Chair in Ocean Mapping

Current and Future Research Activities Y2003-Y2004

"home of the Heron"

January 2004

John E. Hughes Clarke
Associate Professor, Chair in Ocean Mapping
Ocean Mapping Group
Dept .Geodesy and Geomatics Engineering
University of New Brunswick
P.O. Box 4400
Fredericton, NB, E3B 5A3, CANADA
jhc@omg.unb.ca

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 2003 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

ArcticNet – Northwest Passage - Amundsen

In August 2003, the CCGS Amundsen sailed from Quebec City for the start of a 14 year program of research in the Canadian Arctic. The Amundsen is the refitted CCGS Sir John Franklin, a 1200 class icebreaker built in 1984 and refitted in 2003 at a cost of C$28 million.

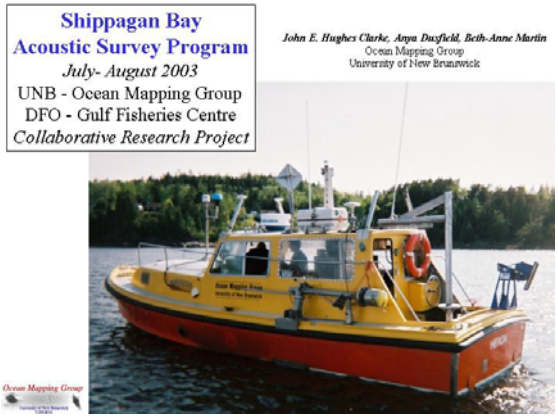
The vessel was rebuilt to be a multi-functional, dedicated Arctic research vessel. As part of her new scientific instrumentation she is equipped with :

- a Simrad EM300 30kHz multibeam echo-sounder,
- a POS/MV orientation sensor,
- a C-Nav WADGPS receiver,
- a Brooke Ocean MVP-300/1700 underway profiler and
- a Knudsen 320R chirped 3.5 kHz subbottom profiler.
-

The Ocean Mapping Group is in charge of the acquisition, management, distribution and interpretation of all the underway geophysical data from the Amundsen.

The refit was funded by NSERC and the Canadian foundation of Innovation. The ArcticNet science program for the next 4 years is funded as part of the NSERC National Centres of Excellence (NCE) program.

Shippagan Bay Habitat Mapping Program



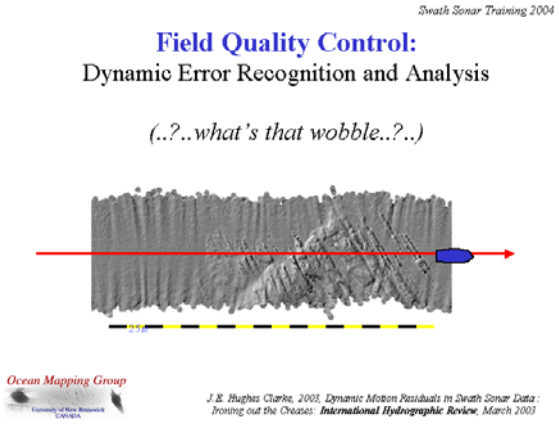
In 2000, 2001 and 2002, the Ocean Mapping Group became involved in a series of extensive coastal mapping projects in partnership with the fisheries scientists of the Department of Fisheries and Oceans, based out of the St. Andrews Biological Station (2000 –Letang Estuary, 2001 – Musquash Estuary, 2002 –Long Island and Duck Island Sounds, Grand Manan). In each case, it was demonstrated that precise, calibrated acoustic mapping programs were able to contribute significantly to fisheries problems in habitat and aquaculture site placement and monitoring.

In 2003, there was the opportunity to do a larger scale operation on the Gulf of St. Lawrence in support of lobster habitat, mussel aquaculture and fish plant waste effluent. All of these problems existed in the Shippagan Bay region of NE New Brunswick. The Ocean Mapping Group undertook this program as part of a 30 day deployment of the CSL Heron.

In contrast to the M2 dominated, macro-tidal and generally deeper water of the Bay of Fundy, operations in the gulf coast side of New Brunswick pose particularly different challenges to efficient survey. The seabed, subsurface and the oceanographic data were all acquired processed and put on line. Current research with this data includes the development of sediment classification algorithms and the construction of a 3D finite element hydrodynamic model of the circulation of the Bay.

Major Research Developments

Wobble Analysis (Dynamic Errors in Swath Sonar data)



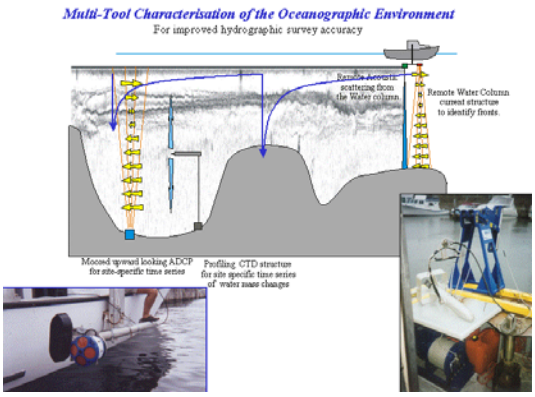
An emerging issue over the past 5 years has been the concern from many swath sonar users that periodic, motion-correlated residuals were present in their data, even after standard field calibration and alignment procedures. These residuals usually are expressed as periodic oscillations in the swath bathymetric corridor, oriented transverse to the ship heading.

To address these problems we have focused on analyzing the source of these systematic errors. Some are due to synchronization problems, others alignment and offset errors and a significant cluster of artefacts are actually due to sound speed errors. In all cases there is a rational systematic cause for each of these artifacts.

Once the cause had been identified we developed a series of automated graphical analysis tools that allowed the operator to visualize the correlation of any of the main artefact types with one of the characteristic driving signatures. The tool is currently built into SwathEd, the Ocean Mapping Group's in-house developed dedicated swath sonar processing software package. The results were recently published in the International Hydrographic Review and the method are routinely used by Chair staff for analysis of operational problems worldwide.

Multi-Sensor Oceanographic Imaging

As part of an ongoing effort to better characterize the spatial and temporal variability in the oceanic sound speed field (for ray tracing purposes) we have developed a suite of software tools to support a new multi-sensor approach to oceanographic imaging.



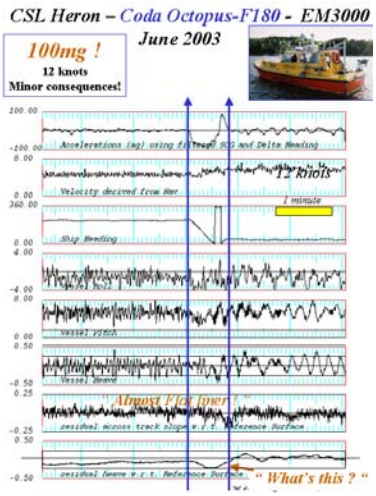
By combining towed, undulating physical sampling instruments (specifically the Brooke Ocean MVP family of instruments) with acoustic volume scattering devices (conventional and ADCP), we have developed an efficient way to examine physical oceanographic processes at a very fine spatial and temporal resolution.

We have applied this methodology now to problems in coastal and estuarine oceanography on the Fundy and Gulf of St. Lawrence coasts of New Brunswick. Plans are underway to apply these methods to the operations of the CCGS Amundsen whilst surveying in the Canadian Arctic Archipelago.

Recent Infrastructure Upgrades - Instrumentation

F-180 GPS aided inertial navigation system

The Ocean Mapping Group have entered into an informal collaborative relationship with Coda-Octopus of the U.K. Coda are interested in getting feedback on their new GPS-



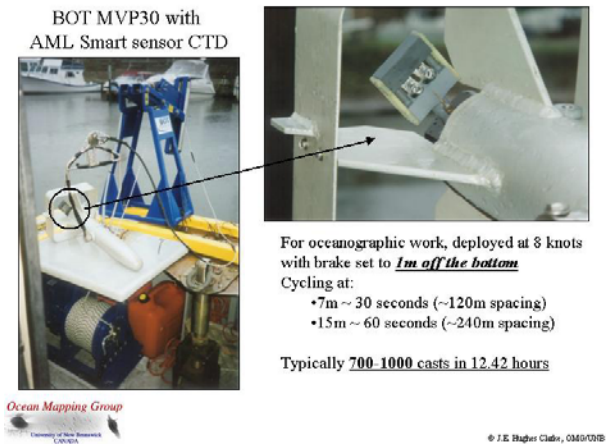
aided inertial navigation system which they have introduced into the marine survey market.

Previously, we had only had short term loans of the higher end GPS-aided inertial solutions (POS/MV and SeaPath) to test motion sensor responses to the particularly high vessel dynamics experienced on the CSL Heron. By comparison, these had clearly revealed the limitations of the cheaper speed aided VGA sensors that we were currently using.

By running the F180 continuously now and simultaneously with the existing MRU-6 we can compare sensor responses as a quality control and most significantly provide redundancy during field programs in the case of hardware failure.

MVP upgrade

In 2002, as part of the delivery of C.S.L. Heron, a Brooke Ocean MVP –30 towbody had been combined with a Valeport winch. At the time, financial constraints had precluded the purchase of a full MVP system. Nevertheless, by slowing down and paying out the Valeport cable (no freefall was possible), reasonably dense sound speed field measurements could be made.



Over the winter of 2002-2003, a full upgrade was completed to have the automatically undulating functionality of a full MVP-30. This has now been used for a full season and has demonstrated itself exceptionally. For oceanographic research, the system has proved capable of continuous operations for periods of a tidal cycle acquiring as many as 1000 profiles in a single day. This capability, for the first time allows us to examine spatial variability in the oceanography over length scales as small as a few100m.

In the fall of the year, through collaboration with GSC-A we purchased and installed an optical backscatter probe, adding to the capability of the instrumentation for suspended sediment studies.

Contents

Personnel

Faculty

John E. Hughes Clarke	Associate Professor, Chair in Ocean Mapping, GGE *Swath Sonar Software Development, Sediment Transport*
David Wells	Professor Emeritus, GGE *Hydrography, Geodesy, Uncertainty management*
Y.C. Lee	Professor, GGE *Geographic Information Systems, Spatial Data Infrastructure*
Sue Nichols	Professor, GGE *Coastal and Marine Cadastral*
Marcelo Santos	Associate Professor, GGE *Kinematic Positioning, Geodesy*
Karl Butler	Associate Professor, Dept. Geology *Exploration Geophysics*
Dave Monahan	Director of Ocean Mapping, CHS *Law of the Sea*

Research Associates and PostDoctoral Fellows

Dr. Susan Haigh	Contract Researcher *Numerical Modeling of Coastal Circulation*
Dr. Jianhu Zhao	NSERC Postdoctoral fellow *RTK GPS – Heave integration*

Support Staff

Shawn Woo	System Manager
Anya Duxfield	Research Assistant
Loren Fleet, Howard Ingalls	Skipper, CSL Heron
Tracey Hawco	Accounting

Graduate Students

Doug Cartwright	JHC	MEng 2000-2003
Ted Byrne	JHC	MEng 2000-
Sam Ng'ang'a	SN	PhD 2000-
Sarah Cochrane	SN	MEng 2000-
Michael Sutherland	SN	PhD 2000-
Garret Duffy	JHC	PhD 2001-
Jonathan Beaudoin	JHC	M.Sc.Eng 2001-
Jennifer Coppola	JHC	M.Sc.Eng 2002 -
Karen Cove	MS	M.Sc.Eng 2002 -

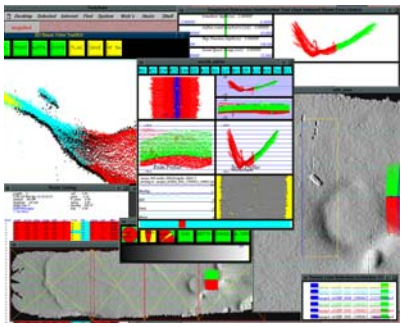
Jim Bradford	JHC	MEng 2002 -
Andy Muir	JHC	MEng 2002 -
Lionel Manteigas	DEW	MEng 2002 -
John Fleming	DEW	MEng 2002 –
Kristian Llewellyn	JEHC	MEng 2003-
Jon Griffin	JEHC	MEng 2003-
Richardo White	KB	MSc 2003-
Nicole Delpeche	JEHC	MscEng 2003-

Adjunct Faculty and Active Collaborators in 2003

Dr. Larry Mayer	Adjunct Professor, University of New Hampshire
Russell Parrot	Research Scientist GSC – Atlantic, BIO
Bill Danforth	Research Scientist USGS – Woods Hole Field Office
Dr. Michel Comeau	Research Scientist DFO – Gulf Fisheries Centre, Moncton
Maria-Ines Buzeta	Research Scientist DFO – St. Andrews Biological Station

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 and Beaudoin OMG
Chair Funding

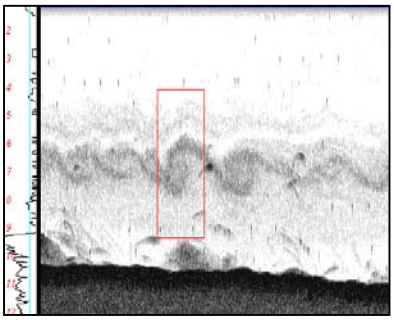
In order to support the core swath sonar research that is active within the Ocean Mapping Group, a UNIX based processing and analysis package (SwathEd) is constantly maintained and enhanced.
Software developments have continued, the most noticeable advancements in the 2003 year include.

- Further automation of Seismic section project software (incl. SEGY support)
- Upgraded MVP 30 profile manipulation software (to include optical backscatter and support SV-T)
- Automated IMU to SRF alignment tool development
- Automated motion correlated residual analysis (wobbles)
- Reson snippet support extended for 8125, 8150
- Knudsen sidescan beam pattern reduction software

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

Delpeche and Hughes Clarke OMG
Chair and NSERC Funding

Beginning in 2003 we are 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.



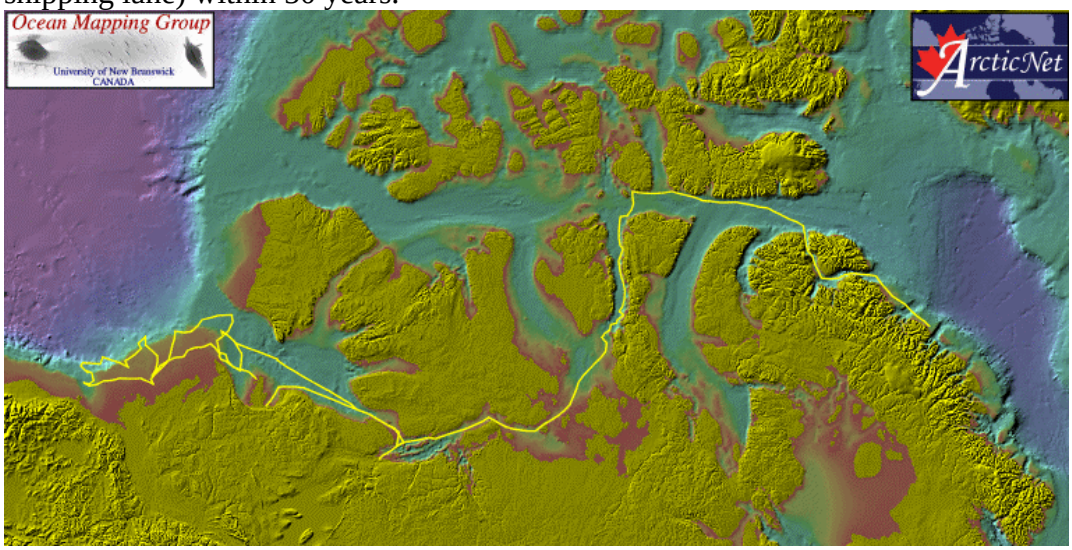
The normal upstream limit of significant saline intrusion occurs at Oak Point, ~ 2/3 of the way up Long Reach where a shallow sill is present. During freshet events, the salt water is almost entirely flushed out of Long Reach. This tremendous contrast in estuarine mixing character as a function of season 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.

Results from one of the 2003 longitudinal sections can be seen at:
http://www.omg.unb.ca/Oceano/lowerSaintJohn/LongReach_OpticalBackscatter.html

The Opening North West Passage – Marine Geophysical Surveys

Hughes Clarke, Beaudoin OMG and Bartlett CHS
ArcticNet NCE Funding

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. 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. 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.



In September 2003, the vessel made its first transit through the Northwest Passage, collecting the first multibeam data in that area. This is the start of a 4 year program, extendable for 14 years, part of which focuses on the geology and oceanography of the Northwest Passage.
Underway geophysical data is available online from:
http://chamcook.omg.unb.ca/~arcticnet/

The focus of research at the OMG is on the handling of the survey data. Aspects include:

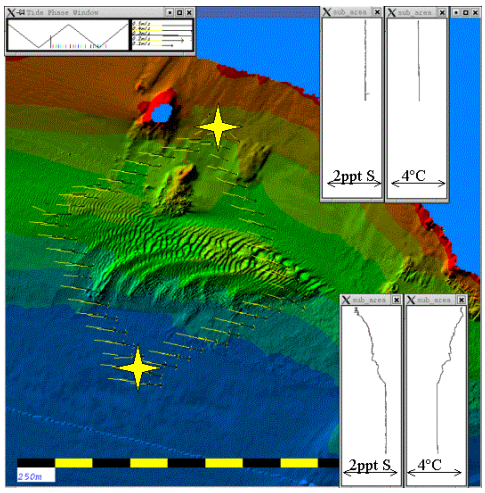
- EM300 data quality issues associated with signal refraction and attenuation through ice-windows
- Coping with incomplete sound speed information (MVP operations must be suspended during the presence of any ice cover, and the surface probe blocks routinely during ice breaking).

- Trying to establish vertical datums and measure tidal perturbations without recourse to tide gauge information. The focus at this point is using WADGPS solutions such as C-Nav.

Precise Monitoring of Bedform Migration

Duffy, Parrott (GSC) and Hughes Clarke
GSC and NSERC funding.

As part of the increased focus on precise resurvey capability, a test bed has been established over a highly dynamic sand wave field off Mispec Bay.



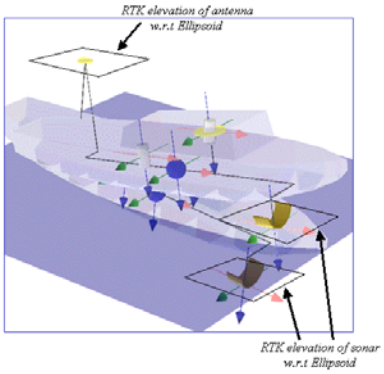
Building on the 2 years of GSC operations on the Mispec Bay sandwave field, an experiment was initiated over the these mobile bedform fields where different motion sensors and RTK integrations would be tested at monthly intervals for the summer period of 2002. In all, 6 surveys were conducted at monthly intervals over the summer period.

In addition 3.5 kHz subbottom was deployed to examine the internal structure of the dune field and 2 ADCP tidal cycle diamonds were implemented to isolate the eddy development centred over the tear shaped body. Simultaneously MVP-30 CTD profiles were conducted to examine the evolution of the oceanography over the tidal cycle allowing us to monitor the location of the Saint John River plume.

In 2003, an additional ADCP cycle was acquired along with a bottom-sampling program involving grabs, bottom photos and video transects. In the fall, parallel investigations of the extent of the Saint John River ebb-tide plume were undertaken (see below).

RTK-Heave Integration

Zhao, Duffy and Hughes Clarke
NSERC COSTA Funding



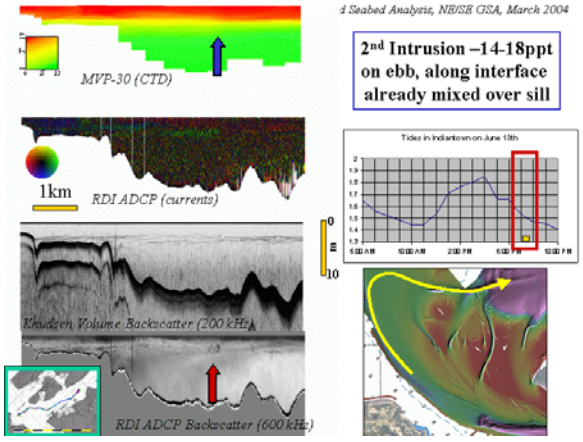
When trying to monitor seabed change on a scale of decimeters, the long period (> 20 second) drifting of many heave sensing systems can be a significant detriment. The nature of the causal filters used in most real-time heave outputs, cannot adequately cope with DC changes in draft of vessels as a function 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 manoeuvres. 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.

Kennebecasis Grand Bay Circulation and Salt Water Exchange

Hughes Clarke OMG, Sutton, Univ. Toulon
Chair Funding

A major focus of the oceanographic research undertaken by the OMG has concentrated on the estuarine circulation of the lower Saint John River system. It had long been recognized that the sill in Grand Bay, controls the exchange of salt water between the gorge, immediately upstream of the Reversing Falls, and both Long Reach and the Kennebecasis Fjord. Beginning in 2000, bathymetric surveys of the sill had recognized that channels were incised on the sill top, through which the much of the exchange of saline water was focused (*http://www.omg.unb.ca/GGE/Sill_Survey.html*).



In the spring of 2003, as part of the GGE5083 Hydrocamp, the full extent of the sill top was finally mapped with 100% multibeam coverage so that the full pattern of both the channels and associated seabed scours could be viewed.
Taking advantage of the recently upgraded MVP-30, we now attempted to improve on the 2000 ADCP tidal cycles (*http://www.omg.unb.ca/~jhc/kenneb/adcp_anim.html*) to look at the evolution of the saline water exchange over a spring tide cycle during the mid-summer low water period.
We were able to view the details of the injection of the dense salt water across the sill into the Westfield channel. We were also able to see the mechanism for injection of the intermediate density intrusion between the main salt and freshwater layers in the Kennebecasis. Animated results can be viewed at
http://www.omg.unb.ca/Oceano/lowerSaintJohn/OMG_UNB_Salt_Water_Intrusion_Dynamics.html
.

Capability Acceptance Trials – HMS Echo, HMNlS Snellius

Hughes Clarke and Beaudoin OMG
Royal Navy and Dutch Navy Funding

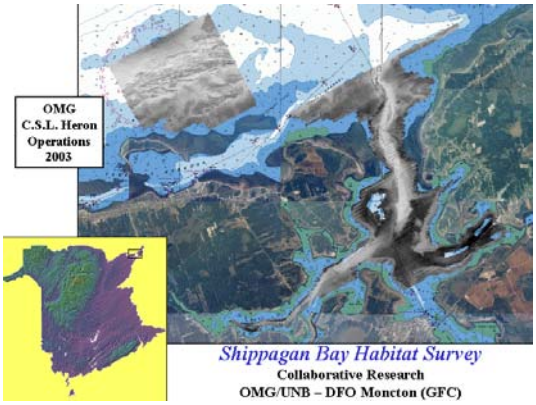
As part of collaborative research with various agencies, the OMG actively conducts capability acceptance trials for the latest surveying hardware being introduced by the world leading government hydrographic survey organizations.

In 2003 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 Echo is the first 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 HNlMS Snellius is the first 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.

Shippagan Bay Seabed Habitat Mapping and Estuarine Circulation Studies

Hughes Clarke, Duxfield and Martin, OMG, Oullette, Comeau DFO-GFC
DFO – Gulf Fisheries Centre Funding

As part of a collaborative research project with the Gulf Fisheries Centre in Moncton, a 40 day field operation was undertaking using C.S.L. Heron in Shippagan Bay, New Brunswick.



The aim was to delineate variations in surficial sediment distribution and to map the variations in the current field and T and S distribution over a summer tidal cycle.

The principal tools used were multibeam sonar and keel mounted sidescans. Only the keel mounted sidescans achieved 100% coverage in the water depths considered (2-20m, average

depth 4m). All maps are available on line at *http://www.omg.unb.ca/Projects/Shippagan/*.
Textural classification algorithms have been developed to try and characterize acoustic habitat from the keel-mounted sidescans.
For all operations a pole-mounted ADCP was continually deployed to capture currents everywhere at random phases of the tide. These were then sorted by phase of the M2 tide to get a picture of the typical circulation over a tidal cycle:

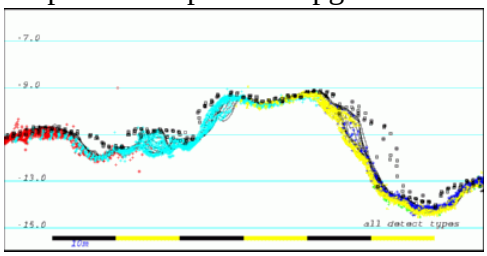
http://www.omg.unb.ca/Projects/Shippagan/OMG_DFO_Shippagan_ADCP.html

For two critical sections of the bay, the section was repeated 30-40 times over an M2 tidal cycle to try and establish the details of the exchange both from the open Bay de Chaleur to the north, but significantly also an inflow through Shippagan Gully to the south.
One of the prime aims was to understand the flushing of Lameque Bay where there is a well establish problem with flushing of fish plant waste:
http://www.omg.unb.ca/Projects/Shippagan/OMG_DFO_Lameque_Bay_Plume.html

Multibeam v. Boom System Comparisons

Hughes Clarke and Duxfield, OMG, McCavour, Port of Saint John
P.S.J. Funding

As part of the planned upgrade in the Port of Saint John's hydrographic mapping capability, a test comparison was performed between the existing Navitronics boom system currently used and the OMG's EM3000S multibeam sonar system. The results indicated that significant advantages in spatial resolution were achievable with the newer multibeam technology. With improvements in water column monitoring, the extremely variably oceanography of the harbour (freshwater discharge severely modulated by state of tide) is no longer an insurmountable detriment to achievable accuracy using oblique beams.



Results are presented at:
http://huron.omg.unb.ca/Analyses/Rodney_Comparison/PSJ_Swath_v_Sweep.html

Optical Backscatter Investigations of dumpsite barge plumes.

Hughes Clarke, OMG, Parrot, GSC-A, NRCan
NRCan Funding

As part of an ongoing study between NRCan, Environment Canada and the OMG into the sediment dynamics in the Saint John Harbour approaches area, an investigation was performed looking at the fate of sediment immediately after release by the dredge barges.

During the fall active dredging operations, the MVP-30 sensor was deployed with a new optical backscatter probe that

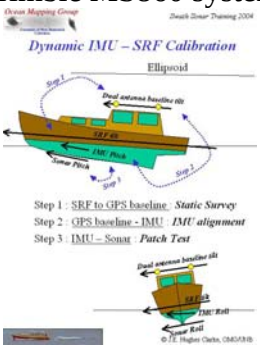
measures suspended sediment concentrations. In addition both 200 and 600 kHz acoustic volume backscatter measurements were made to see if they could act as a proxy for physical (optical) sampling. Two dredge barges were followed out to the Blacks Point dumpsite and the profiler and acoustic sensors deployed on a series of transits through the drop point for a period of about 20 minutes after the drop.
The optical probe was subsequently calibrated against suspended sediment samples at BIO. The optical probe has a number of sensitivity settings. For these initial trials, the most sensitive setting was used which resulted in the digital output saturating.
Results can be seen at:

http://www.omg.unb.ca/Oceano/dredge_scows/OMG_Dredge_Scows.html

Use of dual GPS heading sensors for underway alignment

Hughes Clarke, OMG
Chair and McQuest Marine Funding

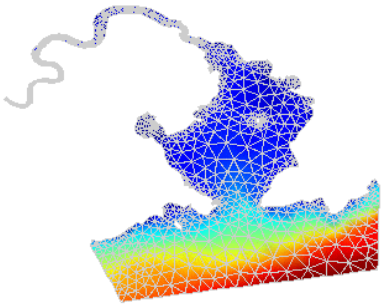
As part of an experiment into the use of stand-alone dual antenna GPS systems, a Trimble MS860 system was installed and operated for a period of a month at the end of 2002. The aim was to see if we could use the inter-antenna tilt (w.r.t. the ellipsoid strictly) as a comparison against a long time series of IMU pitch output. The aim being, knowing the antenna mount coordinates precisely within the ship reference frame (SRF), we could establish the alignment of the IMU reference frame w.r.t. the SRF.



The method was found to be reliable, allowing one to freely change IMU's in a dynamic environment, confident that misalignments with the SRF may be resolved without requiring a stationary survey (assumes your antenna mount positions are already precisely surveyed in).

Musquash Estuary – Hydrodynamic Modeling of Circulation

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



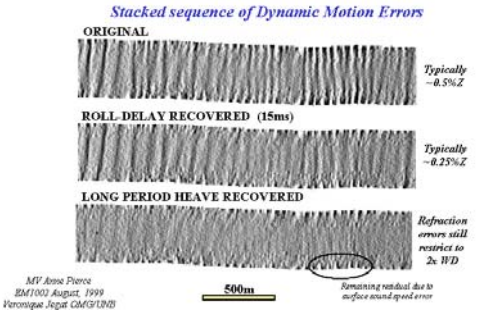
As an informal continuation of an ongoing program with the Musquash proposed Marine Protected Area (MPA), we have developed a hydrodynamic 3D finite element model for the circulation of the Musquash Estuary and Approaches.
The unique feature of this model is that employs a "wetting and drying" algorithm developed by David Greenburg of BIO as an extension to the QUODDY code.

Further results can be obtained at:
http://www.omg.unb.ca/~haigh/musquash.html

Analysis of Dynamic Motion Residuals

Hughes Clarke, OMG
Chair Funding

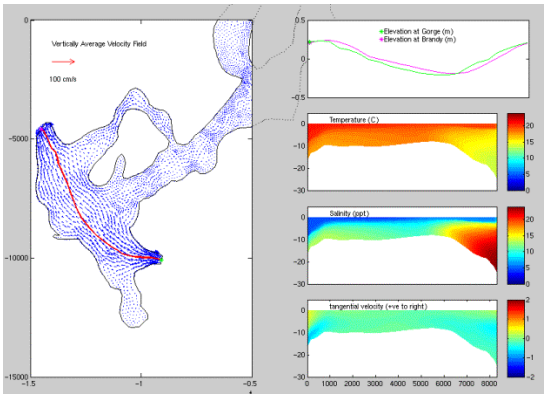
As the quality of aiding sensors, particularly orientation sensors, has improved, one of the principal problems remaining has been the proper integration, most particularly inter-sensor alignment. Whilst the obvious effects of misalignment such as resulting static biases are pretty obvious and easily resolved, a growing concern has been that clear indication of motion within the ocean wave spectrum (heaving and rolling at periods of 3-12 seconds) is still visible in the data even though it is clearly not a failing of the motion sensor. Such dynamic residuals indicate a systematic integration problem. This research is focused on developing analysis tools that can automatically identify the type of systematic problem in the data. The prime method used is correlation of the residual as extracted (on low relief seafloors) with one of the possible driving signatures.



Kennebecasis Project – Numerical Modeling of Sound Speed Variability

Haigh and Hughes Clarke
CHS and Chair funding

As a continuation of our study of the dynamics of the lower Saint John river estuary in support of sound speed variability, in 2002, the QUODDY 3-D numerical model was implemented using full baroclinic extensions. This allows us to realistically predict the estuarine circulation, and most particularly the saline intrusions that are so critical to sound speed prediction.

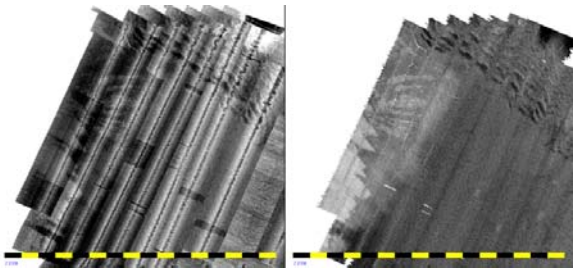


Further multibeam mapping of the ebb flow erosion scar and sections of the upper Kennebecasis was completed in 2003. This allows us to improve the bathymetric model used as a framework for the numerical model. Further MVP/ADCP sections over critical sections was conducted in 2003 providing better constraints to test the model against.
http://www.omg.unb.ca/~haigh/kenneb.html

Backscatter Processing and Registration from RESON Sonars

Beaudoin, Hughes Clarke and Gardner (USGS)
USGS Funding

USGS continental shelf mapping programs over the past 7 years have employed multibeam sonars for both bathymetry and surficial backscatter measurements. This program was originally started to cover the backlog of NOAA backscatter data collected by their RESON sonars deployed as part of their standard hydrographic mapping programs.



In 2002, the algorithms had been expended to include the new snippet telegrams and the 8125 sonar. In 2003, the algorithms were further extended to include RESON 8111, 8160 and 8150 sonars. They were tested for use by Pelagos, one of our new sponsors, for delivering seabed backscatter strength maps for sediment type and habitat classification projects.

Marine Policy, Law, and Administration Course

Nichols and Monahan
University of Southern Mississippi:

Design and delivery of 2- graduate course modules on coastal and ocean boundaries, law of the sea, Article 76 of UNCLOS, and ocean governance at the University of Southern Mississippi, Stennis Space Center, Mississippi. This is part of the alliance between USM, UNB, and University of New Hampshire for hydrographic education.

Tools for Integration of Property Rights, Resource, and Community Data to Develop Good Governance Models for MPAs - Musquash Case Study

Nichols, Ng'ang'a
Fisheries and Oceans Canada Subvention Grant:

Building on past research under GEOIDE, this project will investigate technical tools for integrating and visualizing a variety of datasets related to the proposed Marine Protected Area in Musquash, New Brunswick. Working with DFO and the Musqaush MPA Committee, additional data will be collected and integrated, and portrayed using CARIS Spatial Fusion. Research will include an investigation of the technical, organizational, and data standards required for multi-purpose, multi-user MPA selection, planning, and implementation.

Coastal Adaptation Strategies for Climate Change

Nichols Cockburn, GGE
Climate Change and Adaptation Fund (CCAF).

Led by Environment Canada, this project is part of a larger 3 year project to identify the geomorphological, oceanographic, environmental, and socio-economic impacts of potential sea-level rise due to climate change. The case study area is the north shore of New Brunswick. OMG's involvement is development of a model for identifying and evaluating potential adaptation strategies for sea level rise. These strategies range from policy level responses to coastal land-holder intervention.

Education and Training Options

Multibeam Courses

The international training program organized jointly by the Ocean Mapping Group at UNB and the Center for Coastal and Ocean Mapping (CCOM) at UNH gave 2 more courses in the 2003 year in:

Southampton, UK	in June
Seattle, WA, USA	in December.

The course is taught jointly by, Hughes Clarke and Wells, (UNB) and Mayer and deMoustier (UNH).

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 result 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

Field program in 2003 – 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 2003 – 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 2003 – 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

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

GGE5083 Hydrographic Field Operations

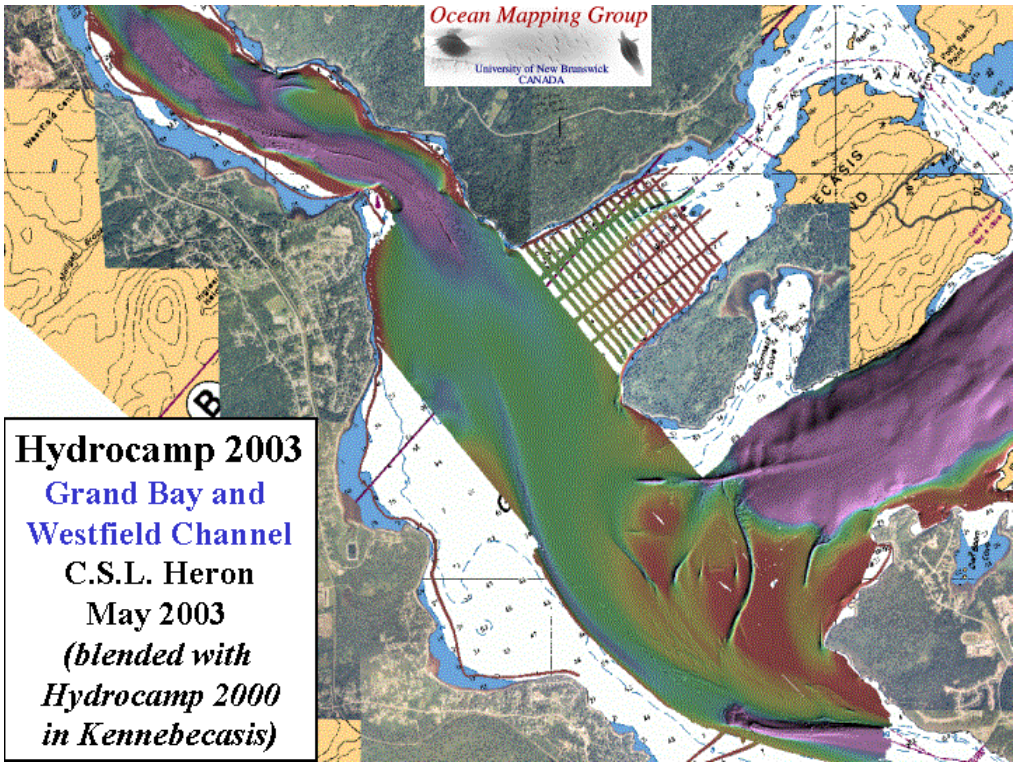
Hughes Clarke
Planning, execution and data processing for a coastal marine field program
http://www.omg.unb.ca/GGE/SE_5083.html

In 2003, the length of the GGE5083 program was increased from the original 3 weeks (10 days of survey, 10 days of processing) to a new model with 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 2003 the area chosen was the sill in Grand Bay and the Westfield Channel (see figure below). These areas are of particular significance because they control the exchange of saline waters between the Gorge (upstream of the Reversing Falls) and both Long Reach and the Kennebecasis Fjord.

The data were reduced using a tide gauge at the Saint John Yacht club. The time chosen was during the spring freshet, allowing an extra 3m of water over summer datum levels. This was particularly important as the sill top in places is less than 5m deep. Whilst the sill top was surveyed at 100% coverage, a new model for shallow water survey was tested for the first time in the Milkish Channel (top right of figure below). In this case line spacing was controlled by keel mounted sidescan coverage (50m per side) rather than multibeam coverage. This model was subsequently used for the Shippagan Bay surveys later that summer.

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 from Grand Bay into the gorge and into the Kennebecasis 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 waterlevel dropped back to summer levels.



Composite image showing the EM3000 multibeam data, acquired during the 2003 GGE5083 Hydrocamp field operations, blended with the 2000 Hydrocamp data from the Kennebecasis to the east. Aerial photography was orthorectified by the students and a mosaic created. 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

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 computing facilities and travel to international meetings, an annual budget of **~C$165k** 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 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 GeoSoloutions	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 2003 include:

Acoustic imaging in support of salmonid mariculture site assessment and nautical charting surveys: *DFO Subvention Grant Program*	,C$15,000
COSTA-CANADA , continental slope stability : *NSERC Collaborative Research Grant* – sub section	C$31,000 pa .
Precise Mapping and Monitoring of Seabed Change: *NSERC Research Grant*	C$28,000 pa
Acoustic Mapping of Seabed and Fisheries Habitat, Shippigan Bay *DFO Moncton (Gulf Fisheries Centre)*	C$60,000
Multibeam Analysis for HMNlS Snellius, Department of The Navy, *Royal Dutch Navy, New Hydrographic Ships*	C$32,000
Seafloor mapping, USGS cooperative agreement # 01WRAG0064, *United States Geological Survey*	C$37,500
Operational trials for HMS Echo EM1002 Royal Navy, *Department of The Navy U.K. Ministry of Defence* DNSOM	C$30,000
Application of new refraction processing tools to multibeam bathymetry data, *National Research Council Canada (NRC)*	C$10,000
Development and testing of improved field techniques and software for fine scale monitoring of the seabed, *Geological Survey of Canada*	C$15,000

Hardware Capabilities

Equipment to Support Field Research Programs

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-wnabled DGPS and electronic chart system

Sonar Systems

Simrad EM3000S 300 kHz multibeam sonar system

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

Knudsen 320M 28 kHz and 3.5 kHz. (320M on loan from Knudsen Engineering and 3.5 kHz transducer on loan from GSC-A)

Datasonics CAP6000 Chirp subbottom profiler (on loan from the GSC, never used though due to weight and aging topside electronics)

RDI 600 kHz Monitor ADCP with Winriver software.

Oceanographic Instrumentation

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.

Ocean Sensors OS500-APV – autonomous winching CTD.

Applied Microsystems Limited SVP16 temperature, 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

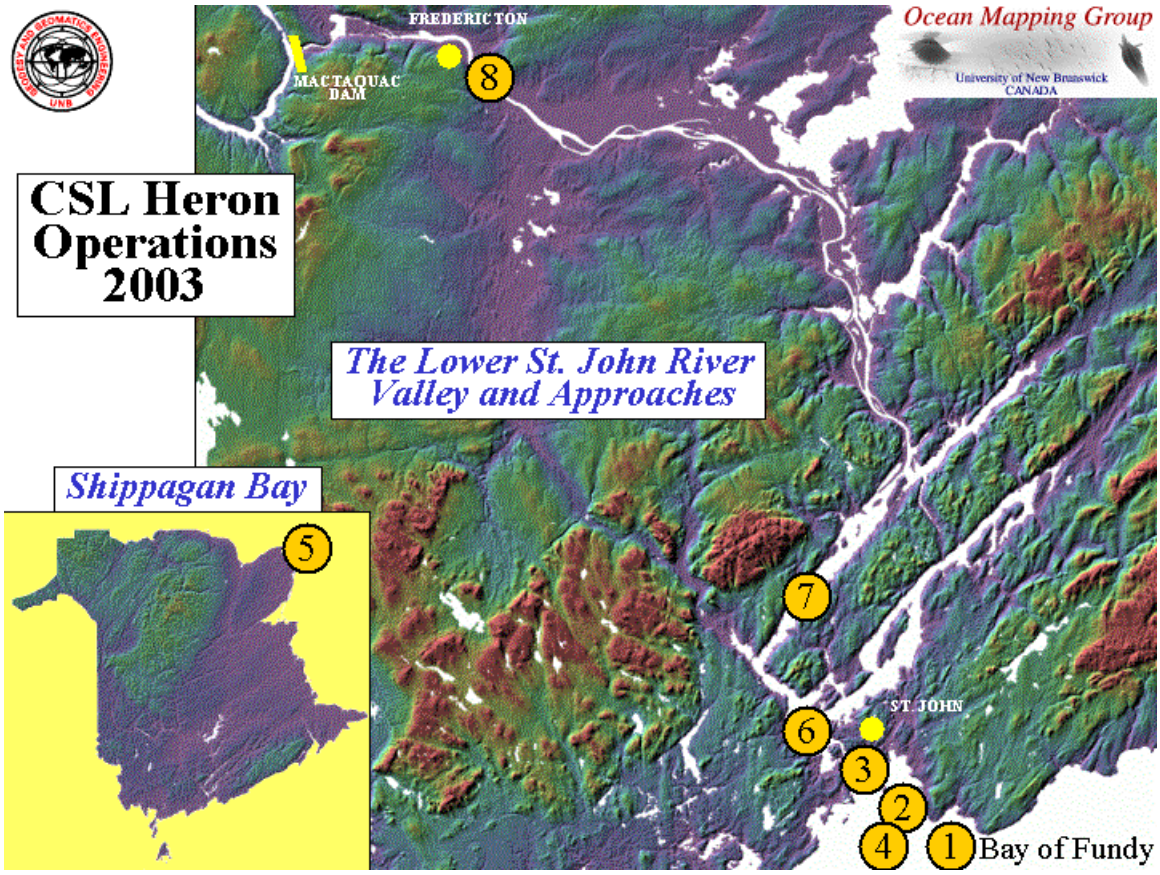
CodaOctopus F180 – GPS-inertial integrated position and orientation system

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

KVH C-100 - fluxgate magnetic compass

Heron Field Operations

2003
For the 2003 field season she was based at the Saint John Marina in Grand Bay, just above the Reversing Falls.



The following field programs were undertaken in 2003 using the Heron:

	Location	Funding
1.	Mispec Bay Dunefield Investigations	NSERC
2.	Blacks Point Offshore Disposal Site Monitoring	GSC-Atlantic
3.	Rodney Terminal – Comparison to Boom System	Port of Saint John
4.	Blacks Point Dumpsite – Dredge Plume monitoring	GSC - Atlantic
5.	Shippagan Bay – habitat surveys	DFO – Gulf Region
6.	Grand Bay – Hydrocamp 2003	Chair
7.	Long Reach, Estuarine Oceanography	Chair
8.	Saint John River- Fredericton	Undergraduate Teaching

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 (SFI-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:

2003

Journal Articles

1. Hughes Clarke, J.E., 2003, Dynamic Motion Residuals in Swath Sonar Data: Ironing out the Creases: **International Hydrographic Review**, v.4, no.1, p.6-23.
2. Gardner, J.V., Dartnell, P., Mayer, L.A. an Hughes Clarke, J.E., 2003, Geomorphology, acoustic backscatter, and processes in Santa Monica Bay from multibeam mapping : **Marine Environmental Research**, v.56, p.15-46

Conference Proceedings

1. Cockburn, Sara; Nichols, Susan; Monahan, Dave, 2003, UNCLOS' Potential Influence on a Marine Cadastre: Depth, Breadth, and Sovereign Rights: International conference on Technical Aspects Of Maritime Boundary Delineation and Delimitation, Monaco, International Hydrographic Organization, **International Association of Geodesy, Advisory Board on Technical Aspects of Law of the Sea** (ABLOS), Unpaginated CD-ROM.
2. Duxfield, A., Hughes Clarke, J., Parrott, R., Wildish, D. and Fader, G. The relationship between linear chains of pockmarks and shallow seismic structure, Passamaquoddy Bay. **NEGSA-AGS** (Halifax 2003; March 27-29th)
3. Garret P. Duffy, John E. Hughes Clarke and Russell Parrott, 2003, Monitoring the temporal behaviour of the submarine sand dunes of Mispec Bay, Saint John, NB through use of monthly multibeam acoustic surveys. **Joint NEGSA and AGS** annual meeting, Halifax, NS. 27-29 March 2003.
4. Hughes Clarke, J.E., 2003, A reassessment of vessel coordinate systems: what is it that we are really aligning: **U.S. Hydrographic Conference**, Proceedings, CDROM
5. Monahan.,D., et al. 2003,Hydrographic Learning 24/7: **U.S. Hydrographic Conference**, Proceedings, CDROM.
6. Monahan, Dave; John Hughes Clarke ; Cartwright, Doug; Buzeta, Maria-Ines, 2003,Hydrography and ocean science in Marine Protected Areas: Lessons from Musquash: **Canadian Technical Report of Fisheries and Aquatic Sciences** #2463 Pages: 79-86
7. Monahan, Dave, 2003, Building the 5th Edition: an exercise in cooperation: Charting the secret world of the ocean floor, the GEBCO project 1903-2003: Monaco: **IHO and IOC**: CD-ROM
8. Monahan, Dave, 2003, A look to the future ocean mapping in the 21st century: Charting the secret world of the ocean floor, the GEBCO project 1903-2003, Monaco,**IHO and IOC**, CD-ROM
9. Nichols, Sue; Monahan, David; Sherin, Andy, 2003, Fundamental contents of coastal GIS- the case for a marine cadastre: **CoastalGIS2003**, Genoa, Italy.
10. Sam Ng'ang'a, Susan Nichols and David Monahan, 2003, The Role of Bathymetry Data in a Marine Cadastre: Lessons from the Proposed Musquash Marine Protected Area: **U.S. Hydrographic Conference**, Proceedings, CDROM.
11. Ng'ang'a, S.M. and S. Nichols (2003). Managing Multiple Uses In Marine Space: The Marine Cadastre Proposition. In Proceedings of **SAMPAA conference**, Vancouver, British Columbia, April, un-paginated CD-ROM.
12. Karen Cove, Marcelo Santos, Lloyd Huff, Ben Remondi, and David Wells, 2003, Assessment of Performance of Ionospheric Delay -free GPS Carrier-Phase Kinematic Relative Positioning with Varying Baseline Lengths: **U.S. Hydrographic Conference**, Proceedings, CDROM
13. Nadeau, J.-C., Butler, K.E., and Parrott, R., 2003, Application of riverine geophysics for delineating recharge to a river valley aquifer - Fredericton, NB, **Proc. of 16th Symposium on**

Application of Geophysics to Engineering and Environmental Problems (SAGEEP 2003), 12 p.

14. Sutherland, M. (2003). "Characteristics of marine boundaries and marine boundary Information required to support Canadian coastal and marine governance**."** Published in the proceedings of the **FIG Working Week Conference** and Workshop, April 2003, Paris, France, unpaginated CD-ROM.
15. Sutherland, M. (2003). "The evolving role of hydrography in ocean governance and the concept of the marine cadastre." Presented at the **7th South East Asian Survey Congress**, Hong Kong, November, unpaginated CD-ROM.
16. Sutherland, M. (2003**).** "Creating New Mental Maps: Managing Conflicting Property Rights in the Marine Environment." Presented at The **Centre for Maritime Research's 2nd. International Conference**, Amsterdam, September, unpaginated CD-ROM.

Technical Reports

1. Hughes Clarke, J.E., 2003, Capability Acceptance Trials, H.M.S. Echo, Simrad EM1002S, 21st-27th February, 2003: **Report to Division of Naval Surveying, Oceanography and Meteorology**, U.K. Ministry of Defence.

2. Martin, B-A, Duxfield, A., Hughes Clarke, J.E., 2003, Shippagan Bay Habitat Survey, C.S.L. Heron,Jult-August 2003, **OMG Cruise Report for Gulf Fisheries Centre**, DFO.

3. Hughes Clarke, J.E., 2003, HOV1- HNlMS Snellius – A802, Integrated Multibeam Sonar System Acceptance Trials: **Report to Hydrographic Office, Royal Dutch, Navy**, Netherlands Ministry of Defence.