitude of Montreal, days are short in the winter - on December 21st there are only 8 hours and 42 minutes of daylight, so this winter limitation significantly compressed the hours during which maritime traffic was able to operate.

Although the various challenges related to winter navigation mentioned above are amplified during night time, the need to maximize the fluidity of traffic, and thereby the efficiency of shipping operations as well as with the competitive position of the Port of Montreal, led to increased demand for pilotage service during nighttime in winter.

Between Quebec City and Montreal, pilots, in collaboration with their partners from industry and various government agencies, have gradually developed procedures for safely navigating more vessels at night during winter, even without the aid of buoys that are normally in place at other times of the year. Quebec to Montreal has had one-way nighttime traffic starting in 1995. No traffic travelled downriver at night and it trickled up. However, in 2004, the Laurentian Pilotage Authority and local pilots started a "Compliant Vessel" program[82] with particular equipment requirements. This started downriver nighttime river traffic on a regular basis. In 2007, the use of PPUs[83] became standard, along with access to tide gauges. That year alone, night traffic

[81] Lighted buoys serve as valuable aids to navigation, yet they are vulnerable to damage or destruction during the harsh winter and ice conditions prevalent on the River. Although a prototype four-season buoy design has been tested (See: http://data.tc.gc.ca/archive/eng/innovation/tdc-summary-12900-12975e-984.htm) that can apparently survive the winter, it has not yet seen commercial deployment. As a result, from December through March (depending on water temperatures) lighted buoys are removed from both the St. Lawrence River and Great Lakes and replaced by spar buoys. Ships must therefore navigate during the winter without the assistance of lighted buoys.

[82] See: http://www.pilotagestlaurent.gc.ca/files/pdf/formulaires/Compliant-Vessel-Form.pdf

[83] See: http://ccom.unh.edu/sites/default/files/publications/Alexander_2008_CHC_Use_Of_Piloting_Units_By_Pilots.pdf

increased by 46%. Subject to certain conditions (e.g., maximum draft, equipment requirements), many ships are now able to sail both up and downriver from Quebec to Montreal at night in the winter.

For assessing the economic value of winter nighttime navigation, the Corporation of Mid St. Lawrence Pilots reports that 415 ships went up or down river by night in the winter of 2015 (i.e. from January 1 to March 15). This number is consistent from year to year.

Since nights last 14-15 hours and the alternative would be to wait until daylight, each ship that uses nighttime navigation will likely save on average 7 hours, which is about half the duration of the night during the winter. The overall level of time savings is estimated as 415 ships x 7 hours = 2,905 hours (or 121 days) of vessel delay avoided by the ability to navigate at night. Some of these are domestic vessels, while many others are foreign flag ships. For estimating the efficiency gains, the U.S. Maritime Administration (MARAD) assessed the cost of U.S. and Canadian flag vessels[84] on the Great Lakes as in Exhibit 4-9.

Exhibit 4-9: Fuel and Capital Cost, Great Lakes Fleet in US $2009

Ship Type	Class 7 Ship Cost (GLSLS-Max)	Class 10 Ship Cost (1000-footer)
Current Daily Operating Cost (except Mortgage and Fuel)	**$19,297**	**$23,101**
Mortgage Daily Rate	**$8,450**	**$15,319**
Current Fuel Cost	**$8,388**	**$15,207**
Current Daily Operating Cost Total	**$36,135**	**$53,627**
% Operating Cost That is Fuel	**23.2%**	**28.4%**
% Operating Cost increase from 86% Fuel Increase	**20.0%**	**24.4%**

To convert from 2009 to 2016 dollars, the inflation factor is 1.11. When vessels are waiting at anchor, they will be incurring time and crew costs, but not burning much fuel. The U.S. Army Corps of Engineers (USACE) data suggest that the daily costs (Mortgage + Operating but excluding fuel) for Great Lakes (U.S. and Canadian Flag) GLSLS-Max vessels will be:

$$(\$19{,}297 + \$8{,}450) * 1.11 = \$30{,}800 \text{ for a GLSLS size vessel}$$

By comparison, a small foreign flag container ship has been reported[85] to cost anywhere from $10,000 to $22,000 per day (based on "in Port" costs, but these are in 1999 US Dollars). The 1999-2016 inflation factor is 1.43. The cost would therefore be from $14,300 to $31,460 per day for a small foreign flag container ship. By comparison, tanker demurrage has been reported as $35,000 per day, but this can be cut in half if the delay was due to weather, due to the unique way in which the tanker contracts are structured.

[84] U.S. Maritime Administration, *Great Lakes Study: Phase 2 Report - Benefit Cost Analysis*, 2011
[85] See: http://www.corpsnedmanuals.us/nedmanual.cfml?pg=4&mpg=157

Comparing all these results, the average cost of vessel delay would appear to be around $30,000 per day for all classes and categories of the ships that are likely[86] to navigate the St. Lawrence River. The costs for U.S. or Canadian flag GLSLS vessels falls in the same approximate range as those for foreign flag container ships (or "salties.") Salties tend to be larger vessels than GLSLS ships, but since Canadian flag vessels have a little higher cost structure than foreign flag ships, the cost ends up in same range for all the ships. In any event, to remain consistent with the conservative approach taken throughout this report, an average figure of $25,000 will be carried forward.

The overall result for winter nighttime navigation is an estimated annual benefit of:

$25,000 per day * 121 ship-days of delay avoided = $3.025 Million per year

Again, similar to the analysis regarding container ships at Vancouver and Halifax, the purpose of this particular case study is not to determine the overall economic impacts attributable to winter pilotage – a strong case could be made that, absent such pilotage, winter navigation would be severely compromised – but to provide insight on the nature of the specific annual benefits provided by winter nighttime pilotage between Quebec City and Montreal. These benefits are net in that, if they did not transit at nighttime, these vessels would still have to transit during daytime. These benefits also come with the real, albeit unquantifiable, additional benefit of enhancing the Port Montreal's reputation and competitive position.

4.2.2 Case Study 6: Extended Season on the Great Lakes

According to the *Detroit District, U.S. Army Corps of Engineers*[87]traditionally the Great Lakes navigation season was early April to mid-December:

> *However, on April 2, 1975 we witnessed for the first time in history, year-round navigation on the Great Lakes. This significant event was a result of a congressionally authorized navigation season extension demonstration study, considered the most important study carried out by the district at the time, because it demonstrated the value of early participation in the planning process of all federal agencies.*
>
> *The study was carried out under the guidance of a Winter Navigation Board which consisted of several federal and state agencies and the shipping and industrial interests. Although the U.S. Army Corps of Engineers Great Lakes and Ohio River Division was the lead for the U.S. Army Corps of Engineers, Headquarters, the District played a significant role in accomplishing a successful study by keeping locks open while completing maintenance on some of the locks due to efficient scheduling and the hard work of the Soo Locks crew. It was determined, because of the demonstration study, that*

[86] A 2009 reference "*A quantitative analysis of container vessel arrival planning strategies,"* suggests that ship delay costs are €8,332 per 2-hour period delay, or €100,000 per day, for a large new 10,000 TEU vessel (Mega-Ship.) 2009 Euro to Dollar exchange rate was 1.40 so the cost would be $155,400 per day for a large mega-ship, but these are not relevant to the analysis since we do not have new mega ships coming to Montreal. see http://link.springer.com/content/pdf/10.1007%2Fs00291-009-0186-3.pdf

[87] US Army Corp of Engineers, see: **https://www.facebook.com/SooLocksVistorsCenter/posts/927464274005146?comment_id=927468914004682&comment_tracking=%7B%22tn%22%3A%22R0%22%7D**

> *it was economically and environmentally feasible to keep the locks open for ten months. Currently, the navigation season has an opening date of March 25 and a closing date of January 15.*

A study[88] published the same year (1975) assessed the economics of year-round shipping, and concluded that *commercial users of Great Lakes and Seaway ships have strong incentives to encourage year-round navigation. Ship owners while seeming to benefit less than their customers, also have good reason to move in the same direction.* The study presumed the technical feasibility of keeping the St Lawrence Seaway open, albeit with some scheduled down time for locks maintenance: the study assumed an operating season of 11.5 months.

The study identified four categories of benefit to a longer shipping season: ***Increased Productivity, Reduced Reliance on Poorer Ships, Lower Inventory Costs*** and ***Cargo Attraction (Modal Shift***.) But since 1975, many of the older ships have already been retired from the fleet, and the issue of inventory cost is closely related to that of modal shift. By this, it is understood that commodities with a higher inventory carrying cost would tend to utilize alternative modes during the winter shutdown, whereas commodities having a lower carrying cost would stockpile water shipments during the spring, summer and fall months so there is enough inventory on hand to last through the winter. Some consignees may have limited stockpiling capability and so may still be forced to use alternative modes to some degree. However, stockpiling creates a big problem if the lakes close early or open late, it is likely that emergency shipments by other modes will be required to maintain the levels of inventory needed for sustaining operations.

As such, this case study will focus on only two of the four dimensions that were identified by the 1975 study: ***Increased Productivity*** and ***Modal Shift***. These benefits are additive and in fact, are synergistic. As water gains efficiency due to a longer shipping season, it improves its competitiveness with other modes of transportation as well.

Productivity Benefit: this identifies the *vessel operating cost savings associated with more efficient handling of existing water traffic*. In terms of **increased productivity,** the 1975 study suggested the following equation as a convenient tool for analyzing and understanding the components of transport costs.

$$RFR = \frac{(CR)P + Y}{C}$$

Where:

- **RFR** = Required freight rate per ton
- **CR** = capital recovery factor before tax (high enough to leave a reasonable yield after tax
- **P=** initial investment
- **Y** = annual cost of operation (fuel, wages, insurance, etc.)
- **C** = annual tons transported

[88] Swift, P M and Benford, H, Economics of Winter Navigation in the Great Lakes and St. Lawrence Seaway, Society of Naval Architects and Marine Engineers, 1975. See:http://www.sname.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=896c80c9-6618-464f-93d5-ed5cd9af6dc8

If the shipping season were extended, the fixed cost of vessel ownership (the CR-P term, primarily constituting the annual mortgage payments on the vessel) can be amortized over a larger number of tons, thereby lowering average costs[89]. Assuming that the operating season is 41 weeks or 287 days), the incremental benefit of lengthening the season by one week to 42 weeks or 294 days will be assessed. A GLSLS-max Class 7 ship is assumed. Costs are from Exhibit 3-6:

- ***Total Cost of a 41 Week Season***: **365* $8,450 + 287 * ($19,297+ $8,388) = $11,029,845**. As a result, the average Operating Cost per Week (41 weeks) is: **$269,021**
- ***Total Cost of a 42 Week Season***: **365* $8,450 + 294 * ($19,297+ $8,388) = $11,223,640**. As a result, the average Operating Cost per Week (42 weeks) is: **$267,229** for a savings of **$1,792** per week or **0.67%** in costs for every week of extended season.

For estimating the level of Productivity benefit for a one week extension of the shipping season, this **0.67% factor** can be multiplied times the Great Lakes shipping bill for the whole year.

For assessing the total benefit, in 2011, Martin Associates[90] completed an economic impact study for the Great Lakes and St. Lawrence Seaway system. This analysis estimates the combined U.S. and Canadian economic impacts of all marine cargo moving on the bi-national Great Lakes-Seaway system, including domestic cargo moving between U.S. ports; domestic cargo moving between Canadian ports; cross-lake cargo moving between the U.S. and Canada; and international cargo moving between system ports and overseas ports. The overall economic impact of the system was reported as $33.6 Billion, as shown in Exhibit 4-10.

Exhibit 4-10: Economic Impacts of the Great Lakes and St. Lawrence Seaway, in $2010

Exhibit III-9 ***Revenue Impact by Category and Flag — Regional Level***

	Canadian Flag		US Flag		Foreign Flag		Total	
	Millions US	Millions Cdn	Millions US	Millions Cdn	Millions US	Millions Cdn	Millions US	Millions Cdn
Surface Transportation								
Rail	$1,759.1	$1,811.9	$2,934.2	$3,022.2	$387.3	$398.9	$5,080.6	$5,233.0
Truck	$761.0	$783.8	$489.6	$504.3	$110.7	$114.1	$1,361.4	$1,402.2
Maritime Service								
Terminal Employees	$891.9	$918.6	$652.2	$671.8	$117.4	$120.9	$1,661.5	$1,711.3
Tug Assists	$45.1	$46.4	$39.8	$41.0	$7.4	$7.6	$92.3	$95.1
Pilots	$0.0	$0.0	$0.0	$0.0	$91.7	$94.4	$91.7	$94.4
Maritime Services	$186.6	$192.2	$264.9	$272.9	$69.8	$71.9	$521.4	$537.0
Forwarders	$266.5	$274.5	$307.1	$316.3	$28.8	$29.7	$602.4	$620.5
Marine Equipment/ Ship Repair	$525.8	$541.5	$244.3	$251.6	$124.8	$128.5	$894.8	$921.7
Laker	$1,309.7	$1,349.0	$1,619.1	$1,667.7	$0.0	$0.0	$2,928.9	$3,016.7
Barge	$100.7	$103.7	$71.9	$74.0	$23.5	$24.2	$196.0	$201.9
Dependent Shippers/ Consignees	$9,715.1	$10,006.6	$8,808.0	$9,072.2	$1,313.3	$1,352.6	$19,836.4	$20,431.5
Port Authority	$117.0	$120.5	$106.5	$109.7	$70.3	$72.4	$293.8	$302.7
Total	**$15,678.5**	**$16,148.8**	**$15,537.6**	**$16,003.7**	**$2,345.0**	**$2,415.3**	**$33,561.0**	**$34,567.9**

Note: Totals may not add due to rounding

[89] Of course since operating costs "Y" including energy costs go up during the coldest part of the winter (due to the need for plowing through ice, along with the cost of ice-breaking services) this can offset part or all of the benefit. This might explain why the shipping season was not extended longer than 10 months as a result of the 1975 study.

[90] Martin Associates, *The Economic Impacts of the Great Lakes and St. Lawrence Seaway System*, October 28, 2011, see: http://www.duluthport.com/uploads/Econ_Study___Full_Report_Final.pdf

These economic impacts were evenly divided between the United States and Canada, with foreign flag vessels taking only a small share. The employment and revenue impacts include not only direct maritime employment but also include jobs with railroads and trucking companies moving cargo between inland origins and destinations, and the marine terminals, as well as the jobs of longshoremen and dockworkers, steamship agents, freight forwarders, stevedores, and others.

Exhibit 4-10 does include some "Indirect Spending" impacts as a result of the use of economic multiplier[91] factors. For example: Laker operators spend some of their $2,928.9 Million in revenue on Marine Equipment/Ship Repair, shown as $894.8 Million in the exhibit above. As a result, these same revenue dollars are counted twice in the economic impacts: first as revenues of the shipping companies, then again as revenues of the marine support industry.

Overall, the water shipping bill is a relatively small share (less than 10%) of the overall economic impact of the Great Lakes and St. Lawrence Seaway system. For Lakers and Barges, the transportation revenues are $2,928.9 + $196.0 = $3,124.9 Million in US $2010.

It should be noted that the economic impact analysis also includes connecting rail and truck transportation. *In fact, according to the Martin data, shippers are spending twice as much getting their shipments to and from the water ($5,080.6 for Rail plus $1,361.4 for truck = $6,442.0 total) than for the water shipment itself.* This includes, for example the cost of rail transportation of Powder River Basin coal from Wyoming to the BNSF coal dock at Superior, WI where the coal is transloaded onto ships. This disparity underscores the efficiency of the water mode, but also points out that access/egress and terminal costs can comprise a significant share of the shipper's overall cost.

For estimating the level of ***Productivity*** benefit, accounting for Inflation from 2010 to 2016 would increases these costs[92] by a factor of 1.11 so the Great Lakes and St. Lawrence Seaway water revenues in current dollars would be $3.125 Billion x 1.11, or $3.469 Billion. Extending the shipping season by one week from would reduce costs by **0.67%,** so the estimated ***Productivity*** benefit is $23.2 Million per year (in current U.S. dollars) for the whole Great Lakes and St. Lawrence Seaway system.

The Canadian share of this is estimated as 45% of the total, so the Canadian benefit would be $10.5 Million U.S. dollars per year, or approximately $13.5 Million Canadian dollars[93] for each week by which the shipping season is extended. While the level of productivity benefit associated with an extension of the shipping season may seem relatively small, it is because water shipping is already very efficient in the Great Lakes Region.

Modal Shift Benefit of a Longer Navigation Season: In terms of cargo attraction (modal shift) the empirical evidence suggests that a longer shipping season would result in more overall tonnage moving by water on the Great Lakes and St. Lawrence Seaway. Modal shift can produce

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[91] US Bureau of Economic Analysis, *RIMS II User Guide*, see: https://www.bea.gov/regional/pdf/rims/rimsii_user_guide.pdf
[92] US Inflation Calculator, http://data.bls.gov/cgi-bin/cpicalc.pl
[93] Assumed 1.28 U.S.- Canada exchange rate

a large benefit because water shipping is much more cost effective than rail at moving grain and other commodities that move on the Great Lakes.

It is very clear that there is an opportunity for modal shift during the winter months. In particular, when grain is harvested in the fall, demand for rail service typically increases at the beginning of October with strong demand lasting for several months and gradually decreasing through summer.[94] The Upper Mississippi River system has a shipping season that is even shorter than that of the Great Lakes and St. Lawrence Seaway: it is ordinarily closed for three months in December, January and February.[95,96] This puts enormous pressure on the railroads for grain shipment during the winter months, which are a time of difficult operations for them anyway.[97,98] **As a result, the longer the Lakes and Seaway stay open, the more grain traffic they will likely carry.** However, the potential is not limited only to grain traffic. Several shippers of other commodities have suggested that they would increase their use of water if shipping season were extended.[99] For example:

- **JONATHAN BAMBERGER**, PRESIDENT OF REDPATH SUGAR LTD. - *During the past few years, it's been evident that we lack sufficient ice-breaking resources to break out the system in the spring. As a company, we need to be as efficient as possible and we run our inventory on the assumption that the Seaway is going to open at the end of March. If it opens even a week or two late, we don't have enough raw sugar for our refinery. We need reliable services to make sure the waterway is open.*
- **JAMES REZNIK**, ST. MARYS CEMENT (VOTORANTIM CIMENTOS), DIRECTOR LOGISTICS – NORTH AMERICA - *We're a big proponent of having more ice-breaking resources. Our cement vessels are usually among the last in at the end of the season and the first out at the beginning. During the last two years, the delays from ice on the Great Lakes forced us to put more products on trucks and rail to ensure our customers had sufficient supplies. That certainly impacted the supply of construction materials in the Great Lakes region."*
- **WARD WEISENSEL**, SVP OF TRADING, PROCUREMENT AND RISK WITH G3 CANADA LTD. - *The Seaway is vital, so we're very supportive of continuing investments in Seaway infrastructure. Beyond that, having Seaway opening and closing dates as consistent as possible from year to year would greatly increase system confidence. We would also like to see a longer season and look at what resources are needed to allow for that, including icebreaking capability. If the shipping season could start even two weeks earlier and end two weeks later, it would allow us to ship more cargo by water.*

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[94] US Dept of Agriculture, *Rail Service Challenges in the Upper Midwest*, http://www.usda.gov/oce/economics/papers/Rail_Service_Challenges_in_the_Upper_Midwest.pdf

[95] Yu, T.H. and Fuller, S, *Factors Affecting Lock Delay on the Upper Mississippi and Illinois Rives and Effect of Lock Delay on Barge Rates*, page 8. see: http://afcerc.tamu.edu/publications/Publication-PDFs/CP%2002%2002%20Lock%20Delay.pdf

[96] *Ice to close upper Mississippi from November 20, earliest on record*, see: http://www.reuters.com/article/us-mississippi-river-minnesota-idUSKCN0J400320141120

[97] Railway Age, *Gearing up for winter*, http://www.railwayage.com/index.php/management/gearing-up-for-winter.html

[98] Railway Age, *Canada grain shippers, railways in a "cold" war*, http://www.railwayage.com/index.php/freight/class-i/canadian-grain-shippers-railways-in-a-cold%E2%80%9D-war.html

[99] ***Marine Delivers*** magazine, 2016. See http://www.marinedelivers.com/sites/default/files/documents/MD-Magazine-2016.pdf

According to the U.S. Army Corp of Engineers, shippers save an average of $3.6 billion per year[100] by using the Great Lakes navigation system, compared to other modes of transportation. This cost savings estimate was originally published and detailed in a 2010 U.S. Army Corp Supplemental report[101] which includes origin and destination detail, shown in Exhibit 4-11. The results are summarized in Exhibit 4-12.

Exhibit 4-11: Sample GLSLS Commodity Group Base Savings, in $2008

Commodity Group	CN-US	FN-US	US-US	US-CN
Wheat			$10,632,014	$20,600,829
Corn				$30,264,795
Soybeans				$30,143,359
Other Grains		$4,291,932		
Aggregates	$58,504,737		$612,512,591	$64,707,467
Non-Metallic Minerals	$150,066,280	$1,107,432	$11,891,631	$16,873,691
Metallic Minerals	$88,218,464	$5,819,959	$506,976,969	$66,367,117
Coal, Coke, Pet Coke	$13,587,375		$380,855,017	$348,307,640
Petroleum Products	$8,647,727		$36,420,786	$452,508
Iron & Steel and Other	$188,797,675	$135,359,242	$162,895,625	$35,364,314
Total	$507,822,258	$146,578,565	$1,722,184,633	$613,081,720

Commodity Group	US-FN	CN-CN	CN-FN	FN-CN	Total
Wheat	$76,785,710	$56,132,827	$29,130,589		$193,281,969
Corn	$7,360,427				$37,625,222
Soybeans	$17,821,955	$1,674,323	$2,145,605		$51,785,242
Other Grains	$7,882,006	$12,948,852	$48,869,499	$12,112,280	$86,104,569
Aggregates		$87,736,755			$823,461,550
Non-Metallic Minerals	$8,247,454	$42,486,666		$7,211,460	$237,884,614
Metallic Minerals		$136,016,346			$803,398,855
Coal, Coke, Pet Coke	$5,351,557	$1,729,467			$749,831,056
Petroleum Products		$51,710,225		$2,080,048	$99,311,294
Iron & Steel and Other	$2,820,809	$11,075,637	$2,824,544	$22,411,901	$561,549,747
Total	$126,269,918	$401,511,098	$82,970,237	$43,815,689	$3,644,234,118

Exhibit 3-12: GLSLS Commodity Summary of Rate Savings, in $2008

US Army Corps of Engineers

Great Lakes Rate Savings Benefits

Commodity Group	(Oct 08) $FY09 Savings per ton	CY 2006 Tonnage	Rate Savings Benefit*
Wheat	$24.02	1,636,000	$39,298,492
Maize	$32.17	1,875,000	$60,326,942
Soybeans	$30.60	1,161,000	$35,531,916
Other grains and seeds	$39.48	2,066,000	$81,570,722
Limestone	$21.78	30,908,000	$673,091,214
Other Minerals	$26.78	7,239,000	$193,848,497
Ores (including iron ore)	$12.89	58,848,000	$758,635,652
Coal	$18.05	44,896,000	$810,365,445
Petroleum Products	$27.43	5,067,000	$139,012,440
Cement	$46.00	7,151,000	$328,946,909
Miscellaneous	$42.73	12,166,000	$519,808,956
	Total	173,013,000	**$3,640,437,183**

* CY 2006 Great Lakes Waterborne Commerce; Oct 08 price level

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[100] US Army Corp of Engineers, Great Lakes Navigation Team, *Great Lakes Navigation System: Economic Strength to the Nation*, 2009. See: http://www.lre.usace.army.mil/Portals/69/docs/Navigation/GLN_Strength%20to%20the%20Nation%20Booklet2013v2_final2w.pdf This number of $3.6 billion is incorrectly cited by some secondary sources as pertaining to the US economy, but in fact it was developed for the whole Great Lakes and St. Lawrence Seaway system, including both the US and Canada – thus the estimate is comparable to Martin economic results.

[101] US Army Corp of Engineers, *Supplemental Reconnaissance Report, Great Lakes Navigation System Review*, February 2010. See: http://www.lre.usace.army.mil/Portals/69/docs/PPPM/PlanningandStudies/glnssuppreport/GLNSSuppReconMain2.pdf

The results in Exhibit 3-11 and 3-12 were originally developed from a 2005 Tennessee Valley Authority (TVA) rate analysis, under contract with U.S. Army Corp in support of the bi-national Great Lakes/St. Lawrence Seaway (GLSLS) study.

- The TVA analysis incorporated 857 movements that had either origin, destination or both in the U.S. or Canada in the GLSLS (Montreal to the head of the Lakes). This data was obtained from the Corps of Engineers Waterborne Commerce Statistics Center data and from Transport Canada. The 857 movements accounted for all moves that exceeded 20,000 net tons annually, representing over 40 individual commodities. By including Canadian traffic the scope of this rate analysis was greater than that required, but the sample of 857 movements includes 739 U.S. movements.
- The movements selected for this transportation rate analysis account for roughly 92.7% of Great Lakes and St. Lawrence Seaway waterborne traffic. These movements were drawn from the U.S. Army Corps of Engineers' Waterborne Commerce Statistics Center (WCSC) 2002 movement data and aggregated into 731 annual movements, each representing an annual flow of a given commodity between a unique origin and destination. Data from 2002 was considered representative of the bulk flows that currently use, or might be expected to continue to use the system. Each of the sample movements can be characterized as either U.S. to U.S., U.S. to Canada (CN), U.S. to Foreign (FN), and vice versa, referred to as country pairing in this analysis.
- Many movements have off-lake origins and or destinations. The transportation rate analysis recognizes this fact in making a full accounting of all transportation charges; from the ultimate origin to ultimate destination. The rates include rail or truck or rail legs to/from the ports; all loading, unloading and transfer costs; and vessel transportation costs. However, the rates exclude any probable storage costs. Actual water, rail and truck rates, and terminal handling charges as provided by shippers, receivers, or port operators, were used whenever possible.

The magnitude of the projected shipper cost savings ($3.64 billion in 2008, or $4.08 billion in current dollars) is very significant as compared to the $3.469 billion total water revenues estimated by Martin – *it implies that if the current water volumes were shifted to rail and truck, shipping costs would more than double*. In respect of pilotage, since pilotage costs constitute only a small fraction of overall water revenues (costs), it follows that small variations in pilotage tariffs cannot significantly impact the competitive position of the marine mode vis-à-vis rail and truck.

To ensure that the costs developed by this study are in the right range, TVA's finding has been independently verified as shown in Exhibit 3-13, which compares known rail, water and truck costs per ton mile. This shows that the resulting doubling of transportation cost (when water is not available) is in fact consistent with the known cost structures of the modes.[102] As can be seen in Exhibit 3-13, 2020 rail costs (at 2.17¢ per ton mile) are, in fact, almost double those of water shipping (at 1.11¢ per ton mile); while trucking costs are almost thirty times more than water per ton mile (at 34.03¢ per ton mile). Because some water traffic has no rail access and would need to be shifted to truck, the cost savings developed by TVA are reasonable in view of

[102] Also from U.S. Maritime Administration, *Great Lakes Study: Phase 2 Report - Benefit Cost Analysis*, 2011

the known cost structures of the modes, and falls reasonably in line with the reported water revenues.

Exhibit 4-13- Estimated Shipping Cost for Bulk Commodities, in $2009

Bulk Unit Cost ($/Ton*Mile)	Water	Truck	Rail
2010	0.0105	0.3066	0.0205
2020	0.0111	0.3403	0.0217
2040	0.0117	0.3778	0.0241

*Truck cost base on 100% empty return which is typical for bulk truck shipment.

The level of Modal Shift benefit clearly depends on the amount of traffic that is diverted to the Great Lakes and St. Lawrence Seaway as a result of a longer operating season. Although some additional cement, iron ore and sugar shipments may also be added, the strongest case can be made for additional grain to move by water if the shipping season were extended. After many years of decline, grain traffic at the Port of Thunder Bay has rebounded[103]:

> *"Our estimate (for grain) … is eight million tonnes, compared with 8.3 million in 2014," Heney said. "Last year (2015) was basically our second highest (grain total) in the last 15 years, and 2014 was our highest, so that's pretty encouraging."*
>
> As well, railways view Thunder Bay as an efficient haul with relatively short unload and turnaround times. *"I think Thunder Bay has become a very efficient go-to place for the railroads, and this is really what's keeping us at these levels," he said. Haney said large grain handling companies have increased their Thunder Bay tonnages noticeably now that they are in complete control of their supply chain logistics. At the same time, less prairie grain is being moved by rail to Eastern Canada.*
> *He said grain companies with facilities in Ontario and Quebec are more inclined to move grain through Thunder Bay. Eastbound domestic shipments are unloaded at the port and transferred onto lake vessels, which complete the haul. "We don't see the big winter rail programs anymore," Heney said. "They (eastbound grain trains) used to bypass the port, but now it seems like the railroads are happy to come this far with grain but not necessarily past here."*

This trend continued in 2016 with the Port Authority reporting that overall cargo total for 2016 virtually matched up the 2015 season, and that "an unprecedented grain volume" for December was recorded[104].

The best-case scenario would be a proportional increase in traffic across all commodity groups. If this were to occur, then the weekly benefit of an extended shipping season would be the full

[103] *Thunder Bay records strong grain business in 2015*, see: http://www.producer.com/daily/thunder-bay-records-strong-grain-business-in-2015/
[104] **Port Authority expects successful 2017 after busy December, see http://www.cbc.ca/news/canada/thunder-bay/shipping-season-over-1.3928964**

$4.08 billion in current dollars divided by the assumed 41-week operating season, or $99.5 Million per week.

A more realistic scenario would be a proportional increase in grain traffic only. This assumption is very conservative, because it ignores the potential for non-grain traffic to take advantage of an extended season on the St. Lawrence Seaway. For the past few years, grain traffic has comprised about 33% of the total cargo of the Seaway.

For assessing only the Canadian modal shift benefit, if we use only the 8 million tons being shipped out of Thunder Bay as the reference, this is an average of 195 thousand tons per week. From Exhibit 3-12, the weighted average savings per ton for four types of grain (the first four lines in the second part of the exhibit) is $32.17 per ton in 2008 U.S. dollars. In current dollars, the savings is $36.05 per ton. Multiplying this by the weekly average shipping volume of 195 thousand tons, the Modal Shift cost savings would be $7.0 million per week in U.S. dollars. At the current 1.28 U.S.-Canada exchange rate, the modal shift benefit associated with Canadian grain traffic would be worth $9.0 million per week in current Canadian dollars.

Summary of the Benefits of an Extended Shipping Season - Exhibit 4-14 conservatively assesses the Canadian benefits associated with a *one-week extension* of the shipping season on the Great Lakes and St. Lawrence Seaway. This is based on the value of productivity improvements for all Canadian vessels, and a Modal Shift benefit based on Thunder Bay grain only. Much of this grain moves in foreign flag vessels that are subject to U.S. and Canadian pilotage requirements. Because of the limited commodity focus of this analysis, it is considered reflective of the benefits of pilotage on the Great Lakes in terms of extending the shipping season. Extending the shipping season would likely produce additional benefits to the U.S. and Canadian flag fleets which primarily focus on the haulage of commodities other than grain. It does not include U.S. benefits of a longer shipping season, but only Canadian benefits that are related to pilotage of foreign flag vessels.

If additional commodities besides grain were also shifted to the water mode, the benefits would be correspondingly increased. The estimates are based on only transportation cost savings and do not include the costs for unplanned disruptions, e.g. the cost of shutting down production lines due to a lack of supplies if vessels get stuck or otherwise delayed by icy conditions.

Exhibit 4-14 - Canadian Benefits of a One Week Extension of the Shipping Season

Benefit Type	Millions of 2016 CDN$
Productivity	$13.5
Modal Shift	$ 9.0
TOTAL	$22.5

In the Great Lakes Region, there would, arguably, be very few, if any, foreign flag vessels calling at the Region's ports were it not for pilots given the complexity and high risk nature of many areas in the Region. While this is the case throughout the shipping season, examining the specific periods at the beginning and at the end of the season, when most buoys are removed from the waters to prevent them from being damaged by winter conditions, is useful to get a sense of the actual contribution made by pilotage to the Region's economy.

The particular challenge of operating without buoys – which, as discussed in the previous case study, also happens in the Laurentian Region – takes place in the early spring and later fall. The schedule for removing buoys is supposed to be determined by water temperature in the St Lawrence River. However, the Canadian Coast Guard has to pull the buoys earlier, and install them later in the Great Lakes due to limited resources; they cannot pull the buoys all at once. This triggers a double pilotage requirement, but by using, among other things, Portable Pilotage Units and precision GPS navigation, pilots are able to continue vessel operations, without the buoys, until the locks actually close in the winter, and resume operations promptly as soon the locks reopen in the spring. It is estimated that the buoys are removed at least one week ahead of the end of navigation in the fall and not fully restored until at least one week after navigation resumes in the spring. It would not be possible for foreign flag vessels to navigate safely and efficiently without the assistance of experienced pilots and the advanced technology and skills they bring. Therefore the actual economic benefit associated with pilotage service to foreign flag shipping *during this particular period of the year on the Great Lakes and St. Lawrence Seaways* is estimated as follows:

2 weeks x $22.5 Million per week = $45.0 Million annually

Since the revenues reported by the GLPA in 2015 were $25.5 Million, for an approximately 38 week season, it follows that the cost of pilotage during the particular period assessed is only a small fraction of the economic benefits reported above. In fact, the benefits for this 2-week period alone exceed the pilotage costs for the entire season.

4.3 Reducing the Economic Impacts Associated with Accidents

Pilotage in Canada plays an important role in coordinating operations not only between ships, but also with recreational and fishing vessels, so waterways can continue to safely meet the needs of different user groups. In addition to examining a particular suggestion to change the status of a compulsory pilotage area, Case Study 7 describes how pilotage has supported the needs of the commercial fishing industry in Placentia Bay. However, since pilots help ensure adequate safety levels for various waterway users in every pilotage region of the country, other compelling case studies could also have been developed.

Chapter 3 assessed the Safety Benefits of pilotage only in regard to the *direct* Safety costs of maritime accidents. That is, accident costs in Chapter 3 reflect only the *direct* damages to the vessel and cargo itself plus any related environmental cleanup costs. However, if an accident were to block the channel access to any of Canada's ports for any length of time, the economic consequences of the shutdown would lead to a large *indirect cost*, which would be *in addition* to the direct safety costs of the accident. Since no such indirect costs were factored in elsewhere in the report, Case Study 8 deals with this question, albeit in only one specific location, Saint John.

4.3.1 Case Study 7: Review of a Compulsory Pilotage Area – The Case of Placentia Bay

In Canada, the designation of compulsory pilotage areas, and the review of the status of these areas, is typically based on the levels of risk identified in risk assessment processes initiated by pilotage authorities, and on a demonstration that pilotage is an effective measure to mitigate levels of risks that would otherwise be unacceptably high. These risk assessment processes are based on a Transport Canada methodology tailored for pilotage, the Pilotage Risk Management Methodology (PRMM).

While PRMMs take into account the financial impact of navigational accidents to determine the severity of adverse consequences – which is one of the two factors that provides for the assessment of levels of risk, the other factor being the likely frequency of such adverse consequences – PRMMs do not analyze the cost-benefit ratio of risk-mitigating measures. The discussion below provides an overview of how such cost-benefit analysis might further inform decisions regarding pilotage requirements.

In 2014-15, the Atlantic Pilotage Authority considered a proposal to reduce pilotage requirements in one of Canada's busiest areas in terms of the volume of petroleum products shipped, Placentia Bay. The proposal consisted in moving the pilot boarding station by approximately 13 miles in the Bay, close to Buffett Island, for tankers at ballast.

The proposal was triggered because there were 40 delays to vessels, out of 673 assignments, in the first nine months of 2014, a 5.9% ratio. This unusually high incidence of delays (Canadian pilotage service levels are typically at 99% and more) resulted from a shortage of licensed pilots following retirements and long term disabilities. Rather than increasing the number of licensed pilots so as to be in a position to again meet the required service level, the proposal suggested to diminish service levels.

The APA conducted a PRMM which determined that removing pilots for a significant portion of a vessel's transit in the Bay would significantly increase risks to navigation, and the proposal was abandoned. While the PRMM ultimately filled the purpose for which it was created, the example of Placentia Bay illustrates that a reduction in a compulsory pilotage area may lead to a significant reduction in safety, with only a marginal decrease in pilotage cost in return.

In the case described above, it is actually even debatable whether there would have been any decrease in actual or projected pilotage costs since the proposal was suggesting to maintain pilotage tariffs at their existing levels, even when shorter assignments were performed. In fact, even when shorter assignments would have been performed, pilots could still have only performed one assignment per day, which means that the problem of vessel delays would still have had to be addressed through an increase in manpower. Minor savings in pilot boat operating costs (resulting from some shorter transits to vessels from which pilots would embark or disembark) were evoked, but proved too small to even document.

The purpose of this discussion is not to duplicate the safety analysis conducted in the PRMM but only to help illuminate the economic implications of the changes that had been proposed.

Tankers “in ballast” still carry significant residual quantities of oil, up to 4,000 cubic meters, enough to pose a significant environmental hazard if the product were released. The safety case for tanker pilotage, as discussed in chapter 2, has already been well documented and will not be repeated here. The costs associated with the prospect of accidents involving tankers, even at ballast, far outweighs any economic “gain” associated with the proposal that was reviewed by the APA.

Another aspect could also have been considered had a cost-benefit analysis of the proposal been performed in conjunction with the risk assessment. This aspect has to do with the role that pilots play in the efficient coordination of vessels in compulsory pilotage areas. Each pilotage area is different but in the case of Placentia Bay, it is interesting to note that, in addition to being one of the most active areas of the country in the shipping of petroleum products, it is also one of the areas with the highest density of fishing vessels, with approximately 500 commercial fishing licenses having been issued. As such, effectively managing interaction with fishing vessels is a notable aspect of the job of pilots in that area.

Pilotage in Placentia Bay helps to minimize loss of life and property due to hazardous interaction between fishers and commercial shipping. Existing pilotages practices in Placentia Bay efficiently carry this out and, as a result, there is no record of ships colliding with fishing boats. Unfortunately, the hazards posed by commercial ships to fishers are very real as shown in Exhibit 4-15. In the Gulf of St. Lawrence, that is, in the waters east of Les Escoumins that are not designated as pilotage waters, Transport Canada’s database records 10 collisions involving fishing boats, and 11 collisions involving other types of vessels since 2004. Since these are basically open waters, the collision rate seems surprisingly high and shows that much still remains to be done to improve safety in the Gulf of St. Lawrence.

Exhibit 4-15 – Fishing Boat Collisions in the Gulf of St. Lawrence since 2004

OccNo	OccDate	Primary Vessel			Secondary Vessel		
M04L0069	17-Jun-04	RESEARCH/SURVEY- OTHER	N/A	CAP DE RABAST	FISHING	UNKNOWN	PERSISTENCE I
M04L0088	15-Jul-04	SERVICE SHIP	PATROL VESSEL	E.P. LE QUEBECOIS	FISHING	UNKNOWN	JEREMIE II
M05L0278	14-Jul-05	FISHING	TRAWLER	KARABOUDGA	FISHING	UNKNOWN	GEORGIANNE
M06L0073	21-May-06	SERVICE SHIP	PATROL VESSEL	CAP ROZIER	FISHING	UNKNOWN	EAUX-VIVES
M07L0089	24-May-07	SERVICE SHIP	PATROL VESSEL	CAP ROZIER	FISHING	UNKNOWN	INCORRUPTIBLE
M07L0123	30-Jun-07	FISHING	UNKNOWN	R.J.H. NO 1	FISHING	UNKNOWN	MYRIAM D.
M08L0081	25-Jun-08	RESEARCH/SURVEY- OTHER	N/A	CAP DE RABAST	FISHING	UNKNOWN	ANDY C.
M09L0168	5-May-09	FISHING	UNKNOWN	MUNROE	CARGO - SOLID	BULK CARRIER	IRMA
M10N0018	22-May-10	FISHING	UNKNOWN	NO. 885-77	FISHING	UNKNOWN	SOULEIADO
M11L0095	19-Jul-11	FISHING	UNKNOWN	STEVEN PAUL	SHIPS BOAT	Recreational Craft	IMMRAMA - 822903

Exhibit 4-16 –Non-Fishing Boats Collisions in the Gulf of St Lawrence since 2004

OccNo	OccDate	Primary Vessel			Secondary Vessel		
M05L0052	11-Feb-05	SERVICE SHIP	ICEBREAKER	AMUNDSEN	CARGO - LIQUID	CHEMICAL TANKER	CATALYST
M05L0227	29-Oct-05	BARGE - UNSPECIFIED	N/A	MCALLISTER NO. 3	CARGO - SOLID	CONTAINER SHIP	PRINSENBORG
M05L0230	31-Oct-05	SERVICE SHIP	DREDGER/HOPPER	I.V. NO. 11	CARGO - SOLID	GENERAL CARGO	I.V. NO. 13
M09L0033	28-Jan-09	FERRY	COMBINATION	GEORGES ALEXAND	SERVICE SHIP	ICEBREAKER	DES GROSEILLIERS
M10L0052	31-May-10	SERVICE SHIP	COASTGUARD DUTIES	LOUISBOURG	BARGE - UNSPECIFIED	N/A	ST-AUGUSTINE FERRY II
M11L0031	22-Mar-11	TUG	N/A	ANDRE H.	CARGO - SOLID	BULK CARRIER	ATLANTIC SUPERIOR
M11L0155	16-Nov-11	CARGO - SOLID	GENERAL CARGO	FINCH ARROW	TUG	N/A	POINTE COMEAU
M13L0018	23-Jan-13	SERVICE SHIP	ICEBREAKER	MARTHA L. BLACK	FERRY	COMBINATION	GEORGES ALEXANDRE LEBEL
M13L0163	22-Oct-13	TUG	N/A	R.F. GRANT	TUG	N/A	CERCLE POLAIRE
M14C0005	7-Jan-14	CARGO - SOLID	BULK CARRIER	LAURA 1	SERVICE SHIP	ICEBREAKER	HENRY LARSEN
M14C0025	13-Mar-14	SERVICE SHIP	ICEBREAKER	PIERRE RADISSON	CARGO - SOLID	CONTAINER SHIP	PERSENK

It is difficult to definitively assess this particular aspect in the efficiency benefits that pilotage brings in Placentia Bay. However, given the very high density of fishing activities in Placentia Bay as well as the lack of maneuverability of the vessels, it is considered that the prospects of one fishing boat collision every ten years, with a probable loss of life, would not have been unreasonable had pilotage requirements been relaxed. The current Transport Canada guideline values a human life at $5 million dollars. Thus, assuming that only one person died in each incident, the annualized benefit associated with protecting fishers in Placentia Bay may be estimated as:

0.1 Incidents per Year * $5 Million per incident = $500,000 per year

The large safety benefits and reduction in environmental risks that pilotage provides to the some 900 tanker transits per year in the Bay, have already been documented in Chapter 2. The above analysis simply indicates that, in addition to the benefits described earlier, the benefit of protecting fishing vessels from direct ship collisions alone, far exceeds any savings in pilot boat operating costs that might have resulted from a reduction of the mandatory pilotage area in Placentia Bay.

4.3.2 Case Study 8: Maintaining Port Operations – the Example of the Port of Saint John

The final case study is different than the previous ones in that it relies on a hypothetical scenario to illustrate the economic benefits resulting from the near-certainty pilotage provides that access to, and use of, critical marine infrastructure – including ports and waterways or parts thereof – will not be compromised.

The economic consequences of an accident crippling the Welland Canal for a few weeks, for instance, would be very severe, as would the consequences of an accident blocking access to the navigation channel in the St. Lawrence River (for ex., to and from the Port of Montreal), or to the Second Narrows in Vancouver.

A classified report from the U.S. Department of Homeland Security, accessed by the *Detroit Free Press* in the spring of 2016 through the *Freedom of Information Act*, provides insight on the consequences that would result from a shutdown of key marine infrastructure, in this case, the Poe Lock in Sault Ste. Marie: "A six-month shutdown of the Poe Lock … *would plunge the nation into recession*, *closing factories and mines, halting auto and appliance production in the U.S. for most of a year and result in the loss of some 11-million jobs*" (emphasis added)[105].

We have selected the Port of Saint John for this case study because given the geography of the Port and the extreme tidal conditions present, a strong case can be made to establish a direct causal relationship between pilotage and virtually all of the economic activity resulting from the Port's existence. Without pilotage, the efficacy of the Port would be severely compromised, perhaps to the point of rendering it non-viable.

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[105] *Inside the aging lock that is one breakdown away from crippling North America's economy*, Peter Kuitenbrouwer, National Post, July 29, 2016, http://business.financialpost.com/news/economy/inside-the-aging-lock-that-is-one-breakdown-away-from-crippling-north-americas-economy[106] see *Wrecked in Port – the loss of the Armed Merchantman BEAVERHILL in 1944*, Ronald J. Jack, http://thelostvalley.blogspot.com/2013/07/wrecked-in-harbour-loss-of-ss.html

Moreover, although precedents are, fortunately, hard to find in compulsory pilotage areas, it is noteworthy that a vessel did ground in Saint John Harbour, in November 1944 – the *S.S. Beaverhill* – illustrating the realistic nature of the scenario below[106]. Finally, in contrast to the very drastic consequences described in the U.S. Department of Homeland Security Report quoted above, and in keeping with the approach adopted throughout the current report, we wanted to continue maintaining a conservative approach in the assessment of benefits.

Overview of Navigation Issues in Saint John - The Port of Saint John is a thriving port[107] that has an enviable marine safety record, due in no small part to the skills of the licensed pilots and their knowledge of the area's navigational and weather conditions. This specialized local knowledge and experience is essential to safe and commercially efficient operation of the port and cannot be assumed to reside in the masters and officers of visiting ships, foreign flag or Canadian, no matter what their general level of qualification may be. Large, deep-draft ships such as container ships and tankers are severely constrained in the tracks they must follow, and in their ability to maneuver. They could also be put in great danger by other ships. It is therefore vital to safety that vessels in the Saint John area be under the conduct of persons with demonstrated expert knowledge of local conditions and practices.

Saint John Harbour is divided into two parts, the main harbour and Courtenay Bay, both approached by narrow dredged channels[108]. Silting is a problem in both dredged channels and depths are liable to change. Neither part of the harbour is large, measuring little more than 2 1/2 cables (460 meters) in width, extremely limiting the maneuvering space for large ships. The Canaport Oil Terminal and LNG Dock are outside the main harbour area and have very deep water access. In the Saint John area, there are some rocky shores and in other places, mud.

A peculiar combination of geographical factors produces the most remarkable tide not only in Canada but probably anywhere in the world in the Bay of Fundy, where the tidal range is over 40 feet. In Saint John Harbour, the range reaches 28 feet (8.5 m) producing currents and eddies described by the Sailing Directions as extremely complex and unpredictable. The factors contributing to this complexity are the large tides, the varying outflow from the Saint John River and the physical shape of the gorge between the Reversing Falls and the harbour, which imparts a rolling or boiling motion on the falling tide.

In the spring, the volume of outgoing river water produces an almost constant surface flow, or freshets, which can attain 5 knots. Differing densities of fresh and sea water produce, at certain stages of the tide, a strong, deep inflowing current while the surface current is strongly outgoing, greatly affecting the handling of deep draft ships. In the approaches to Saint John, the mean rate of tidal currents approaches two knots and one knot off Mispec Point. These rates will be greater at spring tides.

There is a significant risk of grounding or collision occurring to ships within the harbour or in the approaches to the harbour in adverse visibility and the unpredictable weather conditions frequently encountered in the area. The consequences of a casualty could be catastrophic - loss of

[106] see *Wrecked in Port – the loss of the Armed Merchantman BEAVERHILL in 1944*, Ronald J. Jack, http://thelostvalley.blogspot.com/2013/07/wrecked-in-harbour-loss-of-ss.html
[107] See: https://www.sjport.com/assets/PDFs/Turning-Opporutnites-into-Growth-Websize-version.pdf
[108] The channel to the main harbour is approximately 600 feet (183 m) wide while the channel to Courtenay Bay narrows to 500 feet (152 m).

lives and ships, and immense damage to shore lines and marine life from the resulting pollution. Virtually no part of the shoreline or the port's waterfront is immune from this risk, nor are riparian owners or businesses immune from its consequences.

In response to these various conditions, navigational and maneuvering constraints, and to the limitations of the ships involved, having expert knowledge of local conditions is essential to ensure safety. This includes rules and practices regarding traffic priorities between ships in the narrow one-way channels and also having an extensive appreciation of the hydrodynamic effects at play. Examining this knowledge of local conditions in various circumstances constitutes the central part of the pilot licensing process.

Traffic - Irving Oil has four ships of 23,000 gross tons: two Canadian ships which, as product tankers, mostly serve Canada's Atlantic Region, and two foreign flag ships, which mostly go to Boston and New York. Irving Oil has two docks at the inner harbour, and they are usually about 70% occupied. The ships are loaded in the inner harbour at Saint John where:

> *They take turns loading 265,000 barrels each of oil products from two docks at the company's East Saint John terminal. The operation is completed within 12 hours, so the ships come in and go out in a single tide. "The marine aspect is critical to our business, because this area of Canada and the U.S. doesn't have a pipeline infrastructure," said Michael Thompson, director of logistics and distribution, aboard the Acadian, as the ship filled its belly with diesel and gasoline. With the refinery running around the clock, and 90 per cent of its output reaching markets by vessel, Irving Oil's processes, people and infrastructure work closely together to keep product moving and clients satisfied, he said.*[109]

For its part, the Canaport dock is located outside the main harbour. It receives loaded supertankers carrying crude from oil rigs off the coasts of New England and Atlantic Canada, from the North Sea, and occasionally from the Persian Gulf – the deepest draft handled so far having been 75 feet (22.86 m). The major issue with these big ships is their inertia and controlling their speed. As needed, these ships wait for the tide 3,600' feet (1,100 m) offshore at the buoy, where the depth is 120'.

For their part, cruise ships usually stay in the harbour for around eight hours.

Irving Oil has 60-ton Tractor Tugs which are used for both escorting and docking tankers. Two or sometimes three tugs are used to control the ships, depending on conditions. These attach 1-2 miles before the berth. For larger ships, they attach outside the harbour.

Because the inner harbour channels in Saint John are narrow, ships can only proceed directionally, outbound first, then inbound – based on narrow tidal windows, twice a day. Generally, ships depart first in order to free dock space for the arriving ships, and also because departing tankers are loaded and need highest water levels. The pilots work with the docks and ship captains to determine the best sequence of ship departures and arrival each day. Because of

[109] Paying the Piper, see: http://business.financialpost.com/playing-the-piper-in-an-exclusive-interview-arthur-irving-the-spotlight-shy-head-of-irving-oil-makes-the-case-for-energy-east-a-project-he-believes-isnt-just-good-for-his-company-but#sthash.5Cyb29LG.dpuf

this one-way directional flow of channel traffic, it is essential that all vessels comply with the traffic pattern in Saint John – without this directional flow, it would not be possible to get all the ships out of, and back into the harbour within the short time allowed by the tidal windows.

Economic Assessment of Value of Pilotage in Saint John – With pilotage, Saint John's port has been running without major incident for decades, in spite of the complexity of the navigational issues involved. Given the high tidal range, narrow channel and resulting complexities of the single directional navigation, it is extremely unrealistic to expect that the port could operate at all without pilotage.

For the purpose of this assessment, however, the economic benefit resulting from pilotage can be illustrated by a hypothetical base case scenario in which accidents due to not having piloted operations effectively stop port operations for one month a year. In the case of Saint John, one may consider that, if a vessel were not under the conduct of a licensed pilot, it could easily run aground on departure and block the main channel. It is assumed that the vessel settles into the bottom of the harbour at low tide and is severely stressed to the point of scrapping, but does not break apart – a conservative assumption since there is a substantial risk the vessel would actually break in two in this context, bringing about consequences of an entirely different order of magnitude. Salvage and recovery efforts are assumed to take one month[110] (in the summer season) before the tanker can be removed and operations restored.

The economic consequences to the Port and terminal owners including Irving Oil, as well as to the city of Saint John would be far-reaching should the channel leading to the terminals of the main harbour or to Courtenay Bay be blocked. Because Irving Oil does not have the capacity to store one month's worth of output, the economic impact analysis will assume that the refinery would be shut down for a month, and also that cruise ships could not enter the harbour for one month. The economic impact has been estimated as follows:

For cruise ships: At present, 64 ships arrive per year, mostly compressed into a six-month time frame. These represent a $25 Million boost[111] to Saint John's economy: $390,000 per ship, or $60-90 per passenger.[112] It is assumed that 1/6 of this spending, or $4.2 million, would be lost if the port were shut down for one month.

For Irving Oil: According to Hoover's:[113]

> *Irving Oil is engaged in the refining and distribution of oil and natural gas. The company serves customers in eastern Canada and New England, marketing and distributing energy products such as gasoline, diesel, home heating fuel, jet fuel, and lubricants. It*

[110] If a ship is not seriously damaged, it is more typical that a grounding incident may take a week or two to recover, see for example http://splash247.com/elbe-grounding-of-giant-boxship-draws-ire/ and http://gcaptain.com/danube-river-blocked-in-germany-after-ship-grounding/ However, due to the extreme tides in St John severe vessel damage is likely when the tide goes out after a grounding, so it may not be possible to simply refloat the vessel. Any recovery effort of a damaged vessel would likely take much longer. For example, the recovery effort after the Costa Concordia grounding in January 2012 http://www.nytimes.com/2012/01/18/business/cruise-industry-weighs-effect-of-costa-concordias-grounding.html?_r=0 needed 30 months until the vessel was able to be refloated and removed from the reef in July 2014. https://en.wikipedia.org/wiki/Costa_Concordia_disaster The thought of a 30-month blockage of the Saint John harbour is almost unthinkable due to the magnitude of economic damage that might occur.
[111] See https://portcitysj.com/
[112] See http://bofbc.ca/wp-content/uploads/2016/04/Summary-of-Business-Discussion-with-Hon.-Rick-Doucet.pdf
[113] See: http://www.hoovers.com/company-information/cs/revenue-financial.irving_oil_limited.d1a6ea1746835a65.html

> *also provides natural gas to residential and commercial customers in New Brunswick. Irving Oil's more than 320,000-barrels-per day refinery in Saint John is Canada's largest refinery. The company exports more than 80% of its products to the U.S. (about 75% of Canada's gasoline exports to the U.S.). The refinery also accounts for 19% of U.S. gasoline imports.*

Hoover's cites Irving Oil's annual revenues as $6.6 billion, but this is hard to confirm since Irving Oil is a privately held company and does not regularly publish its financial data. It is more reliable, for the purpose of this analysis to estimate Irving's annual revenue based on its known processing capacity of 320,000 barrels of oil, and energy prices for which public data is readily available.

According to the U.S. Energy Information Administration (EIA)[114] on average, each barrel of crude oil (42 gallons) can be refined into 12 gallons of diesel fuel and 19 gallons of gasoline. In early September 2016, the wholesale price[115] of both diesel fuel and gasoline are $1.38 US, or $1.77 CDN in New York harbour. Thus, Irving Oil's annual revenues can be estimated as:

$$300{,}000 * \$1.77 * 365 * (12+19) = \$6.0 \text{ billion per year}$$

One month of lost oil revenues would be $500 million, in addition to whatever cost Irving had to pay for salvaging the wreck of its hypothetically grounded ship. Therefore, the cost of a one-month blockage of the Saint. John, NB, harbour can be summarized as shown in Exhibit 4-17:

Exhibit 4-17 – Cost of a One Month Closure of Saint John, NB, Harbour

Benefit Type	Millions of 2016 CDN$
Cruise Ship	$4.2
Irving Oil	$500.0
TOTAL	$504.2

While these costs are very large, a similar analysis could have been developed for other locations in the country. It is certainly conceivable that the impact of not having pilots at any other major port would be at least as serious as the results estimated above for Saint John. Exhibits 3-4 and 3-6 indicated that, without pilots, there would be at least 34 tanker and 138 cargo ship accidents every year in Canada. As such, without pilots there would be *at least* 172 maritime accident per year (it was explained earlier how this estimate is based on very conservative assumptions). It seems highly likely that *at least one* of these accidents each year – and probably more – would result in the blockage of a terminal, port or waterway and in resulting economic consequences comparable to those forecasted here. Given the volume of maritime commerce in Canada this seems, if anything, to be a low estimate.

[114] See http://www.eia.gov/tools/faqs/faq.cfm?id=327&t=10
[115] See https://www.eia.gov/todayinenergy/prices.cfm

5. Cost Benefit Summary: Safety and Productivity

THis section summarizes the results of the previous chapters to develop an overall benefit assessment of pilotage in Canada. First, Exhibit 5-1 summarizes the results of the productivity case studies that were developed in Chapter 4. Then, the results are consolidated with the safety benefits in Exhibit 5-2.

Productivity Benefits - As can be seen, the largest single productivity benefit relates to the Saint John case study, which assesses the impact of a hypothetical vessel grounding in the main channel that shuts down Irving Oil for a month. While this may seem extreme, given the challenges of navigating in Saint John it is not unrealistic for describing the likely impact if the use of pilotage were no longer mandatory or duly regulated. To avoid the potential for a double count, the productivity result for St. John excludes the direct cost of a vessel accident, which is captured as a safety benefit. In a broader sense, a similar scenario could have been constructed anywhere in Canada, for example, a major shipping incident in the Welland Canal, or blocking the harbours of Montreal or Vancouver, would likely have had similar results, or possibly even more severe as illustrated by the U.S. Department of Homeland Security report mentioned above on the consequences of a shutdown of the Poe Lock in the Great Lakes Region. The economic analysis suggests that one such incident per year would occur; if anything for all of Canada, this estimate is likely to be on the low side. As such, the Saint John scenario is illustrative of the fundamental and general value that pilotage provides in all of Canada. Pilotage prevents not only the direct costs of accidents themselves, but the secondary costs of service disruptions and the related economic impacts, as have been documented by the Saint John case study.

Exhibit 5-1: Summary of Productivity Benefits

District	Productivity Benefit Category	Productivity Benefit (CDN $Mil)
Laurentian	Nighttime Winter Navigation	$3.03
	Shuttle Tankers Montreal to Quebec	$34.00
	Larger Tankers to Montreal	$3.75
	Larger Tankers to Quebec	$2.00
		$42.78
Pacific	2nd Narrows Added Tanker Draft	$2.70
	Larger Container Ships in Vancouver	$24.40
		$27.10
Atlantic	St John Harbor Opening	$504.20
	Larger Container Ships in Halifax	$2.70
	Fishing Boats in Placentia Bay	$0.50
		$507.40
Lakes	Extended Seaway Season	$45.00
		$45.00
TOTAL		**$622.28**

The second largest category of economic benefit relates to the extension of the shipping season in the Great Lakes and St. Lawrence Seaway. It bears some similarity to the Saint John scenario because both scenarios are assessing circumstances under which shipping services upon which the economy depends, become unavailable for some portion of time. The key difference between the St. Lawrence Seaway and the Saint John case studies is that where the Saint John case study assesses an *unplanned* disruption, the Seaway case study examines the anticipated benefits that a *planned* extension of the navigation season would have on the Seaway in order to quantify the benefits that are *actually* derived from pilotage for the two one-week periods, at the beginning and at the end of the current navigation season, when buoys are not available and the transits of foreign flag vessels rely more than ever on the skills and knowledge of pilots. As a result, it should not be surprising that these two scenarios should be the ones that have the highest reported benefits. Given the magnitude of economic benefits that have been identified, especially for grain shippers, serious consideration should be given to the possibility of further extension of the shipping season by any means available.

After these two scenarios, it has been estimated that the larger container ships in Vancouver contribute the next highest level of productivity benefit. This benefit is large because of the high volume of cargo handled in Vancouver and the distance across the Pacific Ocean. An important part of the story (not directly reflected in the productivity benefit) is the fact that by being responsive to the needs of the shipping lines, Vancouver and Prince Rupert have been able to gain market share at the expense of U.S. ports. The foreign exchange thus gained helps Canada's trade balance, while consignees in the United States are able to diversify their supply chain options and receive their products at a lowered delivered cost. The economic impact to Canada turns out to be a multiple of the productivity impact, reflecting the application of multiplication factors, as the additional port spending trickles through the rest of the Canadian economy. After this, a variety of initiatives to maximize vessel payloads and support winter and nighttime navigation round out the list.

In respect of efficiency, the benefits identified in the eight specific situations selected for measurement are $622.28 million, compared to a total system-wide pilotage cost of $208.51 million resulting in a cost benefit ratio of 2.98.

As indicated on various occasions, the specific cases selected did not seek to provide a full assessment of the overall system-wide efficiency benefits of pilotage as the scope of such an assessment would have been impractical. As a consequence, the result is understated, given that the analysis provides only a partial snapshot of the system-wide efficiency benefits generated. The cases, however, provide insight on the value added by pilotage to the efficiency of shipping operations in a number of representative situations.

Safety Benefits – As demonstrated in Chapter 3, the safety benefits associated with pilotage are huge, especially for tanker ships because of the disastrous consequences of any accidents. Fortunately the use of pilotage and tugs has been shown to effectively mitigate these risks and justify the social license needed for oil transportation by water.

Exhibit 5-2 combines the estimated productivity and safety benefits together to develop an integrated view of each pilotage district. It produces a very strong 21.9 to 1 Benefit Cost ratio for the cost of pilotage. This is clearly driven by the very high level of safety benefits derived from the use of pilots in congested marine areas.

Exhibit 5-2: Summary of Overall Benefits and Costs

District	Pilots- Expected Case			
	Reduced Cost of Accidents (CDN $Mil)	Selected Productivity Benefits (CDN $Mil)	Total Benefit (CDN $Mil)	Pilotage Cost (CDN $Mil)
Laurentian	$2,015.04	$42.78	$2,057.82	$85.00
Pacific	$548.79	$27.10	$575.89	$74.49
Atlantic	$1,206.65	$507.40	$1,714.05	$22.48
Lakes	$164.79	$45.00	$209.79	$26.54
TOTAL	$3,935.28	$622.28	$4,557.56	$208.51
BC Ratio	21.86			

6. Conclusions

Pilotage provides considerable benefits to Canada by facilitating the safe and efficient conduct of maritime transportation in Canada's navigable ports and harbours. The benefits of pilotage include:

- Pilotage has been shown to have a dramatic risk reducing effect. Pilotage directly addresses the top two causes of vessel accidents: which are collision and power grounding, and in addition approximately ⅔ of drift grounding accidents. The use of escort and standby tugs eliminates practically all the remaining ⅓ of the drift grounding risk. This is critical for obtaining the social license needed for tanker transportation.
- Because of the high cost of maritime accidents, based on the "Expected Case", the safety benefits of pilotage alone produce a 62.1 to 1 Benefit to Cost ratio for oil tankers; and 3.3 to 1 for other types of ships, resulting in an overall 18.9 to 1 Benefit to Cost ratio for the safety benefits of pilotage. This assessment was purposely conservative but if less systematically conservative assumptions had been applied, it could have been argued that pilotage has a safety Benefit Cost return exceeding 300 to 1.
- Pilots have been instrumental in developing navigational improvements that have improved the productivity of Canadian ports and vessel services. The key contributions of pilots include:
    - The development of new navigational procedures for allowing ever larger vessels to access Canadian ports, and by developing effective technology for increasing port capacity and expediting vessel operations.
    - Ensuring that the efficiency of supply chain operations and the near-certainty pilotage provides that access to, and use of, critical marine infrastructure – including ports and busy waterways – will not be compromised. Such supply chain disruptions, as documented in the Port of Saint John case study, extend considerably beyond the direct cost of vessel accidents and their cleanup.
    - Pilots have developed innovative practices for navigation on the Great Lakes and St Lawrence River without lighted buoys or other normal navigation aids in the winter; thereby extending the operating seasons of both the St. Lawrence Seaway and ports on the St. Lawrence River, especially Montreal. Also, night time navigation during the winter on the St. Lawrence has been greatly enhanced in recent years by the innovative application by pilots of e-Navigation and Portable Pilot Units (PPUs).
    - The positive impact of an extended navigation season in the Great Lakes Region was substantiated by a case study that demonstrated how it enhances the marine mode's competitive advantage as the most cost effective means for moving grain and other commodities
    - Pilots were instrumental in developing new navigational and docking techniques at Vancouver and Halifax, enabling the ports to quickly respond to industry's larger ships, safely accommodating them at docks not designed for vessels of that size in mind. This has enabled Canadian ports to grow their container market share against competitive U.S. ports without potentially crippling new capital

costs. The 7% loss of Seattle-Tacoma container traffic which has shifted to Canada, is evidence of this.

- o In Montreal, Quebec and, and Vancouver, and in other places, pilots have developed new navigation techniques, integrating real time water level measurement and predictive algorithms to maximize the use of the existing channel and allow larger, wide-beam ships to transit, resulting in productivity benefits of up to $341,000 per ship. In respect of Montreal, these innovations have been critical to the port's efficiency allowing it to competitively serve much of the U.S. Upper Midwest, as well as Canadian destinations.

- As a result, the cost benefit ratio based on only the efficiency benefits identified in the specific case studies cited above, is 2.98 to 1 ratio.
- The combined safety and efficiency benefits described above result in an overall cost benefit ratio for Canadian pilotage of 18.9 to 1.
- Traditional Cost Benefit analysis expresses benefits *relative* to costs, but it is also true that *in absolute terms* pilotage makes a huge economic contribution to Canada's economy. As shown in Exhibit 5-2, pilotage contributes $4.5 Billion in economic benefits compared to an annual cost of only $208 million. As such it makes a net contribution of $4.3 Billion *every year* to the economic well-being of Canada's citizens – an average of $120 per person *every year* for each of Canada's 32.6 million people.

Annex

INTERNATIONAL MARITIME ORGANIZATION

IMO

E

ASSEMBLY
24th session
Agenda item 9

A 24/INF.4
14 October 2005
ENGLISH ONLY

CONSIDERATION OF THE REPORTS AND RECOMMENDATIONS OF THE MARITIME SAFETY COMMITTEE

The advantages of taking a pilot

Submitted by Denmark

SUMMARY	
Executive summary:	Denmark has analysed the expenses and losses incurred by a grounding in Danish waters and compared them to the costs of taking a pilot. Against this background, the enhanced use of pilots is advised. The analysis has been sent to relevant non-governmental organizations
Action to be taken:	Paragraph 5
Related documents:	None

1 The narrow Danish straits have time and again proved to be difficult to manoeuvre through. In the period form 1 January 2002 to 30 June 2005, 22 ships grounded in the Great Belt alone. None of the grounded ships had a pilot on board.

2 Because of the risk of possible damage to the ship as well as possible damage to the environment, Denmark strongly advises large ships always to take a pilot on their way in and out of the Baltic Sea, and as a minimum, to follow IMO's resolution MSC.138(76) on recommendation on navigation through the entrances to the Baltic Sea.

3 The attached analysis demonstrates the economic advantages of taking a pilot as opposed to the cost of a grounding. The costs incurred by one grounding surpass by 375 times the costs of taking a pilot.

4 Relevant partners of the shipping industry have received a copy of the attached analysis in the anticipation that it will encourage the enhanced use of pilots and reduce the risk of groundings which time and again damage the image of the industry.

Action requested of the Assembly

5 The Assembly is requested to note the information contained in the attached analysis on the advantages of taking a pilot in Danish waters.

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ANNEX

Accidents in the Great Belt and associated costs as a consequence of not following resolution MSC.138(76) on recommendation on navigation through the entrances to the Baltic Sea

The Great Belt is part of the Baltic Sea, which is recognized by IMO as a particularly sensitive sea area, thus highly vulnerable to oil pollution. Accidents involve risk of oil pollution, which is why the political and public attention is on the risk of groundings and collisions in Danish waters, particularly in the narrow straits such as the Great Belt and the Sound. Further groundings and collisions will continue to fuel the public's negative image of the shipping industry.

One way to significantly reduce the risk of groundings, collisions and consequently oil pollution is to ensure that all ships sailing through the Great Belt or the Sound follow IMO's recommendation on navigation through the entrances to the Baltic Sea. The recommendation pertains to the use of pilots and is attributable to the fact that the waters mentioned above are congested and difficult to navigate.

The advantage of taking a pilot – i.e. avoiding groundings as well as possible damage to the ship or the environment – should be enough to convince shipowners to always follow IMO's recommendation. Generally, most ships sailing along Route T follow the said recommendation and employ a pilot between the Skaw and the southern part of Denmark. However, there are still ships that disregard the recommendation despite the economic repercussions it may have for shipowners.

The purpose of this paper is to illustrate that it is highly recommendable to take a pilot and ensure safe navigation rather than saving a pilot fee. Hopefully, all parties involved – shipowners, charterers and insurers alike – will appreciate the need to ensure that IMO's recommendation is followed.

Resolution MSC.138(76) on recommendation on navigation through the entrances to the Baltic Sea

The MSC resolution entered into force on 1 December 2003. The resolution recommends use of pilots on ships with a draught of 11 m or more, or ships irrespective of size or draught carrying a shipment of irradiated nuclear fuel, plutonium and high-level radioactive waste (INF-cargoes) following the established routing system through the entrances to the Baltic Sea (Route T). Furthermore loaded oil tankers with a draught of 7 m or more, loaded chemical tankers and gas carriers, irrespective of size, and ships carrying INF-cargoes, when navigating the Sound are recommended to use pilots.

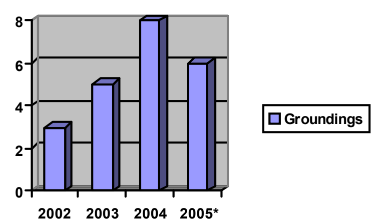
The international consensus on recommending use of pilots is attributable to the fact that the entrances to the Baltic Sea are congested and difficult to navigate, which increases the risk of collisions and groundings.

Denmark has launched a procedure where all vessels entering Danish waters without ordering a pilot in accordance with the IMO recommendation will be called on in order to draw the attention to the recommended use of pilots. When a ship does not comply with the recommendation, the master of the vessel will be informed that Denmark finds it inconsistent with safe navigation practices and procedures to neglect an IMO recommendation. Ships not following the IMO recommendation will be reported to the maritime authority in the flag State of the ship.

Groundings in the Great Belt

The latest oil pollution in the Great Belt took place in January 2005, when a ship's bottom was penetrated for more than 40 m when the ship touched the seafloor en route. The oil polluted the coast in five municipalities along the Great Belt and more than 4,000 sea birds died or had to be put down.

In the period from 1 January 2002 to 30 June 2005, 22 ships grounded in the Great Belt. None of the grounded ships had a pilot on board.



*2005 includes only the months January to June.

Since 1 December 2003 when IMO's recommendation entered into force, 10 ships with a gross tonnage of 10,000 or more have grounded in the Great Belt. Four of the ships had a draught of 11 m or more, and should therefore have taken a pilot on board in accordance with IMO's recommendation.

The Danish authorities detain all grounded ships until it is considered safe for the ships to proceed. A detained ship has to await the authorization of the authorities before it may be set afloat or continue its journey. Typically, it is the relevant classification society – on behalf of the flag State – that determines the criteria for the ship's further navigation.

It is often necessary to discharge a part of the cargo into a lighter before tugboats set it afloat. Lightering of a grounded ship may last up to one week. The maximum period of time that a ship grounded in the Great Belt has had to wait before it could be set afloat was 30 days.

When a ship grounds, a pollution response vessel is sent to the position of the grounding. It is standard procedure for the pollution response vessel to remain standby until the grounded ship has been set afloat and there is no longer any risk of pollution.

A recent grounding in the Great Belt

The Danish Maritime Authority has estimated the costs for the shipowner and the insurance company of a grounding. The example is based on an actual incident, which recently occurred in the Great Belt. The parties involved have declined to provide the actual figures.

The ship in question was a new double-hulled oil tanker, with a gross tonnage of approximately 40,000 and a dead weight tonnage of approximately 72,000.

The tanker loaded with more than 60,000 tonnes of gas oil grounded as it was about to make a turn in the deepwater route at Hatter Reef in the Great Belt. The grounding was caused by a combination of lack of planning of the navigation and miscalculation of the situation, and the ship's ability to turn.

It was daylight and visibility was good. There was almost no current at the time of the grounding. The ship did not have a pilot on board, even though the draught was 13,2 m and the ship was subject to the recommendation on navigation through the entrances to the Baltic Sea. The ship grounded on sand bottom and there was no oil pollution.

After discharging a part of its cargo, the ship was set afloat and shifted to a safe anchorage where divers examined the ship. Five days after the grounding, the ship was released on the condition that it should proceed to a shipbuilding yard after discharging the remaining cargo. The ship was out of commission for an additional 30 days before being able to leave the shipyard.

Expenses and losses

The ship was out of commission for 35 days. When the average freight rate in 2004 – US$41,900 a day – is used, the total off-hire loss amounts to approximately US$1,450,000.

In the given example, it is estimated that 50 tonnes of steel were replaced. Repair expenses are thus approximately US$1,000,000, including expenses spent on tank cleaning and gas freeing.

Salvage expenses including discharging of approximately 10,000 tonnes of oil and tugboat assistance amounts to a figure between US$300,000 and US$400,000.

It costs US$7-30,000 for each day a pollution response vessel has to be standing by. In the given example, the expenses spent on environmental protection amounts to US$30,000.

In this particular incident, there was no oil pollution and thus no expenses with regard to combating oil pollution. However, experience has taught us that cleaning up approximately 2,000 tonnes of oil costs more than US$12 million. Larger oil spills will evidently cost significantly more than this.

Expenses and losses in the actual example:

Off-hire loss	US$1,450,000
Repair expenses	US$1,000,000
Salvage expenses	US$350,000
Environmental protection	US$30,000
Total	US$**2,830,000**

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As these calculations are based on cautious estimates, the actual expenses and losses may have been much higher and in connection with this grounding there were no expenses for combating oil pollution. In addition, where the grounding entails a spill of polluting substances there is a risk of facing criminal charges, ranging from fines to imprisonment.

Use of pilot

In comparison, a pilot – all the way through Danish waters from Bornholm in the Baltic Sea to the Skaw in Skagerrak – costs US$7,500 for a ship such as the one used in the example. As demonstrated, it is common economic sense to use pilot through Danish waters. In this case, the grounded ship could have taken pilot more than 375 times for the amount that was spent on the grounding.

It is difficult to navigate in Danish waters, and particularly in the Great Belt. Many groundings occur in these waters. However drawing on the expertise and local knowledge of a pilot may substantially reduce the risk of grounding.

The Danish Maritime Authority strongly advises large ships always to take a pilot on their way in and out of the Baltic Sea and, as a minimum, to follow IMO's recommendation on navigation through the entrances to the Baltic Sea.

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