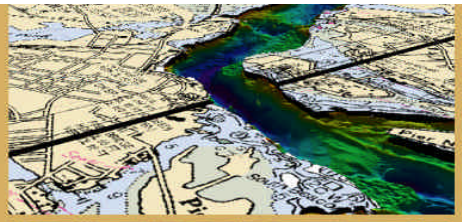

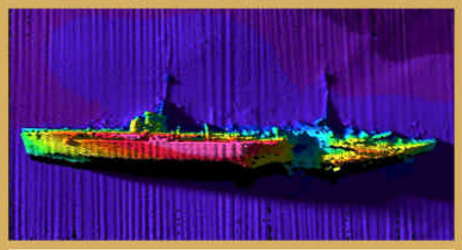

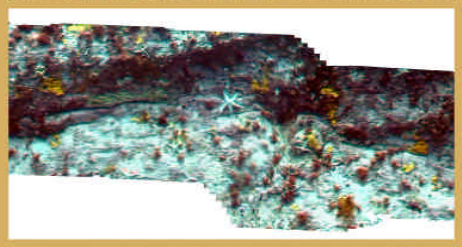

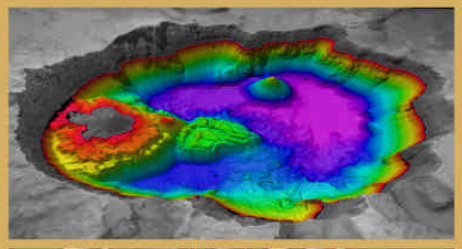

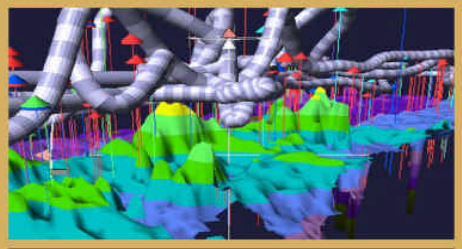

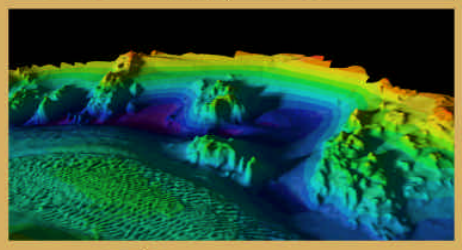

Performance and Progress Report: UNH/NOAA Joint Hydrographic Center

NOAA Ref No.: NA970G0241

Budget Period: 01/01/2001 to 12/31/2001
Project Period: 01/01/2001 to 12/31/2001

Report Period: 07/01/2001 – 12/31/2001

Project Title: Joint Hydrographic Center

Principal Investigator: Larry A. Mayer

Center for Coastal and Ocean Mapping
Joint Hydrographic Center

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 fifth in a series of bi-annual progress reports, highlighting the activities of the Joint Hydrographic Center during the period between 1 July and 31 December, 2001.

ACCOMPLISHMENTS TO DATE:

Infrastructure:

Personnel:

The key to the success of any center is the skill and talent 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 be brought to the University of New Hampshire. This has been accomplished, and with the arrival of **Dr. Christian de Moustier** in January 2002, all positions outlined in the original Center proposal have been filled. In addition, funding from external sources have allowed us to expand our staff to include a new laboratory manager (**Andy McLeod**) supported by ONR and NSF, two new Research Scientists (**Gareth Elston and Barbara Kraft**) supported by the USGS and ONR industrial sources, a GIS specialist (**Pam McLeod**) supported by ONR, and several hourly employees (**Chris Popham, Steve Vitali**, **Eric Lynsky**) as well as **Ben Smith** who maintains our newly acquired research vessel.

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 world-wide 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.

Chrisitan 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 is a senior marine geologist with the U.S. Geological Survey in charge of the Western Region's marine mapping program. He has been responsible for the multibeam sonar mapping of a number of areas off California, Hawaii and Florida, 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 will remain a USGS employee but will be seconded to the Center for several months per year.

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/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 four NOAA employees to the new Center:

Capt. Andrew Armstrong, Co-Director of the JHC, Captain Armstrong recently retired as an officer in the National Ocean 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.

Dr. 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 is 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.

LCDR. Gerd Glang is at the Center in two roles. He is 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. Lcdr 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.

Carl Kammerer, is an oceanographer with the National Ocean Service's Center for Operational Oceanographic Products and Services (CO-OPS) seconded to the Center. He is a specialist in estuarine and near-shore currents and presently the project lead or manager for two projects; one traditional current survey in Southeast Alaska, and the other 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. Dave spends part time at the University of New Brunswick and part time at the University of Southern Mississippi where he is participating in their new hydrographic program. Dave will be helping UNH establish its 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. At the JHC he worked on the use of transparent texture maps on surfaces.

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 recently 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.

Brian Calder, with a Ph.D. in Computing and Electrical Engineering is a Research Scientist in the Center. 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.

Semme Dijkstra 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. From1996 to 2000 he worked at the Alfred Wegner Institute where he has been 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.

Roland Arsenault was a 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 (TYCOM FELLOW) recently 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 will be working on seafloor characterization and the analysis of *in situ* seafloor acoustic data collected as part of the GEOCLUTTER program.

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. Prior affiliations have included Lawrence Livermore National Laboratory, PenMetrics, The Nature Conservancy, Maine Maritime Academy, and URS Corporation. 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.

Andy McLeod Andy is our new 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.

In addition to the academic staff, **Lisa Creitz** is our full-time program assistant and a pillar around which the Center is built.

Facilities and Equipment:

Our new 8000 square foot building is complete and more than fully occupied. Given the very rapid growth of the Center, space has become the limiting factor in our ability to take on new projects. Discussions are currently underway with the University about access to more space. All major computing, networking and plotting facilities are in place and operational including a 4-processor Origin 2100 Silicon Graphic server. A new fiber channel disk stripe brings our central server storage capacity to more than 750 Gbytes of disc space. We also have an SGI Octane workstation, 3 SGI O2 workstations, 32 high-end NT and Linux workstations and laptops and several Mac G4's. All computers 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. 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 several dedicated servers (one to serve as a web-based GIS host and the other as host of the "Common Data Set" collected for Portsmouth Harbor (see below). and a full suite of peripherals (4mm, 8mm, DLT and DVD-R) so that we can re-distribute the data on a range of media. We have completed the outfitting of 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; 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 x-y bridge and carriage system that allows a platform to be precisely positioned anywhere over the tank. We have also acquired and are installing a computer-controlled rotary turntable that will be mounted on the platform and used for

sonar testing and calibration. With the completion of this upgrade, UNH will have one of the largest and most advanced sonar calibration facilities in the Northeast.

We have completed the outfitting of, 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 (see Appendix A). The *Coastal Surveyor* was in almost continuous operation in support of data collection for Shallow Survey 2001 (see below) since its arrival in June. In support of these and other field operations we have acquired several state-of-the-art positioning systems (Ashtech and Trimble), a Seabird CTD system and Vitel and Aandera tide guages. In addition TSS has kindly donated a TS-335B motion sensor and ODOM has donated a Digibar sound speed calibration system. We have also been busy building a range of specialized survey equipment including underwater videography capabilities using a Sea Sciences Inc. controllable tow body as well as pole camera techniques (Huff and Cutter).

Educational Program:

The Center has, under the guidance of Capt. Armstrong, developed ocean-mapping specific curricula that have now been approved by the University (Appendix B). We now offer both M.Sc and Ph.D degrees with a specialization in Ocean Mapping through either the Dept. of Ocean Engineering or through the Dept. of Earth Sciences 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 ESCI/Oceanography program and engineers entering through the Ocean Engineering program. 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, FIG/IHO, NOAA). This has proven very useful as our students are allowed to attend these courses and are thus exposed to a range of state-of-the-art systems and important issues. 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. Captain Armstrong offers a Hydrography course and Colin Ware offers both a Data Structures course and a Data Visualization Course. Larry Mayer teaches a Marine Geology and Geophysics course and Mayer and Brian Calder teach a course on Seafloor Characterization. Dave Wells, Lloyd Huff and Semme Dijkstra offer a Geodesy Course in the summer semester. Dave and Semme are now working on a web-based version of this course for distance education. With the arrival of Christian de Moustier, a sonar signal processing course will be added. We have eight students enrolled in the program, including two NOAA

Corps Officers and produced our first Ph.D this summer with the successful completion of Luciano Fonseca's thesis.

Student	Program	Advisor
Gerd Glang	M.Sc., OE	TBD
Mike Leo	Ph.D. ES	Mayer, Calder, Huff
Tony Hewitt	PhD. ES	Mayer
Luciano Fonseca	PhD.,OE (completed Sept.)	Mayer
Randy Cutter	PhD, ES	Mayer
Matthew Plumlee	Ph.D. Comp Sci	Ware
Richard Raymond	M.Sc., E.Sci	TBD
Shep Smith	M.Sc, OE	TBD
Tianhang Hou	Ph.D., OE	Mayer, Huff

Research Program – 2000 - 2001:

In our first biannual report 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 NOAA. As the need arose, we also started several new initiatives. Here, we report on the progress made on these tasks during our fourth six months of operation as well as several new efforts that have begun.

Innovative sonar design and processing for enhanced resolution and target recognition

While this theme is one of our least active (its activity will be enhanced with the arrival of de Moustier in January), Rzhanov and Peter Runciman of Klein continue with both theoretical and practical work on improved designs and processing algorithms for interferometric sonars. Rzhanov also continues to work on the development of an acoustic communication link based on "multichirps. A provisional patent application has now been filed by the University for this innovative approach to digital communication. The upgrade of our acoustic test tank, the completion of our electronic lab, and the arrival Christian de Moustier will also lead to an expanded effort in this theme. We are already scheduled to use the tank and new rotary table to test and calibrate a Simrad SM2000 multibeam sonar. This work, done in collaboration with researchers from the Canadian Dept. of Fisheries and Oceans and Woods Hole Oceanographic, is aimed at exploring the feasibility of using the SM2000 to simultaneously map both the seafloor and mid-water targets, an important concern of NOAA with respect to upgrades in their fishery research vessels.

New approaches to multibeam sonar data processing:

Binary format data access:

An initial component of this theme was the development of a generally usable software tool that would allow us to read almost all forms of multibeam data. This has been accomplished and to date file descriptions for the Simrad EM 300, 1000, 1002 and 3000 multibeam systems have been tested, along with those for the Reson SeaBat 8100 series, Hydrosweep DS-2 (through GSF), Klein 5000 series sidescan sonar, and the XTF-

meta-format. This reader is now in general use in support of Center activities. A full description of its capabilities can be found in earlier progress reports.

Improved Bathymetric Processing:

An ongoing effort of the Center has been to develop improved data processing methods that will provide NOAA (and others) 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 NOAA "data processing pipeline". Over the past year we have explored a number of different approaches for automated data processing (see earlier progress reports for descriptions of these approaches). We have finally focused on a technique developed by Brian Calder that appears to be both very fast (10's to 100's of times faster than the standard processing approaches) and statistically robust. The technique, known as CUBE (Combined 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. A Kalman filter is used for integration of the estimates providing a recursive optimal solution to the estimation problem, noise suppression and mean/variance estimates. Most importantly, the technique produces an estimate of uncertainty associated with each grid node, and, when the automated technique fails to draw a conclusive decision, it presents 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. Details of this approach have been presented in earlier progress reports; improvements made since the last report include:

- The model has been extended to support Hydrosweep DS, Reson 8125 (preliminary model not including the SNR improvements implicit in dynamic focusing), dual-headed GSF data, static roll offsets in the error model and generic text-format tide files.
- The estimator can now be extracted for easier integration with other systems. It is now presented in three levels: individual nodes, static fixed grids of nodes, and a mapsheet of such grids tiled over an extensive area with caching to speed up access and actively manage memory usage.
- Interfaces to GeoZui3D (see below) file formats have now been built for visualization of raw data scaled by error estimate, and hypothesis clouds scaled by estimate uncertainty.
- CUBE has been used to process NAVO data (EM3000 in SAX'99 survey area) with planted mine-like objects. There was limited success in detecting these objects due to pervasive intermittent swath-wide shoal readings that caused multiple hypotheses. Processing did correctly estimate bathymetry, however, and identified areas with systematic data problems in certain cases.
- Processed SAIC dual-headed 8125 data from Portsmouth Harbor for mock-up integration of CUBE surfaces with Fledermaus.
- Processed EM1002 data from USGS Gulf of Mexico mapping campaign. Comparison of hand-edited and automatically processed surfaces shows that surfaces constructed with/without flags are statistically the same.

- Preliminary analysis for porting the library to Win32 platforms has been started.
- Built a prototype GUI interface to estimation library. This allows for investigation of new data sets as well as acting as a test-bed to clarify required code module interfaces for the library. System is currently limited in functionality, but useful.
- Established interface to MBSystem's MBIO data interface sub-system via GSF files. Allows conversion of almost any data format into something CARIS/HIPS or CUBE can use, at least at a basic level.

A paper describing the CUBE approach to automated multibeam data processing was presented at Second International Conference on High Resolution Surveying in Shallow Water (Calder, 2001) and generated tremendous interest from the hydrographic community. Several meetings with senior NOAA personnel led to the establishment of a verification project whereby the CUBE approach will be applied to three NOAA data sets:

1- a data set that was collected some time ago and has already been processed (Snow Pass, Alaska)
2- a data set that NOAA is currently working on (Woods Hole, MA)
3- a data set that NOAA will collect – the CUBE approach will be carried out in parallel on board (Valdez, Alaska)

In each case, the output of the CUBE processing will be compared to the NOAA smooth sheet for verification of the approach. The verification work will be done under the supervision of Lt. Shep Smith at UNH and LCdr. Guy Noll in Silver Springs.

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 is developing the concept of the "navigation surface" as part of his thesis work. The navigation surface is a surface that is designed to respect all concerns for safety of navigation but at the same time preserves the full detail of the original data when warranted. The verification exercise described above will also address the veracity of the navigation surface as a hydrographic product.

As outlined above, there has been tremendous interest in bringing both CUBE and the navigation surface on-line into the standard processing streams. To address this we have already experimented with near real-time applications of CUBE processing with the USGS during a survey in the Gulf of Mexico and have had several meetings with representatives of NOAA, NAVO, CARIS, SAIC and IVS to discuss implementation of these approaches into the NOAA and NAVO processing schemes. The most exciting of these meetings was a two-day meeting at the Center, of the key players in hydrographic data processing from NOAA, NAVO and industry. At this meeting the organizations exchanged perspectives and approaches and identified shared problems and potential

solutions. In arranging, hosting and participating in this meeting 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 a focal point for more efficient and collaborative research efforts aimed at solving a national need.

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, and House) 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 the last two progress reports; during the current reporting period, GeoZUI3D has continued to develop and grow and made available to the public. New additions to GeoZui3D include:

i. The recording mechanism have been revamped to be more robust to changes in future versions and provide more control over playback speed.
ii. Some of the rendering code has been rebuilt to make GeoZui3D work properly with certain faulty graphics drivers.
iii. More scripting capabilities have been added, documenting the scripting facilities within GeoZui3D.
iv. Lat-long/UTM projection capabilities have been added. We have begun integrating into file formats, to allow lat-long specifications
v. A GUI infrastructure for conversion scripts and internal infrastructure for resampling methods has been added. The internal infrastructure allows GeoZui3D to read ASCII grid data in a number of configurations and convert them to GUTM's in memory. Currently, the only conversion method that has been completed is a bilinear interpolation method.
vi. The ability to display real-time MPEG video has been added.
vii. Real-time data display capabilities have been improved through refinements in the quadtree structure and integration with the CUBE algorithm (see above).

GeoZui3D is now being widely with more than 40 groups having downloaded the software. It is being used as a display and QC tool both on board NOAA survey vessels and in NOAA labs. Expansion of its capabilities done in collaboration with Skip Little and GLOBEC researchers at WHOI have led to the development of displays for visualizing water column and vector field data.

A series of more theoretical studies are also being conducted on human computer interaction so as to optimize interface and display techniques. Included in this research are:

i. Studies with Don House that explore means of optimally displaying one transparent surface over another.

ii. An NSF-funded study designed to better understand perceptual and task-related frames of references in computer displays. This includes looking at the value of wide versus narrow fields of view as well as multiple windows versus zooming.

iii. We are exploring the value of force feedback or "haptic" feedback as an interactive interface. These studies include enhanced route-planning tools, touch-enhanced placement of objects and 3-D touch-enhanced interactive queries. Specific tasks completed in this area include:

1. Creation of a set of guidelines for designing haptic widgets, and creation of a set of center-of-workspace haptic navigation widgets.
2. Implemention of a GeoZui3D-based fishtank VR testbed for research and demonstration, focusing particularly on utilization of haptic feedback as a user interface element. Demonstrated initial haptic scene navigation tools for user interaction in GeoZui3D and touchable bathymetry.
3. Development of storyboard concepts and initial coding for application-specific haptic widget set to support AUV/ROV path planning tool.

Finally we have started work on the application of our visualization capabilities to the development of an interactive display for the N.H. Seacoast Science Center. This project is considered a prototype for the design of interactive museum exhibits that can help bring the wonders of ocean science to the general public.

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 of Oyster Reefs: With additional funding from CICEET and SeaGrant, Semme Dijkstra, working in collaboration with Ray Grizzle and Larry Ward of the Jackson Estuarine Lab and Bruce Smith of the N.H. Dept. of Fish and Game has been exploring the feasibility of using acoustic remote sensing techniques to map and monitor shellfish habitats. To date, several data sets have been collected over local oyster reefs in Great Bay:

1) Video imagery collected with a drop frame camera
2) Multi-transducer single beam "sweep data" collected with an QTC Isah-S system and a Navitronics Seadig system installed on the "Miramichi Surveyor"

3) Multibeam sonar data using a Reson 8125 sounder installed on our pontoon boat – the data from this survey were corrupted (navigation data not logged, although updating during acquisition). We are still investigating the cause of this problem.
4) Sidescan data using a Klein 5000 sidescan sonar hull mounted on the pontoon boat -- the data shows good correlation with the presence of oysters.

We have also been working closely with NOAA staff at the Olympic Coast National Marine Sanctuary in support of their efforts to monitor the effects of the emplacement of a fiber optic cable through the marine sanctuary. Semme Dijkstra has been processing single beam and sidescan sonar data from the Sanctuary in order to remove navigation artifacts. Preparations are now underway for a second habitat mapping cruise in the Sanctuary that will also involve collaborative work with the Quester Tangent Corporation.

In support of these and other seafloor characterization exercises, Dijkstra has continued the development of several software tools. The Lassoo tool for comparing multivariate data sets to imagery data sets in both geographic and multivariate feature space, now supports various input data formats, visualization in 3 data spaces, active querying with text output in two data spaces, selection of areas, and manual classification in two data spaces. All algorithms are now are geodetically correct and mouse coordinates are actively tracked. The application architecture now supports a variable number of features for both data points as well as areas in both geographic and feature spaces. The data structure also supports later addition or removal of feature data.

Sidescan sonar: Lloyd Huff and Tianhang Hou are working with the Alaska Fisheries Service of NOAA/NMFS on a major Klein 5000 sidescan sonar survey in the East Bering Sea. These data are now being processed and analyzed by JHC scientists. To date, data formats have been converted and corrections made for beam patterns, fish attitude and heading. The first mosaics are currently being generated. Once mosaiced, an automated classification technique, developed by Rzhanov and Hou will be 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 (with requested number of clusters) is performed, the mean signature for each cluster is calculated and then fed into an optimization algorithm for inversion for the seafloor property parameters.

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 EM3000 data collected in support of the ONR-sponsored SAX-99 experiment as well as EM1002 data collected in conjunction with the USGS, EM1000 data collected for ONR, and more recently, multibeam sonar data collected by NOAA and others in Portsmouth Harbor (see below).

Luciano Fonseca who recently completed his thesis, used the automatic code generating software developed by Calder (see above) to develop an algorithm to interpret Simrad datagrams and extract beam position, beam angle, and raw backscatter coefficients. Once read, all necessary corrections (Lambertian, TVG flattening near nadir, area of insonification and slope corrections) are done (for slope corrections, true grazing angle for each beam is calculated based on a terrain model of the area). Luciano has also implemented an algorithm to calculate the backscatter angular response based on Jackson and Mourad's (1986) model, but with the addition of the effect of near-surface gas. This model has been tested against EM1000 backscatter data collected in support of the ONR STRATAFORM project off the Eel River, northern California, and against core samples with free gas measurements collected by researchers from the Monterey Bay Aquarium Research Institute. In each case (against the measured backscatter and the ground truth from cores), the model accurately predicts the effect of gas on backscatter and has explained anomalous backscatter data values on the Eel River Margin. PetroBras, Luciano's employer is now designing a major experiment to test this approach in the Campos Basin.

Tianhang Hou and Lloyd Huff have been using the SAX-99, EM3000 data to explore the variations in backscatter (and bathymetry) as a function of grazing angle and vessel heading as well as developing sophisticated wavelet based approaches to segmentation of backscatter data. Interpretation of azimuthally dependent backscatter levels led to the determination of the presence of sand waves with preferred east-west crest orientations. Subsequent ground truth data provided by NAVO supported this remotely determined conclusion. Tianhang has also developed a graphical interface that allows the easy evaluation of the spatial variation of backscatter vs. grazing angle. With a mouse click, images based on different subsets of the data can be compared throughout the survey area

A graphical interface was also built to display Jackson and Mourad's (1986) composite roughness and sediment volume scattering model so that backscatter as a function of grain size, and the six parameters of the model can be predicted. Using these tools, Hou and Rzhanov applied a grain size algorithm that searches for a local minimum, beginning from an initial guess of constant grain size value for the entire area. The cross correlation between the optimized grain size and the 22 ground truth samples of grain size is 0.86, indicating the potential for using multibeam backscatter to predict the grain size of seafloor sediments.

A new approach to seafloor characterization based on the automated segmentation of multibeam sonar data into regions of common geomorphology is being developed 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. Results have been good, robust, and repeatable. Further development will include: optimizating bounding ranges for LFH's, and automating selection of the number of cluster groups. In support of these studies, Cutter has collected a number of ground-truth samples and video data.

Finally, with the arrival of Gareth Elston, we begin a theoretical look at sonar interaction with the seafloor. Elston is developing as 3-D sonar simulation model based on the pseudospectral (PS) time-domain method for solving the acoustic wave equation. The modeled seafloor can be given realistic properties (sound speed, density and attenuation) and for a given sonar geometry, the time dependent pressure at any given node can be determined and animations of the evolving acoustic field created. These models will be used to better understand the performance of our sonars as well as to gain insight into their ability to remotely characterize the seafloor.

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. Further developments to acquisition algorithms have been implemented resulting improved corrections for perspective distortion and more rapid mosaic formation. Camera calibration has been thoroughly tested and demonstrated to provide a 30% improvement in mosaic quality. New software has been written to allow use of Firewire technology and Windows 2000. A new approach to deriving camera path and attitude from the sequence of transforms used to make the mosaic has been developed. This technique may lead to a means of extracting 3-D feature shape from the video imagery.

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), and Mayer and Cutter have demonstrated the feasibility of texture mapping video mosaics over high-resolution 3-D multibeam bathymetry. Cutter has analyzed these mosaics for habitat features as well as developed automated techniques for segmentation and classification based on feature shapes, size and color. These techniques have been used to produce counts and abundance estimates of biogeoacoustic features.

Huff and Cutter continue to work with researchers from the Jackson Lab on designing a combination camera grab-core system that will be invaluable for ground-truthing our acoustic studies.

Data Mining, Blending and Fusion:

During the last year we have begun research aimed at the development of 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 was described in the last two progress reports; a paper describing the technique is currently under review with the Journal of Geophysical Research.

Jakobbson has also applied the same approach to a more controlled, local database collected in Great Bay. As part of a CICEET project in which the Center is

involved (see below), we have compiled all soundings collected over the last 100 years in Great Bay New Hampshire. Working with Armstrong, Alexander and Leo, he has combined data sets from 1913, 1953 and 1954 into a single database and, after tracking the uncertainty associated with each data set, have 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 within the estuary.

NEW PROJECTS:

The Center tries to be as responsive as possible to the needs of NOAA 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:

At the request of NOAA, we have focused some effort on critical areas of Arctic Ocean Bathymetry with respect to Law of the Sea. Details of these efforts for the first 6 months of 2001 have been described in our previous progress report; since this report, Martin Jakobbson has completed the report on the AISC/IOC/IOH Editorial Board meeting held at CCOM 21-24 May and it has been published as a Geological Survey of Canada Open File Report. The final IBCOA contours have been produced and forwarded to GEBCO for inclusion in the GEBCO Digital Atlas. Finally, the Arctic Ocean bathymetry has been updated and forwarded to NGDC for distribution.

Jakobbson has used the newly updated IBCAO bathymetry of the Arctic to study the hypsometry and volume of the Arctic Ocean and its constituent seas (critical to a range of oceanographic modeling efforts), He has also applied image processing techniques to slope data derived from this new bathymetry in order to segment the Arctic Ocean into a series of physiographic provinces.

Shallow Water Survey 2001

A major focus of our efforts over the last six months has been the preparation for, and hosting of, **The Second International Conference on High Resolution Surveys in Shallow Water**, held at the Sheraton in Portsmouth, 24 –2 7 Sept. The meeting was a remarkable success attracting more than 225 participants representing at least 12 nations, 16 government agencies, and 52 corporations. Fifty papers were presented, ten of them by members of the Center. A recent review of the conference in "Hydro International" (Appendix B), the international trade journal of the hydrographic community stated:

> "This inspiring conference was arranged by the Center for Coastal and Ocean Mapping and the Joint Hydrographic Center, both of which are located in the University of New Hampshire. This is really where the cutting edge of hydrography is now located ....."

Not only was the conference itself a success, but the data collected in support of the conference has been, and will be, invaluable to the community and to the growth of the Center. The concept of the Shallow Water Surveying conferences is that a "common data set" is collected well before the conference and then distributed to the international

community. This presented a tremendous opportunity for the Center to "get its feet wet" and become directly involved with the collection and processing of a major data set. Thanks to the tremendous cooperation of NOAA's Office of Coast Survey the NOAA Ship *Whiting* was able to come to Portsmouth Harbor and collect multibeam and sidescan sonar data in early November. NOAA also collected aerial photographs of the New Hampshire and Maine coasts and a NOAA tide station in Portsmouth Harbor was re-established to support the *Whiting* survey and future work.

The NOAA surveys generated a spectacular bathymetric and sidescan data set of Portsmouth Harbor as well as the opportunity for Center personnel to meet the NOAA survey teams and work hand-in-hand with them on the collection and processing of data. As a result of these interactions many ideas were generated and exchanged that will inevitably improve the NOAA data collection and processing flow.

The common data presently includes:

- Reson 8101 data collected by NOAA
- Klein 5000 sidescan sonar data collected by NOAA
- Submetrix interfermetric sidescan data collected by the USGS Woods Hole
- Navitronix sweep data collected by the Dept. of Public Works Canada
- Simrad dual head EM3000 data collected by Simrad
- Reson 8125 dual head and 8128 forward looking data collected by SAIC
- Triton-Elics 200 kHz multibeam data collected by Triton Elics
- Geoacoustics 125 and 250 kHz interferometric sidescan data collected by Geoacoustics
- Odom Echoscan data collected by Odom
- Atlas Fansweep 20 data collected by Odom
- Elac 1180 data collected by Seabeam L3
- Reson 9001 data collected by the Army Corps of Engineers
- EdgeTech MPX multifrequency sidescan data collected by EdgeTech
- IKONOS satellite imagery provided by Space Imaging
- SHOALS LIDAR data collected by the Army Corps of Engineers
- Video mosaic data collected by CCOM
- A core sample database collected by the Jackson Marine Lab

With the exception of the NOAA, USGS, DPW, ODOM and ACoE surveys, all of the other sonar data was collected from our new survey vessel *Coastal Surveyor* operated by either Capt. Armstrong or Lt. Smith.

The data set collected in Portsmouth Harbor is unprecedented, representing the imaging of Portsmouth Harbor with virtually all high-resolution sonar systems in existence. More surveys are planned over the next few months and given the wealth of data already available in Portsmouth Harbor, it will continue to be a focal point for system inter-comparisons for years to come. The data collected in Portsmouth Harbor has also become a major focal point for UNH/JHC research projects. For example, Randy Cutter is analyzing sonar bathymetry and imagery from Portsmouth Harbor with the hope of extracting estimates of roughness and seafloor type that can then be compared to video mosaics and other habitat metrics. Lloyd Huff is using a remarkable time series

of high resolution sidescan records collected over a sand wave field in Portsmouth Harbor (acquired over the last three years by Klein Associates during pre-delivery check-out cruises of their Model 5000 sonar system) to look at the migration of the bedforms and seafloor dynamics.

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. We have already established liaisons with the private sector including Tyco-Simplex, Klein Associates, C&C Technologies, AUSI, Interactive Visualization Systems, Triton-Elics, Reson and ODOM. Our involvement with Tyco-Simplex 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. In addition, grants are already 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 2). The USGS supports collaborative projects involving multibeam sonar mapping as well as a post-doctoral fellow at the Center (in addition to their seconding a senior scientist to the Center). A brief description of the externally funded projects follows:

USGS-UNH Cooperative Agreement:

The U.S. Geological Survey's Western Coastal & Marine Geology Pacific Mapping Project (PMP) has an ongoing collaborative agreement with the Center for Coastal and Ocean Mapping at the University of New Hampshire. As part of this agreement, the CCOM will provide the PMP with high-resolution, multibeam and co-registered backscatter maps of selected offshore areas. Additionally, CCOM provides the USGS with a Post-Doctoral Research Associate whose work is focused on understanding the links between geological facies and backscatter collected by sonar and LIDAR. As part of this arrangement, Dr. Jim Gardner of the USGS PMP spends several months per year at the CCOM.

This year's research effort focused on a major mapping expedition in the N.E. Gulf of Mexico. This cruise, spearheaded by Dr. Jim Gardner, represents a prime example of inter-agency cooperation as objectives of the USGS Biological Resources and Geological Divisions, NOAA's NMFS and the MMS were all addressed. Mapping focused on deep water reef complexes and 3 marine protected areas off the northwestern Florida shelf and upper slope. Mayer and Calder participated in this cruise and in addition to the environmental mapping objectives we also used the cruise as a testbed for developing the automated processing techniques (CUBE) described above. On this cruise, the comparison of automatically edited and hand-edited data showed no statistical difference.

Mutually beneficial collaboration and cooperation with NOS Office of Coast Survey was also demonstrated in the highly successful multibeam mapping of Puget Sound immediately after the 2001 Nisquilly earthquake. Dr. Gardner took advantage of the presence and capabilities of the NOAA Ship *Ranier* to map the three delta fronts of Southern Puget Sound to search for evidence of sediment failure that may be a danger to

the region. Although evidence for failure was found, it is equivocal whether these failures were caused by the 2001 earthquake or earlier events. During the most recent reporting period, Dr. Gardner extended this work by combining LIDAR data with the bathymetry. Collaboration between NOAA NOS Office of Coast Survey and the USGS PMP continues with joint work on Glacier Bay.

GEOCLUTTER – ONR (Mayer, P.I.)

In support of the ONR Defense Research Initiative (GEOCLUTTER), the Center of Coastal and Ocean Mapping has developed and built a system capable of making multiple, *in-situ*, measurements of seafloor sound speed and attenuation in water depths up to 300 m. The instrument was deployed on the *R/V Cape Henlopen* in July of 2001 off the coast of New Jersey. The instrument worked flawlessly, collecting over 30 Gbytes of acoustic data that is now being analyzed by Barbara Kraft. The measurements made with this system will be used to better understand the real distribution of seafloor acoustic properties and thus to improve methods for the interpretation of seafloor acoustic data and the remote characterization of seafloor sediments.

STRATAFORM – ONR (Mayer , P.I.)

The ONR STRATAFORM project is a multi-year, multi-investigator program aimed at understanding the origin of the stratigraphic record that interacts with Navy sonar systems. We collected multibeam sonar data in the study area off Northern California and have been analyzing the backscatter data from this area in an attempt to understand the processes responsible for changes in backscatter. We have also developed an ARCVIEW based GIS that contains most of the data collected in the STRATAFORM area and have converted this into an interactive, 3-D GIS. The STRATAFORM Project and another new Navy program (Mine Burial – see below) has supported the hiring of a new GIS specialist as well as the establishment of a web-based GIS server for the STRATAFORM and buried mine data sets.

Mine Burial – ONR (Mayer, P.I.)-

The Navy has called upon the mapping expertise of the Center to provide base maps and detailed surveys of a small area south of Martha's Vineyard where ONR will be conducting a multiyear experiment to explore the fate of mines deployed in a dynamic environment. A regional survey was recently conducted by the USGS with a Submetrix system and from this survey a specific deployment site will be selected. The selected site will be surveyed in great detail with a Reson 8125 focused multibeam sonar and then instrumented mines (inert) will be deployed. Up to 4 resurveys of the mine deployment site will take place over the next year to monitor the fate of the mine. In addition to this work, the Center will also host a web-based GIS containing all data collected in the multi-investigator program.

Uncertainty – ONR – (Calder and Mayer, P.I.'s)

The Navy has recognized the limitations of their acoustic propagation models in shallow water and has embarked on a major effort to quantify the uncertainty associated with these models. Based on the work of Calder in producing real-time uncertainty maps of seafloor bathymetry (an important component of the propagation model) as well as our experience with both quantifying error sources in multibeam sonars and visualization of a range of complex geospatial data, ONR has asked that we participate in this program.

Great Bay bathymetry - CICEET (Mayer, Armstrong and Ware, P.I. s)

The finite element models that are used to predict the distribution and fate of effluents and contaminated sediments in Great Bay (and other) estuaries are based on the digitization of selected soundings and contours from NOAA charts. We believe that this provides an inappropriate database for flow models and have collected all existing bathymetric data from Great Bay and produced a much more accurate bathymetric model for input into the finite element models. There are 8 historical data sets for the Bay and Jakobbson and Calder have applied the Monte Carlo technique they developed for tracking uncertainty in Arctic bathymetry the Great Bay data. Based on these analyses, real historical changes in channel development can be separated from uncertainties in the data.

Multi-scale interaction with data environments – NSF (Ware, Mayer, P.I.s)

This three year project is aimed at developing new approaches to interactive visualization of environments that must encompass large changes in scale. An example is an AUV that may have only a coarse global bathymetric database to begin its mission but that collects detailed bathymetry as it goes along. A primary goal of this project is to investigate new techniques for 3D data exploration and object interaction. A fishtank VR testbed using GeoZui3D and the Phantom force feedback device, coupled with stereo vision and head tracking is being built to test these new techniques. The results of this work may have important ramifications on the design of future visualization systems and ENC's.

Electronic Charting -- NAVO, St. Lawrence Seaway Dev, Corp., and others (Alexander, P.I.)

Externally-funded research, development, test and evaluation (RDT&E) projects associated with the implementation of electronic chart-related technologies are being performed for various U.S. government agencies.

- St. Lawrence Seaway Development Corporation - Sea-trials are being planned onboard ships transiting the Seaway and into the Gt. Lakes related to the use of official ENC data and proposed international standards for the display of AIS information on ECDIS.
- Naval Oceanographic Office - Technical advice on electronic charting data, systems and infrastructure is being provided to help facilitate the U.S. Navy's goal of making a complete transition from reliance on paper charts to electronic charting by FY07.
- Army Corps of Engineers – Technical advice is being provided to the development of a North American Inland ENC Product Specification. This is being coordinated with a similar effort in Europe.

- U.S. Coast Guard – Technical Advice is being provided related to the Coast Guard's internal electronic charting requirements for data and systems, and it's role as the lead federal agency responsible for regulating the use of electronic charting systems in U.S. Waters.
- Office of Coast Survey, NOAA –*Test Dataset Instructions for Raster Nautical Chart (RNC)* was developed. This document provides a description of the necessary checks and verification procedures required to use this NOAA-issued raster data in conjunction with the RCDS mode of operation for ECDIS. The NOAA-*Maptech BSB File Format Specification* has been verified to be in compliance with the minimum requirements contained in the IHO Product Specification for RNC (IHO S-61).

Advanced aspects of GPS (Huff, P.I)

Lloyd Huff has also taken advantage of the "common data set" acquisition in Portsmouth Harbor and used data collected with the sweep survey vessel from the Canadian Department of Public Works. This activity was an attempt to survey beyond the shoreward bounds of the survey, which the NOAA Ship *Whiting* conducted in November 2000, to the zero depth curve. The survey was conducted using RTK-GPS 3-D positioning. An initial analysis of the time histories of the vessel's vertical position component was made to produce 6-min averages that were compared to water levels from the COOPS gauges at Seavey Island ME (Portsmouth Harbor) and Portland ME. The first two days of the survey were referenced to a benchmark at Fort Point NH (3 km from Seavey Is.) The third day of the survey was referenced to a benchmark near the forward range light of the Portsmouth inner harbor range, which is on the south side of the Piscataqua River and 0.5 km from Seavey Is. On all three days the GPS data were in good agreement with the tide gauges. In addition, Dr. Huff is developing the concept for an RTK-GPS demonstration project using the Portsmouth to Isles of Shoals ferry. The equipment has been assembled and is awaiting installation and operations which should begin in mid-August 2001.

ScapaMAP 2001 (Calder, P.I.)

Calder coordinated the organization of a number of archeological, heritage and technical groups from the U.K. in carrying out a very high resolution survey of the German Grand Fleet scuttle site in Scapa Flow. The survey carried out between 12-16 June 2001, used the new Reson 8125 focused multibeam sonar, resulted in very detailed bathymetry over the wrecks and the general area. Calder and Vitali have now post-processed all data and a website created that describes the results (**http://www.ccom.unh.edu/scapa/index.html)**. There has been much press interest in this survey and Calder has been asked to talk about it at both the Naval War College and the Boston Sea Rovers annual meeting.

Nootka Fracture Zone Mapping: UW and Keck Foundation (Mayer, Calder)

In early July, Calder, Mayer, Plumlee, Vitali and Ware all participated in a deep-water mapping cruise on board the Univ. of Washington vessel *Thomas Thompson*. The

purpose of our participation was to introduce Center scientists to the *Thompson* and UW scientists in preparation for the upgrade of the *Thompson* to a new EM300 multibeam system (it presently has an old Atlas DS2 multibeam). During this cruise CCOM scientists demonstrated real-time data processing and visualization capabilities that were instrumental in the discovery of the "Maquinna" Mud Volcano and better definition of the Nootka Fracture Zone**.**

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

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

- Nootka Fracture Zone, R/V Thompson (TN130), 9-17 July (Arsenualt, Calder, Mayer, Plumlee, Ware).

- Portsmouth Harbor Survey, Coastal Surveyor, JHC, July-August (Armstrong, Cutter, Huff, Mayer, Smith).

- Piscataqua River ground-truthing 20 & 28 Aug. 2001, 29 & 30 October 2001 (Cutter).

- Geoclutter field program, R/V Cape Henlopen, August 2001 (Jabs, Kraft, Lynsky, Mayer, Simpkin).

- Tide guage installation, 14 Sep. 2001 (Alexander, Cutter, Leo).

- Operational ECDIS Training Course, MITAGS, Baltimore, August 2001 (Alexander).

- Oyster River Mapping Project, Durham, NH, August 2001–October 2001 (Alexander, Leo).

- USGS Gulf of Mexico Mapping Campaign Phase 2, R/V Moana Wave, 3-18 September (Calder, Mayer).

- LEO-15 habitat survey, 3-5 October 2001 (Cutter).

- Rainsford Island Survey, 13-16 October, 2001 (Cutter, Huff, Leo).

- AIS – ECDIS Display: Sea Trials, St. Lawrence Seaway/Gt. Lakes, October 2001–November 2001 (Alexander).

- Oyster Reef Survey for CICEET, NH, November 2001 (Dijkstra, Leo, Mayer).

- NOAA Pier Engineering Survey, NH, November 2001 (Armstrong, Dijkstra, Leo).

APPENDIX D:
Other Funding

Grant	PI	Grantor	FY Award	Total Award	Length
Geoclutter Program	Larry Mayer	ONR	$ 51,682.00	$ 195,429.00	3 years
A 3-D GIS	Larry Mayer	ONR	$ 94,948.00	$ 163,229.00	2 years
Collaborative High Resolution Mapping	Larry Mayer	USGS	$ 950,000.00	$ 4,693,730.00	5 years
Mine Burial/Coastal Program Thru Web-Site	Larry Mayer	ONR	$ 41,270.00	$ 128,572.00	3 years
ONR Mine Burial Proposal for FY02 & FY03	Larry Mayer	ONR	$ 139,579.00	$ 339,840.00	3 years
Reconnaissance Mapping of Martha's Vinyard	Larry Mayer	ONR	$ 32,408.00	$ 32,408.00	1 year
Estimation and Visualization of Uncertainty	Larry Mayer	ONR	$ 70,000.00	$ 70,000.00	TBD
Bathymertic Modeling and 3D Visualization	Mayer, Armstrong, Ware	CICEET	$ 91,138.00	$ 178,115.00	2 years
Surveying Midwater Fish	Mayer, Baldwin	NSF	$ 105,870.00	$ 342,946.00	3 years
Multi-Scale Interaction w/3D Data Environment	Ware, Mayer	NSF	$ 162,227.00	$ 499,152.00	3 years
TYCO Endowment interest from prepetuity	na	TYCO	$ 45,000.00	$ 45,000.00	perpetuity
AIS-ECDIS in St. Lawrence Seaway	Lee Alexander	USDT	$ 9,949.00	$ 20,000.00	2 years
Electronic Charting for Naval Operations	Lee Alexander	NAVOCEANO	$ 9,949.00	$ 63,800.00	2 years
ECDIS and ECS Technical Advice to USCG	Lee Alexander	DCS Corp.	$ 9,000.00	$ 39,100.00	2 years
RNC Compliance Specification Development	Lee Alexander	OCS-NOAA	$ 250.00	$ 10,000.00	1 year
Inland Waterways Electronic Charting	Lee Alexander	US Army Corp	$ 38,250.00	$ 71,400.00	2 years
ECDIS Laboratory for Naval Operations	Lee Alexander	USM	$ 50,552.00	$ 50,552.00	1 year
Electronic Charting for OCS-NOAA	Lee Alexander	OCS-NOAA	$ 50,600.00	$ 50,600.00	1 year
Total			**$ 1,952,672.00**	**$ 6,993,873.00**	

APPENDIX E:
Visitors July 2001 – December 2001

Name	Date	From	Visiting	Purpose of Visit
Dr. House	07/01-07/31	Texas A & M University	C. Ware	Collaboration
Gert Buttgenbach	7/13/01	Seven CsGmbH	L. Alexander	Open ECDIS forum
Brad Nickerson	7/20/01	Presented a paper	C. Ware	
Andreas Czerniak	08/06-08/07	SevenCs GmbH	L. Alexander	Open ECDIS forum
Dr. Ron Baird	8/14/01	National Sea Grant, Director	L. Mayer	Information about CCOM
Rob Hare	08/15-08/18	CHS/USM	B. Calder, L. Mayer	Error Model Work
Dr. Roy Wilkens	08/16-08/18	ONR	L. Mayer, P. McLeod, B. Calder	Mine Burial GIS/Uncertainty
Dr. Dick Bennett	08/16-08/18	ONR/SeaProbe	L. Mayer, P. McLeod, B. Calder	Mine Burial GIS/Uncertainty
Conrad Curry	08/16-08/18	ONR/SeaProbe	L. Mayer, P. McLeod, B. Calder	Mine Burial GIS/Uncertainty
Scott Gudes	8/21/01	NOAA	CCOM	informal
Danielle Renart	8/21/01	NOAA	CCOM	informational
Doug Brown	8/21/01	NOAA	CCOM	informational
Michele Dionne	7/26/01	Wells Estuarine Research Reserve	R. Cutter, L.Mayer	Research project
Rich McKenzie	7/26/01	Wells Estuarine Research Reserve	R. Cutter, L.Mayer	Research project
Karl Kieninger	8/28/01	Kongsberg Simrad	A. Armstrong	Informational
Al Rougeau	8/28/01	Reson, Inc.	A. Armstrong	Informational
Adam Kerr	9/11/01	Int'l Hydrographic Reviews	L. Alexander	Int'l Hydropgraphic Reviews
Jorgen Eeg	9/29/01	Royal Danish Authority	CCOM	Information exchange
Morten Solvstein	9/28/00	Royal Danish Authority	CCOM	Information exchange
Rick Brennan	9/28/01	NOAA ship Whiting	B. Calder	Discussion on algorithm dev.
Doug Charmichael	9/28/01	Qinetiq UK	B. Calder	Discussion on collaboration
Ulf Lejdebrink	9/29/01	Swedish Maritime	CCOM	Information exchange
Cmdr Peter Johnson	10/2/01	Royal Australian Navy	L. Mayer	Infromation echange
Phil Chapple	10/2/01	Royal Austrailian Navy	L. Mayer	Information exchange
Robert Snover	10/4/01	Appledorn Engineering	L. Mayer, A. Armstrong	Bathy data of New Castle
Duncan Mellor	10/4/01	Appledorn Engineering	L. Mayer, A. Armstrong	Bathy data of New Castle
Richard Rouleau	10/4/01	UNH Capital Construction	L. Mayer, A. Armstrong	Bathy data of New Castle
Jerry Cronin	10/11/01	Independent businessman	C. Ware	Visualizing financial inforation
Jason Rudzinsky	10/24/01	potential graduate student	B. Calder	Discussion acoustic tomography
Tracy Fredricks	12/17/01	Seacoast Science Center	C. Ware	Collaboration
John Ganson	10/22/01	Boston Sea Rovers	B. Calder	Informational
Gary Melvin	10/23-10/24	DFO Canada	L. Mayer	Midwater Mapping
Mike Jack	10/24/01	DFO Canada	L. Mayer	Midwater fish mapping
Bill Michael	10/24/01	NMFS Woods Hole	L. Mayer	Midwater fish mapping
Dr. Dietrich Welte	10/28/01	International University of Bremen	L. Mayer	Collaboration
William Klein	11/15/01	Klein Associates	L. Alexander	Estab. of ENC Group
Chris Capus	11/26/01	Herriot-Watt University	G. Elston	presented a seminar
Bruce Smith	November	NH Fish and Game	S. Dijkstra	Oyster mapping project
Brian Smith	November	NH Fish and Game	S. Dijkstra	Oyster mapping project
Laurie Waterhouse	12/5/01	British Waterways	B. Calder, L. Alexander	Seminar on survey in UK

APPENDIX F:
Papers, Reports, Abstracts and Talks

From July 2001 to December 2001

Publications:

Al-Hanbali, H., Jakobsson, M., and Holm, N., *Manganese, Carbon and Nitrogen Isotope Composition of Deep Sediments: Tools for Monitoring Paleoceanographic Conditions in the Central Arctic Ocean*, submitted to Marine Geology.

Alexander, L., *Harmonizing Chart and Navigation-related Information on ECDIS,* International Hydrographic Review, Vol. 2., No. 3. December 2001.

Alexander, L., *ENCs and ECDIS: Overcoming a Misperception* [to be published in *Hydro INTERNATIONAL]*.

Elston, G. R., Bell, J. M., and Capus, C. G., *Analysis of the Effects of Numerical Dispersion on Pulses in Finite-Difference and Pseudospectral Time-Domain Methods.* Journal of the Acoustical Society of America, 110(5 Pt. 2):2618, November 2001.

Fenstermacher, L. E., Crawford, G. B., Borgeld, J. C., Britt, T., George, M., Klien, A., Driscoll, N., and Mayer, L. A., 2001, *Enhanced Acoustic Reflectivity Due to High Abundance of Sand Dollars*, Dendraster excentricus, Marine Georesources and Geotechnology, v. 19, p. 135-145.

Fonseca, L., and Mayer, L. A., *The High Frequency Backscattering Angular Response of Gassy Sediments: Model/Data Comparisons from the Eel River Margin, California*, under review, Journal Acoustical Society of America.

Fonseca, L., Mayer, L. A., and Paton,, M., in press, *ArcView Objects in the Fledermaus Interactive 3-D Visualization System: Examples from the STRATAFORM GIS*, in. Wright, D. ed., Undersea With GIS, ESRI Press, Redlands, CA

Hecht, H., Berking, B., Buttgenbach, G., Jonas, M., and Alexander, L., [2002], *The Electronic Chart: A Revolution in Marine Navigation* [a textbook on Electronic Charting to be published by GITC].

Hewitt, T., McDonald, D., and Bornold, B. D., *250,000 Years of Glacier Advance and Retreat in Southern Alaska Recorded by Ice-Rafted Debris in Deep-Sea Cores from the Northeast Pacific.* Quaternary Research (submitted).

Irani, P., Ware, C., and Tingley, M., (2001) *Using Perceptual Syntax to Enhance Semantic Content in Diagrams.* IEEE Computer Graphics and Applications. September, 76-85.

Jakobsson, M., Calder, B. R., and Mayer, L. A., *On the Estimation of Errors in Sparse Bathymetric Data Sets*, in press, J. Geophys. Res., Dec. 2001.

Jakobsson, M., *Hypsometry and Volume of the Arctic Ocean and Its Constituent's Seas*, submitted to Geochemistry Geophysics Geosystems.

Jakobsson, M., Løvlie, R., Arnold, E. M., Backman, J., Polyak, L., Knutsen, J. O., and Musatov, E., 2001, *Pleistocene Stratigraphy and Paleoenvironmental Variation from*

Lomonosov Ridge Sediments, Central Arctic Ocean, Global and Planetary Change, v. 31, no. 1-4, p. 1-21.

Komerska, R., and Ware, C., *Haptic Interface for Center-of-Workspace Interaction* Demonstration paper accepted for VR2002, Orlando, FL, March 2002.

Macnab, R., and Jakobsson, M., (eds) IOC/IASC/IHO Editorial Board for the International Bathymetric Chart of the Arctic Ocean, GSC Open File 4185. p 1-33.

Mangerud, J., Astakov, V., Jakobsson, M., and Svendsen, J.I., in press (2001), *Huge Ice-Age Lakes in Russia*, Journal of Quaternary Science, v. 16, no. 9.

Mayer, L. A., Li, Y., and Melvin, G., in press, *3-Visualization for Pelagic Fisheries Asessment and Research*, ICES Journal of Marine Science.

Melvin, G., Li, Y., Mayer, L. A., and Clay, A., in press, *Automated Tools for Sonar Logging on Commercial Fishing Vessels*, ICES Journal of Marine Science.

Conference Proceedings:

Alexander, L., and Buttgenbach, G., *From High-Density Bathymetry to Next Generation ENC*, Proc. Second Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.

Alexander, L., *Simultaneous Display of Chart and Navigation-related Information*, Proceedings: AIS Conference: Maritime Communication in the New Era, Seattle, WA, October 2001.

Alexander, L., *ECDIS and ENCs: Where are We Heading?* Proceedings: CARIS 2001, San Diego, CA, November 2001.

Alexander, L., van Norden, M., and Fralick, C. M., *ECDIS Development Laboratory and Navigation Technology Demonstration Center*, Proceedings: MTS/IEE OCEANS 2001, Honolulu, HI, November 2001.

Bartram, L., Ware, C., and Calvert, T., *Moving icons: Detection and Distraction*, Interact 2001, Tokyo. June. Proceedings.

Calder, B. R., *Robustness in Automatic Processing of Multibeam Echosounder Data*. Proc. Second Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.

Cutter, G. R., Mayer, L. A., and Rzhanov, Y., *Subtidal Benthic Habitat Mapping Method Development Using Portsmouth Shallow Survey Data.* Proc. Second. Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.

Dijkstra, S. J., *Seafloor Characterization using Vertical Incidence Echosounders: A Study in Portsmouth Harbor and the Great Bay Estuary, New Hampshire*, Second Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.

Gee, L., Paton, M., Mayer, L. A., Ware, C., Gardner, J., and Depner, J., *Interactive 3D Visualization and Analysis of Multi-Sensor, Multi-Relolution Data Sets*, Second Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.

Grizzle, R., Dijkstra, S. J., Ward, L., Adams, J., and Nelson, J., *Comparison of Acoustic Techniques, Videography, and quadrat sampling for Characterizing Subtidal Oyster Reefs*, submitted, 2002 National Shellfisheries Association Meeting, Mystic, CT.

Jakobsson, M., Armstrong, A., Calder B. R., and Mayer, L. A., *Comparing Historical and Contemporary Hydrographic Datasets: An Example from Great Bay, New Hampshire*. Proc. Second. Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.

Mayer, L. A., Fonseca, L., Ware, C., Paton, M., Gee, L., Gardner J. and Orange, D., 2001, *Interactive 3-D Visualization and Exploration of Deepwater Geohazards*, Paper, No. 12955, Proceedings of the Offshore Technology Conference, Houston, TX.,11 pp.

Plumlee, M., Ware, C., Arsenault, R., Komerska, R., and Chappell A.G., *Monitoring Distributed Autonomous Entities through Linkable 3D Windows*. 12th International Symposium on Unmanned Untethered Submersible Technology UUST '01. CD ROM Proceedings, August 2001.

Rzhanov, Y., Huff, L., and Cutter, G. R., *Improvement of Image Alignment Using Camera Attitude Information*, Sixth International Symposium On Signal Processing and Its Applications, Kuala Lumpur, Malaysia, August 2001.

Rzhanov, Y., Cutter, G. R., and Huff, L., *Sensor-Assisted Video Mosaicing for Seafloor Mapping*, International Conference on Image Processing, Thessaloniki, Greece, October 2001.

Ware, C., Plumlee, M., Arsenault, R., Mayer, L. A., Smith, S., and House, D., *Data Fusion for Interpreting Oceanographic Data*. Oceans 2001, Hawaii, CD ROM Proceedings, November 2001.

Abstracts:

Austin, J., Goff, J., Gulick, S., Fulthorpe, C., Nordfjord, S., Wiederspahn, M., Saustrup, S., Schock, S., Wulf, J., Gjerding, K., Mayer, L. A., Sommerfield, C., 2001, *Assessing the ``GEO'' in GEOCLUTTER: New Chirp Sonar, Sampling, and Compressional Wave Veolcity Results >From the New Jersey Shelf*, Eos Trans. AGU, 82 (47), Fall Meeting Suppl., Abstract OS42A-0456.

Calder, B. R., *Automatic Processing of Bathymetric Data from Multibeam Echosounders.* EOS. Trans. AGU, 82(47), Fall Meet. Suppl., Abstract OS11B-0372, 2001.

Dingler, J. A., Kent, G. M., Babcock, J. A., Driscoll, N.W., Harding, A. J., Seitz, G. G., Gardner, J. V., Goldman, C. R., Mayer, L. A., Morgan, C. W., and Richards, B. C., 2001, *Differential Strain Accumulation Across Lake Tahoe as Measured From Submerged Paleo-Shorelines*., Eos Trans. AGU, 82 (47), Fall Meeting Suppl., Abstract S52C-0645.

Hou, T., Huff, L., Rzhanov, Y., and Mayer, L. A., *Seafloor Characterization from Spatial Variation of Multibeam Backscatter vs. Grazing Angle*. AGU Fall Meeting , December 2001.

Jakobsson, M., and IBCAO Editorial Board Members, *Improvement to the International Bathymetric Chart of the Arctic Ocean (IBCAO): Updating the Data Base and the Grid Model*, EOS Transactions, American Geophysical Union, v. 84, December 2001.

Jakobsson, M., Backman, J., Løvlie, R., and Murray, A., *Implications of "Fast" Sedimentation Rates in the Central Arctic Ocean*, Abstract Volume: Changes in Climate and Environment at High Latitudes, NGF Abstracts and Proceedings of the Norwegian Geological Society, no. 2, Tromsø, Norway, October 2001.

Jakobsson, *M.*, *Hypsometry and Volume of the Arctic Ocean and Its Constituent's Seas*, Abstract Volume: Progress in Arctic Ocean Research Over the Past Decades, The Royal Swedish Academy of Sciences, Stockholm Nov. 5-7, Sweden, 2001.

Jakobsson, M., *Sedimentation in the Central Arctic Ocean: What We Knew in 1996 and What We Know Today*, Abstract volume: Progress in Arctic Ocean Research Over the Past Decades, The Royal Swedish Academy of Sciences, Stockholm Nov. 5-7, Sweden, 2001.

Jakobsson, M., Calder, B. R., Mayer, L. A., and Armstrong, A., *The Uncertainty of a Bathymetric Contour: Implications for the Cut-Off line*, ABLOS.

Mayer, L. A., Fonseca, L., Paton, M., Jakobsson, M., McLeod, P., 2001, *The STRATAFORM GIS: Interactive Exploration in 2 and 3 Dimensions , Eos Trans. AGU*, 82 (47), Fall Meeting Suppl., Abstract OS11B-0351.

Ramsey, D.W., Robinson, J. E., Dartnell, P., Bacon, C. R., Gardner, J.V., Mayer, L. A., and Buktenica, M. W., 2001, *Crater Lake Revealed: Using GIS to Visualize and Analyze Postcaldera Volcanoes Beneath Crater Lake, Oregon*, Eos Trans. *AGU*, 82 (47), Fall Meeting Suppl., Abstract V42C-1041.

Riedel, M., Kelley, D.S., Delaney, J.R., Spence, G.D., Hyndman, R.D., Mayer, L.A., Calder, B.R., Lilley, M.D., Olson, E. O., Schrenk, M. O., and Coffin, R. *Discovery of an Active Submarine Mud Volcano Along the Nootka Fault West of Vancouver Island*. EOS Trans. AGU, 82(47), Fall Meet. Suppl., Abstract OS12B-0428, 2001.

Reports:

Alexander, L., *Oyster River Project: Mapping of Historic and Present Navigation Channel: Interim Report*, September 2001.

Talks:

Alexander, L., University of Southern Mississippi, Stennis Space Center, MS "*Electronic Charting: Current Status – Future Challenges*," 01 October 2001.

Alexander, L., MTS/IEE Oceans 2001 Conference, Honolulu, HI, *"Tutorial Session: New Developments in Electronic Navigation,"* 05 November 2001.

Alexander, L., University of New Brunswick, Fredericton, NB, *"Electronic Charting: Current Status – Future Challenges,"* 20 November 2001.

Alexander, L., University of Southern Mississippi, Stennis Space Center, MS,*"What is an ENC: A Product or Service?"* 26 November 2001.

Cutter, G. R., Mayer, L. A., *"Benthic Habitat mapping in the Piscataqua River, New Hampshire."* Marine Habitat Characterization and Mapping Workshop. Sponsored by NOAA and the Gulf of Maine Council for the Marine Environment. October 21-23, 2001, Sebasco Estates, Maine. (Poster presentation)

Gardner, J.V., *"Mapping Deep-water Reefs in the NE Gulf of Mexico"*, invited talk at UC Santa Cruz monthly Marine Seminar.

Hewitt, T., *"Seafloor geology and early post-glacial evolution of eastern Juan de Fuca Strait,"* seminar at University of New Hampshire, 09 November 2001.

Mayer, L.A., New Frontiers in Sea Floor Mapping and Data Visualization - invited address to National Academy of Sciences Ocean Studies Board, Woods Hole, Ma, 10 July 2001

Mayer, L.A., Multibeam mapping and seafloor visualization - invited Lecture: Gulf of Maine Marine Habitat Mapping Workshop-October 22, 2001

Mayer, L.A., New advances in seafloor mapping and data visualization, invited Lecture, GEOFORUM, Houston, TX, 30 October, 2001

Mayer, L.A., The status of scientific planning in the Integrated Ocean Drilling Program, ODP/IODP Town Meeting, San Francisco, CA., 11 Dec. 2001