1.5 The Canadian Arctic Seabed: Navigation and Resource Mapping (Seabed Mapping)

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ABSTRACT

This project undertakes the core seabed mapping component of the ArcticNet research program. Underway acoustic mapping of the seabed relief, sediment distribution and shallow subsurface sediments are the prime datasets used by researchers to understand the geological processes shaping the seafloor, to assess natural hazards and coastal habitats and to reconstruct the history of past climatic changes. These mapping results are applied to specific projects in this proposal including:

- Marine geohazards to hydrocarbon development: Canada has potentially huge economic benefits to gain by having access to the natural resources of the Arctic Archipelago region. Exploitation in this manner however, can only proceed in a safe and responsible manner, by managing the potential detrimental impacts to the environment. A key requirement is to be able to assess potential natural hazards that might result in harmful affects both to persons and the environment. Natural hazards such as underwater landslides, collapse of offshore structures built on gassy seabeds and the impacts of glacial and sea ice must be known and their risk managed.

- Opening new shipping lanes and improving navigational charting: Despite previous focused mapping programs in the bottleneck regions, the Archipelago region remains sparsely mapped with shipping normally restricted to narrow singular corridors that may be ice covered. Because the Amundsen is operating a multipurpose mission throughout the region, there is a golden opportunity to simultaneously map uncharted regions to provide alternate pathways.

- Past to present evolution of sea-ice regime: Understanding past climatic history is the key to predicting potential future ramifications of a changing sea ice regime. To responsibly plan adaptation strategies, we need to be able to predict future climatic responses and their consequences. It is also the key to understanding the nature of these changes-i.e. are they part of a natural cycle or induced by present excess of greenhouse gases. The mapping is an essential precursor to designing seabed sampling strategies to recover undisturbed sediments.

KEY MESSAGES

The ArcticNet Navigation and Resource Mapping program directly addresses our knowledge gaps in two high priority areas:

- **Northern offshore Oil and Gas Development:** One of the major impediments to safe and environmentally responsible oil and gas development in the Canadian Arctic Archipelago is the lack of knowledge about the presence of potentially unsafe natural seabed features (so called geohazards).

- **The need for improved charting in the North:** To undertake the scale of marine shipping required to support any natural resource program in the north, the state of nautical charting has to be vastly improved. The ArcticNet mapping program now represents the most extensive source of modern high density bathymetric surveying in the Archipelago.

In the 2009/2010/2011 seasons, the Navigation and Resource Mapping project has ramped up the focus on the impact of the potential development of hydrocarbon reserves existing in the Beaufort Sea. With over 2 billion dollars in lease blocks allocated, there is a pressing need to understand and manage the risks involved in deep water drilling in this Arctic basin.

The first phase of the Beaufort Sea mapping component, conducted over the last three years, is now complete and impact assessment reports (Blasco et al. 2010, 2011) have been delivered to the prime stakeholders and will directly contribute to the National Energy Board Arctic Offshore Drilling Review. For 2013 and beyond further mapping initiatives in the Beaufort Sea are planned in
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partnership with the Oil and Gas Industry and BREA (Beaufort Regional Environmental Assessment).

For 2012 and beyond, the navigation and resource mapping project will also expand toward coastal issues that more closely address the community level and navigational safety issues. Through developing partnerships with the Nunavut and Nunatsiavut governments and the Canadian Hydrographic Service we are trying to develop a collaborative inshore mapping capability, independent of the prohibitively expensive Amundsen platform.

OBJECTIVES

For the 2011-2018 period, the science seabed mapping needs in the coastal Canadian Arctic are projected to be dominated by the increasingly open access to previously uncharted waters and the opportunities that provides for natural resource exploitation. Exploitation of hydrocarbons is already scheduled for the Beaufort Sea; seabed pipeline access to the Sverdrup Basin (known reserves) is a necessary precursor to that development; exploration is proposed for known hydrocarbon provinces including Lancaster Sound, Baffin Bay and Labrador margin regions; and new initiatives in frontier programs such as the Makkovik and Saglek margins, Hudson Bay & Strait and Foxe Basin are starting.

In line with ArcticNet’s Strategic Framework, the updated rationale is to focus on better quantifying the spatial extent and risks associated with the seabed geological hazards that are so prevalent (iceberg/icekeel scouring, fluid and gas escape structures, mass wasting phenomena and seismicity hazards).

As part of this, improved safety of navigation is an essential prerequisite to any natural resource exploitation. The CCGS Amundsen seabed mapping system remains Canada’s best and most available asset capable of expanding safe shipping corridors in the Arctic Archipelago. With the addition of the barge-based mapping system in 2010 and 2011, her capability in extremely shallow and hazardous areas is greatly enhanced.

In parallel with the resource exploitation and safety of navigation, there is a requirement to better understand the coastal seabed habitat on a community level. The mapping component of this work will be addressed in partnership with a coastal landscapes project, a seabed habitat/benthos project, and freshwater/marine coupling project. For 2012, with the Amundsen temporarily out of commission, the intent is to move the barge-based multibeam onto another platform to address coastal issues. This actually allows us to address the community-level research objectives better.

INTRODUCTION

This project implements underway geophysical mapping programs from the CCGS Amundsen and her barge in support of a wide variety of Network Investigators, parallel ArcticNet projects and external partner objectives. There is continual networking activity between the Ocean Mapping Group at UNB that run the mapping, the other NI’s, collaborators and external partners to ascertain the needs of the specific science programs to see how they can best be met using the capability of the Amundsen mapping suite.

The focus in the Beaufort Sea has been on identifying the presence, extent and risk associated with various seabed geological hazards (“geohazards”). The prime hazards of concern are - ice keel scouring, expulsion of gas and fluid from the seabed, the potential for mass wasting (landslides) and the presence of buried shallow gas. Additional concerns are the geotechnical properties of the surficial (within 10m of the seabed) sediments as this will affect the ability to construct infrastructure in support of drilling and oil field development.

The continual collection of underway swath bathymetric data over 9 years of opportunistic transits and site surveys by the CCGS Amundsen represents the single largest holding of high density, well navigated charting information in the Arctic Archipelago. The Amundsen actively uses this to safely meet her science objectives. That same data has been passed on to the Canadian Hy-
A deliberate byproduct of the mapping and science programs is the generation of highly qualified personnel in the fields of Arctic marine geomatics and marine geology.

**ACTIVITIES**

In the 2011/2012 year the following research activities were undertaken:

**Beaufort Slope - Ajurak and Pokak Blocks:** (NI Blasco) a dedicated mapping effort in 500-1500m of water was undertaken to extrapolate the existing coverage in that area into deeper water. This was in partnership with BP and IOL. The specific focus was on understanding deep water geohazards such as mud volcanoes and landslides.

**Beaufort Shelf - Drill Site and Active Pingo Fields:** (NI Blasco) a dedicated mapping effort was undertaken using both the Amundsen and barge-based multibeam. This examined shallow geohazards that might restrict the safety of proposed drilling activities in the area. A specific focus was the pingo-like features in the area that have been previously only examined in a reconnaissance manner.

**Amundsen Gulf - Delineation of ice-stream activity:** (Collaborator Maclean and NI Blasco and England) Using both transit and time waiting for crew exchanges, a significant amount of new mapping coverage was achieved in 2011 over the mouth of the Amundsen Gulf. This is a critical window into understanding the late Quaternary ice stream activity in the area, which in turn controlled the sedimentation in which the surficial geohazards are developed.

**Saglek Margin - Slope Morphology:** (Collaborator Sonnichsen) a 24 hour dedicated mapping program was implemented in October to extends the Amundsen’s transit coverage on the Labrador continental margin.

The reasons for this were both regional geological evolution and specific hydrocarbon geohazards.

**Cambridge Bay - Proposed Corridor for seabed cabled observatory:** (collaborator - Ocean Networks Canada) Using both the Amundsen and the barge, a reconnaissance seabed mapping corridor was obtained to test the feasibility of putting in a new fibre-optic cabled observatory.

**Peterman ice shelf - direct ice flank mapping:** (Collaborator Tremblay) utilizing an innovative modification of the Amundsen barge-based multibeam, we were able to map the submerged flanks of several iceberg fragments of the ice shelf. Although the AUV-based mapping was unsuccessful, the multibeam mapping provides the first ever definition of the flanks of these features.

**CHONE Hotspot Mapping:** (Collaborators Archimbault and Tremblay) In support of a partner ArcticNet project, seabed mapping at locales identified with high biodiversity was performed as the opportunity arose.

**Transit Coverage (All NI’s):** As with previous years, underway multibeam and subbottom profiling was obtained at all times the CCGS Amundsen was underway. To date, this continues to be our single most fruitful source of mapping information. Serendipitous identification of seabed morphology has created our most successful insights and publications to date (e.g. Maclean et al., 2012, Rogers, 2011).

**RESULTS**

**Geohazard Assessment, Beaufort Shelf and Slope:** based on the results of the 2009/2010 collaborative mapping program, a regional assessment report on the state of knowledge of active geohazards was prepared jointly by NRCan and ArcticNet researchers (Blasco et al. 2011). This report was presented to the National Energy Board in August 2011. In the words of Bharat Dixit at the NEB:
'This is a very comprehensive report on geotechnical information on various aspects in the Beaufort Sea, and you and the authors have done a tremendous job pulling information from diverse sources into one document that would be useful to the NEB and to the Arctic Review participants. The report is well written, cohesive, easy to read, and rich in graphic. The content is of the high standard set by the GSC and its world respected scientists and researchers.'

**Amundsen Gulf Ice-Stream Activity:** Utilizing the growing coverage of Amundsen transit lines across the northern mouth of the Amundsen Gulf, the first comprehensive picture of the ice-flow dynamics has now been extracted (MacLean et al. 2012).

**Moving iceberg and glacier front imaging:** In support of parallel projects interested in the morphology and fate of calved ice shelves and icebergs, a novel adaptation of the Amundsen barge multibeam configuration was undertaken in 2011. The sonar head was mounted tilted to one side to examine from the water line down to > 80m depth on the flanks of fragments of the Peterman Ice Shelf. This was successfully deployed 4 times this summer in Lancaster Sound and Baffin Bay.

Such mapping provides the unique technical challenge that the feature being mapping is moving and rotating. By incorporating on-iceberg GPS receivers, algorithms are currently being developed to reduce the multibeam observations into an iceberg-referenced coordinate frame.

**On-line Multibeam Data Management:** The 2011 field season was the third season to utilize the CFI-upgraded EM302 multibeam. As such, with twice the beams, twice the swaths and with the order of magnitude increase in data due to the continuous water column imaging, the data management challenge continues to expand.

The UNB-based multibeam data processing and on-line distribution model continues to be developed to maintain all this data online for national and international researchers. The standard 10m resolution map sheet series for the whole Arctic has been augmented in 2011 with a new 2m resolution map sheet series, specifically for the Beaufort Shelf: http://www.omg.unb.ca/Projects/Arctic/BeaufortShelf/html/index.html

**Incorporation of Amundsen Multibeam Data into CHS Nautical Charts:** The mapping data, generated by the Amundsen is delivered to the Central and Arctic region of the Canadian Hydrographic Service annually. This data is continually used for incorporation into their charting products. A heavily revised chart of the Pond Inlet region (7212) was released in 2011 using extensive Amundsen coverage. A chart of the Resolute Approaches area (7511) is in construction utilizing Amundsen and Heron data. An updated version of the Arctic Bay chart (7512) is now complete using both Amundsen and Heron data, but not yet released. Electronic Charts CA173369 & CA173378 in Hudson Strait were released incorporating Amundsen data.

**DISCUSSION**

The intended outcome of the Seabed Mapping Project is to translate our growing understanding of the Arctic seabed into impact assessments, national policies and adaptation strategies. The two primary contributions that this project make is in geohazards and navigation:

**Geohazards:** Our collaborating partners in the oil and gas industry have specific foci in areas of potential exploration or development. While their focus is localized, they benefit from a regional context provided by the broader-based interests of the geoscientists within the ArcticNet community. NI’s have interests that range from the immediately relevant (geohazards, e.g.: Blasco et al. 2011) to the more overarching (ice sheet retreat and paleoclimate). Particular advances in the regional understanding have come about from morphologic interpretation (MacLean 2012) and Holocene climate studies (Bringué and Rochon 2012). All this information is required to guide government regulation of the natural resource industry.
This is particularly timely as, in response to the disaster in the Gulf of Mexico in 2010, in early 2011 the National Energy Board (NEB) initiated a review of the safety and environmental requirements for offshore drilling in Canada’s unique Arctic environment. Through the Arctic Offshore Drilling Review, the NEB have been examining “the best information available on the hazards, risks and safety measures associated with offshore drilling in the Canadian Arctic”. The ArcticNet contribution to the geohazards assessment (Blasco et al. 2011) is a significant component of this. The NEB will use the results of the review to inform its decisions on future applications for offshore drilling in the Arctic.

**Navigation:** Although originally perceived as primarily a science tool with only a minor contribution to charting, the *Amundsen*’s underway mapping has become critical to the very safety of the vessel itself. Recent groundings have highlighted the very real dangers of operating in the Arctic Island Archipelago. The existing nautical charting information is focused primarily on the most active shipping lanes. Most of the new Beaufort Shelf lease blocks in which the *Amundsen* has been operating lie outside these regions and are known to contain poorly charted pingo-related shoals. In order to deliver on the mandated ArcticNet science mission, the Amundsen needs to operate well outside these lanes. The Amundsen now navigates using a dynamically-updated series of additional chart overlays showing the newest Amundsen map coverage to extend the safe operating area. This was all developed as part of this project.

The *Amundsen*’s growing database of swath bathymetry is now becoming one of the most extensive sounding databases in the Arctic Archipelago. In much of the area of operation, it represents the sole source of information and is thus unique and therefore critically relevant.

The data is provided to the CHS on an annual basis, and their long term intention is to integrate it with the existing charting information, thereby opening up new areas of the Archipelago to shipping and resource development. The time scales for routine chart updates is several years however, and thus data which is suspected of being of immediate significance is extracted and passed on directly in the form of a memo to the CHS Central and Arctic Region.

**CONCLUSION**

The 2011 field season was the third year of utilizing the industrial partner model between ArcticNet and BP/IOL. The latest results clearly demonstrate the continuing effectiveness of this collaboration. In this time frame, we have established that the mapping, processing and interpretation capability of the *Amundsen*/ArcticNet team is not only unique, but has the full capability to meet the needs of both the academic and government geoscience community as well as the specific requirements of oil and gas seabed geohazard investigations.

In 2011, these mapping results have had direct input into the NEB Arctic Offshore Drilling Review and the state of existing Arctic nautical charting. They thus clearly have contributed to impact assessments, national policies and adaptation strategies.

In 2012 we look forward to the possibility of further extending this collaborative mapping model with new northern partners to better address the coastal and community level issues that fall within the mandate of ArcticNet.

With the return of the *Amundsen* in 2013 and beyond, we will be extending the Beaufort Sea mapping through commitments from BREA and planned new collaborations with both the current and new oil and gas industry partners.

**REFERENCES**


2011-12 PUBLICATIONS

All ArcticNet refereed publications are available on the ASTIS website (http://www.aina.ucalgary.ca/arcticnet/).


