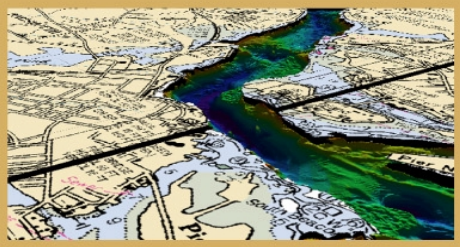

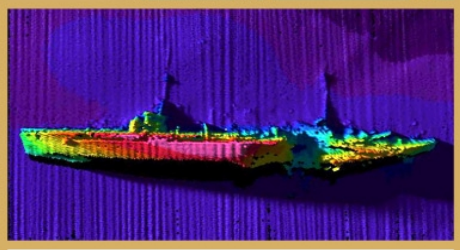

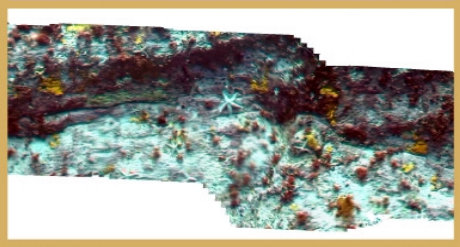

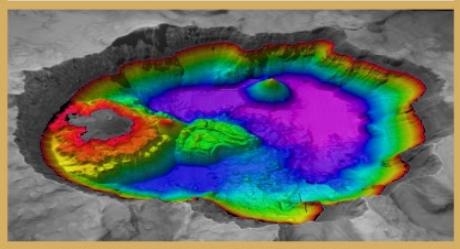

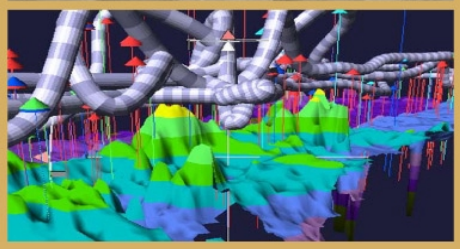

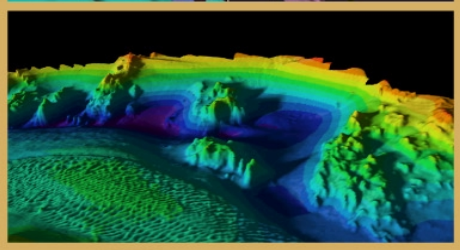

Performance and Progress Report: UNH/NOAA Joint Hydrographic Center

NOAA Ref No.: NA970G0241

NOAA Ref No: NA17OG2285

Report Period: 01/01/2002 – 07/01/2002

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 sixth in a series of bi-annual progress reports, highlighting the activities of the Joint Hydrographic Center during the period between 1 January and 30 June, 2002.

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 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, several hourly employees and 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/ Joint Hydrographic Center and Director of the Center's 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.

Brian Calder, with a Ph.D. in Computing and Electrical Engineering is an Assistant Research Professor in the Center and in the Dept of Electrical Engineering. 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.

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 Staff:

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

Capt. Andrew Armstrong, NOAA (ret.), Co-Director of the JHC, Captain Armstrong recently retired as an officer in the National Oceanic 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.S. 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) who worked 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 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 has helped UNH establish its curriculum in hydrographic training and contributes his expertise in geodesy to our program.

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. Jorgen continues to interact with the Center on the development of hydrographic data processing techniques.

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.

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. 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 and in particular working closely with the Olympic Coast National Marine Sanctuary to develop methods for assessing the impact of submarine cable routes on seafloor 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. Tianhang is also working on the analysis of Bering Sea data, studying the impact of fishing gear on seafloor habitat.

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. Martin has been instrumental in developing our Law of the Sea database.

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 is 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.S. 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.S. 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.

Facilities and Equipment:

The Center is housed in a purpose-built 8000 square foot facility attached to the Chase Ocean Engineering Laboratory. Given the very rapid growth of the Center, space has become the limiting factor in our ability to take on new projects but recent negotiations with the University have assured the Center access to an additional 7000 square feet of space on the second floor of our present facility. Renovation of this space (to create the appropriate office facilities) is expected to begin in the autumn of 2002 with completion by early spring 2003. All major computing, networking and plotting facilities are in place and operational including a 4-processor Origin 2100 Silicon Graphic server with server-based storage capacity of more than 750 Gbytes. We also have an SGI Octane workstation, 3 SGI O2 workstations, 36 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) allowing 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 installed a computer-controlled rotary turntable that is 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, in May 2001, 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 put into immediate operation in support of data collection for Shallow Survey 2001 in the summer of 2001. The vessel was hauled out of the water over the winter and numerous upgrades made to her (see Appendix A). She was put back into service in May of 2002 become the focal point (along with the pontoon boat) of our Hydrographic Field Program. 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, an ODOM Digibar sound speed calibration system, and Vitel and Aandera tide gauges. In addition TSS has kindly donated a TS-335B motion sensor and ODOM has provided a MKIII dual frequency digital echo-sounder on indefinite loan.. 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.S. 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 meetings 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; de Moustier, Mayer and others will also offer an "Advanced Topices in Ocean Mapping" course that will be aimed at the needs of students taking it. We have 10 students currently enrolled in the program, including three NOAA Corps Officers (Brennan, Glang, and Smith) and graduated our second Ph.D student (Tony Hewitt) in May of 2002. In addition to the students listed below, we expect the arrival of at least two new students in September.

Student	Program	Advisor
Gerd Glang	M.Sc., OE	TBD
Mike Leo	Ph.D. ES	Mayer, Calder, Huff
Tony Hewitt	PhD. ES (completed May)	Mayer
Randy Cutter	PhD, ES	Mayer
Matthew Plumlee	Ph.D. Comp Sci	Ware
Richard Raymond	M.Sc., E.Sci	Mayer
Shep Smith	M.Sc, OE	TBD
Tianhang Hou (part-time)	Ph.D., OE	Mayer, Huff
Anthony Doull	Ph. D.,OE	Rzhanov,Mayer
Rick Brennan	M.Sc.,OE	TBD

This summer marked the completion of our first Hydrographic Field Course, organized by Captain Armstrong, and Lt. Smith. During this course, students gained practical experience in planning, executing and processing a hydrographic survey. The course took advantage of both our shallow draft pontoon boat (the R/V Little Bay) and our 40 foot vessel *Coastal Surveyor*. In addition to existing Center equipment, a Reson 9001 multibeam was used for this survey (loaned by Reson) as well as an Odom MKIII sounder (loaned by Odom) and a Trimble RTK GPS receiver, provided by Trimble. Survey work focused on the Great Bay, providing data in support of our CICEET program (see below). During the field course, tide gauges were installed and experiments with real-time kinematic GPS conducted which also supported our RTK research program (see below).

Center staff also actively participated in a range of capacities (judges, moderators, score-keepers, developing scorekeeping software) in the National Ocean Sciences Bowl held at the University of New Hampshire.

Research Program – January – June 2002:

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 and the hydrographic profession**.** As the need arose, we also started several new initiatives. Here, we report on the progress made on these tasks during our fifth six months of operation as well as several new efforts that have begun. While we have made excellent progress in our research, the departure of Laurie Linnet and the vacancy in that position for 1.5 years have resulted in our inability to complete some tasks and to expend all of the funds allotted to those tasks before the impending end of the grant (Dec. 2002). We will thus seek a no-cost extension to the grant to allow us to finish these tasks in calendar year 2003.

Innovative sonar design and processing for enhanced resolution and target recognition

While this theme has been our least active, the upgrade of our acoustic test tank, the completion of our electronic lab, and the arrival Christian de Moustier will lead to an expanded effort in this area. We have already brought a Reson 8125 multibeam sonar into the acoustic test tank to calibrate the acoustic response of small targets built by Lloyd Huff (see Mine Burial Project) and are scheduled to do further testing of other multibeam systems later this year. These new sonars that will be designed to simultaneously map both the seafloor and mid-water targets, an important concern with respect to upgrades in their fishery research vessels. Rzhanov and Peter Runciman of Klein continue with both theoretical and practical work on improved designs and processing algorithms for interferometric sonars.

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, NOAA and USGS, 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 the hydrographic community 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 "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. Development of CUBE has progressed rapidly and it is now undergoing a detailed verification process in cooperation with the NOAA Office of Coast Survey.

Accomplishments since the last progress report include:

- Verification through the comparison with a completed NOAA survey from Snow Passage, Alaska
    - Data proved to be much more difficult to process than expected due to excessive noise from launches, and very significant slopes (45° or more). Improved CUBE infrastructure to compensate; developed processing methodology prototyped using GeoZui3D and CARIS/HIPS Spatial Editor.
    - Found that CUBE's predictions matched smooth-sheet soundings almost everywhere – but only if resolution of CUBE's surface was suitable. Shallow areas were underestimated due to sampling too crudely. A re-run of the process at higher resolution in these areas showed that CUBE could match smooth-sheet soundings, given uncertainty implicit in the surface.
    - Processing time is approximately 2.5 hours to assimilate all data (2.12×10^8 soundings), two hours for operator interventions, and then 2.5 hours to re-assimilate data (last stage can probably be reduced further).
    - Conclusion is that CUBE appears to be able to match the smooth-sheet selection process, but only if we can get the (spatially varying) resolution correct.
- Further testing shows that CUBE operates effectively in many different scenarios, and with different sonar systems:
    - Tested using NOAA Ship WHITING data from Gray's Reef NMS (Reson 8101, 14-21m). Found that data appeared to be correct relative to WHITING's data (formal analysis was not done since smooth-sheet is still being prepared).
    - Tested using data from R/V Thompson cruise TN146 (EM300, 400-2600m). Results appear to need little further hand processing, and in many cases appear 'sharper' and more detailed than the equivalent HIPS weighted grid.
    - Tested using EM3000D and EM1000 data from the R/V Moana Wave cruise (USGS DeSoto Canyon Campaign 2002, 50-300m), running in 'real-time' mode. Assimilated 9.91×10^8 soundings in 22 days. CUBE's surfaces used as decision aids to direct the survey since they were the only fully formed data product.
- Infrastructure improvements:

    - Added HIPS/IO interface for direct access to CARIS data structures.
    - Added support for dual-head and split-head systems.
    - Added ability to make slope corrections using a 'predicted depth' surface constructed from an interpolated, de-spiked, low-resolution median grid.
    - Upgraded disambiguation engine to use 'predicted depth' as a guide to node selection. This is less noisy and significant faster than using local context.
    - Added prototype automatic 'Area of Interest' (AOI) construction code in order to flesh out API for integration with Pydro.
    - Added and tested error models for Elac 1180, EM300/1000/3000D.
    - Ported code base to Win32 environment and tested.
- Development of partnerships for CUBE's future have been on-going:
    - Code release to IVS for development and integration with Fledermaus.
    - Code release to NOAA (Jack Riley) for integration with Pydro.
    - Interaction with CARIS has continued, including provision of CHS documentation on the MBES error model.

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.

New approaches to data visualization and presentation:

GeoZui3D:

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 three 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. Further developed of lat-long/UTM projection capabilities.

ii. Added support for simple animation that allows objects and viewpoints to transit smoothly from point to point or follow an interpolated path. (Related to Seacoast Science Center exhibit – see below
iii. Addition of time, the fourth dimension in GeoZui3D, to support time varying vector fields. As part of the GeoZui3D core, time support allows the synchronized viewing of time varying data objects. Previous time aware objects, such as real time multibeam surface creation, did not synchronize with other objects. Controls are also being added to go forward and back, and vary the time scale.
iv. Basic vector field display capabilities
v. Added scripting mechanism to allow objects to receive messages from users at run-time for tweaking parameters that were previously unreachable.
vi. Expanded addressing system in the scripting mechanism to allow access to more internal pieces of GeoZui3D.
vii. Added ability to specify surface normals for arbitrary surface specifications (.gdt files).
viii. Implemented prototype interaction technique for attaching a view to an aggregate group of objects.
ix. Currently working on speeding up the rendering of GUTM's.
x. Minor user support, bug fixes.

GeoZui3D is now being widely disseminated with more than 40 individuals or 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. Work on water-column and vector-field data sets has led to a new initiative within the Data Visualization Lab – "Flow Vis" – an effort designed to develop optimized techniques for flow field visualization. In support of this effort, Colin Ware has visited with a number of modeling experts (Lynch at Dartmouth; Gross and Schmalz and NOAA/Silver Springs) as well as a person who is already well known in flow visualization (Hauser at VRVis Vienna). He has also been experimenting with using large numbers of animated streak particles (approx 10,000) to represent flow fields. This technique appears to very effective and to offer considerable flexibility

A series of more theoretical studies are also being conducted on human computer interaction so as to optimize interface and display techniques which will be critical for our research on defining the electronic chart of the future. Included in this research are:

Frames of reference studies**:**

This NSF funded project to develop a theoretical understanding of the perceptual and task related frames of reference requirements is progressing well A study relating to the value of wide versus narrow field of view has been completed as has a study of the relative benefits of multiple windows and zooming for finding isolated patterns in information spaces. Two papers have been submitted.

Experimental Semiotics

Experimental work done with PhD students Lyn Bartram at Simon Frazier University and Pourang Irani at the University of New Brunswick (both recently completed their theses under the supervision of Colin Ware) has shown that 3D diagrams can be easier to interpret and remember than their 2D counterparts and that motion can be an effective way of encoding information particularly when the goal is to alert someone's attention to some change in the environment.. These studies will form the theoretical basis for innovative designs of the "Chart of the Future".

Force feedback GIS

Researcher Rick Komerska, under the supervision of lab director Ware, is exploring the potential uses of force-feedback devices as an effective tool for route planning, survey design and interacting with a 3D GIS.. We have a substantial proof-of concept application involving laying out vehicle paths under various constraint conditions. It will include touch enhanced path planning tools, touch enhanced 3D placement of objects and 3D touch enhanced interactive queries. A demonstration paper has given and the Haptic and VR conference.

Tools for Explanation: Collaborative work with the NH Sea Coast Science Center: We have launched a new project with the NH Sea Coast Science Center to provide tools for the development of interactive Museum exhibits to explain aspects of Ocean Science to the general public. Matt Plumlee is taking the lead on this, under the general direction of Colin Ware. Roland Arsenault will also be involved for parts of this project. 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: Mapping and characterization of Oyster Reefs – partners: Ray Grizzle, Larry Ward (Jackson Estuarine Lab, University of New Hampshire), Bruce Smith (NH. Dept. of Fish and Game). The project has the object to study the feasibility of mapping and monitoring

of shellfish habitats with acoustic means such as echosounders. To date, several data sets have been analyzed:

1) Video imagery collected with a drop frame
2) Sweep data collected with an QTC Isah-S system through a Navitronics Seadig system installed on the "Miramichi Surveyor"
3) Single beam data collected with a Knudsen single beam sounder.

It has been found that the video imagery and the acoustic data correlate well, but that neither correlates well to samples retrieved by divers. It is currently hypothesized that the sampling technique used by the divers is the cause for this discrepancy; further analysis is underway. Funding has been approved by the department of Fish and Game for the GIS work involved in this project.

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 Lassoo has been expanded to include the option of overlaying a grid in feature and in geographic space and the determination of statistics of points within each grid cell. Also classification through training in geographic space and determination of eigenvectors in feature space has been added. Finally a maximum Mahobilinis space to be used for classification can now be set by the user, giving tighter control over the classification process in feature space. The application now supports various input data formats, visualization in 3 data spaces, active querying with text output in two data spaces, selection of areas and two manual classification in two data spaces. All algorithms are now 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.

Another tool, TracEd which is used for waveform analysis, has been adapted to take in SEG-Y data streams. The tool is now a near real-time tool as it reads data files produced by data acquisition systems as they are produced. Finally, the ComLog tool has been updated the "ComLog". This tool collects data from up to four serial ports and syncs it to GPS time if available. The tool now takes in various time synchronization inputs.

Sidescan sonar: Lloyd Huff and Tianhang Hou are working with the Alaska Fisheries Science Center of NOAA/NMFS on a major Klein 5000 sidescan sonar survey in the East Bering Sea. Dr. Huff provided assistance to the Alaska Fisheries Science

Center of NOAA/NMFS on the equipment procedures and software for conducting a side scan survey in the East Bering Sea. This work included: (1) setting up equipment, (2) conducting operational training on VELOCWIN, (3) calibration of a short baseline navigation system, as installed, and (4) pre-cruise equipment testing on the Ocean Explorer, in Seattle WA. A trip was made to Dutch Harbor AK to conduct final training, and to reinforce proper procedures for deployment of the side scan sonar. He continued to support data quality assurance measures on the cruise by reviewing short sections of data sent from the ship via e-mail. Working with Tianhang Hou, considerable efforts were made in developing methods for processing the side scan sonar records from the cruise in the East Bering Sea. The Klein 5000 sonar functioned correctly however, the navigational information included in the data recordings were seriously contaminated by numerous sources of errors. The work accomplished during the reporting period includes:

i. Computation of fish position and course make good by using the processed data from Qinsy's database and from the geometry of the vessel tow point and GPS antenna. A set of programs that include FFT data smoothing, coordinate transformation and data interpolation has been developed.
ii. Merging all processed tow fish attitude information back to JCU Gloria sidescan data files (processed and transferred about 250 Gig bytes Klein 5000 raw data).
iii. Beam pattern algorithm is developed. The smoothed beam pattern for each survey line is derived from either its global mean or STD values by scanning XTF sidescan data.
iv. Converting XTF Klein 5000 sidescan to JCU Gloria format in the sequence of processes such as evenly spaced re-sampling, beam pattern correction, ship attitude and heading computation.
v. Designing and applying the weighting function (lower weight for nadir beams and higher weight for off nadir beams) to create sidescan mosaic.

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).

Analyses of Backscatter: Following up on the thesis work of Fonseca, Fonseca and Mayer have published a paper in the Journal of the Acoustical Society of America has describing an approach to calculating the backscatter angular response of a multibeam sonar in the presence of near-surface gas. This model was 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.

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. Amongst the accomplishments of this reporting period are: Backscatter data normalization: the whole working area is divided into 4056 boxes, 20 by 20 meters in size. Computing the signature (average backscatter data by their beam number) of each box, , all backscatter data are then normalized to the nadir beam (or any oblique angle) based on the respective signature in that box. After this normalization, the backscatter mosaic should better represent the variations in the seafloor properties rather than changes caused by changes in gain, beam pattern, or angular response. Wavelet multi-resolution analysis: Once normalized, a 2D wavelet transform is applied to the backscatter image segmenting the image at different scales. Channel and sand wave features clearly show up at different wavelet scales. The normalized and segmented data is then analyzed with an implementation of Jackson's composite roughness and sediment volume scattering model using known values of grain size in the region. Multi-step optimizations have been performed by using Hooke and Jeeves's (1963) direct search algorithm. The grain size optimization for entire area is then used to determine the initial values of six Jackson's parameters in order to search a local minimum for each parameter.

Finally we have begun a lab-wide effort to develop a series of algorithms for the routine correction of multibeam backscatter for local slope. This effort involving Barbara Kraft, Gareth Elston, Yuri Rzhanov, Tianhang Hou and Christian de Moustier, will initially be applied to data collected on the N.J. margin and where we now have excellent ground-truth data (see Geoclutter Program). In this on going project, a work area (11 x 17 km) was selected and divided into 1380 small boxes. For computing the grazing angle, the neighbors of each data point are searched by the radius of 15 meters with UTM coordinates. A weighted least squares method is used to create a surface fitted to the neighboring data. The UTM coordinates are then transformed to vessel frame coordinate (along track and across track) since the along track and across offsets are available for each beam. The grazing angle is then defined by both the vector of the surface normal and the vector from the computation point to the transducer derived by the beam along track and across track offset and its depth. Once this is done, the average backscatter value in each box can be calculated with respect to the true grazing angle as the function of the true grazing angle.

Analysis of high-resolution bathymetry – Fisheries Habitat Studies: A new approach to seafloor characterization based on the automated segmentation of multibeam sonar bathymetric 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. Cutter has

made excellent progress applying this approach to several key study areas as well as collecting critical ground-truth data in the regions. Progress includes:

i. Segmentation of multibeam sonar data from Piscataqua River using Local Fourier Histogram texture feature classification.

ii. Ground-truthing sonar data from Piscataqua River by acquisition of diver video and collection of substrate and biological core samples.

iii. Identification of benthic infauna from Piscataqua samples with aid of Ray Grizzle's laboratory.

iv. Spatial analysis of Piscataqua River multibeam bathymetry data.

v. Development of preliminary annotated species list and visual key for common subtidal benthic invertebrates from New Hampshire.

vi. Stellwagen Bank bathymetry segmentation using LFH texture feature technique, with Yuri Rzhanov. This work is aimed at a collaborative proposal for habitat mapping in the Stellwagen marine sanctuary.

. *Analysis of LIDAR Waveforms:* With the arrival of Gareth Elston, we have begun, with support from both the USGS and the Office of Naval Research, a project aimed at investigating the potential for extracting quantitative seafloor characterization information from LIDAR waveforms. Through the USGS, Elston has obtained LIDAR wavefrom data collected over Lake Tahoe with the SHOALS system. We also have multibeam sonar bathymetry and backscatter in Lake Tahoe. An initial feasibility study has been conducted explore the relationship between bottom reflected laser energy and the peak intensity of the waveform. A plot of peak intensity against peak time-of-arrival showed distinct clusters that were then segmented by hand. Mapping all of the laser-shot geographic positions and coloring them by cluster revealed coherent spatial patterns, with both large areas and small patches of high lidar returns. The sonar bathymetry and backscatter data from a an EM 1000 multi-beam were then compared to the positions of the higher energy lidar returns: some coincide with patches of high backscatter, particularly over rock outcrops; others with regions of steep bottom slope. Distinguishing between these areas requires further work; however, this study has demonstrated that extracting albedo from the lidar waveforms is likely to provide useful information.

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.

Improvements in these techniques over the last six months include: 1- the development of algorithms and software for mosaicing of underwater images of a seafloor with the pronounced relief. In these cases the affine model (vertical camera orientation only) and projective model (arbitrary camera motion) are not directly applicable; 2- the development of suite of programs for modeling of image acquisition process on non-flat terrain; 3- the design and development of two systems for simultaneous acquisition of video imagery and sensor information, one for IBM-compatible computers and a second for a single-board computer (Jackrabbit). These new acquisition systems were tested off (Rainford Island and in Portsmouth harbor); 3- research into methods of eliminating moving objects from video mosaics. This research has also provided a means of automatically identifying and cataloguing moving objects against the background, which may be of great interest to the biological community.

Lloyd Huff, working in conjunction with Ray Grizzle and Larry Ward of the Jackson Lab, has completed the design, development and assembly of a new underwater video camera system, funded, for the most part, by the Hubbard Fund. The system is capable of being towed and making touchdown landings on the seabed at depths up to 100 meters and will be used initially for the characterization of benthic habitats. The completed system was tested in Portsmouth Harbor from the R/V Gulf Challenger. The mechanical aspects of the system functioned flawlessly. The camera frame was shown to be stable in current (or towing) speeds up to 6 knots. The quality of the video imagery, however, was seriously compromised by noise contamination picked up on the cable. The system was redesigned using MPEG2 video image compression in the underwater housing in order to reduce the bandwidth of the signal. Tests on the revamped system successfully demonstrated the utility of the MPEG 2 compression hardware and the up-link communications. The video imagery was high quality and the biologists that will be using the camera for research projects were quite pleased.

Finally, Lloyd Huff has begun the design and developmental of a “swath video” system which is intended to double the swath width of diver operated underwater video, compared to present video systems. A computer program, which controls a stepping motor that changes the camera look-angle, was written and debugged. The control program was embedded in an existing program that collects and records data from the video recorder’s LANC and an attitude sensor. Circuit design was completed for pulsing of a group of Light Emitting Diodes in sync with the video camera.

Data Mining, Blending and Fusion:

We are continuing our 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 were described in previous progress reports; a paper describing the technique is now in press in the Journal of Geophysical Research. The techniques developed for the Arctic have now been applied to the Great Bay of New Hampshire where data sets from 1913 and 1953-54

are analyzed in order to understand whether changes in channel morphology over time are real (see CICEET project below).

Arctic Ocean bathymetry

Work on updating Arctic Ocean bathymetry has continued. The report for the IASC/IOC/IHO Editorial Board meeting held at CCOM May 21-24 was finalized and published as a Geological Survey of Canada open file report. The work of producing IBCAO contours from the grid for the GEBCO digital Atlas was finalized and the contours sent for inclusion into the next GDA. An updated version of the IBCAO grid model (Version 1.0) and new IBCAO products (1° x 1° grid, contours and postscript maps for full size plotters) were presented at the AGU fall meeting (see publication list). Carla More at NGDC will soon update the IBCAO web page in order to make all this new data available. Based on this bathymetry, Jakobsson has begun a project to calculate the volume and hypsometry of the Arctic Ocean and its constituent's seas. He has also derived a slope map from the IBCAO model and used image analyzing techniques to come up with a semi-automated approach of classifying the Arctic sea floor into physiographic entities. Shelf, slope, rise, ridges and abyssal plains are separated and their properties can be analyzed

NEW PROJECTS:

Analyzes of data US continental margin for a US potential claim of extended EEZ
(This project was funded under the new NOAA Grant Number NA17OG2285)

A major undertaking of the Center during over the last six months has been the response to a request from Congress to help lay the groundwork for a potential U.S. Law of the Sea claim. In December, Congress (through NOAA), funded the University of New Hampshire's Hydrographic Center to evaluate the content and condition of the nation's data holdings in relevant areas and, in particular, to evaluate what needs to be done to bring these data holdings to a state of completeness such that they may be used, with full confidence, for substantiating the extension of resource or other national jurisdictions beyond the present 200 nmi limit.

Specifically, the CCOM/JHC was asked to:

1. analyze data needs to identify where existing data are sufficient for delineation of the continental margin as defined in Article 76;
2. identify where data gaps exist
3. determine the survey requirements needed to fill identified data gaps
4. identify the resources required for these surveys
5. outline options for conducting the required surveys
6. complete the initial phase of the study by 31 May 2002

Working in collaboration with NOAA's National Geophysical Data Center, The U.S. Geological Survey and several consultants, the CCOM/JHC collected and assembled all available relevant data into a sophisticated database and Geographic Information

System (GIS) for analysis. This database is one of the most efficient of its kind and will be useful for a number of tasks beyond the Law of the Sea project. Using these tools we chose areas surrounding the U.S. where there is **potential** for a claim of an extended continental shelf under Article 76. Areas identified for detailed study included most of the U.S. east coast, the Gulf of Mexico, the Alaskan margin, the Arctic margin, and the areas around Guam and Palmyra Atoll. This was not an exercise designed to establish a U.S. claim but rather to explore regions where there might be potential for an extended claim. Each area was analyzed to determine the critical data sets required to make a claim for an extended continental shelf under Article 76 (e.g., the 2500 m isobath, the foot of the slope, or the point where the sediment thickness is 1 percent of the distance back to the foot of the slope).

The initial phase of the work was completed and reported to Congress by the end of May. Initial conclusions include that based on data density alone, existing bathymetric data within most of the U.S. EEZ (with the exception of the Arctic) would probably be sufficient for making a claim. However, the relative positional uncertainty and low resolution with which the bathymetry can be defined in older data sets makes any definition of the 2500 m isobath or the foot of the slope subject to question. We thus recommended the collection of modern, high-density, complete coverage multibeam sonar data in those areas where the possibility of an extension of the continental shelf depends on delineating either the 2500 m isobath or the foot of the slope. In addition, having well-navigated, complete, high-density coverage of the critical areas of the EEZ also opens up the possibility of maximizing or optimizing a claim. Such data can also serve a range of other environmental, geologic, engineering, and fisheries habitat needs. We defined bathymetric data "gaps" as those regions where we lack either multibeam or very dense modern single beam echo-sounding data. We also recommended that a careful analysis of the cost/benefit of surveying in particular regions be carried as a prelude to any new data acquisition. The Arctic poses special logistical challenges as either icebreakers or nuclear submarines are necessary to collect data in ice-covered regions.

Definition of a data gap for seismic (sediment thickness) data was more difficult to quantify as the determination of the adequacy of existing seismic data requires time-consuming interpretation by expert geologists and geophysicists. In light of this we recommended that the U.S.G.S. undertake a study evaluating the adequacy of current seismic data holdings. Finally, we also recommended that studies be carried out to develop algorithms and techniques that can optimize a U.S. claim for an extended continental shelf based on newly collected multibeam sonar data. Such a study would propose approaches for using the detailed bathymetry provided by multibeam sonar, in conjunction with a full understanding of the constraints of Article 76, to determine how to maximize a claim based on careful selection of the line segments used to make the claim.

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, ODOM, SAIC, and Coastal Oceanographics. In addition, grants are already in place with the Office of Naval Research, The National Science Foundation, The Army Corps of Engineers, 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 De Soto Canyon area of The Gulf of Mexico on the R/V Mauna Wave equipped with both an EM1000 and EM3000. Center participants included Semme Dijkstra, Gareth Elston, Brian Calder, Larry Mayer and undergraduates James and Chris Glynn. Along with standard watch-standing and data processing support, Calder ran a parallel processing stream using CUBE, generating surfaces for both EM1000 and EM3000D data in pseudo real-time. He also developed code to merge constructed surfaces, filling in gaps from the EM3000 with EM1000 data where available, and blending in EM1000 data below the EM3000's extinction depth.

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. Barbara Kraft made great progress in processing Geoclutter waveform data. Waveforms were processed to determine the sediment attenuation using three methods: 1.) *rms* energy of signal (time domain), 2.) spectral ratio method (frequency domain), and 3.) filter-correlation method. The sound speed (in seawater and sediment) was also calculated using an envelope detection algorithm and the results compared to the sound speed obtained by cross correlation of the sediment and seawater waveforms (relative time delay).

The methods used to calculate sound speed produced consistent results in seawater. The envelope detection method produced an increase in sediment sound speed at 84 stations, with the average increase equal to 10.8 m/s (maximum increase of 25.8 m/s and minimum increase of 0.1 m/s). A total of 13 station locations experienced a decrease

in sediment sound speed, with the average decrease equal to 6.1 m/s (maximum decrease of 14.9 m/s and minimum decrease of 0.4 m/s). This method resulted in an overall average increase in sediment sound speed of 8.5 m/s for all stations. Attenuation results were examined versus grain size distributions as opposed to mean grain size. Station data, including grain size distributions, were sorted into descending order based on the average attenuation coefficient and divided into groups representing 0.1 dB/m·kHz decreases in attenuation. An average grain size distribution (% fraction of sample based on weight) representing each group was calculated using the grain size distributions of each station in the group. Although preliminary, the averaged grain size distributions presented interesting results. The group of stations with the highest attenuation coefficients (0.8 – 0.9 dB/m·kHz), had the largest weight percent of fine sand (.175 to .25 mm) as well as a higher percentage of coarse grains with diameters greater than 4 mm. The group of stations with slightly lower attenuation coefficients (0.7 – 0.8 dB/m·kHz), had the second largest weight percent of fine sand, the highest weight percent of grains with diameters greater than 4 mm, and the highest weight percent of fine grains (silts to clay), sediments with diameter less than 0.062 mm. In contrast, the stations with the lowest attention coefficients had the highest weight percent of medium sand. These stations had grain size distributions indicating moderately well-sorted sediments (mostly homogeneous, medium grained sands), while the high-attenuation stations were poorly sorted and contained a mixture of course to fine grained sediments.

In addition Kraft helped to create a GIS of the Geoclutter field area that includes backscatter imagery, bathymetry, and measured results of seawater sound speed, sediment sound speed, and sediment attenuation. Hyperlinked to each station are still images of the seafloor, captured from video frames, and histograms of grain size distributions. She also has begun implementation of the Biot-Stoll model of acoustic wave propagation in marine sediments (in Matlab). The intent of using the model is to compare experimental compressional wave speed and attenuation results with theoretical predictions. Preliminary results are encouraging. The average percent difference in sediment sound speed (between measured and predicted) is less than 1% (including all stations) and the average percent difference in attenuation is ~ 7%.

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 conducted by the USGS with a Submetrix system and from this survey a specific deployment site will be selected. In early July, Mayer, and graduate students Richard Raymond and Gerd Gland, with support from Lloyd Huff, conducted the Reson 8125 multibeam survey aboard the SAIC vessel *Ocean Explorer*. The survey plan called for a super high-resolution (4 m overlap) survey in a small area surrounding the MVCO node and mine burial sites, a slightly lower resolution survey (12 – 25 m overlap) in a box approximately 1 x 1 km surrounding the "target box" and a lower resolution survey (25 – 40 m line overlap) in a 3 x 5 km region surrounding the 1 x 1 km box. The vessel, the operators, and the Reson 8125 performed flawlessly through a range of

sea states. We completed all of the work scheduled at precisely the coverage levels planned.

In order to obtain the resolution needed for repeat surveys and understand changes in the seafloor at levels of 10 cm or better, we established 3 kinematic GPS base stations on Martha's Vineyard and 3 kinematic GPS receivers on the survey vessel. These systems appeared to have worked well The Reson 8125 produced approximately 1 Gigabyte of data per hour, and the SAIC and UNH teams worked hard to do preliminary processing as quickly as possible. To date all data has undergone preliminary processing. A gridded data set representing the bathymetry of the target area and the medium resolution survey has been generated and made available to other Mine Burial researchers.

The bathymetric resolution we were able to achieve was beyond our expectations. The node site and all diver-emplaced reflectors were clearly identified . Most amazingly, we are able to resolve fields of individual ripples that are less than 2 cm height

Another component of our ONR Mine Burial effort involves developing and maintaining a Mine Burial web-site. This web-site is intended to be both a forum for information and data exchange as well amongst ONR investigators. Our GIS-expert Pam McLeod created a prototype web-site for a mine-burial workshop in January. Enhancements suggested at this workshop have been incorporated and an updated site created by McLeod, Ines Jakobsson and Jamie Adams.

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. In support of this program, the Center staff have established approaches to quantifying and visualizing uncertainty associated with bathymetric data, have provided base information on the spatial scales of variability in relevant seafloor environments (the Geoclutter area), have explored the feasibility of using backscatter as a predictor of seafloor variability, and have provided other ONR investigators with detailed bathymetric data (from a NOAA database) in one of their key field areas.

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. Supplementing this study has been the collection of new bathymetric data as part of the 2002 Hydrographic Field Course. These data, once fully processed, will add a new dimension to the historical study as well as fill in undersampled regions of Great Bay. In conjunction with the development of a bathymetric baseline database for Great Bay, Lee Alexander has led an effort to compile historical hydrographic data of the Oyster River from a variety of sources in conjunction with a town/state project to restore the historic navigation channel.

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

The purpose of this project is to develop software for highly interactive visualization of 3D geographic information spaces, taking into account perceptual and cognitive issues. We have chosen the area of undersea exploration, mapping and visualization as our test domain. Aside from theory development, we have accomplished much that is of direct relevance to the current proposal. We have radically extended a novel 3D visualization environment called GeoZui3D for Geographic Zooming User Interface with a number of capabilities designed to support ocean science visualization. Our development of multiple linked 3D visualization windows and CORBA real-time data interface enables magnifying windows to be attached to moving objects. To refine the system we have established working relationships with various groups of potential users including: Two projects at the Woods Hole Oceanographic Institute (visualizing GLOBEC data, and monitoring ROV and AUV data streams); the new Hampshire Sea Coast Science Center- (a 3D exhibit is being built using our software); the Autonomous Undersea Systems Institute (visualizing simulated autonomous vehicle communications); We are also making good progress in a new interface that applies force feed back to the problem of AUV path planning. A preliminary report on our work appears in Ware et al., 2001.

On the more theoretical side we have successfully developed a predictive cognitive model that can be used to determine when different using interface techniques, such as extra viewing windows, will be useful (Plumlee and Ware, 2002).

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 conducted 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. Other efforts relate to facilitating the use of electronic chart data and systems on major western rivers and inland waterway systems.
- U.S. Coast Guard – Technical advice is being provided related the Coast Guard's internal electronic charting requirements for data and systems, and the 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 – Technical advice is provided related to developing a more efficient means/process to convert high-density bathymetric survey data into a database suitable for producing multiple products and services.

Advanced aspects of GPS (Huff, P.I)

Lloyd Huff has continued development of a concept for the demonstration of RTK-GPS using the Portsmouth to Isles of Shoals Ferry. The mobile equipment was assembled and is awaiting installation/operations, which should commence by mid-July 2002. The installation of a long-term GPS monitoring station at New Castle Island, NH was completed for use on the RTK-GPS demo project and other GPS projects. The station compresses and locally archives the GPS phase data observations, as well as, forwards them on a daily basis to the Chase O. E. Lab Dr. Huff also participated in the planning for the Mine Burial DRI survey conducted off Martha's Vineyard MA in mid-July. The survey was conducted with a RESON 8125 multibeam sonar with the intent of achieving repeatability of 10 cm or better of X, Y, and Z in the WGS-84 ellipsoidal reference frame. OTF-GPS will be used to establish the 3-D position of five acoustic reflectors that will be used to demonstrate the level of repeatability (in X, Y, and Z) and to serve as markers on future surveys.

Nootka Fracture Zone Mapping: UW and Keck Foundation (Calder)
In May, Brian Calder led a team from the Center (Elston, Popham) that was in charge of multibeam mapping aboard the R/V Thomas Thompson (Cruise TN-146) in support of researchers from the University of Washington and the Monteray Bay Aquarium Research Institute.. During this cruise, the UNH team mapped Split Seamount, Endeavour Segment of the East Pacific Rise and Nootka fracture zone, including mud volcanoes 'Maquinna' and 'The Haggis' and produced a series of bathymetric and backscatter maps of these features.

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 multibean

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
January 2002 – June 2002

- Lobster tracking and lobster-corral video mosaic mapping, January 2002, February 2002, June 2002. (Collaboration with Win Watson lab) (Cutter).

- Piscataqua River infaunal characterization, February 2002, R/V Gulf Challenger, (Cutter).

- EM300 Sea trials, 22-26 April, R/V T.G. Thompson Seattle-Seattle, (de Moustier).

- Keck-Nootka Mapping, 14-21 May, R/V Thompson cruise TN146, (Calder, Elston**).**

- USGS Gulf of Mexico Campaign – DeSoto Canyon, 21 June – 9 July, R/V Moana Wave (Calder, Dijkstra, Mayer, Rzhanov).

- Hydrographic Field Course Survey Project, Great Bay, June 2002, (Armstrong, Smith, Students0

APPENDIX D:
Other Funding

Grant	PI	Grantor	FY Award	Total Award	Length
Geoclutter Program	Larry Mayer	ONR	$195,429.00	$195,429.00	2 years
A 3-D GIS	Larry Mayer	ONR	$178,264.00	$178,264.00	2 years
Collaborative High Resolution Mapping	Larry Mayer	USGS	$1,407,205.00	$4,693,730.00	5 years
Mine Burial/Coastal Program Thru Web-Site	Larry Mayer	ONR	$84,814.00	$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 Vineyard	Larry Mayer	ONR	$32,408.00	$32,408.00	1 year
Estimation and Visualization of Uncertainty *	Larry Mayer	ONR	$86,000.00	$243,270.00	
Bathymetric Modeling and 3D Visualization	Mayer, Armstrong, Ware	CICEET	$178,115.00	$178,115.00	2 Yrs.
Surveying Midwater Fish	Mayer, Baldwin	NSF	$231,420.00	$342,946.00	3 years
Multi-Scall Interaction w/3D Data Environment	Ware, Mayer	NSF	$446,844.00	$499,152.00	3 years
TYCO Endowment interest from perpetuity	N/A	TYCO	$45,000.00	$45,000.00	perpetuity
AIS-ECDIS in St. Lawrence Seaway	Lee Alexander	USDT	$10,000.00	$20,000.00	2 years
Electronic Charting for Naval Operations	Lee Alexander	NAVOCEANO	$16,000.00	$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		$10,000.00	1 year
Inland Waterways Electronic Charting	Lee Alexander	US Army Corp.	$38,300.00	$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
			$3,199,530.00	$7,182,178.00	

APPENDIX E:
Visitors July 2001 – December 2001

Name	Date From	Visiting	Purpose of Visit
Woodburry, C.	1/28	Intergraph Corporation	M. Jakobsson
Gardner, J.	2/25	USGS	G. Elston
Berliner, J.	6/18	BBN	C. Ware
Bobrow, R.	6/18	BBN	C. Ware
Brunt, D.	1/15-1/16	CHS, Ottawa	L.Alexander
Cormier, J.	1/15-1/16	CHS, Laurentian Region/MLI	L.Alexander
Doucette, D.	1/15-1/16	CARIS	L.Alexander
Earnshaw, B.	1/15-1/16	Maptech	L.Alexander
Freeman, S.	1/15-1/16	USCG – C2CEN	L.Alexander
Grant, S.	1/15-1/16	CHS (contract)	L.Alexander
Huet, M.	1/15-1/16	IHB, Monaco	L.Alexander
Mades, D.	1/15-1/16	UDCG-NAVCEN/IEC TC80/WG7	L.Alexander
Radice, J.	1/15-1/16	USCG-NAVCEN	L.Alexander
Ryan, J.	1/15-1/16	The Skip'r/USCG–C2CEN / IEC TC80/WG13	L.Alexander
Teadt, T.	1/15-1/16	US Navy – CNMOC	L.Alexander
Van Norden, M.	1/15-1/16	US Navy – NAVOCEANO	L.Alexander
Macnab, R.	3/25-3/27	GSC	M. Jakobsson
Simpkin, P.	August	IKB Technologies	B.Kraft
Dartnell, P.	May	USGS	Y.Rzhanov
Foote, K.	May	WHOI	A. McLeod
Harding, S	May	Mass Crane	A. McLeod
MacLeod, E.	May	MTI	A. McLeod
Smith, B.	June	NH Fish & Game	R. Cutter
Zelzer, D.	May-Sept	Fraunhoffer	C. Ware

Papers, Reports, Abstracts and Talks
From January 2002 to June 2002

Publications:

Alexander, L. "Insiders View - Overcoming a Misperception," Hydro International, Vol.6, No.1, Jan-Feb 2002, p. 65.

Bartram, L., and Ware, C., (2002) "Filtering and Brushing with Motion. Information Visualization," Vol 1 (1) 66-79.

Fonseca, L., Mayer, L.A, Orange, D. and Driscoll, N.,2002, The high frequency backscattering angular response of gassy sediments: Model/data comparisons from the Eel River Margin, California, , Jour. Acoustical Society of America.v. 111, n. 6 pg. 2621-2631.

Fonseca, L., Mayer, L.A. and Paton, M., 2002, 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, pp

Gallaudet, T.C., and de Moustier, C., "Multibeam volume acoustic backscatter imagery and reverberation measurements in the northeastern Gulf of Mexico, J. Acoust. Soc. Am. 112(2), 489-503, 2002.

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

Jakobsson, M., Calder, B. R. and Mayer, L. A. On the Effect of Random Errors in Gridded Bathymetric Compilations, J Geophys. Res. B (Solid Earth), In Press, 2002.

Jakobsson, M., 2002, Hypsometry and volume of the Arctic Ocean and its constituent's seas, Geochemistry Geophysics Geosystems, v. 3, no. 2.

Laramee and Ware, C., Rivalry (In Press) Rivalry and Interference with a Head Mounted Display. ACM Transactions on CHI.

Mayer, L.A., and Balwin, K. C, 2002, Shallow Water Survey 2001: Papers based on selected presentations from the Second International Conference on High Resolution Surveys in Shallow Water, Marine Technology Society Journal, v. 35, n. 4, p. 3-4.

Mayer, L.A., Li, Yanchao, and Melvin, G., 2002, 3-D visualization for pelagic fisheries asessment and research, ICES Journal of Marine Science, v59, pp. 216-225.

Melvin, G., Li, Yanchao, Mayer, L.A., and Clay, A., 2002,, Automated tools for sonar logging on commercial fishing vessels, ICES Journal of Marine Science., v. 59, pp. 226-245.

Smith, S.M., Alexander L., and Armstrong, A. A. [2002] "The Navigation Surface: A New Database Approach to Creating Multiple Products from High-Density Surveys" International Hydrographic Review, in press

Ware, C., and Purchase, H., Colpoys L. and McGill, M. (in Press) Cognitive Measurements of Graph Aesthetics. Information Visualization.

Conference Proceedings and Abstracts:

Alexander, L. "SHARED Project: Extension to Caribbean – Gulf of Mexico Region", Proceedings: GEOMATICA 2002, Havana, Cuba, 16 Feb 2002.

Alexander, L. "Status of Electronic Charting Standards", Proceedings: GEOMATICA 2002, Havana, Cuba, 16 Feb 2002.

Alexander, L. "Alternative Uses of Hydrographic Data", IHO Industry Workshop, Monaco, 24-28 June 2002.

Alexander, L. and Ward, R., "Back-up Arrangements for ECDIS: Different Options and Perspectives", Proceedings: Canadian Hydrographic Conference, Toronto, 28-31 May 2002.

Alexander, L. "Harmonizing the Display of ECDIS and AIS Information", Workshop by National Academy of Science, Transportation Research Board, Committee for Shipboard Display of AIS, New Orleans, 3-4 April 2002.

Bell, J., Elston, G., and Reed, S. Sonar Image Synthesis Techniques and Applications. In Past, Present and Future Acoustics, Proceedings of the Institute of Acoustics, volume 24(2) (CD-ROM), Salford, UK, March 2002.

Brunt, D., Alexander, L. and Barbor, K., "An ECDIS Lab: Facilitating Electronic Charting for Navy Missions, Canadian Hydrographic Conference," Toronto, 28-31 May 2002.

Calder, B. R. and Smith, S. M. A Comparison of the Automated Navigation Surface to Traditional Smooth Sheet Compilation. Proceedings: Canadian Hydro. Conf. 2002., Toronto, Canada, May 2002.

Hou, T., Mayer, L., and Rzhanov, Y., Oceanology International 2002 (March 5-8 London, UK): conference presentation "Application of Wavelet Multi-resolution to Multibeam Backscatter for the Seabed Characterization."

House, D., and Ware, C (2002) A method for perceptual optimization of complex Visualizations. Advanced Visual Interface, Trento Italy, May, Proceedings. 148 – 155.

Jakobsson, M., and Mayer, L., 2002, Using MGE Applications and Geomedia in Marine Geophysical/Geological Research, Conference Proceeding Geospatial World 2002, Atlanta June 10-12, USA, 16 pp.

Komerska, R., and Ware, C, and Matthew Plumlee (2002) Haptic Interface for Center-of-Workspace Interaction. Demonstration paper. Haptics Interfaces for Virtual Environments and Teleoperator Systems. 352-353.

Plumlee, M. and Ware, C (2002) Modeling performance for zooming vs multi-window interfaces based on visual working memory. Advanced Visual Interface, Trento Italy, May, Proceedings, 59-68.

Rzhanov, Y., Huff, L., and Cutter, G.R., (2002) "Underwater Video Survey: Planning and Data Processing, International Conference on Signal and Image Processing (SIP 2002),"
Kauai, Hawaii, USA, August 2002.

Wells, D., Richer J., Santos, M., Dare, P., Allen, I., Wiesenburg, D., Dodd, D., Howden, S., Davis, J., Armstrong, A., Dijkstra, S., Alexander, L., Monahan, D., Chance, J., and Fruge, F. "Open Access Learning At Sea", Proceedings: Canadian Hydrographic Conference, Toronto, 28-31 May 2002.

Reports:

Jakobsson, M., Mayer, L., and Armstrong, 2002, The Compilation and Analysis of Data Relevant to a U.S. Claim Under United Nations Law of the Sea Article 76: Maps, University of New Hampshire Report for the US Congress, 40 Maps.

Mayer, L., Jakobsson, M., and Armstrong, A., 2002, The Compilation and Analysis of Data Relevant to a U.S. Claim Under United Nations Law of the Sea Article 76: A Preliminary Report, University of New Hampshire Report for the US Congress, pp. 1-75 plus Appendices.

Talks:

Alexander, Lee. "Harmonizing the Display of Chart and Navigation-related Information". Seminar Presentation: University of Southern Mississippi, Stennis Space Center, MS, 09 January 2002.

Alexander, Lee. "AIS: What is it, Why Important, and How will it Impact the U.S. Navy?" Presentation to Office, Deputy Chief of Naval Operations (NO96), U.S. Naval Observatory, Washington, DC, 27 February 2002.

Alexander, Lee. "NATO Warship ECDIS and U.S. Navy ECDIS-N: Comparison and Contrast" Seminar Presentation: University of Southern Mississippi, Stennis Space Center, MS, 6 March 2002.

Calder, B.R., ScapaMAP Presentations: Navy War College, Newport, RI, 31 January 2002; Boston Sea Rovers Conference, Boston, MA, 3 March 2002; IHO Marine Information Objects workshop, Durham, NH, 15 January 2002; New England Cable News, 14 May 2002.

Cutter, R., "Using texture to segment multibeam bathymetry data, and relating results to benthic habitats." CCOM Seafloor Characterization Seminar Series. 8 February, 2002. UNH CCOM-JHC, Durham, NH.

Cutter, R., "Automated segmentation of multibeam-derived bathymetry using local Fourier histograms." SAIC seminar series. 15 February 2002. Providence, RI.

Cutter, G. R., Rzhanov, Y., Mayer, L. A., 2002. Automated segmentation of seafloor bathymetry from multibeam echosounder data using local Fourier histogram texture features. Benthic dynamics: in-situ surveillance of the sediment-water interface. Aberdeen, Scotland, March 25th - 29th, 2002.

de Moustier, C., Pan-American Insitute of Geography and History (PAIGH)
Multibeam and High-Volume Data Processing Workshop March 18-22, 2002
University of Southern Mississippi, Long Beach Campus (3 talks: General echosounding theory, characteristics of multibeam echo-sounders, sound speed variability).

de Moustier, C., Deutche Forschungsgemeinschaft workshop on "Impact of Acoustics on Marine Organisms" June 17-19, 2002, invited talk: "Environmental aspects of hull-mounted sonars aboard modern oceanographic research vessels."

Gallaudet, T.C., and de Moustier, C., 143rd meeting of the Acoustical Society of America, Pittsburgh, PA June 3-7, 2002 "Multibeam echo-sounding measurement of the micro-bubble field in a ship's wake."

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

Jakobsson, M., IODP IWG, seminar describing the scientific content of our Arctic-drilling proposal 533, Stockholm, 05 June 2002.

Mayer, L.A., The Mine Burial Prediction Web Site: Mine Burial Prediction Workshop, Scripps Institution of Oceanography, La Jolla, CA, Jan 15, 2002

Mayer, L.A., New Directions in Seafloor Mapping and Data Visualization, Invited Talk, American Academy for the Advancement of Science , Boston, MA, 18 Feb. 2002

Mayer, L.A., New Directions in Seafloor Mapping and Visualization, Invited Talk, Reson User Group Seminar, London, England, 5 March 2002

Mayer, L.A. Seafloor Mapping and Ocean Exploration, Invited Talk, National Academies of Science, International Global Ocean Exploration Workship, Paris , Fr. 14 May, 2002

Ware, C. Vision, Visualization and Computer-Human-Interaction. VRVis Research Center. Vienna Austria, 16 May 2002.

Ware C. GeoZui3D: A Geographic Zoomable User Interface for 3D Visualization. NOAA, Silver Springs MD. May 3.

Ware C. Visual Space and Data Visualization. University of Maryland. May 2.

Ware, C. Data Fusion and Vector Field Vis. Dartmouth College. April 23.

Ware C. (2002) Perception for Information Display. Distinguished Speaker Series. Center for System Science. Simon Fraser University. 20 Feb.

Ware C. (2002) GeoZui3D and the Human Factors of Virtual Reality. New Media Innovation Center. Feb. 21.

Ware, C. (2002) GeoZui3D: A Geographic Zooming User Interface. Seminar. Simon Fraser University. Feb 19