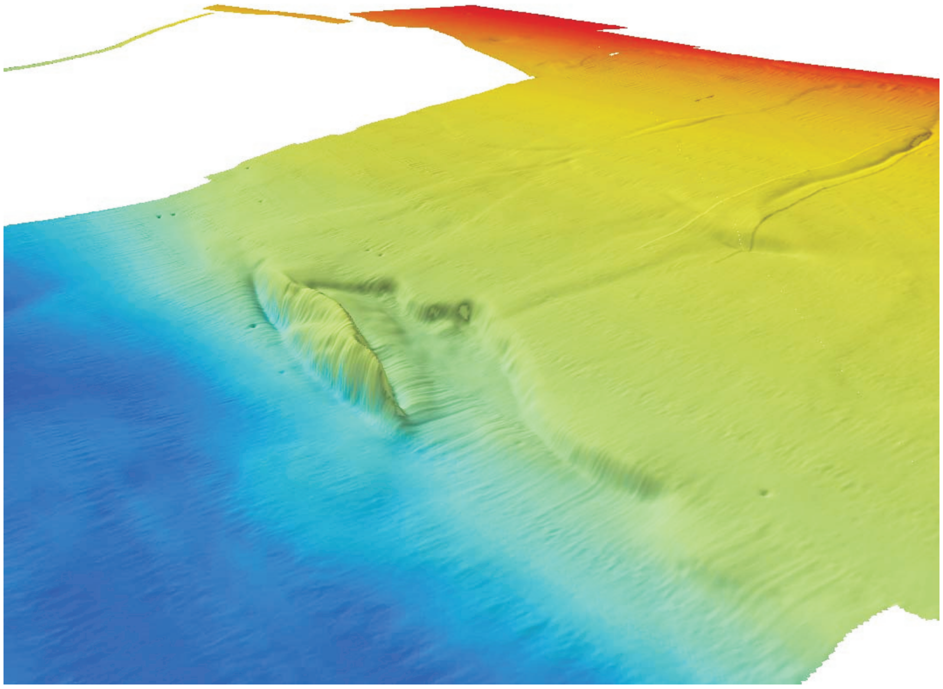
F.G. CREED EXPEDITION 2005-066



Multibeam and magnetometer survey of the St. Lawrence Estuary north of Mont-Joli, Aug 27th to Sept 8th 2005

Geoscience in support of ocean management of the Estuary and Gulf of St. Lawrence

Geological Survey of Canada
Open File Report # 5078

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GEOLOGICAL SURVEY OF CANADA

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Acknowledgements

We would like to thank the officers and crew of the F.G. Creed (figure 1) for their professionalism, their willingness to try new equipment (towed magnetometer) and the excellent hospitality and cuisine. We would also like to thank the staff at Institut Maurice-Lamontagne (IML) for facilitating the installation of the station magnetometer and for allowing occasional access to check the status of the instrument.

Figure 1- Survey vessel, CCGS F.G. Creed at the dock in Rimouski.

Introduction

The St. Lawrence Estuary and upper Gulf of St. Lawrence are the outlet for the Great Lakes catchments. The Great Lakes catchments support a population of over 20 million people. While many of the impacts of this population are felt in the Great Lakes, they also impact the estuary system downstream. The Upper Gulf is an area of competition for use of ocean space, with traditional uses such as fishing and shipping competing with demands for conservation (e.g. marine protected areas), cable and pipeline corridors and other industrial uses.

The need to understand ocean management issues in this region has lead to the development of the *Geoscience in support of ocean management of the Estuary and Gulf of St. Lawrence Project* under the Geological Survey of Canada Geoscience for Ocean Management Program (GOM). The project will deliver the geoscience knowledge within the St. Lawrence Estuary and Gulf upon which sound management planning can be founded. The current phase of the project will compile existing data and information from the area, establish stakeholders in the region and develop partnerships, collect new multibeam and other geophysical data, and provide preliminary reports summarizing the activities, creating a foundation for future work in the eastern and southern Gulf. During this first year, a 4-5 year project plan will be established for identified highest priority areas in the Gulf of St. Lawrence. The multi-year project will deliver maps, databases and interpreted reports of the seafloor morphology, surficial sediments, benthic habitats, geohazards and potential fossil fuel/mineral/aggregate resources of key areas of the Gulf of St. Lawrence.

During August 27th to September 8th, 2005, a multibeam and marine magnetometer survey was conducted by the Geological Survey of Canada in partnership with the Canadian Hydrographic Service. The survey took place in the St. Lawrence Estuary, just north of Mont-Joli onboard the CCGS F.G. Creed (figure 1). This survey is the second data collection component of the project. For more information on the first survey, see Campbell et al. (2005).

Project Objectives

The objective of this project is to provide the geoscientific knowledge necessary for effective decision-making on competing resource management issues in the Estuary and Gulf of St. Lawrence. For example, decisions will need to be made on the location and construction of infrastructures, fisheries, aquaculture, conservation, marine environmental quality, conventional and unconventional hydrocarbon exploration/exploitation, for which prior geoscience knowledge is critical for sound management.

Specifically the objectives are to:

1. Compile existing geological data from the region, including seafloor maps, geophysical data, and ground truth data, into a GIS.

2. Acquire multibeam data (bathymetry and backscatter), ancillary geophysical and physical oceanographic data, and provide preliminary results of field activities in a targeted area of the St. Lawrence system identified through consultation with partners
3. Consult and develop partnerships with other government, university, and private sector stakeholders in the region.
4. Develop a 4-5 year project plan based on the outcomes of year one activities.

Survey Objectives

This survey directly addresses objective 2 of the project objectives and will help in developing the 4-5 year project plan. The proposed field activities for year one are to collect multibeam bathymetry and backscatter as well as coincident magnetometer data in the St. Lawrence Estuary between the Saguenay River and Mont-Joli, with full coverage from the deepwater portion of the estuary to 30 metres water depth. This expedition consisted of 13 days of a planned 50 day field program that is to be completed in the fall of 2005. 12 days were completed in June 2005.

Daily Log

The daily log is a running dialogue of activities and observations throughout the expedition and is compiled on a day to day basis.

Note: During JD 239-241 (survey lines 1-34), bathymetry data were collected in the project area, just north of Mont-Joli by CHS, however there are no coincident marine magnetometer data.

Daily Log

JD 240 Sunday, Aug 28th

- Drove from BIO to Bathurst.

JD 241 Monday, Aug 29th

- Drove from Bathurst to Mont-Joli. Installed station magnetometer at IML. The system setup during the June survey was not satisfactory with a lot of interference resulting in poor station mag data. The second site suggested was an older house on the IML property away from the main building. The house is ~200 ft from the main road and there is a lot of road construction at the time of the survey. Finally, the electronics were setup in the pump house near the workshop at IML. The sensor was setup in an open grassy area away from the pump house and the GPS antenna was installed on a temporary mast (soccer goal post).The initial setup of the mag sensor was successful with readings in the 55 000 nT range with variance of less than 30 nT over an 1 hour period. The station will be checked regularly during the survey.
- Drove from Mont-Joli to Rimouski to meet the Creed. Put gear onboard. Installed towed magnetometer on the Creed. Did a test on the deck and the instrument appears to be operational.

JD 242 Tuesday, Aug 30th

Survey lines 35 to 42

-Steamed from Rimouski at 630 am towards Manicougan to survey in a shallow area near the north shore. Upon arrival, it was discovered that there was no RTK coverage in the area so returned south to the area north of Mont-Joli. Conducted mvp cast and deployed magnetometer. Collected good quality data from the channel floor with the exception of some refraction issues in the deepest portions. Seabed is flat with occasional round and streamlined pockmarks, usually appearing in circular or linear clusters. Docked in Baie Comeau for the evening at 7 pm.

JD 243 Wednesday, Aug 31st

Survey lines 43 to 60

-Steamed from Baie Comeau at 630 am towards the area north of Mont-Joli. Conducted velocity cast and deployed magnetometer. Collected good quality bathymetry, except for some refraction problems in the deepest areas again. About 3 km of data on the last two lines of the day had some vessel motion artifacts. Again we are surveying the channel floor, which appears featureless except for some pockmarks and an occasional drag mark or flute. We discovered a seabed feature with positive relief about 100 m in length and did a second pass over top to determine if it was a ship wreck. The magnetometer did not show a signal associated with this feature. Returned to Rimouski at 7 pm.

JD 244 Thursday, Sept 1st
No survey lines today

- Ship did not sail today. Strong winds associated with hurricane Katrina. Autopilot and other miscellaneous repairs were required. Cleaned data from previous days' surveys. Mathieu Duchesne joins survey. Checked station magnetometer at IML. It is shut down when we arrive, but appears to have collected good quality station data up to Thursday evening. The commissionaire informs us that there was a power failure earlier in the week and this may explain the shut down. Note- a) When back at BIO, will check if a small UPS system is available for the October-November surveys. b) Make sure that the date on the logging computer is set properly. It was not at the start and the Julian Day naming scheme for the files is derived from the clocks calendar, not from the GPS and so the first few days files had to be renamed.

JD 245 Friday, Sept 2nd
Survey lines 61 to 72

- Sailed from Rimouski at 630 toward area north of IML. Conducted velocity cast and deployed magnetometer. Collected good quality data over the southern slope of the channel from 120 m to 30 m water depth. There was no refraction, but there was some significant heave artifacts in the data and there was poor positional information from the POS-MV. Ran a tie line from survey area over two known wrecks; the Empress of Ireland and the HMCS Nipigon in ~ 40 m of water. Both appeared as significant anomalies on the magnetometer. Returned to Rimouski at 7.

JD 246 Saturday, Sept 3rd
Survey lines 73 to 105

- Sailed from Rimouski at 630 am toward the north shore. Conducted velocity cast at survey area and deployed the magnetometer. Survey over gaps in existing coverage in order to complete the coverage to the 30 m mark. There are a numbr of interesting sediment transport features in the area (ripple marks, small channels). Stopped surveying at 8 pm and docked in Baie Comeau.

JD 247 Sunday, Sept 4th
Survey lines 106 to 130

- Sailed from Baie Comeau at 630 and steamed toward area surveyed on previous day. There were problems initially with the POS-MV, but after a half hour of circling, the position quality improved to normal. Conducted velocity cast and deployed magnetometer. Completed survey of the data gaps on the north shore. Around noon we were called to a SAR that was a false alarm. Steamed from the north shore to the area north of IML and continued surveys there. Returned to Rimouski at 6 pm.

JD 248 Monday, Sept 5th
Survey lines 131 to 145

- Sailed from Rimouski at 630 am. Steamed to area north of Mont-Joli. Conducted velocity cast and deployed magnetometer. Surveyed an area of featureless seabed from 30 m water depth to 60 m. Returned to Rimouski at 630. Drove to IML to check status of station mag and to backup data. The station mag was operating when we arrived and appears to have collected good quality data for the duration of the surveys to date.

JD 249 Tuesday, Sept 6th
Survey lines 146 to 154

- Sailed form Rimouski at 630 am. Steamed to middle part of channel just north of Mont-Joli. Conducted velocity cast and deployed magnetometer. At ~1800 UTC, it was discovered that the tow cable for the magnetometer had developed a severe twist. The magnetometer was brought on deck, it was observed that there was some seaweed wrapped around one of the fins which may have been the reason for the twist. The cable was untwisted as well as possible on deck, and the fish was redeployed. The cable will be disconnected from the fish when we get to Matane and the twist will be taken out. Signal quality and strength is still excellent. Docked in Matane at 630.

JD 250 Wednesday, Sept 7th
No survey today, crew change

- Carried twisted magnetometer tow cable onto dock in Matane. Removed twist from cable by twisting in opposite direction at the nose cone and applying tension on the cable to propagate the twists (definitely a two person job). Reinstalled towcable on ship. Discovered that the case for the magnetometer is not weather proof. It was half filled with rain and seawater. It was emptied and set to dry. Backed up magnetometer data to date and created geotiffs of data coverage. Continued cleaning data from previous days' surveys.

JD 251 Thursday, Sept 8th
Survey lines 155 to end of survey

- Sailed from Matane at 630 am to area north of IML. Conducted velocity cast and deployed magnetometer. Magnetometer developed another twist, this time less severe and in the opposite direction. Upon recovering fish, it was discovered that the fish was heavily wrapped in seaweed which was the likely culprit. Returned to Matane at 6 pm. Demobed ship and transferred computers and magnetometer to field vehicle.

JD 252 Friday, Sept 9th

- Left ship at 545 am. Drove to IML from Matane to drop off data backup drive at institute and to demobilize the station magnetometer. Station mag appeared to have collected good data. Drove Mathieu Duchesne to Rimouski to meet train. Left Rimouski at 730 am for Halifax. Arrived in Halifax at 5 pm local time.

Preliminary Results

The following pages illustrate the preliminary results of multibeam bathymetry and towed magnetometer (figures 2, 3, 4, 5 and 6).

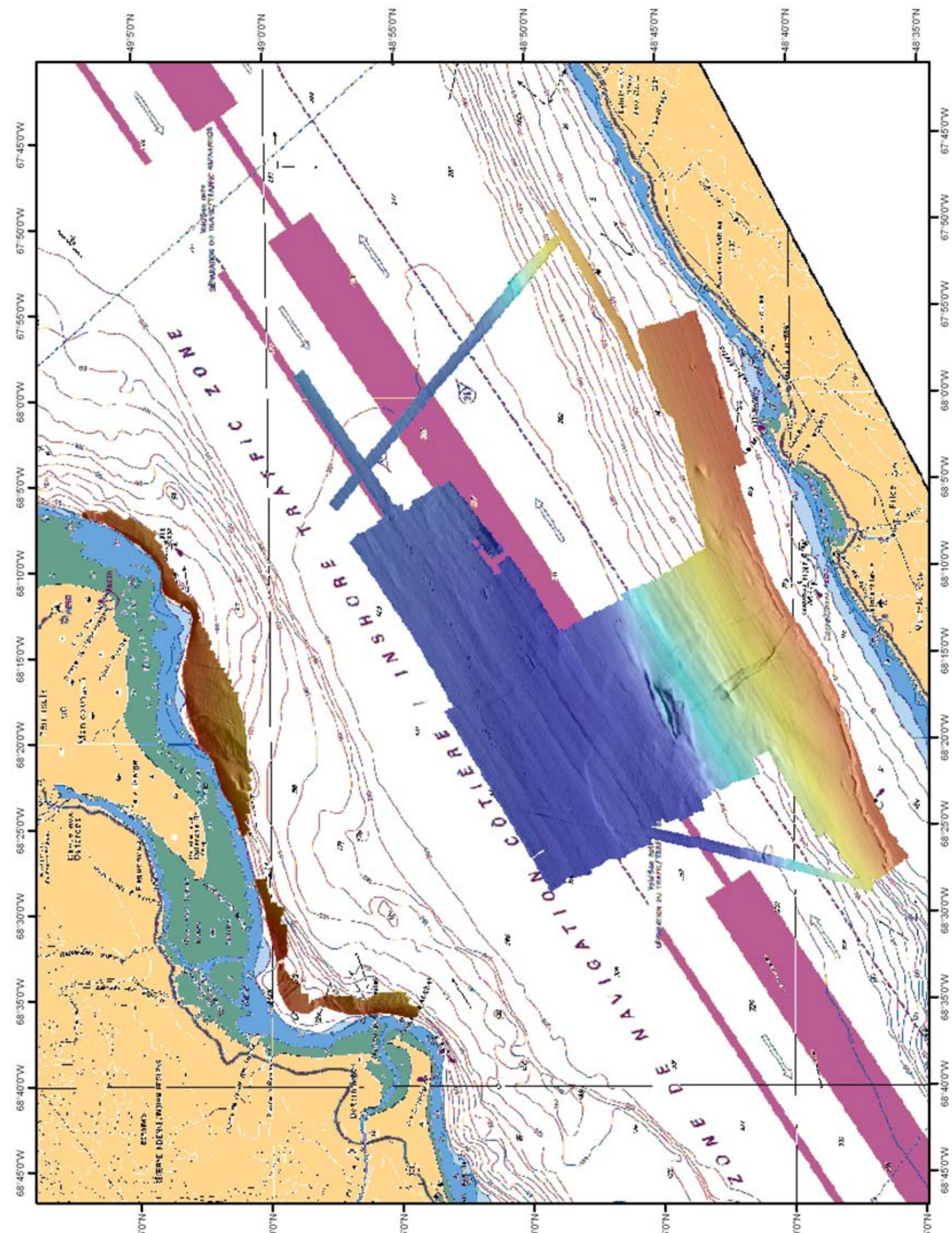

Figure 2- Shaded relief DEM of the mutibeam bathymetry collected during the survey. Water depths range from ~340 m on the channel floor (dark blue) to <30 m on the banks (red).

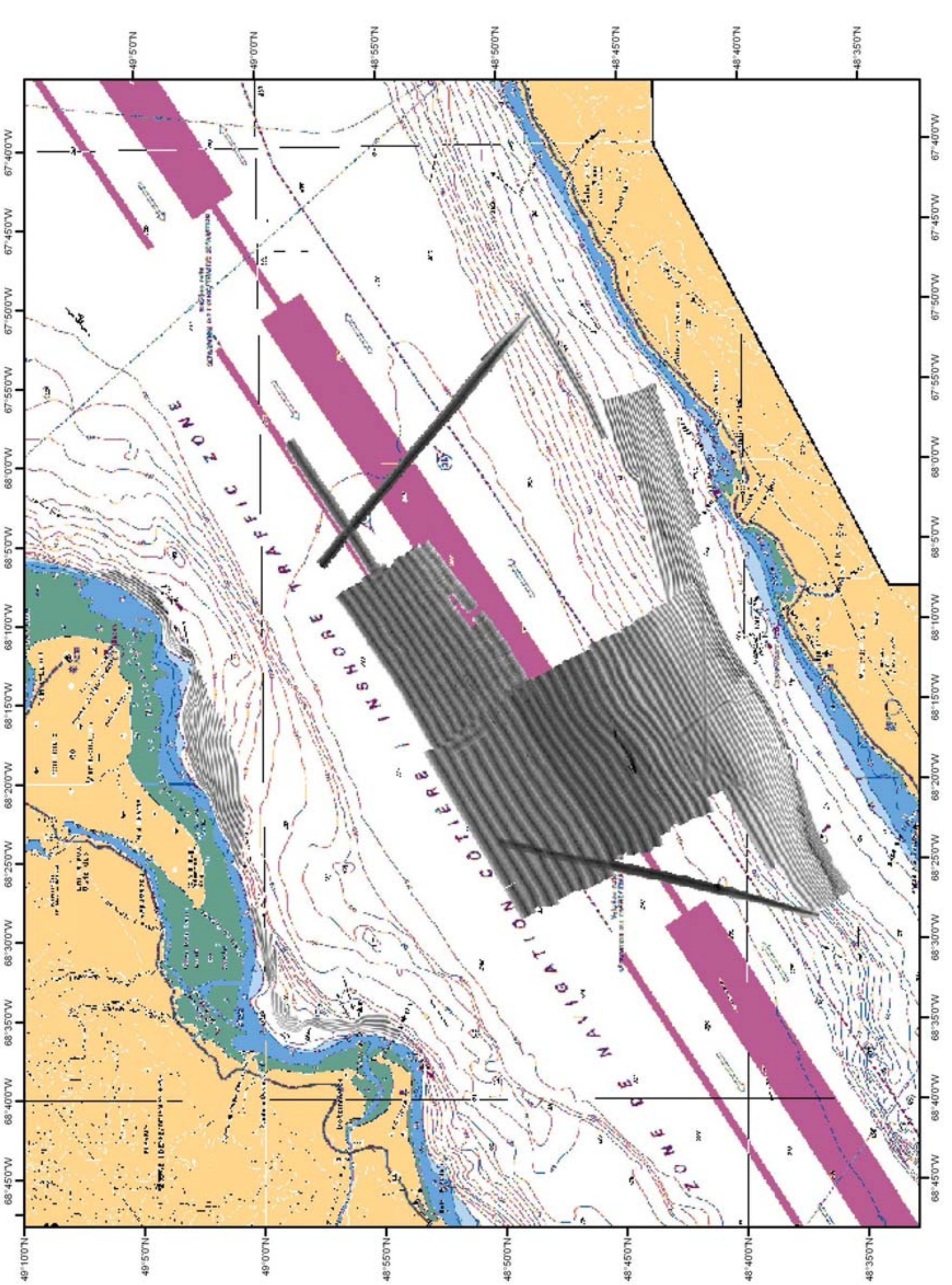

Figure 3- Backscatter intensity from high (black) to low (white). Raw data, no grazing angle correction.

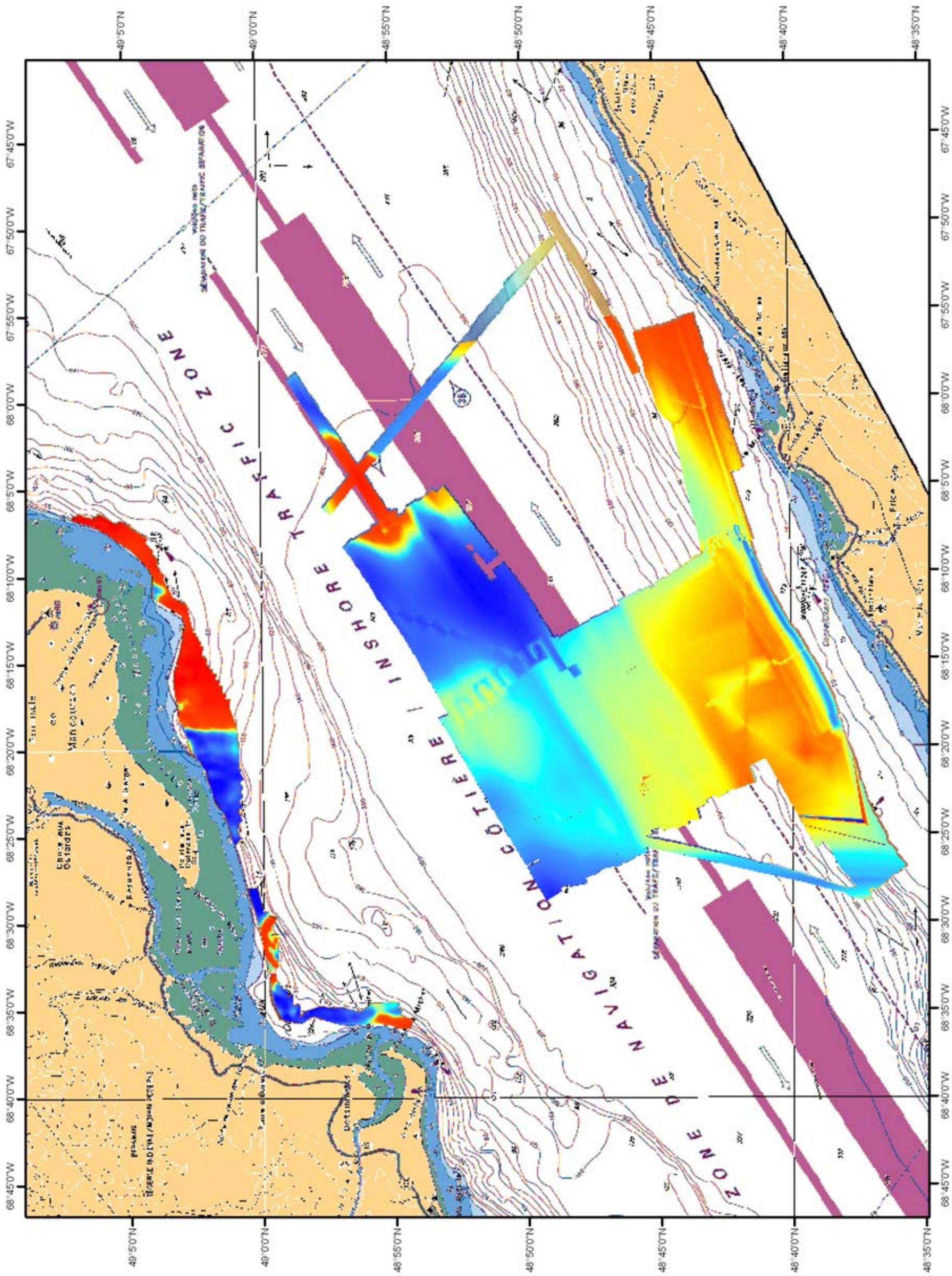

Figure 4- Gridded imagery (20 m pixel) of towed magnetometer data. Warm colours indicate higher values and cool colours indicate lower values.

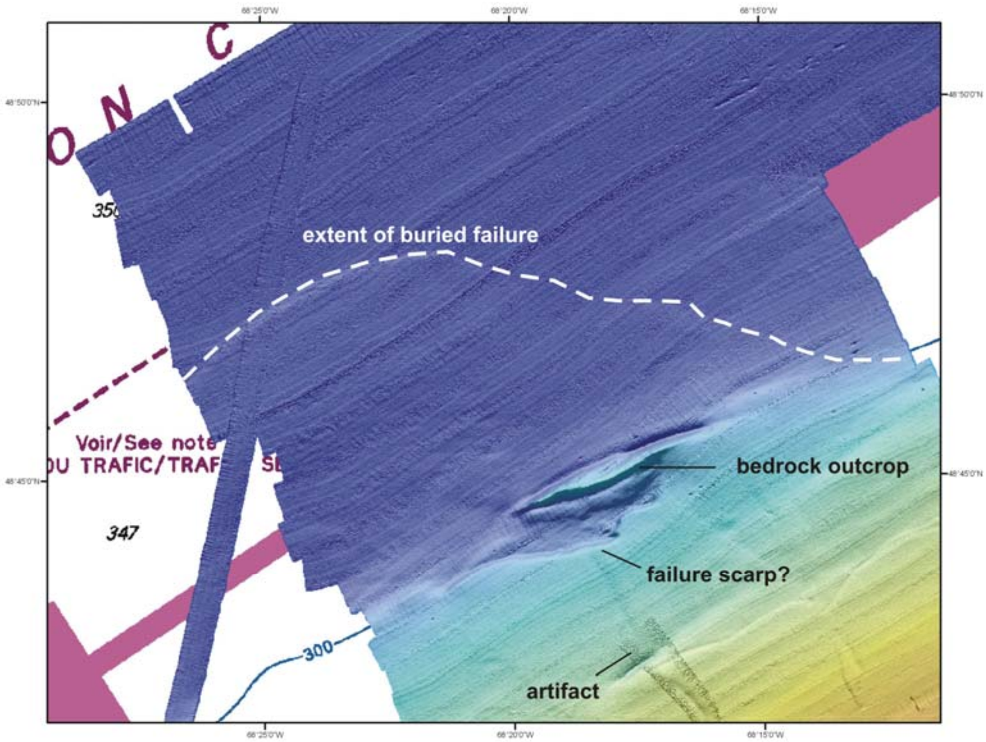

Figure 5- Shaded relief DEM and preliminary interpretation of some seabed features apparent north of Mont-Joli.

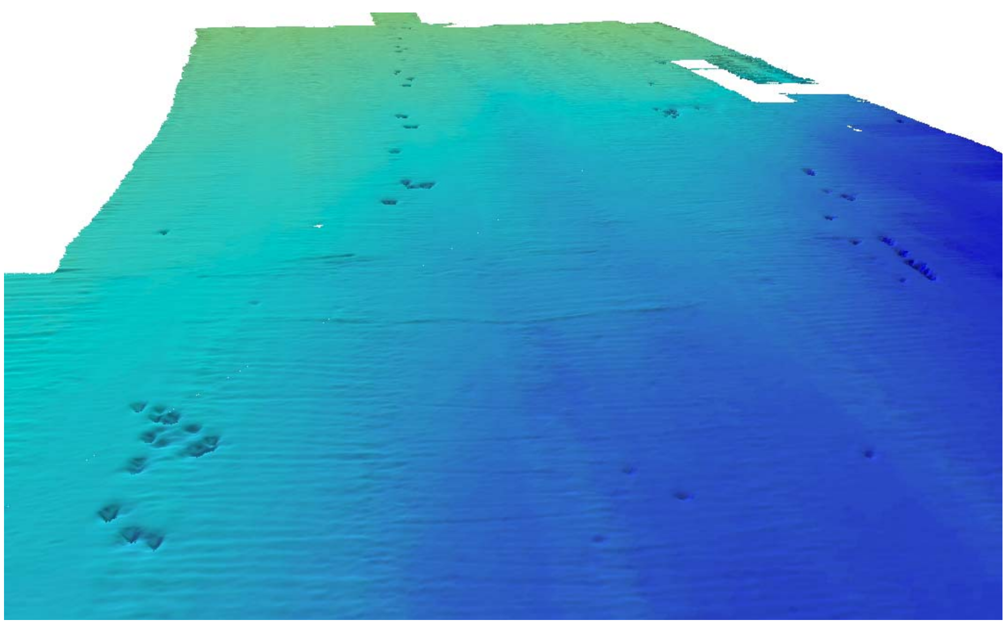

Figure 6- Perspective view (looking northeast) of seafloor DEM showing several depressions interpreted as pockmarks (fluid escape features) on the channel floor north of Mont-Joli.

Technical Summary

Survey Vessel:

The vessel used in this survey was the *CCGS F.G. Creed* (figure 7). The vessel is operated by the Canadian Coast Guard. She is a twin-hulled SWATH (Small Water Area Twin Hull) vessel built in 1988. She is 20.4 m long and 9.75 m wide and can accommodate 4 ship's crew (Captain, Engineer, First Mate, and cook) as well as 5 scientific staff. The vessel has a data processing lab aft which has space for several workstations. She is equipped with a Simrad EM 1002 multibeam echosounder, a BOT MVP100 moving vessel profiler and has a large aft deck for her size which can accommodate other oceanographic equipment, such as the marine magnetometer in the case of this survey.

Figure 7- CCGS F.G.Creed

Multibeam System, Simrad EM1002:

EM 1002 multibeam echosounder is a short to medium range, high resolution echosounder with 111 narrow beams of 2 x 2 degrees, and a sounding accuracy that satisfies the requirements for IHO S-44 order 1 surveys. The 95 kHz operating frequency is robust for pollution and particles in the water, resulting in a range performance in combination with resolution and accuracy which is attractive for many applications. The swath coverage of the EM 1002 Multibeam echosounder is up to 7.5 times the distance from the transducer face to the seabed, or a maximum of approximately 1200 meters (depending upon conditions). The sounding pattern is stabilized for the ships roll movements, and the sounding pattern can be selected as equiangular or equidistant on the bottom. On the Creed, the positioning may come from various sources. The Pos/MV is the primary positioning system and uses differential corrections from the Coast Guard DGPS network (Rivière-du-Loup, 300.0 kHz in this survey area). For the purpose of this survey, independant RTK positioning was used with a base station installed at Mont-Joli. The advantage of RTK positioning is a precision of a few centimeters in the 3 axes (xyz). The z component is very useful as it records the water level during surveying in areas far away from any tide gauges.

Data processing

Processing hardware onboard the Creed included an acquisition workstation on the bridge, one primary ("multifunction") workstation in the lab, and two secondary processing workstations also in the lab that worked on data stored on the "multifonction" station over the ship's network (figure 8). Software included Simrad SIS acquisition software and Caris HIPS/SIPS (v. 5.4) processing suite.

The following steps were used during onboard processing:

1. Once a line was completed, the .all file was copied from the acquisition computer on the bridge to the "multifunction" workstation in the lab.

2. The line was converted to Caris HDCS format (conversion wizard).

3. The line was loaded into Caris HIPS.

4. Navigation data processed. Remove spikes and errors from speed/distance/course made good data.

5. Attitude data processed. Removed spikes from heave/pitch/roll data.

6. Apply tide corrections. Mainly used predicted tides for Rimouski. Measured tide will be applied back at office.

7. Merge file (compute and interpolate depths/positions and apply water level, refraction coefficients, etc.).

8. Swath editor to remove severe sounding anomalies.

9. Create fieldsheet and render a shaded relief image of the data.

10. Subset editor. Systematically edit sounding data to remove spikes.

11. Refraction editor, where needed to remove refraction errors from the data.

12. At the end of each day, a fieldsheet of the entire day was created and a shaded relief image was rendered. A mosaic of the sidescan data (backscatter information) was produced.

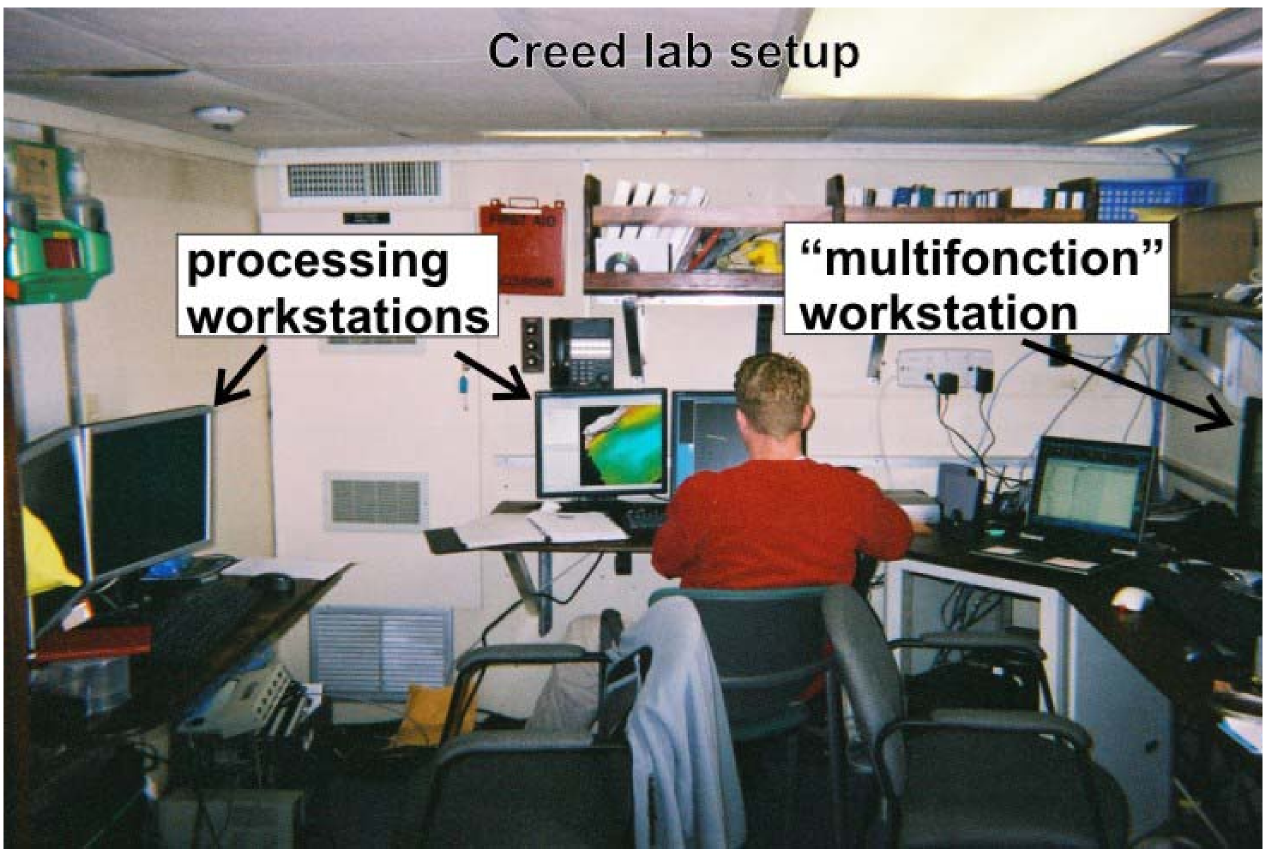

Figure 8- Lab configuration.

SeaSpy Marine Magnetometer:

This was the second GSCA survey with the SeaSpy Magnetometer. The fish was towed at an average depth of 1 m below the sea surface at a speed of 10-12 kts in varying sea states. The system uses Overhauser sensors and measures ambient magnetic field regardless of survey direction or orientation with the field. The system requires 2 people to deploy the fish (~20 kg), but is rather low maintenance once it is deployed. Two known steel hull wrecks were crossed by the magnetometer and significant variance was observed in water depth of approx. 30m. All preliminary field observations show data quality as excellent.

Procedures for Sea-Spy Magnetometer deployment during this survey

1. Tow point on Fish- 60m of cable measured on wharf (3 times vessel length)- Using Samson braid rope, created tow point (braided, clamped and taped).

2. Tow point on Vessel- Approximately 2 m of Samson braid rope tied to aft-port cleat. Tow points connected by two small shackles and a quick release shackle (figure 9).

3. Spool- 60 m *cable* wrapped loosely around port cleats (figure 10), wooden spool on aft quarter/bridge-deck, deck lead to lab through conduit. Deck lead to adapter to small black input box. Black input box output splits to COM port input and power supply. (See manual for more details).

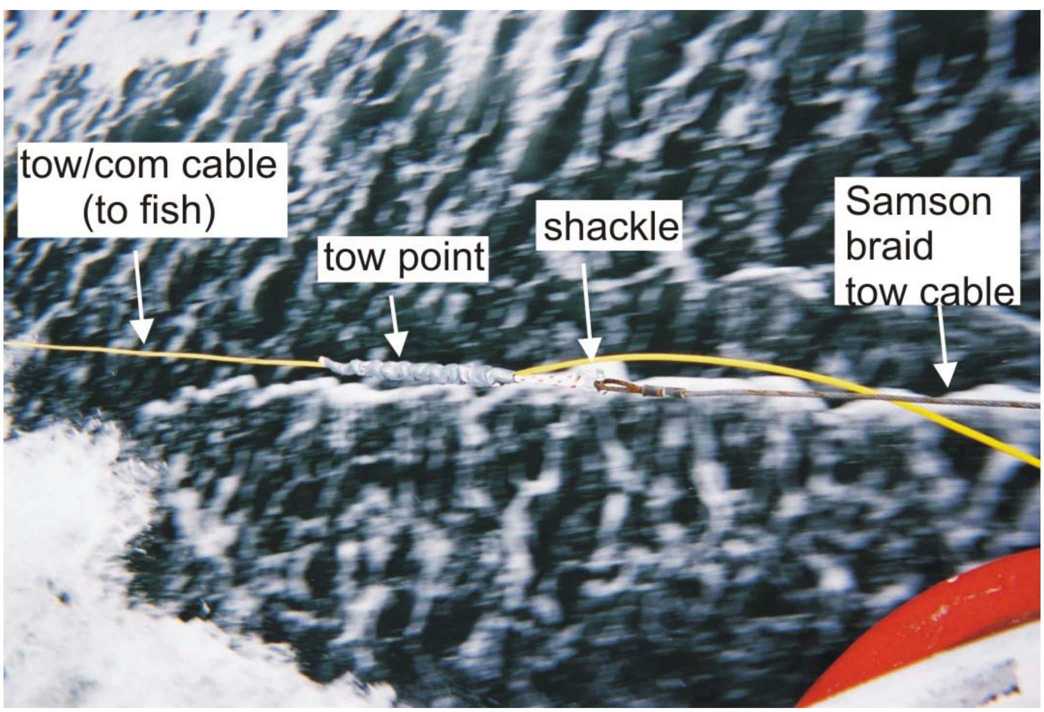

Figure 9- Magnetometer tow point in action.

4. Setup GPS input. Software accepts standard NMEA nav input from a COM port. Software requires baud rate, parity, etc. to be set. In this case it was a baud rate of 9600 and no parity. Nav was updated at 10 Hz.

5. Determine layback. In this case approximately 3 x Vessel Length (60m) + Vessel DGPS/RTK offset (7.5m) + Towpoint (1m) = 68.5m

5. Deployment Procedures- Slowed to deployment speed of 2-4 kts. Before deploying, startup SeaLINK software. Check that GPS data is streaming in the GPS window. Press the "sync GPS" button to sync the computers clock to the GPS. In the command window, enter "p" to zero pressure the depth sensor on the tow fish. Set the cycle rate (usually 1 or 2 Hz). Press the "append GPS values button" to attach position information to the file. Enter the calculated layback. Fish lowered over top of railing on the side of vessel with person 1 holding tension on fish. Wraps were taken off cleats by person 2 as to not tangle cable or transfer tension to deck. Tow point on last wrap handled by person 1 while person 2 pulls wire cable over railing and shackles the rope tow point to wire cable. Tension was then slowly released by person 1. Note two additional wraps were left on deck cleats as safety back up. Once fish is deployed, press the logging button on the acquisition computer to begin logging. Bring ship to survey speed (10-12 kts) (figure 11).

6. Retrieval Procedures- Slowed to recovery speed of 2 to 4 kts. Person 1 hand recovers fish while person 2 neatly wraps the tow cable on deck (not tight around cleats). When tow fish is along side, bring fish on board carefully, ensuring that the fish does not impact the hull. Removed composite nose piece and using potable water (starboard side of the Creed) rinsed thoroughly brass connector and body of the fish, replaced nose piece and secured fish to railing. Note, corrosion takes place fairly quickly when the saltwater, fresh air and brass are all in contact, it is important to rinse the fittings after each retrieval, however it is not necessary to break the brass seal during this process, the o-rings provide the true seal.

Figure 10- Setup of magnetometer while on deck.

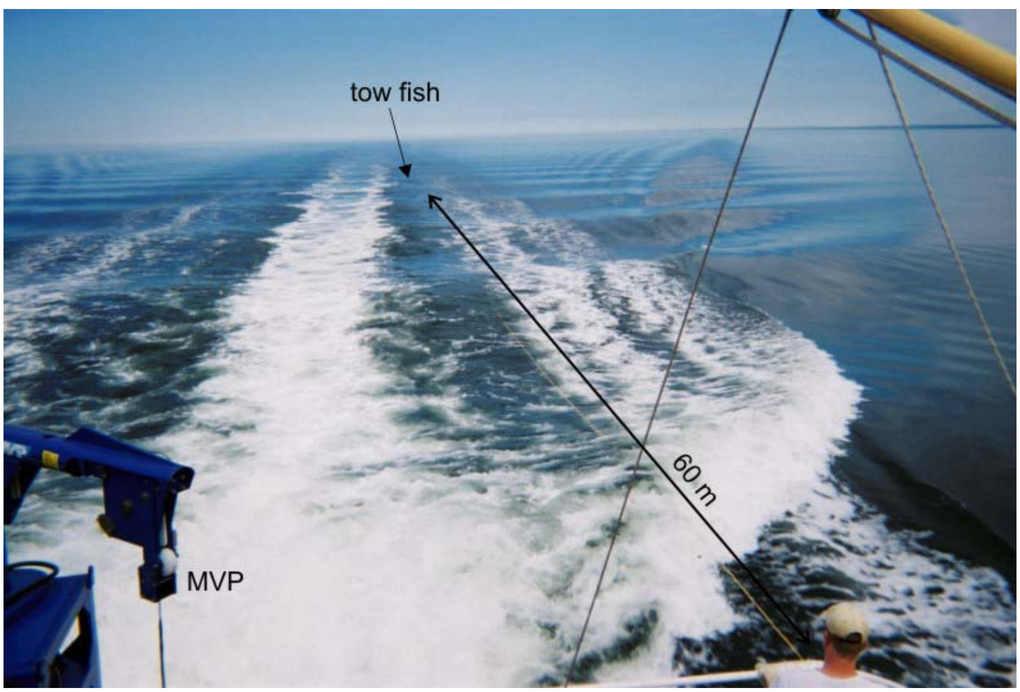

Figure 11- Setup of magnetometer while acquiring data.

SeaLink setup and magnetometer software configuration

- Requirements – System Windows 95 or higher with two available com ports.

- The Magnetometer requires both a Serial connection to the towfish and a real-time NMEA nav string from DGPS.

- A cycle rate of 1 to 2 hz is desirable on the magnetometer at 12 kts, 1 Hz gives reading ~ every 20 metres, 2 Hz every 10 m.

- Mag Baud 9600 string com1.

- GPS Baud 9600 10hz NMEA string com2.

Issues

- No valid navigation string found, program restarted/rebooted until com port found.

- No valid magnetometer com link, Windows OS interpreted mag com port as a plug and play mouse. Power disconnected from magnetometer until windows completed reboot, power reconnected and program initiated.

- The pressure sensor provided erroneous calculations of depth throughout the cruise, sometimes showing fish above surface of the water. Fish could be observed under most conditions riding 60m aft and .5m or greater, below the surface.

- No ability to configure the “x” of “z” offset of the Magnetometer is provided with the sealink software, due to the MVP mounting aft centre, it was necessary to deploy magnetometer approximately 3m to the Port of the RP, giving an overall error of positioning +- 6m instead of the usual DGPS corrected positioning of +- 3m. Primary corrections received from Coast Guard DGPS station in Riviere du Loup (300 Khz) and RTK reference station Ile du Bic

- On Sept 6th and Sept 8th, the magnetometer tow cable developed a twist during survey operations (Sept 6th more severe than Sept 8th). The reason appears to be seaweed which wrapped around the fins on the tow fish thus affecting the hydrodynamics of the towed body (figure 12). The twist developed quite suddenly, within a half hour, and it made recovery of the fish difficult resulting in several localized twists in the cable (figure 13). In both instances, the nose cone was removed from the tow fish and the tow cable was loosely bundled and carried onto the dock. Then the twists were worked out of the cable beginning at the nose cone and working back towards the spool. When this happens in the future, care must be taken not to bend the cable too much and damage the communications cables within the shielded tow cable. The signal strength and signal quality appears to have not been affected based on results from the acquisition software.

Figure 12- Seaweed wrapped around the fins of magnetometer towfish.

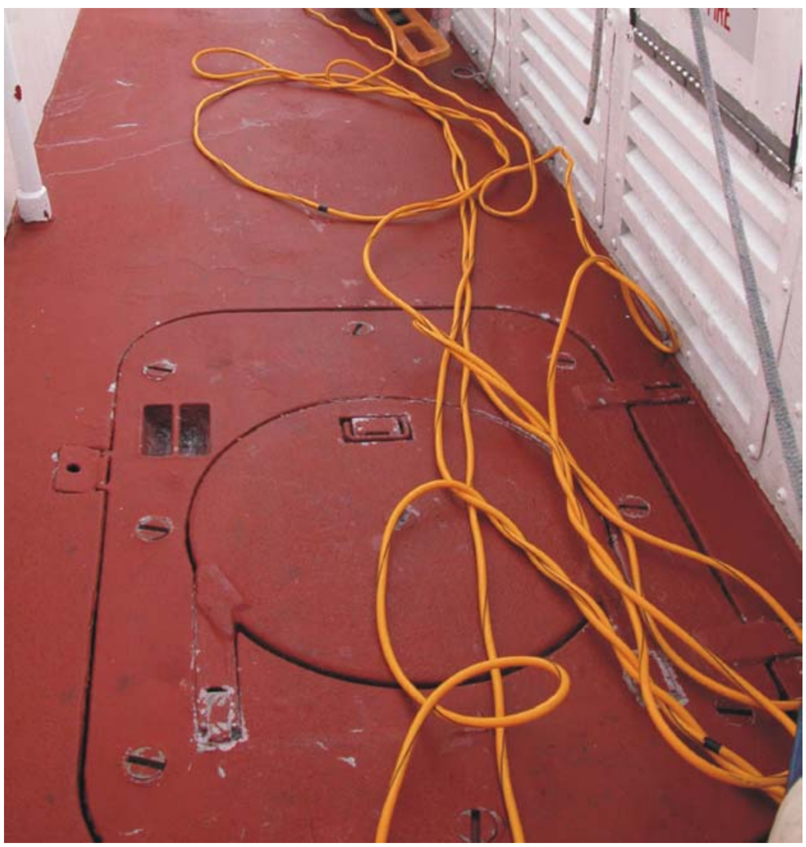

Figure 13- Twisted tow cable on deck.

Magnetometer Base Station at IML:

Base Station at IML was set up Monday Aug 29th. The previous installation of the staion magnetometer at IML (Campbell et al, 2005) resulted in poor quality station data and therefore a new location was selected on the campus of IML. This time the station was setup at the pumping station in a secure area, away from any major underground structures (figure 14). The magnetometer sensor was secured to a cinder block approximately 15 m from the CPU, oriented East West on grassy area. The GPS antenna was secured to a temporary mast. The CPU, GPS, and other electronics were setup inside the pump house and power supply was provided from a wall socket (figure 15). Signal strength was good to excellent for the entire survey and a preliminary assessment of data quality showed that data were within the expected range. A single power outage occurred on Sept 1st resulting in the loss of ~2 hours data, however we were not surveying at this time.

Figure 14- Station mag setup outside IML.

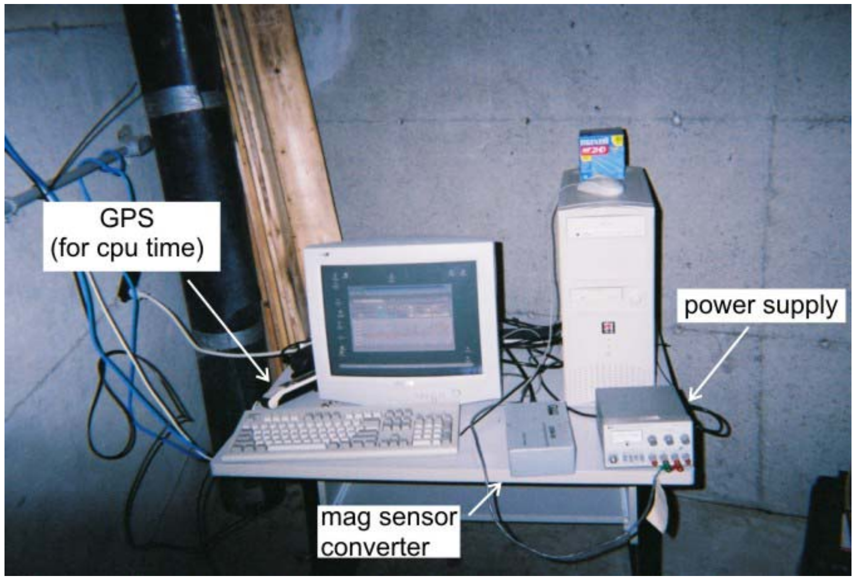

Figure 15- Station mag setup inside pump house.

References-

Campbell, D.C., Hayward, S., Côté, R., and Poliquin, L.
2005: F.G. CREED EXPEDITION 2005-038: Multibeam and magnetometer survey of the St. Lawrence Estuary north of Rimouski- June 5th to 17th 2005, GSC Open File Report 4966.