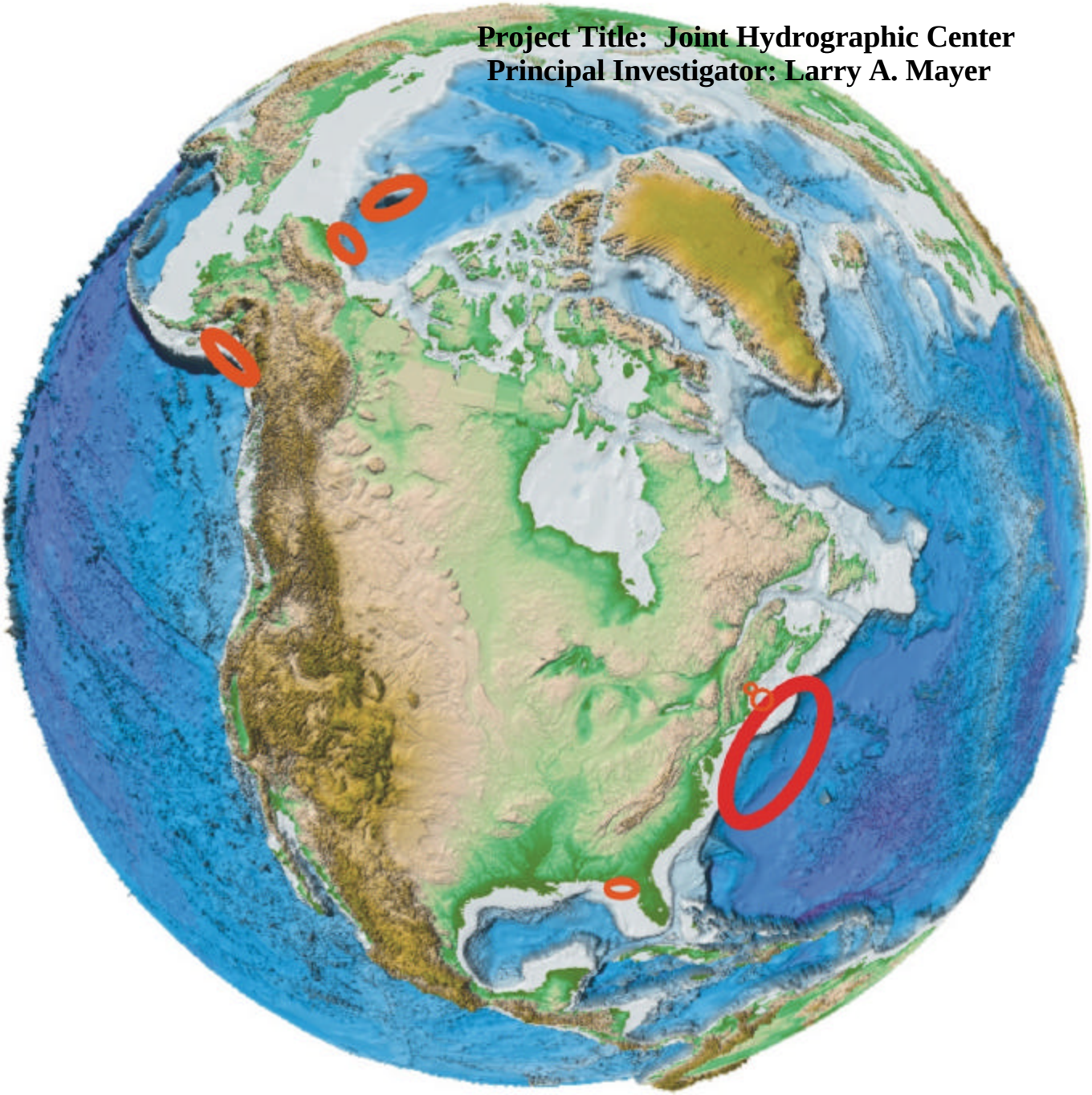
Performance and Progress Report: UNH/NOAA Joint Hydrographic Center

NOAA Ref No: NA17OG2285
Report Period: 01/01/2004 – 12/31/2004

Project Title: Joint Hydrographic Center
Principal Investigator: Larry A. Mayer



JHC/CCOM Field programs in 2004

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INTRODUCTION:

On 4 June 1999 the Administrator of NOAA and the President of the University of New Hampshire signed a cooperative agreement describing a Joint Hydrographic Center (JHC) at the University of New Hampshire. On 1 July 1999 a grant was awarded to the University of New Hampshire providing the initial funding for the establishment of the Joint Hydrographic Center. This center, the first of its kind to be established in the United States, was formed as a national resource for the advancement of research and education in the hydrographic and ocean mapping sciences. The activities of the center are focused on two major themes: 1- a research theme aimed at developing and evaluating a wide range of state-of-the-art hydrographic and ocean mapping technologies, and; 2- an educational theme aimed at establishing a learning center that will promote and foster the education of a new generation of hydrographers and ocean mapping scientists to meet the growing needs of both government agencies and the private sector. In concert with the Joint Hydrographic Center, the Center for Coastal and Ocean Mapping was also formed in order to provide a mechanism whereby a broader base of support (from the private sector and other government agencies) could be established for ocean mapping activities.

This report is the ninth in a series of what were until, December 2002, bi-annual progress reports. Since December, 2002, the reports have been produced annually; this report highlights the activities of the Joint Hydrographic Center during the period between 1 January and 31 December, 2004.

REVIEW OF RECENT PROGRESS:

Infrastructure:

Personnel:

The success of any center will be dependent on the skills and talents of the individuals that make it up. Thus the primary task in establishing the Joint Hydrographic Center was to ensure that an appropriate team of people would be brought to the University of New Hampshire. This has been accomplished, and with the arrival of **Dr. Christian de Moustier** in January 2002, all positions outlined in the original Center proposal have been filled. In 2003 **Dr. James V. Gardner**, a world-renowned marine geologist and leader of the USGS Pacific Mapping Group, retired from the U.S.G.S. and joined the Center as a research faculty member. In 2004 **Nathan Paquin** began a full-time position as our computer system manager and **Jim Case** joined our staff as a database specialist. Following his retirement from NOAA, **Dr. Lloyd Huff** joined our research faculty and **David Monahan** joined our faculty as Program Director for the GEBCO Bathymetric Training Program (funded by the Nippon Foundation -- see below). Funding from external sources has also continued to allow us to expand our

staff to include a laboratory manager (**Andy McLeod**) supported in part by ONR and NSF, three Research Scientists (**Gareth Elston, Luciano Fonseca** and **Barbara Kraft**) supported by the USGS, ONR, and industrial sources, and numerous hourly employees. Finally, in recognition of his active role in developing research initiatives, his success at raising external support and his role in supervising graduate students, **Dr. Yuri Rzhanov** was transferred, in 2004, from the research staff to the research faculty.

Faculty:

Lee Alexander is a Research Associate Professor actively involved in applied research, development, test and evaluation (RDT&E) projects related to the implementation of electronic chart-related technologies. Lee chairs or participates on a number of international committees defining electronic chart standards, and serves as a technical advisor to U.S. Navy, U.S. Army, U.S. Coast Guard, and Coast Survey-NOAA.

Brian Calder with a Ph.D. in Computing and Electrical Engineering has changed his status from Research Scientist to Research Asst. Professor with an appointment shared between the Center and the Dept. of Electrical Engineering. Dr. Calder also comes with a wide range of high-level computing skills. His work has focused on developing methods for textural analysis of seafloor sonar data, as well as exploring innovative approaches to target detection and seafloor property extraction. More recently, Brian is focusing on statistically robust automated data cleaning approaches and tracing uncertainty in hydrographic data. Brian has begun to take a very active role in teaching and advising students prompting the change in position title.

Jim Gardner has been a senior marine geologist with the U.S. Geological Survey in charge of the Western Region's marine mapping program. He was been responsible for the multibeam sonar mapping of a number of areas off California and Hawaii and has pioneered innovative approaches to the dissemination and interpretation of these data. Jim has had a long and illustrious career making important contributions in a number of areas of marine geology and geophysics including leading the U.S. effort to map its EEZ with the GLORIA long-range side-scan sonar. Jim retired from the USGS and joined the Center as a Research Professor in the late summer of 2003.

Lloyd Huff has over 37 years in private industry and the federal government, working with acoustic instrumentation and oceanographic equipment. He received his Doctorate in Ocean Engineering in 1976 from the University of Rhode Island and was one of the lead professionals in the Office of Coast Survey (OCS) working to bring multibeam side scan sonars and multibeam bathymetric sonars into standard practice for shallow water hydrography. He was Chief of the OCS Hydrographic Technology Programs from 1988-1999. Dr. Huff is working on new approaches for a range of hydrographic activities including the application of RTK techniques. Lloyd is now a Research Professor in Ocean Engineering.

Larry Mayer, Director of the Center for Coastal and Ocean Mapping and Co-Director of the Joint Hydrographic Center. Dr. Mayer's position is split between the Ocean Engineering and Earth Science Departments. Dr. Mayer has a background in marine geology and geophysics with an emphasis on seafloor mapping and the remote

identification of seafloor properties from acoustic data. Before coming to New Hampshire he was the NSERC Chair of Ocean Mapping at the University of New Brunswick where he led a team that developed a worldwide reputation for innovative approaches to ocean mapping problems.

Dave Monahan is our new Program Director for the Nippon Foundation General Bathymetric Chart of the Oceans (GEBCO) training program in oceanic bathymetry. Prior to joining CCOM, he served 33 years in the Canadian Hydrographic Service, working his way down from Research Scientist to Director. During that time, he established the bathymetric mapping program and mapped most Canadian waters, built the Fifth Edition of GEBCO, led the development of LIDAR, developed and led the CHS Electronic Chart production program, and was Canadian rep on a number of International committees and boards.

Christian de Moustier is the newest addition to the faculty of the Joint Hydrographic Center/Center for Coastal and Ocean Mapping. His position is split between the Ocean Engineering and Electrical Engineering Departments. He is a world-renowned expert in the theory and engineering aspects of advanced sonar systems for ocean mapping. Christian comes to us from the Scripps Institution of Oceanography where he was responsible for the installation and operation of a number of multibeam and other sonar systems. His research interests focus on development of innovative sonar processing techniques and acoustic seafloor characterization.

Yuri Rzhanov, with a Ph.D. in Physics and Mathematics, is a Senior Research Scientist in the Center. He has a very wide range of computing skills and has built a number of applications for higher education that are presently in use at universities around the world. Most importantly Dr. Rzhanov has been developing models for sonar-seabed interaction for bathymetric and sidescan sonars (including the Klein 2000/5000 systems) as well as software for automatic mosaicing of video imagery and sidescan sonar data.

Colin Ware, member of the Center for Coastal and Ocean Mapping and Director of the Data Visualization Research Lab. Dr. Ware's position is split between the Ocean Engineering and Computer Science Departments. Dr. Ware has a background in human/computer interaction (HCI) and has been instrumental in developing a number of innovative approaches to the interactive 3-D visualization of large data sets. As a member of the UNB Ocean Mapping Group, Dr. Ware was the developer of many of the algorithms that were incorporated into CARIS HIPS, the most commonly used commercial hydrographic processing package.

NOAA has demonstrated its commitment to the new Center by assigning four NOAA employees to the Center:

Capt. Andrew Armstrong, Co-Director of the JHC, Captain Armstrong recently retired as an officer in the National Ocean and Atmospheric Administration Commissioned Corps and is now assigned to the Center as a civilian NOAA employee. Captain Armstrong has specialized in hydrographic surveying and served on several NOAA hydrographic ships, including the NOAA Ship *Whiting* where he was Commanding Officer and Chief Hydrographer. Before his appointment as Co-Director of the NOAA/UNH Joint Hydrographic Center, Captain Armstrong was the Chief of NOAA's

Hydrographic Surveys Division, directing all of the agency's hydrographic survey activities. Captain Armstrong has a B.Sc., in Geology from Tulane University and a M.S. in Technical Management from the Johns Hopkins University. Capt. Armstrong is overseeing the hydrographic training program at UNH and organized our successful certification submission to the International Hydrographic Organization.

LCDR Dave Cole joined the Center to assist with the United Nations Law of the Sea (UNCLOS) Project. He is assisting with database development and architecture for existing bathymetric data, as well as research and planning for future data acquisition to support U.S. sovereignty claims under UNCLOS Article 76. This project integrates with other Center and NOAA-wide ocean mapping programs. Previously, Dave served as Manager of the Bathymetric Acquisition Program at NOAA's National Geophysical Data Center in Boulder, Colorado, and was the commanding officer of the NOAA Ship *Rude* during the execution of NOAA's first in-house shallow water multibeam surveys, conducted in the approaches to Portsmouth Harbor, New Hampshire. **LCDR Cole** retired in October of 2004.

Dr. John G.W. Kelley: John is a research meteorologist and coastal modeler with NOAA/National Ocean Service's Marine Modeling and Analysis Programs within the Coast Survey Development Lab. John has a Ph.D. in Atmospheric Sciences from Ohio State Univ. and a M.S. in Meteorology from Penn State Univ. He is involved in the development and implementation of NOS' operational numerical ocean forecast models for estuaries, the coastal ocean, and the Great Lakes. He is also PI for nowCOAST, a NOAA Web mapping portal to real-time coastal observations and forecasts. John will be working with CCOM/JHC personnel on developing the capability to incorporate NOAA's real-time gridded digital atmospheric and oceanographic forecast into the next generation of NOS nautical charts.

Carl Kammerer, is an Oceanographer with the National Ocean Services' Center for Operational Oceanographic Products and Services (CO-OPS) now seconded to the Center. He is a specialist in estuarine and near-shore currents and presently the project lead or manager for two projects; a traditional current survey in Southeast Alaska, and a more robust survey to ascertain the effects of large bulk cargo ships in Las Mareas, Puerto Rico. Working out of the Joint Hydrographic Center, he acts as a liaison between CO-OPS and the JHC and provides expertise and assistance in the analysis and collection of tides. He has a B.S. in Oceanography from the University of Washington and is an MBA candidate at the University of Maryland.

Other Affiliated Faculty:

Dave Wells: world-renown in hydrographic circles, Dave Wells is an expert in GPS and other aspects of positioning, providing geodetic science support to the Center. Along with his time at UNH, Dave also spends time at the University of New Brunswick and time at the University of Southern Mississippi where he is participating in their new hydrographic program. Dave also helps UNH in its continuing development of the curriculum in hydrographic training and contributed this spring to a UNH course in Geodesy.

Visiting Scholars:

Jorgen Eeg (Oct – Dec, 2000) is a senior researcher with the Royal Danish Administration of Navigation and Hydrography and was selected as our first visiting scholar. Jorgen brought a wealth of experience applying sophisticated statistical algorithms to problems of outlier detection and automated cleaning techniques for hydrographic data.

Donald House (Jan – July 2001) spent his sabbatical with our visualization group. He is a professor at Texas A&M University where he is part of the TAMU Visualization Laboratory. He is interested in many aspects of the field of computer graphics, both 3D graphics and 2D image manipulation. Recently his research has been in the area of physically based modeling. He is currently working on the use of transparent texture maps on surfaces.

Rolf Doermer (March – September 2002) worked on techniques for creating self-organizing data sets using methods from behavioral animation. The method, called "Anaytic Stimulus Response Animation", has objects operating according to simple behavioral rules that cause similar data objects to seek one and other and dissimilar objects to avoid one another.

Ron Boyd (July – December 2003) spent his sabbatical at the Center. Ron is a professor of marine geology at the University of Newcastle in Australia and an internationally recognized expert on coastal geology and processes. Ron efforts at the Center focused on helping us interpret the complex, high-resolution repeat survey data collected off Martha's Vineyard as part of the ONR Mine Burial Experiment.

John Hall (August 2003 – Oct 2004) is also spending his sabbatical from the Geological Survey of Israel with the Center. John has been a major player in the IBCM and GEBCO compilations of bathymetric data in the Mediterranean, Red, Black and Caspian Seas and is working with the Center on numerous data sets including multibeam sonar data collected in the high Arctic in support of our Law of the Sea work. He is also archiving the 1962 – 1974 data collected from Fletcher's Ice Island (T-3).

Research Scientists and Staff:

Semme Dijkstra recently received a Ph.D. in Ocean Mapping from the University of New Brunswick. He is a certified (Cat A) hydrographer from the Netherlands who has several years of hydrographic experience with both the Dutch Navy and industry. From 1996 to 1999 he worked at the Alfred Wegner Institute where he was in charge of their multibeam sonar processing. He is an experienced CARIS user. His thesis work involved artifact removal from multibeam sonar data and development of an echo-sounder processing and sediment classification system. He is now focusing on applications of single beam sonars for seafloor characterization and fisheries habitat.

Tianhang Hou was a Research Associate with the UNB Ocean Mapping for six years before coming to UNH. He has significant experience with the UNB/OMG multibeam processing tools and has taken part in several offshore surveys. In addition to his work as a research associate Mr. Hou has also begun a Ph.D in which he is looking at the

application of wavelets for artifact removal and seafloor classification in multibeam sonar sonar data as well as developing algorithms for determining the "foot of the slope" for Law of the Sea issues and developing new techniques for sidescan sonar processing.

Roland Arsenault was an M.Sc. student and part-time research assistant with Human Computer Interaction Lab of the Dept. of Computer Sciences, UNB before coming to UNH. His expertise is in 3-D graphics, force-feedback and other input techniques and networking. He is currently working on the development of the GeoZui3D realtime 3-D environment.

Gareth Elston joined the Center as a Research Scientist in the fall of 2001. He has a background in sonar signal processing and recently received a Ph.D. from Heriot-Watt University where he developed sophisticated computer algorithms to simulate and visualize the interaction of sonars with the seafloor. Gareth is supported by the U.S Geological Survey and the Office of Naval Research and is focusing his efforts on the continued development of sonar models as well as exploring the applicability of LIDAR data for seafloor characterization.

Martin Jakobsson joined the group in August of 2000 as a Post-Doctoral Fellow. Martin completed a Ph.D. at the University of Stockholm where he combined modern multibeam sonar data with historical single beam and other data to produce an exciting new series of charts for the Arctic Ocean. Martin has been developing robust techniques for combining historical data sets and tracking uncertainty as well as working on developing approaches for distributed database management and Law of the Sea issues. Dr. Jakobsson returned to a prestigious professorship in his native Sweden in April 2004 but will remain associated with the Center and continue to work here during the summers.

Barbara Kraft (TYCO FELLOW) received a Ph.D. in Mechanical Engineering at the University of New Hampshire. Her dissertation research used optical tomography and interferometry to spatially resolve 3-D density fields of turbulent jets. She has taught several courses including digital signal processing and experimental measurement and data analysis. Most recently she has worked on the demodulation of voice and data transmissions for digital radio communications. At CCOM she is working on the GEOCLUTTER program analyzing *in situ* measurements of seafloor acoutstic properties.

Luciano Fonseca received an undergraduate degree in University of Brasilia and his Ph.D. from the University of New Hampshire (he was the first PhD produced by the Center). Luciano's research is focused on developing tools for extracting quantitative seafloor property information from multibeam backscatter and on database support. He is supported by the ONR Geoclutter Program a project aimed at understanding how multibeam backscatter may be used to remotely predict seafloor properties. The work is focused on local sites (Portsmouth Harbor and Great Bay) where we can take advantage of the Shallow Survey 2001 "common data set" and easily collect ground truth data.

Andy McLeod Andy is our Ocean Engineering Lab manager. Andy spent nine years in the U.S. Navy as a leading sonar technician and then earned a B.Sc. in the Dept. of Ocean Studies at Maine Maritime. He is finishing his Masters degree in Marine Geology from the University of North Carolina. At UNH, Andy is responsible for maintenance and

upgrading of the major laboratory facilities including the test tanks, small boat operations, local network administration and assistance with some courses.

Nathan Paquin joined the Center in 2004 taking responsibility for the daily maintenance and upkeep of our ever-growing computer facilities. Nathan comes from a strong background in computing initially gained while serving in the U.S. Army and being responsible for providing secure servers and clients. This experience was expanded through work in the industrial sector for numerous small and large IT companies.

Matt Plumlee became a research scientist with the Center after completing his Ph D. at UNH under Dr. Colin Ware. Matt is continuing his work on data visualization and human computer interaction focusing his efforts on the Chart of the Future project.

Ben Smith, is the Captain of CCOM-JHC research vessel *Coastal Surveyor*, and a research technician specializing in programming languages and UNIX-like operating systems and services. He has years of both programming and marine experience and built and captains his own 45 foot ketch , *Mother of Perl.*

In addition to the academic, research and technical staff, **Abby Archila** and **Ellen Barrows** are our Program Managers and keepers of order with the able assistance of **Abby Czekanski**.

Facilities and Equipment:

With the startup of the Center, the University provided a new 8000 square foot building. Given the very rapid growth of the Center, space became the limiting factor in our ability to take on new projects. In 2003 we expanded into the second floor of the new building providing greatly needed additional office, graduate student and meeting space.

We have added four new dedicated Dell servers (two for data archive, 1 as a firewall and one as a web/development server) and additional Network Attached Storage (NAS) and RAID to our 4-processor Origin 2100 Silicon Graphic server with fiber channel disk stripe. This brings our online storage capacity to more than 10 Terabytes and the total number of servers to 12. Most of our servers are consolidated into two Dell racks with three UPS's monitored across the network. External services have been moved to a Dell Poweredge 650 server, which provides FTP, mail, web and CVS services. Interface between our internal gigabit network and the external world is handled by another Dell Poweredge 650. We also have an SGI O2 workstation, 101 high-end Windows XP and Linux workstations and laptops, and several Mac G4's. There is now gigabit network in every office in the lab implemented over our own network for enhanced security and management, including automated antivirus scanning. All traffic is routed through a firewall where it is audited by an intrusion defection system (Fig. 1). We have a full suite of printers and plotters including both 48 and 60-inch large-format color plotters. Through the generous donation of visiting scholar Dr. John Hall, we now also have a 54 inch wide, continuous feed, high-resolution scanner. All computers and peripherals are operational and fully integrated into both Center and University networks. All systems are interoperable regardless of host operating system and files are shareable between all systems.

A robust daily backup system is in place, with tapes held in a fire-safe. Our tape backup system has been improved with the installation of a robotic tape changer in the Dell server rack. This unit can handle up to 20, 320GB tapes, while writing to 2 tapes simultaneously. We have implemented a real-time log monitoring, filtering, and forwarding system to insure an audit trail is available. We have also acquired a full suite of commercial software packages for both data processing and presentation. In addition, we are developing a great deal of in house software (see Research Theme discussions below). For this software development, a cooperative code development environment is in place (CVS), which allows concurrent development on different platforms with multiple users. A full suite of peripherals (4mm, 8mm, DLT and DVD-R) are available so that we can re-distribute the data on a range of media.

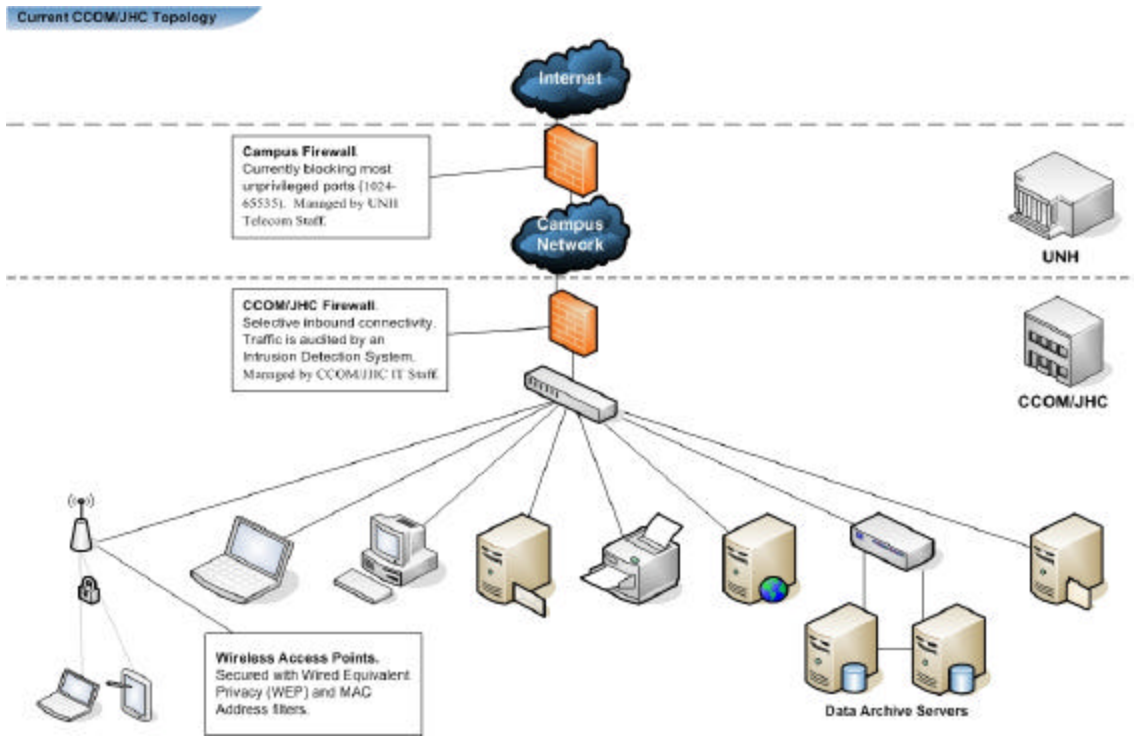

Fig. 1. Current topology of JHC computer network

With funding shared between NOAA and the National Science Foundation, we have upgraded the acoustic test tank facilities at the Chase Ocean Engineering Lab, installing a motorized, rigid steel bridge and trolley system that allows a platform to be precisely positioned anywhere over the tank. We have also acquired and installed a computer-controlled rotary turntable that is mounted on the platform and used for sonar testing and calibration. With these upgrades, UNH has one of the largest and most advanced sonar calibration facilities in the Northeast. We have collaborated with researchers from several institutions and successfully used this facility to calibrate various sonars.

We have outfitted and put into service a very shallow draft pontoon boat for survey work in the local waters of Great Bay and received a very generous gift of a 40

foot, purpose-built survey vessel (The *Coastal Surveyor*) from **C&C Technologies** of Lafayette, LA. **C&C Technologies** also kindly donated a C-Nav commercial GPS correction system to the Center. The *Coastal Surveyor* has seen heavy use supporting both research and class work, in each of the four field seasons we have had the vessel. In support of these research programs we have acquired several state-of-the-art positioning systems (Ashtech and Trimble), a Seabird CTD system, a Digibar sound speed calibration system, and Vitel and Aandera tide gauges. We have also acquired a Knudsen 50 and 200 kHz chirp sounder, and a POS-MV320 inertial motion sensor. In addition **TSS** has donated a TS-335B motion sensor and **ODOM** has donated a MKIII survey echosounder. We have also been busy building a range of specialized survey equipment including underwater videography capabilities using a Sea Sciences Inc. controllable tow body and other camera techniques (Huff and Cutter).

Finally, we have completed construction and initial outfitting of an electronics workshop under the supervision of Andy McLeod and a machine shop under the supervision of Paul LaVoie and preparation has begun for the construction of a new underpass that will increase access and provide added safety to all those working at or with the Center. This project has entered the bidding phase (processes and bid forms, provision of technical clarification in response to bidder inquiries) with the completion and award of a contract expected by the second week in April 2005.

Educational Program:

The Center has, under the guidance of Capt. Armstrong, has developed an ocean-mapping specific curricula that have been approved by the University. We offer both M.S. and PhD degrees with a specialization in Ocean Mapping through the Dept. of Ocean Engineering, the Dept. of Earth Sciences (now expanded to include the School of Natural Resources), the Dept. of Electrical Engineering , the Dept. of Computer Science, or the Institute for the Study of Earth, Oceans and Space. The path chosen depends on the background of the student with physical scientists typically entering through the Oceanography or Earth Science programs, engineers entering through Ocean or Electrical Engineering programs, and computer scientists through the Computer Science program.

We have also established a post-graduate certificate program in Ocean Mapping. This one-year program has a minimum set of course requirements that can be completed in one year and allows post-graduate students who cannot spend the two years necessary to complete a master's degree a means of upgrading their education and receiving a certification of completion of the course work. The first student (from NIMA – now NGA) started in the certificate program in September 2003.

This past year the Center was selected through an international competition (which included all of the leading hydrographic education centers in the world) to host the Nippon Foundation/GEBCO Bathymetric Training Program. UNH was awarded $1.6 M from the Nippon Foundation to create and host a one-year training program for seven international students (initial funding is for three years). Fifty-seven students from 32 nations applied and in just 4 months (through the tremendous cooperation of the UNH Graduate School and the Foreign Students Office) seven students were selected, admitted, received visas and began their studies. These students have added a tremendous dynamic to the Center both academically and culturally. The GEBCO

scholars will receive a "Certificate in Ocean Mapping." Funding from the Nippon Foundation has allowed us to add Dave Monahan to our faculty in the position of program director for the GEBCO bathymetric training program. Dave brings years of valuable hydrographic, bathymetric and UNCLOS experience to our group and, in the context of the GEBCO training program has added several new courses to our curriculum.

With the establishment of these programs we will now turn to our longer-term goal of establishing the training and certification programs that can serve both undergraduates and industry people. We have already begun by offering the Center as a venue for industry and government training courses and meetings (e.g., CARIS, Triton-Elics, GEBCO, IBCAO, IVS, the Seabottom Surveys Panel of the U.S./Japan Cooperative Program in Natural Resources (UJNR), FIG/IHO, NAVO, NOAA, USGS). This has proven very useful as our students are allowed to attend and are thus exposed to a range of state-of-the-art systems and important issues. Particularly important was the visit to the Center by a number of members of NOAA's Coastal Development Lab (in order to explore research paths of mutual interest) and the visit of 40 NOAA scientists to discuss NOAA priorities for multibeam sonar systems and surveys as part of a NOAA Multibeam Workshop.

Finally and most importantly, our program was given a **Category A certification by the FIG/IHO International Advisory Board of Standard of Competence for Hydrographic Surveyors** at their annual meeting in May 2001.

While our students have a range of more general science and engineering courses to take as part of the Ocean Mapping Program, the Center teaches several courses specifically designed to support the Ocean Mapping Program.

JHC – originated Courses

Course	Instructors
Introduction to Ocean Mapping	Armstrong, de Moustier, Mayer
Ocean Bathymetry	Monahan
Hydrographic Field Course	Armstrong
Marine Geology and Geophysics	Mayer
Acoustics	de Moustier, Baldwin
Data Structures	Ware
Data Visualization	Ware
Seafloor Characterization	Mayer, Calder, de Moustier
Marine Geodesy	Wells, Dijkstra, Huff

We have 23 students currently enrolled in the ocean mapping program, including the GEBCO students, two NOAA Corps officers and a NOAA physical scientist; we have already produced three Ph.D.s (Luciano Fonseca (2001) and Anthony Hewitt (2002), Matt Plumlee (2004). Shep Smith received his M.Sc. degree in May of 1993 – the first of our NOAA Corps Officers to graduate, and this past year we have graduated four more

Masters students (Brogan, Gostnell, Sullivan, and Zoksimovski) including the first NOAA physical scientist who completed the "non-thesis" Masters program option (Gostnell).

Student	Program	Advisor
Rick Brennan (NOAA)	M. S. OE	TBD
Daniel Brogan	M.S. EE (rcvd May04)	de Moustier
Chuck Carline	M. Sc. EE	Calder/de Moustier
Randy Cutter	PhD, E. Sci.	Mayer
Gerd Glang (NOAA)	M.S., OE	Huff
Jim Glynn	M.S. EE	de Moustier/Huff
Caleb Gostnell (NOAA)	M.S. E. Sci. (rcvd May04)	Armstrong/Mayer
Tianhang Hou	Ph.D. OE (PT)	Mayer, Huff
Mike Leo	Ph.D. E. Sci.	Huff
Anton Mamaenko	M.S. O.E.	Rzhanov
Malik Mashkoor	M. S. OE	Mayer
Peter Mitchell	M. S. C. Sci.	Ware
Karthikeyan Natham	M. S. C. Sci.	Ware
Chris Plumlee	M. S. EE	Calder
Matthew Plumlee	Ph.D. C. Sci (rcvd May04)	Ware
Matt Quinn	Ph.D. C. Sci	Ware
Lorraine Robidoux (NOAA)	M.S. O.E	TBD
Richard Raymond	M.S., E.Sci	Mayer
Stephan Schaeffer	Ph. D. C. Sci	Ware
Brianna Sullivan	M.S. C. Sci,(rcvd May04)	Ware
Arsen Zoksimovski	M.S. EE (rcvd May04)	de Moustier

GEBCO Students:

Student	Institution	Country
Clive Angwenyi	Marine and Fisheries Res. Inst.	Kenya
Srinivas Karlapati	National Inst. Of Oceanography	India
Hugo Montoro	Naval Hydrography	Peru
Taisai Morishita	Coast Guard Hydrography	Japan
Abubakar Mustapha	Naval Hydrography	Nigeria
Walter Reynoso-Peralta	Navy Hydrographic Service	Argentina
Shereen Sharma	University of South Pacific	Fiji

Status of Research: 2003 - 2004:

In our initial proposal (1999) we identified five research programs, each of which combines long-range research goals designed to make fundamental contributions to the fields of hydrography and ocean mapping with short-term objectives designed to address immediate concerns of the hydrographic community in the United States. We outlined each of these programs, describing the major focus of each research task and identifying what resources (both in terms of people, including collaborators, and equipment) will be required to complete these tasks. As our research has progressed and evolved, the clear boundaries of between these themes have become more diffuse. For example, our data processing efforts (e.g. CUBE) are evolving into our data fusion and chart of the future efforts. The data fusion and visualization projects are also blending with our seafloor characterization and chart of the future efforts as we begin to define new sets of "non-traditional products." This is a natural (and desirable) evolution that slowly changes the nature of the themes and the thrust of our efforts. Nonetheless, for consistency, we will use the original theme categories to review our progress as well as describe progress made in several new initiatives.

Innovative sonar design and processing for enhanced resolution and target recognition

With substantial progress made in the upgrades to our sonar calibration facilities as well as the addition to our faculty of Dr. Lloyd Huff, our involvement in the development and testing of new sonar systems has increased. Our sonar calibration facility (funded in part by NSF) is now one of the best of its kind in New England with a rigid x, y positioning system, computer controlled transducer rotor (with resolution of 0.025 degree) and custom built data acquisition system. In past years the new calibration facility was used to better understand the characteristics of the Simrad SM2000 mid-water multibeam sonar (in collaboration with researchers from Woods Hole Oceanographic Institution) as well as Reson 8101 multibeam sonar (in collaboration with researchers from the University of New Brunswick and Pennsylvania State University. This year we have added to the systems calibrated the WASSP (Wide Angle Sonar Seafloor Processor), a new, inexpensive, New Zealand-designed, multibeam sonar that is currently under development; the acoustic probes that we use for *in situ* measurements of the acoustic properties of seafloor (our ISSAP system– In situ Sound Speed Attenuation and Porosity system – built for the Navy), and; the transducer from the SSPARR (Seafloor Sounding in Polar and Remote Regions) buoy. The SSPARR buoy is an NSF-funded project to build autonomous echosounders that can be deployed from buoys in remote or ice-covered regions and telemeter soundings (via satellite) back to a central data base. In addition to our own projects, the facilities have been used on a cost-recovery basis to calibrate the sonars of several industrial groups (NuvoSonic, Sonetech). Further upgrades for this facility are planned as the acquisition and processing software is being upgraded (Barbara Kraft) and graduate student Chuck Carline is working with Drs.Calder and de Moustier to develop an automatic positioning system for the x-y table.

Two of our faculty members have been involved with the development of new and innovative sonar systems. Lloyd Huff has taken the lead in the test and evaluation of the Klein 5410, the interferometric version (capable of measuring depth as well as backscatter) of Klein's very successful 5000 series sidescan sonar. Working with Chris de Moustier and graduate student Jim Glynn, the 5410 has been in the test tank at least three times and tested in the field several more times. In each of these tests numerous issues have been identified (either with the sonar or the test facility) and significant improvements made. Work is currently underway to model the acoustic behavior of the sonar to gain further insight into the expected capabilities leading to the ultimate goal of using phase information from the sonar to produce accurate bathymetric information.

Dan Brogan has worked with Chris de Moustier on an NRL-sponsored project to develop a toroidal (360 degree) volume search sonar. This work, reported in Daniel's MSEE thesis, has shown the potential to create three relatively independent profiles from each ping and the 27 sets of received beams formed by this sonar. A bottom detection algorithm was implemented to create bathymetry and acoustic backscatter imagery with reasonable bathymetry to +/- 40 degrees from nadir and noisy but potentially useful bathymetry and imagery out to 80 degrees on some pings.

Chris has also worked with Scripps Institution of Oceanography on improving the performance of their EM120 multibeam sonar (of increasing relevance to NOAA as NOAA begins to acquire deep water multibeam systems) and with Electronics Navigation Ltd. of New Zealand on the development of a new 160kHz multibeam sonar (WASSP) targeted towards the fishing industry. Working with summer student Alexandre Schimel, the WASSP was calibrated and beamforming algorithms developed.

Finally, Barbara Kraft and Chris de Moustier have developed a variable bandwidth filtering approach to bottom tracking that greatly improves the bottom detection capability of the Reson 8100 series of sonars. The approach uses the information in the previous ping to calculate filter coefficients for the next ping with the bandwidth of the filter varying across the swath. The cutoff frequencies for each beam are determined by estimating the duration of the received echo (as a function of range, beam angle, beamwidth, and transmitted pulse length) within the –3dB beamwidth. This work was demonstrated in a post-processing mode; real-time implementation will now be investigated. There are many Reson 8100 series sonars in the NOAA hydrographic fleet and thus this improvement, if incorporated by the manufacturer, should be of importance to NOAA.

New approaches to multibeam and sidescan sonar data processing:

*Improved Bathymetric Processing***:**

One of the major efforts of the Center has been to develop improved data processing methods that can provide hydrographers with the ability to very rapidly and accurately process the massive amounts of data collected with modern multibeam systems. This data processing step is one of the most serious bottlenecks in the hydrographic "data processing pipeline" at NOAA, NAVO, and hydrographic agencies and industries worldwide. We have explored a number of different approaches for automated data processing (see earlier progress reports for descriptions of these approaches) and, in the past year focused our effort on a technique developed by Brian Calder that is both very fast (10's to 100's of times faster than the standard processing approaches) and

statistically robust. The technique, known as CUBE (Concurrent Uncertainty and Bathymetric Estimator), is an error-model based, direct DTM generator that estimates the depth plus a confidence interval directly on each node point. Most importantly, the technique produces an estimate of uncertainty associated with each grid node. When the automated editing technique fails to make a statistically conclusive decision, it will generate multiple hypotheses, attempt to quantify the relative merit of each hypothesis, as well as present them to the operator for a subjective decision. The key is that the operator interacts only with that small subset of data for which there is some ambiguity rather than going through the current process of subjectively examining all data points.

In 2003, CUBE was subjected to detailed verification studies in a cooperative research effort with NOAA that compared the automated output of CUBE to equivalent products (smooth sheets) produced through the standard NOAA processing pipeline. Verification studies were done in three very different environments (Snow Passage Alaska, Woods Hole, Mass., and Valdez, Alaska) involving surveys in various states of completion and comparisons done by NOAA cartographers. In each case the CUBE-processed data agreed with the NOAA processed data within IHO limits. Cube processing took from 30 to 50 times less time than the standard NOAA procedures. Based on these verification trials and careful evaluation, Capt. Roger Parsons, director of NOAA's Office of Coast Survey has notified NOAA employees as well as other major hydrographic organizations in the U.S. (NAVO and NIMA) of NOAA's intent to implement CUBE as part of standard NOAA data processing protocols. As described by Capt. Parsons in his letter to NAVO and NIMA, CUBE and its sister development The Navigation Surface (see below) *"…promise considerable efficiencies in processing and managing large data sets that result from the use of modern surveying technologies such as multibeam sonar and bathymetric lidar. The expected efficiency gains will reduce cost, improve quality by providing processing consistency and quantification of error, and allow us to put products in the hands of our customers faster."*

In light of NOAA's acceptance of CUBE, most providers of hydrographic software are now implementing CUBE into their software packages. Dr. Calder has been working with these vendors (CARIS, IVS, SAIC, SIMRAD, Triton-Elics, Reson) to ensure that they will properly implement the CUBE algorithms in their products. IVS is now distributing the first commercial implementation of the algorithm with other vendors soon to follow. Dr. Calder has also worked closely with NOAA, including participating in a field program on the NOAA vessel THOMAS JEFFERSON to develop simplified interfaces for CUBE and sharing data acquisition strategies. In this past year, work has continued to improve the speed, efficiency and robustness of the CUBE algorithm and code written to allow the easy interfacing with various commercial packages. Particular focus has been placed on regions of steep slopes that have historically caused serious bottom tracking problems. Approaches are being developed to identify these slope-generated outliers using multi-algorithm statistical analysis before processing. This approach includes a probabilistic estimate of the location at which the incoming data become inconsistent with theoretical models of the sonar behavior. These estimates are then fused with other independent estimates and an information feedback scheme used to make the system "self-learning." These techniques will be tested on NOAA survey launches working in Alaska this coming summer.

Inherent in the CUBE approach is the need for a robust error model for the sonar being used. This model should be provided by the manufacturer but unfortunately only a few manufacturers publish an error model for their system. In an attempt to develop approaches to extracting an error model from an undocumented sonar as well as checking the manufacturer-provided models, Calder and graduate student Mashkoor Malik have been exploring field calibration methods for extracting error models directly from data. Additionally, Calder has been working with Reson to develop an error model for their presently undocumented 8100 series sonars (many of which are used by NOAA).

Another aspect of the data processing-related research being conducted at the Center involves rethinking of the final output products of a hydrographic survey. We strongly believe that the standard chart product of selected soundings and contours does not at all do justice to the information content of high-resolution multibeam and sidescan sonar data. We are working on a series of new products that will better serve the mariner as well as many other constituencies. In this context, Lt. Smith developed the concept of the "Navigation Surface" as part of his thesis work. The Navigation Surface is a database that maintains bathymetric data sets at full resolution and a rule base for producing a series of derived products. Thus a single database can be the source for hydrographic (safety of navigation) products as well as products for fisheries habitat or other studies that require full-resolution data. CUBE-processed data can be a component of the Navigation Surface and thus the verification exercise described above also involved the navigation surface and tested (positively) the veracity of the navigation surface as a source of hydrographic products. The combination of CUBE and the Navigation Surface set the stage for a new research effort "The Chart of the Future" described later.

In support of the new adoption of CUBE and the Navigation Surface into NOAA and NAVO processing protocols, this past year, the Center organized and hosted a workshop with industry, government and academic researchers to define an open format for Navigation Surface products in order to ensure interoperability amongst the various vendors and agencies. This workshop defined the specifications for the Bathymetric Attributed Grid (BAG) Object, and obtained the commitment of many of those attending (NOAA, NAVO, CARIS, IVS, SAIC, 7C's) to provide source code and adopt the approach. Additionally, a digital security scheme using a digital signature algorithm has been implemented for the Open Navigation Surface. Cross platform libraries for digital signatures have been built and tested and an example certificate construction and management scheme (based on HASP network dongles) has been implemented. As a focal point for the broad interest in CUBE and the Navigation Surface amongst the government and the private sector, the Center is fulfilling one of its prime mandates of serving as a national center of focus for ocean mapping activities. In bringing these groups together we become the focal point for more efficient and collaborative research efforts aimed at solving a national need.

Understanding Uncertainty in Sparse Bathymetric Data:

CUBE has provided, for the first time, a robust technique for providing an uncertainty estimate for multibeam sonar data. Unfortunately, most of the data in NOAA's archives are relatively sparse single-beam data. Several years ago we (Jakobsson, Calder and Mayer, 2002 – On the effect of random errors in gridded bathymetric data, Jour. Geophy. Res. V.107, B12, 2358) proposed a Monte Carlo

approach to attributing sparse historical sounding data for uncertainty. The examples we used in this study were from the Arctic where only single beam sonar data were available. In many situations there may be a small amount of multibeam sonar data available and Calder has begun to explore the use of multibeam data to calibrate sparse data sets and the implications making depth and uncertainty surfaces from sparse data sets. This study focused on the New Jersey margin where NOAA has several generations of archived single beam data and we have collected high-resolution multibeam sonar data as part of an ONR-sponsored project. Initial results of this study have demonstrated that older archived data (1936-1938) were heavily biased due to "hydrographic rounding" (up to 1.4m!) thus older archived data will have limited accuracy. More recent archived data (1970's) did not show this bias and had a accuracy of IHO Order 1 in the depth range represented (30-110 m). A hybrid Monte Carlo/Kriging method was developed to transform measurement errors into an interpolated surface with attributed uncertainty. The uncertainty falls about halfway between IHO S.44 Order 1 and Order 2, (approx 1-2 m vertical uncertainty at 95%) consistent with the age and intent of these surveys. Comparison with the multibeam echo sounder data shows the effect of spatial aliasing in the surface due to the 500m+ line spacing of the single beam data. This leads to increased uncertainty (1-2x S.44 Order 2) everywhere except near the original sounding points and the conclusion that it will be very difficult to robustly predict bathymetry in gaps between sounding lines.

***Improved Sidescan Sonar and Backscatter Processing*:**

While our initial data processing efforts have focused on improving bathymetric processing, it is becoming increasingly clear that there is also a great need for improved processing of backscatter data (both from multibeam sonars and sidescan sonars). With this in mind we have, this year started a new effort aimed at improving the suite of backscatter processing tools available to us and NOAA. Our aim is two-fold: 1- to develop easy to use tools that will generate "pretty" images of sidescan sonar or multibeam backscatter that will be suitable for small object detection as well as geologic and habitat interpretation, and; 2- to develop tools that allow for the quantitative analysis of backscatter data in support of seafloor characterization and small object identification.

In an effort to meet these two objectives, we have begun a lab-wide effort to develop a new suite of backscatter processing tools. This effort is being led by Luciano Fonseca with input from many others. The goal is to create an integrated suite of tools that will allow us to import backscatter or sidescan data from a number of sensors (in various formats, including Reson snippet data), convert these data to an internal GFS format, correct these data (where possible) for source levels, beam patterns, gains, area ensonified, attenuation, and local slope, and then either analyze and/or display these data in a georeferenced mosaic. A number of modules are being developed including GEOCODER, a C++ mosaicing tool that now reads directly from GSF or XTF files (including Reson snippet data), corrects data for gains and removes speckle. Data is then geocoded in a projected coordinate system using an interpolation scheme that emulates the acquisition geometry. Initial tests of GEOCODER have shown clear improvements in noise and artifact reduction.

In another backscatter-related data processing effort, Lloyd Huff and Tianhang Hou have been developing algorithms and software to clean and remove artifacts from Klein 5000 and 5410 sidescan sonar data collected by the Alaska Fisheries Research Center in the Bering Sea specifically with the goal of identifying fishing gear marks. The techniques developed allow the removal of beam pattern and roll effects, pre-whitening, slant-range corrections and recalculation of tow fish position. Finally an equalization technique was applied based on the altitude of the tow fish. After this processing, it was possible to visually identify subtle trawl marks in the data though statistical analyses are dominated by residual artifacts.

In this same context, Mashkoor Malik has developed a series of processing approaches that have led to the clear identification of bottom gear marks in very high-resolution multibeam bathymetric data from Jeffreys Ledge. The bottom gear marks found on Jeffreys Ledge are very subtle (only approximately 3 cm deep) and are thought to be caused by scallop dredges. These subtle bathymetric targets were often obscured by a residual heave artifact. Mashkoor designed a directional filter that was able to surpress the heave artifact and enhance the identification of the bottom gear marks. This will be discussed further in the seafloor characterization section.

New approaches to data visualization and presentation:

We continue a very strong focus on the development of innovative approaches to data visualization and the application of these approaches to ocean mapping problems. The visualization team (Arsenault, Plumlee, Sullivan, Quinn, and Natham) under the supervision of Lab Director Colin Ware has been actively developing a novel and innovative 3-D visualization environment, GeoZui3D. GeoZui3D is a highly interactive 3-D visualization system designed to support a number of different research projects and ocean mapping applications. GeoZui3D was described in detail in previous progress reports; during the current reporting period, GeoZui3D has continued to develop and grow. Most importantly GeoZui3D has begun to incorporate time-varying data opening up a world of new visualization possibilities. It is has been made available to the public and more than 40 groups have downloaded the software. It is being used as a display and QC tool both on board NOAA survey vessels and in NOAA labs. The GeoZui3D task is also blending more and more with the Chart of the Future task (reported below). We will describe some of the new innovations in GeoZui3D in this section but those related to the Chart of the Future will be described under that task heading.

Whereas much of our visualization effort has been focused on the 3-D interactive display of static features like the seafloor, this past year has seen the addition of dynamic, time-varying systems. In collaboration with researchers at Woods Hole Oceanographic and Johns Hopkins University, our visualization group is developing 3-D tools for the planning, monitoring and review of Autonomous Underwater Vehicle (SeaBed) and a Remotely Operated Vehicle (Jason II) missions. We foresee that the techniques developed for these systems will be directly applicable to the newly acquired NOAA REMUS AUV. Particularly exciting has been the work of the group in visualizing the behavior of humpback whales. NOAA and WHOI scientists have developed suction-cup-mounted tags that are attached to a whale and record depth, pitch, roll, and sound for as long as the tag remains on the whale (the record is now 22 hours). Our visualization team has taken these data and created a fully georeferenced 3-D display of the whale's diving and swimming behavior in the context of the bathymetry,

other vessels, and ambient sounds. The result has provided unprecedented insight into the diving and feeding patterns of the whales as well as their response to the approach of vessels.

Specific additions to GeoZui3D this reporting period include: the ability to update some 3D windows more frequently, the ability to support "hover queries" – information about an object that pops up when selected with the mouse; semi-transparency; the ability to apply texture to lines, points, and surfaces; 3-D distance measurement; rubber-band selection tool for areas, and: space-time notes, an exciting innovation that takes a viewer to a particular point in space and time through a single mouse click. This capability has been particularly useful in the whale tracking visualizations.

The incorporation of flow visualization models into the GeoZui3D environment has opened of a range of applications and interest from ocean and current modelers both inside and outside of NOAA. Collaboration with Tom Gross at NOAA's Coast Survey Development Lab and with Changshen Chen at the University of Mass (Bedford) is currently underway. A particular challenge being addressed is the development of methods to visualize multiple layer flows. These tools also have important applications in the Chart of the Future.

GeoZui3D has been developed into a kiosk-based interactive 3-D museum exhibit for Seacoast Science Center (GeoExplorer) and a very effective outreach mechanism demonstrating the importance of seafloor mapping. As part of the thesis work of Briana Sullivan, the prototype exhibit underwent multiple evaluation phases at the Seacoast Science Center and the New England Aquarium. The exhibit has now been installed at the Seacoast Science Center where visitors can pilot themselves through an immersive 3-D environment up and under the Piscataqua River, stopping at interesting sights along the way. The exhibit has been augmented with two extra journeys, one to the open ocean aquaculture site off the Isle of Shoals and the other to the George's Bank.

Seafloor Characterization:

We have a number of inter-connected research programs underway aimed at exploring the ability of our mapping systems to provide quantitative information on the make-up and character of the seafloor as well as its depth. These programs deal with a range of sensors (single beam, multibeam and sidescan sonars, lidar, video, etc.) and involve theoretical studies, the collection of remotely sensed data, and "ground-truth" samples.

Single beam sonar and Mapping and Characterization:

In general support of our seafloor characterization efforts, Semme Dijkstra has continued the development of several software tools. The TracEd tool provides a robust means of tracking, editing and parsing returns from single beam echosounders. This tool, which has the potential to be a very useful aid to single-beam hydrographic data processing, has now been ported to the Windows environment. The Lassoo tool which is used for comparing multivariate data sets to imagery data sets in both geographic and

multivariate feature space has now been implemented in the R environment, a public domain computer language for statistical processing.

Multibeam and interferometric sonars:

We have made substantial progress in developing approaches to multibeam classification on a number of fronts. These developments have been made using EM 300, 1000, 1002, 3000 and Reson 8101 and 8125 data collected in support of the ONR, NSF, USGS, and Icelandic-sponsored programs, as well multibeam sonar data collected by NOAA and others in Portsmouth Harbor as part of the Shallow Water Survey 2001 "Common Data Set" (see previous progress reports). With the availability of these data sets, much of our recent effort in terms of seafloor characterization has focused on the enhancing our ability to extract quantitative information from our sonars (through better processing and modeling) and improving our ground-truthing abilities.

If we are to use sonar backscatter data to correctly characterize seafloor properties, we want the backscatter that we measure to represent changes in the seafloor rather than instrumental changes or changes in the geometry of insonification. While many system and geometric corrections are applied by the manufacturers in their data collection process, a very important parameter – correction for local slope – is not. We have thus embarked on research effort, described earlier, aimed at using the detailed bathymetric data provided by multibeam sonar to calculate local incidence angles and correct backscatter for local slope. Once such corrections are made the resulting backscatter should be much more representative of true sea floor variability.

Luciano Fonseca has begun a focused effort aimed at understanding the relationship of multibeam backscatter to seafloor properties in the well-controlled and easily accessible environment of Portsmouth Harbor and Great Bay. This work, funded for the most part through ONR's Geoclutter program has involved the establishment of a GIS-based database of all existing data in the region (existing data includes all the data collected in support of Shallow Survey 2001, as well as data collected as part of our Ocean Mapping field course), the reanalysis of multibeam sonar-derived backscatter data (particularly data from the Simrad EM3000 sonar) to correct for true backscatter values (including local slope) and the calculation of AVO (Amplitude Versus Offset) parameters. In support of this study we have also collected samples and are making *in situ* measurements of sound speed, attenuation, and resistivity using the ISSAP (In Situ Sound Speed Attenuation and Porosity) Probe, also developed under ONR funding. Luciano has expanded the functionality of the AVO software to automatically adjust AVO parameters calculated from the measured (and corrected) backscatter with AVO parameters derived from one of several mathematical models that describe the interaction of sound with the seafloor (a modified Jackson model and a Biot model). These techniques have been applied to areas of Little Bay and Portsmouth Harbor where we have a large amount of ground truth data and they are providing very encouraging results. Additionally the technique has been used to predict sediment type during site surveys of potential drill sites in the Alaskan Fjords (NSF funded) and has been used to identify regions with near-surface gas in Skajfandi Bay Iceland. We look to the further development of this approach and its adoption as a potentially important component of fisheries habitat mapping.

Over the past three years a new approach to seafloor characterization based on the automated segmentation of multibeam sonar bathymetric data into regions of common geomorphology (roughness) has been implemented by Randy Cutter and Yuri Rzhanov. The technique uses texture-based segmentation techniques (local Fourier transforms and local Fourier histograms (LFH)). The technique is fully automated, except for the choice of the number of classes produced by cluster analysis of LFH results. The technique, which appears to be quite robust and repeatable, has been applied to several of the Portsmouth Harbor data sets as well as regions of the well-studied Stellwagen National Marine Sanctuary and to NOAA study areas around Saipan and the U.S. Virgin Islands. The LFH appears to separate the morphology into regions that have significance in terms of the habitat of several species. This year's efforts have focused on analyzing ground truth data (both video and samples) and developing applications to facilitate the review and analysis of seafloor video imagery. The tools developed read video data and position information and records several user-selected details about substrates and fauna. In addition Cutter has been making estimates of the spectral roughness of the seafloor (a key parameter in most acoustic propagation models) from sediment profiler images. The roughness parameters calculated from the sediment profile images will provide an important parameter for the AVO analysis of Fonseca described above.

In order to better understand the relationship between remotely measured sonar backscatter and the physical properties of the seafloor, we have also developed (with ONR funding) an instrument system designed to make *in situ* measurements of sound-speed, sound attenuation, and resistivity (along with video of the seafloor -- ISSAP). In the past year, Barbara has calibrated the ISSAP transducers (to better understand the measurements made with them) and has upgraded the ISSAP software. ISSAP data from Portsmouth Harbor, Little Bay and the New Jersey Margin were analyzed in support of the Geoclutter work of Fonseca and the ONR Uncertainty project respectively. In the case of the Geoclutter work, ISSAP measurements have been compared with the model predictions of Fonseca with very encouraging results (reported above). With respect to the Uncertainty work, ISSAP measurements were compared with sound speeds predicted by a combination of the SedFlux, Buckingham and Effective Density Fluid models. Initial comparisons indicate that the models appear to predict sound speeds that are too low (grain sizes that are too small) though in some circumstances (water depths less than 100 m) the model predicted sound speeds are too high (grain sizes too large). The results of this effort will be used to re-evaluate the models and will have long-term relevance to NOAA habitat mapping efforts.

Finally, Gareth Elston, with funding from USGS and ONR, has been looking at the waveform characteristic of LIDAR as a possible means for identifying seafloor properties. Gareth has developed two methods for characterizing bottom-reflected lidar pulses by their peak amplitude and pulse width: one based on fitting gamma functions to the pulses and the other based on finding the peak and inflection points through interpolated derivatives of low-pass filtered waveforms. These methods have been combined to improve the robustness of the parameter estimation. In addition, the effect of bottom slope on peak power is now being compensated for. Bottom slopes are derived from gridded surfaces and the normal vector at any point on the interpolated surface is calculated using a vector cross-product of the bottom slope along the horizontal coordinate axes. Given the refractive index of the water, the aircraft location, and the bottom footprint position, the location of the water surface laser spot can be determined

and the bottom incident vector on the bottom calculated. In collaboration with Semme Dijkstra, the bottom slope corrected features are being ported for use in his Trace-Ed and Lasso tools where automatic clustering and segmentation can be applied (see description in Single Beam Characterization section). Initial analyses are indicating that this approach is separating areas with different water mass properties as well as bottom type.

Video/photo image mosaicing and quantification:

Yuri Rzhanov, Lloyd Huff and Randy Cutter have been quite active in the collection of seafloor video data as well as in developing sophisticated algorithms for processing these data. The team has developed a means of remotely controlling a digital camcorder and of recording positional information from a GPS and an attitude sensor on the audio track of the video tape to provide fully georeferenced video imagery that can then be digitally mosaiced. Huff has been particularly active with the development of the "Hubbard Camera" a towed video camera system with a diesel-powered stand-alone winch, which has been used in support of a number of habitat mapping efforts in Portsmouth Harbor (Cutter) and Jeffries Ledge (Malik and Grizzle). This year the Hubbard Camera was used in tandem with a small ROV, overcoming the limitations of operating the ROV in regions of high current. The ROV is hard-tethered to the Hubbard Camera frame with 30 meters of freely rotating tether allowing the location of the camera frame to constrain the area coverage of the ROV. Eight new light-diffusers have also been constructed on the strobe lights of the Hubbard Camera to provide more uniform illumination patterns on the seafloor. The Hubbard Camera has been equipped with laser spots to provide scale in the images. Rzhanov has been working on algorithms to detect and mask (if necessary) these spots and also to derive information about seafloor slope and roughness from the behavior of the spots. This work has been extended (in collaboration with NMFS scientist Mary Yoklavich) to estimate the distance traveled by a submersible.

Cutter and Rzhanov have also been developing a stereo digital camera (Veidere Design Model STH-MDCS-VAR) that will allow us to quantitatively determine 2-D seafloor roughness, as well as measure benthic megafauna. This camera will also be used in collaboration with the Open Ocean Aquaculture Program to measure fish length that can then be related to biomass in the offshore cages.

Rzhanov has continued the development and application of mosaicing algorithms including porting them to the Windows environment, developing algorithms for combining imagery in regions where there are sharp changes in depth, development of software for acquiring video imagery from a range of recording and playback devices, implementation of algorithms for camera calibration, image rectification, and several optimization approaches. Many of these new developments were tested when Rzhanov participated in an Alvin dive program to the East Pacific Rise on the Research Vessel Atlantis. During this cruise, Rzhanov generated dive video mosaics after each dive that were used for planning the next dive. Also for this cruise Rzhanov developed the "PatchMap" program that allows real-time control/assessment of photo coverage during a dive and off-line stitching of acquired imagery on the basis of the navigation provided. The mosaicing tools were also applied to video imagery of the *Titanic* collected by NOAA's Ocean Exploration Program.

Finally, Huff has continued the development of a Swath Video Camera system. The objective of this system is to increase the usable width of imagery acquired on any single pass of underwater video. The electronic components (embedded computer, and LED impulse drivers) have been built and bench tested. The housing arrived in February and was successfully tested, the machining of internal parts and the mounting brackets for the camera, electronics, LED's, batteries, and video recorder have also been completed.

We have begun to use the tools that we have developed for ground-truthing sonar data in support of seafloor characterization for serious studies of seafloor habitat. These studies include Randy Cutter's examination of the habitat of Portsmouth Harbor and Stellwagen Bank and Mashkoor Malik's efforts to analyze Reson 8101, 8125, EM1002, and Klein 5000 data from Jeffrey's Bank. The Jeffrey's Bank study is part of a major inter-disciplinary ecosystem level project funded by the Northeast Consortium and aimed at understanding the effectiveness of the Western Gulf of Maine Closure Area. The area targeted for this work encompasses both a closed area and an area still open to fishing. Mashkoor has been able to use our characterization and processing software tools to identify seven habitats in the Jeffreys Ledge area as well as the unequivocal identification of bottom fishing gear impacts – thought to be the result of scallop dredges. This study has established a detailed basemap for a critically important fisheries area; it will be resurveyed in the coming year to determine temporal changes.

Data Management:

With the arrival of Jim Case as our full-time data manager, we have begun a serious effort at organizing our data holdings and making them accessible both to internal and external users. Since his arrival Jim has evaluated the hardware and software data infrastructure at CCOM. A data management scheme has been designed and in support of this restructure two new data servers have been purchased. In concert with the data management restructuring, Case and Calder are working on a "Knowledge Repository" database concept that will attempt to capture "expert opinion" form CCOM domain experts on relevant information in any particular field. This effort is in its very early stages and will be reported on in more detail in subsequent progress reports.

In addition to the internal restructuring of our database, Calder and system manager Nathan Paquin have been working on developing a "Ship to Shore Newsgroup Server" for the Office of Coast Survey. They have identified technology to allow for newsgroup-based communication between ships and shore facilities and conducted trials of this technology at the Center using multiple servers to simulate two ships plus a shore facility. These trials included tests of security, reliability, access and control; a report has been submitted to HSTP for consideration for implementation in the NOAA fleet.

NEW PROJECTS:

The Center tries to be as responsive as possible to national needs and thus we begin new projects that go beyond the scope of our initial themes as the need demands. Several of these new efforts are currently underway:

Arctic Ocean bathymetry and Law of the Sea Issues:

Growing recognition that implementation of United Nations Convention on the Law of the Sea Article 76 could confer jurisdiction and management authority over large

(and potentially resource-rich) areas of the seabed beyond our current 200 nautical mile (nmi) limit has renewed interest in the potential for a U.S. claim. In this context, Congress (through NOAA) funded the University of New Hampshire's Joint Hydrographic Center to evaluate the content and completeness of the nation's bathymetric and geophysical data holdings in areas surrounding the nation's EEZ with emphasis on assuring their usefulness for substantiating the extension of resource or other national jurisdictions beyond the present 200 nmi limit. The initial portion of this complex study was carried out in less than 6 months and a report submitted to Congress on 31 May 2002 (http://www.ccom.unh.edu/unclos) .

Following up on the recommendations made in the UNH study, Congress funded the Center (through NOAA) to collect new multibeam sonar data in support of a potential claim under UNCLOS Article 76. In 2003, Center staff participated in two separate cruises to collect data in support of a potential law of the sea claim. For the first cruise, under the supervision of Dr. Jim Gardner, NOAA contracted with Thales GeoSolutions Inc. to perform the surveys of portions of Bowers Ridge and the Beringian margin that may be claimed for an extension of US territory and a second cruise focused on the high Arctic where permanent ice cover makes the collection of detailed bathymetry very difficult. In an effort to evaluate the feasibility of collecting Law of the Sea-relevant multibeam sonar data from a surface vessel in ice-covered areas, Center personnel collaborated with scientists from NOAA, NRL, The Arctic Submarine Lab, Denmark, and Sweden on a 10-day expedition aboard the U.S. Coast Guard Cutter *Healy*. We were able to collect more than 1500 nm of Seabeam 2112 multibeam sonar data and 3.5 kHz subbottom profiling data on the Northwind and Chukchi Plateau and Borderland demonstrating that critical bathymetric targets can be mapped even in 9/10's ice cover. The new data revealed a very complex and detailed structure of the 2500 m contour that will result in significant additions to a potential claim. The cruise also mapped numerous ice-grounding features (which are of great importance to models of past climate conditions) and discovered a new seamount (named HEALY Seamount), which rose from 4000 m depths to less than 900 m in an region that previously showed a simple 2000 m contour. Summaries of these cruises were presented in last year's progress report; more details can be found at http://www.ccom.unh.edu/unclos/html/index.htm .

This year we conducted two more Law of the Sea cruises, one off the east coast of the U.S and the other returning to the Chukchi Cap in the high Arctic. The survey work off the U.S. east coast took place on the NAVO vessel *USNS Henson,* a 329-ft, 5000 ton vessel equipped with a hull-mounted Kongsberg Simrad EM121A multibeam sonar, under the supervision of Dr. Jim Gardner. In addition to the multibeam sonar, the *Henson,* also carried an ODEC Bathy2000 3.5-kHz chirp sub-bottom profiler and a BGM-5 Bell Gravity Meter. The planned schedule for the cruise called for 3 legs of 30 days of operations and three port calls. NAVOCEANO was responsible for system calibration, data collection and quality control and overall cruise management whereas Science Applications International Corp. (SAIC) was contracted by NOAA to perform bathymetry processing aboard ship. The overall responsibility of cruise planning, both before and during the cruises, as well as processing MBES acoustic backscatter and 3.5-kHz profiler data were the responsibilities of the UNH/NOAA representative aboard ship.

The first leg of operations required a six-day, 3450 km, transit from Gulfport, MS to an area near the claimed US-Canadian maritime boundary. A patch test (exclusive of a

yaw calibration) was performed in this area and was followed by 17 days of progressively mapping the margin from north to south. Leg 1 of the survey was completed on September 19, 2004 and the ship transited to Newport, RI for re-supply and a crew change. The first leg collected 7899 line km of MBES and 3.5-kHz profiler lines. Leg 2 of the survey departed Newport, RI on September 24, 2004 and collected 10,397 line km of MBES and 3.5-kHz profiler lines before arriving at Little Creek, VA on October 22, 2004. Leg 3 departed Little Creek, VA on October 26, 2004 and collected 13,755 line km of MBES and 3.5-kHz profiles and arrived in Norfolk, VA on November 29, 2004, ending the cruise. The cruise mapped a total of ~130,000 km2 in 59.2 survey days, with an average speed of 13 kts. The remainder of the time was consumed by weather delays, port calls, transits, and evacuations.

Our second Law of the Sea cruise brought us back to the high Arctic on the icebreaker *Healy* to continue our mapping of the 2500 m contour on the Chukchi Cap. Unfortunately changes in the *Healy's* schedule shifted or cruise from the planned time slot of August/Sept to much later in the year (from October 6 to October 26). We departed from Nome, Alaska and returned to Barrow, Alaska, We used the *Healy's* hull-mounted Seabeam 2112 multibeam sonar and ODEC 3.5 kHz echo sounder to collect 6700 km of data in 20 days and completed most of the mapping of the 2500-m isobath (begun on HEALY 0304) as well as a detailed survey of the "foot of the slope" over a segment of the continental margin east of Barrow, AK. The cruise transited northward from Nome over the Northwind Ridge until it intersected the 2500-m isobath at approximately 77° 10'N, 154° W, the point where the 350 nmi cutoff limit from the coast of northern Alaska intersects the 2500-m isobath on the eastern flank of the Northwind Ridge. We first encountered ice at about 76°N and by 77°N the ice was very heavy (9/10 to 10/10) with many ridges and very few leads. Progress was slow and we often had to backup and ram but, nonetheless, we managed to continue mapping the 2500-m isobath up the Northwind Ridge until approximately 78° 45'N. During this time, we covered approximately 100 nmi in 4 days. Data was difficult to collect in these conditions but we were able to continuously map the 2500-m isobath to its furthest north point.

At 78° 45'N, the *HEALY* had great difficulty breaking through the ridges (one ridge took more than 8 hours to break through) and the decision was made to move south to the relatively ice-free waters of the continental slope east of Barrow. This area was chosen so that we could define the foot of the slope in the central portion of the northern Alaskan margin. The foot of the slope can be used in this region as a starting point for determination of the "Gardiner Line" – one of the formula lines used for making a claim under UNCLOS Article 76. The survey of the foot of the slope area began on October 18 and continued until October 24. During this time, complete overlapping multibeam-sonar data was collected over a region of approximately 325 sq. nmi, that ranges in water depth from 800 m to 3800 m. The survey not only delineated the foot of the slope, but it also revealed a complex margin with drift deposits, suggesting contour currents, that are cut by numerous canyons.

Details of both of these cruises can be found at:
http://www.ccom.unh.edu/unclos/html/index.htm

Electronic Chart of the Future:

In FY2003, we began our "Chart of the Future" an evolution of the Navigation Surface concept that also takes advantage of our expertise in visualization. We are taking a two-pronged approach at trying to define the electronic chart of the future. One track is an evolutionary approach to see how additional, non-standard layers (i.e. the navigation surface bathymetric grid, real-time tide information, etc.) can be added to existing electronic charts. This approach requires careful attention to present day standards and the very restrictive constraints of today's electronic charts. This work is being done in conjunction with the standards committees (represented by Center faculty member Lee Alexander) and the electronic chart manufacturers and is intended to provide short-term solutions for the need to see updated electronic charts. In concert with this evolutionary development we also have embarked on a revolutionary development with researchers in our Visualization Lab exploring new paradigms in electronic chart design, unconstrained by existing standards or concepts. This exercise is taking full advantage of the psychology-based human-computer interaction expertise of our visualization researchers to explore optimal designs for displays, the role of 3-D, flow-visualization, stereo, multiple windows, etc. From this research we hope to establish a new approach to electronic charts that will set the standards for the future. Throughout this project (both the evolutionary and revolutionary efforts) our experienced NOAA mariners are playing a key role, ensuring that everything that is developed will be useful and functional.

Within the context of the "evolutionary" approach Lee Alexander and Rick Brennan are working in collaboration with industrial consortium member 7C's and CARIS to investigate various tools and processing steps required to use the Navigation Surface database to produce a high-density bathymetric ENC.

A gridded test dataset has been compiled from existing and new hydrographic surveys of the Thimble Shoals Channel in the Port of Norfolk/Hampton Roads. This dataset will be used by *CARIS* and *SevenCs* to produce:

1) an ENC based on the current ENC Product Specification contained in IHO S-57 3.1.
2) a prototype, "next generation" ENC capable of dealing with x, y, z, and time

In addition to vector data, a high-resolution, gridded dataset will be produced. For both the vector and gridded data, various options will be investigated on the best means to integrate a tidal model. Rick Brennan's MS thesis research is investigating the use of the Tidal Constituent and Residual Interpolation (TCARI) model developed by Curt Hess of NOS-NOAA as a means to produce tidal estimates for electronic charts, Rick's efforts are focusing on Galveston Harbor which is better instrumented than Hampton Roads. Other efforts include investigating suitable means to provide time-varying information to underway vessels (e.g., via shore-based AIS transponders). When coupled with forecast or real-time information, these "next generation" ENC datasets can be used to display time-variant water levels, current flow, and other tactical or marine information object (MIO) information required for both display and decision-support. As agreed at the Nov 2004 IHO TSMAD meeting, high-resolution gridded data, 3-D bathymetry and time-varying data all will be accommodated in the 4th edition IHO Transfer Standard for Digital Hydrograhic Data (IHO S-57) planned for 2006.

Within the context of the "revolutionary" effort, Colin Ware, Matt Plumlee, Roland Arsenault and Matt Quinn have been extending the capabilities of GeoZui3D (as

described above) as well as developing specific applications for the chart of the future. The GeoZui3D version that has become the base for the Chart of the Future project is now called GeoNav3D. Specific additions include:

1. The implementation of segmented ("curved") image panels, which are used for 360° panoramic stills in GeoNav3D. These are circles of imagery constructed from a sequence of viewpoints along a channel. As the vessel progresses, the imagery from the panorama with the closest center is shown.

2. The implementation of a tide-application module that can be updated with tide-gauge information and calculates water-level offsets for tide-aware objects such as a bathymetric grid. Inputs can now be accepted in real time from a tide buoy.

3. The addition of support for sensor input over UDP, such as AIS and depth-sounders. This allows the chart of the future to be updated with and display real-time information about other vessels or the environment.

4. Added infrastructure to support "hover-queries"—information that pops up about an object near or under the mouse. This has been particularly useful for S57 objects, e.g., the interrogation of a buoy for its name and other information.

5. Many improvements of the displays and particularly the ability to link windows and choose what is or is not displayed.

6. In a separate (NSF and NOAA-funded) effort, Colin Ware and Matt Quinn are exploring new ways to visualize flows at various scales (harbors, estuaries, regions like Gulf of Maine, and global flow models). While this visualization capability has many applications, the incorporation of flow visualization into the Chart of the Future is a important goal.

As the Chart of the Future evolves we are beginning the demonstrate it to a range of mariners to gain feedback for its ultimate design. Rick Brennen has organized several meetings with pilots (Maryland and Virginia Harbor Pilots), the Coast Guard (two meetings with the navigation teams of the three U.S. Coast Guard vessels stationed in Portsmouth) that have provided useful suggestions for the evolution of the product. In addition both Larry Mayer and Colin Ware demonstrated prototypes to pilots in Sydney Australia and Andy Armstrong brought a prototype version on board a U.S. Navy vessel. In a more formal sense, Brianna Sullivan, has created a test and implemented programs that will be used to evaluate the use of color schemes in the Chart of the Future. Through feedback of this sort, we hope to produce a tool that will be a valuable navigational aid.

Partnerships and Ancillary Programs:

One of the goals of the JHC is, through its partner organization, the Center for Coastal and Ocean Mapping, to establish collaborative arrangements with private sector and other government organizations. Our involvement with Tyco has been instrumental in the University securing a 5 million dollar endowment; 1 million dollars of this endowment has been earmarked for support of post-doctoral fellows at the Center for Coastal and Ocean Mapping. Our interaction with the private sector has now been

formalized into an Industrial Associates Program. At present members of the Industrial Associates Program are:

C&C Technologies
CARIS Inc.
Interactive Visualization Systems Inc.
Klein Associates
Kongsberg Simrad
ODOM
Reson
SAIC
SevenC's
QPS
QinetiQ
Quester Tangent
Triton-Elics
Tyco

In addition, grants are in place with the Office of Naval Research, The Naval Research Lab, The Naval Oceanographic Office, IEEE, The National Science Foundation, Fugro, The Nippon Foundation, CICEET and the U.S. Geological Survey (see Appendix D). The USGS supports collaborative projects involving multibeam sonar mapping as well as a post-doctoral fellow at the Center. Funding beyond the this grant this past year is on the order of $1.64M from a total commitment from other sources of approximately $10.4M.

Appendix A:
Coastal Surveyor

R/V Coastal Surveyor - The Coastal Surveyor is a purpose built vessel designed specifically for coastal multibeam hydrography. It is integrated with a robust, motor-driven ram system that provides and ideal mount for a range of multibeam and other sonar systems. The vessel incorporates an active roll stabilization feature to limit vessel motions detrimental to multibeam operations.

Dimensions:	40’ x 12’ x 3.7’
USCG:	Designated Research Vessel, subchapter “C”
Flag:	U.S.
Registry:	U.S. Coastwise and Registry
Official Number:	999206
Tonnage:	16 GRT
	11 DWT
Lab space:	9’ x 11’
	6’ x 10’
Speed:	10 knots
Minimum speed for full roll stabilization:	5 knots
Minimum survey speed:	2.5 knots
Propulsion:	1 x Cat 3116; 205 shp cont.”A”; 2.57:1 reduction
Auxiliary:	1 x Isuzu/Lima 20 kw; 240/120 V; 60 Hz;
Power distribution:	38 ea. 115 volt receptacles
	2 ea. 230 volt receptacles
	1 ea. 12 volt receptacles
	7 ea. 24 volt receptacles
Fuel capacity:	400 gallons
Potable water:	60 U.S. gallons
Roll stabilization:	Niad 173 active fins
Loran:	Micrologic Mariner
DGPS:	Magellan 1200XL GPS w/ Magellan 19019 DBR
Magnetic compass:	Ritchie 5”
Fluxgate compass:	Robertson RFC 300
Radar:	Furuno 1930
Depth sounder:	Standard DS 50
Autopilot:	Robertson AP 300DL
VHF:	Standard Omni 25 watt
Side Band:	Sea 222
Cellular phone:	Motorola 5 watt
Air conditioning:	3 x 1.25 tons
Heating:	3 x 16,000 BTU
Weather Tolerance:	
Multibeam:	Beaufort 6; SS3
Sidescan:	Beaufort 5; SS2

Work completed on the COASTAL SURVEYOR this season included:

1. Improved line handling winch and blocks with safety release
2. Installation of Ethernet with 16 access points within vessel and wireless connection to shore
3. Improved safety equipment
    a. EPIRB
    b. VHF with DSC
4. Improved boat stabilization system

Major Projects on *Coastal Surveyor* in 2004+

1. Proposed Mussel Aqauculture Site Survey
2. Summer Hydro Field Camp
3. Seamanship Class
4. Ocean Measurements Class
5. Evaluation of Geoacoustics interferometric sidescan sonar
6. Chart of the Future test cruises
7. Video analysis or center of pitch motion

APPENDIX B:
Graduate Degrees in Ocean Mapping

The University of New Hampshire offers Ocean Mapping options on the Master of Science and Doctor of Philosophy degrees in Ocean Engineering and in Earth Sciences. These interdisciplinary degree programs are provided through the Center and the respective academic departments of the College of Engineering and Physical Sciences. The University has been awarded recognition as a *Category A* hydrographic education program by the International Federation of Surveyors (FIG)/International Hydrographic Organization (IHO).Requirements for the Ph.D. in Earth Sciences and Engineering are described in the respective sections of the UNH Graduate School catalog. M.S. degree requirements are described below.

Requirements for Master of Science in Ocean Engineering
Ocean Mapping Option

Core Requirements:	*Credit hours*
ESCI 858, Physical Oceanography	3
OE 990, 991, Ocean Engineering Seminar I, II	2
OE 810, Ocean Measurements Lab	4
OE 885, Underwater Acoustics	4
OE/ESCI 870 Introductory Hydrography	4
OE/ESCI 871 Geodesy and Geomatics	3
OE/ESCI 972, Hydrographic Field Course	4
Thesis - in addition to required coursework	6
At least 6 additional credits from the electives below:	
OE 854, Ocean Waves and Tides	4
ESCI 859, Geological Oceanography	4
ESCI 959, Data Analysis Methods in Ocean and Earth Sciences	4
OE 954, Ocean Waves and Tides II	4
OE/EE 985, Special Topic (Sonar Signal and Image Processing)	3
ESCI 907, Geostatistics	3
OE/ESCI 973, Seafloor Characterization	3
OE/CS 895, Special Topic (Interactive Data Visualization)	3
EOS 824, Introduction to Ocean Remote Sensing	3
NR 857, Photo Interpretation and Photogrammetry	4
NR 860 Geographic Information Systems in Natural Resources	4
OE 995, Graduate Special Topics	2 - 4
OE 998, Independent Study	1 - 4
Other related courses with approval	

Where a course of equivalent content has been successfully completed as an undergraduate, an approved elective may be substituted.

Requirements for Master of Science in Earth Sciences
Ocean Mapping option

Required:	*Credit Hours*
ESCI 858, Introductory Physical Oceanography	3
ESCI 859, Geological Oceanography	4
OE 810, Ocean Measurements Laboratory	4
ESCI/OE 870, Introductory Hydrography	3
ESCI/OE 871, Geodesy and Geomatics	3
ESCI /OE 972, Hydrographic Field Course	4
ESCI 997, 998, Seminar in Earth Sciences	1-2
Thesis - in addition to required coursework	6
At least 6 additional credits from the electives below:	
ESCI 907, Geostatistics	3
ESCI 8yy, Seafloor Characterization	4
EOS 854, Ocean Waves and Tides	4
OE 885, Underwater Acoustics	4
OE/CS 895, Special Topic (Interactive Data Visualization)	3
OE/EE 995, Special Topic (Sonar Signal and Image Processing)	3
NR 857, Photo Interpretation and Photogrammetry	4
NR 860, Geographic Information Systems in Natural Resources	4
ESCI 8??, Nearshore Processes	3 or 4
EOS 824, Introduction to Ocean Remote Sensing	3
ESCI 895, 896, Topics in Earth Sciences	1 - 4
ESCI 959, Data Analysis Methods in Ocean and Earth Sciences	4
ESCI 996, Advanced Topics in Earth Sciences	1 - 4

Where a course of equivalent content has been successfully completed as an undergraduate, an approved elective may be substituted.

Specific Coursework Required to Complete FIG/IHO Category A Certified Program
(Either Degree Option)

University Academic Courses:	*Credit Hours*
ESCI 858, Introductory Physical Oceanography	3
ESCI 859, Geological Oceanography	4
OE 990, 991, Ocean Engineering Seminar I, II	2
OE 810, Ocean Measurements Lab	4
OE/ESCI 870 Introductory Hydrography	3
OE/ESCI 871 Geodesy and Geomatics	3
OE/ESCI 972, Hydrographic Field Course	4

Non-credit classes:	*Classroom Hours*
CARIS HIPS-SIPS Training Course	40
U.S. Power Squadrons/Joint Hydrographic Center Seamanship Class*	20

*For students who have not completed NOAA (or equivalent national service) Officer Training Class

Coursework Required for the Graduate Certificate in Ocean Mapping

Program Requirements

A Graduate Certificate in Ocean Mapping is awarded for completion of three required courses and four elective courses.

Required Courses:		Credits
ESCI/OE 870	Introduction to Ocean Mapping	4
ESCI/OE 871	Geodesy and Geomatics	3
ESCI/OE 972	Hydrographic Field Course	4
Elective Courses:		
ESCI 907	Geostatistics	3
ESCI 973	Seafloor Characterization	3
EOS/OE 854	Ocean Waves and Tides	4
OE 810	Ocean Measurements Lab	4
OE 885	Underwater Acoustics	4
OE/CS 867	Data Visualization	3
OE	Special Topics	4
NR 857	Photo Interpretation and Photogrammetry	4
NR 860	GIS in Natural Resources	4
ESCI 895,896	Topics in Earth Sciences	1-4
ESCI 959	Data Analysis Methods in Ocean and ES	4
ESCI 995,996	Advanced Topics	1-4

Appendix C:

2004 Field Programs

Chart-of-the-Future: Images of the Approach to Portsmouth Harbor, 19 - 20 May, R/V Coastal Surveyor, collection of video for mosaics and still images for forward approaches for use in developing ideas for GeoNav3D, (Arsenault, Ware, Plumlee).

Whale Tagging, 5-17 July, R/V NOAA Ship Nancy Foster, Tagging humpback whales while tracking area vessels (Arsenault).

Jason II dock trials, 14-15 Oct, WHOI Docks. Testing GeoZui3D with Jason II (Arsenault).

HEALY0304, Nome, AK to Barrow, AK, 4 – 26 October (Calder, Mayer, Armstrong, Hall, Case, Malik, Gostnell, Coakley, Cisternelli, Fertin, Chayes, Arko).

Piscataqua habitat ground-truth video imaging,1-4 March, R/V Gulf Challenger. (Cutter, Ward).

WASSP sea tests in Portsmouth harbor, 12 Aug (de Moustier).

SAX04/RIPPLES DRI multibeam swath bathymetry survey offshore, Destin, FL. Aug 31-Sep 2 (Calder and de Moustier).

SAX04/RIPPLES DRI multibeam swath bathymetry survey offshore
Destin FL. Oct 25-29 (Kraft and de Moustier).

Little Bay – EM3002 Survey, 14-16 June, R/V Coastal Surveyor; Planned the survey areas, and suggested acquisition parameters (Fonseca). Alaskan Fjords- Newport Oregon to Kodiak, Alaska.

21 August - 23 September, R/V Maurice Ewing Cruise EW0408: Sedimentation, Paleoceanography, and Paleoclimatology of Southeast Alaska, (Mayer and Fonseca).

Atlantic margin Law of the Sea cruise HE-1-04, USNS Henson, August 23 to September 20 (Gardner).

Atlantic margin Law of the Sea cruise HE-3-04, USNS Henson, October 25 to November 29 (Gardner).

NOAA Support, March, R/V Gulf Challenger, Field Testing of Klein 5410 (Huff).

NOAA Support, 1 day in July, Field Testing of Klein 5410; R/V Little Bay (Huff)

ONR Geoclutter Program, Little Bay (Portsmouth, NH), 3-4 April, R/V Gulf Challenger, ISSAP probe measurements (Kraft and Fonseca).

Side-Scan Sonar, Klein 5000, June 23rd- 30th, R/V Little Bay, Dissertation Field Work, (Leo).

Little Bay Side-scan Sonar Survey, 8-11 August, R/V Little Bay; Quality control for dissertation work. Last phase of field work for the thesis project (Leo).

UNH, Hubbard camera video graphic survey Jeffrey's ledge, June – September, F/V Karen Lyn (Malik and Huff).

UNH, Benthos 3D side scan sonar mapping of Jeffrey's ledge, 11 September, R/V Gulf Challenger (Malik and Huff).

UNH , Jeffrey's Ledge , 5 , 9 , 18 , 19 , 24 June, F/V Karen Lyn , Bottom videography using Hubbard Camera and Benthos Mk II ROV (Malik and Huff).

Tidal Stations, 1-28 June, Various Small Craft, Tide station support for Great Bay surveys (McLeod).

Chart-of-the-Future: Panoramic Images of the Piscataqua near Portsmouth, 12 November, R/V Coastal Surveyor, demonstration of panoramic images and solicitation of feedback, (Plumlee, Ware, Brennan, Mayer, Smith).

ONR Mine Burial MVCO, 29 March – 10 April, Loughrea Scanner, Final Multi-beam survey of the Mine Burial Site before mine removal (Raymond, Glang).

Whale Tagging, 11-17 July, NOAA Ship Nancy Foster, Tagging humpback whales while tracking area vessels. Lead Scientist: David Wiley – Stellwagen Bank National Marine Sanctuary (Ware).

Jason II dock trials, 14-15 Oct, WHOI Docks. Testing GeoZui3D with Jason II
Lead Scientist – Louis Whitcombe – Johns Hopkins (Ware).

APPENDIX D: Other Funding

·ant Name	PI	Grantor	FY Award	Total Award	Length
3NT Solutions LLC	Ware		2,989	19,758	1 year
gital Seafloor Mapping 2	Mayer	USGS	-	4,693,730	5 years
ectronic Chart Initiative	Alexander	USACE	25,450	25,450	1 year
ectronic Charting	Alexander	OCS-NOAA	50,000	150,404	2 years
timation and Visualization of Seabed Integrity	Calder & Kraft	ONR	79,462	79,462	1 year
ıros Sonar	Rzhanov	FAROS	4,300	4,300	1 year
EBCO/Nippon Foundation	Mayer	NIPPON FOUNDATION	564,625	1,580,951	3 years *project*
eoclutter Program	Mayer	ONR	78,998	450,478	4 years
A Inland Electronic Chart	Alexander	USACE	-	31,068	1 year
urnal of Oceanic Engineering	de Moustier	IEEE	40,000	120,000	3 years
apping of Seafloor off MA	Mayer	USGS	-	182,800	5 years
ne Burial Program Website	Mayer	ONR	-	128,572	3 years
onitoring Marine Protected Areas	Langan & Mayer	CICEET	-	40,263	1 year
ultibeam Swath Bathymetry	de Moustier	SCRIPPS	-	20,088	1 year
avy Surface	Alexander	NAVOCEANO	-	49,640	1 year
R Collaborative Research	Ware	NSF	-	316,658	3 years
leoceanographic Record/Alaskan Fjords	Mayer	NSF	-	57,471	3 years
orting of Video Mosaicing Software	Mayer	USGS	10,000	10,000	1 year
pples DRI	Mayer	ONR	73,931	153,577	2 years
ore Deep Tow Data Processing	de Moustier	SCRIPPS	-	29,000	1 year
afloor Sounding in Polar	Mayer	NSF	-	17,939	1 year
oals Lidar Bottom Classification	Elston	FUGRO	50,000	50,000	1 year
ırvey of Mine Burial FY02 & FY03	Mayer	ONR	-	339,840	3 years
ırveying Midwater Fish	Mayer & Baldwin	NSF	-	342,946	3 years
st Long Range Side-Scan	Huff	NOAA	700,000	1,400,000	2 years *projec*
CO Endowment interest from perpetuity	N/A	TYCO	11,474	11,474	Perpetuity
SM-Navo EDIS Tech Adv	Alexander	University of Miss.	-	30,000	1 year
lume Search Sonar Signal Processing	de Moustier	SCRIPPS	30,000	30,000	1 year
GOMICA	Langan & Mayer	NOAA	9,317	9,317	1 year
GOMICA subcontract	Langan & Mayer	NOAA	40,000	40,000	1 year
			$ 1,637,807	$ 10,415,186	

APPENDIX E: Visitors January 1, 2004- December 31, 2004

Name	**Date**	**From**	**Visiting**	**Purpose of Visit**
Name	Date	From	Visiting	Purpose
C. Dundorff	1/7/2004	Klein Associates	L Huff, J. Glynn	Klein 5410 Calibration
J. Backman	1/23/2004	Stockholm University	L Mayer, Calder	CCOM/JHC, Artic
B. Key	2/18/2004	Klein L3/Seabeam	CCOM/JHC	Seabeam status
P. Runciman	2/18/2004	Klein L3/Seabeam	CCOM/JHC	Seabeam status
R. Schrieber	2/18/2004	Elac	CCOM/JHC	Seabeam status
P. Gimpel	2/18/2004	Elac	CCOM/JHC	Seabeam status
Q. Congdon	2/27/2004	US Army	CCOM/JHC	ARDA Meeting->GI2-VIS
R. Rohrer	2/27/2004	NSA	CCOM/JHC	ARDA Meeting->GI2-VIS
A. Landvoigt	2/27/2004	NSA	CCOM/JHC	ARDA Meeting->GI2-VIS
B. Mackiewicz	2/27/2004	BBN	CCOM/JHC	ARDA Meeting->GI2-VIS
M. Walczak	2/27/2004	BBN	CCOM/JHC	ARDA Meeting->GI2-VIS
R. Bobrow	2/27/2004	BBN	CCOM/JHC	ARDA Meeting->GI2-VIS
J. Prange	2/27/2004	ARDA	CCOM/JHC	ARDA Meeting->GI2-VIS
C. C. Ware	2/27/2004	CCOM/JHC	CCOM/JHC	ARDA Meeting->GI2-VIS
P. Mathous	2/27/2004	ARDA	CCOM/JHC	ARDA Meeting->GI2-VIS
J. Dale	2/27/2004	NGA	CCOM/JHC	ARDA Meeting->GI2-VIS
S. Carroll	2/27/2004	NGA	CCOM/JHC	ARDA Meeting->GI2-VIS
N. Gershon	2/27/2004	MITRE	CCOM/JHC	ARDA Meeting->GI2-VIS
R. Pickett	2/27/2004	UML IVPR	CCOM/JHC	ARDA Meeting->GI2-VIS
D. MachPherson	3/9/2004	HydroComp Inc.	M.M. Plumlee	Explore vessel modelling for Chart-of-the-Future
H. Pelletier	3/9/2004	IXSEA	CCOM/JHC	PHINS OCTANS
P. Igo	3/9/2004	Electronic Sales of New England	CCOM/JHC	PHINS OCTANS
B. Key	3/9/2004	L3-Seabeam-Klein	J. Gardner	Discuss calibrated acoustic backscatter
P. Runciman	3/9/2004	L3-Seabeam-Klein	J. Gardner	Discuss calibrated acoustic backscatter
J. Gardner	3/24/2004	NRL	L Mayer, B. Calder	CCOM/JHC, CUBE, Visualization
C. Nishimora	3/24/2004	NRL	L Mayer, B. Calder	CCOM/JHC, CUBE, Visualization
M. Czarnicki	3/24/2004	NRL	L Mayer, B. Calder	CCOM/JHC, CUBE, Visualization
G. Kozak	3/25/2004	Klein Associates	CCOM/JHC	Visiting Andy Armstrong
D. Fitzgerald	3/29/2004	Boston University	CCOM/JHC	Coastal Mapping
S. Shor	4/5/2004	NSF	L Mayer, C.de Moustier	Marine Mammal Issues
J. Frietag	4/5/2004	ONR	L Mayer, C.de Moustier	Marine Mammal Issues
W. Clifton	4/7/2004	Underwood Engineering	L Mayer, B.Calder	Bathymetry from Portsmouth Harbor
G. Newton	4/10/2024	US Arctic Research Committee	D. Monahan	
A. Silver	5/6/2004	NAVSEA	CCOM/JHC	Underkeel Clearance Protection

P. Kopp	5/6/2004	NAVSEA	CCOM/JHC	Underkeel Clearance Protection
A. Silver	5/7/2004	NAVSEA	M. Plumlee, Brennan, C. Ware, Arsenault	Vessel modeling prospects for Chart-of-the-Future
P. Kopp	5/7/2004	NAVSEA	M. Plumlee, R. Brennan, C. Ware, R. Arsenault	Vessel modeling prospects for Chart-of-the-Future
T. Uozumi	5/29/2004	NOAA Atlantic Hyrdro Branch	G. Glang	MVCO KGPS Work-Assist with equipment configuration and installation
D. Laidlaw	7/26/2004	Brown University	C. Ware	Flow Visualization
P. Noonan	7/28/2004	National Instruments	A. McLeod	LabView
S. Byrne	8/13/2004	SIAC	J. Gardner	visiting James Gardner
R. Evans	8/13/2004	SAIC	J. Gardner	visiting James Gardner
D. Lockhart	8/18/2004	Fugro	J. Gardner	visiting James Gardner
D. Brunt	8/23-24/2004	Candian Hydrographic Services	CCOM/JHC	ENC-DNC Evaluation Test Plan Meeting
M. Casey	8/23-24/2004	IIC Technologies	CCOM/JHC	ENC-DNC Evaluation Test Plan Meeting
J. Conyon	8/23-24/2004	IIC Technologies	CCOM/JHC	ENC-DNC Evaluation Test Plan Meeting
J. Box	8/23-24/2004	ICAN	CCOM/JHC	ENC-DNC Evaluation Test Plan Meeting
D. Roman	8/23-24/2004	Univ. of S. Mississippi	CCOM/JHC	ENC-DNC Evaluation Test Plan Meeting
C. Winn	8/23-24/2004	MCD-OCS, NOAA	CCOM/JHC	ENC-DNC Evaluation Test Plan Meeting
B. Posage	8/24/2004	USCG RDC	CCOM/JHC	Underwater Security Project meeting
R. Hansen	8/24/2004	USCG RDC	CCOM/JHC	Underwater Security Project meeting
B. Calder	8/24/2004	UNH	CCOM/JHC	Underwater Security Project meeting
T. Bellinger	8/24/2004	TSWG (wintec)	CCOM/JHC	Underwater Security Project meeting
G. Glang	8/24/2004	NOAA Coast Survey	CCOM/JHC	Underwater Security Project meeting
S. Barnum	8/24/2004	NOAA Coast Survey	CCOM/JHC	Underwater Security Project meeting
T. Robrecht	8/26/2004	ColBond	A. McLeod	Wave Tank Beach
A. Buchanan	9/10/2004	USCG	CCOM/JHC	USCG Reliance
D. Lounsbury	9/10/2004	USCG	CCOM/JHC	USCG Reliance
B. Davis	9/10/2004	USCG	CCOM/JHC	USCG Reliance
J. Rice	9/10/2204	USCG	CCOM/JHC	USCG Reliance
S. Spotts	9/10/2004	USCG	CCOM/JHC	USCG Reliance
R. Shaye	9/10/2004	USCG	CCOM/JHC	USCG Reliance
Rooney	9/10/2004	USCG	CCOM/JHC	USCG Reliance
Kennedy	9/10/2004	USCG	CCOM/JHC	USCG Reliance
D. Dilulio	9/10/2004	USCG	CCOM/JHC	USCG Reliance
H. Woodsum	9/14-15/2004	Sonetech	A. McLeod	Parametric Sonar
J. Laves	9/14-15/2004	NuvoSonic	A. McLeod	Parametric Sonar
L. Petze	9/15-17/2004	NOS/OCS CIO	CCOM/JHC	CCOM/JHC tour
G. Lebrun	9/28/2004	TMQ	CCOM/JHC	Exchange presentations on research projects
J. Cormier	9/28/2004	CHS-Quebec	CCOM/JHC	Exchange presentations on research projects
G. Ringuette	9/28/2004	CCG-Quebec	CCOM/JHC	Exchange presentations on research projects
A. Langevin	9/28/2004	Innovation Maritime	CCOM/JHC	Exchange presentations on research projects
J. Lacroix	9/28/2004	CIDCO	CCOM/JHC	Exchange presentations on research projects
L. Maltais	9/28/2004	CHS-Quebec	CCOM/JHC	Exchange presentations on research projects
R. Caughie	9/28/2004	Seaquest Tech.	CCOM/JHC	Exchange presentations on research projects
A. Paradis	9/28/2004	Seaquest Tech.	CCOM/JHC	Exchange presentations on research projects

M. Levesque	9/28/2004	CIDCO	CCOM/JHC	Exchange presentations on research projects
J. Benyo	10/5-10/8/2004	IFSMA	CCOM/JHC	IEC TC80/WG13-10 Meeting
D. Blevins	10/5-10/8/2004	Sperry Marine	CCOM/JHC	IEC TC80/WG13-10 Meeting
J. Brandon	10/5-10/8/2004	DCS Corporation	CCOM/JHC	IEC TC80/WG13-10 Meeting
A. Deverre	10/5-10/8/2004	SODENA	CCOM/JHC	IEC TC80/WG13-10 Meeting
G. Diotalevi	10/5-10/8/2004	USCF NAVCEN	CCOM/JHC	IEC TC80/WG13-10 Meeting
J. Earthy	10/5-10/8/2004	Lloyd's Registry	CCOM/JHC	IEC TC80/WG13-10 Meeting
B. Feather	10/5-10/8/2004	The Skip'r	CCOM/JHC	IEC TC80/WG13-10 Meeting
K. Fisher	10/5-10/8/2004	MCA UK	CCOM/JHC	IEC TC80/WG13-10 Meeting
S. Freeman	10/5-10/8/2004	USCG C2CEN	CCOM/JHC	IEC TC80/WG13-10 Meeting
D. Hannah	10/5-10/8/2004	Kelvin Hughes	CCOM/JHC	IEC TC80/WG13-10 Meeting
B. Lamb	10/5-10/8/2004	IFSMA	CCOM/JHC	IEC TC80/WG13-10 Meeting
H. Lindley	10/5-10/8/2004	Swedish Maritime	CCOM/JHC	IEC TC80/WG13-10 Meeting
D. Mades	10/5-10/8/2004	USCG Headquarters	CCOM/JHC	IEC TC80/WG13-10 Meeting
F. Motz	10/5-10/8/2004	FGSN-FKIE	CCOM/JHC	IEC TC80/WG13-10 Meeting
F. Pot	10/5-10/8/2004	UAIS.org	CCOM/JHC	IEC TC80/WG13-10 Meeting
H. Ramsvik	10/5-10/8/2004	DnV	CCOM/JHC	IEC TC80/WG13-10 Meeting
J. Ryan	10/5-10/8/2004	The Skip'r	CCOM/JHC	IEC TC80/WG13-10 Meeting
Y. Takamasa	10/5-10/8/2004	OKI, Ltd.	CCOM/JHC	IEC TC80/WG13-10 Meeting
J. Takita	10/5-10/8/2004	JRC	CCOM/JHC	IEC TC80/WG13-10 Meeting
E. Thelin	10/5-10/8/2004	USCG C2CEN	CCOM/JHC	IEC TC80/WG13-10 Meeting
A. Vorobiev	10/5-10/8/2004	Tranas Marine	CCOM/JHC	IEC TC80/WG13-10 Meeting
L. Greenberg	10/13/2004	Northup-Grumman	CCOM/JHC	CCOM/JHC presentation
G. Hoffman	10/13/2004	Skylet	CCOM/JHC	CCOM/JHC presentation
H. Woodsum	10/25-27-2004	Sonetech	A. McLeod	Parametric Sonar
J. Laves	10/25-27/2004	NuvoSonic	A. McLeod	Parametric Sonar
E. Wendlandt	10/5-10/8/2004	USCG Headquarters	CCOM/JHC	IEC TC80/WG13-10 Meeting
M. Cormier	11/9/2004	Lamont Doherty Earth Observatory of Columbia University	D. Monahan	GEBCO lecture
J. Seinkiewicz	11/9/2004	Ocean Prediction Center of NOAA Nat. Weather Serv.	CCOM/JHC	Guest lecturere in CCOM/JHC/JHC's Basic seamanship class
H. Woodsum	11/12/2004	Sonetech	A. McLeod	Parametric Sonar
H. Singh	11/23/2004	WHOI	C. Ware	AUV Planning interface
J. Laves	11/12/2004	NuvoSonic	A. McLeod	Parametric Sonar
G. Glang	12/8/2004	NOAA	C. Ware	Visualization and planning interface for Remus
D. Pritchard	12/8/2004	NOAA	C. Ware	Visualization and planning interface for Remus
R. Fletcher	12/9/2004		CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
C. Sabo	12/9/2004		CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
R. Morton	12/9/2004		CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125

S. Barnum	12/9/2004	NOAA Coast Survey	CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
H. Orlinsky	12/9/2004		CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
D. Pritchard	12/9/2004		CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
M. Kenny	12/9/2004		CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
G. Glang	12/9/2004	NOAA Coast Survey	CCOM/JHC	meeting discussing integration of the Klein 5000 side scanand the Reson 8125
M. Doucet	12/9/2004	Triton Watsonville CA	G. Glang	Meeting on issues concerning NOAA's new Navigational Response Team boat
J. White	12/9/2004	Triton Watsonville CA	G. Glang	Meeting on issues concerning NOAA's new Navigational Response Team boat
A. Armstrong	12/9-10/2004	NOAA Coast Survey	CCOM/JHC	Presentation on Pourquoi-Pas & Beautemps-Beaupre vessels
X. Lurton	12/9-10/2004	Ifemer & SHOM	CCOM/JHC	Presentation on Pourquoi-Pas & Beautemps-Beaupre vessels
H. Biscay	12/9-10/2004	Ifemer & SHOM	CCOM/JHC	Presentation on Pourquoi-Pas & Beautemps-Beaupre vessels
H. Floch	12/9-10/2004	Ifemer & SHOM	CCOM/JHC	Presentation on Pourquoi-Pas & Beautemps-Beaupre vessels
R. Falconer	12/9-10/2004	Institute of Geological and Nuclear Sciences, NZ	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
W. Smith	12/9-10/2004	Satellite Bathymetry and GMT fame	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
B. Anderson	12/9-10/2004	SAIC	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
H. Werner Schenke	12/9-10/2004	Alfred Wgner Institute	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
M. Jakkobsen	12/9-10/2004	Univ. Of Sweden	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
M. Loughridge	12/9-10/2004	recent director of NGDC	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
B. Whitmarsh	12/9-10/2004	Southampton Oceanography Centre, UK	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
E. Nielson	12/14/2004	Marine Docent	D. Monahan	Briefing
J. Frias	12/9-10/2004	Hydo. Service of Mexico	CCOM/JHC	Meeting of the Project Management Committee, GEBCO
D. House	12/10/2004	Texas A&M University	C. Ware	Visualizing surfaces
R. McConnoughney	12/15/2004	NMFS Alaska Fishery Research Center Seattle WA	L Huff	Discuss the on going collaborative efforts with CCOM/JHC
A. Bilgili	12/16/2004	Dartmouth	C. Ware	Flow VIS tools
B. Woodward	12/16/2004	University of Main	R. Arsenault, C. Ware	Using GeoZui3D for DTAG data visualization
A. Stimpert	12/20-21/2004	University of Hawaii	R. Arsenault, C. Ware	Using GeoZui3D for DTAG data visualization
J. Moller	12/20-21/2004	Stellwagon Bank NMS	R. Arsenault, C. Ware	Using GeoZui3D for DTAG data visualization

Appendix F:

Papers, Books, Conference Proceedings, Abstracts, Thesis, Reports and Talks
From January 2004 to December 2004

Peer- Reviewed Publications:

Alexander, L., 2004, Revival of ECDIS?: Hydro International, v. 8, p. 34-35.

Arsenault, R., and Ware, C., 2004, The Importance of Stereo, Eye Coupled Perspective and Touch for Eye Hand Coordination: Presence, v. 13, p. 549-559.

Bohannon, R. G., and Gardner, J. V., 2004, Submarine landslides of San Pedro Escarpment, southwest of Long Beach, CA: Marine Geology, v. 203, p. 261-268.

Calder, B. R., and Smith, S. M., 2004, A Time Comparison of Computer-Assisted and Manual Bathymetric Processing: Int. Hydro. Review, v. 5, p. 10-23.

Dartnell, P., and Gardner, J. V., 2004, Predicting seafloor facies from multibeam bathymetry and backscatter data: Photogrammetric Engineering and Remote Sensing, v. 70, p. 1081-1091.

Doerner, R., and Ware, C., 2004, Visual Interactive Stimuli Techniques: Exploring Data Using Behavioral Animation: Journal of Visual Languages and Computing, v. 15, p. 161-181.

Elston, G. R., and Bell, J. M., 2004, Pseudospectral time-domain modeling of non-Rayleigh reverberation: synthesis and statistical analysis of a sidescan sonar image of sand ripples: IEEE Journal of Oceanic Engineering, v. 29, p. 317-329.

Gardner, J. V., Dartnell, P., Mayer, L. A., Hughes Clarke, J. E., Calder, B. R., and Duffy, G., 2004, Drowned barrier-island complexes and shelf-edge deltas on the northwest Florida outer continental self: Geomorphology, v. 64, p. 133-166.

Goff, J. A., Kraft, B. J., Mayer, L. A., Schock, S. G., Sommerfield, C. K., Olson, H. C., Gulick, S. P., and Nordfjord, S., 2004, Seabed characterization on the New Jersey middle and outer shelf: Correlability and spatial variably of seafloor sediment properties: Marine Geology, v. 209, p. 147-172.

Hare, R., Calder, B. R., Alexander, L., and Sebastian, S., 2004, Multi-beam Error Management: New Data Processing Trends in Hydrography: Hydro International, v. 8, p. 6-9.

Komerska, R., and Ware, C., 2004, Haptic state-surface interactions: IEEE Computer Graphics and Applications, p. 52-59.

Mayer, L. A., Calder, B. R., Schimidt, J., and Malzone, C., 2004, Exploring the third dimension: high-resolution multibeam sonar as a tool for archaeological investigations-example from the D-Day beaches of Normandy, in Akal, T., Ballard, R. D., and Bass, G. F., eds., The Application of Recent Advances in Underwater Detection and Survey Techniques to Underwater Archaeology, Bodrum, Turkey, Institute of Nautical Archaeology Press, p. 70-79.

Mayer, L. A., Jakobsson, M., and Armstrong, A. A., 2004, Evaluating U.S. data holdings relevant to the definition of continental shelf limits, in Nordquist, M., Moore, J. N., and Heider, T., eds., Legal and Scientific Aspects of Continental Shelf Limits, Leiden, Netherlands, Brill Academic Publishers, p. 313-330.

Monahan, D., 2004, GEBCO: the second century. Looking towards a general bathymetric chart: Hydro International, v. 8, p. 45-47.

Monahan, D., 2004, Determination of the Foot of the Continental Slope as the Point of Maximum Change in the Gradient at Its Base: Legal and Scientific Aspects of Continental Shelf Limits, p. 91-120.

Motz, F., Widdel, H., Oei, P., Mackinnon, S., Patterson, A., and Alexander, L., 2004, Investigations for Ergonomic Presentation of AIS Symbols for ECDIS: International Hydrographic Review, v. 5, p. 26-36.

Ware, C., and Bohannon, R. G., 2004, Motion to support rapid interactive queries on Node-Link diagrams. ACM Transactions on Applied Perception, v. 1, p. 1-15.

Books or Book Chapters:

Hinckley, K., Jacob, R. J. K., and Ware, C., 2004, Input/output Devices and Interaction Techniques, Alan Tucker Ed. The Computer Science and Engineering Handbook, CRC Press and ACM.

Ware, C., 2004, Information Visualization: Perception for Design: San Francisco, Morgan Kaufman, 485 p.

Conference Proceedings:

Alexander, L., Ryan, J. F., and Casey, M. J., 2004, Integrated Navigation System: Not a Sum of its Parts: Canadian Hydrographic Conference.

Arsenault, R., Ware, C., Plumlee, M., Martin, S., Whitcombe, L. L., Wiley, D., Gross, T., and Bilgili, A., 2004, A system for visualizing time-varying oceanographic 3D data: Oceans'04.

Calder, B. R., 2004, CUBE and Navigation Surface: New Approaches for Hydrographic Data Processing and Management: NAVO South American Capability Building Workshop "Beyond Safety of Navigation".

Calder, B. R., 2004, Tackling Modern Multibeam Data with CUBE: CARIS 2004 "Where Waterways Meet".

Calder, B. R., 2004, On the Uncertainty of Archive Hydrographic Datasets: Canadian Hydro. Conf.

Calder, B. R., Kraft, B. J., de Moustier, C. P., Lewis, J., and Stein, P., 2004, Model-based Refraction Correction in Intermediate Depth Multibeam Echosounder Survey: Underwater Acoustics, p. 795-800.

Claesson, S., Huff, L. C., and Jakobsson, M., 2004, Mapping Paleo-Coastlines and Cultural Resources in Boston Harbor, MA: Society for American Archeology 69th Annual Meeting.

Cormier, M. H., de Moustier, C. P., Hall, J. K., Mayer, L. A., Monahan, D., and Vogt, P., 2004, The Global Ocean Mapping Project (GOMap): Promoting international collaboration for a systematic, high-resolution mapping of the world's oceans: International Geological Conference.

Cutter Jr., G. R., 2004, Descriptions of seafloor roughness from sediment profile images: Sediment Profile Imagery Colloquium of Experts (SPICE).

Cutter Jr., G. R., 2004, Benthic Habitat Characterization of the Lower Piscataqua River Estuary: Capacity Development Workshop on Acoustic Techniques in Seabed Assessment.

Dijkstra, S. J., and Elston, G. R., 2004, Bottom Segmentation and Classification Using Expectation-Maximization Clustering Methods on SHOALS Data: ASPRS -Annual Conference and Technology Exhibition.

Dijkstra, S. J., 2004, Robust Characterization of SHOALS Lidar Signals for Bottom Segmentation and Classification: A Combined Parameter-Estimation and Curve Fitting approach: ASPRS - Annual Conference and Technology Exhibition.

Dijkstra, S. J., 2004, Quantitative Inter-Channel Calibration of SHOALS Signals for Consistent Bottom Segmentation and Characterization: ASPRS - Annual Conference and Technology Exhibition.

Elston, G. R., and Dijkstra, S. J., 2004, Waveform characterization, clustering and segmentation of SHOALS: 5th Annual JALBTCX Coastal Mapping and Charting Workshop.

Gardner, J. V., 2004, Geology of outer continental Shelf, Northern Gulf of Mexico: UNJR.

Gardner, J. V., 2004, Visualizing the Marine Geology off Southern California: NE Section Meeting, Geological Society of America.

Hou, T., and Huff, L., 2004, Seabed Characterization Using Normalized Backscatter Data by Best Estimated Grazing Angles: International Symposium on Underwater Technology, p. 153-160.

Kraft, B. J., and de Moustier, C. P., 2004, Variable bandwidth filter for multibeam echosounding bottom detection: Oceans '04 MTS/IEEE Techno-Ocean '04, p. 1154-1158.

Lanziner, H. H., and Alexander, L., 2004, Inland ECS: More than just ECDIS in Montreal Canada: RTCM Annual Assembly Meeting.

Lanziner, H. H., Alexander, L., Ringuette, G., and Virnot, A. D., 2004, Automatic Radar Positioning as a Backup to DGPS: RTCM Annual Assembly Meeting.

Le, N., Pochec, P. R., and Ware, C., 2004, Enhanced stereoscopic imaging: IASTED.

Plumlee, M., Arsenault, R., Brennan, R., and Ware, C., 2004, The CCOM Chart of the Future Project: Maximizing Mariner Effectiveness through Fusion of Marine & Visualization Technologies: 7th Marine Transportation System Research and Technology Coordination Conference.

Rzhanov, Y., Mayer, L. A., and Fornari, D., 2004, Deep-sea image processing: Oceans' 04, p. 647-652.

Zoksimovski, A., and de Moustier, C. P., 2004, Detection of direct-path arrivals for multi-narrowband sequences (3-30kHz) in shallow water: HF Ocean Acoustics, p. 8.

Conference Proceedings (Abstracts):

Brandsdottir, B., Richter, B., Riedel, C., Dahm, T., Helgadottir, G., Kjartansson, E., Dertick, R., Magnusson, A., Asgrimsson, A. L., Palsson, B. H., Karson, J., S'mundsson, K., Mayer, L. A., Calder, B. R., and Dricoll, N., 2004, Tectonic Details of the Tjornes Fracture Zone, an Onshore-Offshore Ridge-Transform in N-Iceland, EOS Trans. **Abstract**: T41A-1172

Brogan, D. S., and de Moustier, C. P., 2004, Bathymetry and seafloor acoustic backscatter imagery with a volume search sonar, J. Acoust. Soc. Am., p. 2547.

de Moustier, C. P., Brogan, D. S., and Schimel, A., 2004, Calibrated seafloor acoustic backscatter imagery with a 160 khz multibeam sonar, J. Acoust. Soc. Am., p. 2, 2576.

Finney, B. P., Jaeger, J. M., Mix, A. C., Cowan, E. A., Gulick, S. S., Mayer, L. A., Pisias, N. G., Powell, R. D., Prahl, F., and Stoner, J. S., 2004, High-Resolution Holocene Records of Paleoceanographic and Paleoclimatic Variability from the Southern Alaskan Continental Margin, EOS Trans. **Abstract**: 0S52A-04

Fonseca, L. E. N., Mayer, L. A., Kraft, B. J., Brandsdottir, B., and Richter, B., 2004, AVO Analysis of Multibeam Backscatter, an example from Little Bay, NH and Skjalfandi Bay, Iceland., EOS Trans.

Gulik, S. S., Powell, R. D., Jaeger, J. M., Cowan, E. A., Mayer, L. A., Mix, A. C., Finney, B. P., Pisias, N. G., Prahl, F., and Stoner, J. S., 2004, Glacial Advances and Retreats in Tectonic Southeast Alaska During the Little Ice Age and Last Glacial Maximum: Preliminary Results from EW0408., EOS Trans. **Abstract**: H51A-1099

Kraft, B. J., Fonseca, L. E. N., Mayer, L. A., McGillicuddy, G., Ressler, J., Henderson, J., and Simpkin, P., 2004, In-situ measurement of sediment acoustic properties and relationship to multibeam backscatter, J. Acoust. Soc. Am., p. 2401.

Mayer, L. A., Rzhanov, R., Fornari, D. J., Soule, A., Shank, T. M., Beaulieu, S. E., Schouten, H., and Tivey, M., 2004, Mosaicking Techniques for Deep Submergence Vehicle Video Imagery - Applications to Ridge2000 Science, EOS Trans. **Abstract**: B13A-0163

Reports:

Alexander, L., The Next Edition of IHO-S-57 (4.0), International Hydrographic Bureau, Monaco, 2004.

Alexander, L., Hydrographic Interoperability Workshop, pp. 11, Ottawa, Ontario, CANADA, 2004.

Alexander, L., Activities of IHO-IEC Harmonization Group on Marine Information Objects (HGMIO), 16th IHO CHRIS Meeting, 2004.

Alexander, L., Inland ECDIS Development and Standardization., pp. 4, 16th IHO CHRIS Meeting, 2004.

Alexander, L., Open ECDIS Forum (OEF) Activities, pp. 2, 16th IHO CHRIS Meeting, 2004.

Calder, B.R., Digital Security in the Open Navigation Surface Model, pp. 12pp, University of New Hampshire, Center for Coastal and Ocean Mapping, Joint Hydrographic Center, Durham, NH, 2004.

Calder, B.R., PHB Evaluation Report on CUBE/Navigation Surface, Snow Passage, Memo for NOS, pp. 4, University of New Hampshire, Center for Coastal and Ocean Mapping-Joint Hydrographic Center, Durham, NH, 2004.

Calder, B.R., B.J. Kraft, and L.A. Mayer, Estimation and Visualization of Seafloor uncertainty-Annual Report, University of New Hampshire, Center for Coastal and Ocean Mapping-Joint Hydrographic Center, Durham, NH, 2004.

Dartnell, P., P. Barnes, J.V. Gardner, and K. Lee, Visualizing the geology of lake trout spawning sites: northern Lake Michigan, edited by S. I-2800, U.S. Geological Survey Geologic Investigations, 2004.

Dartnell, P., and J.V. Gardner, Predicted seafloor facies of central Santa Monica Bay, California., US Geological Survey Open-File Report 2004-1081, 2004.

Dartnell, P., J.V. Gardner, L.A. Mayer, and J.E. Hughes Clarke, Los Angeles and San Diego margin high-resolution multibeam bathymetry and backscatter data, U.S. Geological Survey Open-File Report 2004-1221, 2004.

Elston, G.R., International Lidar Mapping Forum ILMF, pp. 6, Orlando, FL, 2004.
Mayer, L.A., and B.R. Calder, Bathymetric Uncertainty Assessment, ONR Capturing Uncertainty DRI Final Review, 2004.

Mayer, L.A., B.J. Kraft, and L.E.N. Fonseca, Measurement of in situ acoustic properties for the ONR Geoclutter program, University of New Hampshire, Center for Coastal and Ocean Mapping-Joint Hydrographic Center, Durham, NH, 2004.

Motz, F., H. Widdel, P. Oei, S. Mackinnon, A. Patterson, M. Baldauf, and L. Alexander, Investigations for Ergonomic Design of AIS Symbols for ECDIS, FKIE, Watchtberg, Germany, 2004.

Paquin, N., and B.R. Calder, DNews Configuration for Private Ship to Shore Usenet Communication, pp. 21, CCOM/JHC Report (for NOAA OCS HSTP), Durham, New Hampshire, 2004.

Thesis

Brogan, D. S., 2004, Narrow-Beam Monopulse Technique for Bathymetry and Seafloor Acoustic Backscatter Imagery with a volume Search Sonar: Unpub. Master of Science thesis, University of New Hampshire 228 p.

Plumlee, M. D., 2004, Linking Focus and Context in 3D Multiscale Environments: Unpub. Doctor of Philosophy thesis, University of New Hampshire 195 p.

Sullivan, B., 2004, Linking Audio And Visual Information While Navigating In A Virtual Reality Kiosk Display: Unpub. Master of Science thesis, University of New Hampshire 85 p.

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Alexander, L., Navigation Surface to the "Next Generation ENC". Seminar presentation at Maurice Lamontagne Institute, Mont Joli, Quebec, 22 April 2004.

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Alexander, L., Next Generation ENC: Challenges and Opportunities", Seminar presented at University of New Brunswick, Fredericton, NB, 3-4 November 2004.

Calder, B. R., NOAA Pacific Hydrographic Center, Seattle, WA. "New Methods in High-Resolution Multibeam Bathymetry", 12 January 2004.

Calder, B. R., NOAA Headquarters, Silver Spring, MD. , Reinventing Ourselves...Carefully. 26 March 2004.

Calder, B. R., Canadian Hydrographic Conference/Int. Discussion Group on Quality Assurance in Hydrography, Ottawa, Ontario. "CUBE: Explained", 24 May 2004.

Calder, B. R., Australian Coastal Research Center Capability Building Workshop, "Processing for Multibeam Data", 28 May 2004.

Calder, B. R., CUBE and Navigation Surface, CIDCO (Centre Interdisciplinaire de Dévelopment en Cartographie des Océans) and CHS Rimouski (L. Alexander) Seminar, CCOM/JHC, Durham, NH, September 2004.

Cutter Jr., G. R., Seafloor roughness from sediment profile imagery (SPI) and images from the Piscataqua River. UNH CCOM/JHC Ocean Mapping, 26 March 2004.

de Moustier, C. P., Acoustic imagery derived from multibeam echo-sounders Australian Delegation visit to CCOM/JHC, 29 May 2004.

de Moustier, C. P., Acoustic of swath bathymetry: angle of arrival vs. beam angle Seventh European Conf. Underwater Acoustics, ECUA2004, Delft NL, 5 July 2004.

de Moustier, C. P., Sonar system capabilities and limitations
Office of Coast Survey – CCOM/JHC Annual Review, 21 July 2004, Durham, NH.

Elston, G. R., International Lidar Mapping Forum ILMF meeting, Orlando, Florida, 9-10 February 2004.

Elston, G. R., Waveform characterization and bottom classification of SHOALS lidar data, Capacity Development Workshop on Acoustic Techniques in Seabed Assessment, CCOM / JHC, UNH, Durham, 31 May 2004.

Elston, G. R., Waveform characterization and bottom classification of SHOALS lidar data, Optech International, Stennis Airport, MS, 8 September 2004.

Elston, G. R., Waveform characterization, clustering and segmentation of SHOALS lidar data, CCOM/JHC, NH, 3 December 2004.

Fonseca, L. E. N., AVO Analysis of Multibeam Backscatter, CCOM/NOAA Seminar, 16 April 2004.

Fonseca, L. E. N., Acoustic Seafloor Characterization, Introduction to Ocean Mapping OE-ESCI870, 05 May 2004.

Fonseca, L. E. N., Acoustic Seafloor Characterization with Multibeam Sonar, Australian Seminar CCOM, 27 May 2004.

Fonseca, L. E. N., Acoustic Seafloor Characterization with Multibeam Sonar, Office of Coast Survey – JHC Annual Review, 22 July 2004.

Huff, L., GPS activities at JHC: RTK GPS Workshop University of Southern Mississippi., 16-18 March 2004.

Huff, L., Systems Development at JHC: Seabed Science Symposium for Visiting Australian Legion, 26-31 May 2004.

Kraft, B. J., Mayer, L. A., Goff, J. A., and Simpkin, P. G., In Situ Measurement of Geoacoustic Sediment Properties: An Example from the ONR Mine Burial Program (MVCO), CCOM, 5 March 2004.

Kraft, B. J., Mayer, L. A., Goff, J. A., and Simpkin, P. G., In Situ Geoacoustic Measurement Of Surficial Seafloor Variability, Capacity Development Workshop On Acoustic Techniques In Seabed Assessment, CCOM, 31 May 2004.

Leo, M. E., Evaluating User Perception for Fused Oceanographic/Geophysical Data: A Case study Using Acoustic and Magnetic Sensors for Enhanced Ferrous Target Detection on the Seafloor, Center for Coastal and Ocean Mapping, University of New Hampshire, 20 July 2004.

Leo, M. E., Methods for Ferrous Anomaly Detection using a Three-Sensor Magnetic Gradiometer in the Marine Environment, Center for Coastal and Ocean Mapping, University of New Hampshire, 12 July 2004.

Monahan, D., Management of Deep Ocean Data. Seminar Presentation, Geodesy and Geomatics Engineering Department, University of New Brunswick, Fredericton, NB, 29 September 2004.

Monahan, D., Zones in the sea: Rights and responsibilities. Presentation, Center for Property Studies, University of New Brunswick, Fredericton, NB, 30 September 2004.

Rzhanov, Y., Video mosaicing", Seminar presentation, National Marine Fisheries Service, Video Analysis Workshop, Alaska Fisheries Science Center, Seattle, 4-6 August 2004.

Ware, C., and Arsenault, R. 2004, AUV and ROV Visualization in GeoZui3D. NOAA Internal AUV Workshop Agenda. Silver Spring, 5 Feb 2004.
Ware, C., Data Visualization, FVCOM Workshop. Bedford Mass, 15 June 2004.

Ware, C., 2004 Visual queries: The foundation of Visual Thinking. International Workshop on Visual Artifacts for the Organization of Information and Knowledge. Tubingen, 13 May 2004.

Appendix G:
Meetings and Conferences Attended:

Alexander, L., 9th Meeting of IEC TC80/WG13 - Display of Navigation-related Information, Portsmouth, VA, 20-23 January 2004.

Alexander, L., Hydrographic Interoperability Workshop, Ottawa, Ontario. 26-30 January 2004. (Rapporteur)

Alexander, L., Inland Waterways Conference/N. American Inland ENC Working Group, New Orleans, LA, 15-18 March 2004. (Technical Coordinator)

Alexander, L., IHO TSMAD S-57 Edition 4 Sub-Working Group Meeting, Silver Spring, MD, 29 March – 2 April 2004.

Alexander, L., 3rd International Discussion Group for QA in Hydrography, Ottawa, Ontario, 27 May 2004.

Alexander, L., 16th IHO CHRIS Meeting, Ottawa, Ontario, 28-31 May 2004. (Rapporteur)

Alexander, L., ENC and DNC Comparison Study; USCG C2CEN, Portsmouth, VA. 22-24 June 2004.

Alexander, L., Coral Reef – MIO Project: Protecting Corals, Saving Ships, OCS/NOAA, Silver Spring, Maryland, 29 June 2004.

Alexander, L., 2004. Meeting of the Meso-American – Caribbean Sea Hydrographic Commission, Electronic Chart Working Group, Cartegena, Colombia. 29 August – 3 September 2004. (Technical Coordinator)

Alexander, L., 2nd Meeting of the North American – European Inland ENC Harmonization Group, St. Louis, MO, 22-24 September 2004. (Technical Coordinator)

Alexander, L., 10th Meeting of IEC TC80/WG 13 (Navigation Display), Durham, NH, 5-8 October 2004. (Host)

Alexander, L., 11th Meeting of IHO TSMAD, S-57 Edition 4.0 Sub-Working Group, Monaco, 7-13 November 2004. (Rapporteur)

Alexander, L., Meeting of the Florida Keys National Marine Sanctuary – Sanctuary Advisory Council, Marathon, FL, 14 December 2004.

Arsenault, R., NOAA: Auv Meeting, Silver Spring, MD.

Arsenault, R., Right Whale Consortium Research Meeting, New Bedford MA, 3-4 Nov. 2004.

Calder, B.R., Open Navigation Surface Working Group, 1st Meeting, Durham NH, 21-23 January 2004.

Calder, B.R., NOAA Office of Coast Survey Field Procedures Workshop, Seattle WA, 13-15 Jan 2004.

de Moustier, C.P., High Frequency Acoustics Conference, La Jolla, CA, 2-5 March 2004.

de Moustier, C.P., Represented CCOM at the NOAA Stakeholder Forum in Washington D.C. 16 April 2004.

de Moustier, C.P., IEEE Editors Panel Meeting, Boston MA, 23-24 April 2004.

de Moustier, C.P., IEEE Oceanic Engineering Society Administrative Committee Meeting, Houston, TX, 2-3 May 2004. (elected member).

de Moustier, C.P., Acoustical Society of America Spring Meeting, New York, NY, 24-28 May 2004.

de Moustier, C.P., IEEE Technical Activities Board Meeting, Kansas City, MO 17 June 2004.

de Moustier, C.P., Office of Coast Survey - JHC Annual Review, CCOM-JHC/UNH, 21 July 2004.

de Moustier, C.P., IEEE Oceanic Engineering Society ExCom Meeting Boston, MA, 22 July 2004.

de Moustier, C.P., "Beyond Safety of Navigation", Multibeam and Visualization Workshop, Gulfport, MS 26-29, July 2004.

de Moustier, C.P., USCG R&D Center/TSWG visit to JHC 24, August 2004.

de Moustier, C.P., IEEE Oceanic Engineering Society Constitution & Bylaws Meeting. Warwick, RI, 11-12 Sept 2004.

de Moustier, C.P., IEEE Oceanic Engineering Society Constitution & Bylaws Meeting. Arlington, VA 16-17 Oct 2004.

de Moustier, C.P., IEEE Oceanic Engineering Society Administrative Committee Meeting, Kobe Japan, 9 Nov 2004.

de Moustier, C.P., MTS-IEEE Oceans '04/OTO '04 Conference, Kobe Japan Nov 10-12 2004.

de Moustier, C.P., Acoustical Society of America, Fall Meeting, San Diego, CA, Nov 15-19 2004.

de Moustier, C.P., IEEE Oceanic Engineering Society Constitution & Bylaws Meeting Valley Forge PA, 5-6 Dec 2004.

Elston, G.R., International Lidar Mapping Forum ILMF 2004. Meeting, Orlando, Florida, 9-10 February 2004.

Gardner, J.V., State Department Law of the Sea Meeting, Washington, DC. 11 May 2004.

Gardner, J.V., NOAA Methane Hydrates & Climate workshop, Boulder, CO. 13-14 May 2004.

Gardner, J.V., NOAA/NURP AUV proposal evaluation, Hattisburg, MS. 18-19 May 2004.

Gardner, J.V., NSF Amerasian Basin workshop, Washington DC, 8-9 June 2004.

Gardner, J.V., American Geophysical Union, Fall Meeting, San Francisco, CA 12-17 December 2004.

Huff, L., 14th International Symposium of the Hydrographic Society, Galway Bay Ireland, 2-4 November, 2004.

Kraft, B.J., Mayer, L. A., Pratson, L. F., Holland, C. W., and Overeem, I., Comparing SedFlux Predictions to Geoacoustic Data, presented at the ONR Uncertainty DRI Meeting, Chantilly, VA 14-16 June, 2004.

Monahan, D., Thesis Examining Committee, University of New Brunswick, Fredericton, NB, 6 August 2004.

Monahan, D., Thesis Examining Committee, University of New Brunswick, Fredericton, NB, 29 September 2004.

Plumlee, M.D., IEEE Visualization Conference, Austin, Texas, 11-15, October, 2004.

Raymond, R., Annual Mine Burial Program Meeting, Woods Hole, MA, 12-14 April 2004.

Rzhanov, Y., NOAA Fisheries Laboratory, Santa Cruz, California, 1-3 August, 2004.

Rzhanov, Y., National Marine Fisheries Service, Video Analysis Workshop, Alaska Fisheries Science Center, Seattle, 4-6 August, 2004.

Rzhanov, Y., Lucky Strike data processing strategy Meeting (with Woods Hole Oceanographic Institution, University of Jusseiu, Paris, University of Girona), Girona, Spain, 18-21 August, 2004.

Quinn, M., IEEE Visualization Conference, Austin, Texas, 11-15 October, 2004.

Demos

Plumlee, M.D., Demos of GeoZui3D and the GeoExhibit3D given to the Australian visitors on 6/2/2004.

Plumlee, M.D., Demos given to above visitors on 3/9 and 5/7.