



## *Chair in Ocean Mapping*

Research Activity - 2004 Calendar Year



*"home of the Heron"*

January 2005

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## Introduction

### **Overview**

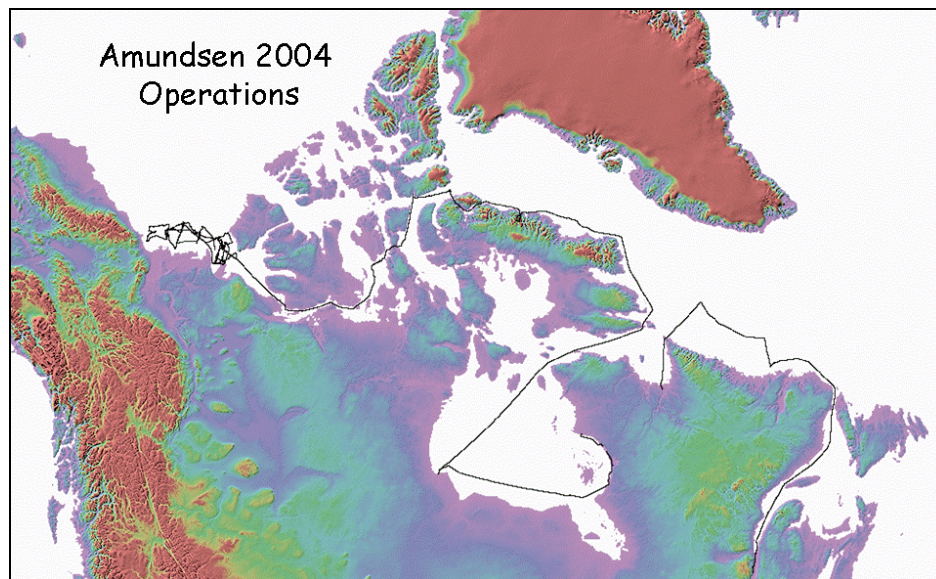
This report outlines the status and current and future research directions of the Chair in Ocean Mapping (COM) at the University of New Brunswick (UNB) at the end of the 2004 calendar year. The Chair works within the Ocean Mapping Group which is a part of the Dept. of Geodesy and Geomatics Engineering (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 Research Programs**

#### **2004 CASES-ArcticNet Operations CCGS Amundsen**

In 2003, the Ocean Mapping Group undertook the first multibeam and subbottom mapping activities from the newly recommissioned research icebreaker, CCGS Amundsen. Over the winter of 2003-2004, the Amundsen was deliberately frozen into landfast ice in Franklin Bay off the Amundsen Gulf in the Western Arctic. During the February-March period, the OMG undertook high latitude C-Nav GcGPS experiments to determine the feasibility of using globally corrected GPS ellipsoid height solutions as a tide measuring tool.



In July of 2004, the CCGS Amundsen broke out of the melting icepack and commenced a 100 day science and mapping program in the Beaufort Sea, the North West Passage and Hudson Bay. OMG staff implemented the mapping program and concurrently logged C-Nav ellipsoid height solutions to investigate the use of this vertical referencing as a

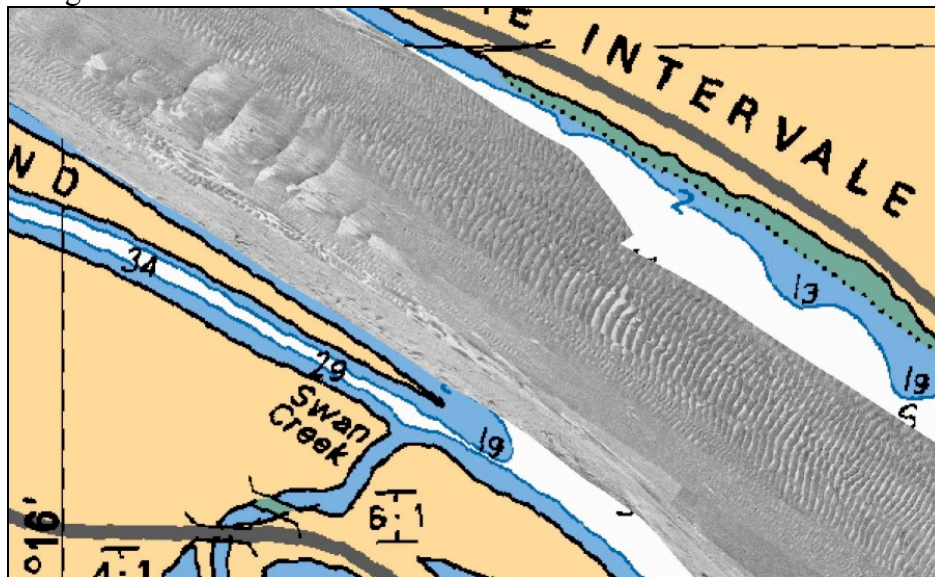
means of tidal reduction. In October 2004, the Amundsen steamed through the Labrador Sea where OMG staff conducted deepwater mapping trials towards assessing the capability of the system for UNCLOS mapping in the Arctic.

The Amundsen now represents one of the largest investments in manpower and research effort by the Ocean Mapping Group. She is a unique platform with acoustic mapping capabilities that are not available on any other vessel in Canada. She represents the second largest CFI/NSERC investment in marine science in Canada ever. She provides the OMG with a hugely expanded ability to develop new marine geomatics techniques (in positioning, mapping, data processing and data management). The mapping conducted by her is both an essential resource for a huge group of national and international scientists and also simultaneously a fabulous opportunity for the OMG to undertake research and train a new generation of personnel.

### Saint John River Mapping Program

In 2004, the ongoing lower Saint John River Estuary mapping program was expanded to include the normally-freshwater, shallow, sandy sections upstream of Oak Point. The aim of the mapping was three fold:

- To test out improved ellipsoid –Geoid –Chart datum separation models to allow GPS vertical control.
- To test RTK –Heave integration algorithms for improved dynamic vessel vertical control
- To map sturgeon habitat for the section of the river in support of sturgeon ecological studies in collaboration with UNBSJ.

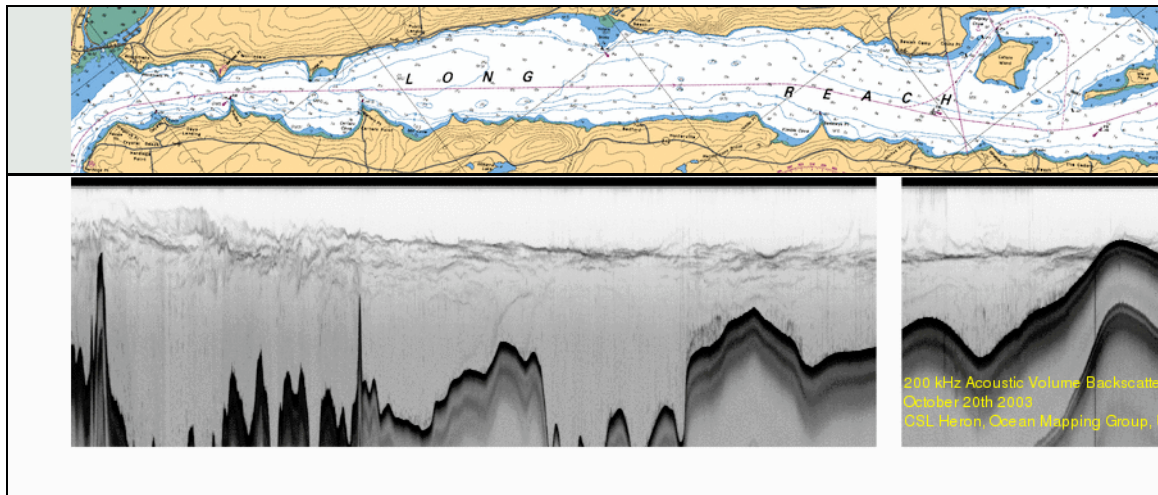


Sidescan coverage was obtained of the river bed deeper than 3m. The mapping took place in week long intervals from June to November.

## Long Reach Estuarine Circulation Project

As an extension of the Grand-Bay and Kennebeciasis salt water exchange studies that had been undertaken from 2000-2003, an additional investigation was undertaken of the Long Reach section of the river, wherein the main salt wedge is developed.

Commencing in May, a multibeam bathymetric survey of the Westfield to Oak Point section of the river was undertaken as part of the 2004 GGE-5083 – Hydrographic Field operations camp. Using three tide gauges along this stretch, precise seabed morphology and bottom backscatter strength was obtained.



In June and September, multiple 12.42 hour tidal cycle sections of the oceanography were obtained over two sections extending from Belyea's Point to Public Landing. The oceanographic sections examined the characteristics of the interfacial mixing in the constricted and open sections of the Long Reach, and looked at whether the mixing was different during neaps and spring tides.

## **Major Research Developments**

### Spatial Cross-Correlation

One of the most critically required measurements, when undertaking engineering in shallow sandy coastal and continental shelf areas, is an estimate of the mobility of the seabed. Being able to remotely estimate a quantity like bedload sediment transport would have huge benefits.

In 2002, six surveys, spaced one month apart, were done over the Mispic Bay sand wave field in an attempt to assess the ability of precise multibeam surveys to map and monitor seabed change (in this case dune field migrations).

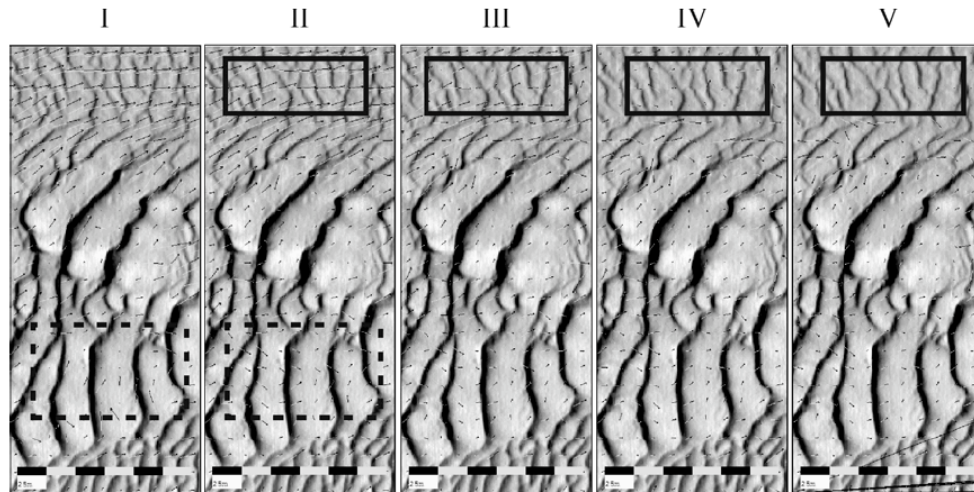
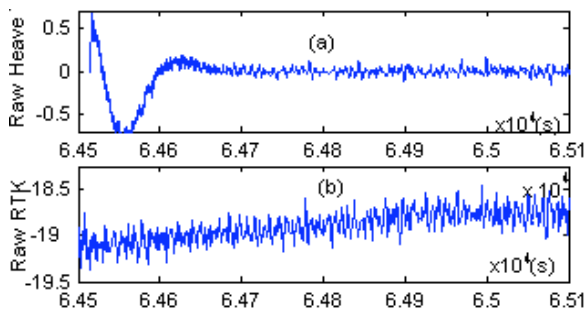


Figure 5.8 Sample averaged weighted centroid vectors from vectors fields I to V resulting from choosing intervals as described in Figure 5.7. Comparison of dashed squares shows better resolution of slow moving large dunes, i.e. more vectors. Solid squares demarcate loss of lock effect due to temporal aliasing in fast moving dunes.

In order to most-precisely and objectively estimate the spatially variable bedform migration vectors, a 2D spatial cross-correlation method was developed in 2004 (Duffy et al., 2004). Application of this method is ongoing, but potentially provides a robust means of estimating bedload sediment transport rate.

### RTK-Heave Implementation

A major limitation of all real-time heave solutions is the impulse response of the causal high-pass filters involved. Motions outside the usable bandwidth of the filter (generally set to a maximum of ~10-15 seconds) cannot be captured using this inertial technology. A means of capturing the full spectrum is needed and kinematic GPS provides one



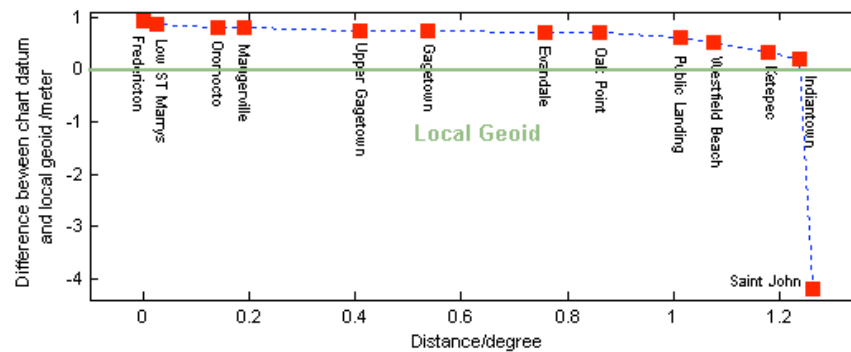
suitable means. The low update rate and potential latencies of kinematic, however, require that this data be integrated with a synchronous inertial heave solution.

kinematic GPS to come up with a full bandwidth solution. These were tested using the CSL Heron whilst she was involved in rapid maneuvers and speed changes.

Using PPK RTK solutions lever-armed to the RP of CSL Heron, together with the F-180 heave solutions, optimal complementary filters were developed that high-pass the heave and low-pass the

## Seamlessly Ellipsoid Chart Datum transformation

To take full advantage of the RTK-Heave blended solutions we need to be able to transfer from the WGS-84 datum to a datum useful to the navigator. For the accuracy level needed, a continuously spatially varying datum offset surface is required. This is always needed anyway for geoid to ellipsoid transformations. But an added complication for hydrographic survey is the need to match this to a chart datum that accounts for varying tidal range. The worst case for such a transformation is in a tidally influenced river system where river slope must be superimposed on top. We have developed a solution for this that is specifically applied to the Saint John River from the Reversing Falls to Fredericton, the most distal point at which tidal influence is felt.



The ellipsoid-referenced solutions generated from a carrier phase GPS survey were shifted to chart datum using a polynomial that combined the Geodetic Survey's CGG 2000 geoid mode for regional trends together with precise benchmark offsets measured at critical benchmarks along the river valley.

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## Personnel

### Faculty

|                       |   |
|-----------------------|---|
| John E. Hughes Clarke | Associate Professor, Chair in Ocean Mapping, GGE<br><i>Swath Sonar Software Development,<br/>Sediment Transport</i> |
| David Wells           | Professor Emeritus, GGE<br><i>Hydrography, Geodesy,<br/>Uncertainty management</i>                                  |
| Sue Nichols           | Professor, GGE<br><i>Coastal and Marine Cadastral</i>   |
| Marcelo Santos        | Associate Professor, GGE<br><i>Kinematic Positioning, Geodesy</i>   |
| Karl Butler           | Associate Professor, Dept. Geology<br><i>Exploration Geophysics</i>   |
| Dave Monahan          | Director of Ocean Mapping, CHS<br><i>Law of the Sea</i>   |

In 2004, Professor Yuk-Chung Lee unfortunately passed away. He was a major contributor to the origins of the Ocean Mapping Group at UNB. He pioneered the development of GIS systems, which led to the development of marine GIS systems such as CARIS. He was widely respected, both as a researcher and an educator and will be sorely missed by all of us.

### Research Associates and PostDoctoral Fellows

|                 |   |
|-----------------|---|
| Dr. Susan Haigh | Contract Researcher<br><i>Numerical Modeling of Coastal Circulation</i> |
| Dr. Jianhu Zhao | NSERC Postdoctoral fellow<br><i>RTK GPS – Heave integration</i>         |

### Support Staff

|                              |                                    |
|------------------------------|------------------------------------|
| Shawn Woo                    | System Manager                     |
| Anya Duxfield                | Research Assistant                 |
| James Leslie, Howard Ingalls | Skipper, CSL Heron                 |
| Tracey Hawco                 | Accounting                         |
| Jason Bartlett               | Hydrographer, (CHS secondment)     |
| Jonathan Beaudoin            | Research Assistant (CCGS Amundsen) |
| Steve Brucker                | Undergraduate Research Assistant   |

### Graduate Students

|           |        |                |
|-----------|--------|----------------|
| Ted Byrne | SN/JHC | MEng 2000-2004 |
|-----------|--------|----------------|

|                    |        |                  |
|--------------------|--------|------------------|
| Sam Ng'ang'a       | SN     | PhD 2000-2004    |
| Sarah Cochran      | SN     | MEng 2000-2004   |
| Michael Sutherland | SN     | PhD 2000-2004    |
| Garret Duffy       | JHC    | PhD 2001-        |
| Jonathan Beaudoin  | JHC    | M.Sc.Eng 2001-   |
| Jennifer Coppola   | JHC    | MEng 2002 - 2004 |
| Karen Cove         | MS     | M.Sc.Eng 2002 -  |
| Jim Bradford       | JHC    | MEng 2002 - 2004 |
| Andy Muir          | JHC    | MEng 2002 – 2004 |
| Lionel Manteigas   | DEW    | MEng 2002 - 2004 |
| John Fleming       | DEW    | MEng 2002 – 2004 |
| Kristian Llewellyn | JHC    | MEng 2003-       |
| Jon Griffin        | JHC    | MEng 2003-       |
| Christian Solomon  | MS     | MEng 2003-       |
| Richard White      | KB     | MSc 2003-        |
| Nicole Delpeche    | JHC    | MscEng 2003-     |
| Xinhai Li          | ML/JHC | PhD 2004-        |

### ***Adjunct Faculty and Active Collaborators in 2004***

|                   |  |
|-------------------|--|
| Dr. Larry Mayer   | Adjunct Professor,<br>University of New Hampshire            |
| Russell Parrot    | Research Scientist<br>GSC – Atlantic, BIO                    |
| Bill Danforth     | Research Scientist<br>USGS – Woods Hole Field Office         |
| Dr. Michel Comeau | Research Scientist<br>DFO – Gulf Fisheries Centre, Moncton   |
| Maria-Ines Buzeta | Research Scientist<br>DFO – St. Andrews Biological Station   |
| Matthew Littvak   | Associate Professor<br>UNBSJ – Biology                       |
| Dave Scott        | Professor<br>Dalhousie - Geology                             |
| Andre Rochon      | Associate Professor<br>UQAR – ISMER                          |
| Steve Blasco      | Research Scientist<br>Geological Survey of Canada – Atlantic |
| Michel Allard     | Professor<br>Laval University, Geology.                      |

## Active Research Directions

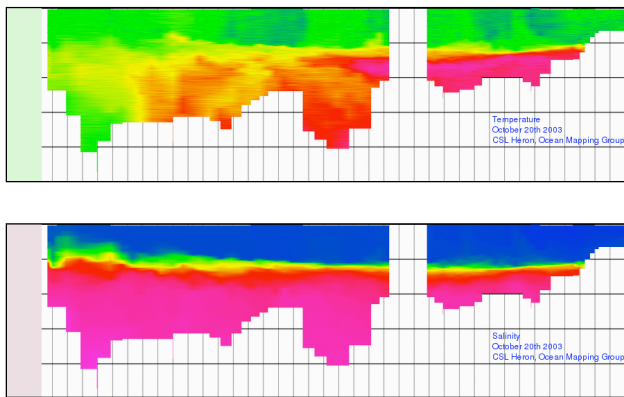
The following short overviews explain the researchers, sources of funding and describe the type of research currently active under the umbrella of the Chair in Ocean Mapping:

### ***Long Reach, Estuarine Oceanography, imaging the nature of interfacial mixing***

*Delpeche and Hughes Clarke, (OMG)*  
*NSERC Discovery Grant Funding*

Beginning in 2003 we have been extending our investigations into the Lower Saint John River Estuary up past Westfield into the Long Reach. Long Reach is a deeper section of the estuary, with a basement geological framework similar to the Kennebecasis. The important difference is that the main St. John River flows through Long Reach.

The normal upstream limit of significant saline intrusion occurs at Oak Point, ~ 2/3 of the way up Long Reach where a shallow sill is present. During freshet events, the salt water is almost entirely flushed out of Long Reach. This tremendous contrast in estuarine mixing character as a function of season is the main interest of Nicole Delpeche as part of her MSc.Eng. thesis. Her focus will be on the nature of the mixing between the river and saline intrusion as a function both time of year and state of tide.



In 2004, the second phase of the field program was implemented. Based on the seasonal longitudinal sections obtained in 2003, two sections between Woodmans Point and Victoria Shoals were examined continuously over an M2 tidal cycle twice (once at springs and the other time at neaps).

In the constricted, section, acoustic imaging of the pycnocline clearly indicates several mechanisms for interfacial mixing, including solitons, topography-related overfalls and possibly holmboe waves. In contrast, in the open and unrestricted sections, much less mixing is observed, although over-thrusting of discrete layers is still seen.

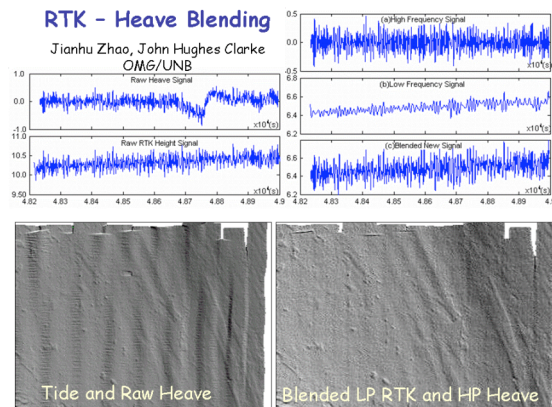
### ***RTK-Heave Integration***

*Zhao, Brucker and Hughes Clarke, (OMG)*  
*NSERC COSTA Funding*

When trying to monitor seabed change on a scale of decimeters, the long period (> 20 second) drifting of many heave sensing systems can be a significant detriment. The

nature of the causal filters used in most real-time heave outputs, cannot adequately cope with DC changes in draft of vessels as a function of speed or cornering. As a result a decaying periodic drifting of the vertical datum routine extends for a period of several minutes after strong maneuvers. This is particularly notable for small high-speed survey launches such as C.S.L. Heron.

One plausible approach to getting a better handle on long-period vertical variations in a vessel's elevation is to aid the solution using RTK or PPK DGPS. Such solutions however are not available at high enough frequencies to satisfy the demands of capturing the ocean wave spectrum, and thus an integrated solution is required. Such solutions are already offered by a number of GPS aided INS systems in real time but depend critically on a robust real-time base-station to rover data link.



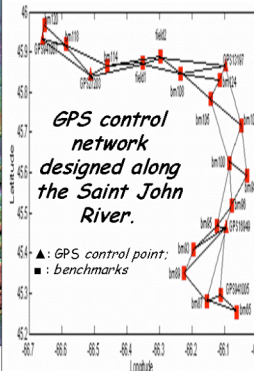
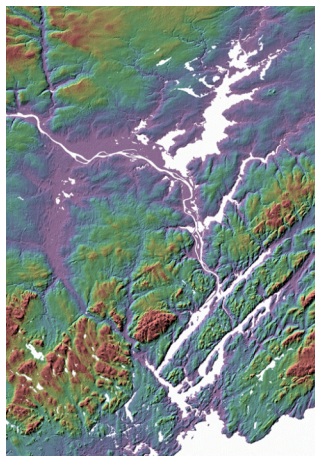
Herein we have been developing algorithms to blend PPK (post –processed carrier phase resolved DGPS solution) with real-time heave. An additional capability we have added is to substitute long period tidal trends where there are interruptions in the RTK solution (radio coverage or poor constellation). This address a significant deficiency due to the recognized imperfect reliability of carrier phase GPS.

### ***Seamless Ellipsoid-Chart Datum model for lower Saint John River Valley***

*Zhao, Brucker, (OMG)*

*NSERC –COSTA funding.*

One of the prime focuses of the OMG research over the past 2-3 years has been the estimation of seabed change. For inner shelf and coastal areas, accuracies in the sub-decimetres level would ideally be achieved.



A large part of the error component is often due to inadequate vertical control. This is especially pronounced in fluvial or estuarine environments where the datum is sloped and the phase and amplitude of the tide are highly variable.

Whilst currently, either discrete or interpolated tidal datums can address this problem, there still is the underlying requirement to maintain an excessive set of tide gauges and we still have the long

period heave, squat problem.

An alternate approach is to use carrier phase GPS for referencing, but this requires an adequate and seamless ellipsoid chart datum model. Such a model has been developed for the lower Saint John by obtaining precise heights for known benchmarks along the river and combining this with the regional geoid model.

### ***Blacks Point Offshore Disposal Sites – Seabed Change Investigations***

*Hughes Clarke and Duxfield, (OMG) Parrott, (NRCan)  
NRCan Funding*

As part of an ongoing collaborative research program with the GSC-A, biannual surveys have been conducted of the Blacks Point dumpsite.

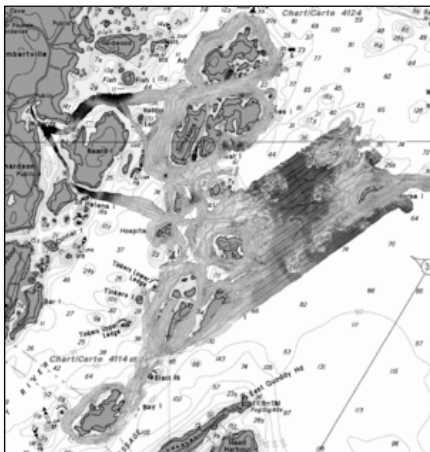
The surveys are conducted immediately after the dumping has finished in the fall and after the winter in the spring to see where the sediments have been redistributed to. In 2004, the surveys were broken up into separate survey periods due to weather restrictions, and when these surveys were differenced with the previous years work, it became clear that there were inter-surface differences that changed abruptly between survey periods.

Through analysis, it is clear that the sense of the surface offsets depends on the rate of change of the tide, indicating that there is an unmonitored tide phase delay required between the gauge (just a few km's away) and the survey site.

The phase delay was determined to be within the 2.5 to 7.5 minute range. The differences were not outside the survey specification requirements, but could clearly be improved upon. This analysis is being continued for all prior survey pairs to improve the results for the GSC.

### ***Fundy Isles – Habitat Mapping***

*Duxfield, Hutchinson and Hughes Clarke, (OMG), Buzeta, (SABS-DFO), Roff (Acadia)  
Acadia Funding*



As part of an ongoing collaboration between the OMG and researchers at the St. Andrews Biological Station and at Acadia, further seabed mapping was conducted in the Fundy Isles region. The underlying aim of the mapping program is to delineate seabed habitat.

Definition of what exactly a habitat is, is a highly contentious issue. However, most parties agree that seabed habitat correlates strongly with physical attributes of the seabed, most notably, depth, rugosity and the physical properties of the

surficial sediments. These, more tangible attributes can be assessed using the high spatial resolution bathymetry and backscatter obtainable from multibeam sonar.

A 7 day multibeam mapping program was implemented around specific, pre sampled sites round the Fundy Isles, SE of Deer Island, The data are being used for a type study of the locations of aquaculture sites and are being combined with older archived data in the SW NB area.

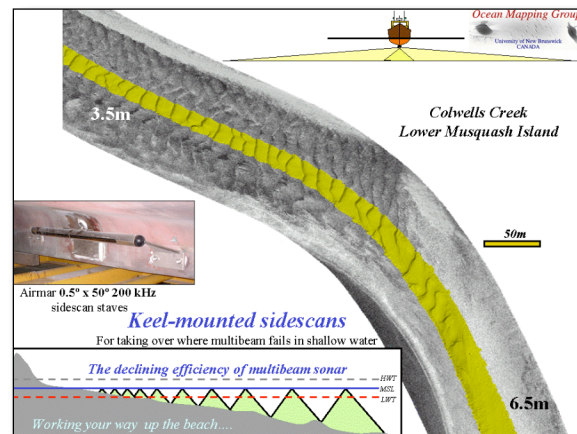
### ***Saint John River – Sturgeon Habitat Mapping***

*Brucker and Hughes Clarke, (OMG), Littvak and Li, (UNBSJ)*

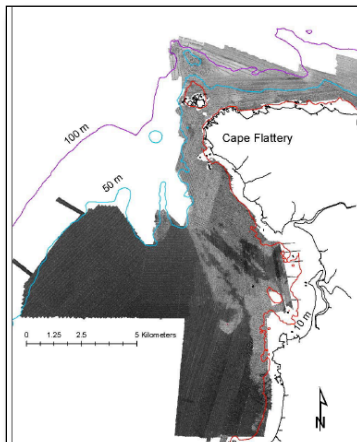
*Chair Funding*

In collaboration with the Biology dept. at UNBSJ, we are delineating surficial bathymetry and sediment type for the shallower sandy sections of the Saint John River between Fredericton and Evandale.

The aim is to use this data as an underlay for acoustic tracking of individual sturgeon migrations being undertaken by Littvak et al., In addition, physical samples will be taken to assess both the physical characteristics of the sediment (grainsize, porosity, density) and the benthic infauna (important to assess sturgeon feeding habits). These results will be correlated with the acoustic backscatter being acquired by the keel-mounted sidescans on the CSL Heron.



Owing to the extreme shallow depths encountered, the 100% sidescan coverage model, developed for the Shippagan surveys in 2003 (accepting <20% bathymetric coverage) is being adopted.



### ***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

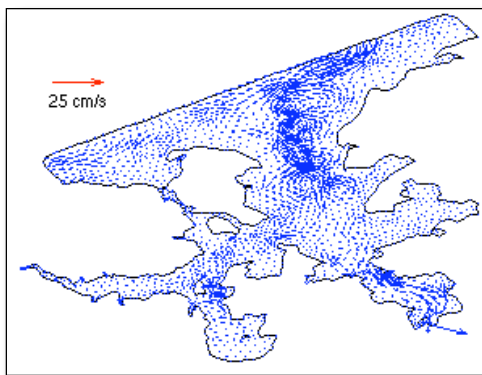
characterize the seafloor in the sanctuary into discrete habitat types.

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.

### ***Numerical Modelling of Shippagan Bay Circulation***

*Haigh and Hughes Clarke, (OMG), Chasse, (DFO-GFC)  
Gulf Fisheries Centre, DFO and Chair Funding*

As a natural continuation of the Shippagan Bay habitat mapping program, a finite element 3D hydrodynamic model of the bay and approaches has been developed.



The aim was to try to describe the flushing of the bay. The greatest volume of exchange occurs through the northern entrance into the Bay of Chaleur. The bay is, however, also connected directly to the Gulf of St. Lawrence through a narrow channel (the gully) at Shippagan itself.

The main concerns, however, were to look at the flushing in the vicinity of Lameque Bay where unwanted build up of organic material in the water column was known to be a problem.

ADCP observations clearly indicate that the smaller input of water through the channel at Shippagan are most responsible for the flushing times of Lameque Bay, rather than the main exchange at the northern entrance.

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

### ***Capability Acceptance Trials – HMS Enterprise, HMNIS Luymes***

*Hughes Clarke and Beaudoin (OMG)  
Royal Navy and Dutch Navy Funding*

As part of collaborative research with various agencies, the OMG actively conducts capability acceptance trials for the latest surveying hardware being introduced by the world leading government hydrographic survey organizations.

Following on from the 2003 trials of HMS Echo and HMNLS Snellius, in 2004 we had the opportunity to work with the new generation SVHO's (Survey Vessel, Hydrographic Oceanographic) that are updating the Royal Navy's operation fleet. HMS Enterprise is the second of a new class of 2 vessels that will undertake military hydrographic and oceanographic research worldwide. She is equipped with a Simrad EM1002 system.

Similarly HNIMS Luymes is the second of a new class of 2 vessels that will undertake The Royal Dutch Navy's hydrographic mapping requirements, mainly in the North Sea.

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.

### Arctic Tides – C-Nav GcGPS

*Wert, Hughes Clarke and Dare, (OMG, GGE) and Jimmy Chance, (C&C Technologies) C&C and ArcticNet funding*

As globally corrected GPS services are improving, there is an increasing interest in their viability for providing remote region and open ocean tides without requiring conventional tidal infrastructure. The Canadian Arctic is a classically ideal case for this. With the

scarcity of tide gauges and the impracticality of the Amundsen installing sufficient gauges to cover her wide ranging operations, it was necessary to look for other means.

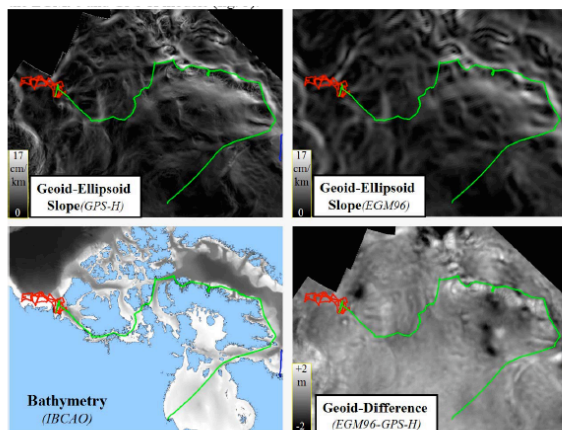


Figure 3: comparing the shortest wavelength undulations through slope and difference maps for the EGM96 and GPS-H models.

During the underway operations of CCGS Amundsen in 2004 (August to October), the C-Nav ellipsoid heights were logged continuously. These heights were then reduced to the vessel RP (from which all soundings were referenced). And that RP height was then shifted from the ellipsoid to the geoid using EGM-96 or GPS-H

(Geodetic Survey of Canada, locally refined height model).

The results closely match the output of WebTide, a spatially continuous 3D hydrodynamic model of the tidal constituents throughout the Arctic Island Archipelago. An added benefit was that it was found that over periods of a few 10's of minutes, the C-Nav solutions had a highly correlated error allowing us undertake squat estimates.

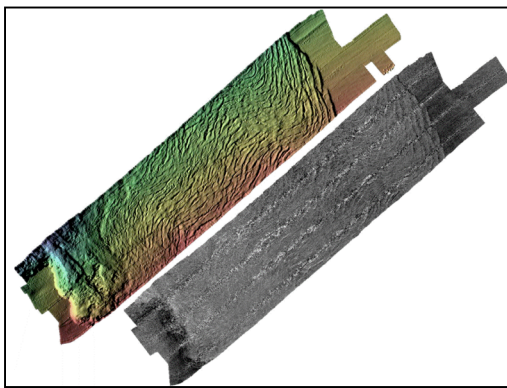
Remaining concerns include very long period residual errors that appear correlated with air pressure, a usable mean-sea-level to chart datum separation model and C-Nav outage periods.

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

*Hughes Clarke, Beaudoin, Brucker and Llewellyn (OMG), Bartlett, (CHS)  
CASES, ArcticNet and CHS Funding*

After breakout from Franklin Bay in July, the CCGS Amundsen proceeded to undertake multi-disciplinary science operations in the Beaufort Sea as part of the CASES program. This involved transits, station sampling and specific site surveys. The mapping built on the September 2003 operations.

A highlight of the mapping was the serendipitous imaging of a submarine instability feature on the outermost shelf edge. First identified in the 1980's from high resolution seismics, the spatial extent and detailed morphology of the feature were mapped out in a 6 hour period.



Additionally, improved imaging was achieved of the subglacial crag-and tail fluting previously picked up on the deeper floor of the Amundsen Gulf.

All data were re-raytraced using MVP and CTD data based on an interpolation model for the watercolumn, still under development.

Leg 8 was funded through the older CASES program, terminating in Kugluktuk

(Coppermine) in August. For Leg 9, the mapping shifted to the NorthWest Passage under the new ArcticNet project 1.6 program.

### **Hudson Bay – Geoscience Mapping**

*Beaudoin, (OMG), Allard and Lavoie, (Laval)  
ArcticNet and Laval Funding*

As part of the Health Surveys in Nunavik, an opportunistic transit of the Hudson Bay and specific sections behind the Nastapoka islands were acquired. This work was done in

collaboration with Laval Quaternary scientists to better understand the Holocene emergence of the south eastern Hudson Bay region.

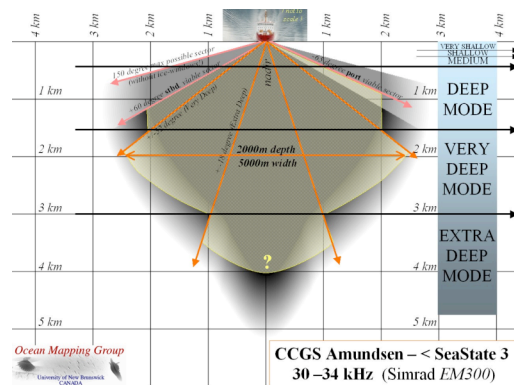
### **Labrador Sea – Deep Water EM300 Trials**

*Hughes Clarke and Llewellyn, (OMG)*

*Chair Funding*

During the transit back through the Labrador Sea, the vessel was diverted to the 2500m contour and a series of tests were undertaken to look at the performance envelope of the Kongsberg Simrad EM300 30 kHz sonar. In these depths the sonar is attenuation limited. In addition, this EM300 sonar is mounted flush with the hull behind titanium polymer ice-reinforced windows to ensure survivability whilst breaking ice. As a result the open water performance of the sonar is compromised.

The transit occurred during a 40 knot gale and thus the performance was assessed as the sea-state (estimated using wind speed and heave magnitude) rose up and gradually dropped down again. The results indicate a markedly reduced weather window for these flush-mounted arrays compared to gondola-mounted arrays. This is believed to be a result primarily of bubble wash-down occurring at sea-states above 4.



As the mandated mission of the Amundsen is to primarily work in the protected waters of the Arctic Island Archipelago (while surviving ice-breaking activities), these results are acceptable. But nevertheless they are a disappointment for potential work in the exposed open water region.

[http://www.omg.unb.ca/Projects/Arctic/LabradorSea/Amundsen\\_EM300\\_deep\\_water\\_performance.html](http://www.omg.unb.ca/Projects/Arctic/LabradorSea/Amundsen_EM300_deep_water_performance.html)

### **Makkovik Bank, Labrador Shelf – Geohazard Investigations**

*Hughes Clarke and Llewellyn, (OMG), Sonnichsen (NRCan)*

*NRCan Funding*

As part of the Geoscience for Oceans Management (GOM) program of the Geological Survey of Canada (GSC), there is a program examining geo-hazards relating to development of frontier resource development projects. With advancing technology it is now feasible that the hydrocarbon reserves under the Labrador Shelf could be developed.

The Ocean Mapping Group undertook mapping operations in support of the GOM objectives in October 2004. In the absence of any tidal control, C-Nav ellipsoid height

elevations (reduced to the geoid) were used. When compared to the WebTide predictions of the outer Labrador Shelf, a significant anomaly was noted that is believed to be a result of the recent passage of a large low–pressure system.

### **Swath Sonar Analysis Software**

*Hughes Clarke and Beaudoin (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 2004 year include.

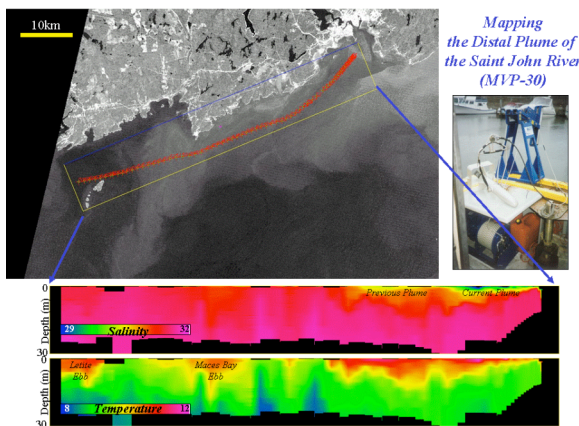
- Blending of low pass RTK ellipsoid heights with high pass heave.
- Support for XTF exported by QINSY – including backscatter.
- New algorithms added to allow squat estimation from either RTK or GcGPS height time-series.
- Automated removal of EGM96 from GcGPS heights for tidal estimation
- Automated embedding of WebTide heights for any location and any time.

### **Saint John River Plume**

*Hughes Clarke, (OMG)*

*Chair Funding*

Building on the success of the oceanographic profiling approach developed for working within the Saint John River Estuary, an opportunistic profile was collected along the transit route from the mouth of the Saint John to the Deer Island region.



This transect traverses the distal plume of the Saint John. Analysis of archived Landsat imagery clearly indicates the typical spatial extent of the plume of the Saint John River, developed each ebb tide. The results clearly indicate the extent of the plume, the degree of mixing of the brackish surface waters, and the presence of secondary fresh and warm plumes from Maces Bay and Letite Passage.

This result will be extremely important for proposed mapping operations along the New Brunswick Fundy coastline. Potential aggregate

resources are likely in this region and the ability to accurately monitor their evolution will be dependent on fully understanding the local oceanographic regime

### ***Great Barrier Reef – Habitat Mapping***

*Beaudoin (OMG), Steiglitz, (JCUNQ)*

*JCUNQ Funding*

As part of a collaborative program with the Physics and Maths department of James Cook University of North Queensland (Australia), we are utilizing our in-house software development to extract near-quantitative backscatter data from a RESON Seabat 8101 sonar. The operations are in support of habitat mapping on the inner Queensland continental shelf (amongst the Great Barrier Reef).

In a pilot study in the Central Great Barrier Reef, some representative inner and mid-shelf habitats including coral reefs were investigated with two high-resolution multibeam echosounders (RESON 8125 and RESON 8101). Key physical attributes of benthic habitats of hard coral, soft coral, sponge and seagrass assemblages were distinguished by their signature in the high-resolution bathymetry and backscatter record. In addition, small and medium scale bioturbation by crustacean and fish, as well as tracks left by bottom-trawl fishing were documented. Towed-video data provided visual biological and geomorphological habitat information for comparison, and was used to identify biota represented by the physical attributes in the bathymetry record. This pilot study illustrates the potential for high-resolution multibeam bathymetry and backscatter mapping to play a significant role in the assessment and monitoring of marine benthic habitats in the Great Barrier Reef Marine Park, in particular with respect to the effectiveness of new Marine Protected Zones introduced in mid 2004.

### ***Frazer Island, SE Queensland Shelf, Australia***

*Beaudoin (OMG) and Boyd (Univ. Newcastle, NSW)*

*Univ. Newcastle Funding*

As part of collaborative operations with the University of Newcastle (NSW, Australia), we are utilizing in-house developed software to process the bathymetry and backscatter from a RESON 8101 sonar. The work is part of a study of the fate of sand, sourced from around Frazer Island (Queensland), moving along the continental shelf and off shelf onto the slope. The field operations involved a 2 week survey from the RV Southern Surveyor in which the sonar was mounted on a pole from the moonpool.

Nighttime operations with the multibeam were alternated with day time coring and seismic work. All data were processed in the field and used to guide the following day's groundtruthing operations. The data were used to examine the dispersion of shallow water sand, sourced from the shoals off the NE tip of Frazer Island.

The data are part of a planned multi-year program. In 2005 an EM300 survey is planned to work on the adjacent continental slope and rise. The shelf sands are believed to be dispersed over the shelf break. The aim of the surveys is to establish the mechanisms for sediment transport in the area.

### ***Princess of Acadia Project***

*Cove, Santos and Wells (OMG/GGE) and (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 base-stations 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](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 2004 year in:

|                    |              |
|--------------------|--------------|
| San Diego, CA, USA | in January   |
| Ottawa, Canada     | in May.      |
| Stavanger, Norway  | in November. |

The course student body is typically 40 to 50 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](http://www.omg.unb.ca/GGE/SE_3353.html)

Field program in 2004 – C.S.L. Heron, Saint John River, Fredericton.  
Introduction to Acoustic Sensors and Survey Procedures

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

###### **Santos and Wells**

Marine, Terrestrial and Airborne dynamic navigational theory and methods.

Field program in 2004 – C.S.L. Heron, Saint John River Fredericton.  
Implementation of Position and Orientation Measurement. Multi-Sensor Integration

**GGE5072 Hydrographic Data Management****Wells**

Principles and issues of data management in marine applications

Field program in 2004 – C.S.L. Heron, Saint John River Fredericton. Patch Test conduct and analysis.

**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](http://www.omg.unb.ca/GGE/GGE5013_Fall_2004.html)

Field Program in 2004 - Tide gauge and bottom mounted ADCP in Long Reach, Saint John River.

**GGE5083 Hydrographic Field Operations****Hughes Clarke**

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

[http://www.omg.unb.ca/GGE/SE\\_5083.html](http://www.omg.unb.ca/GGE/SE_5083.html)

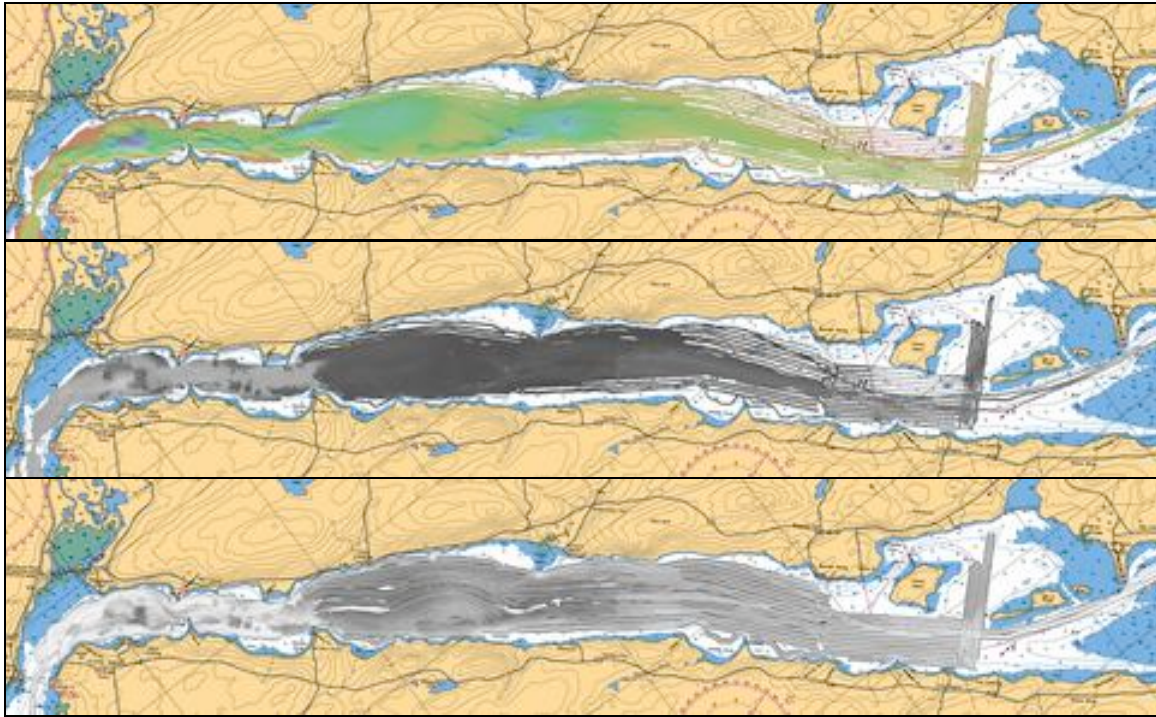
In 2004, the length of the GGE5083 program extended over 30 days of survey (spread from late April for installation and calibration) to end of May. The whole month of June is set aside for data processing. This is now deemed necessary as the aims of the course have moved on from the minimum hydrographic requirements to be a training session including geophysical and oceanographic surveying

In 2004 the area chosen was an extension of the 2003 Hydrocamp in Grand Bay and the Westfield Channel up into Long Reach (see figure below). This area was chosen as it is the focus of an ongoing MscEng Thesis of Nicole Delpeche who is working on the estuarine circulation of this section of the estuary.

The data were reduced using three tide gauges along the length of this section of the estuary (Days Landing, Belyeas Point and Oak Point). The lower section of the estuary, with depths greater than ~15m was covered using the conventional 200% multibeam coverage model standardly adopted by the CHS. For shallower depths the 100% keel mounted sidescan model used in the 2003 operations was adopted.

In addition to the multibeam and sidescan survey, a 3.5 kHz subbottom profile grid was acquired and processed to fence diagrams. In addition, the students undertook regular MVP and ADCP oceanographic sections along Long Reach over the month period of

acquisition. The aim was to monitor the flushing out of the salt water during the freshet and to see the first return of the saline intrusion as the water level dropped back to summer levels.



**Hydrocamp 2004** – Long Reach, lower Saint John River estuary - CSL Heron operation May 2004:

- Top – EM3000 bathymetry
- Middle – EM3000 backscatter
- Lower – K320 – sidescan backscatter

. Underlying image is CHS chart 4142

## 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 Characterization, 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 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 computing facilities and travel to international meetings, an annual minimum budget of ~**C\$165k** is required. To date, this level of support continues to be comfortably 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 organisations). At this point there are 6 sponsors.

### Current Sponsoring organisations ;

- |                                  |        |
|----------------------------------|--------|
| 1. Canadian Hydrographic Service | 1991 - |
| 2. Kongsberg Simrad Mesotech     | 1995 - |
| 3. U.S. Geological Survey        | 1996 - |
| 4. University of New Hampshire   | 2000 – |
| 5. Thales GeoSolutions           | 2003 – |
| 6. Royal U.K. Navy               | 2003 - |

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)

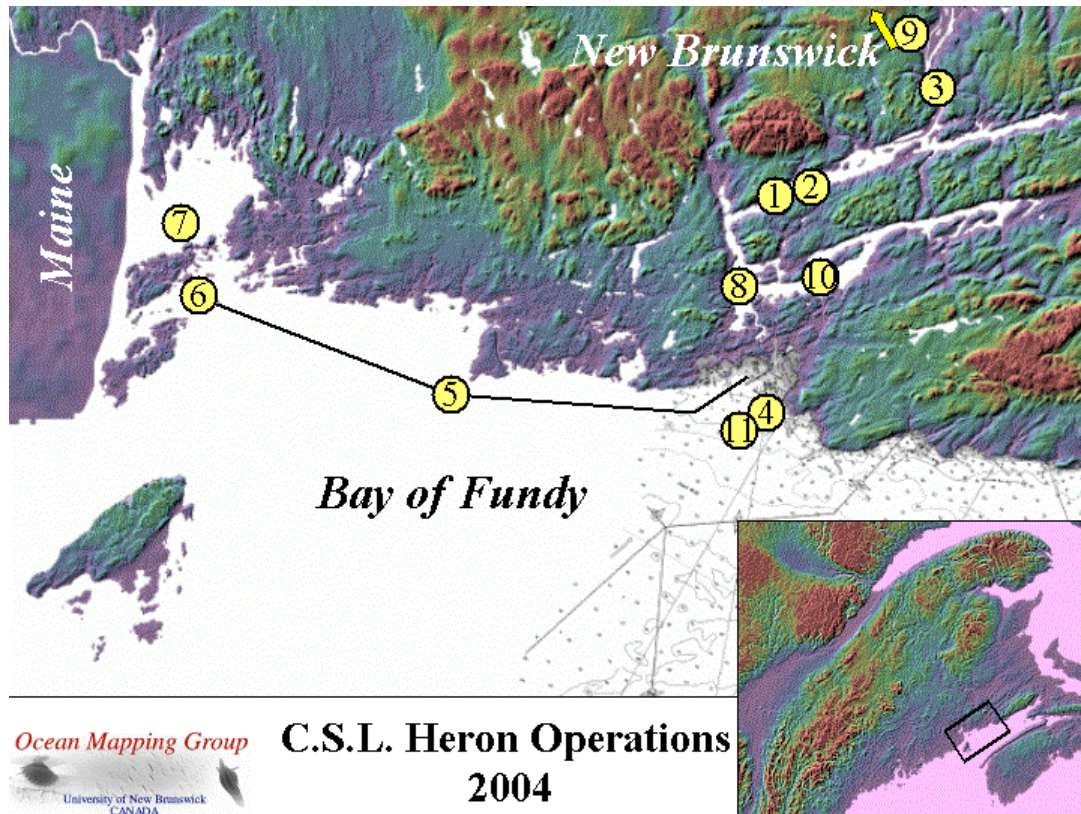
Whilst the sponsorship funding is the prime source of support for the core Chair research program, all the researchers working with the Chair have been successful in attracting funding from other research agencies. This funding allows us to complement Chair research, which is by design very focused on 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 2004 include:

|   |                |
|---|----------------|
| The opening NW Passage<br><i>ArcticNet NCE</i>  | C\$131,000     |
| ADCP and Optical Backscatter for Dumpsite Assessment,<br><i>Natural Resources Canada, Geoscience for Ocean Management</i> | \$17,500       |
| Multibeam Analysis for HMNIS Leeuwin, Department of The<br>Navy, <i>Royal Dutch Navy, New Hydrographic Ships</i>          | C\$32,000      |
| Operational trials for HMS Enterprise EM1002 Royal Navy,<br><i>Department of The Navy U.K. Ministry of Defence DNSOM</i>  | C\$20,000      |
| COSTA-CANADA , continental slope stability :<br><i>NSERC Collaborative Research Grant – sub section</i>                   | C\$31,000 pa . |
| Precise Mapping and Monitoring of Seabed Change:<br><i>NSERC Research Grant</i>   | C\$28,000 pa   |
| Collaborative Multibeam Operations, Labrador Margin<br><i>Natural Resources Canada –Contribution Agreement</i>            | C\$40,000      |
| Seabed Habitat Studies, Fundy Isles Region,<br><i>Acadia University</i>   | C\$12,000      |
| Acoustic delineation of critical species habitats:<br><i>NB Innovation Fund – Research Assistant</i>                      | C\$10,000pa    |
| Great Barrier Reef Habitat Mapping<br><i>James Cook University of North Queensland, Australia</i>                         | C\$5,000       |
| Frazer Island Continental Shelf Mapping<br><i>Newcastle University, NSW, Australia</i>                                    | C\$10,000      |

### ***Heron Field Operations***

For the 2004 field season she was based at the Saint John Marina in Grand Bay, just above the Reversing Falls. Further internal storage chamber and repair work went on over the 2003-2004 winter. Heron was launched in April and was recovered in November:



The projects completed include:

1. **Long Reach**, Lower Saint John River - Hydrocamp 2004 - May
2. **Long Reach** - Salt-Fresh Mixing - Tidal Cycle Studies - June - September - October
3. **Evandale to Gagetown** - Sturgeon Habitat Surveys - June
4. **Blacks Point Dumpsite** NRCan pre-dumping survey - July - post dumping - November
5. **Saint John Plume** - MVP sections - Fundy Coast - July
6. **Fundy Isles** (Deer-Island to Wolves) - Habitat Survey for SABS - August
7. **Passamaquoddy Bay** - Pockmark change and subbottom profiling surveys
8. **Grand Bay** - Undergraduate training -GGE 3353 - 4042-5072-5013 - September
9. **Gagetown to Fredericton** - Sturgeon Habitat Surveys - October
10. **Kennebecasis Fjord** Bathymetry surveys - October-November
11. **Saint John Harbour Approaches** - November -Optical backscatter surveys of river plume (cancelled)

***Computing Hardware***

In order to conduct OMG research, a mixture of Unix and Windows platforms are maintained. For the core swath sonar data processing applications (SwathEd), Linux or UNIX platforms are the prime tool. SwathEd used to be supported on SGI, DEC, Solaris or Linux platforms. Given the strong convergence of almost all users to cheaper linux based platforms, the other operating systems (SGI-Irix, SUN-Solaris, DEC-Ultrix) are now being dropped.

Suffice to say we have a enough (> 20 ) PC running mainly linux (a few with Windows for office-like applications). A few (7) SGI's remain operational, mainly to support undergraduate teaching.

Archiving remains an issue. With the majority of disk being > 100Gb, it is hard to ensure secure backup. At this time, most disks are individual 100-200 Gb IDE disks that can fail (2 in 12 months). Backup to DLT appears the most secure. DVD burning is gradually replacing CDROM's. Exabyte is still available to read old and imported media.

## **Publications:**

### **2004**

#### **Journal Articles**

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Zhao, J., Hughes Clarke, J.E., Brucker, S. and Duffy, G., 2004, On the fly GPS tide measurement along the Saint John River: International Hydrographic Review, accepted, in press.

Lastras, G., Canals, M., Urgeles, R., Hughes Clarke, J.E. and Acosta, J., 2004, Shallow slides and pockmark swarms in the Eivissa Channel, western Mediterranean Sea: Sedimentology, v.51. p.1-14.

Wildish, D.J., Hughes Clarke, J.E., Pohle, G.W., Hargrave, B.T., Mayer, L.M. 2004, Acoustic detection of organic enrichment in sediments at a salmon farm is confirmed by independent groundtruthing methods: Marine Ecology Progress Series, v.267, p.99-105

Butler, K.E., Nadeau, J.-C., Parrott, R., and Daigle, A. (2004). Delineating recharge to a river valley aquifer by riverine seismic and EM methods. *J. Environmental and Engineering Geophysics*, 9, 95-109.

#### **Conference Proceedings**

Duffy, G. and Hughes Clarke, J.E., 2004, Detecting migration of sand dunes using spatial correlation, Sea Technology, October 2004, p.53-58.

Zhao, J., Hughes Clarke, J.E. and Brucker, S., 2004, Establishing a Seamless Vertical Reference along the Tidal Segment of the Saint John River: Lighthouse, Journal of the Canadian Hydrographic Association, October issue, in press.

Bartlett, J., Beaudoin, J. and Hughes Clarke, J.E., 2004, CCGS Amundsen: A New Mapping Platform for Canada's North: Lighthouse, Journal of the Canadian Hydrographic Association; Edition No. 65

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Cove, K., M. C. SANTOS, D. Wells and S. Bisnath (2004). "[Improved tropospheric delay estimation for long baseline, carrier phase differential GPS positioning in a coastal environment](#)." *Proceedings of the Institute of Navigation GNSS-2004*, 21-24 September, 2004, Long Beach, CA, USA, pp. 925-932.

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SANTOS, M. C., Dave Wells, K. Cove and S. Bisnath (2004). "[The Princess of Acadia GPS Project: Description and scientific challenges](#)." *Proceedings of the Canadian Hydrographic Conference CHC2004*, 25-27 May, 2004, Ottawa.

Cove, K. M. and M. C. SANTOS (2004). "[An analysis of carrier phase differential kinematic GPS positioning using DynaPos™](#)". *GPS Solutions*, Vol. 8, No. 4, pp. 210-216 Springer.

Nadeau, J.-C., Butler, K.E., Hunter, J.A., Veillette, N., Douma, M., Burns, R.A., and Good, R.L. (2004). Reflection and downhole seismic studies of a glaciofluvial river valley aquifer, Proc. of 17th Symposium on Application of Geophysics to Engineering and Environmental Problems (SAGEEP 2004), 1408-1419.

### **Technical Reports**

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Hughes Clarke, J.E., 2004, HOV2 – H.NI.M.S. Luymes - A803 Integrated multibeam sonar system acceptance trials, 2nd-6th May 2004, Vlissingen-Ameland: Contract Report to Hydrographic Department, Royal Dutch Navy.

### **Theses**

James Bradford (M.Eng.) - 2004 - [TOWCAM System Sensor-Aided Oblique-Angle Video Mosaics](#)

Travis Wert (M.Sc.Eng.) - 2004 - [Tidal Height Retrieval using Globally Corrected GPS in the Amundsen Gulf Region of the Canadian Arctic](#)