



## *Chair in Ocean Mapping*

Research Activity - 2006 Calendar Year



*"home of the Heron"*

January 2007

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## Introduction

### Overview

This report outlines the status and current and future research directions of the Chair in Ocean Mapping (COM) at the University of New Brunswick (UNB) at the end of the 2006 calendar year. The Chair works within the Ocean Mapping Group which is a part of the Dept. of Geodesy and Geomatics Engineering (GGE) at UNB.

The Ocean Mapping Group is a loose association of researchers at UNB with a common interest in Ocean Mapping. The Chair provides research direction, support staff and infrastructure to support research within the Group.

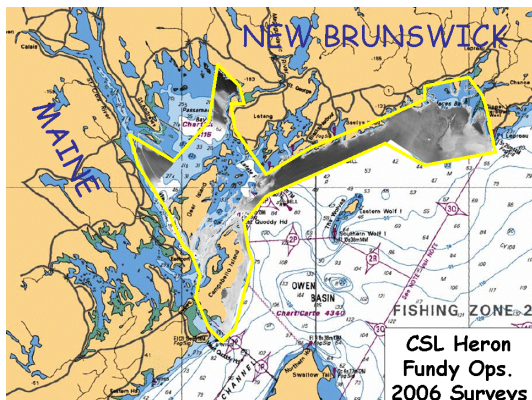
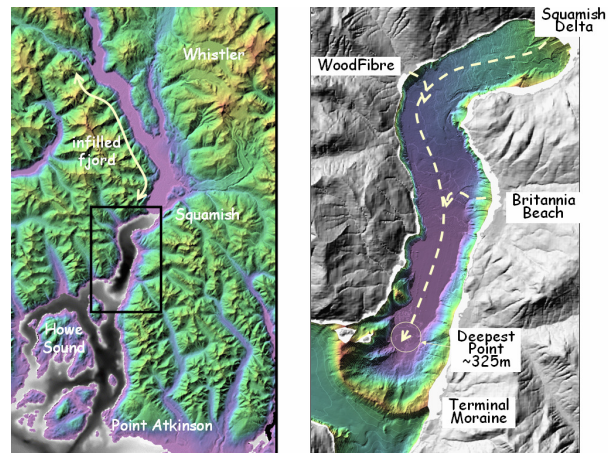
### Major New or Expanded Research Programs

#### Squamish Delta Program

In March 2006, we started a new collaborative research program looking at the temporal evolution of the Squamish Delta. The project is a joint effort between the OMG, the Geological Survey of Canada and the Canadian Hydrographic Service.

The delta lies at the head of Howe Sound and is the location of the discharge of the Squamish River. On the delta, there is a significant port facility that requires active dredging to maintain the clearance. Deposition of sediment, discharged by the river, was known to have resulted in extensive progradation of the delta since the first CHS single beam survey in the 1970's.

Building on analysis of CHS and GSC EM1002 multibeam surveys collected in 2004 and 2005, a survey plan was designed for the EM3002 on the CCGS Otter Bay to do repetitive mapping of the upper delta to monitor inter-season and inter-annual evolution of the pro-delta slope.



#### GOM Phase II SouthWest NB Coastal Mapping – Maces Bay

As part of ongoing collaborative seabed mapping with the Geological Survey of Canada and the St. Andrews Biological Station through the Ocean Action Plan program, we conducted a 35 day mapping mission of the southwest New Brunswick coastline.

The purpose of survey was to delineate geomorphology, surficial sediments and seabed habitat.

This survey was conducted by staff and graduate students on board the CSL Heron. It represented both a training exercise for graduate and undergraduate students (Hydrocamp 2006) and a dataset to test new backscatter processing, data cleaning, tidal reduction and data management algorithms.

## Arctic Coastal Mapping

As part of the ongoing ArcticNet-funded mapping in the Arctic Island Archipelago, the new capability of the CSL Heron was demonstrated for complimentary inshore mapping in 10 locations from the Labrador Sea or the Beaufort Sea.

The Heron added the ability to map up to the 5m contour in regions as varied as fjord-head delta fronts, to the actively calving face of the Belcher Glacier. These mapping programs served both the geomatics research interests of the OMG and the coastal scientific issues of projects 1.2 and 1.6 of ArcticNet.

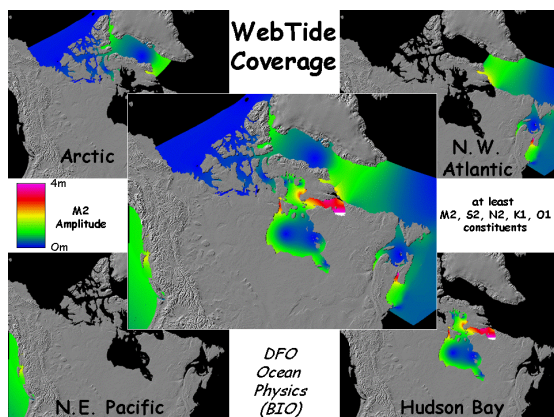


## Major Research Developments

In 2006, ongoing research into marine geomatics methods resulted in a number of significant developments including:

### Integration of WebTide

In order to account for tidal variations in water level throughout the Arctic Island Archipelago, the WebTide models, developed within the Ocean Physics Branch of DFO have been assessed and utilized. The *tidecor* function from DFO has been modified to integrate OMG-format multibeam data with a user-specified hydrodynamic model.



For the area of operation of CCGS Amundsen, the NW Atlantic, Hudson Bay and Arctic 8 models all had to be used as the vessel worked in all three domains.

For CSL Heron operations along the southwest New Brunswick shore, the



Scotian Shelf model has been utilized.

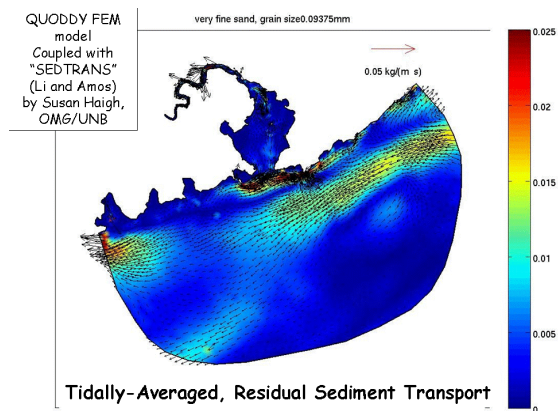
Previous comparison in 2004/5 of the Arctic 8 model to C-Nav GcGPS ellipsoid height solutions (shifted to the EGM96 geoid), showed excellent agreement and avoided the significant reliability issues that plagued the CNav results at high latitudes (low satellite elevation angles, poor constellations in fjords, discontinuous tracking of the geostationary satellites and interference with the Inmarsat communications system).

In the Fundy region, C-Nav heights from CSL Heron, which are more reliable at these lower latitudes, were collected to use as a check on the Scotian Shelf model.

### Linking sediment transport models (SEDTRANS) to coastal hydrodynamic models (QUODDY)

In order to address modern coastal sediment transport questions in the Bay of Fundy, the SEDTRANS model, developed by GSC-Atlantic was integrated into the output of the QUODDY nested models developed for specific coastal areas (Musquash Estuary, Maces Bay). Tidally averaged sediment transport vectors for grain sizes from coarse silt to medium sand were calculated and mapped spatially.

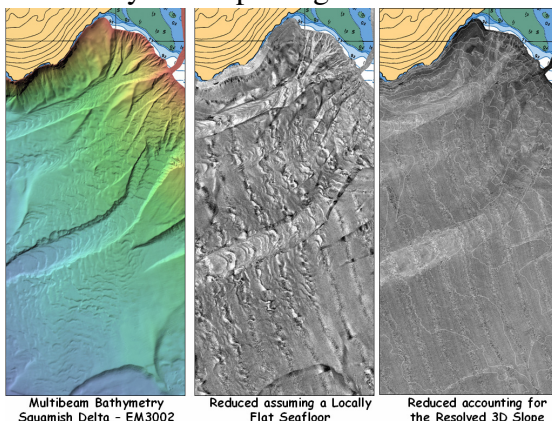
These results will be used to try and explain the modern headland-associated sediment transport processes that form the banner banks so common in Fundy. This work will tie into the repetitive surveys of these banner banks, conducted previously that indicate bedload sediment transport fluxes and directions.



### Slope corrections to Multibeam Backscatter

Previously developed algorithms to calculate instantaneous 3D beam slopes were combined with new algorithms that undo the Kongsberg TVG functions, to allow one to fully account for the seabed-slope-derived signature in high aspect ratio multibeam backscatter.

Once derived, the slope function could be approximated and backed out revealing how much of the signal was textural and how much slope driven. This new method was especially important for the new Squamish delta investigations.



### ***Recent Infrastructure Upgrades - Instrumentation***

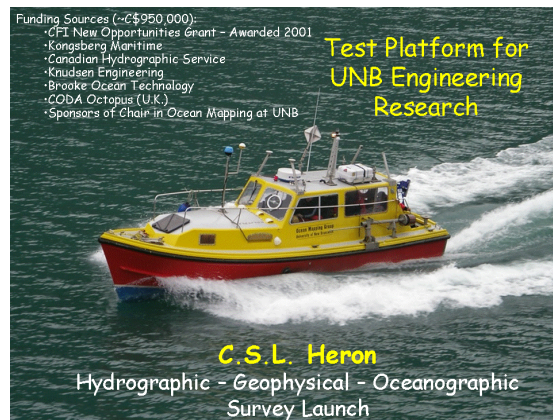
#### **Heron Back on Stream**

The unfortunate accident at the Quebec City Coastguard base in July 2005, which resulted in the sinking of the CSL Heron, severely compromised the research mapping capabilities of the OMG in that year.

Over the winter 2005-2006, Heron was almost entirely rebuilt at the Grand Manan Boatyards. The majority of the costs were covered under insurance, but it still required ~ C\$100,000 of redirected research funds to bring her back to full capability.

Almost all survey systems were replaced as is. The one significant improvement was the purchase of a new engine. A byproduct of this was an increase in the top speed of the vessel from 11.5 knots to 17 knots.

The Heron was used as the key part of coastal mapping in the 2006 Arctic program.



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## Personnel

### Faculty

John E. Hughes Clarke	Professor, Chair in Ocean Mapping, GGE <i>Swath Sonar Software Development, Sediment Transport</i>
Peter Dare	Professor, Departmental Chair, GGE <i>GPS, Geodesy</i>
David Wells	Professor Emeritus, GGE <i>Hydrography, Geodesy, Uncertainty management</i>
Marcelo Santos	Associate Professor, GGE <i>Kinematic Positioning, Geodesy</i>

### Research Associates and PostDoctoral Fellows

Dr. Susan Haigh	Honorary Research Associate <i>Numerical Modeling of Coastal Circulation</i>
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### Support Staff

Jonathan Beaudoin	Research Assistant - ArcticNet
Jason Bartlett	Research Assistant - CHS Central and Arctic
Steve Brucker	Research Assistant - NSERC Major Facilities
Doug Cartwright	Research Assistant - OAP
Ian Church	Undergraduate Research Assistant
James Leslie, Howard Ingalls	Skippers, CSL Heron
Tracey Hawco	Accounting

### Graduate Students

Garret Duffy	JHC	PhD 2001- 2006
Jonathan Beaudoin	JHC	PhD (part-time) 2001-
Nicole Delpeche	JHC	MScEng 2003-2006
Xinhai Li	ML/JHC	PhD 2004-
Reza Ghoddousi-Fard	PD	PhD 2004 -
Pim Kuus	JHC	MScEng 2005-
Aluizio Oliviera	JHC	MScEng 2005 –
Miguel Vasquez	DW	MEng 2005-
Andy Millan	DW	MEng 2005-
Ricardo Almeida	DW	MEng 2005-
Steve Brucker	JHC	MScEng (part-time) 2006-
Ian Church	JHC	MScEng 2006-



***Active Collaborators in 2006***

Russell Parrot	Physical Scientist GSC – Atlantic, BIO
Bill Danforth	Research Scientist USGS – Woods Hole Field Office
Maria-Ines Buzeta	Research Scientist DFO – St. Andrews Biological Station
Lincoln Pratson	Professor Duke University, USA
Mark Anderson	Research Scientist National Park Service, Page, AZ
Andre Rochon	Associate Professor UQAR – ISMER
Steve Blasco	Research Scientist Geological Survey of Canada – Atlantic
Phil Hill	Research Scientist Geological Survey of Canada – Pacific
Patrick LaJeunesse	Assistant Professor University of Laval - Geology
Brian Maclean	Emeritus Scientist NRCan – GSC Atlantic
David Piper	Senior Research Scientist NRCan – GSC Atlantic
Trevor Bell	Professor Memorial University – Geography
Kalman Czotter	Hydrographer in Charge Canadian Hydrographic Service – Pacific
Mike Lamplugh	Hydrographer in Charge Canadian Hydrographic Service – Atlantic
Colin Brown	Professor University of Galway, Ireland
Ronald Perluka	Engineering Manager Rijkswaterstaat, Delft, Holland

## Active Research Directions

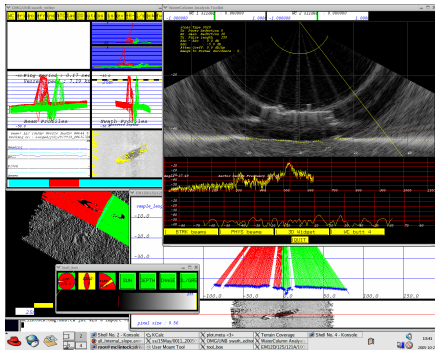
The following short overviews explain the researchers, sources of funding and describe the type of research currently active under the umbrella of the Chair in Ocean Mapping:

### Swath Sonar Analysis Software

*Hughes Clarke, Beaudoin and Brucker (OMG)*

*Chair Funding*

As always, in order to support the core swath sonar research that is active within the Ocean Mapping Group, a Linux-based processing and analysis package (SwathEd) is constantly maintained and enhanced.



Software developments have continued, the most noticeable advancements in the 2006 year include.

- Further improvements in the EM710 – EM3002 Water Column Imaging
- New capability to estimate and extract the grazing angle response of the seabed backscatter, separately from the beam pattern signature..
- Automation of the web-based mapsheet delivery –implemented for both Fundy mapping (1m grids, 2x2 minute mapsheets) and Arctic mapping (10m grids 15x 30 minutes).
- Integration of the WebTide tidecor algorithms to apply spatially variable hydrodynamic tidal mode corrections.

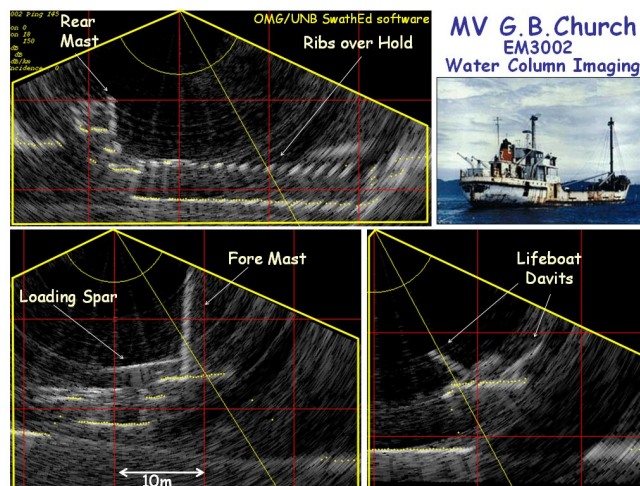
### EM3002 Wreck Imaging – MV G.B. Church

*Hughes Clarke, and Brucker (OMG),*

*Czotter (CHS-Pacific)*

*Chair Funding*

With the development of the capability to read and utilize the new water column imaging capability from EM multibeam sonars, a number of applications were tested. The most significant application at this time appears to be the better delineation and quality control of multibeam bottom tracking about abrupt man-made structures such as wreck and subsea oil



installations.

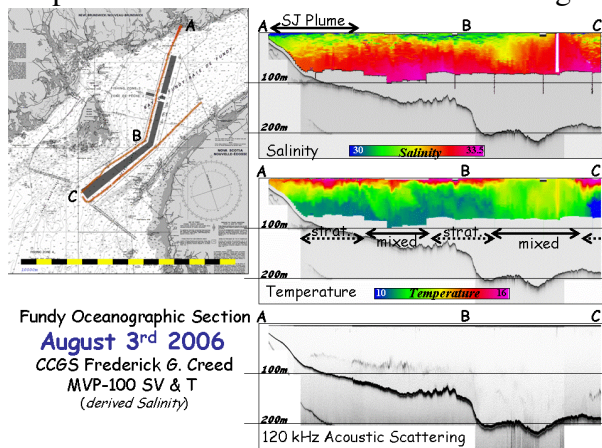
A specific set of trials was performed over a known wreck (MV G.B. Church, sunk as a sport diving site). Results were presented at CHC 2006 illustrating the features that were missed in the sounding solutions and allowing assessment of false spurious soundings.

### **Fundy Oceanographic Sections**

*Hughes Clarke (OMG) and Parrott (NRCan – GSC-A)*

*NRCan Funding*

As part of the Geoscience for Ocean Management Program of the GSC a series of Fundy Oceanographic Sections are being collected to complement the seabed imagery acquired for multi-users.



In 2006, a longitudinal section was collected in August starting in the Saint John River plume and extending out of the Bay of Fundy along the shipping lane. The lateral extent of the summer-time stratification was recognized, including the presence of significant frontal features. Immediately south of the Murr Ledges, a particularly well

mixed zone was noted which changes abruptly south of Machias Seal Island into the strongly stratified waters of the Central Gulf of Maine. This water mass boundary was a particular problem for multibeam data acquired by CCGS Frederick G. Creed (EM1002) in that same year.

### **Beaufort Sea - NorthWest Passage Mapping 2006**

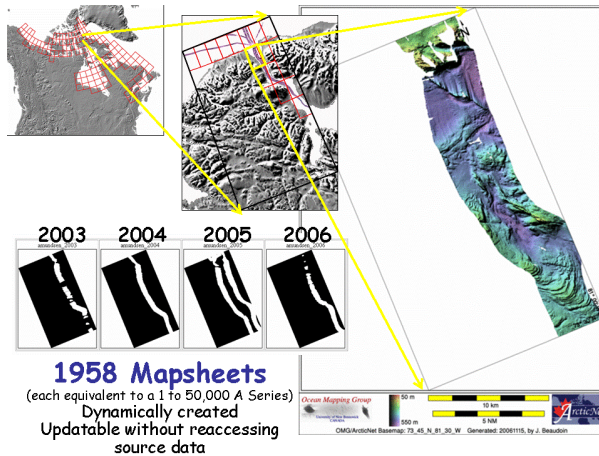
*Beaudoin, Church and Hughes Clarke, (OMG), Bartlett, (CHS)*

*ArcticNet and CHS Funding*

As part of ArcticNet Project 1.6 : “**The opening NW Passage - Resources, Navigation, Sovereignty and Security**”, the OMG continued to collect underway multibeam and subbottom data in the North West Passage and the Beaufort Sea in 2006.

Data is collected under transit conditions, as part of a multi-disciplinary science program. Rare 6-12 hour systematic mapping projects are undertaken.

By combining the first 4 years of mapping, significant insight is now being obtained into the seabed geomorphology and with the likelihood of another 10 years of mapping operations, this will provide an unprecedented view of the seabed of the NorthWest Passage.



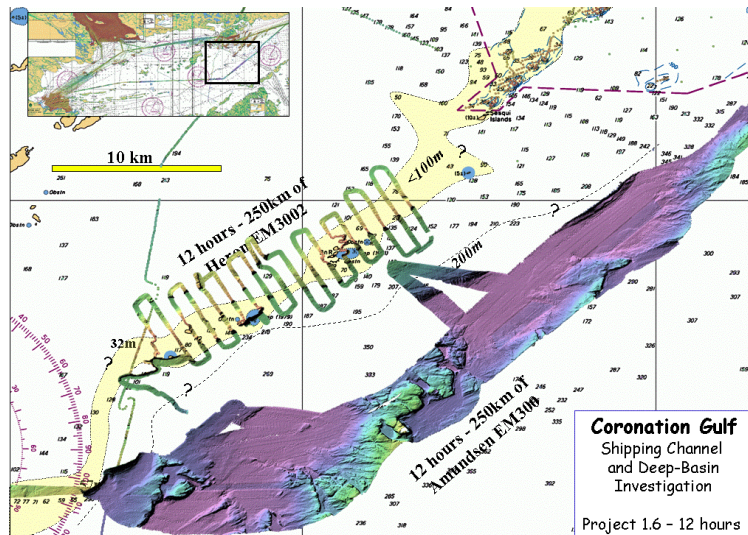
A highlight of the mapping was the serendipitous imaging of actively venting pockmarks in Barrow Strait. These represent a potential geohazard to seabed hydrocarbon development. Similarly, improved imaging of iceberg and ice-ridge scour features is serving to help minimize potential environmental disasters as the resources of the region are developed.

### ***Coronation Gulf – Shipping Lane Investigation***

*Brucker, Beaudoin, and Church, (OMG)  
ArcticNet*

In 2005 an opportunistic single beam transit line run by an icebreaker through the south side of Coronation Gulf was followed as the first step in trying to establish a new shipping lane. The area is otherwise only covered by 6km spacing through-ice helicopter soundings performed in the 1970's.

A series of cuesta ridges were noted along this transit line and in 2006, a deliberate effort was made to expand this corridor. The main cuesta ridge, which include a series of known shoal and islands was subjected to a Heron launch EM3002 survey that far better defined the crest of the ridge over a 15 km length.



While the Heron was working on the ridge crest, the Amundsen significantly expanded the mapping in the deep water basin to the SE.

This data has been submitted to CHS Central and Arctic office for modifications of the existing chart. It is our intent to further expand this shipping corridor in future years.

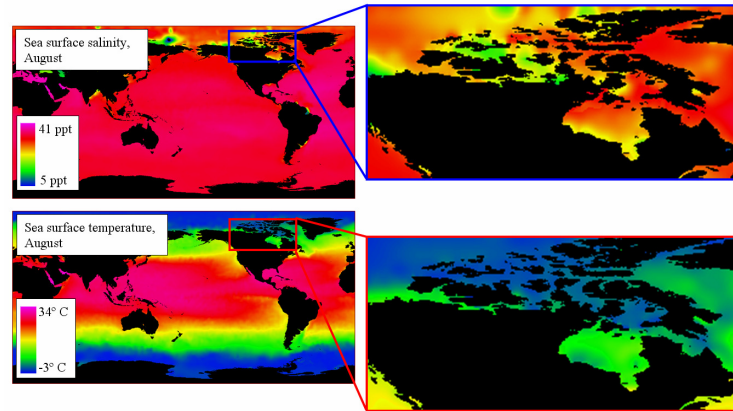


### ***Coping with incomplete sound speed information***

*Beaudoin (OMG)*

*ArcticNet funding*

Obtaining adequate sound speed information from the CCGS Amundsen in ice-covered regions has always been an issue. In 2006 there was no MVP-300 fish and thus extra CTD stations were undertaken along transit corridors to support the sound speed control. These CTD information are being used to test the validity of the World Ocean Atlas database as a valid substitute in the absence of contemporaneous sound speed information.



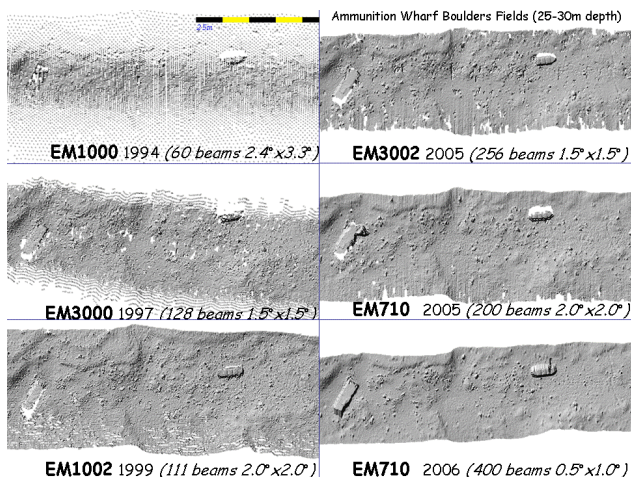
As the CTD density remains low at transit speeds (12 hours – 150 nm) and the underlying density of the WOA database is scarce, linear interpolation of such sparse data along narrow inter-island channels in the archipelago is fraught with danger as the water mass distribution is very discontinuous.

### ***CCGS Matthew EM710 0.5°1.0°Acceptance and Operational Trials***

*Hughes Clarke and Oliviera, (OMG) and Lamplugh (CHS-Atlantic)*

*CHS and Chair Funding*

Following on from the 2005 testing of the 2x2° EM710 on board the CCGS Matthew, further trials were undertaken in April and May of 2006 with the new electronics to support the full array lengths. The system now has a 0.5x 1.0° capability which clearly results in better seabed target resolution.



The system now has a 0.5x 1.0° capability which clearly results in better seabed target resolution.

Trials were conducted to assess the change in detection capability over the 2x2° version and earlier sonars.

The Swathed software has been adapted to cope with the 400 beam solutions and automatically adjust to the possible changes in configuration including switching to/from high density mode and varying the Tx. And Rc. beam widths.



As part of the same trials, the newly installed Knudsen 3.5 kHz was tested and data were acquired simultaneously with the multibeam. New methods for presenting combined high density subbottom data and multibeam bathymetry and backscatter were developed:

[http://www.omg.unb.ca/Ksubbottom/Matt\\_3.5/OMG\\_UNB\\_Matthew\\_320R\\_Trials.html](http://www.omg.unb.ca/Ksubbottom/Matt_3.5/OMG_UNB_Matthew_320R_Trials.html)

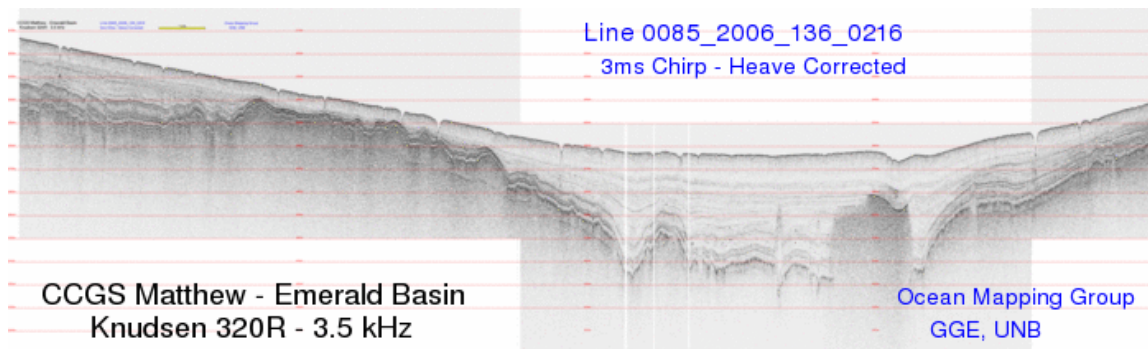
### ***CCGS Matthew Knudsen 3.5kHz trials – testing for reflection coefficients***

Hughes Clarke (OMG), Parrot (NRCan, GSC-A), Brown and Leurer, (Galway)  
OMG funding

On a recommendation from the OMG, NRCan installed a 4 element 3.5 kHz subbottom profiler array on array on an extendable ram on CCGS Matthew. The elements (surplus from a Datasonics CAP-6000 system) were linked to a Knudsen 320R 4KW transceiver and driven using chirped pulses.

The system was tested out for the first time in 2006 and quantitative data was collected over calibration sites in the Emerald Basin where precise physical property measurements are available. The data sets were provided to the University of Galway Geophysics group to test their new sediment classification algorithms.

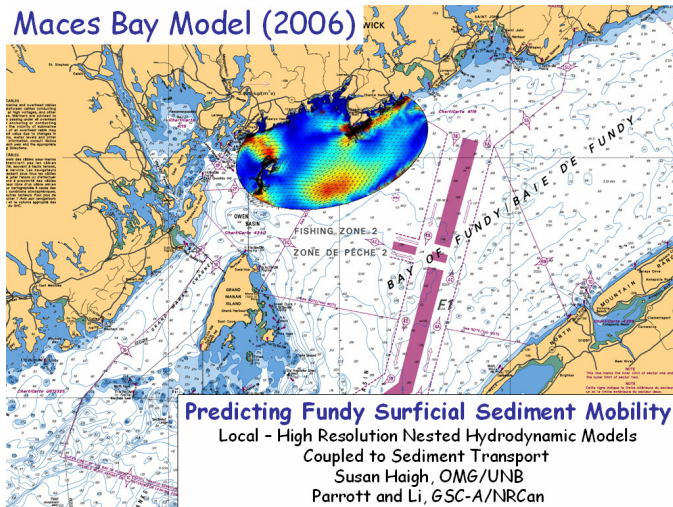
[http://www.omg.unb.ca/Ksubbottom/Galway/Emerald\\_CoreData.html](http://www.omg.unb.ca/Ksubbottom/Galway/Emerald_CoreData.html)



### ***Musquash Estuary and Maces Bay – Linking Sediment Transport to Hydrodynamic Model Results***

Haigh and Hughes Clarke, (OMG), Li, (NRCan, GSC-A)  
Chair Funding

Building on the revised QUODDY model of the Musquash estuary developed in 2005, the SEDTRANS model developed by Li and Amos at GSC Atlantic was implemented to try to predict residual sediment transport over an M2 tidal cycle.



mapping in Maces Bay to the west, a new QUODDY barotropic, wetting and drying model was developed of the coastline from Beaver Harbour to Chance Harbour. This completely covered the OAP Maces Bay mapping operations of CSL Heron in this year (see elsewhere in this report).

For each node of the hydrodynamic model, the tidal velocity 1m above the bed was derived at 10 minute steps through the tidal cycle and used to estimate the bed shear stress. Seabed roughness drag coefficients and normal wave conditions were included to try estimate the resulting suspension and bedload sediment transport.

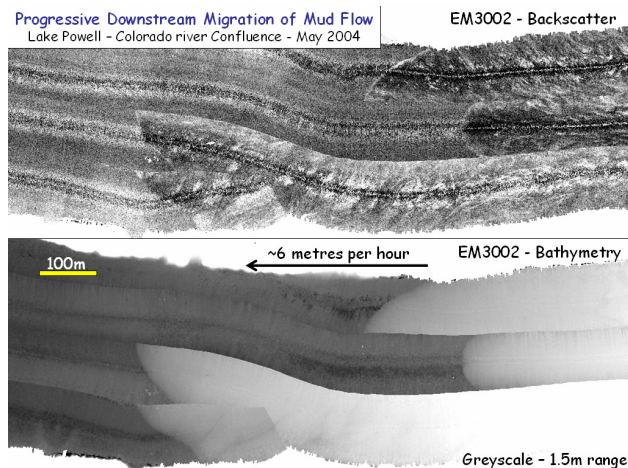
As an extension of this program, and supporting the new OAP

### **Lake Powell AZ/UT – Imaging Active Mudflows**

*John Hughes Clarke, Jonathan Beaudoin (OMG), Lincoln Pratson, (Duke) and Mark Anderson (NPS)*

*Chair, Duke University and U.S. National Park Service funding*

As a follow on of the collaborative research program between UNB, Duke University, and the US National Park Service, we have continued analyzing a 10 day multibeam mapping program of Lake Powell Arizona/Utah.. The aim of the research program is to examine the input and fate of sediment into the dammed lake system.



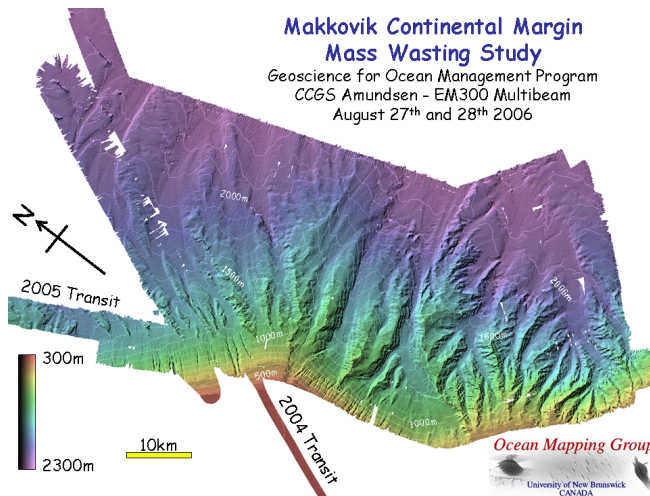
In post-survey analysis it has become apparent that, over the course of a 4 day period, we imaged a moving mud-flow on the floor of the lake. A lens-like body of low backscatter sediment distinct by its swirled backscatter pattern, was seen to migrate at a rate of ~6m per hour. The nose of the flow was approximately 50cm high.

### **Makkovik Margin – GeoHazard Assessment**

*Hughes Clarke (OMG) and Sonnichsen (NRCan – GSC-Atlantic)*

*NRCan funding*

Continuing our on-going collaborative mapping program with NRCan, a 24 hour survey



was conducted of the Labrador continental margin between 500 and 2000m off Makkovik Bank. Iceberg grooving was clearly identified to over 600m and potential sites of ground water tapping were noted.

On the upper rise, several anomalous blocks were observed, that have now been investigated using GSC seismic gear. They appear to be the crests of allocthonous slide blocks, now buried under more than 100m of post-slide sediments.

The mapping on the Makkovik margin

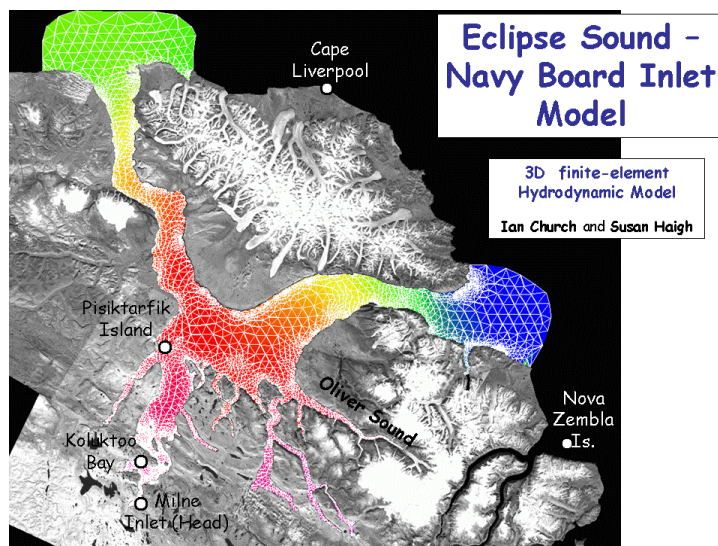
is scheduled to be expanded on an annual basis. Ultimately it is hoped that the margin from Makkovik, up to the Hudson Strait surveys (see elsewhere in this report) will be covered.

### **Eclipse and Oliver Sound – Hydrodynamic Modelling for Tides**

*Church, Haigh and Hughes Clarke (OMG)*

*ArcticNet funding*

In order to support, multi-year sequential surveys of pro-glacial deltas in Oliver Sound, a nested hydrodynamic model has been developed of the Eclipse Sound – Navy Board Inlet region. The aim is to force the model using the lower resolution Arctic-8 model in Lancaster Sound and Baffin Bay. The only tidal constituents available in the area are from Pond Inlet and Milne Inlet. No tidal observations have even been made in the fjord. The aim of the model is to try and predict the propagation of the tidal wave up





the fjord to perform vertical datum adjustments to multibeam survey data.

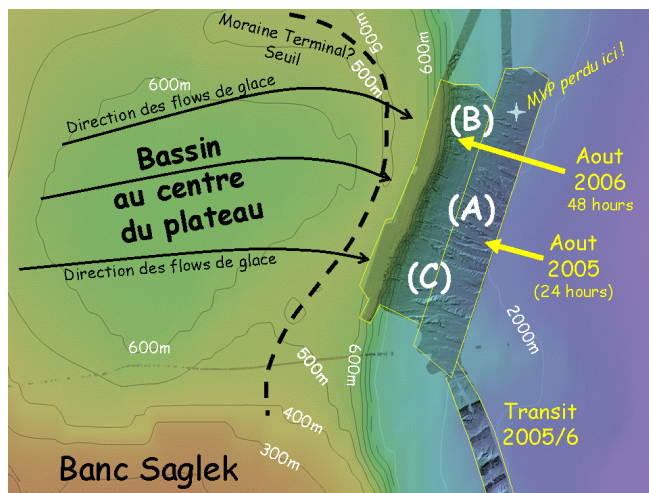
At this time, the first results of the model have been developed for the M2 period. For 2007 addition of the S2, N2, K1 and O1 constituents will be attempted.

### ***Shelf-edge ice-scarring - indicative of Heinrich Events.***

*Hughes Clarke (OMG) and Piper (NRCan – GSC-Atlantic)*

*NSERC STAC and Discovery funding*

In August 2006, the final 2 days of an EM300 survey of the continental margin, just seaward of the mouth of Hudson Strait was conducted to examine the proximal seafloor signature of Heinrich Events.



This survey was funded under the NSERC STAC program.

Hudson Strait is postulated to be the source of the large volume discharge of fresh water into the North Atlantic during the Holocene. These massive discharge events were certainly short lived (< 100 years) and may have been catastrophic, resulting from the failure of an enormous ice-dammed or sub-glacial reservoir.

Initial examination of the resulting imagery reveal a distinct family of

parallel iceberg scouring existing at the low point of the moraine ridge that cuts off the basin in the centre of Hudson Strait. Their non-random orientation suggests strongly that they were made in a single event, perhaps related to a sustained discharge moving icebergs out of the Strait.

Follow-up seismic and piston coring is planned for the region from CCGS Hudson in 2007.

### ***Arctic Coastal Impacts due to Global Warming***

*Bell, Forbes (MUN), Hughes Clarke, Beaudoin, Brucker (OMG)*

*NSERC NCE – ArcticNet project 1.2 and project 1.6 funding*

Project 1.2 of the ArcticNet NCE deals with coastal impacts of a warming Arctic. Project 1.2 uses the underway geophysical data collected by project 1.6 (led by the OMG) to look at near-coastal seabed morphology and subsurface structure. The draft of the Amundsen (7.0m), however, and the frequency of the EM300 (30 kHz), restrict the collection of this data to depths generally greater than 40m. Thus a tool was required to work inshore of this.

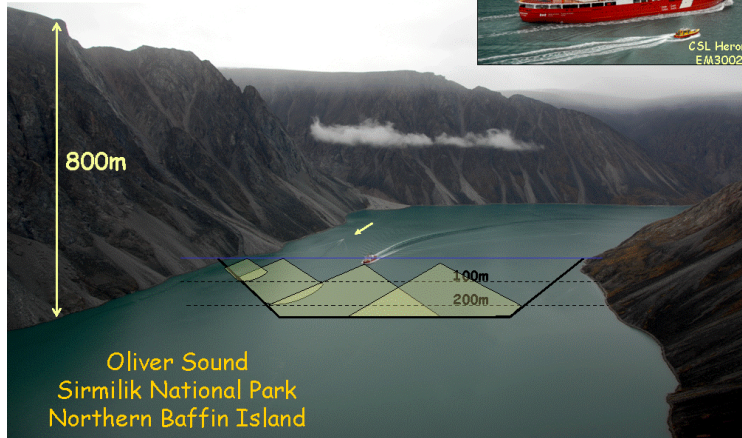
In 2006, CSL Heron was successfully deployed in the Arctic. With only a 1.15m draft and equipped with EM3002, 3.5 kHz subbottom and ancillary equipment, she is ideally suited to address a range of issues relating to coastal sedimentation indicative of recent sea-level variability and coastal processes.

Notable surveys included examining 3 pro-glacial deltas in Oliver Sound, Sirmilik National Park.

The intent of this survey is to create a baseline survey from which inter-year sedimentation can be examined (closely modeling the Squamish Delta program, but with significantly more difficult logistics). Other programs include mapping the seabed immediately in front of the retreating Belcher glacier to look at the recent history of the ice-stream and mapping within three fjords in Labrador as part of a collaborative project with Parks Canada.

#### Surveying in Fjords

EM300 (30 kHz) max ~ 3000m+  
EM3002 (300 kHz) max ~ 120-180m

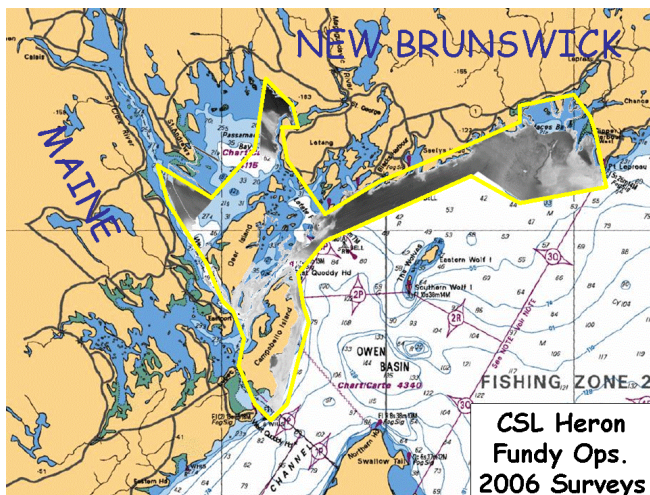


#### Fundy Isles Mapping and Data Integration

Cartwright, Church and Brucker, (OMG), Russell Parrott, (NRCan), Maria Ines-Buzeta and Peter Lawton (DFO-SABS)

Ocean Action Plan (Phase 1), NRCan and DFO-SABS funding

As a continuation of a multi-year program aimed at mapping the coastal waters of SW



New Brunswick, we operated the CSL Heron in the Campobello Island to Maces Bay Region.

The 2006 program utilized the EM3002 system for the first time (all prior data in SW New Brunswick has utilized the EM3000).

For the first time, the WebTide Scotian Shelf model was used for vertical control. This was done in an attempt to better account for the strong variation in phase and amplitude of the tide through this region. It was particularly necessary

in the channels on either side of Deer Island where the greatest phase changes are seen. This region is currently a focus of interest as it is a potential site for tidal power extraction.



The 2x2 minute mapsheet model, used in previous methods for data distribution was upgraded to utilize the new model implemented for the ArcticNet mapping.

### ***Squamish Delta-front Change Monitoring***

*Hughes Clarke and Brucker, (OMG), Hill and Iwanowska (GSC-P), Czotter (CHS-Pacific)*

*Chair and GSC-P (GOM Georgia Basin) funding*

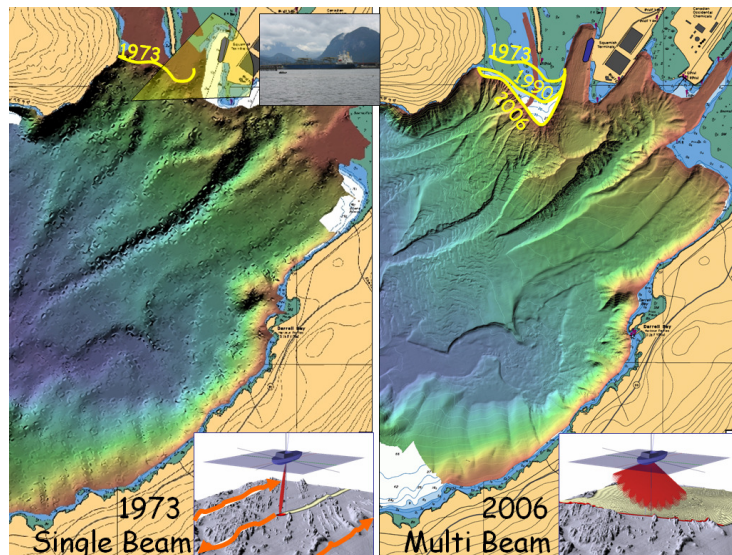
As a follow on from the Sands Head, Frazer River Delta change studies in 2005, a new project was implemented in 2006 to look at the Squamish Delta.

CHS single beam surveys are available for the delta front from 1973 and 1990. Two EM1002 surveys were conducted in 2004 and 2005 that examined the deeper part of the delta in more detail.

These data suffered significant refraction problems owing to the rapidly evolving water mass (the freshwater discharge of the Squamish River modulated by the tide).

The new mapping performed as part of this new program

utilized CCGS Otter Bay with an EM3002. Vertical control was performed using both PPK GPS and a local tide gauge. Frequent MVP-30 dips were performed to minimize the refraction errors.



These new surveys extended right up to the 5m contour. They clearly captured a major mass wasting event over the summer of 2006 that resulting in the loss of ~ 600,000 cubic metres of sediment. This single event reversed the long term trend of progradation of the nose of the delta.

## Education and Training Options

### ***Multibeam Courses***

The international training course organized by the Ocean Mapping Group was given 3 more times in the 2006 year in:

San Diego, CA	in January
Trieste, Italy	in June
Singapore	in November.

The course student body is typically 50 to 60 students per course in order to meet the continued growth in demand for this course. Latest results of research within the Ocean Mapping Group are used to update the course material to ensure that it keeps up with the latest trends in swath sonar surveying. We rely heavily on the benevolence of agencies for whom we conduct trials of their operational systems. As long as no restrictions are placed on these data, they are used as type examples in the course material.

### ***GGE Marine Survey courses :***

In order to ensure that the student body within the GGE dept. benefits from the research activities of the Ocean Mapping Group, a series of courses are provided that pass on both first principles and latest research results to both the undergraduate and graduate student body.

These courses include:

#### **UNDERGRADUATE:**

##### **GGE3353 Imaging and Mapping II, Acoustic Imaging Systems**

**Hughes Clarke and Beaudoin**

Theory of, and operational issues in acoustic marine surveying.

[http://www.omg.unb.ca/GGE/SE\\_3353.html](http://www.omg.unb.ca/GGE/SE_3353.html)

This is the core GGE undergraduate course that provides information about acoustic remote sensing. The student body is normally about 25-30 people, with normally about 5 graduate students. In this course, the principles of acoustic remote sensing are introduced and the theory and practice of singlebeam, sidescan and multibeam surveying are explained.

Laboratory exercises are included that provide the opportunity to implement bottom detection algorithms, to form and steer beams and to integrate the simultaneous output of motion sensing, positioning, sound speed profiles and tides together with a set of sonar relative angles and a two-way travel time to come up with a final sounding solution.

##### **GGE4042 Kinematic Positioning**

**Santos**

Marine, Terrestrial and Airborne dynamic navigational theory and methods.

### GGE5072 Hydrographic Data Management

**Wells**

Principles and issues of data management in marine applications

This was not given in 2006.

### GGE5013 Oceanography for Hydrographic Surveyors.

**Hughes Clarke**

Theory of tides and the reduction of sounding data to a stable vertical datum.

Coastal Oceanographic and Geologic Processes.

[http://www.omg.unb.ca/GGE/GGE5013\\_Fall\\_2006.html](http://www.omg.unb.ca/GGE/GGE5013_Fall_2006.html)

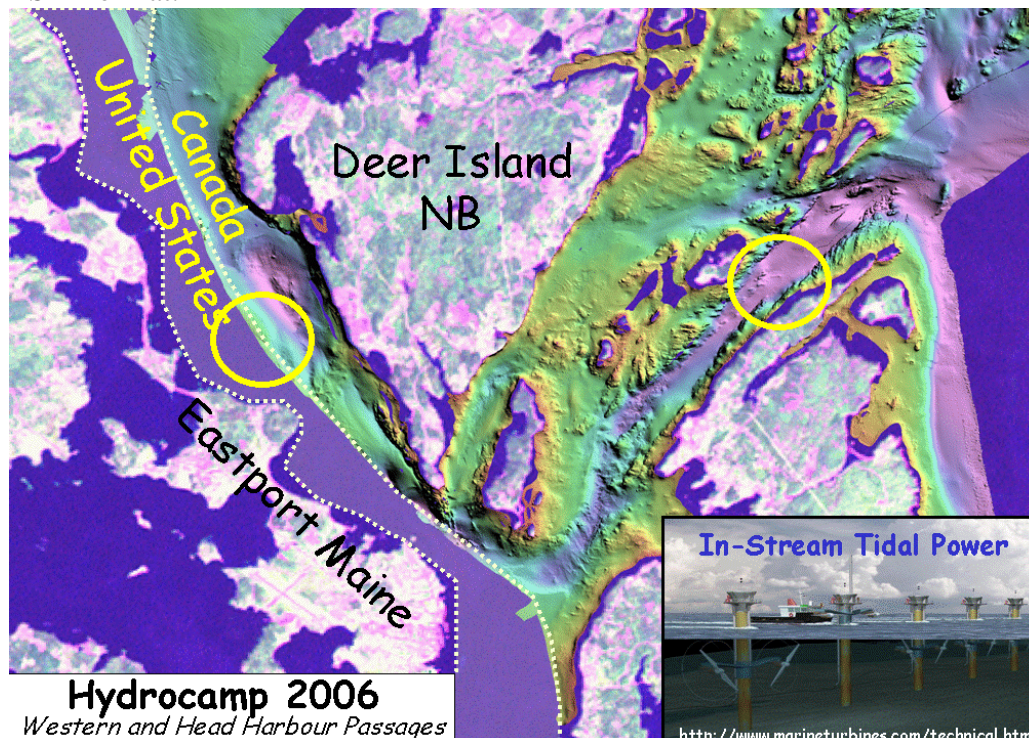
### GGE5083 Hydrographic Field Operations

**Hughes Clarke**

Planning, execution and data processing for a coastal marine field program

In 2006 the Hydrocamp was based out of Saint Andrews in Passamaquoddy Bay, New Brunswick. The survey objectives were to build on the preexisting coverage in the Fundy Isles region as part of a regional ecological and habitat study. The data were nevertheless collected according to IHO Order 1 specifications.

The survey used the CSL Heron with her EM3002 as the prime survey platform. Tidal control was maintained using a pressure gauge at the St. Andrews dock. All data were processed in the field and the results were added to an on-line data portal that allowed the clients (DFO-St Andrews) to download the combined data as 2x2 minute mapsheets in ESRI format.



*Composite image showing the EM3000 multibeam data, acquired during the **2006 GGE5083 Hydrocamp** field operations, blended with the 1992-2005 data from the archived data to the east. Underling LandSat Imagery is from GeoGratis.  
Location of the two proposed in-stream tidal power sites is indicated.*

## GRADUATE:

### GGE6023 Multibeam Sonar

**Hughes Clarke**

Research Topics on Swath Sonar Systems.

[http://www.omg.unb.ca/GGE/SE\\_6023.html](http://www.omg.unb.ca/GGE/SE_6023.html)

This course is designed to allow the graduate students the chance to extract all the raw information from a binary multibeam datafile, including raw range, mount angles, steering angles and two-way travel times along with asynchronous orientation and position time series. The students are required to recreate from scratch the final sounding solution, writing all the algorithms themselves.

This exercise serves as a training for software development for their swath sonar related research. Most students in the Ocean Mapping field end up using these skills as part of their research.

### GGE6022 Special Topics in Ocean Mapping

**Hughes Clarke**

Research Topics in Ocean Mapping (Sediment Characterisation, Coastal Physical Oceanographic Phenomena, Marine Sedimentation, Environmental Monitoring).

[http://www.omg.unb.ca/GGE/GGE6022\\_Fall\\_2003.html](http://www.omg.unb.ca/GGE/GGE6022_Fall_2003.html)

Each student picks a geographic region, normally a semi-enclosed coastal or continental shelf area for which there is a reasonable existing literature describing the oceanographic and geological environment. In the first part of the term, the student is required to write a review of the known bathymetric framework, the principal bedrock controls, the location and magnitude of fresh water inputs and the rainfall, wave activity and winds. In the second half they write a review of the surficial sedimentary and oceanographic environment.

The aim is so that the student can learn how to browse the scientific and environmental literature to glean pertinent information that might effect the design and conduct of a hydrographic, geophysical or oceanographic survey in the region.

### GGE6021 Special Studies in Hydrography

**Wells**

Research Topics in Aspects of Hydrography

GGE5543-6543 Marine Policy, Law and Administration  
Nichols



## Funding and Financial Commitments

Funding for the Chair in Ocean Mapping comes from two sources:

- Sponsorship funds
- Other research organisations

To maintain the Chair technical and administrative staffing at the current levels and to support the necessary field programs, infrastructure upgrades, computing facilities and travel to international meetings, an annual budget of ~**C\$150-200k** is required. To date, this level of support continues to be met or exceeded. The continuation of this level of support, however, will require ongoing commitment from the sponsors of the Chair. That in turn requires that the Chair can show continued relevance and usefulness toward the marine survey community.

## Sponsors

The Chair in Ocean Mapping at UNB can only survive as long as there is external funding. The Chair, originally set up as an NSERC Industrial Research Chair, originally survived by the combination of Industrial Sponsorship together with matching funds from NSERC. In 1996, on the renewal of the Chair the matching funds were withdrawn as planned. From that point on the Chair has been fully dependent on external funding (from Canadian or International, Commercial or Government organizations). At this point there are 6 sponsors. Typical sponsorship levels are ~ US\$25kpa.

### Current Sponsoring organisations

1. Kongsberg Simrad Mesotech	1995 -
2. U.S. Geological Survey	1996 -
3. Fugro Pelagos	2003 -
4. Royal U.K. Navy	2003 -
5. Rijkswaterstaat	2005 -
6. Canadian Navy - Route Survey	2006 -

Active sponsors have access to all current research results developed with Chair funding (at a source code level) and are free to call upon the chair personnel to provide informal advice on operational survey issues. In addition, the chair actively seeks advice on new relevant research directions. Graduate student research topics are driven by Chair needs and access to operational survey data for research purposes is routinely derived from sponsor-owned or chartered vessels and equipment. The continued success of the chair is thus clearly critically reliant on the continued relevance and leadership of Chair research. As this document outlines, new focused research directions are actively being pursued based on current sponsorship suggestions.

## Other Sources of Funding (Current)

Whilst the sponsorship funding is the prime source of support for the core Chair research program, all the researchers working with the Chair have been successful in attracting funding from other research agencies. This funding allows us to complement Chair research, which is by design very focused on immediately relevant problems, with research into more long term and esoteric problems.

Projects names (details of which are included in the list of current research) and level of funding in **2006** include:

Collection and processing of Multibeam Bathymetry data for Passamaquoddy Bay and Maces Bay in the Bay of Fundy

Ocean Action Plan, Natural Resources (Parrott)

Hughes Clarke C\$50,000

Managing Spatially-variable Tidal Datums for Multi-Year South West New Brunswick Multibeam Bathymetric Data and Application to Sediment Transport for GSC-A.

Ocean Action Plan, Natural Resources (Parrott)

Hughes Clarke \$60,000

Processing of Amundsen and Heron multibeam data, NorthWest Passage for GSC-A

Ocean Action Plan Natural Resources (Blasco)

Hughes Clarke C\$38,000

Improved mapping and monitoring techniques to resolve seabed change and associated coupling with the watercolumn.

NSERC Discovery Grant

Hughes Clarke C\$26,000 pa

Labrador Margin – Frontier Geoscience Mapping -2006

Natural Resources Canada (Sonnichsen)

Hughes Clarke C\$45,000

Fundy Isles Mapping

DFO –SABS (Buzeta)

Hughes Clarke C\$20,000

ArcticNet – 1.6 – The Opening North West Passage

NSERC –NCE

Hughes Clarke et al., C\$131,000

GEOIDE – LIDAR project

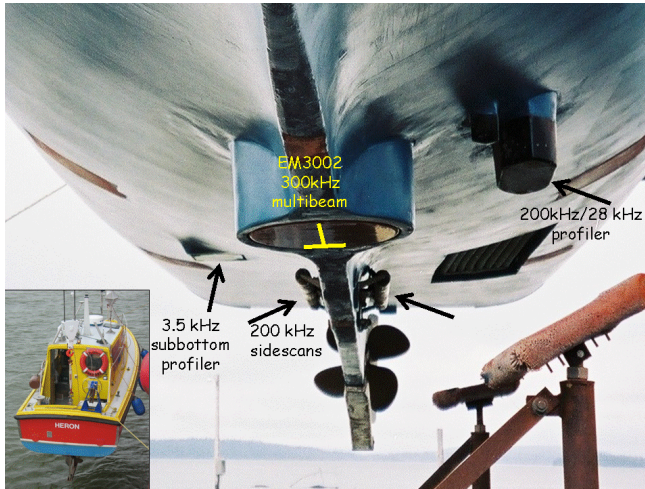
NSERC – NCE

Hughes Clarke (subproject of Long FUDORTERAM) C\$38,000pa

## Hardware Capabilities

### *Equipment to Support Field Research Programs*

#### CSL Heron:



At the end of the 2005 year, our mapping hardware capabilities were almost totally replaced due to the sinking of the Heron. All survey and navigational electronics were replaced. And the main engine was also replaced.

The net result was the vessel has the near identical mapping capability with improved speed (from 11 knots to 17 knots).

In hindsight, as nobody was hurt, the

rebuilding improved the reliability of the mapping system which contributed greatly to the success of the Arctic Mapping programs.

#### Positioning

**CNav** suite rover station capable of RTG output and full RINEX logging for post-processing.

#### Sonar Systems

**Simrad EM3002S** 300 kHz multibeam sonar system

Knudsen 320B/P 2 x 200 kHz keel-mounted sidescan staves.

**Knudsen 320M 28 kHz and 3.5 kHz.** Subbottom profilers

#### Oceanographic Instrumentation

**RDI 600 kHz Monitor ADCP** with Winriver software.

**Brooke MVP-30** winch, towbody, overboarding Sheave with AML Smart CTD (25 Hz).

Optical Backscatter probe.

#### Heading and Orientation Sensors

**Seatex MRU-6** Orientation and heading sensor

**CodaOctopus F180** – GPS-inertial integrated position and orientation system

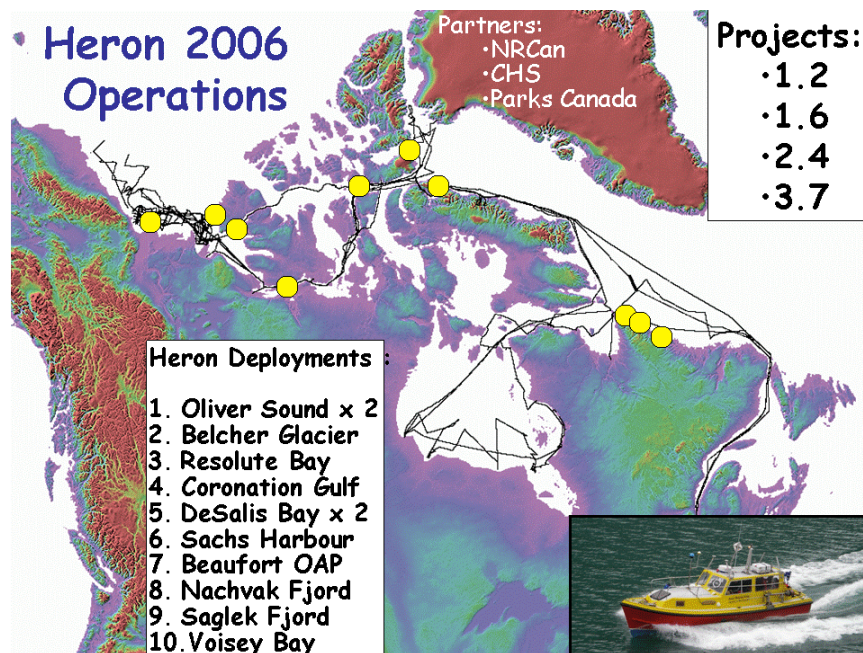
## ***Heron Field Operations***

For the 2006 field season she was deployed both in South West New Brunswick Waters and in the Arctic.

The following field programs were undertaken between April and the end of June 2006 using the Heron:

<b>Location</b>	<b>Funding</b>
1. Passamaquoddy Bay	DFO-SABS (Hydrocamp)
2. Maces Bay	NRCan – GOM/OAP

In July she was trucked to Quebec City for loading onto the CCGS Amundsen. This time, she successfully sailed without mishap and undertook 10 surveys in the Arctic as indicated in the following figure:



At the end of 2006, the Heron was trucked back to Fredericton and stored in the Forestry complex after being stripped of all electronics for the winter.

## Publications:

**2006****Journal Articles**

- Bartlett, J., Beaudoin, J., Hughes-Clarke, J., Brucker, S., Blasco, S., and Bennett, R. 2006. ArcticNet: The Current and Future Vision for its Seabed Mapping Program. **The Hydrographic Journal**, No. 122, pp. 11 – 16.
- Hughes Clarke, J.E., 2006, [Applications of Multibeam Water Column Imaging for Hydrographic Survey](#): **The Hydrographic Journal**, April Issue.
- Hughes Clarke, J.E., Brucker, S. and Czotter, K., 2006, [Improved Definition of Wreck Superstructure using Multibeam Water Column Imaging](#) : **Lighthouse, Journal of the Canadian Hydrographic Association**, Edition No. 68
- Beaudoin, J, Hughes Clarke, J.E. and Bartlett, J., 2006, Usage of Oceanographic Databases in Support of Multibeam Mapping Operations Onboard the CCGS AMUNDSEN: **Lighthouse, Journal of the Canadian Hydrographic Association**, Edition No. 68
- Intelmann, S.S., J. Beaudoin, and G.R. Cochrane. 2006. [Normalization and characterization of multibeam backscatter: Koitlah Point to Point of the Arches, Olympic Coast National Marine Sanctuary - Survey HMPR-115-2004-03](#). **Marine Sanctuaries Conservation Series MSD-06-03**. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Marine Sanctuaries Division, Silver Spring, MD. 22pp.

**Conference Proceedings**

- Hughes Clarke, J.E., Lamplugh, M. and Czotter, K., 2006, [Multibeam Water Column Imaging: Improved Wreck Least-Depth Determination](#): Proceedings, **Canadian Hydrographic Conference 2006**, CDROM.
- Bartlett, J., Beaudoin, J., Hughes Clarke, J.E., and S. Brucker (2006), [ArcticNet: The Current and Future Vision of its Seabed Mapping Program](#) : Proceedings, **Canadian Hydrographic Conference 2006**, CDROM.

**Technical Reports**

- **Hughes Clarke, J.E.** (2006) Baruna Jaya III - Simrad EM12D trials - Baruna Jaya III 18th December 2006: Contract to Black Gold Energy, Jakarta.



## Theses

- Nicole Delpeche (MSc) - 2006 - [Observations of Advection and Turbulent Interfacial Mixing in the Saint John River Estuary, New Brunswick, Canada](#)
- Garret Duffy (Ph.D) - 2006 - [Bedform Migration and Associated Sand Transport on a Banner Bank: Application of Repetitive Multibeam Surveying and Tidal Current Measurement to the Estimation of Sediment Transport](#)

## Invited Presentations:

- JHC - UK Hydrographic Society Plymouth - October 2005 - *Exactly where was the shallowest point on a wreck? Incorporating multibeam water column volume imaging into hydrographic quality control*
- JHC - IOS Friday Lecture Series, Sidney, BC - March 2006 - *Multibeam - Water Column Imaging, Applications for Hydrography and Oceanography*
- JHC - USGS - Woods Hole, MA - ~ May 2006 - *Multibeam - Water Column Imaging, Applications for Hydrography and Oceanography*

## Other Conference Presentations

- R. BENNETT<sup>1</sup>, S. BLASCO<sup>1</sup>, J. HUGHES-CLARKE<sup>2</sup>, J. BEAUDOIN<sup>2</sup>, J. BARTLETT<sup>2</sup>, A. ROCHON<sup>3</sup> AND T. SCHELL<sup>3</sup>, 2006, Seabed morphology, geologic framework, and paleoceanography of the NW Passage: ATLANTIC GEOSCIENCE SOCIETY, Program with Abstracts, 32ND COLLOQUIUM AND ANNUAL GENERAL MEETING 3-4th February, 2006
- Patrick Lajeunesse<sup>1</sup>, Guillaume St-Onge<sup>2</sup>, John Hughes Clarke<sup>3</sup> and Jonathan Beaudoin<sup>3</sup>, 2006, Late-Quaternary glacial and postglacial geology of Hudson Bay and western Hudson Strait: new evidence provided by the CCGS Amundsen: ArcticNet ASM
- Trevor Bell, Dominique St. Hilaire, John Hughes Clarke, Lev Tarasov, Martin Sharp, 2006, Seabed Mapping at the terminus of Belcher Glacier, Devon Island, Nunavut : ArcticNet ASM
- Church, I. <sup>(1)</sup>, Haigh, S. <sup>(1)</sup>, Brucker, S. <sup>(1)</sup>, Hughes Clarke, J.E. <sup>(1)</sup> Comparing GcGPS ellipsoid height records, predicted tides and a Hydrodynamic Circulation Model for the Pond Inlet, Eclipse Sound and Navy Board Inlet System : ArcticNet ASM
- Beaudoin, Jonathan <sup>(1)</sup>, Hughes Clarke, J.E. <sup>(1)</sup> Impact of InterAnnual Oceanographic Variability on ArcticNet Multibeam Echosounding Post-Processing: ArcticNet ASM
- Hughes Clarke, John, E. <sup>(1)</sup>, Brucker, S. <sup>(1)</sup>, Church, I. <sup>(1)</sup>, Bell, T. <sup>(2)</sup>, Forbes, D. <sup>(2)</sup>, Glacial and PostGlacial seabed modification in Oliver and Eclipse Sounds, Sirmilik National Park, Nunavut: ArcticNet ASM.
- Bennett, R., Blasco, S., Kostylev, V. MacLean, B., Rochon, A., Hughes-Clarke, J., Beaudoin, J., Bartlett, J., Seabed processes and geological structure of the Northwest Passage : ArcticNet ASM