



Chair in Ocean Mapping

Research Activity - 2005 Calendar Year



"home of the Heron"

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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 2005 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

Lake Powell –Submarine Mass Wasting

As part of a new collaborative project between UNB, Duke University and the U.S. National Park Service we conducted a 10 day multibeam survey of the floor of Lake Powell. The Lake is the drowned section of the old Glen Canyon that lies immediately upstream of the Grand Canyon straddling the States of Arizona and Utah.

Dammed in 1963, the lake is 300 km long and now has ~ 130m of water in its southern end. It is fed by the Colorado and San Juan Rivers which drain the Rocky Mountains. During the snow melt period, the river discharges are enormous and have been dumping large volumes of fine-grained sediment into the upstream ends of the lake. This survey was specifically designed to examine the evidence for sediment infilling as a result of this.



Using an EM3002 multibeam on a Parks vessel, the entire lake was mapped and the results put on line at:

http://www.omg.unb.ca/Projects/LakePowell/MapSheets/OMG_UNB_Lake_Powell_MapSheet_dep_0.html

The major two finds were evidence of post-flooding landslides and active mud flows. The submerged portions of recorded landslides, known from above-water scars on the canyon walls, were imaged. Additional, previously undocumented mass-wasting events were

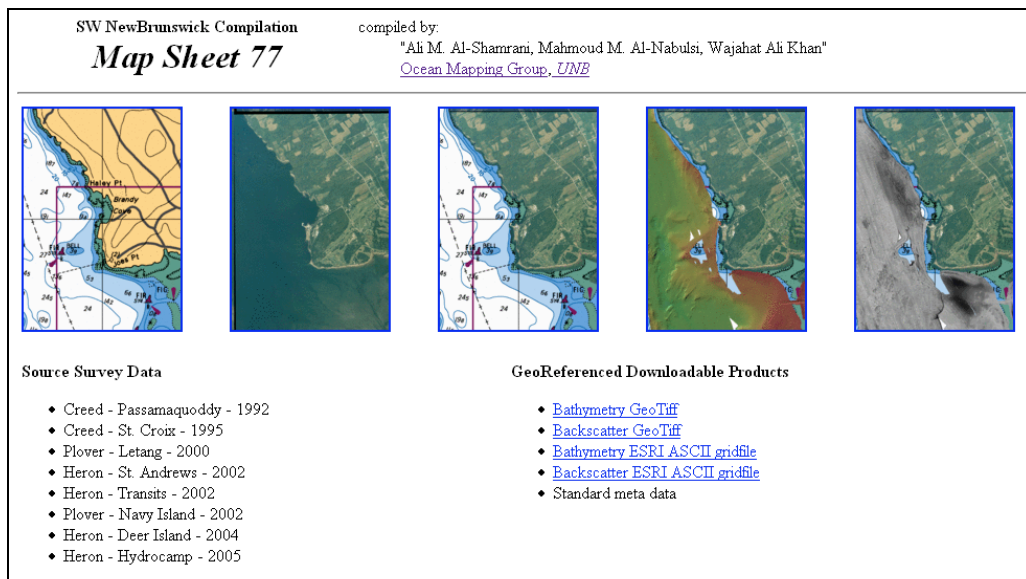
found in the Escalante Branch which have completely blocked the canyon talweg, restricting the movement of turbidity currents and debris flows past that point.

The most startling discovery was the imaging of actively moving mud flows. Lens-like bodies of soft sediment are prograding along the canyon floor at rates of about 6m per hour. Successive passes clearly showed the flow moving forward from day to day. The flows are characterized by a surface braided or anastomosing pattern. A prior sidescan survey in 2004 revealed no evidence of these flows.

This survey is forming the basis for future repetitive surveys to monitor the accretion of sediment in the lake. Follow-on surveys were conducted in late 2005 (ADCP) and a planned multibeam resurvey is scheduled for 2007. In addition to the monitoring aspect of the surveys, they represent a unique opportunity to develop new geomatic software tools to cope with multibeam bottom tracking in extreme relief environments. For example, the newly-developed OMG tools for multibeam water-column imaging were first developed for this EM3002 survey and have now been adapted for the EM710 as well.

Fundy Isles – Habitat Mapping

Since 1992, the OMG has been an active partner in collaborative coastal mapping programs in the Fundy Isles region, extending from St. Stephen to Grand Manan. In the past 2 years (2004, 2005) we have been building on this data compilation, gradually creating a seamless coverage of the area using the CSL Heron.



In 2005, in collaboration with DFO- St Andrews and Acadia University we acquired further data in the Deer Island region and for the first time, compiled all the existing data from 1992 to 2005 into an on-line series of downloadable map sheets.

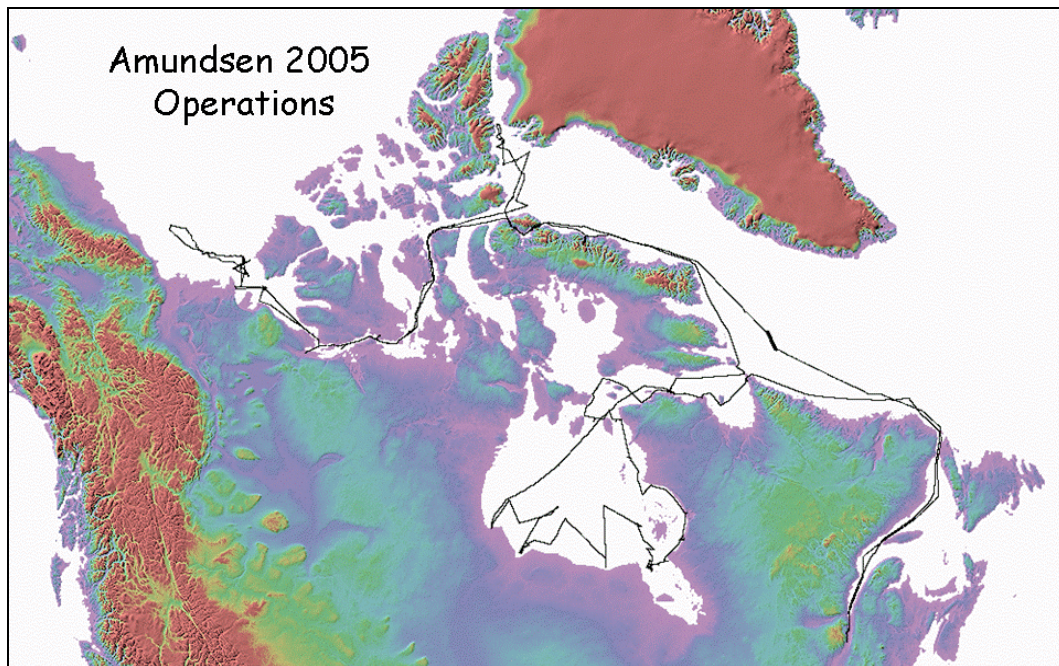
<http://www.omg.unb.ca/Projects/SWNB/>

This data is being used by academics, coastal engineers, aquaculture managers, inshore fisherman, the local ferry operators and whale-watching operators. The field design, acquisition and processing component is used as a training exercise for graduate and undergraduate students in the Hydrography and Ocean Mapping program.

CCGS Amundsen ArcticNet 2005 Operations

The Ocean Mapping Group are leading ArcticNet Project 1.6 “the opening NW Passage”, with a focus on seabed investigations along the various channels through the Arctic Island Archipelago. It is postulated by climatic modelers that the NW Passage could be significantly ice free (to the point of being a viable shipping lane) within 50 years.

The underlying reason for this investigation is to examine the recent geological history of the passages to determine likely changes in oceanography and sedimentation in the event of receding sea ice. An additional requirement is to map the region as a first step towards the opening of a new inter-continental shipping corridor and a region of new natural resource exploitation. The new data will be used to aid in decision-making in support of adaptive strategies to cope with the predicted, climate-induced change in the Canadian Arctic.



In 2005, 84 days of underway multibeam and subbottom was acquired by the OMG as part of the ArcticNet National Centre of Excellence.

Highlights of the 2005 expedition were:

- Investigation into the Proximal Signature of Heinrich Events in the Labrador Sea
- Identification of Active Gas Venting in Barrow Strait
- The first development of a new shipping corridor on the south side of Coronation Gulf.

As part of this program, UNB-led geomatics research projects included:

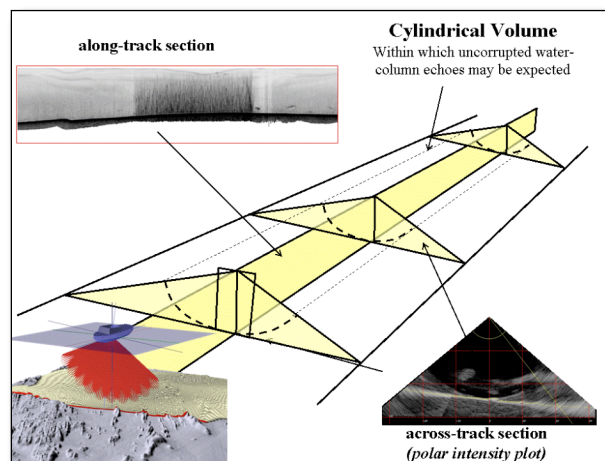
- The use of C-Nav GcGPS for vertical referencing for tidal control
- The use of the oceanographic databases as a source of sound speed control
- Beam pattern removal from ice-shielded EM300 multibeam backscatter

Major Research Developments

Use of Multibeam Water Column

In 2005 we had our first experience of EM3002 and EM710 water column imaging. The 3002 has been available since 2004 but no users of the water column imaging had emerged to date. The EM710 is a new system, for which the Ocean Mapping Group conducted the field acceptance trials of the first two installations (CCGS Matthew and HMS Endurance).

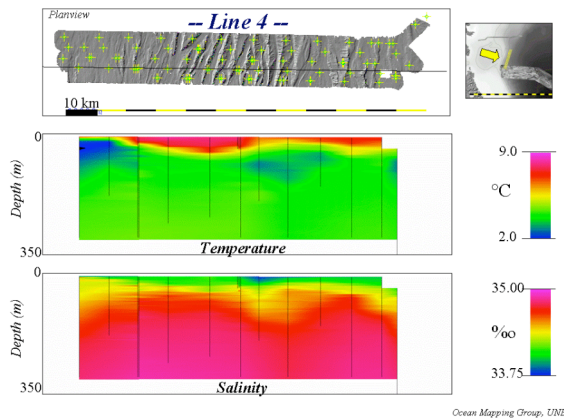
In Lake Powell and as part of the Heron upgrade trials we developed software to extract, display and post-process echo-intensity time series for each of the EM3002 beam forming channels. The 3002 uses a single transmit sector making the analysis quite standard. The 710, in contrast is a 3 sector system.



Working with the first two EM710 systems, CCGS Matthew and HMS Endurance, we have investigated the use of multibeam water-column data for reasons beyond fisheries imaging including:

- Noise Analysis – Ship-generated and other sonars- direct and reverberated
- Thermocline and Internal Wave Imaging
- Wreck and other engineering structure imaging.

Multi-Sensor Oceanographic Imaging

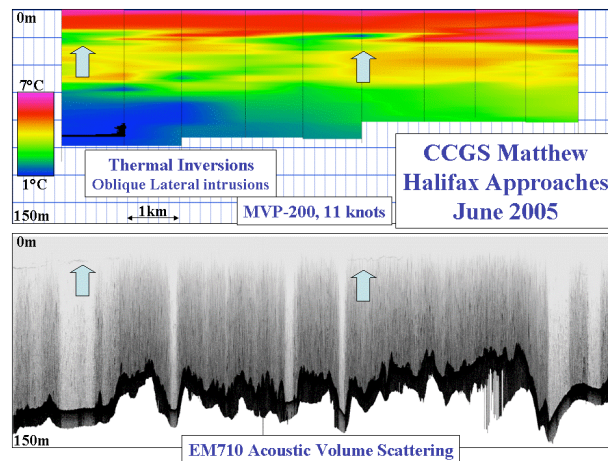


As part of an ongoing effort to make better use of the underway sound speed profiling equipment increasing being used, we have conducted experimental trials and developed software to support new applications in ocean imaging.

To support science mapping and UNCLOS boundary delineation work, an MVP-300 T and S survey was carried out on the back of EM300 multibeam mapping in the Labrador Sea. The survey revealed cold core rings at the base of the thermocline. These rings,

which are spaced ~ 50km (~3 hours steam) apart, would previously have been undetected, resulting in loss of hydrographic accuracy. In addition to the hydrographic survey quality aspect, these data provide the first detailed view of the structure of the meandering edge of the Labrador Current.

A similar set of experiments were performed using the CCGS Matthew MVP-200 along sections off the Halifax Approaches. These data are unique in that they were collected concurrently with the new EM710 water column imaging option allowing us to correlate for the first time, the presence of enhanced thermocline scattering (and associated internal wave fields) against local temperature minima at the base of the thermocline.



The results obtained using these high-density oceanographic observations allow us to provide control on the hydrodynamic modeling that is being conducted by the OMG in various regions including the Musquash Estuary and the lower Saint John River Estuary.

Recent Infrastructure Upgrades - Instrumentation

EM3000 → EM3002

As part of the planned hardware upgrades for the 2005 field season, the EM3000 multibeam on the Heron was upgraded to an EM3002. This utilized the same sonar head, but replaced the transceiver. The result is that, using the same apertures, the system has the following improved capabilities:

- Higher ping rates
- Roll-stabilized receiver beamforming
- Higher number of physical beamforming channels (127→160)
- Option of equidistant beam spacing and user-selectable sector.
- High-Definition beam forming algorithm allowing up to 254 beams
- Water Column Imaging

The system was upgraded and tested in July 2006 and would have been used operationally, were it not for the ...

Sinking of the CSL Heron.

The major setback to the OMG infrastructure occurred in late July 2005 when the CSL Heron was being loaded aboard the CCGS Amundsen for Arctic operations. A cable clamp holding the aft davit cable failed, allowing the vessel to slip abruptly stern first. She was suspended vertically for a moment and then dropped in to the water, punching a hole in the hull as she swung past the mother ship. She filled with water and sank adjacent to the vessel whilst at the dock in Quebec City. Fortunately the crew had just disembarked and thus nobody was hurt.

After four days, the Heron was recovered by crane from the river bed. The hull and superstructure were badly damaged and all the shipboard electronics were lost. Fortunately the majority of the items were insured and she is now currently being rebuilt and re-equipped for 2006 operations.



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Personnel

Faculty

John E. Hughes Clarke	Associate 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	Contract Researcher <i>Numerical Modeling of Coastal Circulation</i>
Dr. Jianhu Zhao	NSERC Postdoctoral fellow (until Jan.2005) <i>RTK GPS – Heave integration</i>

Support Staff

Shawn Woo	System Manager (until May 2005)
Anya Duxfield	Research Assistant (until April 2005)
Jonathan Beaudoin	Research Assistant -ArcticNet
Jason Bartlett	Research Assistant - CHS Central and Arctic
Steve Brucker	Undergraduate Research Assistant
Ian Church	Undergraduate Research Assistant
James Leslie, Howard Ingalls	CSL Heron
Tracey Hawco	Accounting

Graduate Students

Garret Duffy	JHC	PhD 2001-
Jonathan Beaudoin	JHC	PhD (part-time) 2001-
Karen Cove	MS	M.Sc.Eng 2002 - 2005
Kristian Llewellyn	JHC	MEng 2003- 2005
Jon Griffin	JHC	MEng 2003- 2005
Christian Solomon	MS	MEng 2003-2005
Nicole Delpeche	JHC	MscEng 2003-
Xinhai Li	ML/JHC	PhD 2004-
Reza Ghoddousi-Fard	PD	PhD 2004 -
Pim Kuus	JHC	MEng 2005-
Marketa Pokorna	JHC	PhD 2005-
Aluizio Oliviera	JHC	MEng 2005 -

Adjunct Faculty or Active Collaborators in 2005

Larry Mayer	Adjunct Professor, University of New Hampshire
Russell Parrot	Research 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	Associate Professor Earth and Ocean Sciences, Duke
Matthew Littvak	Associate Professor UNBSJ – Biology
Dave Scott	Professor Dalhousie - Geology
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
Karl Butler	Associate Professor, UNBF - Dept. Geology
Steve Intelman	Researcher NOAA – National Marine Sanctuaries
Brian Maclean	Emeritus Scientist NRCan – GSC Atlantic
Mark Anderson	Research Scientist – Manager U.S. National Park Service, Page AZ
David Piper	Senior Research Scientist NRCan – GSC Atlantic
Trevor Bell	Professor Memorial Universtiy – Geography
Ron Boyd	Professor – Environmental Sciences University of Newcastle, Australia
Phil Hill	Research Scientist NRCan – GSC Pacific

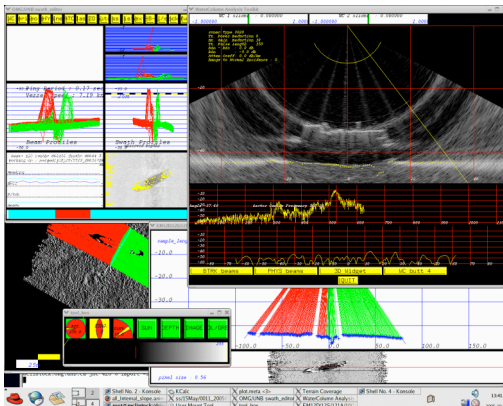
Active Research Directions

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

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 2005 year include.

- EM710 – EM3002 Water Column Imaging
- Full 16 bit SEG Y Carrier Trace maintenance in SwathEd subbottom tools.
- Ability to use SwathEd tools on a Windows platform using the cygWin X Server.

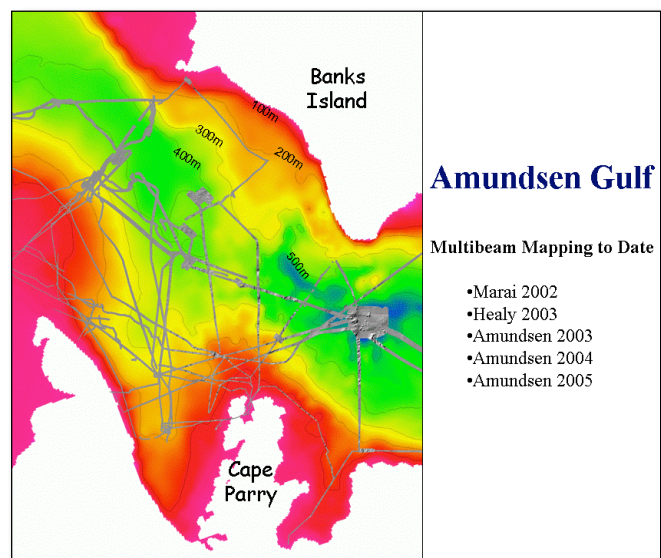
Beaufort Sea - NorthWest Passage Mapping 2005

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 2005.

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 3 years of mapping, however, significant insight is 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.

In order to address the navigational aspects, a new shipping route corridor was investigated on the south side of Coronation Gulf. By building up offset swaths of multibeam data, a safe passage over the uncharted bedrock outcrop ridges known in the region is being mapped. In 2006, this corridor will be the focus of further mapping.

Hudson Bay, Hudson Strait and Baffin Shelf – Geoscience Mapping

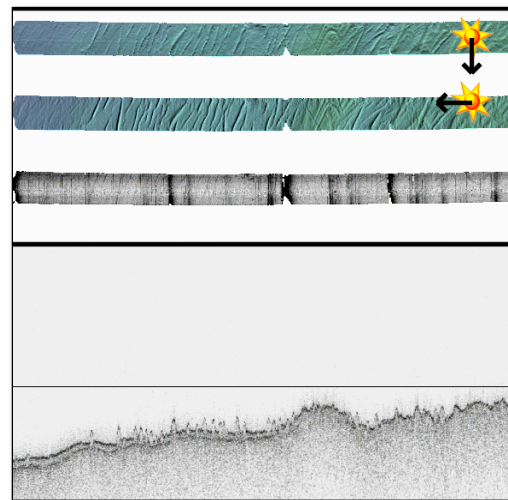
*Bartlett, (CHS), Beaudoin (GGE), LaJeunesse, (Laval) and Maclean (NRCan)
ArcticNet and Laval Funding*

Whilst the OMG is strictly only funded to work on the NW Passage, the staff remain on board for the entire Arctic deployment and collect underway multibeam and subbottom data to support other research programs. A major component of this work in 2005 was located in Hudson Bay.

This work was done in collaboration with Laval and NRCan Quaternary scientists to better understand the Holocene emergence of the Hudson Bay region. LaJeunesse is focusing on the sea level history of central Hudson Bay around Southampton Island and Maclean is focusing on the palaeo ice-flow directions in Hudson Strait.

The surveys build on data acquired using analog technology in the 1970's and 1980's. Given the sparse coverage of the old data, these new data provide unique new insights into an area of enigmatic glacial history.

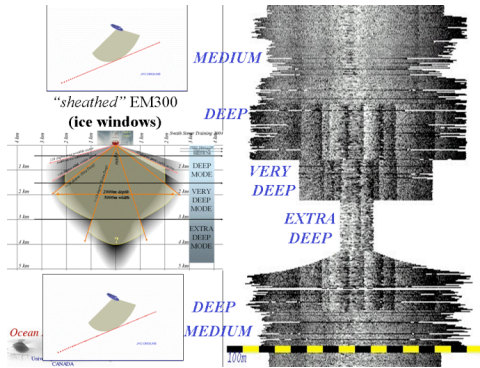
From the point of view of Ocean Mapping the area presents particularly challenging problems for vertical control as the tidal regime ranges from 2 to 13 metres as one moves from the Bay into the Strait. C-Nav GcGPS is seen as the only viable solution for working in this remote and huge region.



EM300 Multi-Sector Beam Pattern Issues

Llewellyn and Hughes Clarke (OMG)
ArcticNet funding

The EM300 on the Amundsen uses either 3 or 9 sectors on transmit to best compensate for yaw and pitch. Whilst the multi-sector approach is a huge benefit to maintaining even sounding spacing, it proves significant problems in backscatter processing.



The MEng project of Kristian Llewellyn was focused on improving the OMG beam pattern reduction software to handle this problem. The main issue to resolve was calculating the original sectors used (not documented in the telegrams) and estimating the original launch and receive

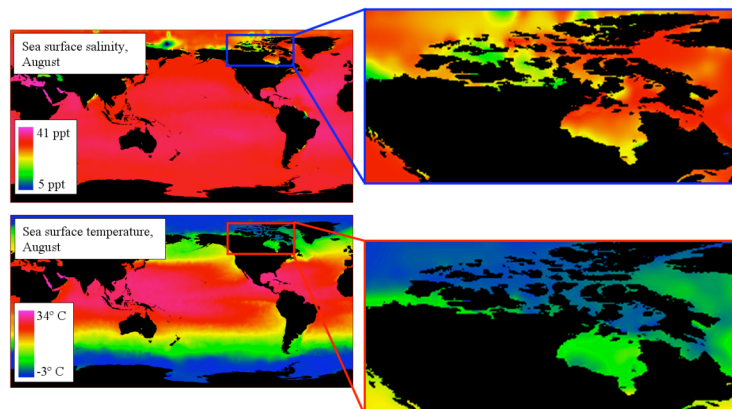
angles. Further work was done to automatically detect when the sonar changed ping modes so that an appropriate beam pattern model could be used.

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 2005 the MVP-300 fish was lost in the Labrador Sea and this reduced even further the ability to obtain reasonable sound speed information. CTD stations every 24 to 48 hours were all that was available. 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.

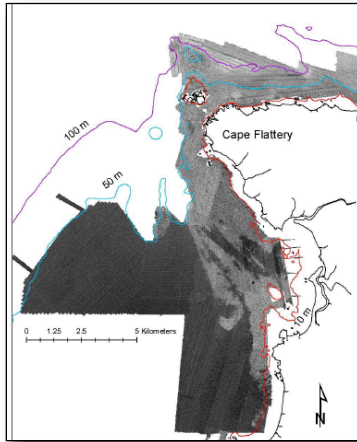
The World Ocean Atlas Database of global ocean temperature and salinity structure was embedded in the SwathEd software to automatically provide a best estimate of the water column structure in the absence of better information. By combining this with the more-generally available keel-depth sound speed probe, it was demonstrated that errors due to refraction could be managed within IHO order 1 error bounds.



Normalization and characterization of multibeam backscatter: Olympic Coast National Marine Sanctuary

Jonathan Beaudoin (OMG) and Steve Intelman (NOAA-NMS)

NOAA funding



A regional scale inshore multibeam bathymetric and backscatter survey was conducted of the U.S. Olympic Coast National Marine Sanctuary by the launches off the NOAA ship Rainer. The purpose of the survey was to characterize the seafloor in the sanctuary into discrete habitat types.

Using software uniquely developed at the OMG, the raw RESON 8101 backscatter intensity data was corrected for source power, pulse lengths, receiver gains and beam patterns to provide a regional map of bottom backscatter strength. This data was then analyzed using textural methods to generate attributes within a hierarchical deep-water marine benthic classification scheme.

CCGS Matthew EM710 Acceptance and Operational Trials

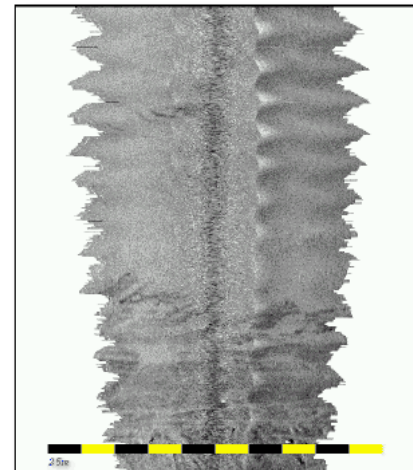
Hughes Clarke, (OMG) and Lamplugh (CHS-Atlantic)

CHS and Chair Funding

The Canadian Hydrographic Service took delivery of one of the first two EM710 sonar systems in the world. The system is the first that provides multi-sector transmits, water column imaging and beam focusing both on transmit and receive. In order to assess the operational performance of this first-of-class, a series of experimental trials were conducted on board CCGS Matthew in June 2005 in partnership between the CHS and the OMG.

The version of the 710 tested was the simpler 2°x 2° system. The aim was to see whether it matches or exceeds the performance of the previously installed EM1002 and the EM1000 (recently removed from the CCGS Creed.).

Target detection trials were performed indicating that the system could comfortably meet IHO Order 1 target detection requirements. The main concern expressed was the noted deeper penetration of the 70 kHz sector in very soft muds with respect to the central 97 kHz central sector and a notable beam-pattern residual in the port-sector.



This was also the first test of the 710 water column imaging. Fish schools, thermoclines and wrecks were used as test targets to assess its capability. The results indicate clearly that the sonar can provide a significant range of products beyond the standard hydrographic mapping role envisaged for the CCGS Matthew.

Capability Acceptance Trials – HMS Endurance, HMS Roebuck

Hughes Clarke (OMG)
Royal Navy Funding

As part of collaborative research with various agencies, the OMG actively conducts capability acceptance trials for the latest systems. In 2005, formal field trials were conducted for 2 vessels :

- HMS Endurance – EM710
- HMS Roebuck – EM1002

For each vessel a 7 day period is used at sea, undergoing operational testing and analysis of the integrated survey system. The results are presented as a formal report. Deficiencies in the survey system are noted and subsequent tests are analysed by the OMG. As part of the agreement, the data is used as teaching and research material within the Department here at UNB. This approach allows us to keep up to date with the latest developments in survey hardware capability.

The EM710 on the Endurance performed similarly to the CCGS Matthew system. It did not suffer the beam pattern residual problems seen on the Matthew, but suffered from poorer seastate performance, as expected when comparing the gondola-mounted array on the Matthew versus the flush-mounted array necessary for the Endurance ice-breaker hull.

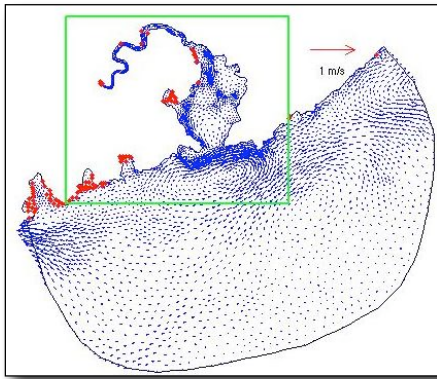


As expected, the EM1002 on the Roebuck, performed near-identically to the EM1002 on HMS Echo and HMS Enterprise, as analyzed by the OMG in 2003 and 3004.

Musquash Estuary – Hydrodynamic Modeling of Circulation

Haigh and Hughes Clarke, (OMG), Buzeta, (DFO-SABS)
Chair Funding

A limitation of an earlier model of the Musquash estuary (using QUODDY, barotropic with wetting and drying) was that, whilst it adequately showed the flushing of the interior of the estuary, it failed to accurately reproduce flow outside the estuary mouth including headland- associated shadowing of the current field and the circulation about a headland associated eddy .



The model was therefore adjusted in 2005 to have more distant boundaries so that circulation around the adjacent headlands could be included. The model was nested into the lower resolution M2 model of the whole bay of Fundy, developed at BIO by the group of Greenberg. The bathymetry of the estuary and immediate approaches was derived from both multibeam and dense single beam data. The outer boundary bathymetry was derived from the Signell et al. lower resolution model of the whole Bay of Fundy, Gulf of Maine region.

The model now illustrates the strong shear boundary observed off Gooseberry Island and the developed of an eddy to the east of the estuary mouth.

<http://www.omg.unb.ca/~haigh/musquash.html>

Kennebecasis Project – Numerical Modeling of Sound Speed Variability

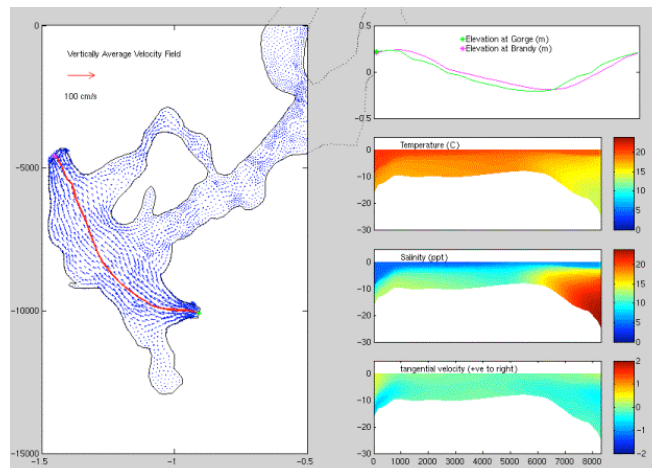
Haigh and Hughes Clarke (OMG)

CHS and Chair funding

In our efforts to produce a hydrodynamic model of the Saint John River Estuary, we have successfully implemented the baroclinic version of finite element coastal ocean

circulation model QUODDY. One advantage of QUODDY is that it uses a non-uniform triangular mesh which allows one to densify the numerical grid in areas of interest. QUODDY reproduces the circulation in the Saint John River portion of the model domain reasonably well. It does, however, have problems reproducing the particularly unique circulation in the Kennebecasis Fjord.

QUODDY uses a sigma-coordinates (terrain following coordinates) in the vertical. It is well known that sigma-coordinate models produce an error in the computation of the baroclinic pressure gradient when encountering steep bathymetry. The Kennebecasis Fjord is an area which is particularly difficult to model as there is a sudden drop in depth at the entrance to the fjord and there is a permanent pycnocline in the fjord which the sigma levels must cross when the bathymetry deepens.



In order to address the problems in modelling the Kennebecasis Fjord, as described above, we are now attempting to model the Saint John River Estuary with MICOM (the Miami Isopycnal Coordinate Ocean Model). An isopycnal model uses density as the vertical coordinate instead of length. Thus instead of predicting the density at a given depth, an isopycnal model predicts the depth at which a given density occurs. The user is required to prescribe the number of isopycnal layers that the model uses and the density of each layer. For our purposes, the chief advantage of using an isopycnal model is that steep topography does not pose a problem in isopycnal models.

Lake Powell AZ/UT - Mechanisms for Sediment Influx and Deposition

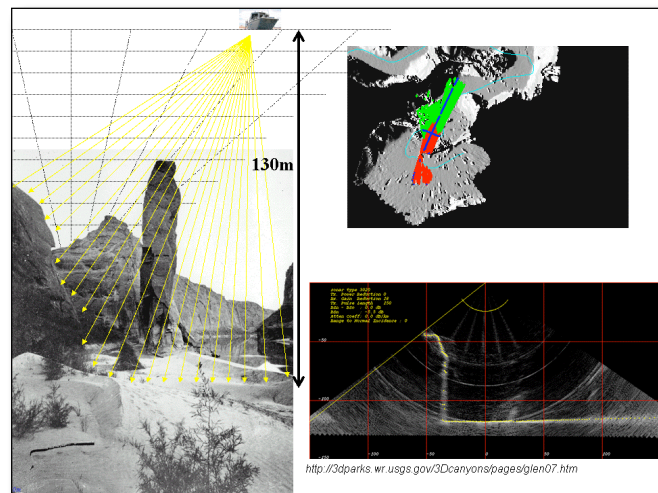
John Hughes Clarke, Jonathan Beaudoin (OMG) , Lincoln Pratson, (Duke) and Mark Anderson (NPS)

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

As part of a collaborative research program between UNB, Duke University, and the US National Park Service, we undertook a 10 day multibeam mapping program of Lake Powell Arizona/Utah. This is the first survey of a planned multi-year program in the lake. The aim of the research program is to examine the input and fate of sediment into the dammed lake system.

The lake created in the 1960's is the drowned Glen Canyon. The area is fed primarily by the Colorado and San Juan Rivers. As a result of the spring snow melt in the Rockies, there is a massive influx of turbid water in the May-June period. This influx is burying the old canyon floor relief very rapidly (in places exceeding 3m of deposition per year). This deposition is of concern to the maintainers of the Glen Canyon Dam but is also a wonderful analog of modern deep-sea mass wasting sedimentation style.

In partnership with Duke University, we are examining the style and evolution of the muddy build up of sediment. Multiple year surveys have been performed and will be repeated as part of this program. It is clear that liquefied mud flows are common and active (moving 100's of metres over the duration the survey in May). In other regions, such as the Escalante, the canyon walls are collapsing as the water table has risen, blocking the talweg of the old canyon, limiting the downstream extent of these turbid flows.



Lake Powell is a National Recreational Area and is a huge source of revenue for the region. The US National Park Service is tasked with managing the competing concerns of the tourist industry and the health of the environment in the area. Their interest in the survey is to better monitor the canyon floor habitat that supports large recreational fisheries and to be able to monitor change in that environment over time.

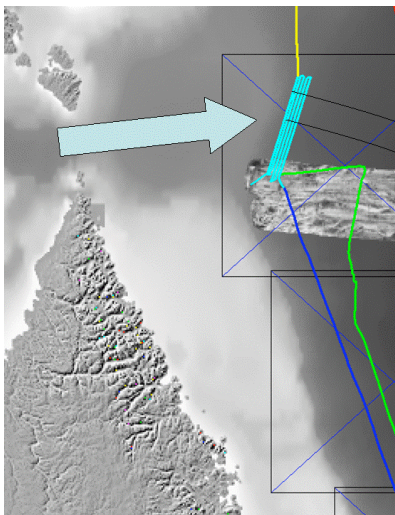
For the Ocean Mapping Group, the survey represents a unique chance to test new software tools to cope with bottom tracking and TVG problems in extreme topography. In addition the new water column imaging capability of the EM3002 was tested for the first time and new software developed.

Proximal Seafloor Signature of Heinrich Events.

*Hughes Clarke (OMG) and Piper (NRCan – GSC-Atlantic)
NSERC STAC and Discovery funding*

In August, 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. 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.



We are seeking evidence of high-velocity near-seabed flow. Prior studies into the North West Atlantic Mid-Ocean Channel (NAMOC) have demonstrated that a pathway for coarse sediment lies along its northern flank. We seek to establish the source region and triggering mechanism for these high velocity flows.

A 30 hour survey was conducted in August 2005. The planned survey extension in November was postponed due to weather and time. It is currently scheduled to be completed in August 2006.

The data collected to date clearly show evidence of an abrupt change in continental slope morphology from the muddy, thick-leveed channels to the south (which feed NAMOC), to a lower-relief, clearly erosional domain to the north which feeds the braid plain corridor, first recognized by Hesse.

Arctic Coastal Impacts due to Global Warming

Bell, Forbes (MUN), Hughes Clarke, Beaudoin, Brucker (OMG)
NSERC NCE – ArcticNet project 1.2 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 preparation for Arctic Coastal Operations, the CSL Heron was prepared in the summer of 2005 to work off the davits of the CCGS Amundsen. The launch was upgraded to an EM3002 and the shipboard computing hardware all replaced. The vessel was repainted and extra storage capability and safety equipment was added together with a surface sound speed probe, in-line with the generator cooling water intake.

All these preparations however, were ultimately in vain as the launch was accidentally dropped whilst being loaded just 10 days before the vessel was due to sail. Nevertheless, through insurance and extra funds from the Chair in Ocean Mapping, the Heron is currently being rebuilt on Grand Manan for another attempt in 2006.

**Tropospheric Delay Modeling in the Arctic**

Ghoddousi-Fard, and Dare (UNB)
NSERC, CFI and RICS funding

The increasing importance of high latitude regions for high precision positioning and meteorological studies on one hand, and the role of GPS in both applications on the other, encourage regionally focused research for high precision GPS positioning and GPS meteorology in the Arctic. The challenging GPS constellation and unique atmospheric conditions are encouraging factors to propose regional GPS meteorology related research work in the Arctic.

This research is intended to develop a regionally-tuned strategy for GPS tropospheric delay retrieval in the Canadian Arctic. Spatial and temporal tropospheric delay error covariance models, which are expected to benefit both numerical weather prediction (NWP) tropospheric delay assimilation procedure and GPS zenith total delay (ZTD)

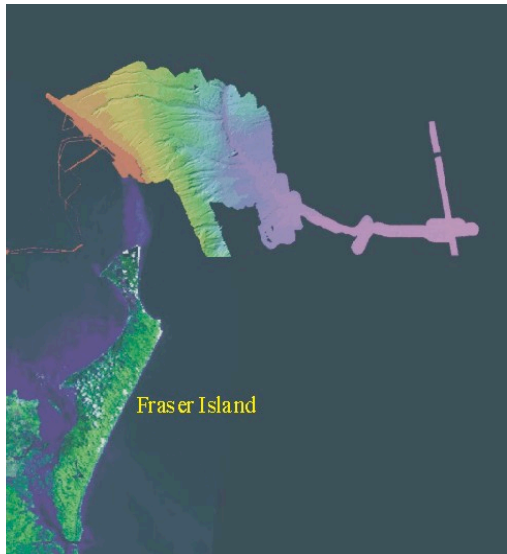
retrieval itself, will be empirically determined. An additional objective is to derive a regional tropospheric propagation zenith delay model for the Canadian Arctic using statistical modelling of long term meteorological data and newly available radio occultation measurements. A field observation campaign provides a unique opportunity to validate both empirical and NWP models in the Canadian Arctic.

Frazer Island, SE Queensland Shelf, Australia

Llewellyn (OMG) and Boyd (Univ. Newcastle, NSW)

Univ. Newcastle Funding

As part of continued collaborative operations with the University of Newcastle (NSW, Australia), we are utilizing in-house developed software to process and manage the bathymetry and backscatter from the Kongsberg EM300 sonar permanently mounted on the RV Southern Surveyor. In 2005, Kristian Llewellyn sailed as part of the survey and ran the EM300 for the duration of the project, processing all the data on board.



The work is part of study of the fate of sand moving along the continental shelf and off-shelf onto the slope, sourced around Fraser Island (Queensland). This survey builds on a 2004 survey using a RESON 8101 on the continental shelf. The 2005 operations extended the survey to water depths in excess of 3500m.

Particular data processing issues that had to be addressed were insufficient sound speed information and continuously changing sonar modes. The mode changes have a detrimental impact on the empirical beam pattern estimation. New software was developed to better implement beam pattern corrections.

Fundy Isles Mapping and Data Integration

Brucker, Church and Llewellyn, (OMG) Maria Ines-Buzeta (DFO-SABS) Roff (Acadia)
DFO-SABS and Acadia 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 Deer Island Region. The work was driven by the need to better define seafloor habitat and to extrapolate diver and towed video camera observations.

The data were combined with archived multibeam data collected by the OMG and SABS over the past 14 years. The data were then integrated with digital charts and orthophotos and put on line for downloading by the user community.

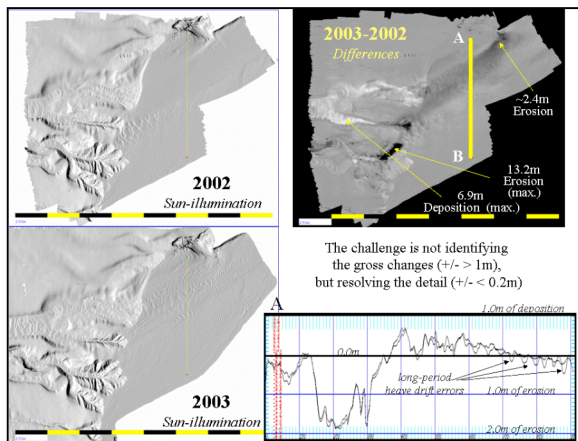
Collectively, these data form the largest inshore coastal multibeam survey compilation in the Bay of Fundy. They provide a particular challenge to properly attribute as the meta-data much be able to fully capture the quality aspects relating to the specific varied platforms, varied sensors and varied survey accuracies (e.g.: predicted, v. actual, v. RTK tides).



Sands Head – Fraser River Delta-front Change Monitoring

*Hughes Clarke, (OMG), Hill and Iwanowska (GSC-P), Czotter (CHS-Pacific)
GSC-P (GOM Georgia Basin) funding*

A new collaboration was started involving quantifying change between successive surveys in the Fraser River Delta Slope. A multi-year program on the Sand Head region



of the Fraser River delta has been ongoing at the Pacific Geoscience Centre for many years. This involved repetitive multibeam surveying (by the Canadian Hydrographic Service) of the outermost channel mouth and the upper part of the slope off the delta front. Large scale change in the slope morphology had been recognized.

The interest, however, was in quantifying the much smaller scale of changes that may be happening outside the major slump scars. The scale of vertical change has been on the

order of several decimeters rather than the multi-meter spectacular failures that were most obvious. Problems with long period heave drifting, tidal imperfections and refraction were seen as the major sources of systematic error.

Princess of Acadia Project

*Cove, Santos and Wells (OMG/GGE) and Dodd and Howden (USM)
USM funding*

This project is a partnership between the University of New Brunswick (Department of Geodesy and Geomatics Engineering) and the University of Southern Mississippi (Department of Marine Science).

The basic idea behind the *Princess of Acadia Project* is to study long-range kinematic GPS positioning by using a network of static GPS reference stations and a rover GPS



receiver on-board the ferry, The Princess of Acadia, which runs between St. John, New Brunswick, and Digby, Nova Scotia, in the Bay of Fundy (in Canada). This basic set up provides an opportunity to study the effect of weather fronts on high-accuracy positioning, the relationships between vertical frames, and the local effects induced by the Bay of Fundy having the highest tides in the world. Local effects include tidal loading and sea surface

topography, and specific site dependent effects such as GPS multipath.

Two GPS basestations were established in Saint John and Digby, together with two tide gauges at each end. The vessel steams between the two locations, twice daily. The elevation of the vessel, as calculated using each of the base stations separately, is continuously monitored as it steams between the two and compared to a distance-weighted estimate of the water level at each end. The atmospheric conditions at both ends were monitored to try and compare the residual errors inherent in GPS propagation conditions at the vessel to establish the typical role of these errors as a function of baseline distance.

http://gge.unb.ca/Research/GRL/PrincessOfAcadia/princess_frame.htm

Education and Training Options

Multibeam Courses

The international training course organized by the Ocean Mapping Group was given 3 more times in the 2005 year in:

Gulfport, MS, USA	in January
Sydney, Australia	in July
Plymouth, UK	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

Theory of, and operational issues in acoustic marine surveying.

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

GGE5013 Oceanography for Hydrographic Surveyors.

Wells and 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_2004.html

Not taught in 2005 - as JEHC was on sabbatical

GGE5083 Hydrographic Field Operations

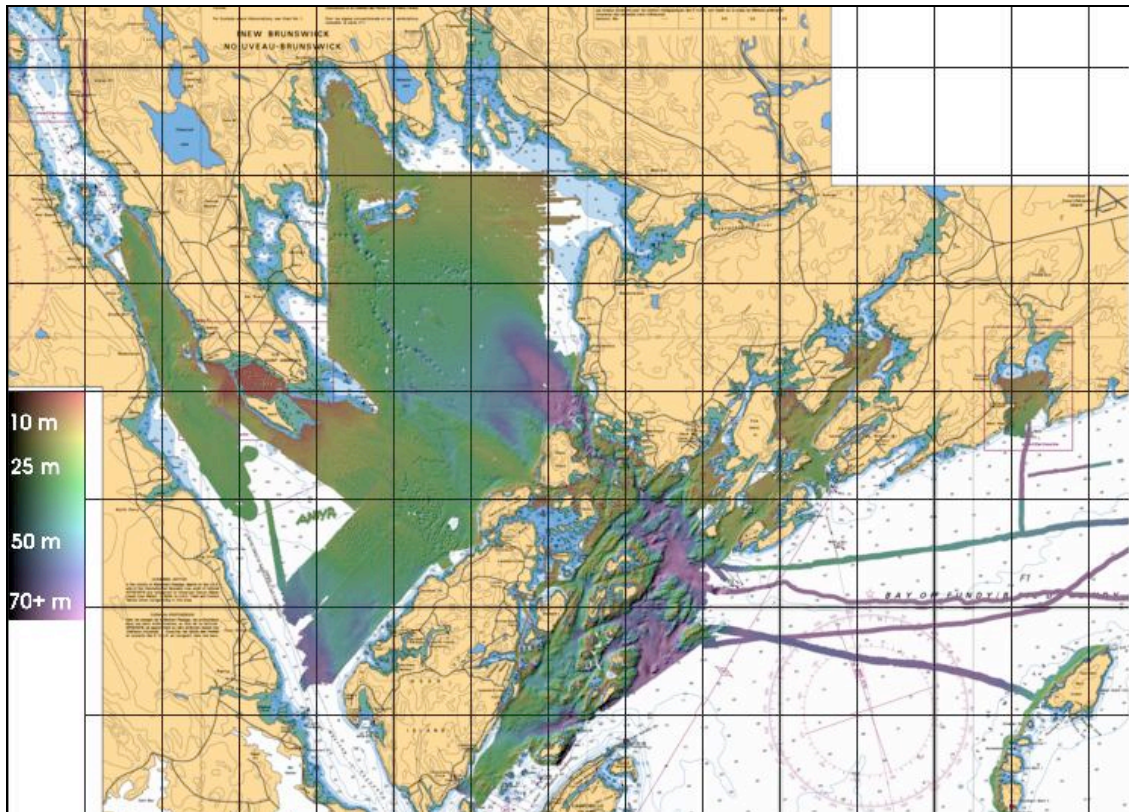
Hughes Clarke

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

<http://www.omg.unb.ca/SWNB/>

In 2005 the Hydrocamp was based out of Deer Island in SW 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 EM3000 as the prime survey platform. Tidal control was maintained using a pressure gauge at the Lords Cove dock. All data were processed in the field and the results were added to an on-line data portal designed by the students 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 **2005 GGE5083 Hydrocamp** field operations, blended with the 1992-2004 data from the archived data to the east. Aerial photography was ortho-rectified by SNB and stenciled by the students. Underlying image is CHS chart*

GRADUATE:

GGE6023 Multibeam Sonar

Hughes Clarke

Research Topics on Swath Sonar Systems.

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

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 8 sponsors. Typical sponsorship levels are ~ US\$25kpa.

Current Sponsoring organisations

1. Canadian Hydrographic Service	1991 - 2005
2. Kongsberg Simrad Mesotech	1995 -
3. U.S. Geological Survey	1996 -
4. University of New Hampshire	2000 - 2005
5. Fugro Pelagos	2003 -
6. Royal U.K. Navy	2003 -
7. Rijkswaterstaat	2005 -
8. 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 2005 include:

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

NSERC Discovery Grant

Hughes Clarke C\$26,000 pa

Heinrich Events – Mouth of Hudson Strait Mapping

NSERC Shiptime Grant

Hughes Clarke and Piper, C\$89,000

Labrador Margin – Frontier Geoscience Mapping

Natural Resources Canada (Sonnichsen)

Hughes Clarke C\$45,000

Beaufort Sea Margin – UNCLOS mapping trials

Dept. Fisheries and Oceans (CHS)

Hughes Clarke C\$90,000

Fundy Isles Mapping

DFO –SABS (Buzeta)

Hughes Clarke C\$15,000

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

At the end of the 2005 year, our hardware capabilities are being almost currently totally replaced due to the sinking of the Heron. The essence was...

Positioning

Trimble 5700 suite: base station, radio link and two rovers capable of 10Hz RTK

Ashtech Z12 suite: base station, radio link and one rover capable of 1Hz RTK

Trimble AG-132 combined GPS and Racal Landstar or Coastguard beacon receiver.

Garmin GPSMAP 182C WAAS-enabled DGPS and electronic chart system

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.

Oceanographic Instrumentation

RDI 600 kHz Monitor ADCP with Winriver software.

Sutron Model 8200 data logger (on loan from CHS)

for tidal measurements interfaced to:

- pressure gauge and
- AMASS encoder
-

2x **OTT tide gauges** with encoders.

Applied Microsystems Limited SVP16 Temp., sound speed and depth logger.

Brooke MVP-30 towbody, overboarding Sheave with AML Smart CTD (25 Hz) integrated with a Valeport SK172 winch. Optical Backscatter probe added November 2003.

Heading and Orientation Sensors

Seatex MRU-6 Orientation and heading sensor

CodaOctopus F180 – GPS-inertial integrated position and orientation system

Honeywell HMR –3000 - fluxgate magnetic compass and roll and pitch tilt sensor

KVH C-100 - fluxgate magnetic compass

NOTE – the state of the hardware on the Heron is currently in a state of flux. Most items should be replaced under insurance, but a complete inventory will need to be updated in 2006.

Heron Field Operations

2005

For the 2005 field season she was based at the Saint John Marina in Grand Bay, just above the Reversing Falls.

The following field programs were undertaken between April and the end of June 2005 using the Heron:

Location	Funding
1. Kennebecasis Bay	NSERC
2. Deer Island Region	DFO-SABS

In July she was trucked to Quebec City for loading onto the CCGS Amundsen. During the month that she was based there, she was upgraded to an EM3002 and testing performed.

Unfortunately on the 27th July, she was dropped whilst being loaded onto the vessel and sunk.

Publications:

2005**Journal Articles**

- Gardner, J.V., and Beaudoin, J., 2005, High-Resolution Multibeam Bathymetry and Acoustic Backscatter of Selected Northwestern Gulf of Mexico Outer Shelf Banks: **Gulf of Mexico Science, June 2005, V.XXIII, No. 1, 5-29**
- Gardner, J.V., Dartnell, P., Mayer, L.A., Hughes Clarke, J.E., Calder, B.R. and Duffy, G., 2005, [Shelf-edge deltas and drowned barrier-island complexes on the northwest Florida outer continental shelf](#): **Geomorphology 64 (2005), 133-166**
- Duffy, G.P. and Hughes Clarke, J.E., 2005, Application of Spatial Cross-Correlation to Detection of Migration of Submarine Sand Dunes, Special Publication on Marine and River Dune Dynamics, Journal of Geophysical Research, VOL. 110, F04S12, doi:10.1029/2004JF000192.

Conference Proceedings

- Hughes Clarke, J.E., Dare, P., Beaudoin, J., and Bartlett, J. 2005, [A stable vertical reference for bathymetric surveying and tidal analysis in the high Arctic](#). Proceedings of the United States Hydrographic Conference 2005, San Diego, California.
- Hughes Clarke, J.E. and Haigh, S.P. (2005), [Observations and interpretation of mixing and exchange over a sill at the mouth of the Saint John river estuary](#). Proceedings of the 2nd CSCE Specialty Conference on Coastal, Estuary and Offshore Engineering, Toronto, Canada, June 2-4.
- Haigh, S.P. and Hughes Clarke, J.E. (2005), [A numerical study of exchange and mixing over a sill at the mouth of the Saint John river estuary](#). Proceedings of the 2nd CSCE Specialty Conference on Coastal, Estuary and Offshore Engineering, Toronto, Canada, June 2-4.
- Hogan, M and M. C. SANTOS (2005). "[Advanced Mission Planning Tool For Real-Time Kinematic \(RTK\) GPS Surveying](#)." *Proceedings of the Institute of Navigation National Technical Meeting*, 24-26 January, 2005, San Diego, Cal., USA, pp. 480-488.
- Ghoddousi-Fard, R. and P. Dare (2005) "Online GPS Processing Services: An Initial Study". Accepted by *GPS Solutions*, April.
- Ghoddousi-Fard, R. and P. Dare (2005) "a". Proceedings of the 33rd Annual Conference of the Canadian Society of Civil Engineering, Toronto, Ontario, June 2-5 2005.
- Nievinski, F., K. Cove, M. C. Santos, D. Wells and R. Kingdon (2005). "[Range-Extended GPS Kinematic Positioning using Numerical Weather Prediction Model](#)." *Proceeding of the Institute of Navigation 61st Annual Technical Meeting*, 27-29 June, 2005, Cambridge, MA., USA, pp. 902-911.
- Santos, M. C., F. Nievinski, K. Cove, R. Kingdon and D. Wells (2005) "[Range-Extended Post-Processing Kinematic \(PPK\) in a marine environment](#)." *Proceedings of the Institute of Navigation GNSS-2005*, 13-16 September, 2005, Long Beach, CA, USA.

Technical Reports

1. Hughes Clarke, J.E., 2005, HMS Roebuck (H130) - Kongsberg Maritime EM1002 Multibeam Trials *Hurd Deep and Middle Rocks, Western English Channel*, 26th July to 1st July August 2005: **Contract Report to Division of Naval Survey and Oceanography and Meteorology, Royal Navy.**
2. Hughes Clarke, J.E., 2005, HMS Endurance (A171) - Kongsberg Maritime EM710 Multibeam Trials *Hurd Deep and Middle Rocks, Western English Channel*, 5th to 13 July 2005: **Contract Report to Division of Naval Survey and Oceanography and Meteorology, Royal Navy.**
3. Hughes Clarke, J.E., 2005, CCGS Matthew - Kongsberg Maritime EM710 Trials Bedford Basin, St. Margarets Bay and Halifax Approaches, 8th to 12 June 2005: **report to Canadian Hydrographic Service:**
http://www.omg.unb.ca/Analyses/Matthew_html/OMG_Matthew_EM710_trials.html
4. **Santos, M. C.** (2005), "Princess of Acadia Project." Final research project report prepared for the University of Southern Mississippi and the Office of Naval Research, Fredericton, N. B., February, 145 pp.

Theses

- Kristian Llewellyn (M.Eng.) - 2005, Corrections for Beam Pattern Residuals In Backscatter Imagery From The Kongsberg-Simrad EM300 Multibeam Echosounder

Other Conference Presentations

- Beaudoin, J., Hughes Clarke, J.E. and Bartlett, J.. Usage of oceanographic climatologies and databases in support of multibeam mapping operations onboard the CCGS Amundsen, Poster Presentation, ArcticNet Annual Scientific Meeting 2005, Banff, Alberta
- Bennett, R., Blasco, S., MacLean, B., Rochon, A., Hughes-Clarke, J., Beaudoin, J., Bartlett, J., Jenner, K., Schell, T., 2005. Paleooceanography, Seabed Morphology and Geologic Framework of the NW Passage. ArcticNet 2nd Annual meeting, Banff, Canada, 12-16 December 2005.
- Blasco S.M., Bennett R., Hughes-Clarke J., Bartlett J., Shearer, J.M., 2005. 3-D Multibeam Mapping Reveals Geological Processes Associated With Fluted Seabed, Slump Feature, Pockmarks, Mud Volcanoes and Deep Water Ice Scours in the Beaufort Sea–Amundsen Gulf. Geological Association of Canada – Mineralogical Association of Canada (GAC-MAC) Annual Meeting, Halifax, Nova Scotia, May 16-18, 2005.
- Blasco, S., Bennett, R., Hughes-Clarke, J., Rochon, A., Beaudoin, J., Bartlett, J., Scott, D., Jenner, K. 2005. The Investigation of Seabed Geohazards in the Canadian Arctic: Assessing the Opening NW Passage. ArcticNet 2nd Annual meeting, Banff, Canada, 12-16 December 2005.
- Blasco, S., MacLean, B., Mudie, P., Sonnichsen, G., Bennett, R., Rainey, W., Scott, D., Praeg, D., Hughes-Clarke, J., Bartlett, J., Mayer, L., Monahan, D., 2005. Northwest Passage Marine Sediments: A Record of Quaternary History and Climate. 32nd Arctic Workshop, Edmonton, Canada, 10-15 March 2005.

- Rochon, A., St-Onge, G., Schell, T.M., Scott, D.B., Blasco, S., Bennett, J.R., Jenner, K., Beaudoin, J., Hughes Clarke, J. and Ledu, D. 2005. Multi-proxy record of Holocene climatic changes in the Eastern Canadian Arctic: preliminary results. ArcticNet 2nd Annual meeting, Banff, Canada, 12-16 December 2005.
- R. Ghoddousi-Fard. and P. Dare (2005), "An investigation on the performance of regional GEM Zenith Delay Products in the Canadian Arctic". Presented at the Canadian Meteorological and Oceanographic Society 39th Annual Congress, Vancouver, May 31-June 3.
-