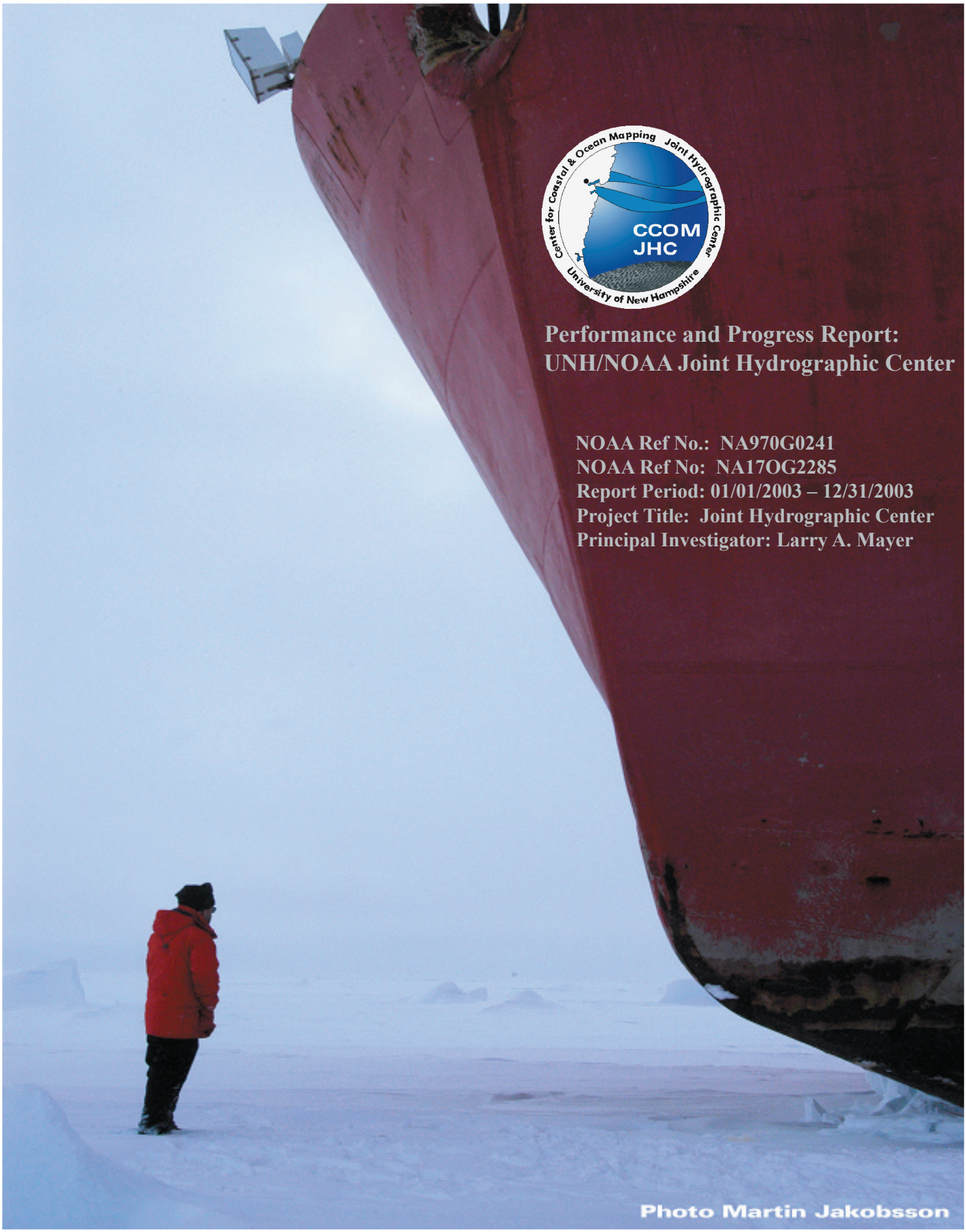

Performance and Progress Report: UNH/NOAA Joint Hydrographic Center

NOAA Ref No.: NA970G0241
NOAA Ref No: NA17OG2285
Report Period: 01/01/2003 – 12/31/2003
Project Title: Joint Hydrographic Center
Principal Investigator: Larry A. Mayer

NOTE: This report serves as the Progress Report for the period 01/01/2003 – 12/31/2003 for NOAA Ref No.: NA970G0241 as well as the Final Report for NOAA Ref No.: NA970G0241. It is also the Progress for NOAA Ref. NA170G2285 for the period 01/01/2003 – 12/31/2003

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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 eighth 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, 2003.

REVIEW OF RECENT PROGRESS:

Infrastructure:

Personnel:

The key to the success of any center will be 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. We added to our staff this year with the addition **Dr. James V. Gardner**, a world-renowned marine geologist and leader of the USGS Pacific Mapping Group, who has retired from the U.S.G.S. and joined the Center as a Research Faculty member and **Nathan Paquin**, a part-time system manager. Funding from external sources has continued to allow us to expand our staff to include a laboratory manager

(**Andy McLeod**) supported by ONR and NSF, three new Research Scientists (**Gareth Elston, Luciano Fonseca** and **Barbara Kraft**) supported by the USGS, ONR, and industrial sources, and a GIS specialist (**Pam McLeod**) supported by ONR as well as several hourly employees and **Ben Smith** who maintains our research vessel. Finally NOAA has seconded two more employees, **Dr. John Kelly** and **LCDR Dave Cole**, to the Center, providing valuable expertise in oceanographic and atmospheric modeling and database development.

Faculty:
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.

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.

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.

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.

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.

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.

NOAA has demonstrated its commitment to the new Center by assigning five 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.

Cdr. Gerd Glang is at the Center in two roles. He has been the NOAA Navigation Advisor for the Northeast Region, serving as an ambassador to the maritime community and directly supporting the NOAA strategic goal to "promote safe navigation" by helping to resolve charting and navigation questions, educating constituents on emerging charting technologies, and soliciting feedback on NOAA's navigation products and services. He is also a full-time graduate student. Cdr. Glang commanded the NOAA ship *Whiting* during its successful search for the wreckage of Egypt Air Flight 990 and John F. Kennedy, Jr.'s, downed Piper Saratoga.

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:

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.

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.

Rick Komerska joined the Data Visualization Research Lab in March 2001. His background includes degrees in Aerospace and Civil Engineering. Rick has worked on a wide range of systems engineering projects spanning several disciplines. Recently, he has been involved in the development of a simulation/visualization tool in support of cooperating AUVs. He is now investigating techniques for using haptic feedback in carrying out various generic and application-specific tasks, with the goal of transitioning these results into tools used by the ocean community.

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.

Pam McLeod received a B.Sc. in Electrical Engineering from the University of Wyoming and an M.S.Eng. in Geomatics/Civil Engineering from Purdue University. Her area of expertise is Geographic Information Systems (GIS), and she holds a joint appointment at UNH between CCOM and the Climate Change Research Center (CCRC). She is currently working on internet information visualization with ArcIMS, GeoMedia, XML, and ColdFusion; geodatabase design with Oracle and ArcSDE; and application development with ArcObjects/VB and Avenue.

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 just 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 towards the end of the year 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.

In addition to the academic staff, **Abby Archila** is our full-time program administrator and keeper of order and **Ellen Barrows** is our accounting assistant.

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. This past year we have been able to expand into the second floor of the new building providing greatly needed additional office, graduate student and meeting space all cabled for gigabyte Ethernet. We have added two dedicated Dell servers and additional Network Attached Storage (NAS) and RAID to our 4-processor Origin 2100 Silicon Graphic server with fiber channel disk stripe bringing

our online storage capacity to more than 6 Terabytes. We also have an SGI Octane workstation, 3 SGI O2 workstations, 99 high-end NT and Linux workstations and laptops, and several Mac G4's. We have added We also have a full suite of printers and plotters including both 48 and 60-inch large-format color plotters. 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 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.

We now have seven dedicated servers consolidated into a Dell rack with dual UPS monitored across the network. Network attached storage servers (Dell Powervault 770N with attached Powervault 220S drive housings) now provide an additional 4,380GB beyond our configuration of last year. External services have been move to a new Dell Poweredge 650 server, which provides FTP, mail, web and CVSservices. Interface between our internal gigabit network and the external world is also handled by a Dell Poweredge 650. 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. We are outfitting and upgrading an electronics lab and have acquired a range of high-end test equipment. We have also built data acquisition systems and associated software in support of several research projects (see below). Arrangements have been made with the Research Computing Center to handle routine system maintenance and backup and system security has been increased significantly.

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. This past year **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 three 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, a POS-MV320 inertial motion sensor. In addition **TSS** has kindly 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 pole camera techniques (Huff and Cutter).

Finally, we have completed construction and initial outfitting of both an electronics workshop under the supervision of Andy McLeod and a complete machine shop under the supervision under the supervision of Paul LaVoie.

Educational Program:

The Center has, under the guidance of Capt. Armstrong, developed ocean-mapping specific curricula that have now been approved by the University. We now offer both M.S. and PhD degrees with a specialization in Ocean Mapping through either the Dept. of Ocean Engineering or through the Dept. of Earth Sciences (now expanded to include the School of Natural Resources) and 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 program and engineers entering through the Ocean Engineering 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 this past September.

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 submission to the FIG/IHO International Advisory Board of Standard of Competence for Hydrographic Surveyors has been accepted and our program was given a **Category A certification by the FIG/IHO Advisory Board** at their annual meeting in May 2001.

While our students have had a range of existing courses to take as part of the Ocean Mapping Program the Center now teaches several new courses specifically designed to support the Ocean Mapping Program.

JHC – originated Courses

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

Dave Wells and Semme Dijkstra are now working on a web-based version of the Geodesy course for distance education.

We have 14 students enrolled in the ocean mapping program, including two NOAA Corps officers and a NOAA physical scientist; we have already produced two Ph.D.s (Luciano Fonseca (2001) and Anthony Hewitt (2002). Shep Smith received his M.Sc. degree in May of 1993 – the first of our NOAA Corps Officers to graduate.

Student	Program	Advisor
Rick Brennan (NOAA)	M. S. OE	TBD
Daniel Brogan	M. S. EE	de Moustier
Randy Cutter	PhD, E. Sci.	Mayer
Gerd Glang (NOAA)	M.S., OE	Huff
Caleb Gostnell (NOAA)	M.S. E. Sci.	TBD
Tianhang Hou	Ph.D. OE	Mayer, Huff
Mike Leo,	Ph.D. E. Sci.	Mayer, Calder, Huff
Malik Mashkoor	M. S. OE	Mayer
Karthikeyan Natham	M. S. Comp. Sci.	Ware
Matthew Plumlee	Ph.D. Comp Sci	Ware
Richard Raymond	M.S., E.Sci	Mayer

Brianna Sullivan	M.S. Comp.Sci,	Ware
Shep Smith (NOAA)	M.S, OE (received May03)	Mayer
Arsen Zoksimovski	M.S. EE	de Moustier

Status of Research: 2002 - 2003:

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. Here, we briefly review the progress made on these tasks over the past year as well as describe progress made in several new initiatives.

Innovative sonar design and processing for enhanced resolution and target recognition

While this is the least active of our themes, we are seeing growing activity with the development of our sonar calibration facilities and our involvement in the development of new sonar systems. This 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. We have also used the facility to calibrate hydrophones to be used for the acoustic conditioning of fish (in conjunction with Dr. Ken Baldwin of the Ocean Engineering Dept. and the New England Aquarium). Reson is expected to bring a new generation of dynamically focused sonar to our facility so that we can carefully measure its characteristics and ability be used to simultaneously map both the seafloor and mid-water targets. The capability to simultaneously map both the seafloor and water column is an important concern of NOAA with respect to the capabilities of their fishery research vessels.

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. These tests, including a field trial in August 2003, have resulted in significant enhancements to both the hardware and software. Chris DeMoustier and graduate student Dan Brogan have worked with NRL on the development of a toroidal (360 degree) volume search sonar

(with NRL). Chris has also worked with Scripps Institution of Oceanography on improving their EM120 multibeam sonar and with Electronics Navigation Ltd. Of New Zealand on the development of a new 160kHz multibeam sonar targeted towards the fishing industry.

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 would 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, the NAVY, 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, and, when the automated editing technique fails to make a statistically conclusive decision, it will present multiple hypotheses 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.

Last year 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. The past year CUBE's capabilities were extended to include the implementation of a tracking filter that improves performance in areas of steep slopes, restructuring of the code to allow it to easily facilitate future developments, and the implementation of an interface to flag data in HDCS format so that it can be fed immediately back into CARIS. CUBE was further tested when it was used to process all multibeam sonar data collected in support of Shallow Survey 2003, the international conference on shallow water surveying that alternates between Sydney Australia and Portsmouth New Hampshire. During this exercise, it was demonstrated that CUBE can provide a very powerful method to identify even subtle problems in data quality.

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 support of the exciting news that NOAA (and others, e.g. NAVO) will be officially adopting CUBE as an essential component of their approach to hydrographic data processing, Dr. Calder has been working with a number of commercial software vendors who provide hydrographic processing software to NOAA and NAVO (CARIS, IVS, SAIC, SIMRAD) to ensure that they will properly implement the CUBE algorithms in their products. He has also been working 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.

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 has 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 thus can be used to display 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.

With the completion of his Master's Thesis in May, Lt. Smith was assigned to the NOAA vessel THOMAS JEFFERSON, where he has been developing protocols for the implementation of both CUBE and the Navigation Surface. This work has directly led to the acceptance of CUBE and the Navigation Surface as new standards for NOAA processing.

In support of the new adoption of CUBE and the Navigation Surface into processing protocols, the Center will be organizing and hosting a workshop amongst 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. 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.

In another effort to push the limits of bathymetric resolution, Lloyd Huff and Yuri Rzhanov have been working to use the algorithms developed for image correlation (see Seafloor Characterization section below) to correlate spatial patterns derived from overlapping lines of high-resolution multibeam bathymetry. Through the correlation, it is possible to re-navigate one of the two survey lines such that the internal details of its bathymetry spatially overlay those of similar details in the reference line. The technique not only holds promise for "correcting" navigation data, it can also provide an estimate of the precision of the survey navigation.

We have also been developing new approaches to improve the bottom detection capability of Reson 8111 sonar. Kraft, DeMoustier and Calder participated in the ONR-sponsored Kauai High Frequency Experiment. During the course of this experiment deficiencies were noted in the robustness of the bottom detection algorithm of the Reson 8111 multibeam sonar. Also as part of this experiment, Calder, Kraft and deMoustier examined the potential for using ocean models (from SSI in Nashua New Hampshire) as input for the sound speed profile needed for multibeam sonar work. The team examined the quality of the depth information produced from EM120, and Reson 8111 when an isospeed (1500 m/sec) ocean was assumed; when sound speed was derived from the SSI ocean model and; when the full suite of CTD measurements were used. Results show that the model did a good job in capturing the detail of the sound speed structure in the area.

Improved Backscatter Processing:

In concert with our activities related to improving the processing of multibeam sonar bathymetry, we also have been involved with several projects aimed at improving the processing of multibeam backscatter. These developments are in support of our seafloor characterization efforts and the hope of using remotely collected backscatter to better define seafloor properties (much of this work is funded by ONR). Efforts include the work of Fonseca, Kraft and Elston to develop techniques for correcting multibeam backscatter for local slope. In addition, Fonseca has developed a software tool suite that includes these corrections, carries through the full calculation of backscatter as a function of angle of incidence, and provides tools to visualize the seafloor response. These projects will be discussed in greater detail in the Seafloor Characterization section below.

***Improved Sidescan Sonar Processing*:**

In another data processing research program, Lloyd Huff and Tianhang Hou have been developing algorithms and software to clean and remove artifacts from Klein 5000 sidescan sonar data collected by the Alaska Fisheries Research Center in the Bering Sea. The techniques developed allow the removal of beam pattern and roll effects, pre-

whitening, slant-range corrections and recalculation of tow fish position. After this processing, the sonar images show, much more clearly, trawl marks and other seafloor targets. Huff and Hou have been able to begin to develop techniques to quantify the impact of fishing gear on the seafloor. In the current year, Huff and Hou have extended this research to Klein 5410 data collected during the Trawlex-02 project, processing another 5 gigabytes of data. For these data they developed new calculations of TVG, attenuation, beam pattern, etc. had to be made.

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, Komerska, Sullivan, 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. 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.

During this reporting period the user interface for GeoZui3D has been updated multiple window features that support scale changes have been added. An important development has been the support for real-time and time-varying data sets. In particular has been the support for time-varying terrain models, moving objects (e.g. AUV's or ROV's) and flow fields. The incorporation of time-varying data sets also has allowed us to explore the feasibility of creating "tide aware" 3-D bathymetric charts, laying the groundwork for the "Chart of the Future" discussed later.

The incorporation of flow visualization models into the GeoZUI-3D environment has opened of a range of applications and interest from ocean and current modelers both inside and outside of NOAA. Collaboration with modeling teams at Dartmouth and with NOAA's Coast Survey Development Lab is currently underway. A particular challenge being addressed is the development of methods to visualize multiple layer flows.

GeoZUI-3D has become the basis for a prototype 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. This prototype exhibit allows visitors to pilot themselves in 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.

Force-feedback (haptic) interfaces have also been developed for GEOZUI-3D. These interfaces are being used for the exploration of the usefulness of clickless menus and 3D drawing in the haptic environment. In addition, haptic techniques for creating and editing AUV mission paths (using *in situ* haptic pie menues and haptic state surfaces) have been developed

Finally, a series of theoretical studies of perceptual and task-related frames of reference have been carried out that look at the mismatch between visual and haptic images of an object. Additionally, models are being developed to predict the likelihood that an individual will make an error in discriminating between two visual patterns. These theoretical studies form the basis for the development of user interfaces for things like the Chart of the Future. This has been supported with NSF funding.

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.

Sidescan sonar:

As discussed above, Lloyd Huff and Tianhang Hou are working with the Alaska Fisheries Science Center of NOAA/NMFS on a major Klein 5000 and 5410-sidescan sonar survey in the East Bering Sea. Once the records have been corrected, an automated classification technique, developed by Rzhanov and Hou is being applied. In this technique the surveyed area is divided into small squares (typically 20 x 20 m). For each square the mean backscatter-vs-beamnumber "signature" is calculated. After application of corrections, a Chebyshev polynomial is fitted to the signature, and the polynomial coefficients are used as data vector for the clustering algorithm. When the clustering is performed, the mean signature for each cluster is calculated and then fed into an optimization algorithm for inversion for the seafloor property parameters. This technology development has the potential for a variety of sonar processing applications.

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 the EM 300, 1000, 1002 and EM3000 and Reson 8101 data collected in support of the ONR- and 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 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 (Amplitue Versus Offset). In support of this study we are also collecting samples and 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 is also doing a similar analysis on EM300 data collected off Iceland in collaboration with the Icelandic Hydrographic Bureau. The analysis of these data is specifically to see if there are indicators of near-surface gas.

Over the past two years a new approach to seafloor characterization based on the automated segmentation of multibeam sonar bathymetric data into regions of common geomorphology 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. The LFH appears to separate the morphology into regions that have

significance in terms of the habitat of several species. This past year Cutter has supplemented these analyses with the development of applications to also calculate landscape metrics and spectral parameters for the segmented seafloor and integrated these tools with GeoZui3D (see above) for image feature selection and extraction. In support of these studies as Cutter is also developing innovative approaches to ground-truthing the sonar with samples and video data. These will be discussed more below.

In order to better understand the relationship between remotely measured backscatter (with a sonar) 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 upgraded the user control of the ISSAP hardware. In addition, new, 47kHz transducers have been added and allowing in situ measurements to be made at 47, 65 and 100 kHz. Beam pattern measurements were made for all probes and the resistivity probes were calibrated. The new additions were tested in Portsmouth Harbor as part of the Geoclutter work there. Using these measurement as well as analyses of seafloor samples done by other investigators, TYCO Fellow Barbara Kraft has been exploring both the empirical and theoretical relationships between physical and acoustic properties and between these properties and backscatter. This theoretical and empirical work, feeds directly back into our attempts to interpret backscatter in terms of seafloor character or habitat.

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 implemented a lidar pulse characterization algorithm that determines the peak value and pulse width from the zeros of the first and second derivatives of the (low-pass filtered) waveform. Classes have been defined to hold the lidar waveforms (with their supporting metadata) and methods to implement the pulse characterization. These classes rely on a flexible binary file parsing class for importing the lidar data from multiple binary files. In collaboration with Semme Dijkstra, these classes are being ported for use in his Trace-Ed and Lasso tools (see description in Single Beam Characterization section). These tools will form the basis of our bottom segmentation and classification work.

Initial work on matching the overlapping data from the two lidar sensors used during surveys of Lake Tahoe (shallow APD and deep PMT) revealed that the two clusters in the peak value vs. depth plot have different slopes indicating that these may reflect changes in the optical properties of the overlying water. Dijkstra is developing algorithms to eliminate this effect so that differences in bottom reflectivity can be addressed. LIDAR data is now also available from Portsmouth Harbor. The DTMs from the two survey days, although individually self-consistent, show a vertical offset. The cause is unknown, even to SHOALS. Initial investigations have revealed some minor anomalies in the tide data applied and in the scanning pattern of the lidar shot positions, but more research is required to determine their effects, if any, on the DTMs.

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). A video camera system and strobes were also integrated with a SEA SCIENCES lightweight tow body for imaging through schools of fish. Components of this same system were also used to support archaelogical surveys off Morocco.

Cutter has demonstrated the applicability of Rzhanov's mosaicing algorithms to both seafloor video and "continuous profiling camera" video (a camera that collects video of a side view of the sediment water interface). He has developed a new methodology for collecting diver-deployed overlapping video transects with extended areal coverage called "Arc Video." With this technique a diver uses a dive-reel attached to a temporary mooring to trace out arcs downstream. Each new arc is defined by lengthening the reel line and growing the radius. The arc sector imaged spans the 5 to 10 m radii from the mooring. This method facilitates medium-area (approx. 30 m^2) video mosaic coverage and overcomes some of the problems associated with diving and imaging in high-current waters. During arc video acquisition, the buddy diver makes counts of all megafaunal invertebrates and fish in the area, and can collect samples if desired.

Rzhanov has extended his mosaicing algorithms to include the combination of images from non-planer 3D objects. This approach was elegantly demonstrated when Rzhanov took 700 photos from an Alvin dive on the Rosebud hydrothermal vent site on the Galapagos Spreading center and created a mosaic with mm-scale resolution that represented a 50 x 60 m area of the seafloor. Mayer texture mapped this mosaic on 1-m lateral resolution bathymetry and then created an interactive 3-D fly-through along the path of the Alvin navigation. This fly-through can be viewed in stereo with appropriate projectors and glasses and has created a sensation amongst those studying ridge-crest processes.

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 should be arriving at JHC the second week of January 2004. The final internal mounting details will be determined soon after the housing is received. It is anticipated that the system will be finally assembled and tested by May 2004.

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 Clusure Area. The area targeted for this work encompasses both a closed area and an area still open to fishing. Mashkoor is studying the range of acoustic data collected in both areas to see if differences can be found and if the effect of trawling in the non-closed area can be quantified.

Data Mining, Blending and Fusion:

The last of our original research themes is aimed at developing robust approaches to combining historical bathymetric data sets of varying quality and to tracking uncertainty in bathymetric data sets. To develop this approach the Arctic Ocean bathymetry database used by Jakobsson to generate the recently published International Bathymetric Chart of the Arctic Ocean, (IBCAO) was used. The details of this approach were described in earlier progress reports; a paper describing the technique has been published in The Journal of Geophysical Research. The same approach was to predicting uncertainty for historical data was applied to a more controlled, local database collected in Great Bay, New Hampshire. As part of a CICEET project in which the Center is involved, we have compiled all soundings collected over the last 100 years in Great Bay New Hampshire. Working with Armstrong, Alexander and Leo, Jakobbson has combined data sets from 1913, 1953 and 1954 into a single database and, after tracking the uncertainty associated with each data set, has concluded that real changes in the estuary channels can be seen. We have also produced a new, much more realistic, composite bathymetric chart of Great Bay that will be used for modeling flow and sediment transport within the estuary.

In support of these and other mapping and database efforts, Jakobsson and Fonseca have developed a graphical user interface (GUI) that makes the functionality of the GMT (Generic Mapping Tools) available in a windows GIS environment (Geomedia). At present this interface handles all GMT gridding algorithms and pre-grid filtering.

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 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. 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. The survey which took place in July 2003, with Thales GeoSolutions Inc. using a 175-ft, 833-ton research vessel with a hull-mounted Reson 8150 MBES to conduct the surveys. The planned schedule for the so-called "UNCLOS cruise" had 6 days for transits to and from Dutch Harbor, AK and 15 days for operations.

The operations commenced with a transit from Dutch Harbor, AK to the survey area on the north flank of Bowers Ridge. Once that survey was completed, the ship transited to the Beringian margin where operations continued until completion. The total survey time used 15 days for operations and 6 transit days and completed 3438.42 km of MBES lines, mapping a total area of ~21,000 km. In the course of these surveys the complex nature of both margins was clearly delineated by the multibeam data. Using these new data the U.S. will be able to significantly add to the area claimed under Article 76. Details of this cruise can be found at http://www.ccom.unh.edu/unclos/html/report_beringsea.htm.

The second cruise in support of a potential Law of the Sea claim 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 (Armstrong, Brennen, Calder, Hall, Jakobsson, Kraft, and Mayer) 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. In the course of the cruise 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. Details can be found at http://www.ccom.unh.edu/healy/index.html. The success of this cruise has led us to plan a longer cruise next summer.

In further support of our Law of the Sea efforts, Martin Jakobsson has continued to update and support the International Chart of the Arctic Ocean (IBCAO). Several new data sets have been included into IBCAO, including AMORE multibeam data covering most of the Gakkel Ridge, Hydrosweep data covering large areas in the Fram Strait and east of Greenland, and USGS data in the Canadian Basin and over the Chukchi Borderland. In addition, the full Fletcher Ice Island T3 data set has been provided by John Hall to supersede the previously included sub-sampled version.

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. An initial focus for this project will be Hampton Roads, an extremely active harbor that is of great importance to both NOAA, in their support of maritime commerce, and the Navy, in their national and homeland defense mission.

Within the context of the "evolutionary" approach Lee Alexander and Rick Brennan are working in collaboration with industrial consortium member SevenC's to investigate various tools and processing steps required to use the Navigation Surface database to produce a high-density bathymetric ENC. "*Grid Manipulator*" (prototype software developed at CCOM by Shep Smith) was first used for "defocusing" and generalization-to-scale. IVS *Fledermaus* was then used to generate contours from the optimized gridded dataset. Finally, SevenCs *ENC Designer* tools were used to produce prototype, bathymetric ENCs. Using this approach, two basic types bathymetric ENC data have been produced: 1) a static ENC with high density contours conforming to existing IHO S-57 3.1 ENC Product Specification, and a dynamic ENC capable of generating

numerous user-defined depth areas based on a DEM model that is adjusted with respect to the actual water level.

Two different options were investigated for combining high-density, bathymetric ENC data into a standard ENC:

1) Nautical information not contained in bathymetric ENC (e.g., navigation aids, traffic separation schemes, etc.) is extracted (i.e., copied) from the existing ENC or other sources (e.g., a nautical database), and then inserted into the new bathymetric ENC.

2) The bathymetric ENC data is interleaved (i.e., incorporated) into the existing ENC. It is then the ECDIS or ECS application that deals with the supplemental capability provided by the bathymetric ENC.

Further research is planned to test and evaluate the functional capability of each option in existing/new ECDIS and electronic chart systems.

Rick Brennan and Lee Alexander are also working to organize a Demonstration Project in Hampton Roads, VA to investigate the challenges and opportunities of developing the "Next Generation ENC" and "Electronic Chart of the Future." In particular, a three-phase effort is being planned:

1. Compile test datasets from existing and new hydrographic surveys using advanced data processing and compilation procedures (i.e., *CUBE* and *Navigation Surface*).

2. Investigate innovative approaches to produce an interactive time- and tide-aware navigation display, and to evaluate such a display onboard commercial and government vessels.

3. Integrate real-time/forecast water depth information and port information services transmitted via an Automated Identification System (AIS) communications broadcast.

The overall goal of this project is to fully utilize the high-resolution multibeam data and leverage the existing ENC and ECDIS technology to provide the mariner with a more advanced navigational tool capable of dealing with time-dependent nature of the waters they transit (e.g. tides, currents, wind, etc.). It is anticipated that the outcome of this research will contribute the 4th edition the IHO Transfer Standard for Digital Hydrograhic Data (IHO S-57) planned for 2006.

Within the context of the "revolutionary" effort, Colin Ware, Matt Plumlee and Roland Arsenault have been extending the capabilities of GeoZui3D to incorporate a range of data types that will be particularly valuable for the chart of the future. These include:

1) Use of photographic imagery for navigation support. We are taking advantage of our video mosaicing capability (see above) to integrate video mosaics of the shoreline and forward-looking camera imagery into an interactive 3-D scene. Initial work on performed by Arsenault while on the THOMAS JEFFERSON allowed the input of S-57 objects and real-time navigation. This will now be extended to also handle imagery.

2) Tide-aware chart. GeoZui3-D has been modified to handle real-time tide input and display changes in bathymetry as a function of tidal data. It can also be used as a planning tool for entrance into areas where bottom clearance at certain points

in the tidal cycle is a problem. We now have the ability to transform the NOAA hydrographic model of Chesapeake Bay and load it into GeoZui3D. NOAA is now standardizing on the same data format so that we will be able to handle other models. What remains to be done is (a) a task analysis to determine how a tide aware 3D chart should be used, and (b) the design of a proper user interface suitable for the end users to carry out those tasks. Also, more work is needed to define how a system might be built to transmit tide model information to the working vessel.

3) Multiple views. The display of tides, currents, weather as well as conventional electronic chart information is beyond the capacity of a single data view. We are planning to continue to explore ways of visually linking multiple views (e.g. radar, and AIS).

4) Currents. The issue of how to display currents to the mariner is almost completely unexplored. Although there may be potential benefits to giving mariners access to tidal flow models there are also pitfalls. Flow models only show large-scale flow patterns and not local eddies and may therefore be misleading. Also, showing flow everywhere is likely to be cluttering. Some simplifying method of display is needed. Flow visualization tools are also being developed for estuarine and coastal zone modelers. New interpolation tools enable irregular sigma-coordinate models to be converted to regular gridded sigma-coordinate models. It is now possible to load multi-layer data into GeoZui3D.

In addition to studies are currently underway to identify key roles and tasks that the Chart of the Future must support. Finally, Ware and Arsenault are assembling four CPU's and two 9.2 Megapixel monitors (Ultra high-resolution) in order to create a stereo capable display that has the resolution of a paper chart.

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. CCOM has already established liaisons with the private sector including Tyco, Klein Associates, C&C Technologies, AUSI, Interactive Visualization Systems, Triton-Elics, Reson and ODOM. 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
SAIC
SevenC's
Quester Tangent
Triton-Elics
Tyco

In addition, grants are in place with the Office of Naval Research, The Naval Research Lab, The National Science 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 from non-NOAA grant sources this past year is on the order of $1.7M from a total commitment of non-NOAA sources of approximately $5M.

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:

Stripped aged nonskid matting from outside surfaces and replaced it with non-skid impregnated epoxy and paint

Replaced malfunctioning conventional (sanitary) head with vacuum head Repaired holding tank and installed pump-out fitting

Rebuilt prop-shaft strutt and replaced cutlass bearing

Replaced worn and missing fixed fenders

Ran diagnositics and tuned up main engine (Catapillar)

Removed excess wiring
Replace tackle and pendant of mooring at Jackson Lab

Installed KVH gyro-fluxgate compass

Installed buffered multiplexor for distributing data from GPS Receivers

Completed connection between survey data resources and ships autopilot

Improved dual control of ship's computer so that it can be operated both in the lab and at the helm

Built transducer mounts for single beam and multibeam

Improved automatic bilge pump switches and sensors

Completed vessel documentation and licensing

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

Appendix C:
Field Programs

Toledo Bend Reservoir, TX, 10-12 March 2003, R/V Inland Surveyor. Advise and provide software to aid in data processing in the search for remains of the Space Shuttle Columbia (Calder, Mayer).

UNH TECH 797, 18 April 2003, R/V Gulf Challenger, Field Testing of Stabilization for Electric Boat Capsule, (Huff).

Lobster mesocosm video mosaic mapping, May - June 2003. R/V Galen, Diver collection of seafloor video, (Cutter and Watson).

Joint Germany-Singapore-Canada-USA AIS-ECDIS Display Trials, 5-9 May 2003, Centre for Marine Simulation (Full Mission Ship Simulator), St. Johns, Newfoundland (Alexander).

NOAA Support, 14 May 2003, R/V Gulf Challenger, Field Testing of Klein 5410, (Huff).

Piscataqua River ground-truth sediment profile imagery, 19 May 2003, R/V Gulf Challenger, collection of sediment profile imagery (SPI), (Cutter).

Magnetic Gradiometer Survey May 20-June 6, R/V Coastal Surveyor, Dissertation Field Work, (Leo).

EM120 sea tests, 29 May- 8 June 2003, R/V Roger Revelle, (deMoustier).

Target Deployment, 30 May 2003, R/V Little Bay, dissertation Field Work, (Leo, Gibney, Elston, Arsenault and Jackobsson).

Piscataqua River ground-truth sediment-water interface (SWI) roughness measurement, 22 May 2003, collect imagery of device designed to measure SWI profiles (Cutter).

Hubbard Camera, 2 and 6 June 2003, M/V Karen Lynn, Field Testing of Winch Installation and Integrated System, (Huff).

Great Bay, NH. 3-6 June 2003, R/V Coastal Surveyor. Installation and testing of Coda Octopus F-180 IMU in support of Summer Hydro Field Course (Calder).

Summer Hydro, Multibeam Survey, 6- 27 June 2003, R/V Coastal Surveyor, Dissertation Field Work, (Brennan, Malik, Armstrong, Leo).

Mike Leo's Dissertation Research, 9 June 2003, R/V Coastal Surveyor, Magnetic Gradient Survey, (Huff).

Calibration of Hubbard Camera system, 13 June, 2003, R/V Gulf Challenger, diver deployment of targets for lens distortion and color corrections, and testing light diffuser materials (Huff, Grizzle, Ward).

Piscataqua River ground-truth video, 13 June 2003, R/V Gulf Challenger, collection of seafloor video using Hubbard Camera system (Cutter).

UNH Open Aquaculture Site 17-18 June 2003, R/V Gulf Challenger, Full bottom multibeam survey (Brennan).

Testing Hubbard Camera system, 27 June 2003, M/V Karen Lynn, reassembly and testing diffusers on Hubbard Camera video strobes (Huff, Grizzle, Ward).

Kaua'i, HI, 21 June – 01 July 2003, R/V Roger Revelle, Mapping of HFX experimental area bathymetry in support of HFX'03, SBIR project with SSI and ONR Uncertainty DRI. (Calder, Kraft, de Moustier).

Common Data Set, Portsmouth Harbor, NH, June 30-July 1, 2003, R/V Coastal Surveyor,
Map Portsmouth harbor using QTC View Series V, (Dijkstra).

NOAA/CCOM LOTS Bering Sea, 7-28 July, R/V Davidson, Law of the Sea mapping. (Gardner)

Hubbard Camera, 8 days in July and August 2003, M/V Karen Lynn, Field Operations. (Huff)

Island (Húsavik Sound), 1-10 August 2003, S/V Baldur Surveys of Húsavik-Flatey Fault offshore extension in conjunction with Hydrographic Service of Island, University of Reykjavik and Woods Hole Oceanographic Institute. (Calder, Mayer)

NOAA Support, 12 August 2003, R/V Gulf Challenger, Field Testing of Klein 5410. (Huff)

Chart of The Future Project, 18-29 August 2003, NOAA Ship Thomas Jefferson, Familiarizing with Bridge operations and Chart of The Future related development. (Arsenault)

NOAA, Stellwagon Bank, 19 – 29 August 2003, NOAA Thomas Jefferson, Stellwagon Bank mapping. (Malik)

Arctic Ocean (Barrow to Barrow), 28 August – 13 September 2003, USCGC Healy Survey of the Chuchki Borderlands in support of the US UNCLOS mapping mission. (Calder, Mayer, Jakobsson, Kraft, Brennan, Armstrong, Hall)

Arc video imaging, 29 Aug. 2003, R/V Gulf Challenger, 10 Sep. 2003, 26 Sep. 2003, 3 Oct. 2003, R/V Coastal Surveyor. (Cutter)

Piscataqua habitat ground-truth imaging. 02 Sep. 2003, 07 Sep. 2003, 18 Oct. 2003, 21 Nov. 2003, 09 Dec. 2003; R/V Gulf Challenger. (Cutter, Ward, Huff, Grizzle)

Mike Leo's Dissertation Research, 9 September 2003, R/V Coastal Surveyor, 8125 Bathymetric Survey. (Huff)

Multibeam Survey, Reson 8125, Sep 12 – 22, R/V Coastal Surveyor, Dissertation Field Work. (Leo)

ONR Mine Burial Program Survey, 28 Sept – 08 Oct, Martha's Vineyard, Multibeam survey following initial placement of mines in test area. First of three target surveys. (Raymond, Glang, Mayer)

NOAA / CCOM, Jeffrey's Ledge / Stellwagon Bank, 29 September – 3 October 2003, NOAA Thomas Jefferson, Collection of supplemental data for Jeffrey ledge SAIC survey 2002/2003. (Malik)

ONR Geoclutter (Portsmouth Harbor) 25-29 October and 4 November, R/V Gulf Challenger, *in-situ* geoacoustic measurements with ISSAP. (Kraft)

Long Island Sound (Newport, RI to Norfolk, VA), 28 October – 7 November 2003, NOAA Ship Thomas Jefferson. Modifications, implementation, installation of a custom CUBE system tuned for the ship's processing systems. Training for crew in operation of software. (Calder)

Little Bay and Portsmouth Harbor, October 17 through October 18, 2003, R/V Coastal Surveyor, Sediment Sampling, Choose sampling sites based on maps of AVO attributes of multibeam backscatter. (Fonseca)

Little Bay and Portsmouth Harbor ISSAP Survey 15,25,26,27 & 29 October, 2003 R/V Gulf Challenger, Choose sampling sites based on maps of AVO attributes of multibeam backscatter. (Fonseca)

Little Bay and Portsmouth Harbor, 4 November, Gulf Challenger, ISSAP Measurements. (Zoksimovski)

ENL's WASSP sea trials in Auckland Bay NZ, November 25, 2003. (de Moustier)

ONR Mine Burial Program Survey, 24 Nov – 04 Dec, Martha's Vineyard Multibeam survey before mine repositioning in test area. Second of three target surveys. (Raymond, Glang)

APPENDIX D:
Other Funding

Grant	PI	Grantor	FY Award	Total Award	Length
Alaska Fjords	Mayer	NSF	$57,471.00	$57,471.00	3 years
Collaborative High Resolution Mapping	Mayer	USGS	$50,000.00	$1,771,979.25	5 years
Collection of Bathymetry on Healy	Mayer	USGS	$25,000.00	$25,000.00	1 year
ECDIS Laboratory for Naval Operations	Alexander	University of Miss.	$55,000.00	$70,600.00	3 years
Electronic Chart for OCS-NOAA	Alexander	OCS-NOAA	$50,600.00	$50,600.00	1 year
Electronic Chart Imitative	Alexander	USACE	$31,608.00	$31,608.00	2 years
Electronic Charting	Alexander	NOAA	$25,101.00	$100,404.00	4 years
Electronic Charting for Naval Operations	Alexander	NAVOCEANO	$16,000.00	$63,800.00	3 years
Geoclutter Program	Mayer	ONR	$135,005.00	$450,478.00	4 years
Inland Waterways for Electronic Charting	Alexander	USACE	$49,640.00	$71,400.00	2 years
Intergraph Mapping	Jakobbson	Geo Media Research	$2000.00	$2000.00	1 year
Mapping Sea Floor off MA	Mayer	USGS	$169,300.00	$169,300.00	1 year
Mine Burial/Coastal Program Thru Web-Site	Mayer	ONR	$10,939.00	$128,572.00	3 years
Multibeam Swath Bathymetry	de Moustier	SCRIPPS	$20,088.00	$40,314.00	2 years
Multi-Scale Interaction w/3D Data Environment	Ware & Mayer	NSF	$169,213.00	$499,152.00	
Navigation Surface to Multiple Electronics Products	Alexander	NAVOCEANO	$49,640.00	$49,640.00	1 year
ONR Mine Burial Proposal for FY02 & FY03	Mayer	ONR	$100,798.00	$339,840.00	3 years
Perceptual Optimization for Data	Ware	NSF	$316,658.00	$316,658.00	2 years
Porting of Video Moasaicing	Mayer	USGS	$8294.00	$8294.00	6 months
Score Acoustic Survey Data Processing	de Moustier	SCRIPPS	$25,100.00	$25,100.00	1 year
Seacoast Science Center	Ware & Mayer	SSC		$45,468.00	2 years
Seafloor Sounding in Polar Regions	Mayer	NSF	$17,939.00	$17,939.00	1 year
St. Lawrence Seaway AIS-ECDIS	Alexander	DOT	$20,000.00	$20,000.00	2 years
Surveying Midwater Fish	Mayer & Baldwin	NSF	$111,526.00	$342,946.00	3 years
TYCO Endowment interest from perpetuity	N/A	TYCO	$23,148.00	$23,148.00	Perpetuity
Uncertainty	Mayer	ONR	$26,632.00	$256,586.00	2 years
Total			**$1,642,003.00**	**$4,978,297.25**	

APPENDIX E: Visitors January 1, 2003- December 31, 2003

Name	Date	From	Visiting	Purpose of Visit
Peter Simpkin	1/1/2003	IKB Technologies	Barbara Kraft, Mayer	ISSAP probe
Harry Maxfield	1/7/2003	RDI Inc	CCOM/JHC	Collaboration discussions
Masc Parent	1/7/2003	RDI Inc	CCOM/JHC	Collaboration discussions
Masc Parent	1/7/2003	RDI Inc	CCOM/JHC	Collaboration discussions
Fran Roe	1/7/2003	RDI Inc	CCOM/JHC	Collaboration discussions
Changli Fang	1/7/2003	RDI Inc	CCOM/JHC	Collaboration discussions
Paul Igo	1/7/2003	Electronic Sales of New England	CCOM/JHC	Collaboration discussions
Rob Morton	1/7/2003	SAIC	CCOM/JHC	Collaboration discussions
Dan Jagoe	1/7/2003	SAIC	CCOM/JHC	Collaboration discussions
Shannon Byrne	1/7/2003	SAIC	CCOM/JHC	Collaboration discussions
Paul Buttrose	1/7/2003	Loughridge Research	CCOM/JHC	Collaboration discussions
Edgar	1/7/2003	Loughridge Research	CCOM/JHC	Collaboration discussions
Bob Rowland	1/8/2003	USGS-ret	CCOM/JHC	Collaboration discussions
Richard Bates	1/9/2003	St. Andrews Univ. Scotland	Mayer, Cutter	Collaboration and visiting scholar
Bill Schwab	1/9/2003	USGS Woods Hole	Mayer	Collaboration on paper
Jane Denny	1/9/2003	USGS Woods Hole	Mayer	Collaboration on paper
Denise Crimmins	1/10/2003	NUWC Newport	Mayer, Armstrong, De Moustier	Collaboration
Tracy Fredericks	1/13/2003	Seacoast Science Center	Plumlee	Update progress of exhibit
Tracy Fredericks	1/24/2003	Seacoast Science Center	Plumlee	Set up second exhibit machine, train her in the use of the exhibit creation tools
Doug Hrovic	1/30/2003	Marine Magnetics	Mike Leo	Discussions - Magnetic Fusion/Open Talk/SeaQuest
Gary Kozak	1/30/2003	Klein	Paul Pelletier	Talk of Shipwrecks and Technology
Jim Jalbert	2/4/2003	Falmouth Scientific Inc.	Komerska	Use of GeoZui3DE in Solar AUV data analysis
Charles Benton	2/5/2003	TSI	Mayer	AV Meeting
David A. Patch	2/5/2003	TSI	Mayer, Ware	AV Meeting
Tracy Fredericks	2/6/2003	Seacoast Science Center	Plumlee	Update progress of exhibit
Mark Amend	2/7/2003	NOAA Fisheries, Santa Cruz Lab	Rzhanov	Discussion of Laser Line Scan data processing
David O'Brien and Tracy Fredericks	2/12/2003	Mystic Scenic Studios Inc. and Seacoast Science Center	Plumlee, Ware, and Arsenault	Update progress of exhibit
Chris Ward	3/4/2003	SONTEK/YSI	Glang, Huff	Presentation on SONTEK ADCP Product Line
Kevin J. McClurg	3/4/2003	SONTEK/YSI	Glang, Huff	Presentation on SONTEK ADCP Product Line

Todd Mudge	3/4/2003	SONTEK/YSI	Glang, Huff	Presentation on SONTEK ADCP Product Line
Dennis Hill	3/5/2003	NOAA (PHB)	Calder and Smith	Discussion of Snow Passage (H10949) Processing
Cathleen Barry	3/5/2003	NOAA (PHB)	Calder, Smith	Discussion of Snow Passage (H10949) Processing
LT John Longenecker	3/7/2003	NOAA Office of Coast Survey	UNH VP & CCOM/JHC (Armstrong)	Status of NOAA Swath Vessel Procurement
Mr. Geoffrey Fuller	3/7/2003	NOAA Office of Coast Survey	UNH VP & CCOM/JHC (Armstrong)	Status of NOAA Swath Vessel Procurement
Mr. John Kelly	3/13/2003	NOAA Coast Survey Development Lab	CCOM/JHC (Armstrong)	Introduction to CCOM/JHC
Bart Buelens	4/3/2003	Sonar Data- Tasmania Australia	Mayer/ CCOM	Discuss midwater fish mapping, give seminar
Friedhelm Moggert	4/7-4/11	SevenCs	Alexander	Visiting Specialist/Industrial
David O'Brien	4/24/2003	Mystic Scenic Studios Inc.	Plumlee, Ware, and Arsenault	Receive modified control yoke for exhibit and discuss logistics
Nigel Calder	4/30/2003	Author	Smith, Alexander, Brennen, & Ware	Author of books and popular magazine articles on chart reading and boat operations
Shannon Byrne, Joanne Wiggin	5/9/2003	SAIC Newport	Calder, Mayer & CCOM staff	Implementation of CUBE & SAIC future product plans
Terje Pedersen	5/13/2003	Kongsberg Simrad	Calder, Mayer & CCOM staff	Implementation of CUBE and Simrad processing methods for the future.
David Lane	5/15/2003	Heriot-Watt University	Mayer & Elston	Tour of Center
Tracy Fredericks	5/15/2003	Seacoast Science Center	Plumlee, Ware	update progress of exhibit, more training for exhibit creation
Dave Switzer	5/20/2003	NH State Marine Archaeologist, Plymouth State College	Leo	Discussion of potential wreck sites in region
Costa Rican national parks officials and students	6/2/2003	Costa Rica	Komerska and Plumlee	Demos of GeoZui3D and Haptic-GeoZui3D
B. Collins K. Rhynas	6/30/2003-7/1/2003	Quester Tangent Corporation	Dijkstra	Fieldwork and discussions, Vertical incidence echosounder and LIDAR seafloor characterization
M. Amend	7/7/2003	NOAA Fisheries	Rzhanov	Laser line-scan processing
L. Whitcomb	7/22/2003	Johns Hopkins University	Visualization Lab	Discussions on collaborative efforts
K. Niewiadomska	7/27/2003	Webb Research	McLeod	Engineering Tank
F. Moggert	7/30/2003- 8/30/2003	SevenCs	Alexander	Visiting Specialist/Industrial Consortium (Navigation Surface-> ENC)
D. Chu	8/1/2003	WHOI	McLeod Baldwin	SM2000 Calibration
F. Spickler	8/12/2003	Photo Science	Alexander Moggert	Navigation Surface-> Inland ENC
H. Danley	8/25/2003	NOA/OCS/NSD	CCOM	NOAA Progress Presentation

M. Gibson	8/25/2003	NOAA/OCS/HSD	CCOM	NOAA Progress Presentation
S. Gill	8/25/2003	NOAA/NOS/CO-OPS	CCOM	NOAA Progress Presentation
J. Hall	8/25/2003	UNG/GEOL SURV ISRAEL	CCOM	NOAA Progress Presentation
G. Noll	8/25/2003	NOSS/OCS/HSD	CCOM	NOAA Progress Presentation
B. Parker	8/25/2003	NOAA/NOS/OCS/CSOL	CCOM	NOAA Progress Presentation
R. Parsons	8/25/2003	NOAA/OCS	CCOM	NOAA Progress Presentation
K. Ries	8/25/2003	NOAA/OCS	CCOM	NOAA Progress Presentation
J. Riley	8/25/2003	NOAA/CSDL HSTP	CCOM	NOAA Progress Presentation
B. Taggart	8/25/2003	NOAA/NAS/RSD	CCOM	NOAA Progress Presentation
B. Barr	9/15/2003	NOAA National Marine Sanctuaries Program	Mayer	Discuss NMSP and CCOM joint work
C. Alexander	9/15/2003	NOAA National Marine Sanctuaries Program	Mayer	Discuss NMSP and CCOM joint work
J. Ressler, J. Henderson	10/16/2003- 10/18/2003	University of Rhode Island	Kraft, Mayer, Fonseca, Smith	Geoclutter Field Experiment (Portsmouth Harbor)
P. Simpkin	10/23/2003- 10/29/2003	IKB Technologies	Kraft, Mayer	ONR Geoclutter Field Experiment (Portsmouth Harbor)
J. Weirich	10/12/2003	NOAA, Ocean Exploration	Rzhanov	"Titanic" photomosaic
D. Cole	10/28/2003	OCS/CCOM/JHC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
B. White	10/28/2003	NMAO/Program Services	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
M. Yoklavich	10/28/2003	NOAA Fisheries	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
M. Webb	10/28/2003	OMAO/EED	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
R. Fields	10/28/2003	NMAO	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
B. Barr	10/28/2003	ONMS	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
K. Nadeau	10/28/2003	NMAO	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
A. Shepard	10/28/2003	OAR/NURP	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
A. David	10/28/2003	NMFS-SEFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
J. Weirich	10/28/2003	OE	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
K. Heron	10/28/2003	OE	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
J. Meehan	10/28/2003	NMFS-Ofc. Science &Tech.	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
B. McConnaughey	10/28/2003	NMFS-AFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
S. Ferguson	10/28/2003	NMFS-PIFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II

J. Miller	10/28/2003	NMFS-PIFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
D. Chu	10/28/2003	WHOI	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
M. Jech	10/28/2003	NMFS-NEFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
W. Michaels	10/28/2003	NMFS-NEFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
L. Hufangle	10/28/2003	NOAA-F NWFSC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
J. Swallo	10/28/2003	NOAA	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
D. Perry	10/28/2003	NMAO/MOC/EED	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
T. Loi	10/28/2003	NMAO/MOC/EED	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
J. Hotaling	10/28/2003	NMFS S+T	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
D.Renart	10/28/2003	NMAO/Program Services	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
C. Fox	10/28/2003	NESDIS/NGDC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
S. Fromm	10/28/2003	NMFS EPD	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
S. DeBow	10/28/2003	NOAA/DYS Formally NOAA OCS	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
F. Colohan	10/28/2003	NMAO/MOC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
J. Thomas	10/28/2003	NMFS/HC	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
R. Parsons	10/28/2003	NOS/Office of Coast Survey	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
C, McLean	10/28/2003	NOAA Ocean Exploration	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
G. Noll	10/28/2003	NOS/Coast Survey	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
M. Gibson	10/28/2003	NOS/Coast Survey	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
H. Pizzamiglio	10/28/2003	NMAO	CCOM/JHC	NOAA Multibeam Sonar/Ocean Mapping Workshop II
J. Frederickson	11/14/2003	NUWC	Komerska, Visualization lab	Discussions on collaborative efforts using haptics and GeoZui3D for AUV mission planning
R. Grizzle	12/4/2003	JEL UNH	CCOM/JHC	Discussion of observable effects of fishing in Jeffrey Ledge

Appendix F:
Papers, Reports, Abstracts and Talks
From January 2003 to December 2003

Publications:

Alexander, L. and R. W. Ward, 2003, We Visited You – 2nd International ECDIS Conference, *Hydro International*, Vol. 7, No. 10, p.38.

Arsenault, R. and C. Ware, (in press) The Importance of Stereo, Eye Coupled Perspective and Touch for Eye-Hand Coordination. *Presence*: *Teleoperators and Virtual Environments.*

Barnes, P., Fleisher, G., Gardner, J.V., and Lee, K., 2003, Bathymetry and selected perspective views of 6 reef and coastal areas in northern Lake Michigan. US Geological Survey Open-File Report 03-120 (http://geopubs.wr.usgs.gov/open-file/of03-120).

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Calder, B. R. and L. A. Mayer, 2003, Automatic Processing of High-Density, High-Rate Multibeam Echosounder Data, *Geochemistry, Geophysics, Geosystems*, *(DID 10.1029/2002GC000486) 4*.

Cutter, G. R., Y. Rzhanov, L. A. Mayer, 2003, Automated segmentation of seafloor bathymetry from multibeam echosounder data using local Fourier histogram texture features. *Experimental Marine Biology and Ecology*, *285/286*, 355-370.

Dartnell, P., J. V. Gardner, J. E. Hughes Clarke, L. A. Mayer, 2003, Bathymetry and acoustic backscatter of the mid and outer continental shelf, head of De Soto Canyon, northeastern Gulf of Mexico data, images, and GIS, U.S. Geological Survey Open-File Report OF03-007 (DVD).

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Gardner, J. V., P. Dartnell, L. A. Mayer and J. E. Hughes Clarke, 2003, Geomorphology, acoustic backscatter, and processes in Santa Monica Bay from multibeam mapping. Marine Environmental Research, v. 56, p. 15-46.

Gardner, J. V., in press, Predicting seafloor facies from multibeam bathymetry and backscatter data, Photogrammetric Engineering and Remote Sensing.

Goff, J. A., B. J. Kraft, L. A. Mayer, S.G. Schock, C.K. Sommerfield, H. C. Olson, S. P. Gulick and S. Nordfjord, 2003, Seabed characterization on the New Jersey middle and outer shelf: Correlability and spatial variability of seafloor sediment properties, in press *Marine Geology*.

Irani, P. and C. Ware, 2003, Diagramming Information Structures using 3D Perceptual Primitives. *ACM Transactions on CHI.* ACM Press. 1-19.

Jakobsson, M., J. Backman, A. Murray and R. Løvlie, 2003, Optically stimulated luminescence dating supports central Arctic Ocean cm-scale sedimentation rates, *Geochemistry Geophysics Geosystems, 4(2),* 1-11.

Jakobsson, M., L. A. Mayer and A. Armstrong, 2003, Analysis of data relevant to establishing outer limits of a continental shelf under Law of the Sea Article 76, *International Hydrographic Review, 4(1),* 36-52.

Jakobsson, M., A. Grantz, Y. Kristoffersen and R. Macnab, 2003, Physiographic provinces of the Arctic Ocean, *GSA Bulletin*, *115 (12),* 1443-1455.

Kosara, R., C.G. Healey, V. Interrante, D.H. Laidlaw and C. Ware, (in press) Thoughts on User Studies: Why, How and When. *IEEE Computer Graphics and Applications*.

Kraft, B. J., L. A. Mayer, P.G. Simpkin and J. A. Goff, 2003, In-situ measurement of geoacoustic sediment properties: An example from the ONR Mine Burial Program, Martha's Vineyard Coastal Observatory, *J. Acoust. Soc. Am.* 113, No. 4, 2318.

Lee, H. J., R. E. Kayen, J.V. Gardner and J. Locat, 2003, Characteristics of several tsunamigenic submarine landslides, in Locat, J. and Mienert, J., (eds.), Submarine mass movements and their consequences, Kluwer Academic Publishers, Amsterdam, p. 357-366.

Ramsey, D. W., P. Dartnell, C.R. Bacon, J.E. Robinson and J.V. Gardner, 2003, Crater Lake Revealed. U. S. Geological Survey Investigations I-2790.

Smith, D.H., L. Alexander, and M.F. van Norden, 2003, A world class ECDIS Laboratory, *Hydro International*, *Vol. 7*, No. 5, p.7-9.

Sternlicht, D. S. and C. de Moustier, "Time dependent seafloor acoustic backscatter (10-100 kHz)", J. Acoust. Soc. Am., 114(5), 2709-2725, 2003.

Sternlicht, D. S. and C. de Moustier, "Remote sensing of sediment characteristics by optimized echo-envelope matching", J. Acoust. Soc. Am., 114(5), 2727-2743, 2003.

Books or Book Chapters:

Grizzle, R. E., J. R. Adams, S. J. Dijkstra, B. Smith and L. G. Ward, 2003, Mapping and Characterizing Subtidal Oyster Reefs Using Acoustic Techniques, Underwater Videography, and Quadrat Counts, *Benthic habitats and the effects of fishing*, P. Barnes and J. Thomas, American Fisheries Society, Bethesda, MD, in press.

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

Jakobsson, M., A. Grantz, Y. Kristoffersen and R. Macnab, 2003, Bathymetry and physiography of the Arctic Ocean and its constituent seas, in *Arctic Ocean Organic Carbon Cycle: Present and Past*, edited by Stein, R., and R.W. Macdonald, R.W., Springer Publisher, Berlin, Heidelberg, New York, in press.

Ware C*.,* Design as Applied Perception, John Carroll Ed. *HCI Models, Theories & Frameworks*, pp 10-26, Morgan Kaufman.

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Alexander, L. 2003, Marine Information Objects (MIOs) and ECDIS: Content and Practice. Proceedings: U.S. Hydrographic Conference, Biloxi, MS.

Alexander, L. and R.T. Brennan, The Next Generation ENC: Dealing with X, Y, Z and Time*. Conference Proceedings: 2nd International ECDIS Conference,* Singapore, 7-9 Oct 2003.

Alexander, L. and M.J. Casey, The Rise and Stall of ECDIS: Where Are We Heading? *Conference Proceedings: 2nd International ECDIS Conference,* Singapore, 7-9 Oct 2003.

Arsenault, R., S. Smith, C. Ware, L. A. Mayer and M. Plumlee, 2003. Fusing Information in a 3D Chart-of-the-Future Display. U.S. Hydro 2003, CD-ROM Proceedings

Alexander, L. and P. Klutenaar, Harmonization of European and North American Inland ECDIS Standards, *Conference Proceedings: 2nd International ECDIS Conference*, Singapore, 7-9 Oct 2003.

Brennan, R., C. Ware, L. Alexander, A. Armstrong, L. A. Mayer, L. Huff, B. R. Calder, S. Smith, M. Plumlee, R. Arsenault and G. Glang, 2003, Electronic Chart of the Future: The Hampton Roads Project. Proceedings: U. S. Hydrographic Conference, Biloxi, MS.

Calder, B. R., Comparison and Combination of Shallow Survey 2003 Datasets. *Proceeding: 3rd Int. Conf. On High-Resolution Surveys in Shallow Water*, Sydney, Australia, Nov. 2003

Elston, G. R., Lidar Waveform Characterization for Bottom Classification, 4 th Annual Airborne Hydrography Workshop, Fort Lauderdale, FL, 27-29 Aug 2003.*Proceedings to be published on CDROM*.

Gallaudet, T.C. and C. de Moustier, "High-frequency volume and boundary acoustic

backscatter fluctuations in shallow water", J. Acoust. Soc. Am., 114(2), 707-725, 2003.

Jakobsson, M., M. Siegert and M. Paton, 2003.The grounding of an ice shelf in the central Arctic Ocean: A modeling experiment, ICAM-IV Meeting, Halifax, Sep 30-Oct 3 2003.

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Komerska, R. and C. Ware, Haptic-GeoZui3D: Exploring the Use of Haptics in AUV Path Planning, *CD ROM Proceeding: 13th International Symposium on Unmanned Untethered Submersible Technology* (UUST'03), Durham, NH, 24-27 August 2003.

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Monahan, D., J. Chance, P. Dare, S. Dijkstra, D. Dodd, S. Howden, J. Richer, M. Santos, D. Wells and D. Wiesenburg, 2003, Hydrographic Learning 24/7. *United States Hydrographic Conference 2003*, Paper 4B.4 CD-ROM.

Paton, M., L. Gee, B. R. Calder and L. A. Mayer, The Integrated Seafloor: Efficient Multi-Sensor Processing and Visualization Techniques for Seafloor Mapping Data. *Proceedings: 4th Australasian Hydrographic Symposium*, Nov 2003, Christchurch, NZ.

Paton, M., B. R. Calder and S. Sebastian, Automated and Visual Inspection Tools for Multibeam Quality Assurance and Data Analysis. *Proceedings: 3rd Int. Conference on High-Resolution Surveys in Shallow Water,* Sydney, Australia, Nov 2003.

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Smith, D. H., L. Alexander and M. F. van Norden, Joint USM – NAVOCEANO ECDIS Laboratory, *Proceedings: 2nd International ECDIS Conference*, Singapore, 7-9 Oct 2003.

Conference Proceedings (Abstracts):

Alexander, L., R.T. Brennan and F. Moggert, Converting High-Density Bathymetry into the 'Next Generation' ENC, paper presented at Shallow Survey 2003 Conference, Sydney, Australia 17-20 Nov 2003.

Anderson, R.M., D. Chayes, M. Rognstad and L. A. Mayer, 2003, Seafloor Sounding in Polar and Remote Regions. *EOS Transactions,* AGU 84 (46) Abstract OS42A-0831.

Backman, J., M. Jakobsson, R. Løvlie, L. Polyak, L. A. Febo, Central Arctic Ocean sedimentation: mm/ka-scale or cm/ka-scale rates? XVI INQUA Congress, Reno, Nevada 23-30 July 2003.

Backman, J., M. Jakobsson, R. Lovlie, L. Polyak and L. Febo, Is the central Arctic Ocean a sediment-starved basin? Paper presented at EGS-AGU-AUG Joint Assembly, Nice, France, 6-11 April 2003, Abstract CL25-1TH1P-1038.

Bransdsottir, B., P. Einarsson, R. S. Detrick, L. A. Mayer, B. R. Calder, N. Driscoll and B. Richter, 2003, Lost in Iceland? Fracture Zone Complications Along the Mid-Atlantic Plate Boundary. *EOS Transactions,* AGU 84 (46), Abstract, T22A-0504.

Detrick, R. S., B. Brandsottir, N. Driscoll, B. Richter, L. A. Mayer, D. Fornari, B. R. Calder and G. Kent, 2003, The Tectonic Evolution of the Tj \"{o}rnes Fracture Zone, offshore Northern Iceland-Ridge Jumps and Rift Propagation. *EOS Transactions,* AGU 84 (46), Abstract, T21E-03.

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Jakobsson, M. et al., Huge ice-dammed lakes in Russia during the last glaciation, XVI INQUA Congress, Reno, Nevada 23-30 July 2003.

Jakobsson, M., R. Macnab, A. Grantz and Y. Kristoffersen, Hypsometry, volume and physiography of the Arctic Ocean and their paleoceanographic implications, paper presented at EGS-AGU-AUG Joint Assembly, Nice, France, 6-11 April 2003, Abstract no CL25-1TH4O-004.

Krinner, G., M. Mangerud, M. Jakobsson, M. Crucifix, C. Ritz, J. I. Svendsen and C. Genthon, Impact of ice-dammed lakes on the Early Weichselian climate of Northern Eurasia. XVI INQUA Congress, Reno, Nevada 23-30 July 2003.

Lewis, C. F.M., S. M. Blasco, D. A. Forsyth, L. A. Mayer, S. Dijkstra, R. D. Jacobi,

B. J. Todd, J. P. Coakley and J. W. King, 2003, Do Quaternary sediments register paleoseismicity or neotectonic rejuvenation of ancient faults beneath Lake Ontario?, Geol. Soc. Amer. NE Section 38 Annual Meeting.

Løvlie, R., M. Jakobsson and J. Backman, Paleomagnetic chronology of Arctic Ocean sediment cores; reversals and excursions – the conundrum, paper presented at EGS-AGU-AUG Joint Assembly, Nice France, 6-11 April 2003, Abstract CL25-1TH4O-008.

Macnab, R. and M. Jakobsson, The International Bathymetric Chart of the Arctic Ocean (IBCAO): an improved morphological framework for oceanographic investigations, paper presented at EGS-AGU-AUG Joint Assembly, Nice, France, 6-11 April 2003, Abstract CL25-1TH1P-1047.

Mayer, L. A., B. R. Calder, R. Brennan, L. Gee, S. Smith, C. Ware, L. Alexander, A. Armstrong, R. Arsenault, M. Jurley, F. Mogger, M. Paton and M. Plumlee, New Paradigms for Hydrographic Data Processing and Products (invited), *Proceedings: 3rd Int. Conference. On High-Resolution Surveys in Shallow Water*, Sydney, Australia, Nov. 2003.

Mayer, L. A., B. R. Calder and J. S. Schmidt, 2003, High Resolution Multibeam Sonar Survey and Interactive 3-D Exploration of the D-Day Wrecks off Normandy. *EOS Transactions,* AGU 84 (46) Abstract, ED31E-02.

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Reports:

Alexander, L. 2003, A Synopsis of Electronic Charting Standards and Organizations, with Recommendations for U.S. Army Corps of Engineers Involvement, 14pp, USACE Topographic Engineering Center, Fort Belvoir, MD.

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Calder, B. R., 2003, How to run CUBE (with the baseline CCOM/JHC Implementation), CCOM internal report, 8pp. CCOM/JHC, Durham, NH.

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Huff, L. and T. Hou, 2003, Processing Klein 5410 data from Trawlex-01, Contract report for the U. S. National Marine Fisheries Services (NMFS), Alaska Fisheries Science Center, NOAA.

Talks:

Alexander, L., "Availability of Electronic Chart Data and Services in the Caribbean – Gulf of Mexico Region", Marine Press Seminar Series - North American Cruise Ship Industry, Miami, FL, 1 April 2003.

Alexander, L., "Current Plight of ECDIS Implementation" and "Next Generation ENC", Seminar presentation: Univ. of New Brunswick, Fredericton, 21 October 2003.

Alexander, L., "Reality of ECDIS Implementation" and "Next Generation ENC", Seminar presentation: Univ. of Southern Mississippi, Stennis Space Center, 3 December 2003.

Arsenault, R., "The Challenges of Data Visualization", Seminar presentation: UNH Retired Faculty, 18 October 2003.

Calder, B. R., On Error Models of MBES Systems, and their use in Hydrographic Data Processing, University of New Hampshire, Center for Coastal and Ocean Mapping, Durham, NH, 2003.

Cutter, G. R., Benthic Habitat Characterization of the Lower Piscataqua River Estuary Doctoral Proposal Presentation, Dept. of Earth Sciences, University of New Hampshire, Center for Coastal and Ocean Mapping, Durham, NH, 5 May 2003.

Calder, B. R., " The CUBE Method and Implementation Plans". Seminar presentation: NAVO visitors, NOAA staff and visiting scholars. CCOM/JHC, 14 July 2003.

Calder, B. R., 2003, "CUBE: What, How, When, Where". Seminar presentation: NOAA Ship Thomas Jefferson, 30 October 2003.

de Moustier, C., Water column assessment with a 68 kHz toroidal multibeam sonar NOAA Multibeam Sonar/ Ocean Mapping Workshop II, UNH-CCOM/JHC, October 29, 2003

de Moustier, C., T.C. Gallaudet and D.S. Brogan, " Three dimensional acoustic backscatter measurements in the water column with hull-mounted and towed multibeam echo-sounders",J. Acoust. Soc. Am., 114(5-2), Nov 2003 - (invited talk).

de Moustier, C., Overview of the Center for Coastal and Ocean Mapping, NOAA/UNH Joint Hydrographic Center, NH Sea Grant College Status site visit,

24 March 2003.

de Moustier, C., Acoustical Society of America Fall meeting, Nov 10-11, 2003. Austin, TX. (invited talk in special session on multibeam sonar applications in the water column)

Fonseca, L., "AVO Analysis of Acoustic Remote Sensing Data for Detection of Hydrocarbon Seepages on the Seafloor", Seminar presentation: CCOM/NOAA, 26 August 2003.

Gardner, J. V., "Deep-water reefs in the Northern Gulf of Mexico?" What are these things?" Seminar Presentation: Marine Sciences Univ. of California Santa Cruz, 20 August 2003.

Hou, T., "Techniques of Multibeam Surveying, Data Processing and Backscatter data Interpretation" Seminar presentation: Guangzhou Marine Geological Survey, Ministry of Land & Resources, P. R. China, 24-25 November 2003.

Jakobsson, M., 3D-visualization of geophysical and geological data sets, Seminar/ presentation at Bjerknes, Centre for Climate Research, University of Bergen, 17 January 2003.

Jakobsson, M., CCOM/JHC database compilation in preparation for a U.S. claim under the United Nations Law of the Sea (UNCLOS) Article 76, Seminar presentation at Instituto Hidrografia, Lisbon Portugal, 23 April 2003.

Kraft, B. J., In-situ determination of the variability of seafloor acoustic properties: An example from the ONR Geoclutter area, NRL, Stennis Space Center, MS, 28 March, 2003.

Mayer, L. A., Martha's Vineyard Multibeam Surveys, ONR Mine Burial Workshop, St. Petersberg FL, 28 Jan. 2003

Mayer, L. A., Fundamentals of Multibeam Mapping, NOAA Multibeam Workshop, Silver Springs MD, 12 Feb. 2003

Mayer, L. A., Future Directions in Seafloor Mapping, NOAA Multibeam Workshop, Silver Springs, MD. 12 Feb. 2003

Mayer, L.A., Visualization Tools for Seafloor Mapping, Invited presentation at workshop, U.S. Hydrographic Conference, Biloxi MS, 27 March 2003

Mayer, L. A., The Future of Seafloor Mapping, Invited Presentation GEBCO Centenary Celebration, Monaco, 17 April 2003

Mayer, L. A., Jakobbson, M, and Armstrong, A., Evaluating U.S. Holdings Relevant to Definition of the Limits of the Continental Shelf, Invited Presentation, Intl. Symposium on Legal and Scientific Aspects of Continental Shelf Limits, Reykjavik Iceland, 26 June 2003

Mayer, L. A., Visualization of Geophysical Data Sets, Invited Lecture, Darling Marine Center Summer Institute for Geospatial Data Analysis, 22 July 2003.

Mayer, L. A., Evaluating U.S. Holdings Relevant to Definition of the Limits of the Continental Shelf, U.S. Senate Forum on Law of the Sea, Washington D.C., 1 October 2003.

Mayer, L. A., New Paradigms for Multibeam Data Processing, Keynote Lecture, Shallow Survey 2003, Sydney, Australia, 18 Oct. 2003.

Mayer, L. A., Overview of NOAA Technical Needs for Multibeam Mapping, NOAA Multibeam Workshop, Durham, N.H., 27 October.

Mayer, L. A., Jeffries Ledge Multibeam Surveys, Marine Closed Area Working Group, Brown Center, Durham N.H. 30 Oct. 2003.

Mayer, L. A., New Directions in Seafloor Mapping and Visualization, Deep Submergence Lab Lecture Series, Woods Hole Oceanographic Inst. Woods Hole MA, 3-4 Nov.

Mayer, L. A. and M. Jakobsson, CCOM/JHC database, Seminar/presentation, given at NOAA Silver Springs, MD, 3 June 2003.

Plumlee, M., GeoZui3D Scripting Tutorial, University of New Hampshire, Center for Coastal and Ocean Mapping, 20 June 2003.

Raymond, R., "Remote Sensing of Sediment Transport in Glaciated Coastal Zone Environments." Seminar presentation: Sedimentology Class, University of New Hampshire.12 Dec 2003.

Rzhanov, Y., "Galapagos Mosaic: Lessons Learned",
Seminar presentation: Woods Hole Hydrographic Institution, MA 4 November 2003.

Taylor, R. Interrante, V., Ware, C., SIGGRAPH Full-day Tutorial Perceptually-base visualization design. 30 July 2003.

Ware, C., Information Seeking and the Objects of Visual Attention. Arthur M Sackler Colloquium of the National Academy of Sciences, Irvine CA, 9-11 May 2003.

Ware, C., Visual Space and the Cost of Knowledge, University of Toronto, 28 February 2003.
Alexander, L., Availability of Electronic Chart Data and Services in the Caribbean – Gulf of Mexico Region, Marine Press Seminar Series - North American Cruise Ship Industry, Miami, FL, 1 April 2003.

Ware, C., Visual Space and the Cost of Knowledge, University of Toronto, 28 February 2003.

Ware, C., "Thinking with Visualizations." VISSOFT Workshop on Software Visualization, Amsterdam, 22 September 2003.

Ware, C., "Thinking with Visualizations." Seminar presentation: InfoVis. Seattle, 20 October.

Ware, C., "Thinking with Visualizations." Seminar presentation: Advanced Research Development Activity. (ARDA). GI2Vis Phase II: Meeting. Mitre Corp.Washington.27 October

2003.

Ware, C., " Thinking with Visualizations." Seminar presentation: Brown University Computer Science Seminar. Providence RI, 27 October 2003.

Ware, C., "Distinguished Lecture Series. "Thinking with Visualizations." York University, Toronto, 19 December 2003.

Ware, C. and R. Arsenault, "GeoZui3D." Seminar presentation: Wood's Hole Oceanographic Institution. Wood's Hole, 4 November 2003.

Datasets:

Jakobsson, *et al*., 2003, Bathymetric contours and grid models above 64°N contributed to the General Bathymetric Chart of the Oceans (GEBCO) Digital Atlas (GDA), CD-ROM is available through the British Oceanographic Data Centre (BODC): (http://www.bodc.ac.uk/frames/index2.html?../projects/gebco/index.html&2)

Demos:

Plumlee, M., Demos of GeoZui3D given to Vice Admiral Lautenbacher on 8/20/2003.

Plumlee, M., Demos given to participants from NOAA Coast Survey in Planning meeting 8/25/2003.

Plumlee, M., Demos given to visitor from Mexican Hydrographic Program on 11/13/2003.

Plumlee, M., Talk and demos given to high school students at GIS day at UNH on 11/19/2003

Appendix G:
Meetings and Conferences Attended:

Alexander, L., U.S. Navy Electronic Chart Tactical Display Workshop, NAVOCEANO, Stennis Space Center, MS, 13-14 February 2003.

Alexander, L., MesoAmerican – Caribbean Sea Hydrographic Commission – Electronic Chart Working Group Meeting, Biloxi, MS, 24 March 2003. (Technical Coordinator)

Alexander, L., Marine Information Object (MIO) and Additional Military Layer (AML) Workshop, Biloxi, MS, 28 March 2003.

Alexander, L., IHO Transfer Standard Maintenance and Application Development (TSMAD) – ENC Extension Sub-Working Group 2nd Meeting, Canadian Hydrographic Service, Ottawa, Ontario, 12-16 May 2003.

Alexander, L., IHO Colours and Symbols Maintenance Working Group (C&WMWG) 14th Meeting, Canadian Hydrographic Service, Ottawa, Ontario, 18-20 May 2003.

Alexander, L., IEC Technical Committee 80, Working Group 13 (Navigation Display) 7th Meeting, St. Petersburg, FL, 21-24 May 2003.

Alexander, L., IHO Committee on Hydrographic Resource and Information Systems (CHRIS) 15th Meeting, IHB, Monaco, 10-13 June 2003.

Alexander, L., North American – European Inland ECDIS Workshop, Nijmegen, The Netherlands, 30 June – 3 July 2003. (Technical Coordinator and Rapporteur)

Alexander, L., 8th Meeting of IEC Technical Committee 80, Working Group 13 (Navigation Display), Portsmouth, UK, 22-24 September 2003. (Task Group Leader)

Alexander, L., North American Inland ENC Ad Hoc Working Group Meeting, Pittsburg, PA, 4-6 November 2003. (Technical Coordinator and Rapporteur)

Alexander, L., IHO-IEC Harmonization Group on Marine Information Objects (HGMIO) 2nd Meeting. IHB, Monaco, 14 June 2003.

Alexander, L., IHO Industry-Stakeholder Days, IHB, Monaco, 16-17 June 2003.

Arsenault, R., SIGGRAPGH 2003, San Diego, California, 27 July - 1 Aug 2003.

Calder, B. R., ONR Uncertainty DRI Science Meeting, Crystal City, Washington, D.C., April 2003.

de Moustier, C., UNH-BAE collaboration workshop, BAE, Nashua, NH, 4 February, 2003.

de Moustier, C., IEEE Oceanic Engineering Society Administrative Committee meeting

22 September 2003, San Diego CA (elected member)

de Moustier, C., NOAA Multibeam Sonar/ Ocean Mapping Workshop II, UNH-CCOM/JHC, October 28-29, 2003

de Moustier, C., IEEE Oceanic Engineering Society Administrative Committee meeting, Houston, TX, 3-4 May, 2003, (elected member).

Elston, G., 3rd International Lidar Mapping Forum, New Orleans, LA, 27-28 January 2003.

Gardner, J. V., Morphology and Geological Nature of Deep Seabed and Submarine Elevations in the Arctic Basin: Controversial Scientific Issues in context of UNCLOS/Article 76, St Petersburg, RU, 9 June-5 July, 2003.

Gardner, J. V., American Geophysical Union Fall Meeting, San Francisco, 5-14, December 2003.

Jakobsson, M., JEODI Workshop, Copenhagen Denmark, 13-14 January 2003.

Komerska, R., Virtual Reality 2003 Conference, Los Angeles, CA, 22-26 March 2003.

Komerska, R., Solar AUV Design Review, AUSI, Lee, NH, 3 Feb 2003.

Komerska, R., AUSI / NUWC AUV Common Control Language Meeting, AUSI, Lee, NH, 16 July 2003.

Komerska, R, AUSI / Rensselaer Polytechnic Institute RiverNet Project Meeting, Lee, NH, 3 October 2003.

Komerska, R., AUSI / Technology Systems, Inc. AusNet Project Meeting, Lee, NH, 21 November 2003.

Komerska, R., AUSI / Falmouth Scientific, Inc. / Technology Systems, Inc. Solar AUV Project Meeting, Lee, NH, 18 December 2003.

Kraft, B. J., US Hydro Conference, Biloxi, MS, 24-27 March 2003.

Kraft, B. J., ONR Uncertainty DRI Scientific Workshop, Arlington, VA, 8-10 April 2003.

Kraft, B. J., ONR Uncertainty DRI Meeting, Providence, RI, 18-19 June 2003.

Kraft, B. J., 146th Meeting of the Acoustical Society of America, Austin, TX, 10-14, November 2003.

Malik, M., 2003 Hydro Conference, Biloxi, MS, 24-27 March 2003.

Mayer, L. A., JEODI Workshop, Copenhagen Denmark, 13-14 January 2003

Mayer, L. A., National Academy of Sciences Coastal Mapping Wkshop, 16-17 Jan 2003

Mayer, L. A., Ocean Drilling Program Science Planning Committee, Austin TX 17-20 Mar 2003

Mayer, L. A., ONR Uncertainty Meeting, Arlington VA, 8-10 April 2003

Mayer, L. A., NSF Ocean Information Technology Steering Committee Wasthington DC 30 April 2003

Mayer, L. A., NSF Ocean Information Technology Steering Committee, Skamania WA 21-23 May 2003

Mayer, L. A., Chair, NRL External Review Team Meetings Stennis, MS, 29 – 31 July 2003

Mayer, L. A., NSF Ocean Information Technology Steering Comm. San Diego CA 27-29 August 2003

Mayer, L. A., NSF Information Technology Workshop, Washington DC 11-12 Nov. 2003

Plumlee, M., forUse 2003, (Second International Conference on Usage-Centered Design), Portsmouth, NH, 18-22 October 2003.

Rzhanov, Y. Oceans 2003, San Diego, CA, 22-26 September 2003.

Sullivan, B., forUse 2003, (Second International Conference on Usage-Centered Design) Portsmouth, NH 18-22 October 2003.

Ware, C., SIGGRAPH'2004 San Diego, July 27-30.

Ware, C., ACM Conference on Human-Computer Interaction, Fort Lauderdale, Florida 5-10 April 2003.

Ware, C., Graphics Interface Conference, Halifax, Nova Scotia. 11-13 June 2003.