Chair in Ocean Mapping

Current and Future Research Activities Y2001-Y2002

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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 2001 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.

Recent Progress

This is now the second year of the third phase, and the new Chair model (as described in the previous annual report) has been fully implemented. The graduate student and research staff within the Ocean Mapping Group are now back up at, and exceeding the 20th century levels.

CSL Heron

The most significant change in the last year has been the successful acquisition of a suite of coastal survey equipment to support Chair research (obtained though grants from the Canadian Foundation of Innovation, Kongsberg Simrad and ACOA). This is all being installed on a newly available dedicated 34 ft coastal survey launch. Through a Joint Partnering Arrangement with the Canadian Hydrographic Service, a surplus H-Class launch is being refitted and remobilized for use as a dedicate OMG research platform . This platform is expected to be first operational in April 2002 and will be equipped with multibeam, ADCP, keel-mounted sidescans, various sub-bottom profiling systems and components of a Brooke MVP-30.

There are three prime thrusts of research that will be investigated using this dedicated suite of instruments.

Improved Oceanographic Imaging for Better Sound Speed Information

This research direction will design, test and implement improved software algorithms that combine and interpolate dense oceanographic observations for the purpose of precisely compensating for spatial and temporal variability in the watermass sound speed field. The system will be used to provide boundary conditions and benchmark data to test hydrodynamic numerical models of coastal circulation.

Precise Repetitive Surveying.

This research will explore the use of integrated RTK GPS with heave, together with dense oceanographic information to produce repeatable survey results at the sub-decimetre level.
Two particularly dynamic areas, a dredge disposal site and a sand wave field in a headland-trapped eddy will be resurveyed at periods of as short as a month to test the limits of repeatability and ability to monitor subtle change. Both sites have previously been monitored at 6 monthly basis for the past 2 years. Whilst the results clearly show that decimetre level change is happen over these time scales, it has been clearly apparent that inadequate vertical control (especially the effect of long period heave and draft changes) and a rapidly changing water column (an area of fresh water lenses and internal waves) have significantly compromised the usefulness of the data.

Use of Calibrated Backscatter Measurements to Investigate Aquaculture Sites.

The aquaculture industry in Canada, and especially in New Brunswick is a prime source of employment, export earnings and thus essential for sustained coastal communities. This industry however, has the potential to harm the delicate coastal environment. In an effort to accelerate the mapping and monitoring of the effect of aquaculture site development we have tested acoustic imaging methods to outline the spatial extent and concentration of organically-enriched sediments that are prone to build up under aquaculture cages.
Initial experiments show that the build up is strongly correlated with the pattern of cage use and the prevailing current field in the vicinity of the cages. Preliminary repetitive surveys also clearly show that these signatures are ephemeral, changing within a few months of cessation of activity.
In order to quantitatively establish the time periods over which these deposits develop and decay we are planning a long term monitoring program using both conventional keel-mounted sidescans and backscatter and bathymetry from the EM3000S. A particular focus of this program will be to try and establish and maintain a calibrated measure of the bottom backscatter strength

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	Associate Professor, GGE *Coastal and Marine Cadastral*
Marcelo Santos	Associate Professor, GGE *Kinematic Positioning, Geodesy*
Karl Butler	Assistant Professor, Dept. Geology *Exploration Geophysics*
Dave Monahan	Director of Ocean Mapping, CHS *Law of the Sea*

Research Associates and PostDoctoral Fellows

Susan Haigh	Contract Researcher *Numerical Modelling of Coastal Circulation*
Martin Gee	Postdoctoral Fellow (4/2001-9/2001) *Submarine slope stability,*
Yanchao Li	Research Associate (up to May 2001) *Fisheries Acoustics*
Michael Weber	Honorary Research Associate (up to July 2001) *Palaeoceanography*

Support Staff

Jerry Zhang	System Manager (until May 2001)
Shawn Woo	System Manager (after May 2001)
Anya Duxfield	Research Assistant (after April 2001)
Debbie Smith	Accounting (until June 2001)
Joan Henry	Accounting (after Sept. 2001)

Graduate Students

Graham Nickerson	LAM	M.Sc.Eng 1997 +
Aldino Campos	DEW	MEng. 1999-2001
Doug Cartwright	JHC	MEng 2000+
Enrique Silva	DEW	MEng 2000+

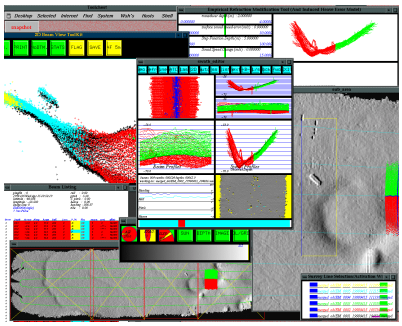
Ted Byrne	JHC	MEng 2000+
Sam Ng'ang'a	SN	PhD 2000+
Sarah Cochrane	SN	MEng 2000+
Michael Sutherland	SN	PhD 2000+
Garret Duffy	JHC	PhD 2001+
Jonathan Beaudoin	JHC	M.Sc.Eng 2001+

Adjunct Faculty

Dr. Christian deMoustier	Adjunct Research Associate, Scripps Institute of Oceanography
Dr. Larry Mayer	Adjunct Professor, University of New Hampshire
Dr. Gary Melvin	Adjunct Professor, 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
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 2001 year include.

- Gradual transfer to Linux as the preferred operating system.
- ADCP current data support:
  - Current field plan views.
  - Backscatter imaging
  - projection onto a common geographic cross sections
  - Animation capability for all of the above
- Single beam editing tools – using full echotrace and power/gain settings.
- Knudsen sidescan mosaicing and beam pattern enhancement tools
- XTF, Q-MIPS sidescan support.
- Ability to modify sonar-relative beamsteered angles based on instantaneous sound speed and orientation

Geophysical Investigation of Submarine Aquifer Replenishment

Butler and Parrott, GSC
NSERC-NCE and City of Fredericton

The glaciofluvial sand and gravel aquifer underlying the City of Fredericton in the Saint John River valley is one of many river valley aquifers that serve municipalities in Atlantic Canada and world-wide. It is currently the focus of a multi-disciplinary study of water quality and supply issues in alluvial aquifers that exchange water with rivers above and fractured bedrock below. Geophysicists are contributing by searching for evidence of bedrock faulting or structure that could represent significant pathways for infiltration, and by searching for areas where the aquifer may be in direct hydraulic connection with the

river bed. Delineation of the river-bottom recharge zone for Fredericton's well field is a project priority as knowledge of that infiltration pathway is required in order to site piezometers for hydrogeological and hydrogeochemical studies. Riverine seismic and riverbank resistivity surveys are proving to be highly effective and complimentary in imaging these so-called clay windows.

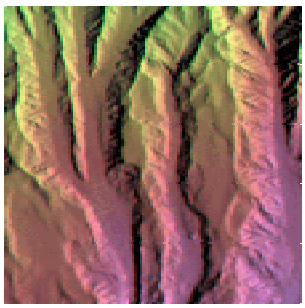
In June, 2001, over 30 line-km of high resolution, single-channel seismic reflection and side-scan sonar data were collected on the Saint John River using real-time kinematic GPS for navigation in late May, 2001. Equipment was deployed from UNB's 40-foot research vessel Mary-O in water as shallow as 1.5 metres. Data quality seemed to be dependent on river bottom type but in most areas the 'Seistec' seismic profiling system with it's boomer source and special line-in-cone hydrophone receiver generated excellent broadband records showing reflection events with dominant frequencies of approximately 2.5 kHz at depths as great as approximately 50 m. The edges of inferred recharge zones are identified as boundaries where reflectors present within the clay/silt layer suddenly terminate and are draped on the sides of an interpreted esker.

Seistek boomer system (GSC)

Submarine Slope Stability

Gee, Mosher (GSC) and Beaudoin
NSERC

As part of the NSERC funded COSTA Canada project, analysis of acoustic swath sonar data has been carried out in support of two different scales of mass wasting. The first project involved reprocessing of the surficial backscatter derived from EM300 multibeam surveys of the central Scotian slope. This was complemented with a seismic and piston coring groundtruthing program from CCGS Hudson in July 2001. The studies have been carried out in order to better understand the mechanism for late Quaternary mass wasting off the Canadian East Coast.



incised continental slope 1500-2500m Scotian Margin

The second project involved the collection of a fourth time series survey of the Saguenay Fjord region to monitor the time evolution of the surficial sediments deposited as a result of the 1996 floods. Surveys in 1995, 1997, 1999 and now 2001 allow us to establish the preflood, immediate post-flood

and long term evolution of the fjord bottom sediments. In order to compare subsequent surveys significant software development was necessary to account for inadequate monitoring of the water column during the first few surveys.

A Comparison of the Surface Topography and Acoustic Scattering Characteristics of Seabeds Imaged by Multibeam Sonar and 3D Seismics

Atlantic Canada Petroleum Institute
Mosher (GSC), Hughes Clarke, La Pierre and Gilbert (CSR)

This project seeks to assess the relative resolution and information content derived either using conventional multibeam sonar or the first arrival time and reflection coefficient from dense 3D seismic surveys. Three data sets collected by Petroleum companies on the Scotian Margin are being compared against EM300 and EM1002 multibeam backscatter and bathymetry. The data sets range in water depth from 200 to 3000m allowing the relative accuracy of the two methods to be assessed as function of water depth.

Immersive Imaging for Marine Navigation

Canadian Hydrographic Service
Lee, Hughes Clarke, Zhang, Coleman and Wells

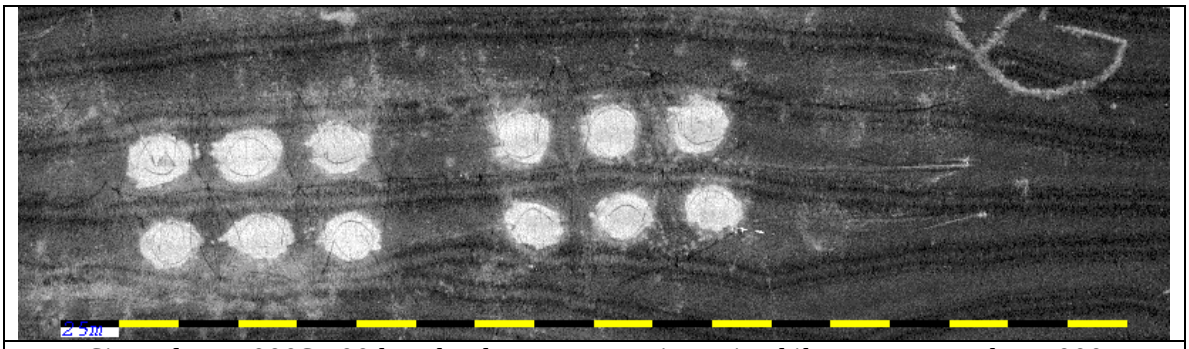
We propose to develop an interactive software module designed to enhance marine navigation by allowing mariners to view and interact with coastal deck-level photographs. Marine information management systems include both real-time and analysis software tools that allow both the port manager and mariner to have access to timely and accurate information about the coastal marine environment. Of prime importance is the need to ensure safety of navigation. Secondary importance is to ensure the most efficient, economic, and environmentally sound management of our coastal zone (including shipping lanes, living and non-living resources).

Mariners traditionally have been faced with the task of translating the plan view of a chart into the deck-level view from the bridge wing. This is hampered during times of low visibility (such as night, rain and fog). The proposed innovative product would allow the mariner to view natural looking pre-processed scenes of the coastal environment collected very cheaply using photographic methods. These scenes could be directly compared with the visible horizon during daylight, or act as a point of reference for navigating when the natural view is obscured. These scenes, however, would be fully spatially referenced so that merely by pointing, the mariner can translate this view into exact geospatial coordinates and be therefore able to access available information about that area. Furthermore, static and dynamic targets would be added to the scene including buoyage, radar targets, and subsurface information (such as bathymetry, seabed sediment, and habitat types) to highlight navigational information or to show features usually submerged.

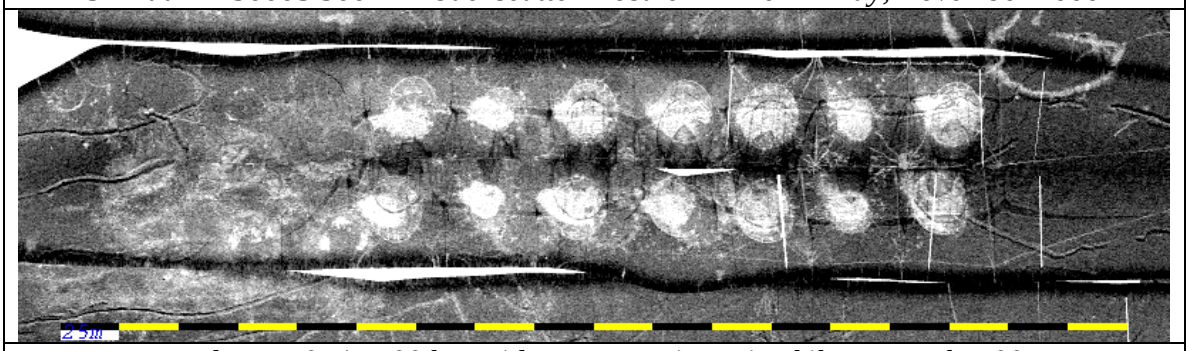
Acoustic Imaging of Acquaculture Sites

Hughes Clarke, Beaudoin and Wildish (DFO)
CHS and DFO funding

Based on earlier OMG work in the Bay d'Espoir, NF, a reconnaissance multibeam survey of the Letang Inlet in SW New Brunswick was performed by the CHS in late 2000. Processing of the backscatter data by the OMG clearly identified the seabed signature of the sub-cage waste products. The extent and magnitude of this signature was found to be highly variable, depending on preexisting bottom types, local current field and age of site occupation.



Simrad EM3000S 300 kHz backscatter mosaic – Limekiln Bay, November 2000



Knudsen 320B/P 200 kHz sidescan mosaic – Limekiln Bay, July 2001

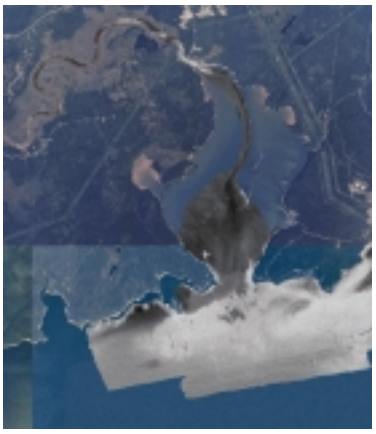
The above figure illustrates the potential for mapping organic enrichment under aquaculture cages. The change over 8 months is striking (related to abandoning one set of cage sites and replacing it with another set relocated). Traces of the old deposit can still be seen. The upper image has been reduced for source level, pulse length, receiver gains and beam patterns. The lower image, however, is uncorrected with merely a simple TVG function (40logR) and an arbitrary mapping to greyscale. The most noticeable problem with the lower image is a gross beam pattern residual.

In order to establish the time variability of these signatures, a second survey was performed in July 2001 using a cheaper pole-mounted sidescan technology. These results clearly indicate that these feature are ephemeral with residence times ranging from a few months to several years. Based on these results, presented at the ESSA meeting in January 2001 and 2002, a mapping program is being designed.

Coastal Boundary Delineation – the Musquash Proposed Marine Protected Area

Byrne, Nichols, Ng'ang'a, Sutherland and Cockburn
GEIODE HSS # 55

In order to better understand the technological implication of modern submarine survey methods to boundaries, a case study was implemented as part of the proposed Marine Protected Area (MPA) in the Musquash Estuary. The Musquash Estuary MPA, has conflicting jurisdictional control from Federal, Provincial Municipal and Private stakeholders.



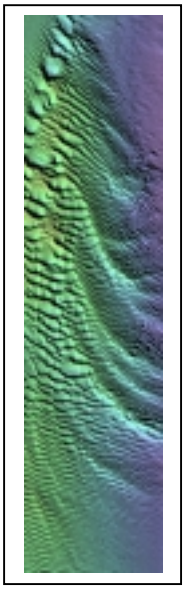
EM3000 backscatter imagery Of the Musquash MPA

As part of the proposed MPA two critical submerged boundaries are proposed including delineating the limit of allowed scallop trawling with the MPA and the absolute seaward limit of the MPA. Currently undefined is the extent of an outer zone of influence outside the MPA boundary within which activities may be controlled. These boundaries are currently proposed based solely on extrapolation of subaerial features. Dense multibeam backscatter, bathymetry and sidescan surveys were conducted in the boundary regions to ascertain both whether the boundaries represented any natural physiographic change in the seafloor and whether other, more logical boundaries might be defined using seabed character.

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. The site lies between two prominent headlands on the north side of the Bay of Fundy, off Saint John This site has been examined 4 times over 2 years and the results analysed.



Whilst it is immediately clear that rapid migration of the sand wave field takes place (displacements of 50m over 6 month are typical for the asymmetric bedforms), residual artifacts are clearly contaminating the results.

Imperfect water column corrections, long period heave drift, and dynamic motion artifacts have all being clearly identified at the 1-4 decimetre level. As the site lies within 10 km of the mouth of the Saint John river, considerable watermass heterogeneity is experienced due to the presence of surface fresh water lenses and internal wave field packets at the deeper interfaces.

Using relative coordinate systems (bedrock or boulders) as a substitute for more accurate control, it is clear that even in areas without bedforms, erosion and deflation of the seabed is taking place at this level.

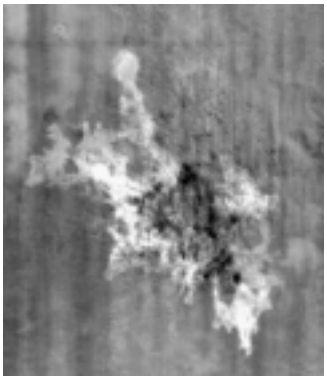
This site will be the prime testbed for new RTK-GPS heave integration algorithm development. Empirical methods to compensate for current hardware inadequacies will be compared against newer results using RTK.

Of increasing relevance at this time is the issue of mine burial. It has been proposed that we establish a series of seabed targets within the wave fields to examine the effect of target visibility

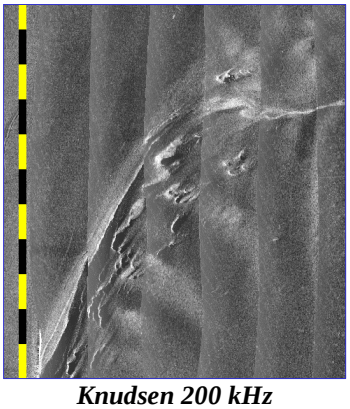
Monitoring Dispersal of Dredge Spoil at an Open-Ocean Disposal Site

Parrott (GSC) and Hughes Clarke
EnvCan and GSC funding

Four 6-monthly surveys of the Blacks Point Open Ocean Disposal site have allowed tracking of the fate of sandy dredge spoil over two field seasons. Proximal redistribution from the dump crest into deeper waters happens as clearly discernable grain flows.
More tantilising however is the more distal fate of the sediment in layer thicknesses that are only at the decimetre level.
With the current hardware utilized, this level of accuracy is not being achieved. Methods to improve this accuracy will be test including continuous watermass monitoring and RTK-GPS integration with heave.
What make this site particular valuable as a testbed is that the precise volume, content and time of input of the introduced sediment is known from the dredging contractor allowing us to calibrate our results.
Based on the results of these repetitive surveys, the dumpsite location has been moved to try and minimize the extent of remobilisation. Activity at the new site and residual creep at the old site will continue to be monitored.



6 month surface difference Blacks Point disposal site



Knudsen 200 kHz pole-mounted sidescan mosaic

Software Development and Field Trials in Support of Keel-Mounted Sidescans.

Hughes Clarke, Crutchlow (CHS) and Buzeta (DFO)
CHS and DFO funding

In an effort to more cost- effectively survey in water depths less than ~ 10m, the CHS is keen to utilize existing dual channel single beam echo sounder technology (Knudsen 320M's). A trial usage of fixed 200 kHz sidescan staves was first implemented in May 2000 by the OMG. As a result of that, software development has proceeded so that these data, logged in a unique Knudsen binary format can be handled as conventional sidescans.
Based on the 2000 results. Knudsen modified their logging to support root intensity (linear scalar amplitude) data so that the existing 8bit dynamic range would better preserve the available data. In addition, the 16 bit SEGY

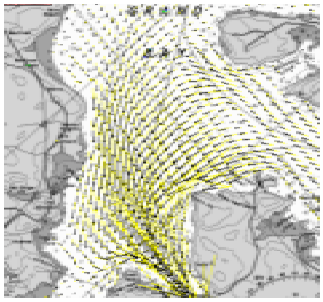
format data, previously only available for the deep water 320R systems was retrofitted to all Knudsen systems allowing higher dynamic range logging.

For the 2002 field season, the twin staves are being keel-mounted on the CSL Heron together with a dedicated dual 200 kHz channel logging system. This will be used as a testing platform by the CHS. If successful, it will be used to enhance survey quality (target detection and regional seabed characterization) for single beam operations in water depths less than ~ 15m.

Kennebecasis Project – Numerical Modeling of Sound Speed Variability

Haigh and Hughes Clarke
CHS funding

One particularly strong barrier remains which precludes the general acceptance of wide-swath sonar systems. That barrier is the ocean itself. As we have managed to minimise the importance of the other sources of error, our imperfect knowledge of the sound speed field in the ocean itself has become one of the primary remaining sources of error. To in part address this, the CHS has promoted the development of Canadian designed and manufactured towed mechanical sensors (BOT-MVP). Such sensors, however, are expensive, prone to loss and have limitations in their use (finite sample spacing, inability to approach the seafloor too closely).



snapshot of surface current field on the ebb tide in Grand Bay.

One possible alternate means of estimating the sound speed field is to predict it based on sparse samples rather than measure it directly. Simple linear interpolation in time or space has been previously attempted (Hughes Clarke et al., 2000) and shown to be inadequate given the nature of coastal physical oceanographic processes. If we are to intelligently interpolate sparse data we need to build a knowledge of the physical oceanographic processes themselves into our interpolation methodology.

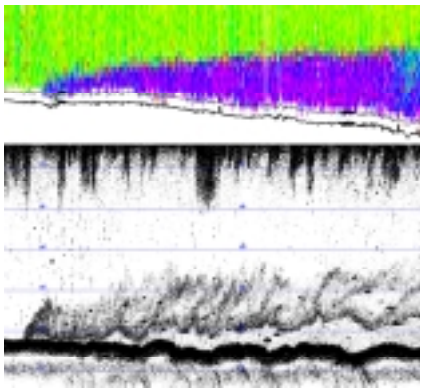
We have implemented a 3D hydrodynamic model of a coastal area (the Kennebecasis Estuary) as a basis on which to predict sound speed variability between sparse observations. The prediction scheme would combine the actual observations (pre and post SVP's and time series of surface sound speed) as end member solutions, but the intervening interpolation would reflect modelled water mass distribution over the transect position and time. Such an approach, if feasible, would allow improved hydrographic survey accuracy for CHS operations.

Application of MVP-30 and Acoustic Imaging to Swath Mapping Surveys off the Mouth of the Frazer River

Cartwright and Hughes Clarke

CHS Funding

The Canadian Hydrographic Service's primary concern and overriding responsibility is the accurate measurement of bathymetry for the production of charts to aid in safety to navigation. Using multibeam echosounders, the extent and accuracy of seafloor coverage has been vastly increased. The primary remaining constraint on accuracies is the ambiguity of the knowledge of the water column. The Pacific region of the CHS has recently acquired an MVP 30 moving vessel profiler in order to address this issue. This equipment allows the sampling of the water column at much closer intervals and while the vessel is still under way.



ADCP horizontal velocity graph and single beam echo trace showing prograding salt wedge in the Fraser River mouth.

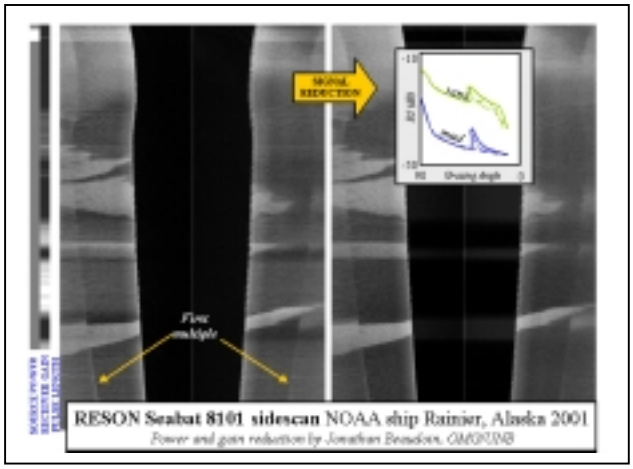
During the summer of 2001, the Pacific region of the CHS performed a multibeam survey off the mouth of the Fraser River on the West coast of Canada. Due to the large influx of fresh water and the resultant salt/freshwater mixing, this survey represents some of the worst possible conditions for multibeam surveys. Using this survey as a backdrop, the research is focused on how to utilize moving vessel profile equipment to the maximum benefit and how to apply the results in post processing. The most recently collected profile data was applied in real time, however in post processing the profiles can be used to interpolate the data between profiles. The potential of the different methods of post processing to best take advantage of this high-density sound speed profile data are being investigated. An attempt is also being made to correlate single beam echosounder and acoustic doppler current profiler (ADCP) data with the sound speed profile This is primarily in order to understand the structure of the water column, however the possibility of utilizing this data directly in real-time prediction of the water column is also being investigated.

Backscatter Processing and Registration from RESON 8101 Sonars from NOAA Rainier Launches

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. In order to make estimates of surficial backscatter strength, the sonars primarily employed to date have been Simrad systems because the sonar's geometric and radiometric parameters are automatically logged and reduced for.

A far larger scale mapping program however has now been implemented (since 1997) by the National Ocean Survey, primarily for nautical charting purposes. The vessels of NOAA and her contractors use a wide variety of multibeam systems optimized for bathymetric mapping. A large fraction of this data has been collected using RESON systems. To date, whilst most of the sonar setting are recorded in the RESON native telegram format, this is rarely preserved in the final logging stream and there is no commercial means of extracting estimates of the bottom backscatter strength.

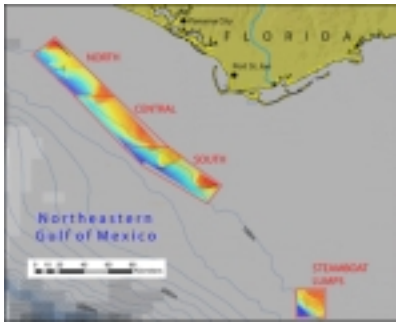


This research program is directed towards extracting and properly reducing the backscatter data provided by the NOAA RESON systems for use by the USGS for surficial sediment mapping.
Initial work with the beam averaged and simple time series data has confirmed the correct interpretation of the encrypted power and gain setting. Future research is likely to focus on the new snippet formats.

Offshore mapping of West Florida Shelf – Support for EM1002 surveys

Hughes Clarke, Duxfield, Duffy
USGS Funding

As part of a long standing collaborative research arrangement between the US Geological Survey and the OMG, the OMG provides planning advice, field calibration, processing tools and data analysis support for USGS continental shelf mapping programs.



areal extent of 2001 surveys off Panama City FL.

The USGS has been conducting wide-scale outer shelf and upper slope mapping using US-contracted 30-300 kHz swath sonars within the US EEZ. The surveys have ranged from Hawaii to the Gulf of Maine. Most recently, in support of MMS work in the Gulf of Mexico, large scale surveys using 95 kHz sonars have been undertaken.

Specific problems encountered included highly dynamic sound speed field and the economic requirement to adopt extremely wide line spacing (3.5 to 4.5 X local water depth). Innovative software has been developed to minimize the appearance of refraction errors
In addition, because surficial sediment mapping is a prime, aim, the proper reduction of the backscatter intensity values is necessary. Significant problems have arisen with

imperfect data reduction by the sonar-native software. These imperfections have to be identified in post-processing and compensated for. A particular complication here is the fact that these surveys are built up through multi-year programs with changing sonar hardware and software.

Kinematic Carrier Phase Differential GPS Data Analysis

Santos and Wells
U.S. Naval Oceanographic Office

The University of New Brunswick is providing technical assistance to University of Southern Mississipi on the effort to evaluate advances in vertical positioning with the goal to establish an on-the-fly real-time kinematic (OTF RTK) capacity within NAVOCEANO. We have been using the software DYNAPOS, provided by XYZ's of GPS for processing and analysis of RTK data. We are also planning an RTK data collection campaign which goal is to test distance limitations of RTK under various marine climate conditions.

Hydrographic elements of the United Nations Convention on Law of the Sea (UNCLOS)

Monahan (CHS), Wells and Nichols
CHS Funding

UNCLOS is a treaty that, among many other things, provides rules for dividing the sea floor into zones over which Coastal States have varying degrees of jurisdiction. The act of delineating ocean space based on these rules requires extensive hydrographic input. Over the last year, we have concentrated on two of these. First, the impact of different vertical datums on the horizontal location of the "Baselines from which the breadth of the Territorial Sea is measured" and second, the suitability of existing standards for depth measurement when applied to problems of outer limit determination. In addition, we continue to advise on the development and application of the CARIS LOTS software suite, which is becoming the de facto standard for developing a submission for an extended Continental Shelf under Article 76 of UNCLOS. In the upcoming year, we intend to focus on methodologies for determining the Foot of the Slope, or of proving its non-existence.

Education and Training Options

Multibeam Courses

The international training course organized by the Ocean Mapping Group gave 4 more courses in the 2001 year in:

San Diego, CA, USA	in January
Stennis Space Centre, MS, USA	in June
Amsterdam, the Netherlands,	in October and
Norfolk, VA, USA	in December.

The course student body was increased 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 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

GGE4042 Kinematic Positioning

Santos and Wells
Marine, Terrestrial and Airborne dynamic navigational theory and methods.

GGE5072 Hydrographic Data Management

Wells
Principles and issues of data management in marine applications

GGE5013 Tides and Water Levels

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

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

details of prior field survey courses:
http://www.omg.unb.ca/GGE/previous_hydro_ops.html

GRADUATE:

GGE6023 Multibeam Sonar

Hughes Clarke
Research Topics on Swath Sonar Systems.
http://www.omg.unb.ca/GGE/SE_6023.html

GGE6022 Special Topics in Ocean Mapping

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

GGE6021 Special Studies in Hydrography

Wells
Research Topics in Aspects of Hydrography

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.	U.S. Geological Survey	1996-
3.	U.S. Naval Research Laboratory	1996 -
4.	U.S. Naval Oceanographic Office	1997-
5.	State University of New York	1998-
6.	University of New Hampshire	2000-

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 include:

Improved Acoustic Sound Velocity Field Predictions using Numerical Models of Coastal Watermasses

Canadian Hydrographic Service
Hughes Clarke and Haigh, C$15,000

Development of Hydrographic Modules for Open Access Learning

Canadian Hydrographic Service
UNB *e*-learning Centre and Wells C$15,000

Marine Boundaries Classification and Data Base

Canadian Hydrographic Service
Nichols C$20,000

Assessment of EM1002 and EM120 data quality

Geological Survey of Ireland
Hughes Clarke, C$10,000

Application of New Refraction Corrections to Archived Multibeam Data

Geological Survey of Canada
Hughes Clarke, C$10,000

Deep-water seafloor rendering for environmental and geohazard assessment: A comparison study of 3D seismic reflection and multibeam sonar surfaces

Atlantic Canada Petroleum Institute
Mosher, Hughes Clarke, La Pierre and Gilbert C$35,000pa

Multibeam sonar for mapping and monitoring decimetre-level seabed changes

Canadian Foundation for Innovation, ACOA,, Kongsberg Simrad
Hughes Clarke C$340,000 one-time infrastructure grant

Immersive Imaging for Marine Navigation

Canadian Hydrographic Service
Lee, Hughes Clarke, Zhang, Coleman and Wells C$20,000

Good Governance of Canada Oceans

GEOIDE
Nichols, Hughes Clarke et al., C$ 180,000 pa

Extraction of backscatter information from US Government Contract Surveys

U.S. Geological Survey
Hughes Clarke, C$45,000 pa

COSTA-CANADA , continental slope stability

NSERC Collaborative Research Grant,
Hughes Clarke and Gee, sub contract - C$31,000 pa .

Precise Mapping and Monitoring of Seabed Change.

NSERC Research Grant
Hughes Clarke C$28,000 pa

Geophysical imaging of a river valley aquifer

Canadian Water Network, (NSERC,NCE).
Butler subcontract C$68,500.

Kinematic Carrier Phase Differential GPS Data Analysis

U.S. Naval Oceanographic Office
Santos and Wells subcontract C$30,500

Optimal Integration of Geodetic Techniques for Positioning and Navigation.

NSERC ResearchGrant
Santos C$16,000 pa.

Hardware Capabilities

Equipment to Support Field Research Programs

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.

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

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

Datasonics CAP6000 Chirp subbottom profiler (on loan from the GSC)

RDI 600 kHz Monitor ADCP with Winriver software.

Sutron Model 8200 data logger (on loan from CHS)
for tidal measurements interfaced to:
- pressure gauge and
- AMASS encoder

Simrad EM3000S 300 kHz multibeam sonar system

Seatex MRU-6 Orientation and heading sensor

Ocean Sensors OS500-APV – autonomous winching CTD.

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

Brooke MVP-100 towbody, overboarding Sheave with AML Smart CTD (25 Hz) integrated with a Valeport SK172 winch.

Heron Mobilisation

Previously, OMG field programs had been based either on sponsor-owned or chartered survey vessels or on the UNB research vessel the Mary-O. Open water sustained programs were primarily driven by sponsor needs. In particular, research and software development in support of CHS operational needs have taken place on a variety of CHS platforms (CCGS Creed, Matthew, Young, and CSL's Revisor, Puffin and Plover).

Small-scale coastal operations were sometimes conducted using the RV Mary-O. She is ideal for work in the Fundy coastal region but suffered from a limited availability (shared

with other, mainly biological researchers) and poor equipment mounting and installation infrastructure.
With the recent acquisition of a far more extensive suite of research instrumentation (including the EM3000 multibeam, the MRU-6, ADCP and subbottom systems) we have come to a mutually beneficial arrangement with the Canadian Hydrographic Service, Atlantic Region.
Together, we are remobilizing one of the old "H-boats". This class of vessel (34 ft Nelson Hulls custom built by C&C of Ontario for the CHS) were developed specifically for operations on CSS Baffin for single beam launch operations in the Canadian Arctic. There were two generations of construction. In 1983, CSL Heron and Hagdon were delivered to BIO. In 1988 CSL Hawk, Harrier, Helldiver were also delivered.

CSL Heron being outfitted at BIO

We are currently mobilizing CSL Heron. The decision to go with one of the earlier launches was based on the fact that it had the most recently rebuild power plant (a Caterpillar 300 Hp diesel) and the fact that the earlier builds had a simpler skeg arrangement making them more maneuverable.

First operational trials are scheduled for March 4th in the Bedford Basin with first field deployment in April off Saint John, New Brunswick. The vessel's expected area of operations will extend from the Fundy Isles region (based at the St. Andrews Biological Station) to the lower Saint John River Estuary (based at Ketepec Marina).

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) , the UNIX platforms are the prime tool. SwathEd is currently supported on SGI, DEC, Solaris or Linux. For historical reasons SGI is the most used hardware platform. SUN operability is maintained to support sponsors who use that hardware (SUNY, C&C) and DEC is supported for CHS operations.

To take advantage of the cheap PC hardware, Linux support was introduced in 2000. It is intended that Linux be the main operating system for SwathEd in the future. Recent purchases have been Linux hardware only.

SGI-Irix 6.5

3 – SGI Extremes	(clownfish, stereo and southern)
4 - SGI 02's	(solomon, cyclops, bliss and blacks)
1 – SGI Indy	(indian)

Compaq/DEC

1 DEC Alpha	(alpha)

Solaris

1 – SUN Sparc20	(coral – EM3000)
1 – SUN Sparc 2	(atlantic)
1 –SUN Sparc 2	(hudson)

Linux

2 Dell Optiplex 400 MHz	(baffin, dipper)
4 Dell Optiplex 800 MHz	(heron1, heron2, stcroix, letang)
1 Dell Dimension 1 GHz	(bocabec)

Windows

2 Dell Optiplex 300 MHz	(erie, huron)
2 Dell Optiplex 450 MHz	(gee, louise)
1 Dell Optiplex 600 MHz	(hydro1)
2 IBM laptops (A20 and A21)	(chance and kennet)
1 IBM workstation (1.8 GHz)	(for fledermaus)

Plotters

HP 650
HP 2500
Lexmark 1200dpi

SCSI Disks (on SGI's and DECs)

1x 50 Gb, 3 x 36 Gb, 4 x 18 Gb, various 9's, 4's,and 2's……
(and 20-80Gb IDE disks on the various PC's).

Tapes Drives

DLT
Exabyte
DAT

Publications:

2001

Journal Articles and Conference Proceedings

Brissette, M.B., Hughes Clarke, J.E. and Cartwright, D., 2001, Object Detection Using Multibeam Echosounder Temporal Imagery: United States Hydrographic Conference Proceedings, CDROM. 11pp.

Cockburn, Sara, Susan Nichols, Dave Monahan and Ted McDorman, 2001. Intertwined Uncertainties: Policy and Technology on the Juridical Continental Shelf. Proceedings, International conference on Technical Aspects Of Maritime Boundary Delineation and Delimitation. International Hydrographic Organization, International Association of Geodesy, Advisory Board on Technical Aspects of Law of the Sea (ABLOS). Monaco, 18-19 Oct Un-paginated CD-ROM

Hughes Clarke, J.E. and Parrot, R., 2001, Integration of dense, time-varying water column information with high-resolution swath bathymetric data : United States Hydrographic Conference Proceedings, CDROM. 9pp.

Monahan, Dave, Horst Hecht, Dave Wells, Maureen Kinney, and Aldeno Campos, 2001 Challenges and Opportunities for hydrography in the new century. International Hydrographic Review, v2,n3(new series) pp 56-67.

Monahan, Dave , 2001. Variable errors and fixed boundaries: the role of deep echo-sounding in the United Nations Convention on Law of the Sea (UNCLOS) Lighthouse, Journal of the Canadian Hydrographic Assoc, Edition 59, pp17-23.

Monahan, David and D E Wells, 2001. Deep water challenges to hydrography stimulated by the United Nations Convention on Law of the Sea (UNCLOS). US Hydrographic Conference, 21-24 May, Norfolk, Va, un-paginated CD-ROM.

Monahan, Ilona C and David Monahan, 2001. The quality control cycle in the age of electronic chart production, contracted work and ISO certification. US Hydrographic Conference, 21-24 May, Norfolk, Va, un-paginated CD-ROM.

Monahan, Dave, Dave E Wells and John Hughes-Clarke, 2001. Ocean Mapping, a slantendicular look ahead. Sea Technology, v42, No6, pp 44-51.

David Monahan, Susan Nichols, Sam Ng'ang'a and Rob van de Poll, 2001. Assessing the impact of uncertainties in the locations of "baselines from which the breadth of the

Territorial Sea is measured" on the outer limit of the juridical Continental Shelf Proceedings, International conference on Technical Aspects Of Maritime Boundary Delineation and Delimitation. International Hydrographic Organization, International Association of Geodesy, Advisory Board on Technical Aspects of Law of the Sea (ABLOS). Monaco, 18-19 Oct Un-paginated CD-ROM

Monahan, Dave, 2001. Explorations of the Wilderness: Making Maps with GPS. GPS World, v12, n10, p.32-40

Monahan, Dave and Dave E Wells, 2001. The suitability of the International Hydrographic Organization's "Standards for Hydrographic Surveys, Version 4 for determining depth accuracy in the Scientific And Technical Guidelines of the United Nations Commission On The Limits Of The Continental Shelf. Proceedings, International conference on Technical Aspects Of Maritime Boundary Delineation and Delimitation. International Hydrographic Organization, International Association of Geodesy, Advisory Board on Technical Aspects of Law of the Sea (ABLOS). Monaco, 18-19 Oct Un-paginated CD-ROM

Monahan, David, Susan Nichols, Edward Byrne, R. Castonguay, Sara Cockburn, M. D'Arcy, Larry Felt, Roger Guadet, John Hughes Clarke, Maria Innes-Buzeta, Anne LaForest, Wade Locke, Ted McDorman, Sam Nganga, Gilles Paquet, Rob van der Poll, Michael Sutherland, Dave Wells and Kevin Wilkins, 2001. The contribution of digital boundary information to good governance for improved decision-making The 2nd International Conference On Digital Earth, Fredericton, Jun 24-28. Paper Number DE-A-86

Nichols, Sue and Dave Monahan, 2001. From High Water to the Continental Shelf: Canada's challenges in Marine Boundaries. Workshop for Assn of New Brunswick Land Surveyors Annual General Meeting, Fredericton, Jan 18-20.

van de Poll, Rob, Dave Monahan, and Ted McDorman, 2001. The application of an integrated software suite to marine boundary delineation –the CARIS LOTS and spatial fusion approaches. GEOIDE Annual Conference 2001, Paper Number HSS#55.

Vessie, David, Robert van de Poll, Susan Nichols and David Monahan, 2001. A Multifunctional GIS Mapping And Analysis Tool For Use Within The Coastal Zone. Coastal GeoTools '01, January 8 to 11, Charleston, South Carolina

Wells, DE and Dave Monahan, 2001. IHO S44 Standards for Hydrographic Surveys and the variety of requirements for bathymetric data *Lighthouse*, Journal of the Canadian Hydrographic Association, Edition 60, Fall/Winter 2001, pp. 31-39.

Technical Reports

Hughes Clarke, J.E. and Beaudoin, J., 2001, Data Quality Assessment - G.S.I. Bathymetric Survey of the Irish Continental Margin, MV Bligh-EM120 and MV Siren-EM1002: consulting report to the Geological Survey of Ireland.

Hughes Clarke, J.E., 2001, Remote Acoustic Characterisation of Mariculture Site Sediments: in Hargrave and Phillips Eds., Environmental Studies for Sustainable Aquaculture (ESSA), Canadian Technical Report of Fisheries and Aquatic Sciences No. 2352.

Nichols, Sue, Michael Sutherland, Sam Ng'ang'a and David Monahan, 2001. Offshore Issues. Consultation Workshop Report. Assoc of Canada Lands Surveyors , 37pp.

James V. Gardner, Larry A. Mayer, John E. Hughes Clarke, Peter Dartnell, and Kenneth J. Sulak, 2001, The bathymetry and acoustic backscatter of the mid shelf to upper slope off Panama City, Florida, Northeastern Gulf of Mexico, September 3, through October 12, 2001, RV Moana Wave Cruise M1-01-GM, USGS Open File Report 01-448. (http://geopubs.wr.usgs.gov/open-file/of01-448/)