ECONOMIC BENEFITS OF HYDROGRAPHY IN THE CANADIAN ARCTIC – A CASE STUDY

Andrew Leyzack, Canada

Abstract. Remote communities in the Canadian Arctic are accessed and re-supplied by air and by sea. The latter mode of transportation presents a more cost-effective solution for re-supply and in recent years, an extended navigation season has seen an increase in both cargo and passenger vessel traffic. Traditionally, communities in the Western Canadian Arctic have been re-supplied by barge and tug however deep draught ocean-going vessels are now starting to compete for service to these same communities. The cost savings realised from deep draft vessel re-supply are significant and modern hydrographic surveys are an enabling factor for deep draft access to Arctic trade routes, for both cargo and passenger liners, especially where under keel clearance is a concern. Citing case study, this paper will endeavour to illustrate the economic benefits of hydrography in the Canadian Arctic, with focus on reducing the costs associated with shipping goods and materials.

Key words: Hydrography, Capacity Building, Economic Benefits

1 FOREWORD – THE CASE FOR ARCTIC HYDROGRAPHY

Communities throughout the Canadian Arctic are continually growing[1]. This is clearly evident when we compare the cultural information on hydrographic field sheets and charts compiled from the 1960's through to the 1980's with what we see upon returning to update hydrography some 20 to 40 years later. Within the Kitikmeot Region, of Nunavut Territory, Cambridge Bay is the largest community and serves as the region's administrative centre. This community has seen a population growth of 12.8% during the 5-year period between the last two census counts. As of 2006, its population was 1,477 and presently it is unofficially over 1,800, a 22% increase in just 4 years. It has become the regional hub for both air and sea lift cargo service for this part of the Cana-

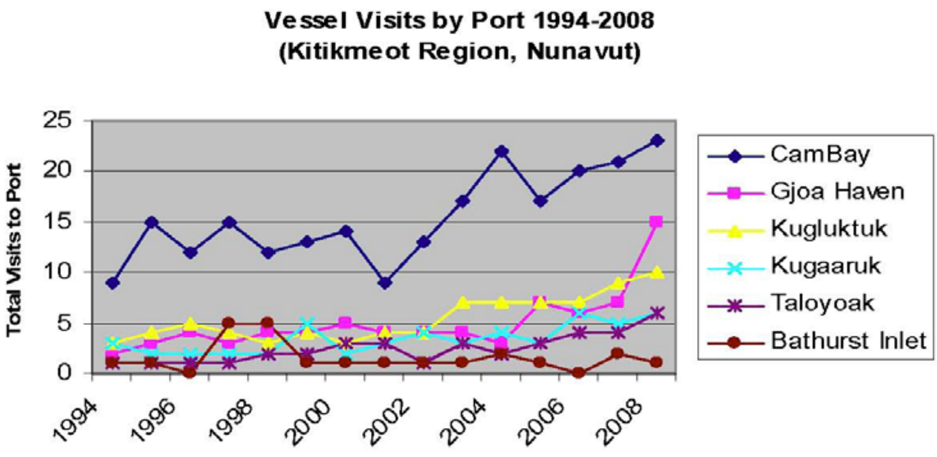

Figure 1: *Vessel Traffic by Port (Kitikmeot Region, NU).*

dian Arctic, the latter made possible by deep water access (greater than 9 m) and modern charting. With a decade of relatively ice-free navigation throughout the Northwest Passage, Cambridge Bay has harboured the greatest number of sea-going vessels of all other communities within the Kitikmeot Region (see Figure 1). "'Sealift' is a strategic and vital link for all Nunavut communities and their residents to obtain their annual resupply of goods and materials needed throughout the year. It remains the most economical way to transport bulk goods to the arctic. Each year, ocean going ships travel from several southern Canada Ports with a variety of goods ranging from construction materials, vehicles, heavy equipment, house wares and non-perishable items".[2] Since these communities use diesel generators to produce electricity, the need for bulk diesel to be shipped by barge and tanker is significant. It wasn't until the first large-scale modern chart, Pelly Bay, was published in 1993 that ice-breaking ships could deliver fuel to Kugaaruk. Prior to this time, the only way for fuel to be shipped in was by air freight. Here, the cost savings were significant.

1.1 Population Growth in Kitikmeot Region[3]

Communities are listed in order of population as of the last census in 2006. The percentage of growth is based on a five year period between 2001 and 2006:

Table 1: *Growth by Community (Kitikmeot Region, NU).*

Community	Population	Growth
Cambridge Bay	1,477	12.8%
Kugluktuk (Coppermine)	1,302	7.4%
Gjoa Haven	1,064	10%
Taloyoak (Spence Bay)	809	8.6%
Kugaaruk (Pelly Bay)	688	13.7%

This growth has placed an increased emphasis on efficient and cost effective Arctic resupply.

Anyone who has travelled the Canadian Arctic will be aware of the high cost of goods and services in the north. For example 4 litres of milk can cost upwards of $14.00 CDN dollars[4], about 3 times the price of southern markets. This is primarily due to the cost of transporting freight to the north. In 2007, Nunvut households spent nearly twice the national average on food ($14K vs $7K)[5] and this coupled with low income has created food insecurity in the north. A 2003 study on food insecurity found that 5 out of 6 households in Kugaaruk were classified as "food insecure."[6]

Resupply by sea provides a less expensive alternative to air freight ($0.80/kg versus over $9/kg)[7] Where under-keel clearance permits, resupply of large volume, general cargo and fuel by deep draught vessels can be even more cost efficient than supply by barge and tug. The deeper the vessel draught, the greater the cargo capacity for a single trip and the faster the delivery time. Also, the maximum speed for a typical tug/barge combination is 5–7 knots whereas a deep draught vessel can cruise at 10–15 knots, effectively halving the delivery time.

***Figure 2:** An Arctic Perspective (Source: Northern Transportation Company Ltd.)*

1.2 Cost-Effective Transportation

Sample Freight Tariffs (in Canadian Dollars) for a metric tonne (1,000kg) of general cargo from Montreal, QC to Cambridge Bay, NU):

***Table 2:** Cost of Freight by Mode of Transportation.*

Mode of Transportation	Vessel	Cost
Airfreight	737	$9,080.00
Overland + Sealift	Tug and Barge	$1,200.00[8]
Sealift	Deep Draught General Cargo	$510.00[9]

In view of the above data, the cost savings realized from deep draught sealift can be up to $8,500.00 per tonne when compared to air freight. It must be noted when comparing the two types of sea lift tariffs (tug and barge vs. deep draught) the overall cost of sealift by tug and barge will more than double that of deep draught because of the additional cost to truck cargo overland from Montreal, QC to the inland port of Hay River, NWT.

These tariffs demonstrate the overall cost effectiveness of transportation by deep draught (ocean-going) vessels. However, deep draught transportation to and from the Arctic depends upon reliable information including ice conditions, meteorology and most importantly hydrography. Under keel clearance is an issue for deep draught transportation in the Kitikmeot Region, perhaps more than any other region in the Arctic. Almost all northern ports do not have deep sea docking facilities and ships are required to anchor as close to shore as possible to transfer cargo to the beach (above the high water line) using self-contained barges and tugs. Fuel is transferred by large diameter hoses, floated ashore to a supply manifold on beach. Large-scale modern

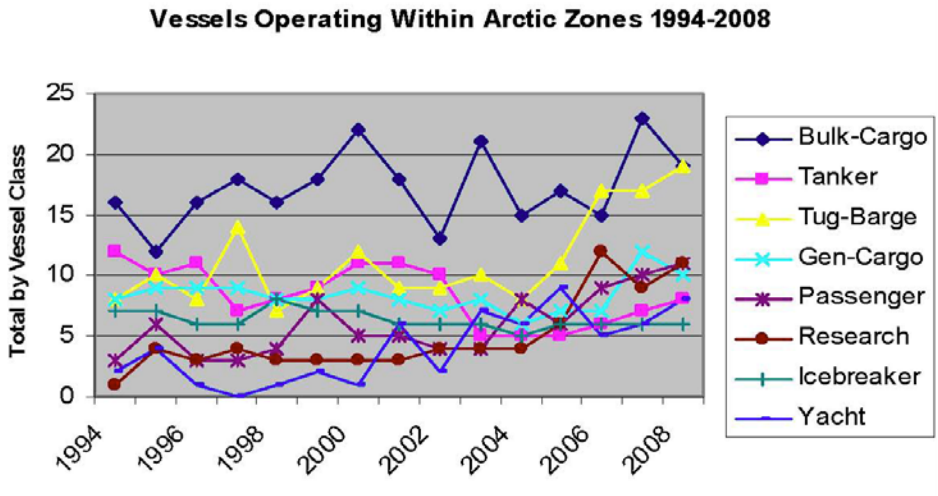

Figure 3: *(Note: Bulk Cargo includes grain carriers to Port of Churchill, Hudson Bay).*

charting is needed to not only enable close, inshore access to northern communities and other commercial destinations such as mining or oil and gas sites but to provide alternate routes in situations where ice navigation is neither practical nor cost effective or should be avoided.

Where alternate routing to avoid ice navigation does not exist, the cost of icebreaker escort support may apply, effectively reducing the overall cost effectiveness of deep draught transportation. In southern waters, this cost is recovered through an Icebreaking Service Fee (ISF) administered by the Canadian Coast Guard. Presently in Arctic waters (north of latitude 60 degrees north) this fee has been waived as part of the Canadian Government's Northern Strategy which promotes actions that support economic and social development in Canada's Arctic[10] and is therefore subsidized by the public purse. Therefore, the cost of icebreaking as a hidden cost should be considered a government subsidy for shipping freight by sea. Icebreaker operating costs will vary depending on the area of operation and may range between $25,000 to $90,000 CDN dollars/per 24 hour period.

2 ACCESS TO ARCTIC WATERS

Over the past decade, relatively "ice-free" conditions throughout the Northwest Passage have resulted in an extended navigation season, a season which during summer months can exceed 3 months in duration. This is attracting more vessel traffic (commercial passenger & cargo ships as well as pleasure craft) to the Canadian Arctic. In response to this, federal, provincial and territorial governments are investing in port infrastructure for northern communities to better support transportation by sea.[11] However, unlike southern trade routes and passages, navigation in the Canadian Arctic can be a far more complex affair. This is due to the large expanse of uncharted or incompletely charted waters (comprising approximately 90% of Arctic waters) and the ongoing potential for the presence of ice. Therefore, to access Arctic ports, an understanding of anticipated ice regimes with up-to-date information on sea ice conditions is essential. Likewise, modern nautical charts enable the mariner to determine the most efficient routing as well an alternate route(s) to take when ice is present. Often, when a potential route around the ice edge appears, there is an absence of hydrography to support safe navigation.[12] As will be demonstrated in the following cases, where local ice regimes exceed the limitations of vessel and no adequately charted alternative route(s) exist, the requirement for an icebreaker escort arises.

2.1 Ice Navigation and charting

Charting a corridor centered about a recommended or preferred track of 2 to 5 nautical miles width may be an acceptable practice for ice-free waters, however, this approach will not hold true in areas where ice may be present. Transport Canada's Zone/Date system has established 16 zones throughout the Canadian Arctic related to the probable ice conditions at specific times of year[13]. While experts in ice forecasting have been able to take into account prevailing environmental factors to develop models of the concentration, type and form of sea ice[14], local variations in weather will introduce sufficient variables to seriously affect the accuracy of ice forecasts. Continued and on-going ice surveillance whether by aircraft or satellite remote sensing[15] is therefore required.

In consideration of the uncertainty of ice movement, one must consider the need for alternate routes outside the preferred track in order to avoid ice. Depending on vessel draught and the quality of hydrographic information, a passage close to shore may be taken in shallow water where ice keels will cause the pack to find ground thus leaving a corridor of open water skirting the shoreline[16]. Furthermore, not all ice-strengthened vessels or vessels designed to break ice are capable of navigation through all ice conditions and therefore must seek alternate routes while breaking ice. For example, icebreakers rated as Arctic class 2 will be capable of navigation through 1st year ice up to 1 meter in thickness versus Arctic class 4 vessels which are capable of navigation through tougher multi-year ice up to 3 metres in thickness. Whereas the concentration, thickness and/or type of ice will affect the speed of vessel transit, limitations in hydrographic charting may further increase ice-breaking costs as the availability of alternate "lighter-ice" routing for the icebreaker will not be available. In simple terms, the greater the concentration and thickness of the ice, the greater the power requirement vis a vis fuel consumption required to make way.

The Kitikmeot region is serviced by a class 2 ice breaker, CCGS Sir Wilfrid Laurier, whose operating cost is $28,000 per day.[17] Where transit to and from the escort area plus the execution of icebreaking may take upwards of 2–3 days of ship time, the cost per day has the potential to multiply accordingly. Furthermore where analysis indicates that the local ice regime[18] exceeds vessel construction limitations, ice-breaking costs could further escalate if the specific ice-regime warrants the use of a heavier-classed icebreaker.

2.2 Environmental Concerns

There is a greater potential in the Arctic for environmental damage due to spills resulting from groundings or ice damage. This is primarily due to limited spill response assets, the magnitude of the distance required to deploy these limited resources within the extreme weather conditions of the Arctic environment, and the nature of the Arctic ecosystem. Canada's Arctic Waters Pollution Prevention Act asserts our obligation to preserve the "peculiar ecological balance that now exists in the water, ice and land areas of the Canadian arctic."[19] The latter factor provides for an environment which, unlike warmer waters to the south, would take significantly longer to breakdown waterborne pollutants.

The deployment of conventional booms for the containment of spills would be nearly impossible in ice covered waters. Adequate nautical charts serve first as a preventative measure, however, used with relevant tidal and current information, they provide a "base-map" for emergency response to threats to the environment and the safety of life at sea (SOLAS). Without adequate nautical information, authorities charged with mitigating environmental damage caused by vessel groundings and/or collisions (with ice or other vessels) and search and subsequent rescue operations would be severely challenged to model the movement and extent of pollutants.

3 CASE STUDIES IN COST/SAVINGS IN ICEBREAKING ESCORT

The following examples are based on the author's observations while at sea aboard CCGS Sir Wilfrid Laurier (Aug–Sept. 2009). In all cases, interviews were conducted with vessel captains to discuss both their navigation preferences and limitations. Mariner feedback has been instrumental in developing a new charting scheme for the region.

3.1 M/V Camilla Desgagnes

- A Canadian Flagged, General cargo carrier, with lightering capabilities servicing Kitikmeot Region ports.
- This vessel did not require icebreaker escort as it was able to transit an alternative ice-free route through James Ross Strait using GPS waypoints derived from preliminary (unpublished) hydrographic data.
- The estimated escort savings: $56,000 (2-days combined transit and escort time).
- Since the ice-free routing also provided the most direct route to market ports, the vessel saved an estimated 1.5 days transit time.

Figure 4: *M/V Camilla Desgagnes (Desgagnes Transarctik) in James Ross Strait.*

3.2 Akademik Ioffe

- A Russian Flagged, Research Vessel engaged in Arctic passenger trade.
- This vessel required icebreaker escort to reach Cambridge Bay.
- The ship's owner did not authorize use of GPS waypoints in the absence of large scale published hydrographic data. Furthermore, the ship's captain was reluctant to venture off adequately surveyed route while under escort despite heavier ice cover.
- The estimated escort costs: $125,000 (4-days combined transit and escort time).

Figure 5: *Escorting Akedemik Ioffe out of the ice.*

3.3 Lyobov Orlova

- A Russian Flagged, Passenger Vessel enroute to Gjoa Haven.
- This vessel did not require icebreaker escort as it was able to transit an alternative ice-free route through James Ross Strait using GPS waypoints derived from preliminary (unpublished) hydrographic data.
- The estimated escort savings: $125,000 (4-days combined transit and escort time).

3.4 M/V Umiavut (Nunavut Eastern Arctic Shipping Ltd.)

- A Canadian Flagged, General cargo carrier, with lightering capabilities servicing Kitikmeot Region ports.
- The ship's captain was reluctant to transit James Ross Strait with GPS waypoints derived from preliminary hydrographic data until their load was first discharged at Kugluktuk and Cambridge Bay (thus reducing draught).
- Estimated escort savings: $56,000 (2-days combined transit and escort time).

The above-mentioned examples cite cases where only preliminary hydrographic data was available. Remarkably, in view of these limitations, those vessels engaged in the cargo trade were still willing to assume a certain level of risk in reaching their destinations.

Figure 6: *M/V Umiavut.*

Figure 7: *Tug and Barges.*

Deep draught vessels have been servicing eastern Arctic ports for many years. Recent large-scale port surveys and electronic nautical charts (ENCs- see figure 8) have been published for the Nunavik region of Northern Quebec, Ungava and Hudson Bays. 2008 was the first year a deep draught cargo vessel serviced the ports within the Kitikmeot region and that number doubled to two in 2009. A program is currently underway to publish a number of new, large-scale charts for the Nunavut, Kitikmeot Region.

4 CONCLUSION

Worldwide, hydrography enables cost effective transportation by sea, particularly sealift by deep draught ocean-going vessels with access to world markets. There is an economic benefit to having deep draft access to Arctic ports in that freight costs and transit times are significantly reduced. In 2007 "the three carriers which were contracted to the GN [government of Nunavut] for community re-supply are estimated to have delivered in excess of 500,000 m^3".[20] Assuming a modest weight of 100kg per m^3 of cargo, the estimated savings over air freight would be $425,000,000 and $60,000,000 if shipped by deep draught sealift versus tug and barge alone. The requirement for adequate charting as an enabling factor for deep draught cargo access and increased water-borne tourism by passenger liner gives evidence of the *Economic Benefits of Hydrography* in the Arctic.

Additionally, improvements to nautical charting in the Canadian Arctic will enable vessels to find alternate routes to avoid ice thus reducing the cost to the Canadian public for icebreaker escort. From the examples given for 2009, the estimated savings in ice escort costs alone would be $360,000 within the Kitikmeot Region. Simply stated, with modern hydrography (surveys, sea level monitoring and charting), complementing modern aids to navigation and improvements to marine infrastructure, hydrographers are playing a significant role in attracting and enabling more cost-effective means of transportation to support freight, passenger traffic and tourism in the Arctic.

The cost for conducting modern hydrographic surveying and charting must be considered an investment to build capacity in many facets of economic development in Arctic coastal communities. While this paper has focused on hydrography's beneficial impact on costs and accessibility for marine transportation it would probably require a second edition to justify hydrography as a significant investment in support of mineral and

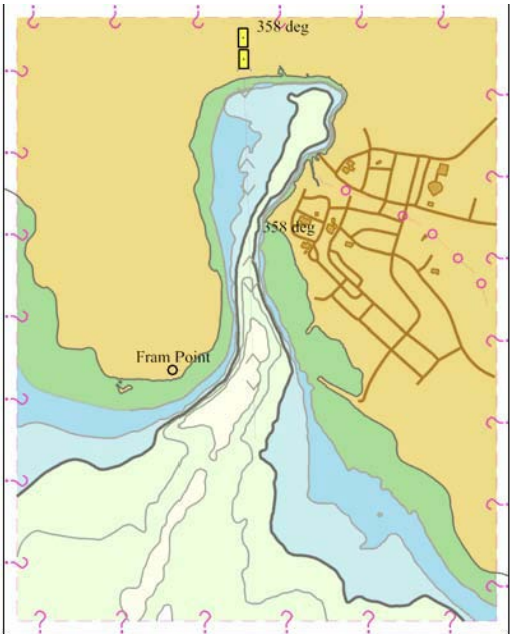

Figure 8. *S-57 ENC of Gjoa Haven.*

oil and gas development, fishing, national sovereignty, national defence and coastal zone management. The concept of hydrography as an investment not only applies to economic development in Canadian Arctic but to other developing lands worldwide.

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BIOGRAPHICAL NOTES

A graduate of Humber College's Hydrographic and Land Survey Technologist program, Andrew has been surveying for over 20 years, with varied experience in topographic, cadastral, offshore/industrial and hydrographic surveys for nautical charting. He is a Canada Lands Surveyor, employed as an Engineering Project Supervisor with the Canadian Hydrographic Service, Central and Arctic Region (Federal Department of Fisheries and Oceans Canada). He is currently assigned as Hydrographer-in-Charge of the Western Arctic Survey, Kitikmeot Region. He is past president of the Canadian Hydrographic Association and the present chair of FIG Commission 4.

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CONTACT

Mr. Andrew Leyzack C.L.S.
Canadian Hydrographic Service, Fisheries and Oceans Canada
867 Lakeshore Road
Burlington, Ontario
CANADA
Email: andrew.leyzack@dfo-mpo.gc.ca
Website: www.charts.gc.ca