GEOLOGICAL SURVEY OF CANADA
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CCGS F.G. Creed Expedition 2009-007 Multibeam survey of Honguedo Strait

V. Brake, L. Maltais, R. Côté, E. Poirier

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Natural Resources Canada / Ressources naturelles Canada

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Brake, V., Maltais, L., Côté, R. and Poirier, E. 2010. CCGS F.G. Creed Expedition 2009-007: Multibeam survey of Honguedo Strait; Geological Survey of Canada, Open File 6437, 16 p.

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List of Personnel

Name	Function	Dates
Côté, Roger	Chief Hydrographer	July 30-August 5, 2009
Maltais, Louis	Chief Hydrographer	August 5-August 13, 2009
Brake, Virginia	Geologist	July 30-August 13, 2009
Poirier, Estelle	Hydrographer	July 30-August13, 2009

Acknowledgements

The authors would like to thank the officers and crew of the Canadian Coast Guard Ship (CCGS) Frederick G. Creed. The Canadian Hydrographic Service (CHS) organized multibeam collection and provided tidal predictions. Cruise 2009007 was financed by the Program of Energy Research and Development (PERD) and Offshore Geoscience Program (OGP) of the Geological Survey of Canada (GSC). This manuscript was reviewed by Mathieu Duchesne (GSC-Quebec)

Introduction

The Gulf of Saint Lawrence is the outlet of the North American Great Lakes. The study area of Honguedo Strait is located within the Gulf of St. Lawrence, between the Gaspe Peninsula and Anticiosti Island. This area was the locus of a five year, fossil fuel resource evaluation project carried out by the Earth Science Sector of NRCan.

The Gulf of St. Lawrence is one of the few offshore frontier areas close to major population centers to still hold potential untapped hydrocarbon energy resources. The need for evaluation of resource potential has led to the project *Evaluating seabed and shallow sub-surface conditions to support exploration strategies in the Gulf of St. Lawrence* under the Program of Energy Research and Development (PERD) and Offshore Geoscience Program (OGP) of the GSC.

The project consists of seafloor mapping, geohazard assessment and development of a geological framework for northern Gulf of St. Lawrence. The OGP aspect of the project focuses on geoscience activities for the marine resource development stream and has outputs that lead to the reduction of exploration risk, increased investment in the energy sector, and enhanced energy supply.

A multibeam bathymetry survey of Honguedo Strait was conducted from July 31 to August 13, 2009 by the Geological Survey of Canada in partnership with the CHS. Data were collected over three survey sites within Honguedo Strait on board the CCGS F.G. Creed (Fig. 1). This survey concludes data acquisition for this project.

Project Objectives

This project aims to provide a geologic knowledge base to be used by stakeholders for integrated management of the Gulf of St. Lawrence. Seabed mapping in areas with potential hydrocarbon reserves will be carried out in order to identify possible geohazards and build the geological framework needed for the Gulf of St. Lawrence

Survey Objectives

The objective of survey 2009007 was to extend current multibeam (bathymetry and backscatter) and sub-bottom profiler surveys to the highly prospective area of Honguedo Strait between Anticosti Island and the Gaspe Peninsula. Furthermore, the survey aims to provide an understanding of geological framework of Honguedo Strait

Daily Log

JD 211, July 30, 2009
Depart Quebec City 0700, drive to Institut Maurice-Lamontagne (IML), Mont-Joli, QC. Arrive at IML 1120, meet hydrographer Estelle Poirier. Depart IML with Estelle Poirier 1510. Arrive in Rivière-au-Renard 2100 to join the CCGS F.G. Creed.
JD 212, July 31, 2009 Survey lines 0000-0022
Depart Rivière-au-Renard 0510 for survey site A near Anticosti Island. Orientation to ship and safety procedures. Introduction to multibeam collection and processing programs CARIS SIS (acquisition) and HIPS (processing). Arrive in Rivière-au-Renard 2100.
JD 213, August 1, 2009 Survey lines 0023-0036
Sail from Rivière-au-Renard 0500, Survey in Sites B and C, near Gaspe. Process multibeam data from JD 212. Arrive in Gaspe 1500 to bring new fridge onboard the vessel.
JD 214, August 2, 2009 Survey lines 0037-0062*line 0040 rejected
Depart Gaspe 0600 for survey areas B and C. Conduct patch test to verify pitch, roll and heave parameters. Process data from JD 213. Arrive in Rivière-au-Renard 1900.
JD 215, August 3, 2009 Survey lines 0063-0086, *0064 rejected
Depart Rivière-au-Renard 0500 for survey site A. Process data from JD 214. Arrive in Rivière-au-Renard 2000.
JD 216, August 4, 2009 Survey lines 0087-0104
Depart Rivière-au-Renard 0500 for survey site A. Process data from JD 215. Arrive in Rivière-au-Renard 1830
JD 217, August 5, 2009
Spend the day in Rivière-au-Renard tied up at wharf for crew change. Roger Côté departs 0700 for IML. Process data from JD 216. Ship crew change at noon. Louis Maltais arrives 1900.
JD 218, August 6, 2009 Survey lines 0105-0123
Depart Rivière-au-Renard 0500, set out to finish the remainder of survey in site A, closest to Anticosti Island. Process remaining data. Finish Anticosti site A.

JD 219, August 7, 2009 Survey lines 0124-0143
Depart Rivière-au-Renard 0600 for survey areas B and C. Process data from JD 218. Arrive in Gaspe for the night 1800. Louis Maltais takes cab to Rivière-au-Renard to pick up the van and drive it to Gaspe.
JD 220, August 8, 2009 Survey lines 0144-0159
Depart Gaspe for survey sites B and C 0700. Turn back from sites B and C before noon due to weather. Collect data in site B nearest the shore. Process data from JD 219. Arrive in Gapse 1430. Transducer not working properly to give temperature data. Seeing refraction artefacts.
JD 221, August 9, 2009 Survey lines 0160-0184
Depart Gaspe for survey sites B and C 0700. Process data from JD 220. Arrive in Gaspe 1900.
JD 222, August 10, 2009 Survey lines 0185-0203, *185 rejected
Depart Gaspe 0800 for Survey site area B, after delay in fuel delivery. Several casts in the morning. Process data from JD 221. Arrive in Gaspe 1930
JD 223, August 11, 2009 Survey lines 0204-0233
Depart Gaspe 0530 to finish survey area B and head to site C. Process data from JD 222. Arrive in Gaspe 1800.
JD 224, August 12, 2009 Survey lines 0234-0263
Depart Gaspe 0630 for survey area B. Process data from JD 223. Arrive in Gaspe 1800.
JD 225, August 13, 2009 Survey lines 0264-0275
Depart Gaspe 0600 for Survey area B. Process data from JD 224. Arrive in Gaspe 1330. Complete data back-up and ship de-mobilization. Drive to IML.

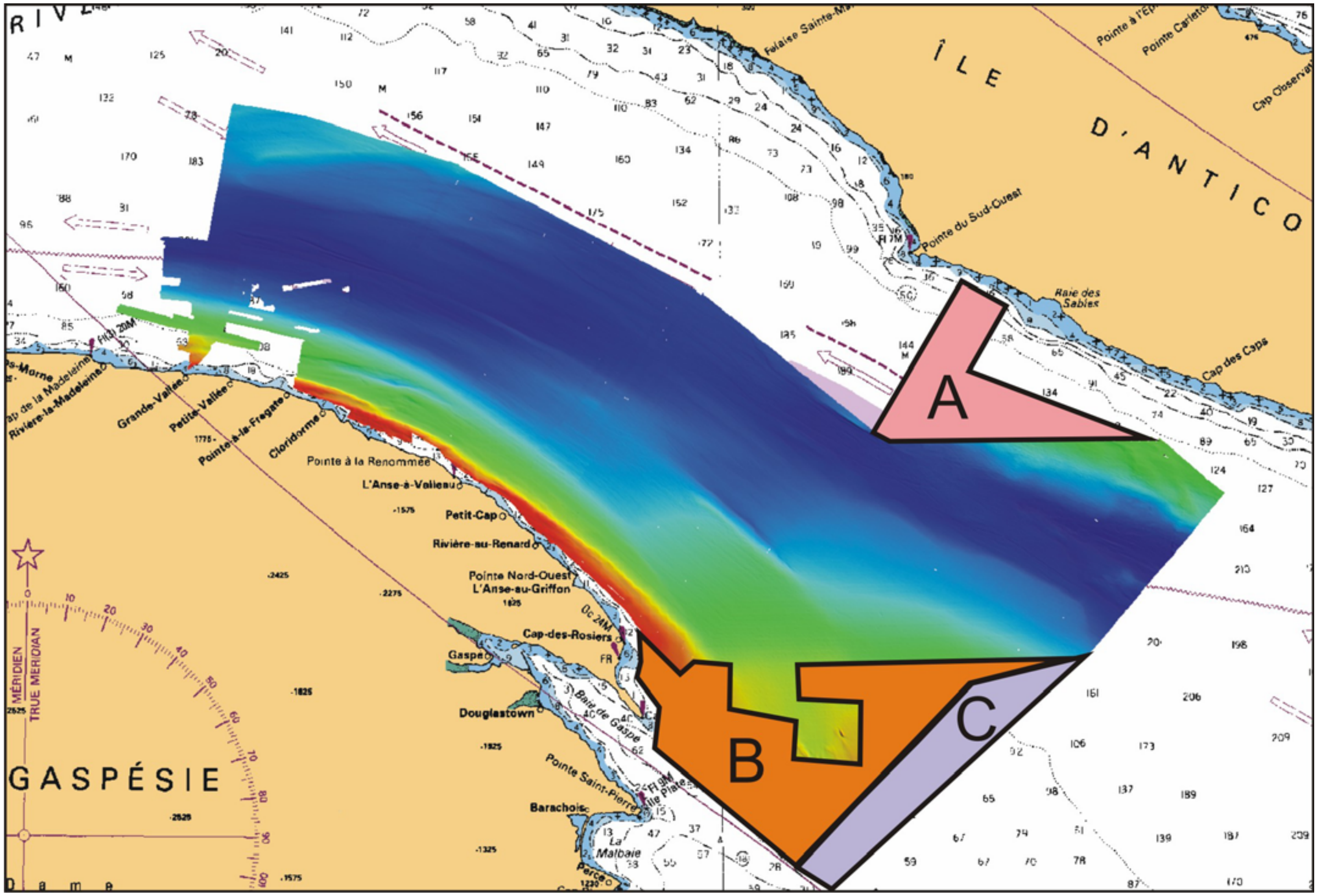

Figure 1: Proposed survey sites A, B and C (in decreasing priority) for the 2009 Honguedo survey. Survey site A was the first site survey to be completed. Sites B and C were surveyed together to maximize ship time, thus decreasing transit time.

Technical Summary

Survey Vessel:

The vessel used for the Honguedo survey was the Frederick G. Creed operated by the Canadian Coast Guard (Fig. 2). The Creed is a SWATH (Small Waterplane Area Twin Hull) semi-submersible catamaran measuring 20.4 m in length and 9.75 m in width. The vessel can accommodate 4 coast guard personnel (Captain, First Mate, Engineer and Cook) and up to 5 scientists. The F. G. Creed is currently used to identify and measure biomass in the water column, and for hydrography to map and characterize the seafloor.

The F. G. Creed is equipped with a Simrad EM-1002 multibeam echosounder that operates at a frequency of 95kHz. The vessel is also equipped with a Moving Vessel Profiler (MVP100) from Brooke Ocean Technology (BOT), used for sampling the water column. An acquisition workstation is located on the bridge of the vessel while 2 processing workstations are located in the aft lab.

Figure 2: CGGS F.G. Creed docked at Gaspe at the end of the 13-day survey

Multibeam System:

The EM1002 multibeam echo sounder with hull mounted transducer array is designed for high-resolution seabed mapping. The echosounder operates 111 beams each having a width of 2.0 degrees. The coverage width is up to 7.5 x depth (between 20 and 100 m) at an acquisition rate from 0.5 to 12 pings per second. Beams were consistently open at 70 degrees on each side during the Honguedo survey.

The sounding pattern is stabilized for the ship's movements using the Position and Orientation System for Marine Vessels (POSMV) positioning system. POSMV provides position and attitude data for use by equipment on board the vessel, including the multibeam sounder, to correct for the effects of vessel motion during survey operations.

Moving Vessel Profiler:

The Moving Vessel Profiler (MVP100) is a self contained profiling system for sampling the water column. MVP provides vertical profiles of oceanographic data such as sound velocity and CTD (conductivity, temperature, depth).

Procedure for deploying the MVP for each cast consisted of a pre-deployment check, free fall, auto recovery, and return to towed position. Profiler free fall stopped when one of the following four parameters were reached: ships log (typically 12kn), cable out (maximum of 300m (cable length)), maximum depth (m) or depth of bottom (m). Parameters were input into MVP controller on the main multifunction workstation. Casts of the MVP profiler were conducted prior to multibeam collection each morning and as required throughout the remainder of the day either when the sensor at the transducer indicated a velocity inconsistent with the velocity profile; when there was a significant change in water temperature (5 degrees); or when refractions were noted on the outer beams.

Data Acquisition

CARIS Sonar Image Processing System (SIPS) was used for the acquisition of multibeam data and allowed for visualization of sidescan and related sensor information. The velocity profiles collected using MVP Controller were sent to the acquisition workstation located on the bridge of the vessel where the new velocity data from the cast was merged with the theoretical velocity profile of the transducer.

Data processing

Two workstations in the aft lab were designated for multibeam processing. Sounding data were processed using CARIS HIPS Multibeam Professional 6.1. HIPS, or Hydrographic Information Processing Systems, is a software system designed to process bathymetric datasets.

Data processing consisted of the following procedures:

1) Attitude editor

The attitude editor displays sensor data related to the movement of the vessel (gyro, heave, pitch and roll). Data are plotted in chronological order and time stamped. Data can be edited directly (according to track line) in the attitude editor. Data were inspected for quality control, editing was not necessary.

2) Navagation editor

The navigation editor allows for the examination and cleaning of position data for the ship according to track line. The editor contains three time-series graphs: Speed, Distance and Course Made Good. Data were inspected for quality control, editing was not necessary.

3) Swath editor

The swath editor functions as a tool for cleaning multibeam data. Data cleaning consists of interactively selecting and rejecting outlier soundings according to track line in order to remove bad beams.

4) Load tide data

Tidal predictions were loaded and applied to multibeam bathymetric data. Measured tide data will be applied at IML.

5) Refraction editor

The refraction editor simulates the effects of altering the Sound Velocity Profile (SVP) to derive a better refraction solution. Refraction errors are most pronounced in the outer parts of the survey line coverage and tend to create curved artefacts. The application of a velocity correction at a user-defined depth allowed the values to be adjusted to change the swath profile. The refraction editor was applied, where necessary, by CHS personnel.

6) Subset

The subset editor allows for viewing and editing the georeferenced soundings. Unlike the Swath Editor where soundings are referenced along track, the data are corrected for attitude, navigation, swath, tide and refraction. Data were systematically edited to remove spikes

7) Fieldsheet

At the end of each day a field sheet of data collected thus far was created. A mosaic of backscatter data was also produced.

Preliminary Results

Over 2000 km of multibeam survey lines and shallow subsurface profiles were collected during the 13 day survey (Fig. 3). Data were processed onboard the vessel to correct for attitude, navigation, swath, tide and refraction (Fig. 4) and the backscatter data were extracted (Fig. 5). Data will be further processed by CHS.

Preliminary interpretation of the data provides insight into the geological framework of the region. Numerous morphological features are recognized on the processed multibeam images including structural bedrock features, iceberg scours, and pockmarks (Fig. 5).

Several lineaments are observed on the bathymetric image of Honguedo Strait, yet evidence of slope instability in the form of paleo-slides was not observed. Iceberg scours are the most prominent feature at sites A, B and C (Figure 6). Scours are observed irrespective of water depth and are present in the deepest areas surveyed (Sites A and C; ~350m water depth) as well as nearshore (Sites B and C; water depth <100m). The majority of scours range from 30-70m in width, have an average length of 5km and are up to 6m in depth. Numerous cross-cutting orientations are observed.

Pockmarks are another prominent features that were observed at site A near Anticosti and at sites B and C near the Gaspe Peninsula. With the exception of 2 linear pockmark chains near Anticosti Island the distribution of pockmarks appears to be random. The pockmark chains observed at site A consist of 4-6 linearly arranged pockmarks that occur parallel to the shoreline over distances of 250-300m, in water depths of approximately 230m. In general pockmark distribution is random and unaffected by scour distribution. Pockmarks are usually isolated, yet may occur in clusters of 2 or 3, with diameters ranging from approximately 50-100m with an average depth of 8-10 m.

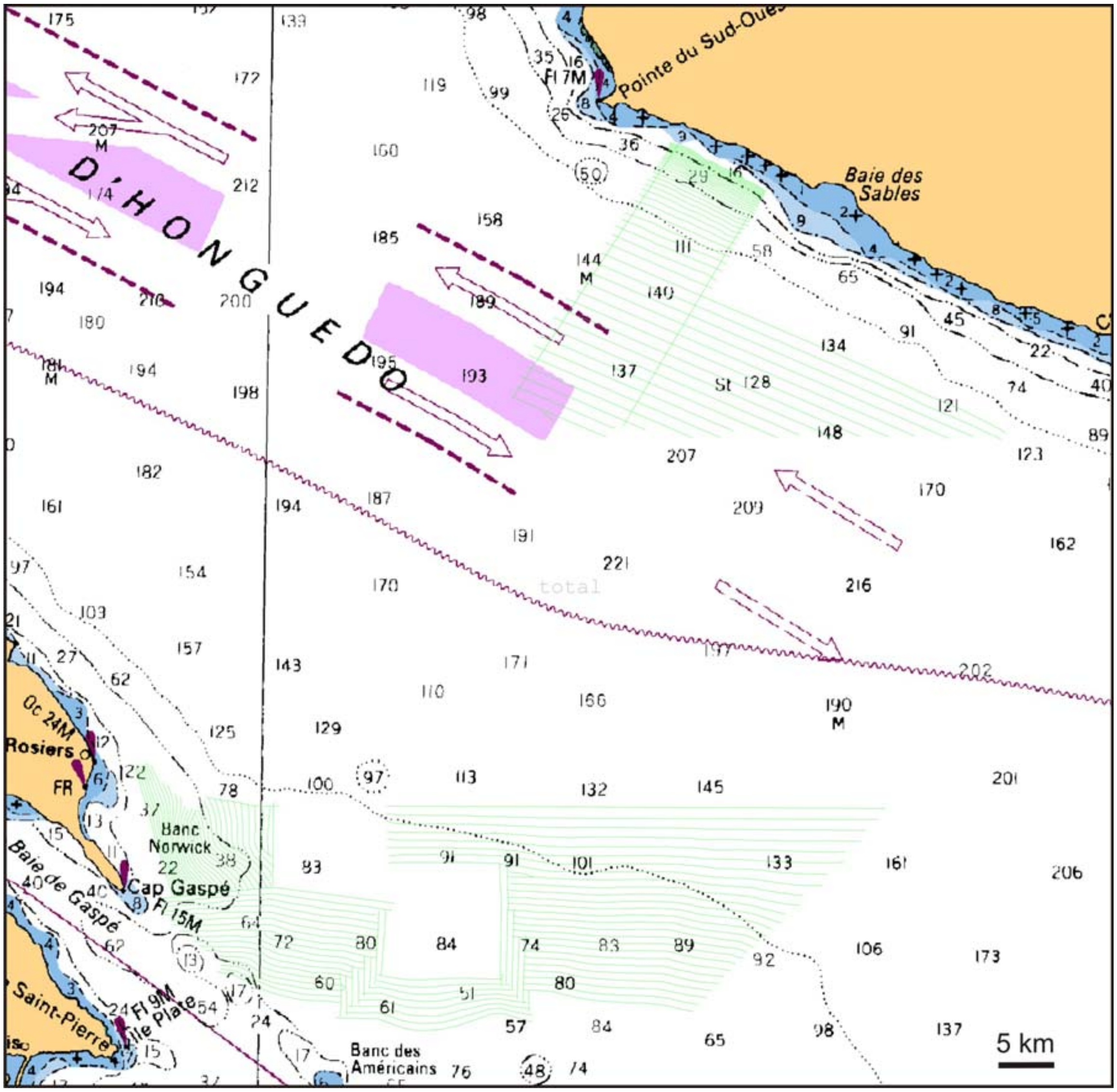

Figure 3: Survey lines for the 2009 Honguedo Survey. Line spacing was dependant upon water depth, target feature resolution and tide. Survey line spacing ranges from approximately 1000m in deep water, to approximately 100m in the shallowest section (Site A).

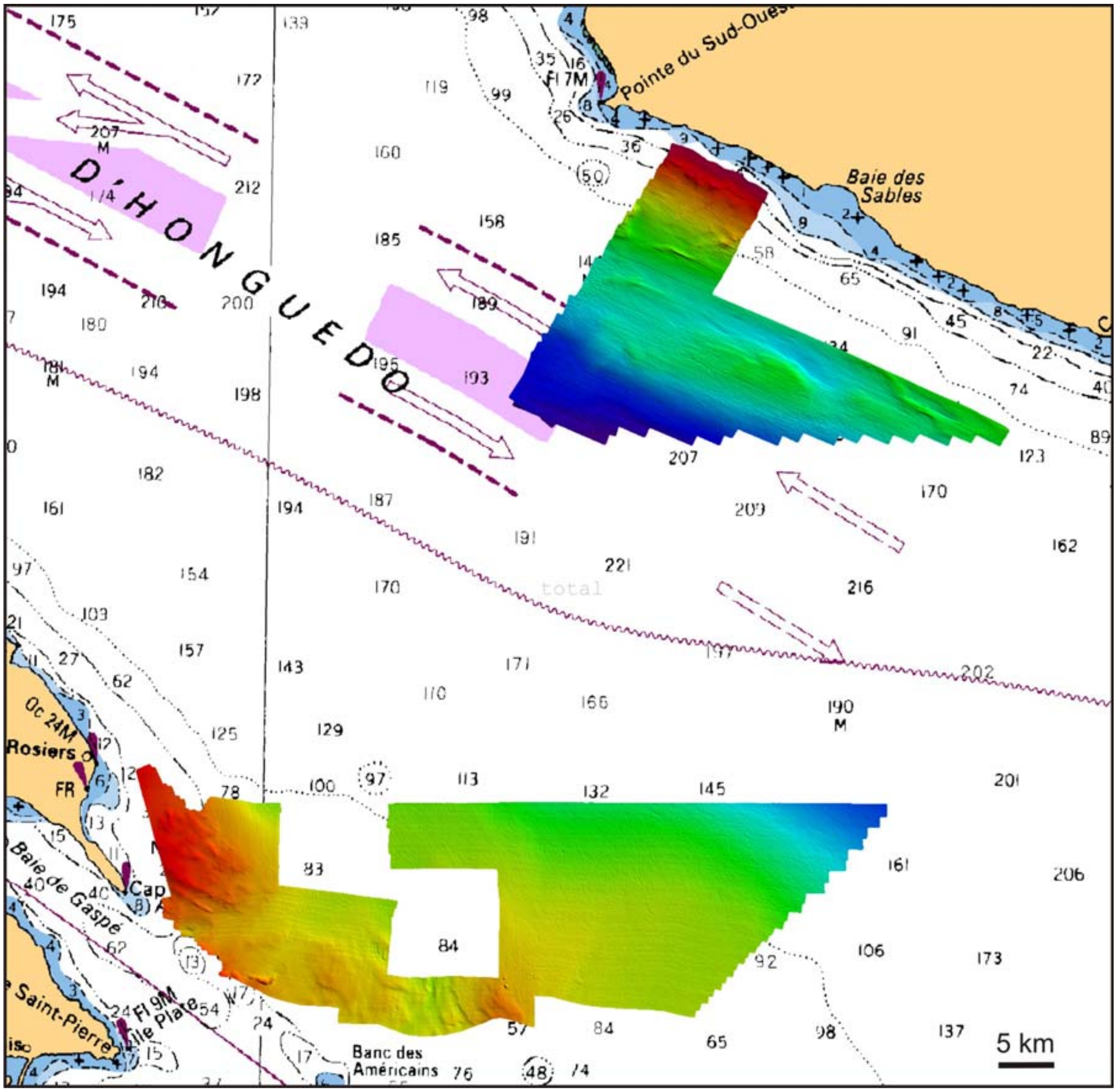

Figure 4: Multibeam bathymetry data collected in water depths ranging from 20-400m.

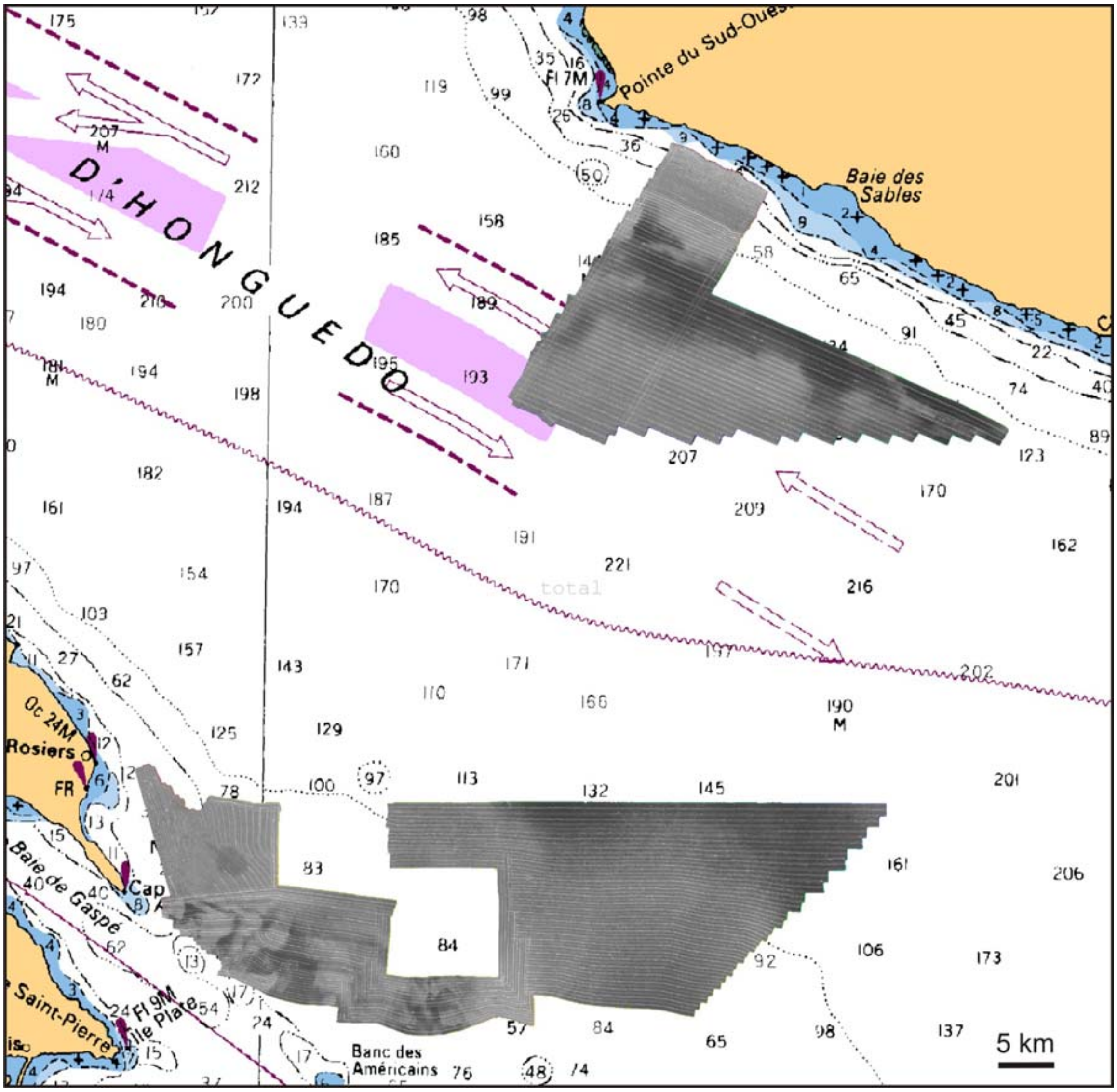

Figure 5: Backscatter data extracted from multibeam bathymetry data.

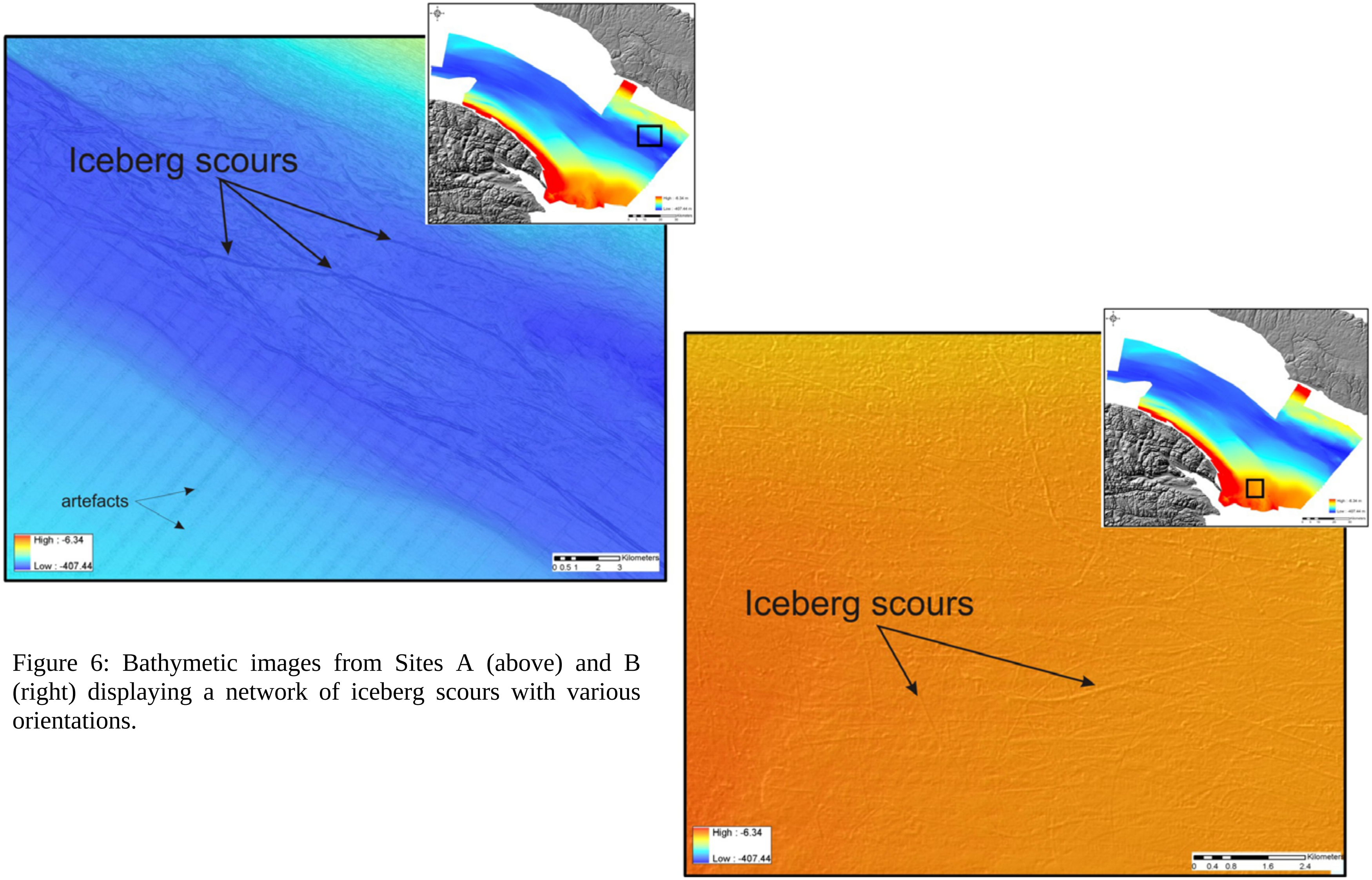

Figure 6: Bathymetic images from Sites A (above) and B (right) displaying a network of iceberg scours with various orientations.