# Hydrographic efficiencies of operating a 19 m research platform in the eastern Canadian Arctic.

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**Abstract**

A new research mapping program has been initiated as a partnership between the ArcticNet consortium and the Government of Nunavut (GN). GN owns and operates a 19m fisheries research vessel with a mandate to conduct fisheries resource investigations in Nunavut waters. The geographic focus is the heavily ice-impacted eastern coast of Baffin Island.

With only three hamlets over a 600nm coastline and the compounded difficulty of access due to ice, the only significant prior charting activity has been specific corridors in support of the Distant Early Warning (DEW) Line and North Warning Systems. In order to fulfill the new fisheries mandate, the vessel has to predominantly operate in uncharted waters. In doing so, there is the opportunity to compile new seabed mapping corridors that serve charting, ArcticNet geoscience and GN fisheries science objectives simultaneously.

Traditionally, charting and science programs in the Arctic Archipelago have been supported from major icebreaker assets (with ancillary launches) with commensurate associated costs. An independently operating 19m platform is an order of magnitude cheaper to operate, but must work safely within the constraints of the ice and weather windows.

## Introduction

In 2012 a collaborative partnership was undertaken between the Government of Nunavut, the ArcticNet NCE and the Canadian Hydrographic Service (CHS) to implement a seabed mapping capability on a 19m research vessel for operations in the eastern Canadian Arctic.

At the present time, there is no dedicated federal hydrographic survey vessel operational in Canada's Arctic waters. Federal hydrographic operations are conducted on an opportunity basis using launches aboard non-dedicated Canadian Coastguard icebreakers. Charting priorities are driven by the core shipping access requirements of the communities. As such seabed mapping activity in areas outside these core priority corridors is not routinely addressed.

This paper reports on the development of an alternative seabed mapping capability which meets the differing, yet complementary, needs of the collaborating partners.

**Political Framework**

In 1993, the Nunavut Lands Claims Agreement was signed. That agreement obliges the federal government to recognize the principles of adjacency and economic dependence of Nunavut communities on marine resources. Until recently, however, that obligation had not been met as offshore living resource development was predominantly being undertaken by foreign and non-Nunavut commercial organizations. Furthermore, that development has had only limited oversight to ensure the sustainable development of this emerging resource. As a result a Nunavut Fisheries Strategy was devised.

In 2005, the Nunavut Fisheries Strategy (GN and NTI, 2005) clearly identified that there was a lack of scientific knowledge behind the development of Nunavut living marine resources. Comparable research in this field in other areas of Canada's waters is far more developed through a long history of publicly-funded programs. The current federal model, however, has been to defer to "user pay" approaches which have proven inadequate.

As a result "*emerging fisheries such as flounder and clams are subject to virtually no scientific research upon which to make management decisions*" (GN and NTI, 2005). As such, a recommendation was made in 2005 to establish a Nunavut Fisheries Science Agenda that would address: "*fundamental marine ecosystem and hydrographical research, regulatory requirements, climate change impact assessment and modeling, research in support of inshore and offshore industry development*"

This has lead to the implementation of the Nunavut Fisheries Science and Research Agenda (Lynch, 2010) with a commitment of C$7.5 million over 4 years (2010-2013). A dedicated new fisheries research vessel, the MV Nuliajuk, has been the prime tool for the implementation of that Agenda for the 2011-2013 years.

Implementing that Agenda requires significant improvement in marine infrastructure in Nunavut. This includes harbour and port facilities, marine service centres, processing plants and cold storage facilities, and also significantly, ocean research capability. Examples of improvements in this infrastructure include the dredging of the Pangnirtung port (AMEC, 2010), feasibility studies for a deep water berth in Qikiqtarjuaq (Bridger Design Associates, 2010) and, most significantly for this paper, the construction of the MV Nuliajuk (Bollivar, 2010) to meet the mandate for fisheries research.

It should be noted that the impact of this infrastructure development extends well beyond the fisheries needs. Such infrastructure will also play a key role in improving maritime safety, and in facilitating the improvement of other important activities such as hunting, sea-lift re-supply, and tourism (GN and NTI, 2005).

With the implementation of a seabed mapping capability as an extension to the Nuliajuk, there are a wider group of users that can now utilize the platform collaboratively. This paper reports on the implementation of this capability and demonstrates its applications for fisheries habitat, nautical charting, dredge spoil disposal, port development and palaeo-sea level history.

**History of Charting off Eastern Baffin Island**

The first dedicated hydrographic operations off eastern Baffin Island were undertaken in 1955 by the USS Tanner (AGS-15) in support of the Distant Early Warning (DEW) line of radar stations. This involved single beam operations from four survey launches (Fig. 1). As the DEW line stations were downgraded in 1963, there was no subsequent requirement for further surveying. Only very localized work was done by private contractors in the late 1980's to support the North Warning System.

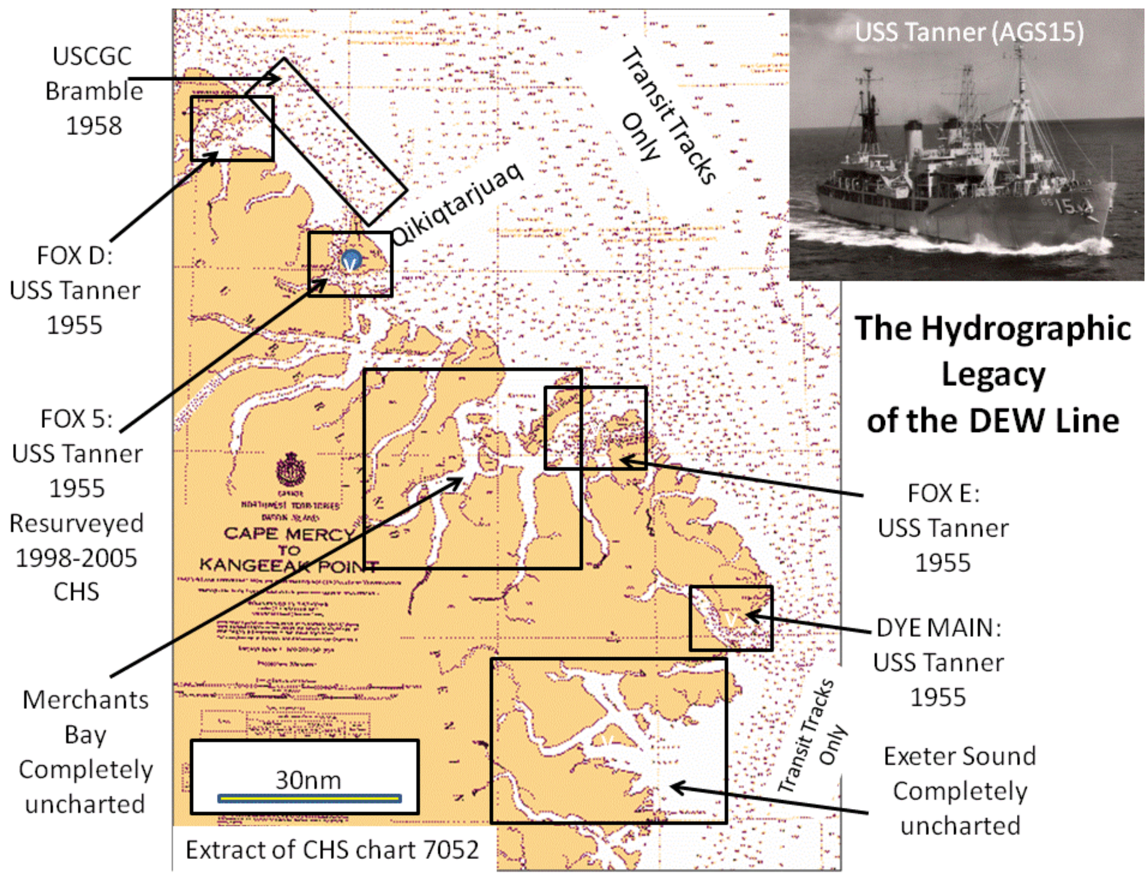



*Fig. 1: State of hydrographic charting in early 2012 along eastern Baffin Island. Note that the offshore regions are almost entirely covered only by transit ship tracks and that much of the inshore region does not even have reconnaissance data.*

During the DEW line period, Canada undertook delivery of the CSS Baffin in 1958 which provided a dedicated hydrographic survey capability in the north. With six hydrographic launches, the CSS Baffin represented an extremely efficient means of undertaken coastal surveys. Those surveys, however, from 1960 to 1989 were focused primarily on perceived shipping needs for the Northwest Passage and thus other areas were not addressed. For example Exeter Sound and Merchants Bay (Fig. 1) which are now of interest to emerging fisheries and scientific studies (Siferd, 2005 and Cowan et al., 2012) remain uncharted.

In 1989, the Baffin was withdrawn from service without replacement. Since that time, no regional-scale hydrographic charting operations have taken place in the eastern Arctic. Only localized charting activities around communities have continued through the use of non-exclusive time on coastguard icebreakers. More extensive work is precluded due to the high cost and limited availability of these icebreaker assets.

As a result, areas that are now of interest to the emerging fisheries and scientific communities are often completely uncharted. Therefore there is a pressing need to find an alternate way to undertake coastal seabed mapping surveys. One model, pioneered by the Royal Danish Administration of Navigation and Hydrography (RDANH) has been to utilize groups of much smaller vessels during the short ice-free windows. Since 1958, the RDANH have operated the SKA boats in west Greenland waters (RDANH 2004). Because of the longer ice-free season, viable operations extend from late May to October. The original four vessels were 15m long and were operational until 1980 utilizing single beam sounder technology. In 1989 they were replaced with two 20m long vessels and as of 2002 they now utilize multibeam sounders. Because of well developed coastal infrastructure, these vessels are pulled out of the water and stored ashore in a dedicated building in Grønnedal.

As long as the local ice-free window is clearly understood, the SKA boat model could be extended to the Canadian side of Baffin Bay. This paper reports upon the trial implementation of multibeam sonar seabed mapping technology on the MV Nuliajuk, a solitary, 19m long, vessel. Because no comparable port and harbour infrastructure exists in Nunavut, the vessel has to transit from Newfoundland annually.

**Core Fisheries Research Mandate**

As originally delivered, the MV Nuliajuk was designed to undertake research in support of the emerging offshore and inshore fisheries. The offshore fisheries are focused around two species: The Turbot or Greenland Halibut (*Reinhardtius hippoglossoides*) and the Northern shrimp (*Pandalus borealis).*

These species are currently harvested in Northwest Atlantic Fisheries Organization (NAFO) geographic Divisions 0A and 0B. Division 0B (off SE Baffin Island) has the longest record of development, dating from about 1981 involving mainly foreign organizations. Division 0A (Eastern Baffin Island Shelf) has had more recent development, with exploratory fisheries starting in the early 1990's. The 2006 Turbot quota was 8,500 metric tonnes and worth about C$37.1 million (including C$5.1 Million in royalties to Nunavut Industry). Of that quota, 500 metric tonnes is designated for an emerging inshore fishery in Cumberland Sound.

Turbot are generally only caught in water depths greater than 400 fathoms (Young and Treble 2010). Thus most of the fisheries locales are along the shelf break or in the cross-shelf, glacially-excavated troughs, such as off Sam Ford Fjord and Scott Inlet, (Walsh et al., 2008) and the >1000m deep basin in Cumberland Sound (Young and Treble, 2010). Note that the offshore extension of the Nunavut Land Claims Agreement only extends out to the limit of the territorial sea (12nm) and thus excludes most of the offshore fishery with the exception of the Cumberland Sound and other glacial trough locations.

The inshore fishery of interest off eastern Baffin Island is the possible exploitation of soft shelled clams (Mya Truncata). A preliminary study of the density and distribution of this species was carried out by Siferd (2005). That study utilized bottom photography referenced to depth measurements along a series of transects. Notably that study did not have the ability to delineate the substrate to assess any correlation. Acoustic backscatter from multibeam sonar can provide that capability.

**Identification of Opportunity and Implementation**

Since 2003, the Ocean Mapping Group at the University of New Brunswick (UNB) has collected multibeam sonar data throughout the Canadian Arctic from the Canadian Coast Guard Ship (CCGS) Amundsen and ancillary survey launches (Bartlett, 2006). The CCGS Amundsen is a 1200 Class icebreaker owned and operated by the Government of Canada. It is made available to scientific researchers primarily through ArcticNet, a Canadian Network of Centres of Excellence (Laval, 2013).

Over the winter of 2011/2012, the CCGS Amundsen's engines underwent detailed testing. It was found that several of the six diesel engines aboard were failing and needed replacement. This meant that the regular home for the Ocean Mapping Group's Arctic operations was to be out of service for the 2012 mapping season. As a result, talks began in January 2012 with personnel from the Nunavut government to gauge both the feasibility and interest that existed in adding seabed mapping capability to the Nuliajuk.

The Ocean Mapping Group at UNB assisted with the design of the transducer blister that was to be installed on the Nuliajuk. The installation of the remainder of the systems necessary for multibeam and sub-bottom survey were also designed and carried out by various members of the Ocean Mapping Group. The full sounder suites and additional support equipment were either already available at UNB or borrowed from participating groups.

Costs for the design, construction, installation, and testing of the mapping sonars were shared by UNB, the CHS, Memorial University, and the Government of Nunavut. Costs were also divided between the multibeam echosounder (MBES), sub-bottom sounder, and the Furuno FCV-30 fisheries sounder, which was installed at the same time on a new blister.

A Kongsberg EM3002 multibeam was chosen for installation on the Nuliajuk due to its compact installation size and availability due to the cancellation of the 2012 Amundsen barge program. The deep fjords of eastern Baffin Island, however, presented some operational challenges for the system, as the 300 kHz EM3002 MBES system normally reaches its operational limit in about 150 m of water. The cold and brackish waters of the Arctic, however, allowed for an additional 50 to 100 m of quality data to be collected. The system tracked as deep as 300 m in the summer of 2012 aboard the Nuliajuk, but the data coverage and quality are reduced. A reliable 300-400 m wide swath was produced in 200 m of water depth (Fig. 2).

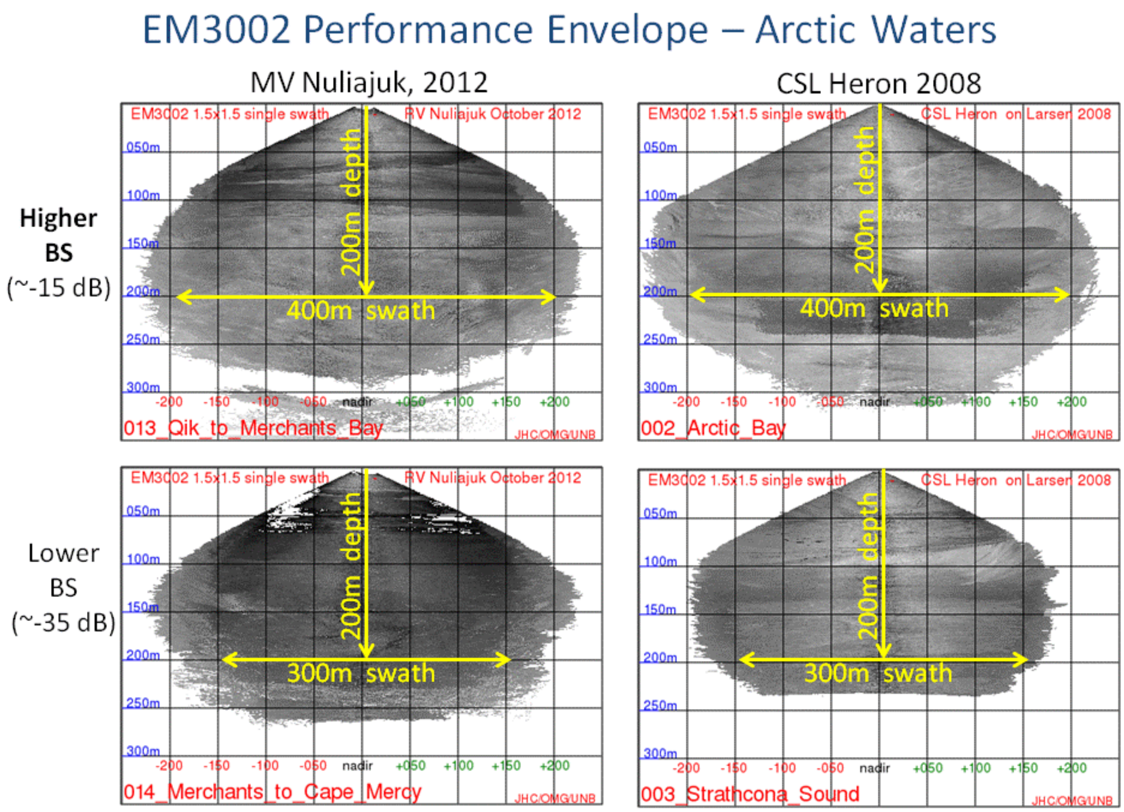



*Fig. 2: EM3002 Performance Envelopes on two platforms operating in eastern Arctic waters.*

The fjords and bays of Baffin Island where the Nuliajuk worked during the 2012 season have many areas that exceed the functional depth limit of the installed MBES. For example the depths at which data is required for turbot habitat mapping are beyond the operation depths achieved by a 300 kHz system, but it was ideally suited to mapping potential clam habitats, undertaking exploratory charting surveys and monitoring sea level history.

**Nuliajuk Mapping Hardware and Design Specifications**

The Nuliajuk has a length of 19.4 m, a beam of 6.4 m and a draft of 3.5 m. The vessel is constructed of steel with an aluminum wheelhouse. Normal operation in Arctic water requires four crew members. Additionally there are six berths in a single forward cabin for crew trainees and scientists. The Nuliajuk is a well equipped vessel for autonomous operations in the Arctic, having dual engines, twin screws, two independent generators and redundant water makers.

One of the requirements originally laid out during the design phase was that the vessel be capable of resting out of the water on its keel. This characteristic would be put into use when in ports such as Iqaluit which have large tidal ranges and a 'high tide only' wharf. It could also be skidded ashore for work or storage in remote areas. The Nuliajuk was specifically delivered with a strengthened central keel and two side skegs to meet this requirement (Bollivar, 2010). After the initial construction, however, a 150 kHz acoustic doppler current profiler (ADCP) was flush mounted next to the forward section of the keel, negating the Nuliajuk's ability to rest on the seabed except in case of emergency, as the transducer would be destroyed.

The face of the blister that contains the multibeam, sub-bottom sounder and FCV-30 transducer (Fig. 3) is adjacent to the ADCP blister and is just above the base of the keel, further reducing the practicality of purposefully grounding the vessel.

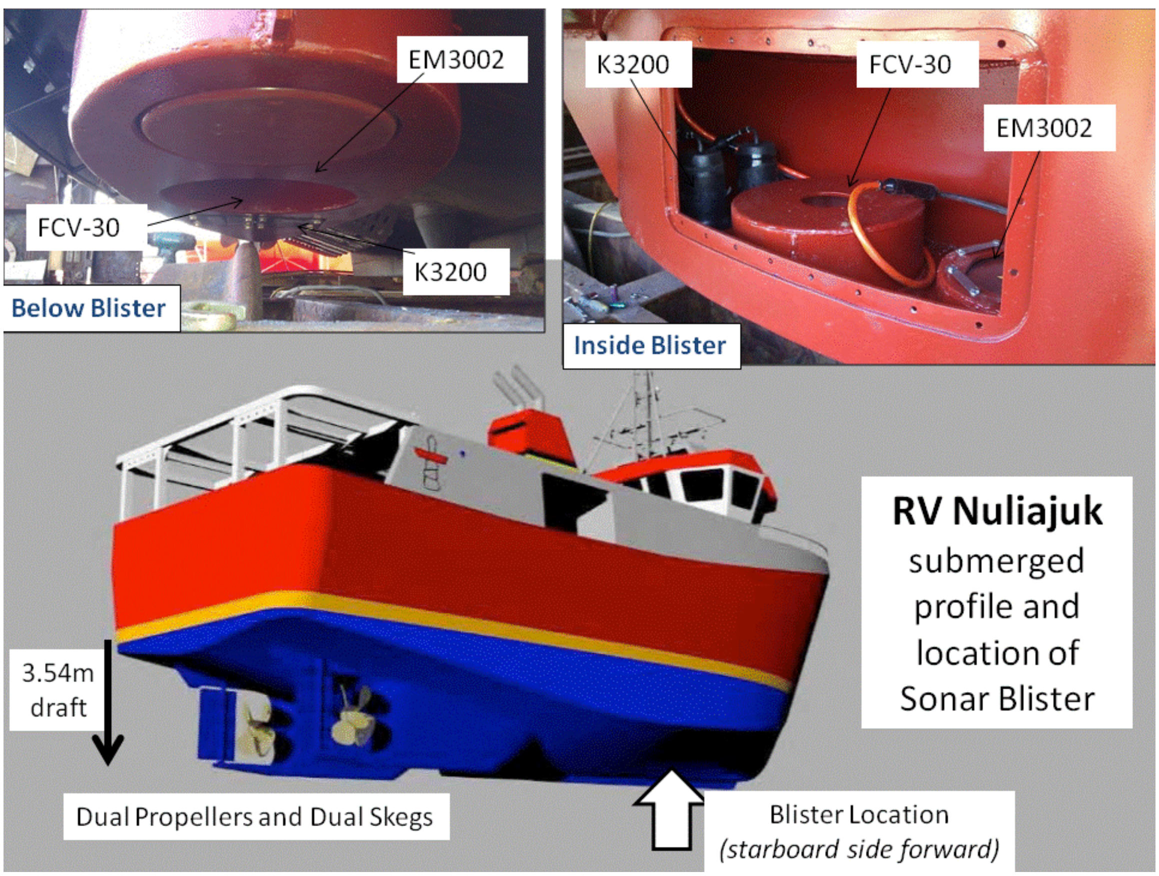



*Fig. 3: rendering of Nuliajuk stern submerged profile and detail on blister construction. Note dual propellers and skegs. (CAD drawing from Bollivar,2010).*

As described earlier, a Kongsberg EM3002 was immediately available for quick installation on the Nuliajuk. Also available for use was the Coda Octopus F185 motion sensor and C&C Technologies CNav 3050 GPS systems that normally accompany the 3002 (Fig. 4).

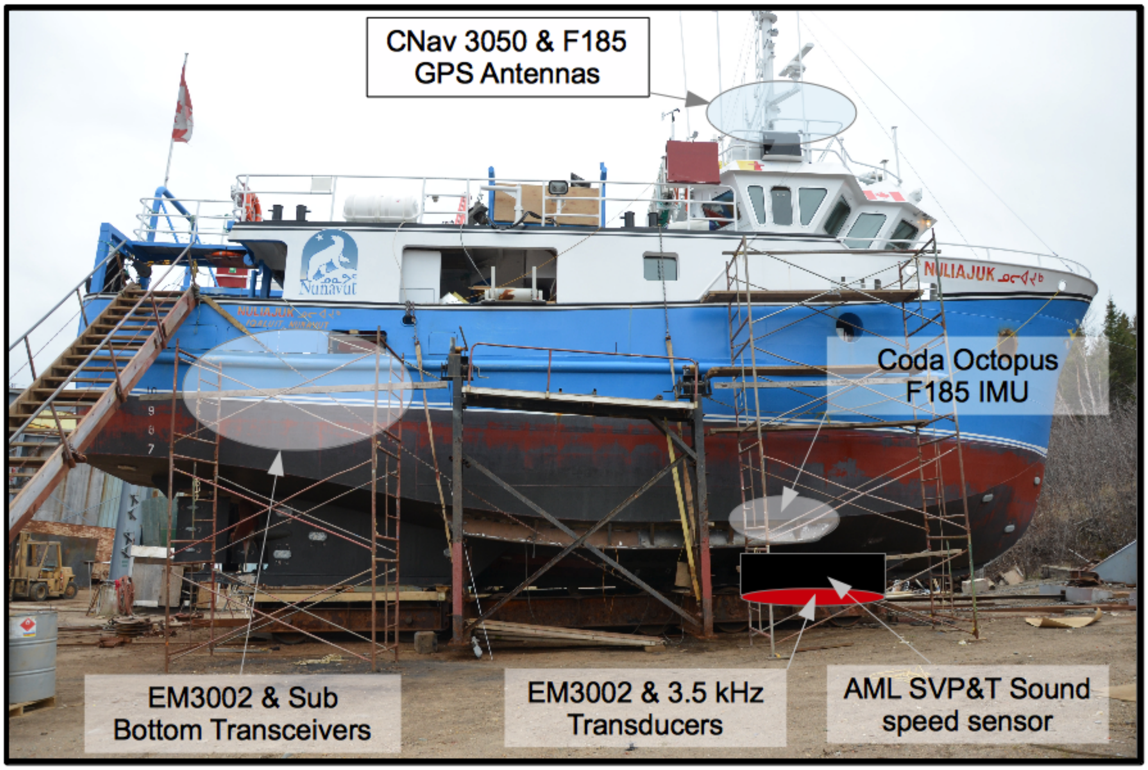



*Fig. 4: Mapping System Components.*

**Vertical Datum Reduction**

The east coast of Baffin Island is a tidally complex region. The semi-diurnal (M2) component of the tide varies between macro-tidal in southern areas of Baffin Island to micro-tidal in the central region around Clyde River, as illustrated in figure 5. The presence of an amphidrome for the semi-diurnal tides in the centre of Baffin Bay, shown in the left hand image of figure 5, significantly decreases the amplitude of that component of the tide between the areas of Qikiqtarjuaq and Clyde River. The diurnal component (K1), shown in the right hand image of figure 5, is negligible in the areas of Frobisher Bay and Cumberland Sound, but becomes significant further north along the coast. The variability in the tidal regime complicates vertical reduction of hydrographic survey data as existing tidal predictions at sparse historic stations along the coast do not account for the propagation of the tides throughout the long narrow fjords and there was no operational tide gauge in the region for the 2012 season. To overcome this limitation, two solutions were pursued. The first, and ultimately preferred implementation, was the method used aboard the CCGS Amundsen of employing national tidal models to apply predictions of the spatially varying tides. The second was the use of ellipsoidally referenced surveys (ERS).

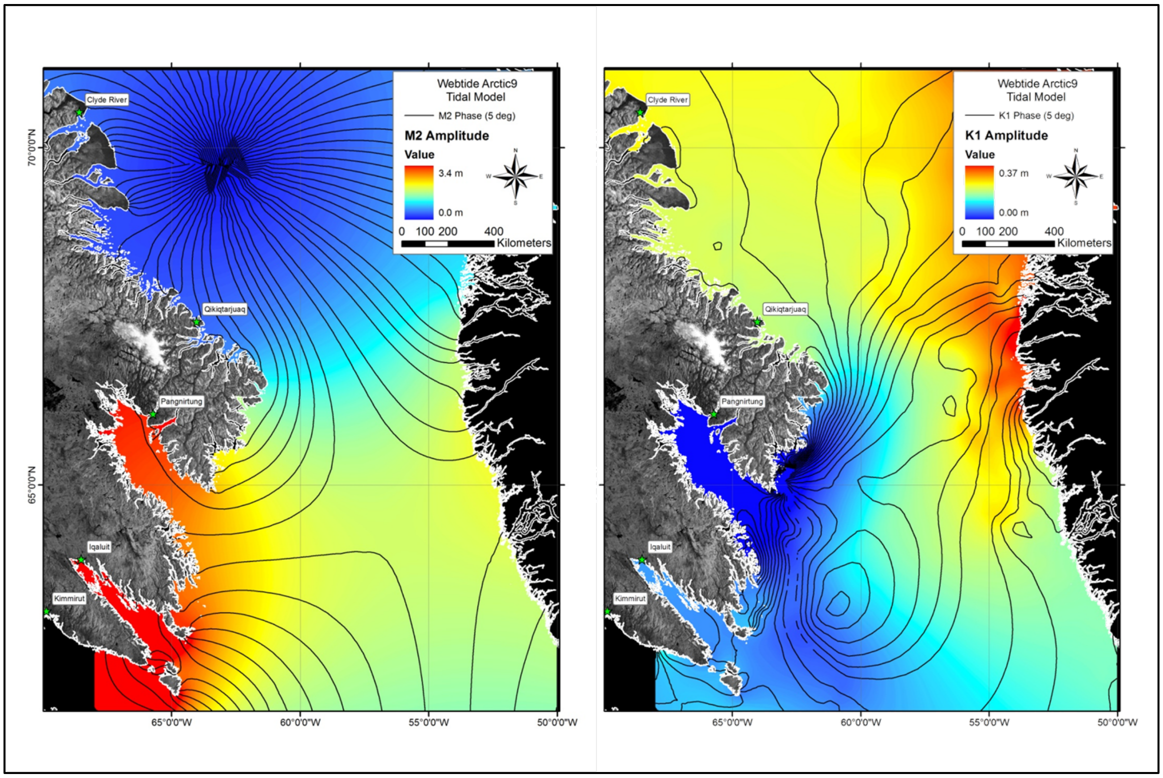



*Fig. 5: Semi-Diurnal and Diurnal Tidal Range and Phase of southeastern Baffin Island*

Application of ERS has a number of challenges in the eastern Canadian Arctic. Vertical accuracies will initially be limited by the quality of the GPS data available. While the CNav corrections provide the vessel with decimetre level vertical uncertainty in real-time, they are often obstructed at high latitudes in steep walled fjords. The collection of raw GNSS pseudoranges allowed for the post-processing of Precise Point Positioning (PPP) solutions, but the results were heavily degraded by radio-frequency interference with the original GPS signal, which is still under investigation. With tolerable vertical trajectories, depth measurements must be referenced to a more meaningful datum than the ellipsoid. To accomplish this, the vertical position of the vessel needs to be reduced to a local Geoid, such as the Canadian Geoid model CGG2010 or the global EGM08. The area of southeastern Baffin Island exhibits a strong gradient in the Geoid-Ellipsoid separation, as shown in the left hand image of figure 6, and many Geoid models differ in this area. As shown in the right hand image of figure 6, differencing the CGG2010 and EGM08 Geoid-Ellipsoid separation models demonstrates the impact of choosing one model over the other, with discrepancies on the order of half a metre.

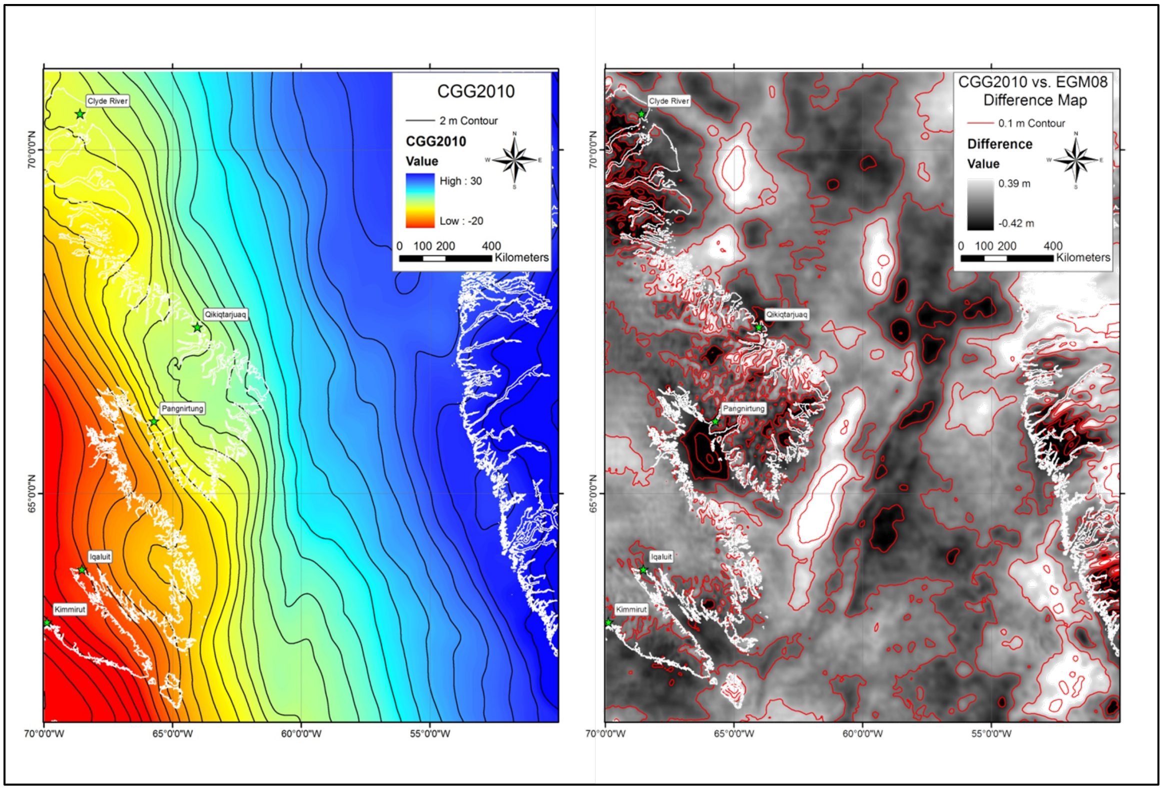



*Fig. 6: CGG2010 Geoid-Ellipsoid Separation and Difference with EGM08*

The arctic9 tidal model was ultimately used to reduce the hydrographic survey data to mean sea level for the 2012 season. The model, as described in Collins, et al. (2010) and partially shown in figure 5, accounts for the propagation of the tide throughout the complex region of southeastern Baffin Island. It is tuned to reproduce predictions at coastal gauges and provides a smoothly varying reference to mean sea level. At present, the models are not without their complications and deficiencies. Unlike the previously mentioned ERS, the model predictions still require the inclusion of dynamic and static draft adjustments and do not account for spatially varying sea-surface topography, which can be difficult to measure in the Arctic. The model domain also only covers a limited area and a different model must be used for work along the Labrador Coast.

**Analysis of Ice Regime**

As the Nuliajuk has no icebreaking capability, she must operate in predominantly ice-free waters. As such her area of operations and time window are limited by the departure and return of significant ice.

Crane (1978) published an analysis of the spatial and temporal variability in retreat and advance of ice in the Labrador Sea and Davis Strait area based on available 1964-1974 ice records. On average, he found that sea ice is present for up to 40 weeks per year in the Davis Strait and for 30 weeks off the northern Labrador Coast. He demonstrated that there is significant variability in early and late advance and retreat of ice (Figs. 7 and 8) which could be linked to meteorological forcing. The prime factor was wind direction with southerly flows promoting early ice retreat and northern flows promoting early ice advance.

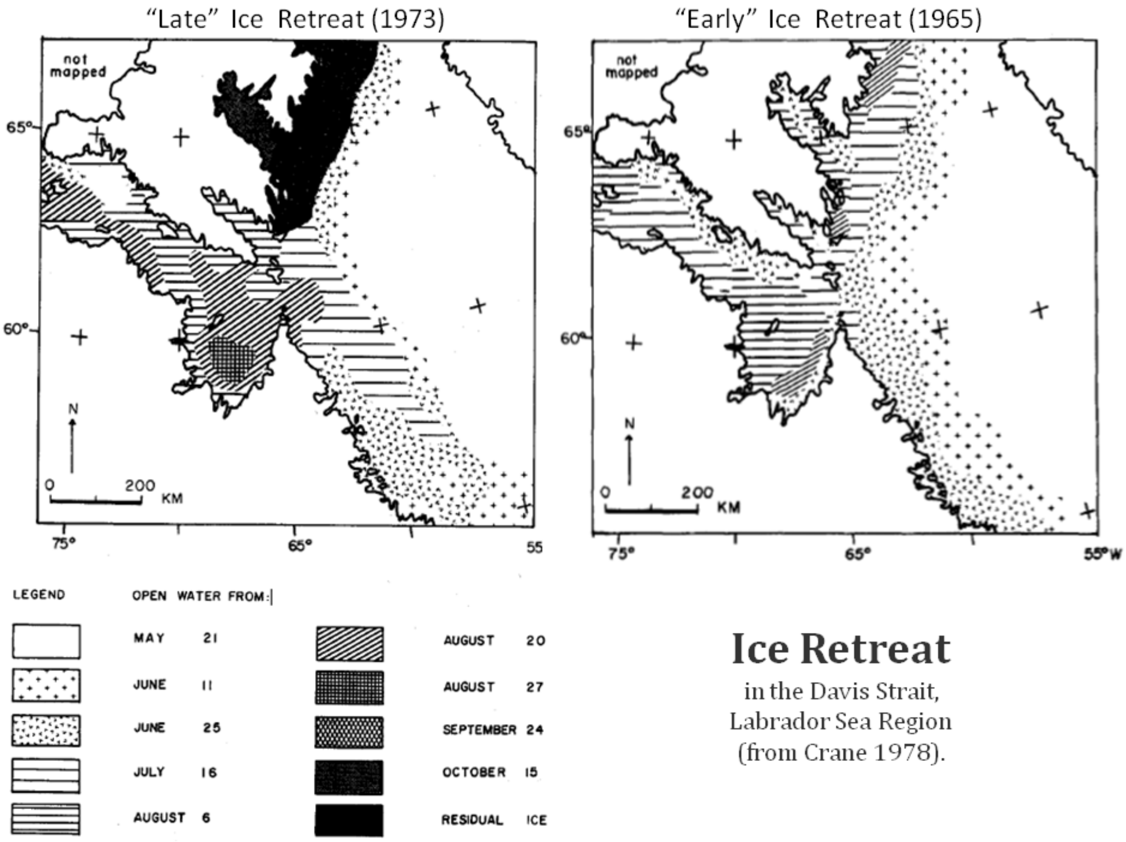



*Fig. 7: Variability in the retreat of Ice in the Davis Strait/Hudson Strait region (adapted from Crane (1978).*

Notably, Crane's work illustrates that the first viable use of the Nuliajuk, on leaving Glovertown, along the Labrador Coast may not occur until mid to late June (Fig. 7). Note also that access into Hudson Strait could be possible along the northern side as early as late June but might still be blocked in mid August. In the 1960's there were years in which residual ice prevented access to Cumberland Sound all year. Given the recent changes in Arctic ice regimes, these 50 year old analyses must now be reassessed in the light of climate change.

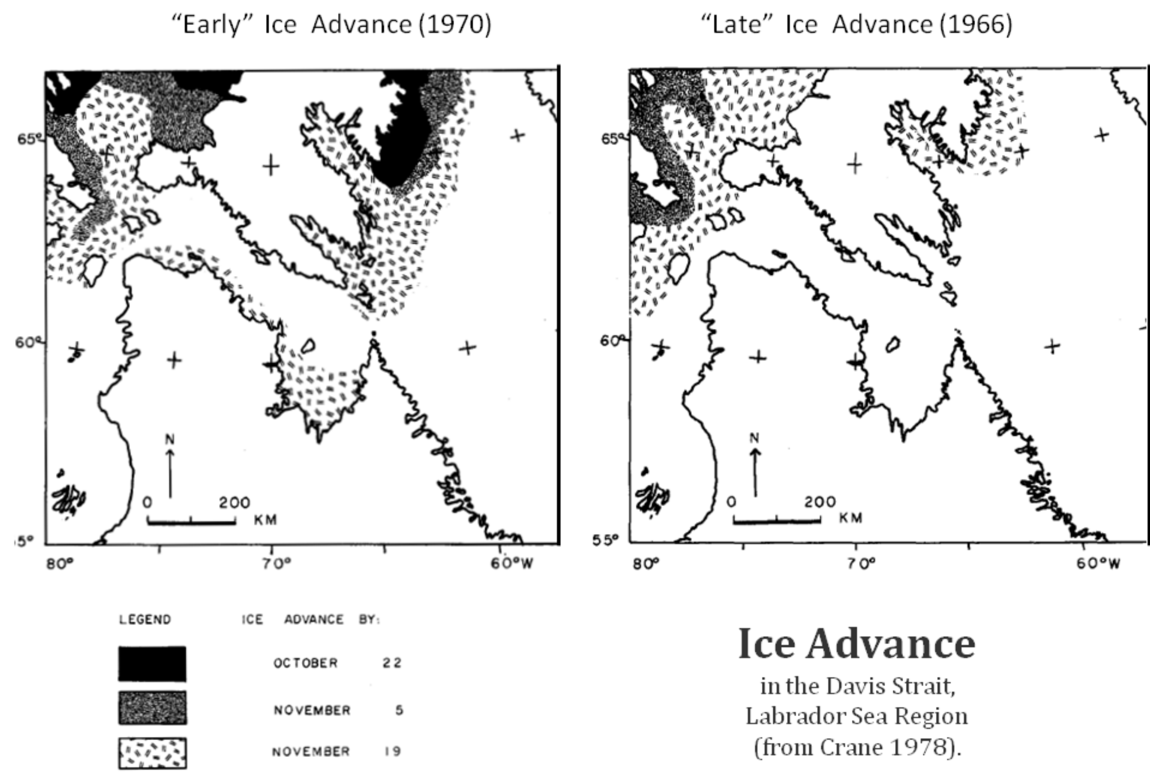



*Fig. 8: Variability in the readvance of Ice in the Davis Strait/Hudson Strait region (adapted from Crane (1978).*

Crane's analysis of the ice readvances (Fig. 8) demonstrated that mapping within Hudson Strait could be undertaken as late as early November. It also illustrated that in some years, however, the ice could be past Cape Dyer before the end of October. Again, these extreme ice events need to be reassessed given the changing ice regimes due to climate change.

More recent analysis conducted herein has compiled Canadian Ice Service weekly synopses for the past 9 years (2004-2012). This examines the more northerly potential operating area of the Nuliajuk from Cumberland Sound up to the Lancaster Sound (Figs. 9 and 10). Ice retreat is highly variable and depends on the penetration of the West Greenland current up the east side of Baffin Bay (Fig. 9). The northern end of Baffin Island may well open up before the section by Cape Dyer. Notably, while the open shelf opens up more predictably, the presence of ice in Cumberland Sound can be accelerated (e.g. 2011) or retarded (e.g. 2012). This presumably reflects the meteorological forcing demonstrated by Crane (1978).

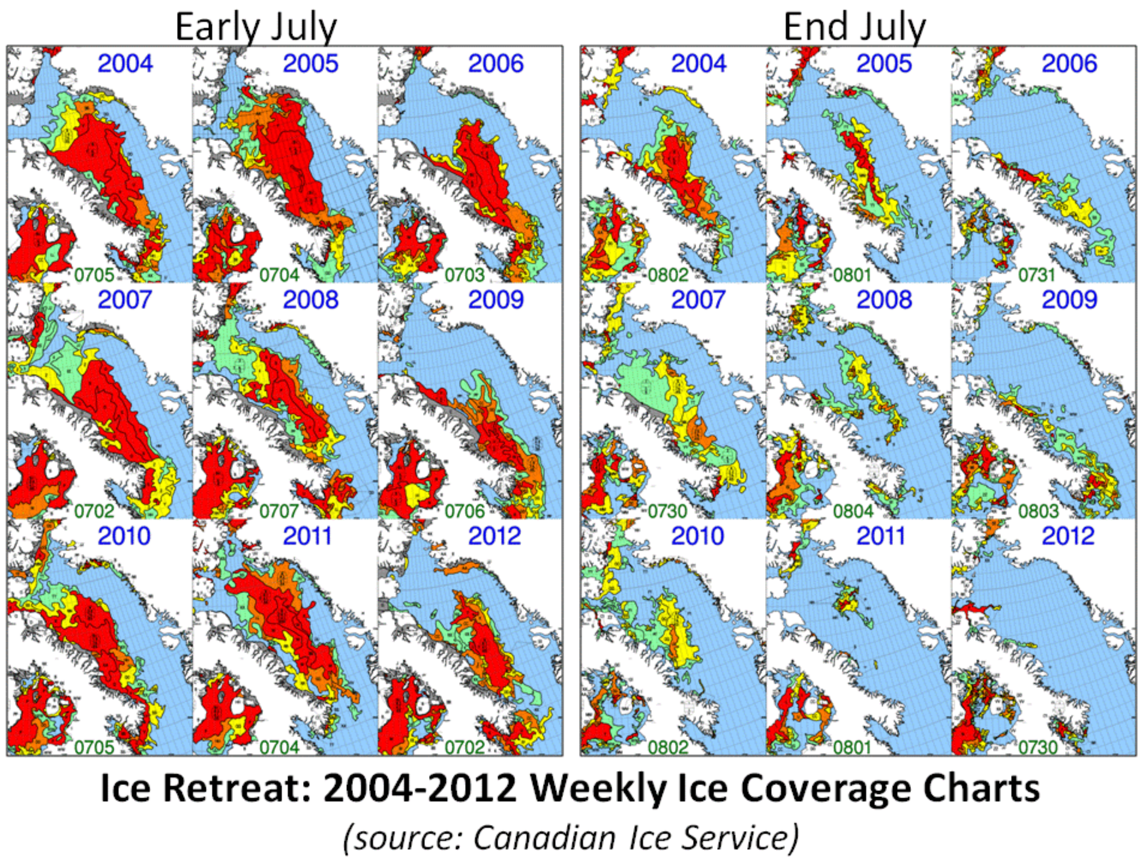
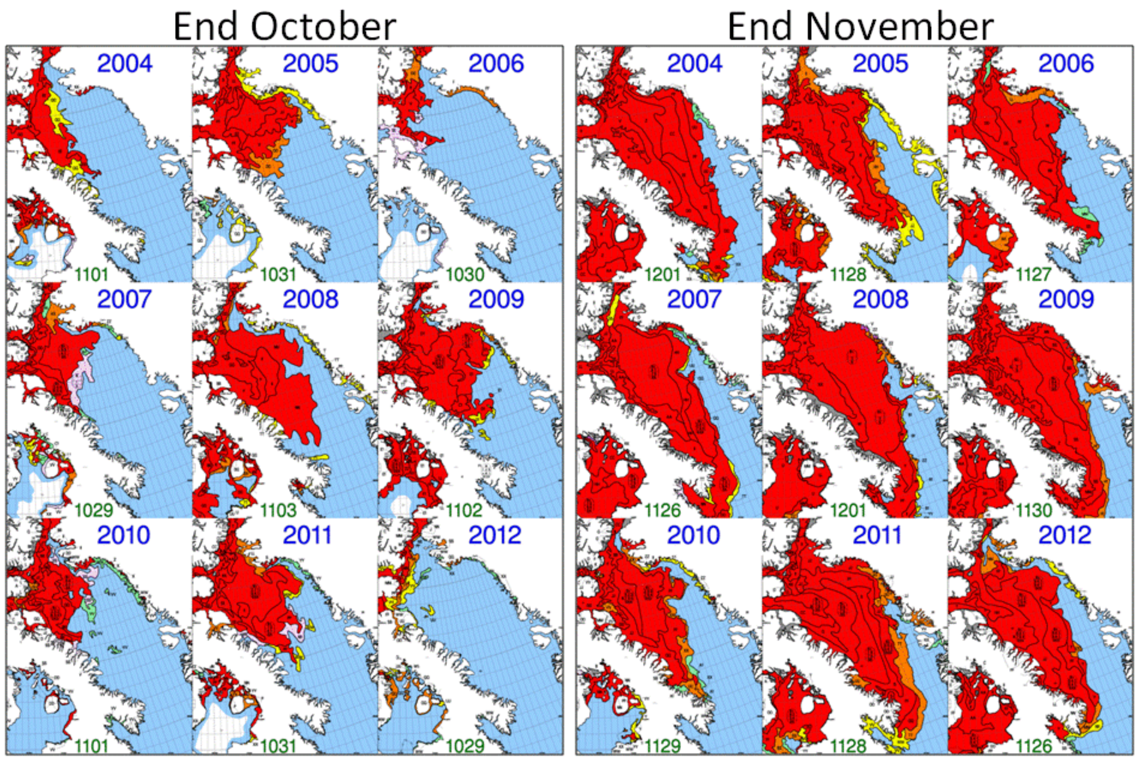



*Fig. 9: Ice retreat in Baffin Bay over the past nine years.*

In contrast to the retreat of ice, the return of the ice is strongly dependent on latitude, advancing from the north along the east coast of Baffin Island (Fig. 10). The variability in arrival time from year to year is significant however, with open water still present at the end of October at Pond Inlet in 2012 and 2006 whereas at the same period the ice extended down to Clyde River in 2008 and 2009.




**Ice Advance: 2004-2012 Weekly Ice Coverage Charts**

*(source: Canadian Ice Service)*

*Fig. 10: Ice advance in Baffin Bay over the past nine years.*

**Discussion of Operations, Cost, and Logistics**

The Nuliajuk is very cost effective for both research institutions and governmental departments. Crewing demands and operating costs are small compared to a large vessel with ancillary launches. As long as the ship is already near the area where the work is to be conducted, transit costs are kept to a minimum.

The charge for a research group to conduct sampling or mapping from the Amundsen under the ArcticNet banner is currently $50,000 to $60,000 CDN per day (Montreal Gazette, 2011). A vessel of similar size to the Nuliajuk under contract to conduct hydrographic surveying would cost in the area of $15,000 to $20,000 per day. The current cost per day for non-commercial research use of the Nuliajuk is ~$5500. This covers both vessel operations and crewing.

To date, support for fisheries research from the vessel came from Fisheries and Oceans Canada, the Canadian Northern Economic Development Agency, the University of Windsor, University of Victoria, Dalhousie University, the Sir Alistair Hardy Foundation for Ocean Science, the community of Pangnirtung and the Nunavut Department of Development (Government of Nunavut, 2012). The mapping campaign in 2012 saw additional support from Memorial University, University of New Brunswick, ArcticNet and the Canadian Hydrographic Service.

The Nuliajuk has a top cruising speed of approximately 8 knots. While this is generally fine for hydrographic surveys where data quality is the main concern, it reduces the potential to increase the area covered per day. It also increases the cost and time that needs to be allocated to transiting between work sites, anchorages and resupply ports. The benefit to this speed limitation is that there is almost no data degradation from speed related effects while collecting valuable transit survey data in uncharted regions.

With the base four man crew, only 12 hour per day operations are currently supported. With an additional two crew members, 24 hour operations are possible, but the survey staff berths are correspondingly reduced.

The Nuliajuk is quite manoeuvrable, having twin screws, each on its own skeg. While it would not be considered a shallow draft vessel for inshore work, 3.5 metres is reasonable for working in depths up to ~10 metres. Slow, methodical investigations of shoals are possible, accepting that the least depth will not necessarily be found by this vessel.

The operation of the Nuliajuk in the remote, mostly uncharted inshore waters of southeast Baffin Island would not have been possible without the aid of the Furuno CH-300 Searchlight Sonar. Having the ability to scan 360° around the vessel at various tilt angles provides a preliminary view through the uncharted waters. One example that highlights the use of this sonar was in the previously uncharted Boas Fjord in Merchant's Bay (Fig. 1). Steaming towards the head of the fjord, the searchlight sonar detected a shoal extending across the centre of fjord. The shoal was subsequently mapped, with the least depth still unknown (less than 7m).

The endurance of the vessel depends on specific operations but is generally a maximum of 2 weeks. Refuelling in many of the small communities was challenging, as there are only two wharves in the region capable of handling the Nuliajuk. In the remote communities, drums of diesel are ferried in small craft to the Nuliajuk and it is then pumped into the main tanks.

Although the Nuliajuk operates in remote areas, the nearby communities are of sufficient size to support crew changeovers with commercial airports and limited restocking of ship supplies. As operations dictated, the mapping and fisheries research groups, as well as crew, swapped in and out over the summer and fall, maximizing use of the available time.

**2012 Season Overview**

The 2012 season consisted of 3 main segments. Dedicated mapping in Labrador was followed by shared research time in southern Baffin Island and more dedicated mapping time in various locations across the southeastern shores of Baffin Island.

Mapping in Labrador was conducted for Memorial University as part of their research in Lake Melville. Due to a later than anticipated sailing date, the window of opportunity in Labrador was thought to be lost but the 2012 ice retreat along southern Baffin Island proved to be later than average and much later than 2011 (Fig. 9). The intended work zones for July in Baffin Island were inaccessible so the Nuliajuk continued to work in the ice free region of Lake Melville.

Once the ice began to dissipate in Frobisher Bay and Cumberland Sound, the Nuliajuk headed north to begin work near Iqaluit. The ice proved, however, to be persistent and the Nuliajuk and supply ships alike were forced to wait outside the bay. The second segment of mapping aboard the Nuliajuk was intended to be shared time (and cost) between active fisheries research and seabed mapping. The fishing activities were to take place during the days and transit lines to and from anchorage, as well as some dedicated mapping in the afternoons, was expected for hydrography.

One of the major lessons learned in 2012 was that operations need be scheduled around traditional ice retreat times more than any other events. In addition alternate plans need to be made in advance so they can be implemented when ice-conditions dictate.

**Example Seabed Mapping Projects**

*Clam Habitat Mapping around Qikiqtarjuaq*

Siferd (2005) had illustrated significant variations in the total density and depth dependence of the clam comminutes along the coastlines around the community of Qikiqtarjuaq (Fig. 11). An experimental fishery for these species had already been undertaken in that region but baseline mapping was lacking to adequately define the areal extent of the available resource.

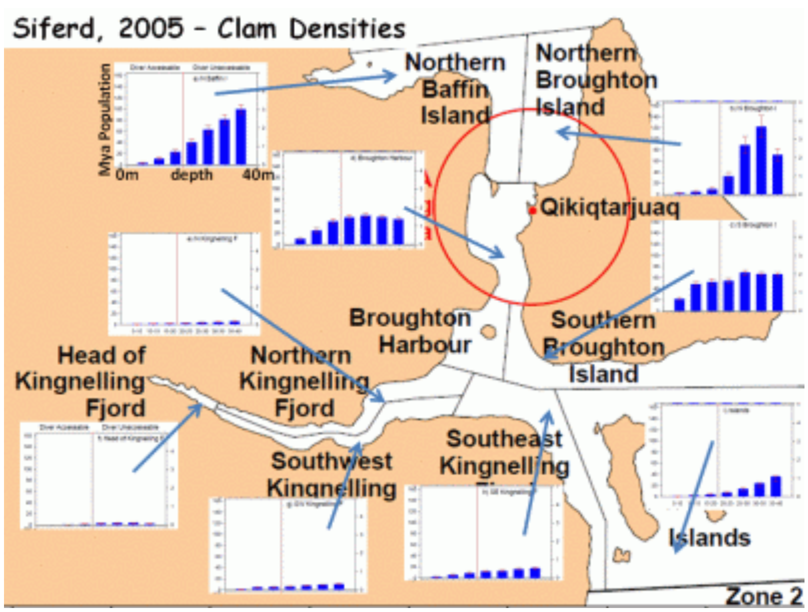



*Fig. 11: Assessment of a clam fishery near Qikiqtarjuaq, Nunavut. Canada. From Siferd( 2005.)*

The Nuliajuk mapping deliberately overlapped the survey areas of Siferd (2005) (Fig. 12) to determine if the seabed sediment type (as identified from backscatter) could be used to explain the variability in densities reported by Siferd. The multibeam surveys were then extended along the coastlines into other areas of less than 100m of water depth in which potential clam habitats might be expected. It is hoped that correlation between measured clam density and acoustically-defined surficial sediment type can be demonstrated.

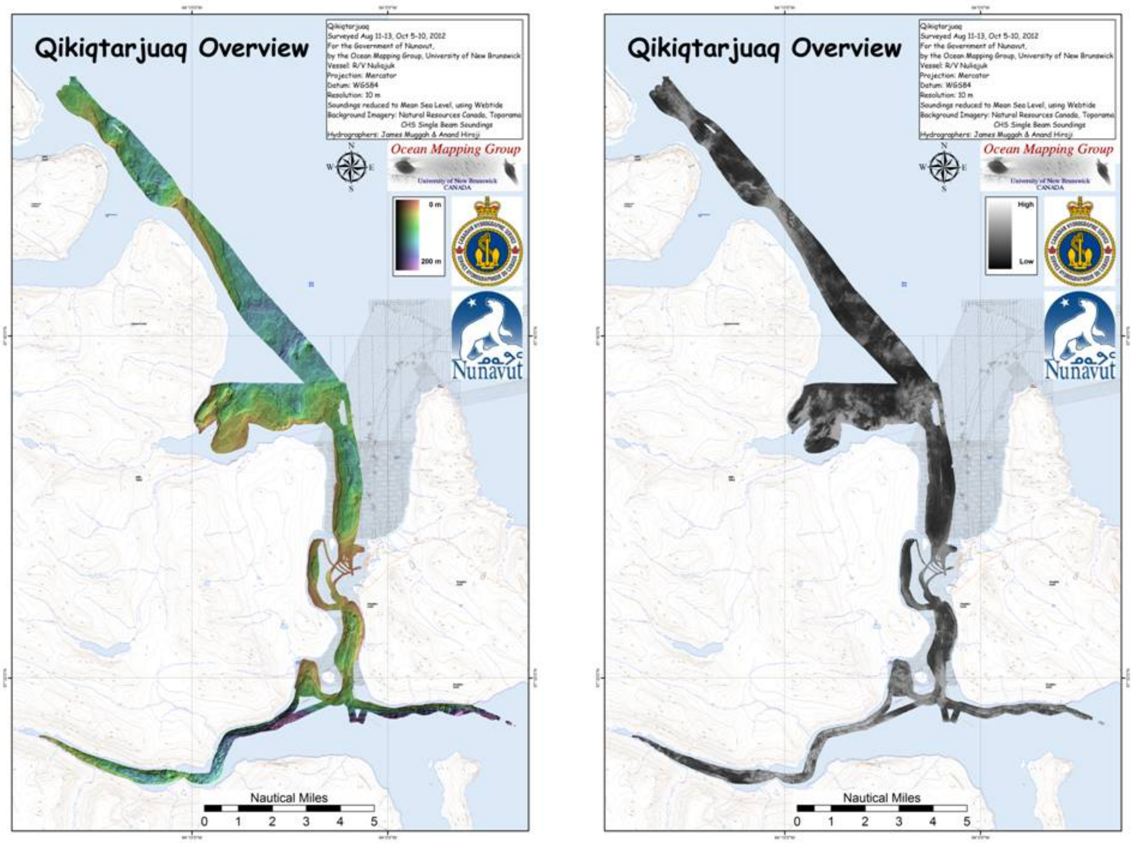



*Fig. 12: Bathymetry and Backscatter maps of the Qikiqtarjuaq vicinity acquired for the purpose of delineating seabed habitat for potential clam fisheries. Extent of previous CHS single beam charting is indicated as grey mesh. All other areas were previously unsurveyed*

*Palaeo Sea-Level History of Eastern Baffin Island.*

Relative Sea level models of the Canadian Arctic combine the global record of eustatic sea level history with the local predicted level of isostatic crustal motion. Such models require validation through the recognition of raised fossil coastlines (visible on land as emergent beaches) and submerged fossil coastlines (only resolvable through multibeam mapping). Palaeo-sea level research provides important baseline data to support projections of future sea levels under various climate-change scenarios. These local sea-level projections provide important guidance for the management of coastal hazards, erosion, and development within coastal Arctic communities (Cowan et al. 2012).

The ArcticNet component of the 2012 Nuliajuk mapping program was specifically aimed at identifying potential drowned shorelines along the Cumberland Peninsula off the SE coast of Baffin Island (Cowan et al., 2012). Locales with high sedimentation rates are required to develop and preserve a sea level record. The Exeter Sound region was chosen for this work. The Sound previously had never been surveyed (Fig. 1) and thus access corridors had to be established prior to undertaking detailed surveys of potential submerged terrace sites (Fig. 13).

Subsequent to this work, piston coring will need to be undertaken from the CCGS Amundsen to date these terraces. The Amundsen can only enter these areas using the access corridors established by the MV Nuliajuk.

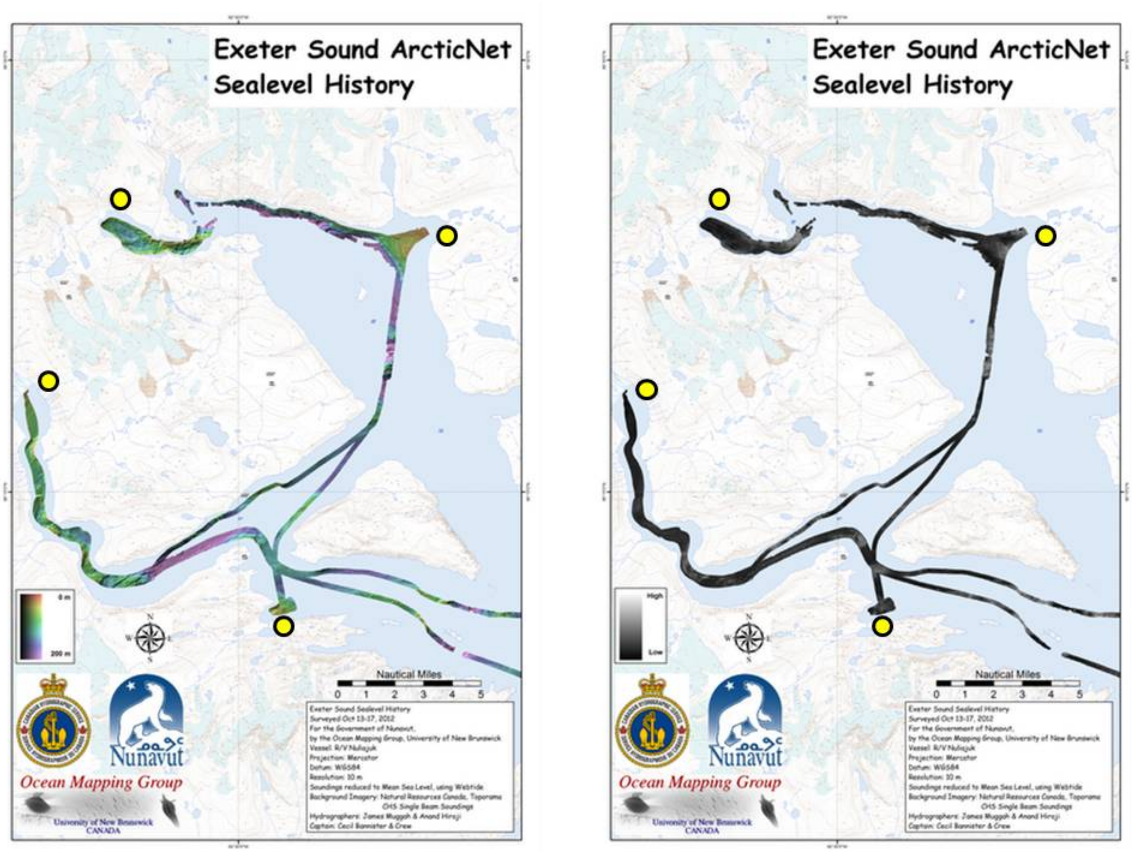



*Fig. 13: Access corridors and sea level terrace search locations (yellow) in Exeter Sound.*

*New Shipping Corridors*

A combined interest of the Government of Nunavut and the CHS was to improve the shipping access to sites routinely visited in the Cumberland Sound area. Kekerton Island is a historic site, regularly visited by tourist vessels, and a potential safe anchorage for vessels seeking refuge. The approaches and the anchorages within the Kikistan Island Group had never been surveyed. Thus a reconnaissance survey was requested to establish safe access to this area (Fig. 14).

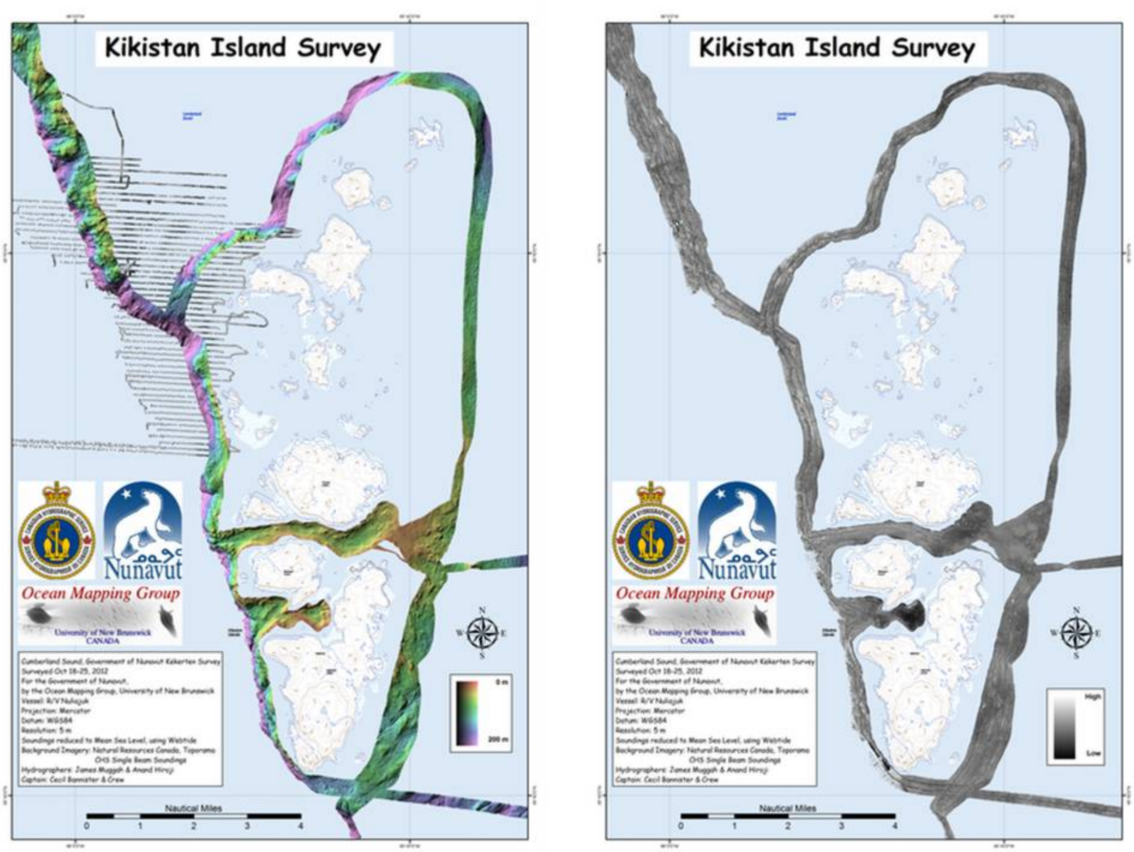



*Fig. 14: Nuliajuk multibeam access corridors around Kikistan Island Group. Left: bathymetry, right: backscatter.*

**Summary**

The 2012 Nuliajuk program has demonstrated the viability of undertaking coastal seabed mapping in the eastern Arctic from a small yet autonomous, non-icebreaking platform. As long as the constraints imposed by the ice retreat and advance (including its variability) are well understood, safe and efficient mapping operations can be planned. The vessel has the endurance, shoal draft, and obstacle avoidance equipment to operate independently in these predominantly uncharted waters.

2012 operations were able to address the specific needs of the collaborating parties including fisheries habitat, nautical charting and scientific seabed surveys. All data collected in the 2012 field season will be collated and integrated with the growing ArcticNet multibeam dataset, all of which is available online through the use of a Google maps portal (Muggah et al., 2010). All data is provided to the Canadian Hydrographic Service for incorporation into their bathymetric database to aid in chart updating.

Based on the ice regime analyses presented above, 2013 operations are currently being planned for both the SE Baffin Island and Hudson Strait areas. Exact locales will depend on the needs of various funding agencies (e.g. GN, 2008 AANDC, 2013).

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