A Proposal for a Cooperative Agreement on:

IOCM Research in Support of Super Storm Sandy Disaster Relief

Federal Funding Opportunity NOAA-NOS-OCS-2013-2003801
(FY 13 Disaster Relief Appropriations Act IOCM Processing Center Research)

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Performance Period:
October 1, 2013 – September 30, 2015

Location:
Center for Coastal and Ocean Mapping [CCOM], University of New Hampshire, Durham NH. CCOM is co-located with the Joint Hydrographic Center, and appropriate arrangements have been taken to co-operate on this work there.

Programmatic Priorities Covered:
All programmatic priorities specified in the Federal Funding Opportunity are addressed in this proposal.

Funding Request:
Year 1 (October 1, 2013 – September 30, 2014): $492,392
Year 2 (October 1, 2014 – September 30, 2015): $507,592
Total Funding: $999,984
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Project Summary

Project Name

Proposed Funding
$999,984 over 24 months ($492,392 in year 1, $507,592 in year 2).

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Outline & Benefits
The University of New Hampshire's Center for Coastal and Ocean Mapping proposes collaborative agreement for a research and development initiative that will address improvements in lidar, optical and acoustic coastal and ocean mapping as well as marine debris mapping data processing problems associated with the FY 13 Disaster Relief Appropriations Act, in support of disaster relief and recovery in response to Super Storm Sandy. Super Storm Sandy caused massive amounts of damage and flooding along the United States eastern seaboard, and impacts on submerged and intertidal zones are still being determined. As large amounts of coastal and ocean mapping data are collected and processed, NOAA has requested that additional research in the areas of lidar, marine debris mapping, acoustic data and techniques, specialized data processing, and public outreach be conducted in order to improve coastal and ocean mapping practices in the wake of the storm.
Our proposal outlines a two-year program of research and outreach to meet the broad goals defined above. Specific research objectives include: 1) advancing lidar processing with an emphasis on creating new Integrated Ocean and Coastal Mapping [IOCM] multi-use products and analyzing shoreline change and erosion patterns; 2) developing sophisticated means of planning successful lidar surveys by combining lidar, spectral, and acoustic system data; 3) advancing procedures for water column and seafloor characterization using lidar intensities, focusing on integrating results into existing habitat classification and coastal engineering index standards; 4) investigating the use of automated methods to identify and classify submerged marine debris and develop approaches to recognize and inventory marine debris items; 5) investigating methods to decrease the time required by human analysts to process and analyze data in disaster response situations, including evaluating the benefits of parallel computation, scalable capabilities and new visualization techniques; 6) developing acoustic survey acquisition procedures that will maximize efficiency in post-disaster response situations giving prominence to assessing the benefits and limitations of multibeam echosounder [MBES] and phase measuring bathymetric sonar [PMBS] systems; 7) developing PMBS data processing techniques that account for measurement uncertainties, assessing whether these techniques expedite the processing of PMBS data and preserve detected objects throughout the processing workflow; 8) examining the applicability of using multibeam and PMBS data to assess storm-related impacts on the seabed as a function of sonar resolution; 9) improving marine debris data display and use for response and restoration efforts using applications such as GeoPlatform and ERMA; 10) investigating the potential benefits of developing a system that automatically displays potential marine debris targets in multiple views and orientations to enhance the data analyst's processing efficiency and ability to discriminate between natural and artificial targets; and 11) developing project-specific websites that highlight the aims and results of the research through an array of interactive infographics.

Our proposal has many multifaceted benefits that will enhance research and data production within the hydrographic and oceanographic fields, as well as expanding the general public's understanding of the Sandy-inflicted impacts to many coastal and ocean resources. A major intended benefit of this proposed research includes advancing existing coastal and ocean mapping survey acquisition, processing, and analysis techniques and incorporating data into multi-use products that will benefit a wide user base, adhering to the concept of "map once–use many times". Another key benefit of this research proposal is the investigation of automated procedures for marine debris identification and classification, which have the potential to both increase the efficiency and limit the subjectivity in marine debris removal prioritization efforts. This research further benefits disaster response and outreach efforts by enhancing data visualization and data dissemination through the use of interactive infographics and websites.

To meet these objectives and benefits, we have put together a multidisciplinary team of scientists, engineers, and support staff with an established reputation within the hydrographic and coastal and ocean mapping community. We have both the physical capacity and IT infrastructure to successfully implement the proposed research objectives. We have experience incorporating our research into practical applications and tools, and we are confident we will be able expand these abilities to encompass the coastal and ocean mapping research and development put forward in this proposal.

**Partners**

- Dr. John Brock, Coastal and Marine Geology Program, USGS
- Dr. Christopher Parrish, National Geodetic Survey, NOAA
- Jason Rolfe, Marine Debris Program, NOAA
- Dr. Art Trembanis, Coastal Sediments, Hydrodynamics and Engineering Lab, U. Delaware
Project Description

1 Goals and Objectives

In the broadest sense, the goals of this proposal are to serve NOAA and the nation through support of NOAA’s role in promotion of resilient coastal communities, coastal zone protection and management, and a safe, efficient and environmentally sound marine transportation system. In the context of the current Federal Funding Opportunity [FFO], we see these through the lens of three primary goals.

First, we consider the problem of the response to a significant storm event, and take the goal of improving the efficiency in survey operations conducted in support of post-storm disaster recovery. For communities devastated by wind damage, flooding and utility outages, working out how to ensure the safe delivery of emergency services, often by sea, is a priority. Efficiently surveying the near-shore, determining where there are problems, and in which order to tackle them, is a major concern.

Second, we consider the problem of best scientific practice in hydrographic and ocean mapping, and take the goal of raising the level of awareness of good processing, data collection and management techniques to support protection, restoration and management of near-shore, coastal and ocean resources. Whether responding to the current storm event, or planning for the next one, having the best available tools and procedures is essential.

Third, we consider the inherent problems associated with planning for the uncertain future, and take the goal of supporting flexible and efficient planning and preparedness for, and response to, significant storm events through provision of widely disseminated data products, services and protocols. Good planning starts with good data, and the means to use it.

Our approach to meeting these general goals is to establish four primary objectives that focus on themes of object detection, limitations of performance, and product creation, along with engagement and communications of the research outcomes.

The first objective is to develop methods for automatic detection, aggregation and characterization of submerged marine debris. Successfully fulfilling this objective will provide information vital to disaster response activities, feeding into the first goal of supporting first responders during the immediate aftermath, and secondary activities of restoration thereafter. Another outcome of this objective will be a sound understanding of the best practices and standard operating procedures necessary to take best advantage of the data being collected, feeding to the second goal of best scientific practice. This objective is designed to be agnostic as to the data sources used, since we expect to use multiple sources in conjunction, and achieve results that will answer multiple uses. For example, the same techniques that automatically find objects for marine debris cleanup prioritization can be used to detect objects of navigational significance for nautical charting purposes.

The second objective is to examine the performance envelope of various remote sensing methodologies for use in disaster recovery survey operations. In an emergency response situation, resources are often spread thin, which enjoins us to use them most efficiently. Unless we understand their limits, alone and in combination, it is very difficult to make rational resource allocation decisions. Success in this objective will assist in our first goal, particularly in survey planning, and in our second goal, by informing best practice for the systems in question.

Our third objective is to develop methodologies to construct information relevant to coastal zone planning, disaster response and community preparedness from a combination of remotely sensed data sets, and the efficient communication of these products to decision-makers, stakeholders, and the public. Data only becomes information when it has been interpreted, and information that is not adequately presented is effectively useless. Success in this objective will feed into our second goal by establishing...
recommended procedures for data processing and presentation, and into our third goal by establishing the routes by which information is made available for decision making and planning.

Finally, our fourth objective is to engage decision-makers, stakeholders and the general public in understanding the science involved in marine debris management, ocean mapping and disaster response through appropriate tools, datasets and interactive visualizations. As scientists, we should feel a compulsion to explain both what we do, and what it means, to the communities that (at some remove) fund it. Although less defined than our other objectives, success here would address primarily our third goal by communicating, in a manner appropriate to the audience, why the research we are doing matters, what it means for them, and how they can become involved in the process themselves. If planning cannot happen in a vacuum, satisfying this objective is one way to provide the information that fills the void.

The research proposed in Section 5 is organized according to the themes outlined in the FFO and are presented in the order in which they occur in that document. This precludes organizing them by objective, but each of the proposed research activities satisfies one of the four objectives outlined here. Where appropriate, the objective is indicated in the narrative. This crosscutting match of research activities to primary objectives is, perhaps, an objective of its own: to develop multi-use techniques from multidisciplinary science teams that support multi-use data products. Appropriate, we hope, for a proposal heavily influenced by the goals of Integrated Ocean and Coastal Mapping.

2 Background

At 1930 EDT on the 29th of October 2012, Super Storm Sandy made landfall on the U.S. east coast near Brigantine, NJ. The convergence of the storm with an intense low-pressure system, its unusual approach direction (from the east rather than from the south) and its coincidence with astronomically high tides made Super Storm Sandy one of the deadliest and costliest hurricanes in U.S. history, causing 147 deaths in the U.S. and more than 50 billion dollars in damages (costs are still being tallied) (Sullivan and Uccellini, 2013). Most of the damage caused by Super Storm Sandy was focused on the coastal zone, with flooding (the hurricane caused record high storm surges in New York, New Jersey and Connecticut), high winds and powerful waves resulting in the destruction of buildings, homes, roads, vehicles, and many other objects over hundreds of miles of coast. While the damage caused by the storm can easily be documented by airborne or satellite imagery for those areas that are above sea level, the impact of the storm on those areas at or below sea level (i.e., the presence of debris and changes in the shape of the seafloor that can create navigational hazards, or the impact on benthic marine habitat) is much more difficult to assess. Recognizing this, the FY 13 Disaster Relief Appropriations Act [DRA] contains funds to support state and federal efforts to acquire and process coastal and ocean mapping data in order to support marine debris removal and beach nourishment efforts, as well as to update nautical charts, create more accurate inundation models and better understand the impact of the storm on marine habitat.

NOAA’s plans call for data collected through the DRA to be processed at the NOAA Integrated Ocean and Coastal Mapping [IOCM] Processing Center located at the Joint Hydrographic Center at the University of New Hampshire. In support of these processing efforts, NOAA has issued a Federal Funding Opportunity [FFO] (NOAA-NOS-OCS-2013-2003801) calling for a research team to work collaboratively with the IOCM to develop, test, and evaluate new and alternative processing and analysis tools and procedures, as well as to assess the suitability of various types of remotely sensed data for the identification and classification of marine debris, for updating nautical charts and for creation of advanced decision support tools. In response to this FFO, the Center for Coastal and Ocean Mapping [CCOM] at the University of New Hampshire submits this current proposal. (Hereafter, ‘the Center’ and CCOM should be considered synonyms.) As outlined below, we believe the CCOM team is uniquely qualified to address the program priorities and meet the collaborative requirements presented in the FFO.

CCOM was established thirteen years ago with the objective of developing tools and offering training that would help NOAA and others to meet the challenges posed by the rapid transition from the sparse
measurements of depth offered by traditional sounding techniques (lead lines and single-beam sonars) to the massive amounts of data collected by the new generation of multibeam echo sounders [MBES] and to promote the development of new coastal and ocean mapping technologies. Over the years, the focus of research at the Center has expanded, and we have grown from 12 to now more than 90 faculty, staff and students, exploring a broad range of ocean mapping applications. While we continue to focus our efforts on data processing in support of safe navigation, our attention has also turned to the opportunity provided by this huge flow of information to create a wide range of products that meet needs well beyond safe navigation. Our current research activities are divided into seven major themes:

1. Sensors: improvements in acoustic, lidar and other sensor technology used for ocean and coastal mapping applications, including Autonomous Underwater Vehicles [AUVs].
2. Processing: development of new approaches to the processing of ocean and coastal mapping data.
3. Habitat and Water Column [WC] mapping: the development of new ways to locate, characterize and manage critical marine habitat and marine resources, including features in the water column.
4. Integrated Ocean and Coastal Mapping [IOCM]: the development of technologies and tools for creating new products from hydrographic data and using non-hydrographic data for charting purposes – “map once–use many times.”
5. Visualization: improvement in the visualization, presentation and display of hydrographic, ocean and coastal mapping data, including 4-dimensional and real-time display of mapping data.

In addition to these focused research themes, the Center also maintains a dedicated staff supporting a large IT infrastructure (see Section 4.2), state-of-the-art data management procedures, and a team devoted to outreach activities.

Our research efforts have seen numerous successful transitions from research to operations. Our automated processing algorithm (CUBE) and our new database approach (The Navigation Surface), were, after careful verification and evaluation, accepted by NOAA, the Naval Oceanographic Office and many other hydrographic agencies, as part of their standard processing procedures. Today, almost every hydrographic software manufacturer has, or is, incorporating these approaches into their products. Another long-term theme of our research efforts has been our desire to extract information beyond depth (bathymetry) from the mapping systems used by NOAA and others. We have made significant progress in developing a simple-to-use tool (GeoCoder) for generating a sidescan-sonar or backscatter mosaic—a critical first step in analyzing seafloor character. There has been tremendous interest in this software and many of our industrial partners have now incorporated GeoCoder into their software products. Like CUBE’s role in bathymetric processing, GeoCoder is becoming the standard approach to backscatter processing.

Our efforts to support the IOCM concept of “map once–use many times” are also coming to fruition. In 2011, software developed by Center researchers was installed on several NOAA fisheries vessels equipped with Simrad ME70 fisheries multibeam echosounders. These sonars were originally designed for mapping pelagic fish schools but, using our software, the sonars are now being used for multiple seabed mapping purposes. For example, data collected on the NOAA Ship Oscar Dyson during an acoustic-trawl survey for walleye pollock has been opportunistically processed for seabed characterization in support of essential fish habitat [EFH] and also in support of safety of navigation, including submission for charts and identification of a Danger to Navigation.

We have also been developing visualization tools that allow both seafloor and water-column data to be viewed in 3D and 4D (time). Although the ability to map 3D targets in a wide swath around a survey vessel has obvious applications in terms of fisheries targets (and we are working with fisheries scientist to exploit
these capabilities), it also allows careful identification of shallow hazards in the water-column and may obviate the need for wire sweeps or diver examinations to verify least depths in hydrographic surveys. These water-column mapping tools were a key component in our efforts to map submerged oil and gas seeps and monitor the integrity of the Macondo 252 wellhead as part of the national response effort to the Deepwater Horizon oil spill.

The small sampling above demonstrates the broad-based background and high productivity of the CCOM research team; this is further documented in our annual reports (http://ccom.unh.edu/reports) and in the hundreds of publications referenced in these reports and on our website (http://ccom.unh.edu/publications). The depth and breadth of research experience at CCOM makes the Center ideally suited to address the programmatic priorities outlined in the FFO. Shachak Pe’eri and on-site NOAA partner Chris Parrish are world leaders in the field of lidar waveform analysis and feature extraction and pioneers in the application of the narrow beam (topographic-bathymetric) lidar systems to hydrographic and shoreline change problems. They have also developed a suite of state-of-the-art sensors and sampling devices for quantifying and ground-truthing lidar measurements. Jennifer Dijkstra brings a strong marine ecology background to our team, enabling us to explore, in depth, the use of our sensors for seagrass or habitat studies, and Post-Doc Giuseppe Masetti, whose previous work at CCOM dealt with the automatic detection of Potentially Polluting Marine Sites [PPMS] in backscatter data as well as developing databases and risk indices for these sites, is well-placed to apply these skills to the area of marine debris. The Center is known internationally for its expertise in understanding the capabilities and limitations of acoustic mapping systems; through funding from the National Science Foundation, the Center is leading the Multibeam Advisory Committee, a national effort to provide oversight, guidance and training to the operators of multibeam sonars across the UNOLS fleet. We will build off this expertise and particularly our lab-wide effort to understand the sources of uncertainty in backscatter measurements (the NEWBEX experiment) and the work of Val Schmidt in developing new approaches for processing Phase Measuring Bathymetric Sonar data to guide and inform our proposed Acoustic Data Processing efforts.

Ubiquitous across the research efforts of the Center has been a concerted effort to understand the uncertainty associated with the measurements we make (e.g., the CCOM-derived CUBE algorithm was the first to use uncertainty in hydrographic data processing) and an overarching belief in the value of innovative visualization techniques for the delivery and analysis of our data products. The steady suite of visualization innovations that have come from our Visualization Lab (e.g., interactive 3D seafloor visualization tools, 4D visualizations of flow, marine mammal behavior, and water column targets) will be the foundation upon which visualization tools for the proposed work will be built. Through our long-standing mapping efforts supporting the establishment of a U.S. Extended Continental Shelf under Article 76 of the United Nations Convention on the Law of the Sea, we have developed sophisticated tools for sharing our data products with both the public and national data repositories. Finally, given our co-location with the NOAA IOCM Processing Center, our ongoing daily collaboration with employees and contractors of the NOAA IOCM and our already established integrated (with NOAA IOCM) IT infrastructure, we believe that we are particularly well-suited to carry out the research program proposed below.

3 Personnel

Possibly the most important component in the success of the proposed research is the people who are tasked with prosecuting it. Below, we offer short introductions to the identified personnel with particular emphasis on their relationship to the research proposed; full CVs for the PI and Co-PI, and concise CVs for all other researchers are provided in Appendix B.

**Thomas Butkiewicz** has a Ph.D. in Computer Science from the University of North Carolina at Charlotte, where he specialized in new interactive geospatial visualization techniques. His research interests include highly interactive visualizations, 4D dynamic ocean simulations, stereoscopic multi-touch displays and image processing/computer vision. In this proposal, he will be focusing on visualization of
marine debris data with an emphasis on rapid evaluation of complex data configurations, and the potential for outreach activities from these results.

**Brian Calder** has a Ph.D. in Electrical and Electronic Engineering from Heriot-Watt University in Edinburgh, Scotland, where he specialized in statistical methods for the detection of objects in sidescan sonar and other data types. His research interests include computer-assisted hydrographic data processing, and uncertainty estimation, management and representation in ocean mapping data. In this proposal, he will be focusing on object detection in sidescan, multibeam echosounder and lidar data, along with data fusion and metrics to assess the likelihood of the object being marine debris. He is also principal investigator for the project.

**Jennifer Dijkstra** has a Ph.D. in Zoology from the University of New Hampshire, where she specialized in marine biodiversity, habitat structure and non-native species; her research interests now include the use of remote sensing to map and characterize benthic habitats. She will be using these techniques in this project to address the question of seagrass habitat change and benthic habitat classification.

**Christina Fandel** has an MS in Earth Sciences (Ocean Mapping) from CCOM, where her thesis research looked at maintenance of sub-sea pockmarks and flow circulation patterns and associated survey planning methods. In this project, she will be focusing primarily on issues of efficiency in survey operations during response activities, with particular emphasis on the efficiencies that can be achieved through combined survey activities, and the trade-offs required in such circumstances.

**Paul Johnson** has an MS in Geology and Geophysics from the University of Hawaii’i at Manoa; he is currently the Data Manager at CCOM where he deals with all aspects of data management from physical storage through metadata capture and structure to distribution and public availability. He will be applying these skills in this project to ensure that the data constructed as part of the research is appropriately advertised, documented and available.

**Giuseppe Masetti** has a Ph.D. in Systems Monitoring and Environmental Risks Management from the University of Genoa, Italy, and a MS in Ocean Engineering (Ocean Mapping) from CCOM, where he focused on GIS and database issues in the management of Potentially Polluting Marine Sites, risk index development, and analysis of backscatter data for target detection. In this proposal, he will be applying these techniques to the identification and assessment of marine debris objects from multiple data sources, and the communication of these results to multiple users and databases.

**Larry Mayer** has a Ph.D. in Marine Geology and Geophysics from Scripps Institute of Oceanography. He is the founding director of CCOM, and before that was the NSERC Chair of Ocean Mapping at the University of New Brunswick. Larry has an international reputation for research and innovation in the field of ocean mapping, and has chaired many panels at both national and international levels that have set the agenda for the future of the field. He is also co-principal investigator for the project.

**Lindsay McKenna** has an MS in Earth Sciences (Ocean Mapping) from CCOM, where her research looked at bedform migration in shallow water environments. In this project, she will be focusing on limitations on the detection and quantification of shoreline change and erosion/deposition, and translation of the methods used into SOPs and best practice information.

**Shachak Pe’eri** has a Ph.D. in Geophysics from Tel Aviv University. His research interests revolve around understanding the performance of lidar systems in variable environmental conditions and usage of laser measurements for coastal applications, such as shoreline delineation. He will be applying these techniques to understanding of the limitations of lidar in difficult environmental conditions such as those found in the wake of significant storm events, along with extraction of useful information from lidar waveforms, and shoreline change analysis.

**Val Schmidt** has an MS in Ocean Engineering (Ocean Mapping) from CCOM where he specialized in acoustic data processing with particular application to underwater positioning systems. His current
research interests involve sonar signal processing with application to phase measuring bathymeters, where he has focused on new processing techniques that use estimates of uncertainty to transform raw data into useful information. He will be using these techniques to address the questions of the limitations of such systems in response activities, their capability to resolve objects, and their utility for storm impact assessment.

4 Equipment and Facilities

4.1 Office and Research Space

CCOM has 18,000 ft² of office and laboratory space. Approximately 4,000 ft² is used for teaching, with 11,000 ft² for research and outreach. In addition, CCOM has extensive meeting spaces, IT support spaces with a dedicated support staff and two secure, environmentally controlled, machine rooms for servers and data storage. CCOM is co-located with the Chase Ocean Engineering Laboratory, providing extensive experimental facilities including a large engineering test tank, a wave tank, a high-speed flume, a full machine shop and electronics lab, and a dedicated support staff for the same.

CCOM has committed to providing dedicated space for the researchers named in this proposal and NOAA collaborators co-located at JHC, and to provide for their IT and research support using the resources available within the Center. Co-located NOAA staff would be integrated into our environment through the protocols already in place for our current close interaction with NOAA staff seconded to the Joint Hydrographic Center; office space is available within the Integrated Ocean and Coastal Mapping Processing Center, attached to CCOM. All of the research and laboratory facilities are fully available to co-located NOAA staff.

4.2 IT Infrastructure Capabilities & Compatibility

CCOM operates an extensive research and administration computer network. From its two physically secure, environmentally controlled machine rooms (with UPS and backup generator power), the CCOM network encompasses dozens of servers, over 200 workstations and laptops, and over 150 TB of high-performance, mid-tier and commodity storage. CCOM’s network is supplied through a dedicated, redundant pair of gigabit fiber connections. A full range of internal and external network services are provided such as FTP, e-mail, web-sites, an intranet website, etc. We also provide full software development tool suites, distributed version control systems, and a number of common scientific computing platforms (e.g., MATLAB), with the capability to conduct high-performance and parallel computation. CCOM’s facilities include desktop color and monochrome printers, a high-volume printer/scanner, large format plotters (to 60” width), a large format scanner (to 54” width), and a variety of media devices (including various formats of tapes and discs) for distribution of data. All machines on the network are protected by a central, automated backup system that runs daily; tapes are vaulted off site for safety.

Security is maintained through multiple layers of monitoring and management protocols. All traffic into and out of the network is monitored using CheckPoint intrusion prevention systems and firewalls. The network is segmented into virtual LANs internally to maintain traffic segregation and control, while all data stores are appropriately limited in access as required. Automatic log forwarding and analysis is used to identify issues as they arise and alert the dedicated IT staff. Virus scanning is mandatory on all machines, and extra scanning of e-mail is conducted centrally. The security system and protocols undergo an annual independent certification and accreditation inspection to FISMA/NIST standards.

The IT infrastructure for the Joint Hydrographic Center is fully integrated with CCOM’s IT infrastructure, and is maintained by CCOM personnel on behalf of NOAA under a cooperative agreement. There are by design, therefore, no issues to be addressed in respect of either smooth integration of IT systems, or of security, when considering the conduct of the proposed research within and with the Joint Hydrographic Center.
4.3 Ocean Mapping Technology & Laboratory Facilities

CCOM is located within the Jere A. Chase Ocean Engineering Laboratory, and has full access to all of the facilities in the building as outlined previously. CCOM operates two survey vessels capable of multibeam, phase measuring bathymetric sonar [PMBS] and sidescan sonar survey in the near shore, and has access to UNH’s larger research vessel if required.

CCOM owns and operates a full suite of ocean mapping instruments including high-performance, geodetic grade, GPS systems with RTK, motion sensors with GPS aiding, sound speed sensors, drop cameras and grab samplers, etc. It also owns a small, portable multibeam echosounder [MBES] system, a GeoSwath PMBS for use on an AUV, and a number of single-beam echosounders. It also has access to a Klein Hydrochart PMBS. In addition, CCOM has over forty industrial partner organizations, including all major ocean mapping hardware and software manufacturers. The industrial partners are obligated to provide use of their equipment for a certain period each year. This allows CCOM to have access to the latest hardware and software for ocean mapping-related research, without having to fund depreciation and maintenance costs.

5 Proposed Research and Development Effort

In the following sub-sections, we outline a two-year effort that represents an integrated approach to the problem of identification of marine debris from remotely sensed data, methodologies for response to the aftermath of extreme storm events, and new methods for analysis of data for multiple uses with multiple users. We believe that the proposed efforts are consistent with the programmatic priorities outlined in the Federal Funding Opportunity and have therefore organized them to follow the headings outlined in that document; we have also added a separate visualization heading, since this effort cuts across all of the themes. It is important to note that although we have tackled the programmatic priorities separately here (primarily for clarity), there is in truth much overlap and interaction between the efforts, and we expect that results from one theme will be input for others as the proposed efforts proceed. The benefits, beneficiaries and opportunities for dissemination of the results of the proposed research often overlap, and are therefore treated uniformly in Section 7. We have also not always explicitly called out the construction of best practice and standard operating procedure documents, since these are typically outgrowths of the research as it progresses. These are, however, explicitly detailed in the milestones in Section 8. Where internal reports are generated, they will be sequentially numbered from a registry specific to the proposed research project, and published in PDF format on the project website (see Section 5.5); publications will be advertised through appropriate technologies (e.g., RSS feeds, tweets, etc.)

5.1 Lidar Processing

FFO Text: Evaluation of and development of methodologies for such purposes as using topo-bathy lidar data for: nautical charting (especially in shallow-water areas), generating new IOCM multi-use data products, extracting enhanced information from lidar waveforms, shoreline change analysis, analysis of erosion and deposition, bathymetric mapping in adverse conditions, assessing seagrass habitat change, and benthic habitat classification and analysis.

Despite the threat of severe storms, people continue to live and develop along the coastline. This is particularly true along the New Jersey coast where 60% of the state’s population lives in coastal counties (Cooper et al., 2005). Changes to the shoreline and shallow water bathymetry caused by severe storm events can have significant impacts on (1) coastal marine resources such as fisheries and marine mammal breeding grounds; (2) shoreline stability structures, including dunes and groins; (3) navigation channels and buoy markers; (4) infrastructure, such as roads, bridges, and pipelines; (5) navigation hazards including derelict vessels and fishing gear; and much more. Measuring changes in very shallow water using traditional acoustic survey methods proves to be difficult and time consuming. Lidar is an alternative technique for efficiently surveying substantial areas of shallow water (e.g., entire back bay regions).
Furthermore, newly developed topographic-bathymetric lidar [TBL] systems can simultaneously measure topography and bathymetry, making lidar ideal for seamlessly mapping large extents of coastline.

In recent years, two types of Airborne Lidar Bathymetry [ALB] systems have emerged. The first type is broad-beam systems (e.g., Optech SHOALS-1000, LADS MKIII, Optech Coastal Zone Mapping and Imaging Lidar [CZMIL] and AHAB HawkEyll) that use a transmit pulse with a large beam divergence (20-40 mrad) and a correspondingly large receiver field of view [FOV], and have a typical footprint size of 2-4 m on the water surface. The second type is narrow-beam systems (USGS Experimental Advanced Airborne Research Lidar [EAARL-B]; AHAB Chiroptera, Riegli VQ-820-G, Optech Aquarius) that use a transmit pulse with a small beam divergence (less than 5 mrad) with a typical footprint size of less than 1 m on the water surface. Narrow-band systems typically do not offer the same maximum depth penetration as the broad-beam, large FOV systems. However, they typically use high measurement rates and can provide seamless, high-resolution coverage across the backshore, intertidal and shallow nearshore regions.

ALB sensors can store their measurements as an entire sequence of interactions of the laser pulse with environment, known as a waveform. The waveform is a time series of the received intensity (digital number) relative to time (ns). In standard ALB surveying conditions, in which the water clarity and the water depths allow for detectable bottom returns, the interactions of the green laser pulse with the water surface, water column, and the seafloor are observed as two peaks in the green-channel waveforms (Guenther, 1985; Wang and Philpot, 2007; Pe’eri et al., 2011a) (Figure 1). The shape of each return characterizes the water medium and the interfaces (air/water and bottom).

![Figure 1: Schematic illustration of the ray-path geometry for the green-channel waveforms and the received waveforms as a function of water depth (Pe’eri et al., 2011).](image)

State-of-the-art TBL systems now being deployed in the Sandy-impacted region offer the potential to extend these basic datasets and create new products supporting multiple uses. However, extraction of enhanced information typically requires applying sophisticated digital signal processing to lidar waveforms. Many organizations that stand to benefit from these new products simply do not have this level of processing expertise, let alone access to the raw lidar waveform data. As a result, they use only the lidar position (X,Y,Z) and lidar peak intensity (I). To address this challenge, we will investigate the ability to extract a number of simple, computationally efficient waveform features upstream in the processing workflow, such that they can be provided to end-users as new IOCM multi-use products. These features will include waveform slopes, integrals, amplitudes, and statistical moments, as described in Parrish et al. (2013). The implementation will leverage our recent efforts with the American Society for Photogrammetry and Remote Sensing [ASPRS] enabling the LAS lidar file format to be modified for TBL
data, using LAS “Extra Bytes” variable length records [VLRs] to store new attributes (ASPRS, 2013). We will develop procedures for reading these lidar waveform-derived features from the LAS files and gridding them to generate raster data sets that can be directly ingested into an existing GIS within federal, state, and local offices. We will also investigate the use of these new products in supporting other portions of this project, such as marine debris recognition, benthic habitat mapping and calculation of coastal engineering indices [CEI].

In ALB surveys, the morphology of the seafloor is a concern primarily because of its effect on the accuracy of depth measurements and limitations of the lidar’s ability to resolve objects (e.g., large rocks or ship wrecks) that are hazards to navigation (Figure 2). This is especially important for monitoring coastal areas before and after major storms. Previous studies on broad-beam ALB have shown that bottom detection is dependent on bottom slope and roughness characteristics in addition to water clarity (Pe’eri et al., 2011). However, such studies have yet to be conducted on the more recent narrow-beam ALB systems. Using available acoustic datasets, it is possible to evaluate the performance of ALB systems as a function of depth (Imahori et al., 2013). However, in order to identify the environmental conditions that influence the performance of narrow-beam ALB systems, it is important to map the different environmental conditions during the ALB survey. We propose developing procedures to map the water column and the seafloor using aerial optical, and satellite multispectral imagery. Additional attributes of the seafloor (e.g., slope, aspect, and roughness) will be derived using surface analysis applied to the bathymetry measured by a reference acoustic survey. A spatial intersection between the successful bottom detection areas from the narrow-beam ALB systems with environmental conditions mapped using the auxiliary datasets (i.e., spectral and acoustic systems) will allow planning of future ALB surveys with a high success of bottom detection, and highlight areas that are not appropriate for ALB surveying.

![Figure 2: (Left) Grey-scale shaded relief multibeam-bathymetry map of Pe’eri et al. (2011b) of an offshore study site near Gerrish Island, ME. The depth values are relative to Mean Lower Low Water [MLLW]. (Right) ALB waveforms over a subset of the study area (denoted by the rectangle area in the left image), where the bottom returns are circled in yellow). A color ramp indicates successful bottom detection by the ALB system. Laser measurements that were not detected are colored dark red.](image)

Lidar data can be used to measure shoreline change and also analyze patterns of erosion and deposition. We propose to develop methods that will allow for more precise and rapid monitoring of these changes. These methods can be developed into a tool that can be utilized by government officials and engineers for future coastal planning and storm mitigation measures. The general public can also benefit from these results by becoming better informed of how future storm events may affect their coastal homes and communities.

We propose developing methodologies for shoreline change analyses, and analysis of erosion and deposition in the Sandy-impacted region, including, but not limited to Barnegat Bay, NJ, Long Beach Island, NJ, and Fire Island, NY, using TBL surveys collected before and after the storm by NOAA and JALBTCX
partner agencies (e.g., USGS and USACE). The USGS have collected data using the newly developed EAARL-B system, the USACE acquired data with the CZMIL system, and NOAA National Geodetic Survey [NGS] collected data using the Riegl VQ-820-G system. CZMIL point cloud data is available through Digital Coast, while EAARL-B and Riegl point cloud files can be obtained through collaborative partners (see letters of collaboration in Appendix C, and data sources in Appendix I). As part of the proposed analysis, we will reference the lidar point cloud files to a consistent vertical datum using NOAA's VDatum software and generate Digital Elevation Models [DEMs]. From these surfaces, pre- and post-storm Mean-High-Water [MHW] and Mean-Lower-Low-Water [MLLW] contours will be extracted according to NOAA NGS’s VDatum-based lidar shoreline extraction procedures (White, 2007). In order to include water bodies that were also impacted by Super Storm Sandy, such as estuaries and wetlands, we propose testing the ability to extend NGS's lidar shoreline mapping procedures into broader coastal areas. We propose to investigate various methods for conducting shoreline change analysis in the Sandy-impacted region using shorelines extracted from the lidar data (e.g., Stockdon et al., 2003; Boak and Turner, 2005), with horizontal uncertainty being estimated for a portion of TBL survey data to test the ability of the Monte Carlo estimation method developed by White et al. (2011).

Conducting analysis of erosion and deposition in Barnegat Bay, NJ is proposed using GIS workflows and depicting results with change maps. This proposed analysis involves subtracting pre-storm DEMs from post-storm DEMs to determine where changes to the seafloor have occurred. While the DEM differencing procedures are relatively straightforward using readily-available GIS packages, a key component of this proposed analysis will entail estimating vertical uncertainty of the grids, such that elevation differences below the total propagated uncertainty [TPU] are not depicted as actual changes. A variety of published techniques can be investigated for estimating the TPU in the elevation difference grids, and the output maps can then be displayed at an appropriate level of granularity. In particular, erosion and deposition changes that are smaller than the calculated TPU of the difference grids will be classified as having “no change.”

Seagrass provides many important ecological functions such as habitat for fish and shellfish species, filtering suspended sediments and nutrients from coastal waters and stabilizing sediments. Seagrasses are light-sensitive plants that are a very useful environmental indicator for deteriorated water quality as they decline with excess turbidity and nutrient concentrations. Other submerged aquatic vegetation [SAV], such as macroalgae require less light (typically, less than 10% of the light needed by seagrasses to survive). In the Mid-Atlantic region of the U.S., this depth typically ranges from less than half a meter to over two meters, depending on water clarity. Alterations in plant density are slower than the changes that occur in the water column. As a result, they can be mapped using optical remote sensing and their densities can then be used as a proxy for the quality of local waters before and after a significant storm event, such as Super Storm Sandy. While in situ physical sampling of the water column has traditionally been used to evaluate temporal changes in water quality, this method is labor intensive and typically covers a small area. Optical remote sensing may provide a way to measure water quality over large spatial areas through time. One of the main challenges in mapping seagrass beds is that there are many species of seagrass and macroalgae that can grow at varying densities over the seafloor and can be mixed with other biota (e.g., other species of SAV, detritus and corals).

We propose to explore methods to distinguish between seagrass and macroalgae based on fusion between TBL data (position and intensity) with available optical imagery and TBL intensity. A key component in the mapping procedure is the identification of the extinction depth of light (Secchi disk depth). Using the bathymetry measured from the TBL system, water clarity can be estimated using optical imagery at different acquisition periods. The attenuation of light will be inferred and the study will focus over areas that are shallower than the seagrass survival depth criteria. Based on previous work conducted on hyperspectral imagery and publicly available algorithms, different algorithms will be used to evaluate the ability to map SAV and separate seagrass from macroalgae (e.g., Pe’eri et al., 2008) (Figure 3). The algorithms will include corrections to light attenuation in the water column using the TBL bathymetry. To
validate the results, ground truth measurements that will include optical (video imagery and spectral) measurements will be conducted over the study site in selected areas. We further propose to create habitat maps of before and after Super Storm Sandy in order to determine storm induced changes in seagrass and macroalgae using spatial metrics such as percent cover, patch size and patch density. These spatial metrics will be used to compare before and after Super Storm Sandy densities of SAV that we can then use as a proxy for changes in water quality.

![Eelgrass (green) and macroalgae (yellow) distribution over Great Bay Estuary, NH based on hyperspectral imagery (AISA Eagle) overlaid on the survey project mosaic (Pe’eri et al., 2008).](image)

**Figure 3:** Eelgrass (green) and macroalgae (yellow) distribution over Great Bay Estuary, NH based on hyperspectral imagery (AISA Eagle) overlaid on the survey project mosaic (Pe’eri et al., 2008).

In addition to seagrass habitat, we propose to investigate how the parameters we derive from lidar and multispectral data can be used to address the broader issue of benthic habitat in regions impacted by Super Storm Sandy. Many of the parameters that we can derive map nicely into the benthic habitat Coastal and Marine Ecological Classification Standard [CMECS] that has been approved by the Federal Geographic Data Committee [FDGC] and adopted as a standard for benthic habitat classification by many NOAA labs. CMECS provides a comprehensive framework for organizing information about coasts and oceans and their living systems using four fundamental components – water clarity, geoform, substrate and biota to define the ecosystem. Many of these components can be derived directly from the data we will be processing. Water clarity, for example, can be estimated using remote sensing algorithms applied to aerial optical, and satellite multispectral data combined with bathymetry measured from a TBL system. The depth of extinction can be calculated for different time periods based on the acquisition times of the imagery and compared to available tide and current data. The geomorphology (geoform) can be described in terms of slopes (i.e., a height difference between adjacent laser measurements) and a roughness (i.e., small-scale height variability within the footprint of the laser measurement) that can vary from one local area to another. These properties will be measured using the TBL bathymetry and intensity. Slope and aspect can be derived directly from the bathymetry. Although TBL intensity can provide information on the roughness, it is hard to separate the roughness of the substrate containing different mineral compositions or different SAV types based solely on the TBL intensity. We propose to integrate lidar data with hyperspectral imagery, and *in situ* measurements (Finkbeiner et al., 2001; Kendall et al., 2001) to gain insight into the composition of the substrate. Many of these same parameters will also be valuable in providing Coastal Engineering Indices [CEIs].
5.2 Marine Debris Analysis

FFO Text: Development of tools and protocols to post-process sonar and lidar data to identify submerged marine debris objects; development of tools to analyze raw sonar and lidar data and imagery to determine the objects considered marine debris; investigation of the feasibility of automated and novel approaches to identifying and characterizing sonar and lidar targets; development of improved approaches for the visualization and display of marine debris data; development and documentation of best practices and standard operating procedures for processing the various data types to identify submerged marine debris.

Marine debris is typically defined as any man-made object discarded, disposed of, or abandoned that enters the coastal or marine environment (http://marinedebris.noaa.gov/whatis). While most studies of marine debris have focused on floating or near surface objects (e.g., Mace, 2012; Pichel et al., 2012), this study will focus on submerged marine debris. Given the resolution limits of commonly used remote sensing systems and the standards used for hydrographic charting, we will limit our identification and classification efforts to debris that is greater than or equal to one cubic meter in size. Typically, submerged marine debris have been identified through the subjective evaluation of sidescan sonar records by a human operator. We propose exploring the use of automated approaches to identify and classify submerged marine debris, using the techniques developed for the detection of mines, unexploded ordinance and pipelines (e.g., Petillot et al., 2002, 2006; Reed et al., 2003; Clem, 2012) as a starting point. We will build on the existing research in these fields and, as outlined below, develop approaches that are best suited to the recognition and inventory of marine debris. We will also investigate possible approaches to reduce the time required by human analysts to process and analyze large amounts of data, evaluating the adoption of parallel computation, scalable capabilities and new visualization techniques.

The problem of target detection is a fundamental basis on which to develop more complex techniques. This basic process can be used for marine debris detection, and for navigational chart update (i.e., for marine debris that is not going to be removed). The background literature in this area is significant, since mine counter-measures, unexploded ordnance removal and pipeline inspection, among other fields, have generated a suite of techniques that can be exploited. We therefore propose, after a literature search in appropriate fields, to adapt the appropriate approaches to target detection to the problem of marine debris detection (Masetti and Calder, 2012). Particular efforts will be made in algorithm development to smooth the transition from other fields into submerged marine debris detection, and investigate features related to their acoustic and electro-optic characteristics aligned with this aim.

Many algorithms have poor performance in practice since the conditions present in test scenarios are often not representative of the conditions used to develop and train the algorithm (Stack, 2011), violating a fundamental assumption of traditional pattern recognition. Gathering a robust test set that fully explores all parts of the potential object set that will be encountered in the field is, however, extremely difficult (and often time-consuming). The solution, therefore, is in development of algorithms than can appropriately respond to changes in the environment, detection context, and the skills of human operators. In other words, the algorithms need to attempt to adapt to the new underlying test-data distributions in case they are not sufficiently well represented in the training data.

Marine debris may have very different acoustic and electro-optic signals due to their size, reflectivity, and angle of incidence (e.g., variable target strength). In relation to the wide definition of “marine debris”, it will be necessary to define some criteria to define the debris targeted or, alternatively, to include the intervention of a human analyst. Thus, we propose investigation of methods that allow the algorithms to adapt through user-tunable parameters for the searched debris type (size, debris material on seabed material, etc.), which may be applied at different stages of the processing chain. Furthermore, the object detection issue (whether an element belongs to an object or to the background) will need to be addressed at different data levels: pixel, snippets, and beam (if applicable), and we propose consideration of
algorithms that can take advantage of the differences between these representations of the data to improve performance.

One common technique used in mine counter-measures and general image processing, is the idea of change detection through multiple snapshots of the data. In the context of marine survey, this translates as before and after surveys with inter-comparison. Direct comparison of repeated surveys is often difficult, however, due to the variability in the environment, or inter-system differences (e.g., in acoustic frequency, beam-width, pulse length, etc.); economic concerns also mandate that if before and after surveys were to be considered, they could only be done in very limited and targeted areas. We therefore propose an investigation of the feasibility of multi-sensor inter-comparable surveys for object detection purposes, with particular emphasis on normalization of backscatter values to enable this approach. We would also consider the practical implications of this suggestion in order to assess the applicability of this technique in future response events.

A key issue in marine debris recognition is that even the best performing techniques can result in a significant number of “false alarms” for any reasonable probability of classification. A common solution for this issue is represented by data fusion, which is the use of multiple data sources (e.g., multiple viewing aspects and sensing modalities) in the decision process in order to increase the decision quality (Stack, 2011). Although the algorithms used may not be statistically independent, each of them can suffer different types of error if they have largely different workflows. As a direct consequence, the fusion process eliminates a large number of false alarms (Dobeck, 2001). Several of the algorithms considered previously will be based on physical models (coming from principles of underwater acoustics and active electro-optics), while another subset of algorithms will attempt the detection of marine debris from a primarily statistical point of view. This dual approach, aimed at the reduction of cross-correlation between algorithms, will reduce the level of false alarm. We therefore propose to build a data fusion system for marine debris detection that will attempt to take advantage of the differences between the available algorithms to provide a meta-algorithm that is better than any individual detection method. The physics-oriented algorithms will be based on existing theories (e.g., for underwater acoustics, models for acoustic response, reverberation, geometrical spreading, target strength, etc.). The existing knowledge might require some calibration for marine debris, and therefore we propose to conduct experiments (e.g., target strength of plastic debris-like objects) in the Chase Ocean Engineering Laboratory test tank as required. The algorithm evaluation will be based on the level of false alarm as well as the probability of correct detection and classification.

Identification of individual targets is an important aspect of tackling the marine debris problem, but working on individual targets is only part of the problem. To be effective, the techniques developed will need to be able to handle aggregations of targets, enabling the analysis of spatial distributions, meta-analysis, and inventory. We propose enabling the construction of a marine debris inventory through use of a spatial relational database. The attribute fields will be defined from a survey of possible useful and commonly available information. Having the results of object detection and filtering activities available as a spatial database will allow us to consider the feasibility of a relevant marine site risk index for marine debris prioritization (Masetti et al., 2012a, b). The output of the tool will be a marine debris list stored in a geodatabase with information organized using ISO Geographic Markup Language [GML] schemas, ready to be used in web GIS (through ERMA and GeoPlatform implementations) and environmental databases (e.g., NOAA RULET/RUST) through a process of automatic translation.

5.3  Acoustic Data and Techniques

FFO Text: Assessment of different mission requirements for acoustic surveys to determine how they might be modified to improve acquisition coordination efforts, for example evaluate multibeam and interferometric data for whether/where full bottom coverage requirements might be reduced, but from which full bottom character can be extrapolated; investigate new approaches for processing
interferometric (phase measuring bathymetric systems) data, including the development of methods for assessing uncertainty and extracting features; investigation of the applicability of interferometric and other acoustic data for assessing storm impact; investigation and evaluation of new approaches for the application of 3rd-party marine debris surveys for use in support of improved nautical charting and other applications.

Acoustic survey efforts in disaster response situations require rapid data collection, effective collaboration between multiple agencies, and an appropriate understanding of the benefits and limitations of different sonar systems (e.g., multibeam and PMBS systems) in order to maximize survey efficiency. PMBS systems have a number of advantages as early response tools. They are small, lightweight, low power, readily available, and provide improved inshore efficiency due to a large swath width. However, they produce apparently “noisy” raw data in the outer reaches of their swath and, as a result, their use in U.S. hydrographic surveying efforts has been limited.

The development of acoustic surveying acquisition procedures to optimize data collection effectiveness in post-disaster circumstances would benefit future acoustic response survey efforts and minimize data collection redundancy. The question, however, is how to find the balance between the various sensors, and their associated costs. We therefore propose to investigate the necessity of conducting full-bottom coverage surveys during post-disaster response efforts by assessing the benefits and limitations of data acquisition using multibeam and PMBS systems.

We propose to evaluate the optimal acoustic survey acquisition procedures necessary to maximize efficiency in response conditions using co-located multibeam and PMBS datasets in the Redbird artificial reef site, located approximately 30 km off the coast of Delaware. The Redbird artificial reef datasets were acquired using a Reson SeaBat 7125 MBES and a 500 kHz GeoSwath Plus PMBS both pre- and post-Super Storm Sandy. Using these datasets, we propose the development of new protocols by which full-bottom coverage requirements may be modified in storm-response situations to maximize survey efficiency, while maintaining survey-specific resolution requirements (e.g., full-bottom PMBS sonar coverage with limited multibeam coverage over high priority, or calibration areas). Protocols for PMBS and multibeam surveys benefit from prior knowledge of the geomorphologic environment, as survey line spacing and overlap requirements are dependent on seafloor roughness and depth. Therefore, specific protocols will be modified according to the survey area environment.

Additionally, we propose to investigate new and innovative techniques to process PMBS data. Although PMBS systems can be advantageous in disaster response situations, they have a reputation for generating “noisy” data in the outer reaches of their swath, and produce large volumes of “data” in the form of raw measurements which makes it difficult to process these data in conventional hydrographic data processing software.

In fact, this reputation is not well founded: PMBS systems typically generate one measurement for each sample in the received signal, which makes their data appear to be “noisier” than MBES data would be in the same circumstances, even if they are evincing the same amount of intrinsic phase noise within the acoustic measurements. With suitable processing, however, this difference can be compensated; such processing typically also reduces the data volume to something more akin to a conventional MBES system, which resolves the second issue, although this has to be balanced against a more restricted swath than is typically advertised for PMBS systems.

CCOM has previously developed techniques for processing of PMBS data to attempt to isolate the data points that are reliable using a Most Probable Angle Algorithm (Schmidt et al., 2012). Currently, we are developing techniques that use estimates of data uncertainty, based on the work of Lurton and Augustin (2010), to generate depth solutions from PMBS raw data that meet a given uncertainty specification (Schmidt et al., 2013). We propose to investigate the use of these techniques on the data being collected at the Redbird artificial reef site (see letter of collaboration in Appendix C). We propose to use these datasets
to assess whether they can be used to accelerate the processing of PMBS data, and therefore improve survey efficiencies in a response situation. Improvements in processing will be assessed through comparison of the level of uncertainty and noise present in the output products using the proposed, and conventional, techniques.

In addition to data volume and perceived uncertainty, a significant question with PMBS systems is whether they can effectively preserve small objects through the whole data processing chain. That is, although a PMBS might respond to a small object on the seabed, this response may become sufficiently modified during processing that it is not reflected in the final result. This has obvious negative side effects in a debris rich environment. We propose two phases of research to address this question. First, we will investigate the behavior of our proposed processing algorithm on the detection of objects in PMBS systems, comparing against reference processing methods to identify at what remove from the sensor a standard target can be distinguished. (A 1m x 1m x 1m cubical target, although unrealistic in nature, is commonly used as an idealized detection goal for hydrographic and marine debris studies.) The Redbird site data described previously, which contains many small targets, will be used for this analysis. We will also consider the dichotomy between recognition of an object and merely observing some effect in the data, in order to establish an effective range of detection (i.e., at which the effect of the object is preserved sufficient that it can be recognized by an operator), which has significant implications for survey planning as previously outlined.

Secondly, we will investigate whether it is possible to extend the proposed processing technique, given knowledge that objects may be present, and their approximate size, by tuning the algorithm so that it preferentially constructs depth estimates that emphasize the presence of objects in the resulting data. For example, knowledge of the approximate size of the objects might be used, in conjunction with the geometry of data capture, to adjust the digital filtering applied to the data in order to better preserve the potential object. Or, the processing could use an expected size of object to pre-screen the data for likely targets, and then focus more processing effort on these areas of the returned signal. Comparison against the baseline performance established previously could be used to estimate the significance of any adjustments to the algorithm. The results of this analysis may benefit the marine debris portion of the proposed research (Section 5.2), and may in turn benefit from the results of that research.

An investigation of the use of acoustic data to assess storm impact would assist with future storm-related change analysis studies and provide guidance to coastal zone managers in post-storm remediation efforts. We propose to investigate the feasibility of using multibeam and PMBS data to assess storm-related impacts on the seabed as a function of sonar resolution using the pre- and post-Super Storm Sandy MBES and PMBS data collected at the Redbird artificial reef site. Using these datasets, we propose to investigate the finest resolvable seabed feature as a means to identify items on the seabed and detect and measure storm-related changes in the seafloor (e.g., bedform migration).

5.4 Specialized Data Processing

FFO Text: Lead development of a costal engineering index for a standard way to “index” coastal parameters on a national/regional level using standard datasets; develop documentation of best practices and standard procedures for processing the various data types and make these available for application at the IOCM Processing Center and by other processing users in the hydrographic and ocean mapping field; develop improved means of using and displaying marine debris data in response, restoration, and marine debris GIS applications such as GeoPlatform and ERMA.

A number of coastal vulnerability indices [CVI] have been developed that quantify the relative risk of different coastal areas to erosion and inundation, due to sea level rise and storms (e.g., Gornitz et al., 1994; Hammar-Klose and Thieler, 2001). Recently, the Joint Airborne Lidar Bathymetry Technical Center of Expertise [JALBTCX] has developed new coastal engineering indices [CEI] that synthesize coastal conditions of interest for regional sediment management, engineering, and emergency response
applications (Dunkin, 2013; Dunkin and Rief, 2013). These indices are computed using geomorphic parameters (e.g., dune height, beach width), as well as environmental and human use parameters.

To augment these efforts, we propose investigating the use of lidar and acoustic ocean and coastal mapping data in the Sandy-impact area to compute indicators that facilitate and enhance CEI generation. This will include, for example, investigating the use of new lidar waveform shape-based features for estimation of geomorphic parameters and other sub-indices. We also propose to investigate the ability to extend the computation of these indices into new areas, including back bays and wetlands, within the Sandy region. Where possible, we will compute indices using both pre- and post-Sandy data to investigate their use in storm impact assessment. Best practice information, and standard operating procedure documents for this effort will develop naturally from the documentation of this research; these will be captured for distribution to IOCM personnel.

Data products that remain on the shelf (or disc platter) are of no use to anyone. CCOM, over the past year, has therefore developed and deployed a GIS server populated with data predominately related to the mapping efforts of the Extended Continental Shelf/Law of the Sea program and CCOM’s mapping programs in the Gulf of Maine. Using ESRI’s ArcGIS server CCOM has been able to create the necessary infrastructure to effectively serve data related to both of these mapping programs to users within and outwith the lab. Currently CCOM is distributing bathymetry, backscatter, and associated vector based data through this server. This existing infrastructure and knowledge base means that CCOM will be well positioned for supporting the efforts to display and use marine debris data for response and restoration using applications such as GeoPlatform and ERMA. All of the data objects constructed as part of the proposed research will be distributed in this manner.

Data currently being distributed through the CCOM GIS server are fully documented with all relevant metadata and available through many different protocols (REST, WMS, JSON, SOAP, etc.). Because of this, integrating datasets from the CCOM GIS server into other web based or desktop GIS applications is typically almost effortless. Figure 4 shows that by supplying the URL address of CCOM’s GIS server’s REST (Representational State Transfer) web service, a listing of all available datasets from the server are shown, which in turn means any of these datasets can be easily added to a GIS applications, in this case, to NOAA’s GeoPlatform map viewer.

Not all visualizations of data are created equal: the difference between simple data and useable information can often be in the manner in which the user can experience and interact with the measurements available. Our proposed research in visualization of marine debris data is covered in section 5.6.

5.5 Outreach

FFO Text: Provide outreach and information to convey the aims and results of the program to the public, particularly in areas affected by the storm.

To inform the public about the scope and importance of post-Sandy cleanup efforts, we propose the creation of a website providing not only information on the project, but an array of interactive infographics. Such infographics are a popular method of conveying complex information to general audiences. They engage users with interactivity, allowing them to explore the data within carefully constructed constraints. This type of format is easily consumable and more likely to be “shared” by members of the public via social media than traditional documents.

An example would be an interactive map of the Atlantic coastline, which users could navigate and zoom in on to see their area-of-interest (Figure 5). Following along the coastline would be an indicator showing the amount of debris recovered offshore from each section. Significant debris fields and other areas with concentrated cleanup efforts would be highlighted offshore. By selecting these areas the user could bring up detailed information including photos and descriptions of the recovered debris. (e.g., “15 vehicles were
discovered to have been deposited in this spot"). Examples of these interactive products being used to share project results and engage the public can be found in the U.S. Census Bureau’s Data Visualization Gallery (http://www.census.gov/dataviz).

In addition to communicating the goals and objectives of the proposed research to the public through conventional means and publishing data products so that they can be readily incorporated into other products by professionals, we aim to provide some insight into the science being conducted, and potentially extract some useful “citizen science” at the same time.

**Figure 4:** The figure on the left shows a NOAA GeoPlatform map viewer webpage (http://www.geoplatform.noaa.gov/home/webmap/viewer.html) with a CCOM Law of the Sea sun-shaded bathymetry grid overlaid on a NOAA-generated hydrographic chart compilation. The CCOM data was accessed by supplying the URL of the Center’s GIS server to the GeoPlatform map. All web services served from the CCOM GIS server are fully documented with metadata (right) and can be queried directly from the GIS server.

**Figure 5:** Mockup of an interactive infographic showing debris cleanup results.
One of the significant issues with any computer-assisted data processing is that there will always be some situations that the algorithm cannot handle, or which need some human inspection to complete. The normal course of action is to present these cases to a trained operator. In a response situation, however, it is often the case that resources are spread fairly thin, and there may not be enough trained operators to go around. Experience has shown, however, that the general public, given some suitable guidance, can often be very generous with their time. This has been exploited, for example in identifying fish species in high definition video from the deep ocean (http://digitalfishers.net), or identifying ground cover and species (http://www.seafloorexplorer.org) for habitat studies. Not only does this engage the public in the science, communicating the needs, methods and goals of the research, it can also provide scientifically useful data. In a response situation where the typical reaction (at least from those at a suitable distance) is to want to help – if only there was a way – this sort of public outreach has the potential to be especially effective.

We therefore propose taking the results of our investigation on how to best visualize the marine debris objects for trained operators (see Section 5.6), and construct a version that can be shown to the general public via a website. The goal here is to provide the information in two complementary forms: a narrative that explains the science and its importance, and a visual interactive component that allows the user to see real marine debris objects, and lets them assist in the classification of objects using a simple interface. Appropriate instructions will be provided, and individual scores will be aggregated to provide voted classifications for multiply-viewed objects. To encourage participation, we propose promoting this activity through different channels (e.g., social media, 4H clubs, middle and high schools, local science education centers such as the Seacoast Science Center in Rye, NH, local museums, and published media such as Scientific American), and to provide a mechanism whereby users can track how many objects they have classified, their hit/miss rate compared to the consensus opinion (or groundtruth where available), and allow this information to be displayed on their website, or social media outlet. Comparison of the “citizen science” classification against available groundtruth might be used to quantitatively assess the utility of these types of techniques. We will also provide dissemination venues through seminars, and web-casts and recorded videos of these events throughout the performance period.

5.6 Visualization

Although not called out explicitly in the FFO, our experience with previous data processing in complex situations leads us to believe that the visualization of the results of our proposed research is a research theme in its own right. We have therefore included a separate theme that brings together a number of the proposed processing and data extraction techniques and poses the question: how do we most efficiently convert our raw data into actionable information through appropriate visualization?

Due to the extent of the data to be collected and processed, automated target recognition will play the most significant role in detecting and identifying marine debris. However, even with the best algorithms, there will always be ambiguous cases that require human evaluation. Even if these represent only a small fraction of potential debris, the overwhelming number of them requires a streamlined approach to evaluation. Current methods (in conventional data processing software) present a view of the data to the analyst, who must then navigate and reposition their viewpoint to inspect the candidate from various angles. We propose to investigate the potential benefits of creating a system which automatically generates a collection of multiple views for each candidate, based on metrics determining which combinations of data sources (MBES, areal imagery, backscatter, etc.) and angles/presentations are most likely to help the viewer discriminate natural from artificial features. Our interface would present these views simultaneously to the analyst, who would be able to quickly scan over them, select an evaluation, and proceed automatically to the next target.

This research would have benefits beyond just identifying marine debris. It would also help improve the efficiency of the time-intensive task of sonar data processing. A significant portion of the data inspection time is repositioning views of the data such that outliers can be identified and remediated. By
automatically determining which views are most likely to highlight these outliers, and presenting these views in a streamlined workflow, the time required between data collection and creation of a usable product could be considerably reduced.

As part of our ongoing CCOM efforts towards producing visualizations that compellingly convey the contents of complex marine datasets in an intuitive manner, we have developed a suite of 4D visual analysis tools, the most recent of which is shown in Figure 6. Here we present the models produced by sediment transport simulations. The software presents 3D animations that depict the flow vectors throughout the water column, the dynamic changes to the bathymetry, and the movement of sediment particles from areas of erosion to areas of deposition. This work is aimed at evaluation of marine engineering designs, e.g., pilings to support offshore wind farms, and the study of extreme weather events on coastal features. As a test case, we are focusing on the Redbird artificial reef site off the coast of Delaware Bay (Figure 7). The site features a large collection of intentionally sunk debris, which reacted to Super Storm Sandy causing intriguing changes to the seafloor in the area, as revealed by extensive pre- and post-storm surveys. Through our study of what has happened there we hope to learn more about the dynamic processes involved, as well as strengthen our sediment transport simulations through comparison of hindcasts with observed changes. We propose leveraging this research to address this proposal’s objectives of understanding climate change with respect to the effects of increased storm severity on marine environments and how society can plan and respond to them through better informed engineering of coastal structures.

![Figure 6](image)

**Figure 6:** Screenshot of our 4D dynamic sediment transport visualization environment. In this dataset, the tide moves water in and out of a narrow inlet flanked by walls, causing significant changes to the seafloor around the inlet. The blue areas denote sediment accumulations while the red areas indicate areas experiencing erosion/scour. Streamlets are used to illustrate the 3D flow vector field.
5.7 Connections and Collaborations

The proposed research package is multi-disciplinary, and multi-faceted. As such, we expect to generate a number of the outcomes (as outlined in Section 8) that will be of use in the fields of hydrographic and ocean mapping practice, particularly in post-storm disaster recovery operations. Research results that are simply published, however, are of little utility; to be useful, they need to be conveyed into practice too.

CCOM has an established track record of transitioning research results into practice. This has taken a number of routes, including formal software licensing through one or more of our Industrial Associate organizations (e.g., CUBE, CHRT and GeoCoder), collaborative projects with one of our Industrial Associates (e.g., FMGT processing pipeline re-development), collaboration with Federal partners (e.g., flow visualization in NowCOAST, CastTime algorithm, sensor calibrations), or public outreach efforts (e.g., the WhaleAlert mobile app). In all cases, however, the goal is the same: to make sure that the products of our research are available for the community, and particularly our project sponsors, in an appropriate (and hopefully useful) form.

In the proposed research, we expect that a mixed-model transition strategy will be required. For best practice and standard operating procedure documents, publication will happen through our proposed website extension, although we will also promote their use through appropriate community involvement at conferences and meetings, and through interactions with the stake-holders and Federal partners (see below). For the work in marine debris detection, characterization and dissemination, it is likely that we will partner with one or more of our Industrial Associates in order to transition the techniques into practice through COTS software, although it is likely that we will also want to engage the international standards community (through the IHO S.100 working groups) to ensure that the exchange standard for marine debris forms part of the S.10X family of standards. We expect that the proposed research on PMBS data processing will take a similar route, although we expect that the transitions there will be focused more tightly on the OEMs with an interest in the market. For the lidar and CEI work, the primary transition routes will be through collaboration with Federal partners (since the software will generally be developed with standard tools). In all cases, it is possible that a full transition to practice might take longer than the 24-month performance period of the current proposal. Our plan, therefore, is to develop the techniques within the performance period to the stage where they can be handed off to the appropriate collaborator for future development and deployment. The techniques will also, of course, be published in appropriate academic journals and publicized in appropriate conferences and meetings.
As a cooperative agreement, we anticipate, and welcome, significant interaction with NOAA and other Federal partners as part of the proposed research. We expect that this will happen in at least three different modes. First, we will interact with data collectors, including the USGS, USACE (through JALBTCX), NOAA Remote Sensing Division, Office of Coast Survey and Marine Debris Program, state agencies such as the New Jersey Department of Environmental Protection, academic partners such as the University of Delaware CSHEL (see letters of collaboration in Appendix C), and particularly the IOCM Processing Center at JHC, in order to source data for the research. Second, we will encourage interaction with many of the same partners to help us refine the target goals for the outputs of the research through web-meetings, teleconferences, and side meetings at workshops and conferences. We will also take full advantage of being literally just down the corridor from the IOCM Processing Center to ensure that we remain in contact with developments on a daily basis, and keep them informed of progress. These interactions will include, for example, making sure that the output data products being generated are aligned with stake-holder needs, and that the procedures being recommended are achievable in the field. Third, we will interact with Federal partners, most prominently through NOAA’s Coast Survey Development Laboratory (and its Hydrographic Systems and Technology Program), to ensure that appropriate testing of field procedures, data products and recommended algorithms takes place before they are transitioned into the field. This testing, in which CCOM has an established track record through development of CUBE, CHRT, GeoCoder and CastTime, has been essential to efficient transitions in the past; we expect that it will be similarly essential in the proposed research.

We therefore anticipate that Federal responsibilities will be primarily in review and archive of data products, best practice and standard operating procedure documents in the short to medium term, and in joint testing of research developments in the medium to long term. We would also welcome input on specific areas of the Sandy-affected region that might be of interest, so that we can target our research efforts effectively. Finally, we would welcome feedback on the research, and particularly the scope of output products, as it develops.

6 Data Management

The Center for Coastal and Ocean Mapping recognizes that data management is a key component both for data security and workflow efficiency. To meet both of these needs the Center has established the necessary infrastructure, personnel, and protocols to allow users at the Center to work with large volume datasets in a safe, secure, and organized environment.

The primary components of any data storage needs are the systems and media upon which the data are stored. Within the Center’s secure, climate-controlled and power-conditioned environment, CCOM runs a pair of NetApp FAS 3240 storage solutions running in a cluster mode with about 120 TB of usable storage. This configuration allows for multiple levels of redundancy, both at the storage controller level and at the drive level. In the event of failure of one of the two control units, the system will instantly switch over to the second unit, meaning no downtime or loss of data. Each NetApp unit is also populated with highly reliable enterprise grade hard drives. These drives are configured in a manner where even if multiple drives were to fail, no data would be lost, and no downtime would be experienced. Coupled to the NetApp units is a tape backup solution, CommVault Simpana, which makes full backups of all data on each unit. As backup tapes are filled, they are migrated to an offsite storage facility for a period of three months. This tape backup would allow the Center to do a full recovery of all data in the event of a disaster affecting our primary location.

CCOM also provides users at the Center many networks services to aid them in organizing, using, and securing their data. Included amongst these many services are source-code version control systems, an internal wiki, a GIS server, and a data storage database. Source-code version control systems allow users to maintain multiple versions of their code and other data, and to recover code in the event of a loss or mistake. This also allows us to maintain a central repository of the intellectual property of the Center. An
internal wiki allows us to gather, store, and distribute information on topics such as resources available to the Center, data storage information, protocols, and general usage information. A GIS server, with associated geo-databases, allow users in the lab a single point to access GIS data, and is also used to serve data and content to users outside the lab. Finally, the Center provides a storage database to track information on shares, such as dates, locations, stewardship, quotas, data types, etc.

Complementing this infrastructure is a highly skilled IT group tasked with maintaining the Center’s workstations, servers, network, storage solutions, and software. The Center currently employs a System Manager, a System Administrator, a Data Manager, and two student helpers.

As part of the Center’s mission to properly manage data and to ensure its long term availability to the public at large, we have developed both the in-house infrastructure necessary to publish and distribute data locally, as well as maintaining strong ties with NOAA’s National Geophysical Data Center [NGDC], NSF’s Rolling Deck to Repository [R2R], and Lamont-Doherty Earth Observatory’s Marine Geosciences Data System [MGDS] group responsible for GeoMapApp. All data, either collected by the Center, or in a derived product generated by researchers at the Center, are thoroughly quality controlled and documented with metadata before being released. At present, CCOM is producing metadata in the FGDC format; the results have been validated by NGDC both for accuracy and completeness. However, as the U.S. government is encouraging the transition from the FGDC format to the ISO 19115 format, CCOM has also begun the development of the necessary tools and methods to generate complete and accurate metadata in the ISO 19115 standard.

We are confident that integrating the data associated with the proposed research within this well-established system will satisfy the requirements of data protection, and provide for efficient and effective data access for researchers at the Center, for our partners externally, and for the public (as part of our outreach effort, detailed in Section 5.5). A more detailed data management plan, constructed with the DMPTool on-line service, is provided in Appendix H.

7 Benefits
In the broadest sense, the proposed research will benefit a hierarchy of users ranging from those charged with processing acoustic and lidar data collected in the wake of events like Super Storm Sandy, to the first responders and local, state, and federal agencies (and their contractors) charged with planning and executing data collection, response and restoration activities, to the residents of coastal communities and the general public who expect a healthy and safe coastal zone that supports safe navigation, healthy ecosystems, recreation and a vibrant economy. More specifically, those charged with data processing will benefit from the delivery of protocols and standard operating procedures that will be tailored for the problems associated with storm response (i.e., protocols for measuring shoreline change and regions of erosion and deposition from lidar and other data sets; optimal processing techniques for acoustic data sets including, potentially, tools for the automatic detection of marine debris and other navigation hazards). Those charged with planning data acquisition programs will benefit from the development of protocols that maximize survey efficiency in post-disaster conditions, minimize data collection redundancy and support multi-purpose data acquisition efforts and inter-agency data interoperability.

The proposed research will also provide tools to coastal zone managers and decision-makers at the local, state, and federal level that will help them make critical decisions about priorities in terms of remediation efforts. Shoreline change and erosion/deposition maps will provide information critical for the understanding of long-term shoreline stability for the planning of beach nourishment efforts, and will provide guidance to engineers maintaining navigation channels. Lidar waveform analyses and intensity maps as well as seagrass and habitat analysis tools will provide guidance to planners on the health of the ecosystem and the potential to identify “environmental hotspots.” Before/after studies will help provide quantitative metrics on the impact of events like Super Storm Sandy as well as baseline data for determining the impact of future events. The outputs of our analytical tools (both lidar and acoustic) will
also provide critical input into coastal models, particularly coastal engineering indices. Marine-debris specific tools will hopefully provide a rapid and objective means for the identification, characterization and assessment of the distribution of marine debris. Combined with GIS and visualization tools, managers will be in a better position to make informed decisions about prioritization of remediation efforts. To ensure that the tools that we produce are appropriate, we plan to work closely with the NOAA IOCM Processing Center, and response agencies, in particular with representatives of NOAA’s Marine Debris Program and the New Jersey Department of Environmental Protection.

As described in our data management and data-sharing plans, the results of our efforts will be made available to responders and the general public through publications, presentations, documentation and web-distribution. Our co-location with the NOAA IOCM Processing Center will ensure almost daily communication with the key data processors and regular conference calls/web-based meetings will be scheduled with collaborators from the NOAA Marine Debris Program and the New Jersey Department of Environmental Protection. We also have proposed a series of web-based infographics and a "citizen science" approach to marine debris detection that will hopefully engage the general public (see Section 5.5) and make them aware of the efforts underway and the state of their offshore environment.

8 Milestone Schedule

In order to align with the required reporting schedule, we have identified the milestones by quarters, and organized them according to the research themes. The converse (i.e., organized by time) is given in Appendix G. Although not explicitly stated, production of the required quarterly reports should also be considered a milestone in each fiscal quarter; dissemination of results through seminars (including webcasts) will also take place throughout the performance period. Note that “document” should be understood to mean, generically, a journal paper, conference paper or report, as appropriate for the material.

8.1 Lidar

- Develop written procedures for generating new IOCM multi-use products from Sandy-region topo-bathy lidar data (Q1, FY15)
- Document describing a procedure for preprocessing the different source layer and an initial SOP workflow document for erosion/deposition change maps (Q1, FY14).
- Document describing the results of research into new geospatial data products from NOAA and partner agency topo-bathy lidar waveform data in Sandy-impact area (Q4, FY15)
- Document describing the methods used to: create DEMs from lidar point cloud files, extract shoreline contours, create change maps, and analyze shoreline change (Q4, FY14).
- Document describing shoreline change for selected coastlines and preliminary results for evaluating lidar intensity maps and depth estimation (including bottom detection) (Q3, FY14).
- Document describing the classification scheme that includes: defining the effective area for classification, separation of SAV from exposed areas, characterization of the exposed areas based on surface analysis, and characterization (Q2, FY15).
- Document describing the classification scheme by comparing maps of eelgrass and macroalgal habitats and maps of benthic habitats for Barnegat Bay, NJ with ground truth measurement (Q3, FY15).

8.2 Marine Debris

- Document describing the selection and the development of adaptive algorithms (Q3, FY14)
- Document describing the development and the test of the adopted fusion approach (Q1, FY15)
- Document describing the outline of adopted geodatabase data structure and GML schemas (Q2, FY15)
- Document describing the overall workflow for marine debris recognition, inventory, and outputs optimization for web GIS and environmental databases, documentation of best practices and standard operating procedures (Q4, FY15)
8.3 Acoustic Data and Techniques
- Develop written protocols to satisfy the bathymetric and hydrographic data requirements of Federal Partners (e.g., NOAA and USGS) in response situations that maximize acoustic survey acquisition effectiveness (Q4, FY14).
- Document evaluating use of CCOM processing techniques on Super Storm Sandy PMBS data (Q3, FY14).
- Document describing the potential for modified processing techniques to improve object retention in PMBS data processing (Q4, FY15).
- Document describing 'effective' object detection in PMBS data (Q4, FY14).
- Document describing the results of research into using PMBS and multibeam sonar systems to assess storm impact in Sandy-impacted regions (Q4, FY15).

8.4 Specialized Data Processing
- Document describing new methods of using Sandy IOCM multi-use data sets to generate parameters/sub-indices for CEI calculation within the Sandy region (Q4, FY15).
- Develop written procedures for construction of CEI-facilitating metrics and features (Q4, FY15).
- Develop written procedures for data distribution methods associated with web-based distribution (Q2, FY14).

8.5 Outreach
- Construct initial website for the project (Q2, FY14).
- Promote outreach program through appropriate channels (Q3, FY14; Q1, FY15; Q2, FY15). Note multiple milestones to correspond to components of the website becoming active.
- Demonstrate infographics for composite datasets in the website (Q4, FY14).
- Demonstrate user-driven "citizen science" visualization and identification of marine debris on website (Q1, FY15).
- Improve infographics and “citizen science” outreach to include results of latest research (Q4, FY15).

8.6 Visualization
- Demonstration of data visualization tool with limited display of information (Q4, FY14)
- Demonstration of improved data visualization tool taking into account latest research (Q4, FY15).

9 Project Budget
We are requesting a total budget of $999,984 ($492,392 FY14, $507,592 FY15) consisting of personnel $485,630; fringe benefits ($164,909) (using a FY14 full fringe composite rate of 45.8% and a partial fringe composite rate of 8.0% since the performance period covers two different rate periods; a FY15 provisional full rate of 44.6% and partial rate of 8.3% were used); travel ($8,144); supplies ($6,350); publication costs ($7,500); and computer services ($5,422). There are no costs for sub-contracts or construction. This gives total direct costs of $677,955 and a Facilities & Administrative overhead of $322,029 using UNH’s negotiated rate of 47.5% for the first year, and the provisional rate of 47.5% in FY15. A full budget is provided, along with further details, in Appendix A; UNH’s recommended inflation rate of 3%/yr. has been included in all costings.

As with most research, the majority of the costs are personnel. We are requesting full time support for Masetti, McKenna and Fandel for 24 mo., since they will be working full time on the research. We are also requesting summer salary for the other academics and staff to direct, lead and participate in the research: 1 mo./yr. for Calder (marine debris and PI), 1.75 mo./yr. for Pe‘eri (lidar), 1.0 mo./yr. for Butkiewicz (visualization), 1 mo./yr. for Johnson (data management), 1mo./yr. for Schmidt (PMBS data processing), and 2 mo./yr. for Dijkstra (seagrass and habitat). Since communication of results and interaction with the stakeholders is essential for the success of the proposed research, we are requesting a travel budget to
support two domestic conference/workshop trips in FY14 (budgeting at $1,600 for travel, accommodation and registration fees), and three in FY15. We will use these as opportunities to publicize the results of our research, and to gather feedback on the direction of the research (e.g., the applicability of our marine debris metrics, lidar-derived products, or SOPs) from stakeholders. We are also requesting support for publication costs, targeting five journal papers at a cost of approximately $1,500 each (based on IEEE page charges, which are typically $100/page).

Most of the software and hardware required for the research are already available to CCOM and our share of their costs are included in the computer services item described above ($5,422). We are, however, requesting support for purchase of a license for LP360 ($2,500), a lidar data processing program by QCoherent. We are also requesting support for field supplies to use in support of our drop-camera based ground-truthing effort ($1,500).

Finally, we are requesting support for web-site development to support the outreach portions of the research ($2,350).
Appendices

A. Detailed Budget Information

A full budget for the proposed research is shown following the budget justification. There are no sub-awards or contracts. All of the funds will be directed to the Center for Coastal and Ocean Mapping at the University of New Hampshire’s Durham campus (24 Colovos Road, Durham, NH, 03824), which is in New Hampshire’s first Congressional District. The primary place of performance for the proposed research is at CCOM’s building in Durham, NH as before, although some portions of the research may be conducted at Silver Spring Metro Center 3, 1315 East West Highway, Silver Spring, MD, where Pe’eri has an office.

The budget justification below is written against, and in the same order as, the categories in SF424-A, even where no request is made in the category.

A.1 Personnel

Salaries of the faculty and staff associated with the proposed research are the single largest cost in the budget, but this pays for our single greatest asset, and the one that is most critical to the success of the program.

A.1.1 Faculty

Faculty salaries associated with the program are for summer salary. We are requesting one month salary per year for Calder, to act as PI for the program, and to contribute primarily to the marine debris object detection, fusion and representation aspects of the proposed research. We are also requesting one month salary per year for Butkiewicz to support the visualization components of the program. Finally, we are requesting 1.75 months per year for Pe’eri to lead the lidar portion of the program, and contribute primarily to the research on capabilities of lidar systems, waveform analysis and change modeling.

Per University guidelines, faculty salaries were inflated by 3% for the second year of the program.

A.1.2 Staff

Support for 12 months per year for Masetti (marine debris detection, fusion, product management and dissemination), McKenna (lidar shoreline change, erosion/deposition, waveform analysis, etc.), and Fandel (innovative survey planning, system capabilities, PMBS systems). We are also requesting support for two months per year for Dijkstra (seagrass mapping, habitat studies), and one month per year for Schmidt (PMBS data processing methods, object detection) and Johnson (data management).

Per University guidelines, staff salaries were inflated by 3% for the second year of the program.

A.2 Fringe Benefits

Fringe benefits are calculated using UNH’s negotiated rates, but the performance period cuts across UNH’s budgeting period. We have therefore used 46.3% to the end of CY13, and 44.5% for CY14 for full-rate fringe benefits, to give a composite rate of 45.8% for FY14; UNH’s provisional rate of 44.5% was used for FY15.

For summer salaries, and labor rates, we have used 7.9% to the end of CY13, and 8.3% for CY14 for partial-rate fringe benefits, to give a composite rate of 8.0%; UNH’s provisional rate of 8.3% was used for FY15.

A.3 Travel

The travel budget is requested to support personnel to travel to conferences in order to report on the research being conducted, and to garner feedback from the community. Since the locations of appropriate conferences have not been identified, fully accurate costing is problematic. However, we have estimated...
that a ‘typical’ domestic conference in the U.S. costs approximately $1,600 to cover flights, accommodations and registration fees. We are requesting support for two conference trips in the first year, and three in the second year; costs have been inflated 3% in the second year.

A.4 Equipment

There is no equipment requested in the budget.

A.5 Supplies

UNH defines supplies as non-expendable items costing less than $5,000, and any expendable items used to support research. Here, we are requesting support for three categories. First, we request support for development of an adjunct to the CCOM website to support the program, including the interactive visualization and “citizen science” outreach effort (see Section 5.5); this support will be supplied by UNH-based developers. Second, we request support for purchase of a software license for lidar processing software. Third, we request support for general supplies (copying, paper, postage, expendable media, etc.), but in particular to support research expendables for any field work to groundtruth lidar/seagrass measurements using drop cameras and other methods.

A.6 Contractual

There are no sub-contracts in the budget.

A.7 Construction

There is no construction in the budget.

A.8 Other Costs

We are requesting support for auxiliary costs in two categories. Since archival communication of the results of the research are essential, we are requesting support for publishing costs associated with academic papers that will result from the research. Specifically, we are requesting support for five papers in the second year. Publishing costs are variable by journal, but we have used a budgetary estimate of approximately $100/page and 15 pages/paper.

We are also requesting support for computer services. CCOM provides a number of central services for users, including full network connectivity, central backup services, virus scanning, network security, a full general and field-specific software suite, managed servers for storage, e-mail, FTP, web-sites, etc., and IT support. This is charged out at a rate per person-month; we are requesting support for the covered periods of the individuals outlined in the salary section above. An inflation rate of 3% has been used for the second year of the proposed program.

A.9 Indirect Cost Basis

UNH’s Facilities and Administration rate is 47.5% for the first year, and also, provisionally, 47.5% for the second year.
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<td>0</td>
<td>0</td>
<td>0</td>
<td>Y</td>
</tr>
<tr>
<td>Computer Services</td>
<td>711200</td>
<td>3,351</td>
<td>2,071</td>
<td>5,422</td>
<td>Y</td>
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<tr>
<td>Subawards (App'y F&amp;A)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>Y</td>
</tr>
<tr>
<td>Subawards (Exempt F&amp;A)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>Total Direct Costs</td>
<td>333,825</td>
<td>344,130</td>
<td>677,955</td>
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<tr>
<td>Total Direct Costs in F&amp;A Base</td>
<td>333,825</td>
<td>344,130</td>
<td>677,955</td>
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<tr>
<td>H. Facilities &amp; Administrative</td>
<td>158,567</td>
<td>163,462</td>
<td>322,029</td>
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<td>Total Sponsor Costs</td>
<td>492,392</td>
<td>507,592</td>
<td>999,984</td>
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<tr>
<td>Total Project Costs</td>
<td>492,392</td>
<td>507,592</td>
<td>999,984</td>
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</table>
B. Resumes
Brian R. Calder
Center for Coastal and Ocean Mapping & Joint Hydrographic Center
University of New Hampshire
Durham, NH 03824

Personal
Age: 42  Telephone: (603) 862 0526
Nationality: British  E-mail: brc@ccom.unh.edu
U.S. Legal Permanent Resident (2005)

Education

Tertiary Education
Degree: M.Eng Electrical and Electronic Engineering (with Merit, 1989-1994). Department of Computing and Electrical Engineering, Heriot-Watt University, Edinburgh, UK.
Summary: Five year enhanced degree leading to Masters in Engineering. Optional subjects concentrated on signal and image processing. Dissertation concentrated on speaker independent speech recognition using wavelet transforms and Hidden Markov Models.

Postgraduate
Title: Bayesian Models for Sidescan Sonar Image Analysis
Summary: Sidescan Sonar is a remote sensing modality typically used for imaging the seabed for mapping, mineral prospecting and military purposes. My thesis considered problems with sidescan processing in a Bayesian context, with particular emphasis on inference with empirical models, and application in object detection, texture analysis for sediment segmentation and hidden parameter extraction using direct inverse modeling.

Work Experience

2005-Present  Associate Research Professor, Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, New Hampshire.
2010-Present  Associate Director, Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, New Hampshire.
2003-2005  Assistant Research Professor, Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, New Hampshire.
1997-2000  Post-Doctoral Researcher, Dept. of Computing and Electrical Engineering, Heriot-Watt University, Scotland.
1994-1997  Graduate Research Associate, Dept. of Computing and Electrical Engineering, Heriot-Watt University, Scotland.
**Professional Societies**

Institute of Electrical Engineers (now Institution of Engineering and Technology), Institute of Electrical and Electronic Engineers, The Hydrographic Society of America.

**Research**

**Interests**

My principal research interests are in the development of Bayesian approaches to data processing and analysis. This methodology provides a consistent way to manage and control domain uncertainty and side-information, and combine them in order to extract useful information. Currently, my main research interest is the application of these techniques to the problem of automatic hydrographic data processing, the estimation of uncertainty in composite datasets, and the computational infrastructure to support such problems.

**Contracts**


1999  Thompson Marconi Sonar Ltd., Templecombe, UK. Object driven forward-looking sonar compression.

1999-Present  NOAA – Center for Coastal and Ocean Mapping. Principally involved in methods for automatic processing of high resolution bathymetry data, modeling depth estimate uncertainty and methods for the combination and processing of these error figures.

2001-2004  ONR Uncertainty DRI. Funding to pursue research in measurement, propagation and exploitation of uncertainty in the marine environment.


2003  ONR SBIR (with Scientific Solutions, Inc.) Using Dynamic Ocean Circulation Models with Ship-Based and Remote Instrumentation to Improve Echo-Sounding Data Analyses.


2006  Triton Imaging Inc. Implementation of CUBE processing software for real-time and post-processing uses.
2006-2011 ONR Quantifying, Predicting and Exploiting Uncertainty DRI. Funding to assist in the design of field experiments for the ONR QPE DRI.

Service

In addition to normal academic duties, I also act as a reviewer for IEEE Journal of Ocean Engineering, International Hydrographic Review, Continental Shelf Research, and Journal of Coastal Research among other journals, and from 2004-2009 was an Associate Editor of the IEEE Journal of Ocean Engineering. I am also a member of the International Working Group on Data Quality in Hydrography, a group consisting of hydrographers from all of the US agencies, the UK, Australia and other countries along with academics and other interested parties, with the remit to promote best-practice in hydrography, particularly with respect to quality control, quality assurance and data processing. From December 2003, I have been chair of the Open Navigation Surface Working Group, a community-led effort to develop a portable, open file format to allow the free interchange of bathymetric data between organizations involved in the processing of remotely-sensed acoustic into nautical charting and other products. University of New Hampshire, NOAA, NAVO, IVS, SAIC, CARIS and SevenCs support the Working Group, and the overall community also includes the UK Hydrographic Office, NGA (formerly NIMA) and other industrial and academic partners. The product of the working group, the Bathymetric Attributed Grid (BAG), has been adopted by the International Hydrographic Organisation as their Standard S-102 for interchange of high resolution bathymetric data.

Cruises

Since 2000, I have participated in or led the mapping effort in approximately 50 cruises, including deep water missions in Kauai, HI, Nootka, BC, the Atlantic Seaboard of the US, the Equatorial Pacific, and the high Arctic aboard the icebreaker USCGC Healy; intermediate depth missions in the Gulf of Mexico and Iceland; shallow water archaeological missions in Scapa Flow, Scotland and Normandy, France; and many shallow water missions in Alaska and around the contiguous US.

Invited Lectures

NOAA Field Procedures Workshop, Norfolk, VA. "Implications in Survey of a CHRT Implementation" (2013)

NOAA Field Procedures Workshop, Newport, OR. "CHRT (CUBE with Hierarchical Resolution Techniques" (2012).

University of Connecticut COSEE-TEK Ocean Technology Panel, Groton, CT. “Ocean Mapping with Multibeam Echosounders” (2011)


NOAA Field Training Seminars, Norfolk, VA and Seattle, WA. “CUBE Data Processing for MBES Data Systems” (2011)

NOAA Field Procedures Workshop, Norfolk, VA. “Resolution Determination, Variable Resolution and CHRT” (2011)

NOAA Field Procedures Workshop, Seattle, WA. “CUBE and Variable Resolution Grids” (2010)

International Seminar on the Latest Hydrographic Survey Technology (Japan Coast Guard, Hydrographic and Oceanographic Department), Tokyo, Japan. “Bathymetric Processing with PMBS” (2009)


NOAA Field Training Seminars, Norfolk, VA and Seattle, WA. “CUBE Data Processing for MBES Data Systems” (2009)

NOAA Field Procedures Workshop, Norfolk, VA. “Uncertainty and Risk Models in Charting” (2009)


NOAA Field Procedures Workshop, Virginia Beach, VA. “High-Precision Absolute Time Synchronization in Distributed Data Capture Systems” (2007)


Granite State Distance Learning Network, Durham, NH. “Marine Research over Internet 2: The Lost City Virtual Cruise, 2005” (2005)

UNH Marine Docents, Durham, NH. “Virtually at Sea: Lost City, 2005” (2005)


NOAA Field Procedures Workshop, Norfolk, VA. “CUBE: Some Lessons and Questions”, (January 2005)


NOAA Headquarters, Silver Spring, MD. “Reinventing Ourselves ... Carefully.” (2004)


Publications

Journals


International Conferences


**Abstracts**


Magazines


Larry A. Mayer

Professor and Director  
Center for Coastal and Ocean Mapping  
NOAA/UNH Joint Hydrographic Center  
University of New Hampshire  
Durham, N.H.  03824

Birthdate:   17 May 1952  
Citizenship:  U.S.

Larry Mayer is a Professor and the Director of the Center for Coastal and Ocean Mapping at the University of New Hampshire. He graduated magna cum laude with an Honors degree in Geology from the University of Rhode Island in 1973 and received a Ph.D. from the Scripps Institution of Oceanography in Marine Geophysics in 1979. At Scripps he worked with the Marine Physical Laboratory's Deep-Tow Geophysical package, applying this sophisticated acoustic sensor to problems of deep-sea mapping and the history of climate. After being selected as an astronaut candidate finalist for NASA's first class of mission specialists, Larry went on to a Post-Doc at the School of Oceanography at the University of Rhode Island where he worked on the early development of the Chirp Sonar and problems of deep-sea sediment transport and paleoceanography. In 1982, he became an Assistant Professor in the Dept. of Oceanography at Dalhousie University and in 1991 moved to the University of New Brunswick to take up the NSERC Industrial Research Chair in Ocean Mapping. In 2000 Larry became the founding director of the Center for Coastal and Ocean Mapping at the University of New Hampshire and the co-director of the NOAA/UNH Joint Hydrographic Center. Larry has participated in more than 90 cruises (over 70 months at sea!) during the last 35 years, and has been chief or co-chief scientist of numerous expeditions including two legs of the Ocean Drilling Program and five mapping expeditions in the ice covered regions of the high Arctic. He has served on, or chaired, far too many international panels and committees and has the requisite large number of publications on a variety of topics in marine geology and geophysics. He is the recipient of the Keen Medal for Marine Geology and an Honorary Doctorate from the University of Stockholm. He was a member of the President's Panel on Ocean Exploration, National Science Foundation's Advisory Committee for the Geosciences, and chaired a National Academy of Science Committee on national needs for coastal mapping and charting. He is currently co-chair of the NOAA's Ocean Exploration Advisory Working Group, Vice-Chair of the Consortium of Ocean Leadership's Board of Trustees, and a member of the State Dept's Extended Continental Shelf Task Force. He is also currently chairing the National Academy of Science Committee charged with evaluating the impact of the Deepwater Horizon Spill on ecosystem services in the Gulf of Mexico. Larry's present research deals with sonar imaging and remote characterization of the seafloor as well as advanced applications of 3-D visualization to ocean mapping problems and applications of mapping to Law of the Sea issues, particularly in the Arctic.
Larry A. Mayer

Professor and Director  
Center for Coastal and Ocean Mapping  
NOAA/UNH Joint Hydrographic Center  
University of New Hampshire  
Durham, N.H. 03824

Phone: (603) 862-2615  
Fax: (603) 862-0839  
Email: lmayer@unh.edu

Birthdate: 17 May 1952  
Citizenship: U.S.

Education:
1979 Ph.D.  
Scripps Institution of Oceanography, University of California, San Diego, Marine Geology/Geophysics.
1973 B.S.  
University of Rhode Island, magna cum laude, Honors program Geology.

Work Experience:
2004 - Adjunct Scientist – Woods Hole Oceanographic Institution
2000 - Professor and Director of Center for Coastal and Ocean Mapping  
University of New Hampshire, Durham, New Hampshire
1991-99  
Professor and NSERC Chair in Ocean Mapping  
Dept. of Geodesy and Geomatics Engineering, Univ. of New Brunswick
1988-89  
Visiting Professor, Dept. de Geologie Dynamique, Univ. of Paris.
1986-91  
Associate Professor of Oceanography, Department of Oceanography, Dalhousie University.
1986  
Visiting Professor Chair, University of Kiel, W. Germany.
1982-86  
Assistant Professor of Oceanography, Department of Oceanography, Dalhousie University.
1980-Present  
Adjunct Professor of Ocean Engineering, Department of Ocean Engineering, University of Rhode Island.
1980-82  
Assistant Marine Scientist, Graduate School of Oceanography, University of Rhode Island.
1979-80  
Post-doctoral Research Associate, Graduate School of Oceanography, University of Rhode Island.
1979  
Post-doctoral Research Associate, Marine Physical Lab, Scripps Institution of Oceanography
1974-79  
Research Assistant, Marine Physical Lab, Scripps Institution of Oceanography.

Professional Societies:
American Geophysical Union, Oceanography Society, The Hydrographic Society

Honors and Awards:
Superior Honor Award – Department of State 2013  
Class of 1944 Professorship – University of New Hampshire – 2013-2016  
Vice-Chair Consortium of Ocean Leadership Board of Trustees 2013-2015  
Chair – National Academy of Sciences Committee on Effects of Deepwater Horizon Spill on Ecosystem Services in the Gulf of Mexico – 2011 --
Trustee – Consortium of Ocean Leadership – 2009 - 2012
University of Rhode Island – School of Oceanography Distinguished Alumni Award - 2007
University of New Hampshire Excellence in Research Award - 2007
Chair- Nat. Academies Committee on National Needs for Coastal Mapping and Charting , 2003
Member of U.S. Presidential Panel on Ocean Exploration – 2000
Doctor of Philosophy honoris causa – University of Stockholm, 1999
Geological Assoc. of Canada’s Michael J. Keen Medal for contributions to marine geoscience – 1998
President -- Canadian Geophysical Union -- 1997 - 1999
Member, Minister of Natural Resources Canada National Advisory Board for Earth Science – 1996 – 1999
Member, Board of Directors Ocean Networks Canada, 2012-
Member, Board of Directors, Canadian Scientific Submersible Facility
Member, Board of Directors, ISOTRACE Laboratories, Toronto 1993 - 1997
Member, Board of Directors, Institute of Acoustics of Atlantic Canada – 1994 - 1997
Member, Board of Directors, Champlain Institute - 1996 - 1997
Vice President, Board of Directors, Atlantic Center for Remote Sensing of the Oceans 1993
Lansdowne Visiting Appointment -- University of Victoria 1991-1992
CONOCO Distinguished Lecturer, Woods Hole Oceanographic Inst., May 1987
Kiel University Visiting Professor Chair, 1986
Scripps Institution of Oceanography Dissertation Fellowship
Selected as Astronaut Candidate finalist for the NASA Space Shuttle Program
Phi Kappa Phi Honor Society
N.Y. State Regents Scholarship

Committee Memberships:

International:
Herzberg Medal Selection Committee – Natural Sciences and Engineering Research Council of Canada – Member - 2010
International Review Committee – Natural Sciences and Engineering Research Council of Canada
Member – 2007
Scientific Board – Research Center on Ocean Margins, Bremen Germany – Member 2006-
Data Management Task Force – Integrated Ocean Drilling Program – Member 2006-
Scientific Planning Committee – Ocean Drilling Program and Integrated Drilling Program (Interim) – Member – 2000-2003
Inter-Union Commission on the Lithosphere - Arctic Geology\Geophysics W.G. - Member
Executive of the Organizing Committee for the Conference on the Scientific Objectives of Ocean Drilling Beyond 2003
IUGS Task Group on Global Changes - WG1 - Member
Executive Committee of the Ocean Drilling Program – Member 1994 - 1998
US National Science Foundation Academic Fleet Review Committee – 1999
American Geophysical Union - Comm. on Education & Human Resources – Member 1993 - 1998
GEBCO -- Scientific Advisor
SCOR WG 100 - Member
Walter Munk Award Selection Committee -- Member
Nansen Arctic Drilling Program Scientific Committee - Chairman 1993- 1996
Sediments and Ocean History Panel - Ocean Drilling Program - Chairman 1987 - 1989
USAC Workshop on Sealevel -- Deep-sea Working Group -- Co-chairman 1989
American Geophysical Union Committee on Paleoceanography - Member - 1990 - 1993
National:
National Academy of Sciences Committee on Effects of Deepwater Horizon Spill on Ecosystem Services in the Gulf of Mexico -- Chair
Joint Analysis Group – Deepwater Horizon – member
NOAA Hydrographic Services Review Panel - member
NOAA Ocean Exploration Advisory Working Group – Co-chair
National Geographic OCEANUS TV series Board of Advisors
UNOLS Arctic Icebreaker Coordinating Committee - member
Interagency Task Force on the Extended Continental Shelf – member
OOI Program Advisory Committee – member – 2010-2013
ORION Cyberinfrastructure Committee - Chair 2002-2006
National Science Foundation Geosciences Directorate Advisory Committee 2004 - 2006
NSF Ocean Sciences Subcommittee – AC/GEO – Chair 2004 - 2006
NOAA – Hydrographic Services Review Panel
NSF – EWING Replacement Review Committee
NSF – Ocean Information Technology Working Group
NOAA – Conversion of the USNS CAPABLE – Requirements Working Group
National Academy of Sciences Committee on National Needs for Coastal Mapping and Charting – Chair – 2002-2004
President’s Ocean Exploration Panel – A panel on ocean exploration reporting to the President of the United States – member 2000-2003
Minister of Natural Resources Canada National Advisory Board for Earth Sciences 1996-2000
Natural Sciences and Engineering Council’s Committee on Research
Royal Society of Canada’s Global Change Program (CGCP) - Working group
on Marine-Atmospheric Interactions - member
Marine Geoscience Committee of the Canadian Geoscience Council - executive member
Scientific Advisory Committee -- Marine Science Workshop
NSERC Strategic Grant Selection Panel -- member 1993 - 1996
NACOM -- National Action Committee for Ocean Mapping -- invited member
Canadian Planning Committee for ODP - member -- 1988 - 1991
NSERC Ad Hoc Committee on Research Vessels - Chairman 1992 - 1993
Canadian National Programme for JGOFS - Working Group on Paleoceanography and Paleoclimate -- Co-chairman

Cruise Participation:
Participated in more than 90 cruises (over 70 months at sea!) over the last 35 years; have been chief or co-chief scientist of numerous expeditions including two legs of the Ocean Drilling Program and five mapping expeditions in the ice covered regions of the high Arctic.

Reviewed Publications:


Mayer, L.A., 1994, Paleoceanography from a single hole to the ocean basement through seismsics and logging, OCEANUS, v. 36, n. 4, p. 40 - 44.


**Unreviewed Conference Proceedings or other papers:**


28


Invited Talks and Published Abstracts (1984)


Invited Talks and Published Abstracts (1985)


Paleoceanography in the Equatorial Pacific: Can Geophysics tell us what the weather was like twelve million years ago? Department of Oceanography Seminar Series, Dalhousie University, Sept. 1985.

Invited Talks and Published Abstracts: (1986)

Marine geological/geotechnical acoustic testing, Workshop on Geotechnical In Situ Testing for the Canadian Offshore, Bedford Institute of Oceanography, January 1986.


Sediment and Ocean History Problems, ODP. Conference on Ocean Drilling, Dalhousie University, March 1986.


Tectonics and morphology of the Mid-Atlantic Ridge - Special Lectures in Modern Oceanography - Institute of Geology and Paleontology, University of Kiel, June 1986.

Paleoceanography and acoustic stratigraphy: Special Lectures in Modern Oceanography - Institute of Geology and Paleontology, University of Kiel, June 1986.


Submersible observations of the slope failure and giant bedforms resulting from the 1929 Grand Banks earthquake, (w/ J.Hughes Clarke) SEPM Meeting, September 1986.


Invited Talks and Published Abstracts (1987)


Invited Talks and Published Abstracts (1988)


Invited Talks and Published Abstracts (1989,1990)

Acoustic Stratigraphy -- a special lecture series given at the Univ. of Paris VI, Feb. 1989

High resolution acoustic stratigraphy: Applications in paleoceanography; ETH, Zurich Switzerland, May 1989

Quantitative acoustic profiling and remote sediment property determination, IPG, Paris France, June 1989


High-resolution acoustic profiling: progress towards the direct extraction of sediment properties and paleoceanographic data, Canadian Acoustical Association Annual Meeting, Halifax, Oct. 1989


Invited Talks and Published Abstracts (1991):


**Invited Talks and Published Abstracts (1992):**


**Mayer, L. A.,** and Hughes Clarke, J.H., Ocean Mapping at the University of New Brunswick and the Hydrographic Ground Truthing Experiment, Atlantic Geoscience Centre Science Hour, Feb., 1992

**Mayer, L. A.**, The Ocean Drilling Program and Unravelling the History of Climate, Landsdowne Lecture, University of Victoria, March 1992


Invited Talks and Published Abstracts (1993):


A multifaceted hydrographic ground-truthing experiment in the Bay of Fundy, Keynote Talk, Acoustic Classification and Mapping of the Seabed, Institute of Acoustics, Bath England, 15 April 1993

Carbonate Sedimentation in the Pacific, Third Technical Meeting on Natural Sources and Sinks of Greenhouse Gases, AES, Toronto, 21 April, 1993

New Tools and Approaches for Exploring Ocean Mapping Data -- Inst. of Geophysics and Planetary Physics, Scripps Inst. of Oceanography, La Jolla, Calif. 5 May, 1993

HYGRO-92 -- An Acoustic Ground Tuthing Experiment in the Bay of Fundy -- Canadian Inst. of Mapping and Surveying Annual Meeting, Toronto, 10 June, 1993

New Tools and Approaches for Exploring Ocean Mapping Data -- Univ. of Bergen, Norway, 18 June 1993


Invited Talks and Published Abstracts (1994):


Ocean Mapping Activities at The University of New Brunswick -- Address to Naval Oceanographic Office and Naval Research Lab, Stennis Space Center, Bay St. Louis Miss., 28 Feb. 1994.
New Tools and Approaches and Approaches to Seafloor Mapping and Seafloor Visualization University of Rhode Island Marine Geology Seminar - Narragansett R.I., 1 April 94.
Ocean Mapping Trends and Article 76, Law of the Sea Article 76 Workshop, Fredericton N.B., 14 April, 1994


**Invited Talks and Published Abstracts (1995):**


Royal Danish Hydrographic Organization -- Multibeam Training Course -- Hundasted, Denmark, 13 - 17 March, 1995

Storage and Display of Bathymetric and Coastline Information for Tactical Sonar Applications, Defence Research Establishment Atlantic, 4 April 1995

Three Dimensional Visualization of Orbital Forcing and Climatic Response: Interactively Exploring the Pacemaker of the Ice-Ages, Dalhousie University Oceanography Seminar Series, 4 April, 1994

Real-time Processing and Interactive 3-D Visualization of Multibeam Sonar Data, European Union of Geosciences, Strasbourg, France, 11 April 1995


Climate System History and Dynamics, Royal Society of Canada Global Change Meeting, 28 Sept. 1995


Canada and the Ocean Drilling Program, Korea Inst. of Geology, Mining and Materials, Taejon, Korea, 15 Nov., 1995

Ocean Mapping and Seafloor Classification, Korea Inst. of Geology, Mining and Materials, Taejon, Korea, 16 Nov., 1995
Ocean Mapping Group Activities: Applications to Fisheries Geomatics, Inst. Maurice LaMontagne, Mont Joli, P.Q., 30 Nov. 1995

Building a high-resolution database: the experience from ODP Leg 138, Ocean Drilling Stratigraphic Network Workshop, Bremen, Germany, 20 Dec. 1995

Invited Talks and Published Abstracts (1996):

Fisheries Geomatics at UNB -- Canadian Hydroacoustics Program Workshop, Ottawa, March 4, 1996
Western Australia Hydrographic Association/Naurtonix -- Multibeam Sonar Training Course -- Perth Australia, 11 - 15 March, 1996
Ocean Mapping at UNB -- Western Pacific Hydrographic Assoc Meeting, Perth, Australia, March 14, 1996
US Army Corps of Engineers Multibeam Sonar Training Course, Mobile Ala., 18-20 March 1996
IMAGES - The Marine Component of CSHD, Can Geophysical Union Meeting, Banff, Al. May, 1996.
Interactive 3-D Visualization of Passamaquoddy Bay -- RARGOM Conference, St. Andrews N.B., Sept. 1996

Invited Talks and Published Abstracts (1997):

Jan. 15 1997 -- Multibeam Mapping and Fisheries Geomatics -- Invited Talk at World Bank, N.Y.
Multibeam Sonar Training Course, RACAL Ltd. Grt Yarmouth UK, 3 - 7 Feb., 1997
April 3, 1997 -- Recent advances in seafloor mapping and remote seafloor classification -- Invited Talk -- Alaska Fisheries Science Center -- Seattle, WA
April 19, 1997 -- Recent advanced in Seafloor Mapping and Visualization -- Keynote Talk -- Spatial Data and Remote Sensing in Invertebrate Fisheries Workshop -- Fort Walton Beach, Florida.


13 June, 1997 Multibeam Mapping and the STRATAFORM Program -- Invited Talk -- IFREMER -- Brest France


Invited Talks and Published Abstracts (1998):


Mayer, L. A., Unraveling Climatic Variability through Ocean Drilling, Univ. of Western Ontario, 1 October 1998


Invited Talks and Abstracts Published (1999)


John E. Hughes Clarke and Mayer, L. A., John Shaw and Russell Parrott, Mike Lamplugh., Jim Bradford, Data handling methods and target detection results for multibeam and sidescan data collected as part of the search for SwissAir Flight 111., High-Resolution Shallow Water Acoustics, Sydney Australia, October, 1999

Mayer, L. A., Hughes Clarke, John, Ware, Colin, Gee, Lindsay Paton, Mark, Gardner, Kleiner, Art, and Elson, Scott, 1999, Interactive 3-D visualization and analysis of multi-sensor, multi-resolution data sets, High-Resolution Shallow Water Acoustics, Sydney Australia, October, 1999


Invited Talks and Published Abstracts (2000):


Mayer, L. A., Ocean Mapping at the Univ. of New Hampshire, Coastal Environmental Technology Briefing, U.S. Congress, April, 2000


Weber, M E, Mayer, L. A: Hillaire-Marcel, C., 2000, Physical Properties and Their Relation to High-Frequency Climate Change as Recorded by IMAGES Cores From the Labrador Sea, EOS, Transactions of the American Geophyscial Union, V. 82, Dec, 2000, OS52C-14


Invited Talks and Published Abstracts (2001)


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


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

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

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

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


**Invited Talks and Published Abstracts (2002):**

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

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


Mapping the U.S. EEZ: Presentation to the U.S. Commission on Ocean Policy, 22 July, 2002


Feasibility and technical limitations in sonar detection of time-dependent seafloor topography, Seafloor Geodesy Workshop, Deep Ocean Exploration Institute, Woods Hole, MA. 11 October, 2002


**Invited Talks and Published Abstracts (2003):**


Invited Talks and Published Abstracts (2004):


Invited Talks and Published Abstracts (2005):


New Directions in Seafloor Mapping and Visualization, Invited Presentation, Lamont Colloquium , Lamont Doherty Earth Observatory, N.Y., Feb. 25, 2005

Mapping the Unseen: High Tech Imaging of the Seafloor, Invited Presentation, Sea Secrets Lecture Series of the University of Miami and The Ocean Research and Education Foundation, Miami, Fl., March 16, 2005

New Directions in Seafloor Mapping and Data Visualization: Keynote Talk – RESON Multibeam Users Workshop – Tokyo Japan, April 20, 2005

New Directions in Seafloor Mapping and Data Visualization: Invited Lecture – National Geospatial Intelligence Agency – Bethesda Md., July 13, 2005

Mapping the Unseen: New Directions in Seafloor Mapping and Data Visualization – Bock Memorial Lecture, United States Naval Academy, October 18 2005.

Invited Talks and Published Abstracts (2006):


“New Approaches to Ocean Mapping and Data Visualization”, Ocean Seminar Series, the University of Delaware, Newark, Delaware, 16 March 2006.


Invited Talks and Published Abstracts (2007):


New Directions in Seafloor Mapping and Data Visualization, invited lecture, Portsmouth Propeller Club, 15 February 2007

New Directions in Seafloor Mapping and Data Visualization, invited seminar, University of New England, 16 February, 2007


New Views of Seafloors and Tsunamis: Interactive Visualization of Geospatial Data, invited seminar, Institute for Pure and Applied Math, Univ. of Calif. Los Angeles, 21 May, 2007


Testimony to House Subcommittee on Fisheries Wildlife and Oceans, Washington, D.C., 5 June 2007

Hydrography: Its not just for charting anymore, invited presentation, Capital Hill Oceans Week, 6 June, 2007

Changing Perspectives of the Seafloor – Geologischc Vereiningung e.V., Bremen Germany, Invited Plenary Lecture , 4 October 2007

New Directions in Seafloor Mapping and Visualization – InWaterTec: International Conference on Marine Technologies, Kiel, Germany, Invited Plenary Lecture


Invited Talks and Published Abstracts (2008):


Mayer, L. A., Arctic Mapping in Support of Law of the Sea, Invited Lecture, Southwest School of Law, Los Angeles California, 3 October, 2008,


**Invited Talks and Published Abstracts (2009):**


**Mayer, L. A.**, Center for Coastal and Ocean Mapping Activities – A national center for ocean mapping activities, Invited Talk Portuguese Hydrographic Institute, Lisbon Portugal, 23 April 2009.


**Mayer, L. A.**, New Views of the Chukchi Borderland and Alpha/Mendeleev Ridge Complex, Invited Presentation, Penrose Conference on Tectonic Development of the Amerasian Basin, Banff, AL Canada, 5 October, 2009

**Mayer, L. A.**, Mapping in the Arctic, Invited presentation to National Geographic Society Advisory Board for OCEANUS TV Series, 27 October, 2009


**Invited Talks and Published Abstracts (2010):**


**Mayer, L. A.**, Delineating the Continental Shelf in the Arctic, Invited Lecture – Preserving the Environment of the Arctic Region, Beckman Center of the National Academy of Sciences, Irvine CA., 12 Nov., 2010.


Invited Talks and Published Abstracts (2011):

Battle for the Arctic? 2011, Keynote Speaker – Heritage Dinner, Seacoast Science Center, Rye, New Hampshire 10 February, 2011


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Bell, K.L.; R D. Ballard; D F. Coleman; C Roman; M L. Brennan; T Turanli; M Duman; S Carey; P Nomikou; M Marani; M Rosi; J A. Austin; M Canals; Jy Karson; Mayer, L. A.; Y Makovsky New Frontiers in Ocean Exploration: The 2011 E/V NAUTILUS Field Season, Abstract OS21A-1570, presented at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec.

Invited Talks and Published Abstracts (2012):


Invited Talks and Published Abstracts (2013):


Thomas Butkiewicz

Contact Information
Research Assistant Professor
Center for Coastal and Ocean Mapping
University of New Hampshire
Durham, New Hampshire, 03824
Phone: 603 862-3289
Fax: 603 862-0839
tbutkiewicz@ccom.unh.edu

Education
B.S.  2001-2005  Computer Science  Ithaca College
M.S.  2005-2007  Computer Science  University of North Carolina, Charlotte
Ph.D.  2007-2010  Computer Science  University of North Carolina, Charlotte

Professional Experience
2012-Present  Research Assistant Professor, Data Visualization Research Lab, Center for Coastal and Ocean Mapping, University of New Hampshire.
2011-2012  Post Doctorate Research Fellow, Data Visualization Research Lab, Center for Coastal and Ocean Mapping, University of New Hampshire.
2010-2011  Research Scientist, Data Visualization Center, University of North Carolina, Charlotte.

Relevant Publications (for the last five years)

Jennifer A. Dijkstra

Habitat Research Specialist
University of New Hampshire
Center for Coastal and Ocean Mapping NOAA/UNH Joint Hydrographic Center S122A
Jere A. Chase Engineering Laboratory
24 Colovos Road Durham, NH 03824

Tel: 603-862-1775
Fax: 603-862-0839
jdijkstra@ccom.unh.edu

Professional Preparation
University of Bremen (Germany) Marine Biology M.Sc. (2000)
University of New Hampshire (USA) Zoology Ph.D (2007)

Appointments
Center for Coastal and Ocean Mapping, UNH Habitat Research Specialist (2012-present)
Department of Biological Sciences, UNH Affiliate Assistant Professor, Dept. of Biol. Sc. (2010-present)

Professional Experience
Wells National Estuarine Research Reserve Research Scientist (2012)
Wells National Estuarine Research Reserve Post-Doctoral Research Fellow (2008-2012)
Department of Zoology, UNH Post-Doctoral Research Assistant (2007-2008)

Professional Societies
Coastal Estuarine Research Federation
Ecological Society of America
Northeast Aquatic Invasive Species Panel

Products
Other Products


Synergistic Activities

- Guest Associate Editor: Estuaries and Coasts.
- Mentor to undergraduate and graduate students at the University of New Hampshire
- Mentor to undergraduate and recently graduated students at the Wells National Estuarine Research Reserve
- Instructor: University of New Hampshire
Christina L. Fandel

Contact Information
Research Scientist
Center for Coastal and Ocean Mapping
University of New Hampshire
Durham, New Hampshire, 03824

Phone: 603 862-5357
Fax: 603 862-0839
cfandel@ccom.unh.edu

Education
2010-2013 Center for Coastal and Ocean Mapping, University of New Hampshire, M.Sc
2010-2013 FIG/IHO/ICA Category A Hydrographic Certificate
2006-2010 College of Charleston, Department of Geology and Environmental Geosciences, B.Sc

Professional Experience
2010-2013 Graduate Research Assistant, Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, NH
- Supported hydrographic and oceanographic research at the Center for Coastal and Ocean Mapping/Joint Hydrographic Center
2009-2010 Laboratory Teachers Assistant, Department of Geology and Environmental Geosciences, College of Charleston, Charleston, SC
- Assisted students with upper level Geology laboratory (Marine Geology and Oceanography and Seafloor Mapping), assignments, review sessions, and grading
2009 Assistant Hydrographic Surveyor Intern
- Acquired, processed and analyzed hydrographic survey data in support of NOAA’s nautical charting program

Research Projects
2010-2013 Graduate Research Thesis, University of New Hampshire, Durham, NH
Observations of pockmark flow structure in Belfast Bay, Maine
2009-2010 Undergraduate Research Thesis, College of Charleston, Charleston, SC
Seabed Characterization of the Transect Meanders using Bathymetry, Backscatter, and Sedimentology
2008-2009 Undergraduate Research Assistant, College of Charleston, Charleston, SC
Assessing seabed morphology in regions within and adjacent to the marine protected, Grey’s Reef Marine Sanctuary using multibeam bathymetric data

Research Cruises And Field Experiments
2013 Lead Hydrographer - R/V Hugh R. Sharp, Lewis, DE
2012 Hydrographic Survey Technician, NOAA Ship Ronal Brown, Charleston, SC
2012 Field Technician, Rivers and Inlets Experiment, New River Inlet, NC
2011 Hydrographic Surveyor, USCGC Healy, Arctic Ocean
2009 Student Hydrographic Surveyor, NOAA Ship Nancy Foster, Vieques, Puerto Rico
Professional Societies
American Geophysical Union (AGU)

Conferences And Presentations

Paul D. Johnson

Professional Experience

Data Manager

2011 to Present  Center for Coastal and Ocean Mapping, University of New Hampshire

- Organization, management, and oversight of the large and multi-faceted data holdings of the Center for Coastal and Ocean Mapping/Joint Hydrographic Center.
- Implementation of an ArcGIS Server data management and visualization system.
- Co-P.I. of the National Science Foundation’s Multibeam Advisory Committee.
- System acceptance, calibration and performance testing of multibeam echosounder systems installed on the ships of the U.S. Academic Fleet.
- Development of tools to aid in visualization, mapping, testing, and troubleshooting of multibeam data.

Interim Director of the Hawaii Mapping Research Group

2009 to 2011  Research Corporation of the University of Hawaii

- Management of daily operations, sea going programs, personnel, and logistics.
- Project manager and visualization specialist for the Main Hawaii Islands Multibeam Synthesis. Includes developing an automated script based system of incorporating new datasets and generating derivative products with little user interaction besides quality assurance of the generated products.
- Development of interactive web based map products using the Google Maps API for the Hawaii Ocean Observing system web site.

Director of Field Operations

2005 to 2009  Research Corporation of the University of Hawaii

- Management of field personnel and logistics for sea going programs.
- Party chief of multiple at sea field programs.
- Project manager for the Main Hawaii Islands Multibeam Synthesis.
- Development of processing and visualization routines for acoustic imagery and bathymetry from multibeam and phase difference mapping systems operated by NOAA and the University of Hawaii.
- Development of interactive web based map products using Microsoft Virtual Earth, Google Maps, and UMN Map Server.

Education

M.S. Geology and Geophysics – 1996 - University of Hawaii at Manoa, Honolulu, HI
- Thesis: Recent Structural Evolution of the East Pacific Rise 29°S Large-Scale Dueling Propagator System
- Advisor: Dr. Richard Hey

B.S. Geology and Geophysics – 1993 - University of Hawaii at Manoa, Honolulu, HI

Specialized Software Experience

Visualization and Mapping Software

- Generic Mapping Tools (GMT) - http://gmt.soest.hawaii.edu/
- Fledermaus - http://www.qps.nl/display/fledermaus/main
- ENVI - http://www.ittvis.com/ProductServices/ENVI.aspx
- Global Mapper - http://www.globalmapper.com/
Multibeam Data Processing Software

- SAIC Survey Analysis and Area Based Editor (Saber)
- Caris HIPS and SIPS
- Fledermaus
- MB-System

Other Software

- Extensive use of the UNIX, Linux, Macintosh, and Microsoft Windows
- Script (CSH, TCSH, and BASH) programming
- IDL (Interactive Data Language) programming for processing and visualizing airborne hyperspectral data.
- Python programming for interacting and working with multibeam data.

Field Programs

2013  **Multibeam & Subbottom Watch Leader - E/V Nautilus**, Western Gulf of Mexico
     Gas seep exploration using an EM302 multibeam echosounder and a Knudsen subbottom
2013  **Multibeam Acceptance Specialist - E/V Nautilus**, Toulon, France
     System performance testing and acceptance of an EM302 system
2013  **Multibeam Quality Control - R/V Falkor**, Bahamas
     System performance testing and calibration of an EM710 and EM302 system
2013  **Multibeam Quality Control - R/V Roger Revelle**, San Diego, CA to Anacortes, WA
     System performance testing and calibration of an EM122 system
2012  **Multibeam Quality Control - R/V Marcus Langseth**, Portland, OR
     System performance testing and calibration of an EM122 system
2012  **Multibeam Acceptance Specialist - R/V Falkor**, Norway
     System performance testing and acceptance of the EM710 and EM302 systems
2012  **Multibeam Acceptance Specialist - R/V Kilo Moana**, Portland, OR to Honolulu
     System performance testing and acceptance of the EM710 and EM122 systems

Publications

Giuseppe Masetti
Tel: +1 (603) 866 - 3445  E-mail: gmasetti@ccom.unh.edu
Nationality: Italian  Date of Birth: 8th August, 1980

Education

PhD in Systems Monitoring and Environmental Risks Management, University of Genoa (2010 - 2013)
Thesis title: Management and environmental risk monitoring of Potentially Polluting Marine Sites (PPMS), Supervisors: Dr. R. Sacile and Dr.. A. Trucco

MSc in Ocean Engineering - Ocean Mapping Option, University of New Hampshire (2011 - 2012)
Thesis title: A Geo-database for Potentially Polluting Marine Sites and Associated Risk Index, Supervisor: Dr. B.R. Calder


Master (Hons) in Marine Geomatics, University of Genoa (2007 - 2008)
Thesis title: Prospective of integration between ENCs and Regional topographic databases, Supervisor: Dr. L. Surace

Master (Hons) in International Science and Diplomatic Relations, University of Trieste (2003 - 2004)

Master (Hons) in Political Science, University of Pisa (1999 - 2003)

Employment

August 2013 - continue → Postdoctoral Research Associate
Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, NH (USA)

April 2013 - August 2013 → Operation Officer
Hydrographic Vessel 'Ammiraglio Magnaghi', Italian Navy
Planning and execution of multiple hydrographic and oceanographic surveys

August 2011 - December 2012 → Research Assistant
Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, NH (USA)
Assisting research activity related to underwater acoustics and risk management

January 2011 - August 2011 → Visiting Scholar
Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, NH (USA)
Development of a project focused to the remote characterization of seafloor adjacent to shipwrecks using mosaicking and analysis of backscatter angular responses

July 2008 - December 2010 → Operation Officer
Hydrographic Vessel 'Aretusa', Italian Navy
Planning and execution of multiple hydrographic and oceanographic surveys

April 2008 - May 2008 → Intern
'Sistemi Informativi e Telematici' department, Ligurian Region (Italy)
Production of regional topographic DB and control quality methods

May 2004 - October 2006 → Navigation Officer
Hydrographic Vessel 'Ammiraglio Magnaghi', Italian Navy

August 1999 - May 2004 → Cadet
Naval Academy, Livorno (Italy)
Publications/Conference Papers

- **Masetti, G.,** and Orsini, F., (2010), La Missione Atalanta e la politica estera dell'Unione Europea, Aracne Editrice, Rome, Rome, Italy. *Book*
- **Masetti, G.,** (2009), Carte nautiche elettroniche dell’I.M. e cartografia tecnica regionale: studio di fattibilità per una necessaria integrazione, Atti 13a Conferenza Nazionale ASITA, Bari, Bari, Italy, Dec 1 - Dec 4. *Conference Proceeding*
- **Masetti, G.,** and Orsini, F., (2009), Environmental Risks Monitoring of Shipwrecks in Italian Seas, *International Hydrographic Review, Volume 11*, p.52-60. *Journal Article*

Professional Memberships

- The Institute of Electrical and Electronics Engineers (IEEE, Nr. 92349274)
- The Hydrographic Society of America (THSOA)
Lindsay McKenna
Project Director, Center for Coastal and Ocean Mapping
lmckenna@ccom.unh.edu | (603) 862-5246

Education
2003 - 2007 Brown University, Department of Geological Science, Sc.B.
2010 - 2013 University of New Hampshire, Center for Coastal and Ocean Mapping, M.S.

Professional Experience
2010 - 2013 Graduate Research Assistant, University of New Hampshire, Center for Coastal and Ocean Mapping. Supported hydrographic and ocean engineering research at the Center for Coastal and Ocean Mapping.
2007 - 2010 Project Geologist, Malcolm Pirnie, Inc. - Fair Lawn, New Jersey
  Executed geological studies in support of water resource and environmental engineering projects. Performed data analysis and interpretation, GIS mapping, permit procurement, work plan and report writing.

Research Projects
2013 Graduate Thesis, University of New Hampshire, Center for Coastal and Ocean Mapping Observations of Bedform Evolution and Current Flows in a Tidal Inlet Hampton, NH
2007 Undergraduate Thesis, Brown University Coastal Change at Annawanscutt Beach and its Impacts on a Tidal Marsh

Research Cruises And Field Experiments
2012 USCGC HEALY, Hydrographic Survey Technician
2012 E/V Nautilus, Science Intern
2012 River/Inlets Field Experiment, Field Technician

Professional Societies
▪ American Geophysical Union (AGU)

Certificates And Licenses
▪ Category - A Hydrographic Certificate
▪ New Hampshire Small Boating License

Presentations And Abstracts

Shachak Pe’eri

Contact Information
Research Assistant Professor  Phone: 603 862-1892
Center for Coastal and Ocean Mapping  Fax: 603 862-0839
University of New Hampshire  shachak@ccom.unh.edu
Durham, New Hampshire, 03824

Education
1993-1996  Tel-Aviv University, Department of Geophysics and Planetary Sciences, B.Sc.
1996-1997  Tel-Aviv University, Department of Geophysics and Planetary Sciences, M.Sc.
1999-2005  Tel-Aviv University, Department of Geophysics and Planetary Sciences, Ph.D.
           (co-supervision from Stanford University and the Hebrew University).
2005-2006  Center for Coastal and Ocean Mapping, University of New Hampshire, Post Doctorate.

Professional Experience
2008-Present  Research Assistant Professor, Optical remote sensing (LIDAR and hyperspectral), Center for Coastal and Ocean Mapping, University of New Hampshire.
2006-2008  Research Scientist II, Optical remote sensing (LIDAR and hyperspectral), Center for Coastal and Ocean Mapping, University of New Hampshire.

Professional Societies
American Geophysical Union (AGU)
IEEE (Geoscience and Remote Sensing Society/Oceanic Engineering Society)
The Hydrographic Society of America (THSOA)

Honors And Awards
2002  Dan Lowenthal Prize on excellent Ph.D. in earth sciences - TAU
2005-2008  Tyco post-doctoral fellowship award - UNH

Service (Advisor, Reviewer, And Editor)

Graduate Student:
Ricardo Friere (Ph.D., UNH, Co-advisor)
Firat Eren (Ph.D., UNH, Co-advisor)
Xiao Gou (M.Sc., UNH, Co-advisor)
Olumide Fadhunsi (M.Sc., UNH, Co-advisor) – (graduated 12/2012).
Chukwama Azuike (M.Sc., UNH, Co-advisor) – (graduated 9/2012).
Lynn Morgan (M.Sc., UNH, Co-advisor) – (graduated 12/2007).

Undergraduate Intern Students
Torbjorn Karlsson (CIEE intern, Applied Physics, Lund University, Sweden, 2011), Jacob Chamberlin (Mechanical Engineering, UNH, USA, 2011), Nicholas Parrillo (Physics, UNH, USA, 2011), Isabel Cormier (Geology, UNH, USA, 2011), Abigail Morris (Geology, UNH, USA, 2009-2011), Joshua Kuperstein (Applied Physics, Northeastern University, USA, 2010), Ronak Bhatia, James Flynn, and Charles Bardwell (Civil Engineering, UNH, USA, 2013).
Co-editor on a special issue


Relevant Publications (For The Last Five Years) - Scientific Papers


Relevant Publications (For The Last Five Years) - Reports

Val E. Schmidt

Center for Coastal and Ocean Mapping
The University of New Hampshire
24 Colovos Rd, Durham, NH 03820

Tel: 614.286.3726
Email: vschmidt@ccom.unh.edu

Education

The University of New Hampshire, Durham, New Hampshire, USA
M.S. Ocean Engineering – Mapping Option, September 2008
- Thesis Topic: Tracking of Humpback Whales with HF Acoustic Pingers and Digital Recording Tags
- Completed required coursework for IHO Cat. A certification

The University of the South, Sewanee, TN
B.S., Physics – w/ Honors, May 1994

Profession Experience

University of New Hampshire, Durham, New Hampshire
Research Engineer September 2005 – present
- Field research involving the design and construction of sonars for whale tracking, acoustic propagation studies in Portsmouth Harbor, acoustic test tank transducer/array calibrations, acoustic signal processing and underwater acoustic modeling.

Lamont Doherty Earth Observatory, Palisades, NY
Project Research Engineer January 2002 – August 2005
- Responsible for project planning, system engineering and project execution for a wide array of scientific projects. These include data and communications engineering for oceanographic research ships R/V Ewing, the USCGS HEALY and the R/V Langseth. Also designed and developed instrumentation such as remote wireless sensor systems, remote expendable buoys and air-quality monitoring systems for children.

Qwest Communications, Denver, CO
Voice over IP – Cyber Voice Manager December 1999 – December 2002
- Technical Director of a design and test team dedicated to rapid development, certification and deployment of “Next Generation” voice-over-IP network components. Responsibilities included budget oversight and technical leadership for seven test engineers.

United States Navy, Honolulu, HI
US Naval Officer, Naval Nuclear Engineer/Submariner June 1994 – November 1999
- Assistant Combat Systems Officer/Science Liaison Officer: Provided leadership for thirty personnel in three Divisions aboard the USS Hawkbill. Responsible for mission execution, training, equipment repair and administrative oversight. Also served as the Science Liaison Officer for SCICEX-98 and SCICEX-99 – unclassified scientific missions to the Arctic. Awarded Naval Commendation Medal for outstanding achievement (1999) and the Navy Achievement Medal (x3)
- Chemistry and Radiological Controls Division Officer: Duties included oversight of reactor plant chemistry control, administration of the ships radiological dosimetry program, and training and leadership for the ships chemists. Brought division to “strongest on the waterfront”.

65
Technical Skills

MATLAB, Python, Perl and C developer. Embedded system design engineer. Extensive experience with multibeam sonars and associated software, RTK GPS surveys and processing, Applanix POS/MV, HYPACK, Caris HIPS/SIPS, IVS Fledermaus, ESRI products. Author of the MBSystem Cookbook.
C. Letters of Collaboration

C.1. NOAA Marine Debris Program

Hi Christy and Lindsay, as we have discussed over the past several months, we at the NOAA marine Debris Program are very excited for the opportunity to collaborate with the University of New Hampshire's Center for Coastal and Ocean Monitoring on Superstorm Sandy marine debris detection efforts.

The NOAA MDP is working with many partners to assemble spatial data on the location and impacts of Superstorm Sandy debris; those data take many forms including aerial imagery, commercial satellite imagery, side-scan sonar data, bathymetric data and field assessments.

The NOAA MDP will be happy to share with UNH-CCOM the data gathered from federal, state and local partners to support the proposal "IOCM Research in Support of Super Storm Sandy Disaster Relief."

Please let me know if you need anything. Thank you,

Jason

Jason Rolfe
Southeast and Caribbean Regional Coordinator
NOAA Marine Debris Program
N/ORR, SSMC4, Rm. 10205
1305 East-West Highway
Silver Spring, MD 20910
Desk: (301) 713-2989 x111
Mobile: (301) 461-3236
Email: jason.rolfe@noaa.gov
http://marinedebris.noaa.gov
C.2. USGS Coastal and Marine Geology Program

Larry, Brian,

Following numerous related discussions since the date of the landfall of Hurricane Sandy last year, the USGS Coastal National Elevation Database Applications (CoNED) Project has a strong interest in collaborating with the University of New Hampshire's Center for Coastal and Ocean Mapping to develop improved methods to map cross-shoreline elevation in the Sandy Region, and to assimilate those observations within enhanced models that are to serve as a baseline for predicting vulnerability to future storms.

Based mainly at the EROS Data Center and in close collaboration with NOAA's National Geophysical Data Center, the CoNED Project is actively acquiring disparate topographic and bathymetric datasets across the Sandy Region, and is working closely with the USGS National Geospatial Program, the NOAA NGS Remote Sensing Division and various other partners to insure the collection needed topographic and bathymetric lidar coverage within the Sandy Region.

The USGS CoNED Project anticipates a close collaboration with UNH-CCOM to maximize the benefits that will result from your proposed project entitled "IOCM Research in Support of Super Storm Sandy Disaster Relief".

Best wishes for the success of your proposal,

John

--

John C. Brock
Coastal and Marine Geology Program
USGS National Center, Mail Stop 915-B
12201 Sunrise Valley Drive
Reston, VA 20192
ph#: 703-648-6053
fx#: 703-648-5464
Telecon Bridge:
Ph#: 703-648-4848
CC: 10690#
email: jbrock@usgs.gov
http://marine.usgs.gov
http://ngom.usgs.gov
C.3. **NOAA National Geodetic Survey**

Lindsay and Shachak,

This is to confirm that I will supply NGS topo-bathy lidar data for Barnegat Bay, NJ project sites that can be used in your research. We are starting to receive processed data from NGS's recent "Tri-Lidar project," and I anticipate being able to provide data sets as early as next week.

Please don't hesitate to contact me, if I can provide any further assistance.

Regards,
Chris

--

Christopher Parrish, Ph.D.

University of New Hampshire, NOAA-UNH JHC/CCOM
24 Colovos Rd, Durham NH, 03824
Ph: 603-862-0250; Fax: 603-862-0839
e-mail: chris.parrish@noaa.gov, cparrish@ccom.unh.edu

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C.4. University of Delaware Coastal Sediments, Hydrodynamics and Engineering Lab

Dear Larry and Brian,

I'm writing this message (from the deck of a sailing ship in the Aegean) to acknowledge and enthusiastically support your proposal to utilize the ONR project seafloor mapping data (both MBES and PMBS) of before and after conditions caused by superstorm Sandy. I think this type of effort is a great application of these data and epitomizes the concept of "map once and use many times".

Best of luck with the proposal and I look forward to continued work together.

Most sincerely,

Art Trembanis, PhD
Associate Professor
CSHEL
University of Delaware
D. Data Sharing Plan

The Integrated Ocean and Coastal Mapping research in support of Super Storm Sandy disaster relief implemented by the Center for Coastal and Ocean Mapping [CCOM] will generate environmental data and information, including lidar, sonar, and optical data products for portions of the eastern U.S. coastal states.

Products generated will include:

- Topography/Bathymetry grids – ESRI GIS Grid Files and ASCII Files
- Maps – JPEGs and/or PDFs
- GIS Shapefiles
- Documentation and Reports – PDFs
- Metadata – XML
- GML Based Interoperable Databases – Geography Markup Language

CCOM will make use of raw and processed data, to generate said products, from many organizations and services including:

- NOAA’s Integrated Ocean and Coastal Mapping Processing Center
- NOAA’s National Geodetic Survey [NGS]
- NOAA’s Remote Sensing Division
- U.S. Geological Survey [USGS]
- U.S. Army Corp of Engineers’ National Coastal Mapping Program [NCMP]
- Digital Globe

Derivative products, documentation on processing, and metadata will start to be made available to the public as it is processed and validated, with initial release starting as early as Quarter 1, FY14. Contact Paul Johnson, pjohnson@ccom.unh.edu, the data manager at the Center for Coastal and Ocean Mapping for specific data requests.

Data will made available using standard protocols, including REST, SOAP, JSON, and WMS, through CCOM’s GIS server, http://gis.ccom.unh.edu:6080/arcgis/rest/services for easy integration into other web and desktop based GIS applications. Data will also be made available for download through CCOM’s website, http://ccom.unh.edu. We will work with NOAA’s National Geophysical Data Center [NGDC] to archive all relevant data products with full metadata in order to make sure that the data is available to the public for future work.

New procedures, methods, documentation, and data products derived from this research will be reported in the quarterly progress reports, as well as being presented either at national conferences, through peer-reviewed scientific journals, or through documents distributed by the Center’s web server.
E. National Environmental Policy Act Statement

OMB Approval No.: 0648-0538
Expires: 11/30/2015

Environmental Compliance Questionnaire for National Oceanic and Atmospheric Administration
Federal Financial Assistance Applicants

Instructions

The National Environmental Policy Act (NEPA) (42 U.S.C. 4321-4347) and the Council on Environmental Quality's (CEQ) Regulations for Implementation NEPA (40 CFR 1500-1508) require that an environmental analysis be completed for all major federal actions significant affecting the environment. NEPA applies only to the actions of federal agencies. Those actions may include a federal agency's decision to fund non-federal projects under grants and cooperative agreements. In order to determine NEPA compliance requirements for a project receiving National Oceanic and Atmospheric Administration (NOAA) funding, NOAA must assess information which can only be provided by the federal financial assistance (grant) applicant.

NEPA requires that a number of items be considered prior to funding and conducting any activity. The following Environmental Compliance Questionnaire provides federal financial assistance applicants and NOAA staff with a tool to ensure that project and environmental information is obtained. NOAA staff will use the information provided in answers to the questionnaire to determine compliance requirements for NEPA and conduct subsequent NEPA analysis as needed. Information provided in the questionnaire may also be used for other regulatory review requirements associated with the proposed project, such as permitting and Endangered Species Act Section 8 consultations.

Applicants are not required to answer every question in this questionnaire. Applicants are only required to answer the questions indicated in the Announcement of Federal Funding Opportunity. Applications should answer the questions to the best of their ability with as much detail as possible. If the applicant does not answer all of the questions indicated in the Announcement of Federal Funding Opportunity the application may be considered incomplete.

Some of the questions may overlap with material provided in other parts of the application. This overlap occurs because the answers to the questionnaire are provided to NOAA staff who do not review the other parts of the application. If appropriate, the applicant may copy the information from other parts of the application and paste it into the answers to the questionnaire.

Many questions have a "yes" or "no" response. If the response is "no" the applicant does not need to elaborate on their answer. If the response is "yes" the question will have a second part asking the applicant to provide more information. Applicants should use the space provided to answer the questions. If the applicant needs additional space, additional pages may be attached to the questionnaire, indicating which question is being continued.

A. Project Information

A1 Provide a brief description of the proposed activity.

The University of New Hampshire (UNH), Center for Coastal and Ocean Mapping, has proposed a package of research under Federal Funding Opportunity NOAA-NOS-OCS-2013-2003801 (FY13 Disaster Relief Appropriations Act IOCM Processing Center Research). The Federal Funding Opportunity involves research in data processing for hydrographic and ocean mapping data collected in support of the Disaster Relief Appropriations Act, with specific focus on the areas affected by Super Storm Sandy, along with methods for derivative analysis of the products from this research, and dissemination of same. The work will not include any field programs that include acoustic (i.e., sonar) or optical (i.e., lidar and imagery) collection,
but may include tank-based experiments in our research facilities, and, potentially, a non-invasive collection of optical data in the coastal ocean using surface-tethered underwater cameras.

A12 Does the proposed activity involve the temporary or permanent placement of equipment (e.g., scientific monitoring equipment) or other structures in the environment? If yes, provide a detailed description of the equipment or structures and schedule for the deployment and recovery (if applicable) of the equipment or structures.

No.

B. Funding Information

No questions required by FFO.

C. Federal Involvement

C1 Is the proposed activity going to be conducted in partnership with NOAA or would the proposed activity require NOAA’s direct involvement, activity, or oversight? If yes, describe NOAA’s involvement, activity, or oversight, including the name of the office or program that is involved.

The proposed project would be funded through a cooperative agreement between NOAA and the University of New Hampshire. NOAA personnel may be assigned to the activity. The primary office responsible for the cooperative agreement is the Office of Coast Survey of the National Ocean Service, along with components of the National Geodetic Survey. NOAA’s primary involvement will be provision of data, some collaboration on research, including review of proposed research products, and assistance in testing methodologies and technologies developed.

C2 Would the proposed activity involve any other federal agency(ies) partnership, direct involvement, activity, or oversight? If yes, provide the name(s) of the agency(ies) and describe its involvement, activity or oversight.

The proposed activity may involve collaboration with the USGS and U.S. Army Corps of Engineers. These activities would most likely involve collaboration over data provision (from their activities) in support of the proposed research.

D. Project Location

D1 Provide a brief description of the location of the proposed activity.

The activity will be primarily limited to shore-side work at the University of New Hampshire campus in Durham, NH. Some portions of the work may be conducted at the NOAA building (SSMC3) in Silver Spring, MD due to the work assignment of one of the investigators. One possible activity is to use an underwater camera to acquire non-invasive video imagery of marine debris or seagrass to support groundtruthing efforts in the proposal. If necessary (i.e., if equivalent data cannot be obtained through other means), this activity would take place in a Super Storm Sandy-affected area, most probably Barnegat Bay, NJ. NOAA involvement in this activity is not expected.

E. Permits

E1 List any federal, state, or local permits, authorizations, or waivers that would be required to complete the proposed activity. Provide the date the permit, authorization, or waiver was obtained or will be obtained. Provide copies of the permit, authorization, or waiver. Was a NEPA analysis prepared for the permit, authorization, or waiver? If yes, state the title of the NEPA analysis and provide copies of the NEPA analysis.

No known permits or waivers are required for the proposed activities.
F. Potential Impacts of the Proposed Activity

F1  Is there the potential for the proposed activity to cause changes that would be different from normal ambient conditions (e.g., temperature, light, turbidity, noise, other human activity levels, etc.)? If yes, describe the changes and the circumstances that would cause these changes.

The proposed activity may involve some limited use of small light sources in conjunction with drop video cameras, primarily to collect images of the sea bottom in targeted areas for groundtruth comparison with products constructed from remotely-sensed data.

F11 Would the proposed activity involve sonar transmissions at a combination of frequency, power level, duration, and insonified area known or expected to harm marine mammals? If yes, describe the sonar transmissions; the location; and list the marine mammals known to occur in the area.

No.

G. Potential Impacts of the Proposed Activities Related to Damage Assessment and Restoration

No questions required by FFO.

H. Potential Impacts of the Proposed Activities Related to Fisheries Sampling and Research

No questions required by FFO.

Paperwork Reduction Act Statement

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F. References


G. Milestones by Time Period

The following list contains all of the milestones for the project, organized sequentially by quarterly reporting period. The converse (i.e., ordered by research theme, in order of the FFO text) is given in the main narrative in Section 8. Note that “document” should be understood to mean, generically, a journal paper, conference paper or report, as appropriate for the material.

G.1 Quarter 1, FY14
- Document describing a procedure for preprocessing the different source layers and an initial SOP workflow document for erosion/deposition change maps (Lidar).
- Quarterly progress report (All).

G.2 Quarter 2, FY14
- Develop written procedures for data distribution methods associated with web-based distribution (Specialized Data Processing).
- Construct initial website for the project (Outreach).
- Quarterly progress report (All).

G.3 Quarter 3, FY14
- Document describing shoreline change for selected coastlines and preliminary results for evaluating lidar intensity maps and depth estimation (including bottom detection) (Lidar).
- Document describing the selection and the development of adaptive algorithms (Marine Debris).
- Document evaluating use of CCOM processing techniques on Super Storm Sandy PMBS data (Acoustic Data and Techniques).
- Promote outreach program through appropriate channels (Outreach).
- Quarterly progress report (All).

G.4 Quarter 4, FY14
- Document describing the methods used to: create DEMs from lidar point cloud files, extract shoreline contours, create change maps, and analyze shoreline change (Lidar).
- Develop written protocols to satisfy the bathymetric and hydrographic data requirements of Federal Partners (e.g., NOAA and USGS) in response situations that maximize acoustic survey acquisition effectiveness (Acoustic Data and Techniques).
- Document describing 'effective' object detection in PMBS data (Acoustic Data and Techniques).
- Demonstrate infographics for composite datasets in the website (Outreach).
- Demonstration of data visualization tool with limited display of information (Visualization).
- Quarterly progress report (All).

G.5 Quarter 1, FY15
- Develop written procedures for generating new IOCM multi-use products from Sandy-region topobathy lidar data (Lidar).
- Document describing the development and the test of the adopted fusion approach (Marine Debris).
- Promote outreach program through appropriate channels (Outreach).
- Demonstrate user-driven “citizen science” visualization and identification of marine debris on website (Outreach).
- Quarterly progress report (All).
G.6  Quarter 2, FY15

- Document describing the classification scheme that includes: defining the effective area for classification, separation of SAV from exposed areas, characterization of the exposed areas based on surface analysis, and characterization (Lidar).
- Document describing the outline of adopted geodatabase data structure and GML schemas (Marine Debris).
- Promote outreach program through appropriate channels (Outreach).
- Quarterly progress report (All).

G.7  Quarter 3, FY15

- Document describing the classification scheme by comparing maps of eelgrass and macroalgal habitats and maps of benthic habitats for Barnegat Bay, NJ with ground truth measurement (Lidar).
- Quarterly progress report (All).

G.8  Quarter 4, FY15

- Document describing the results of research into new geospatial data products from NOAA and partner agency topo-bathy lidar waveform data in Sandy-impact area (Lidar).
- Document describing the overall workflow for marine debris recognition, inventory, and outputs optimal for web GIS and environmental databases, documentation of best practices and standard operating procedures (Marine Debris).
- Document describing the potential for modified processing techniques to improve object retention in PMBS data processing (Acoustic Data and Techniques).
- Document describing the results of research into using PMBS and multibeam sonar systems to assess storm impact in Sandy-impacted regions (Acoustic Data and Techniques).
- Document describing new methods of using Sandy IOCM multi-use data sets to generate parameters/sub-indices for CEI calculation within the Sandy region (Specialized Data Processing).
- Develop written procedures for construction of CEI-facilitating metrics and features (Specialized Data Processing).
- Improve infographics and “citizen science” outreach to include results of latest research (Outreach).
- Demonstration of improved data visualization tool taking into account latest research (Visualization).
- Final progress report (All).
H. Detailed Data Management Plan

In order to advance responsible data management as part of our proposed research, the following information was prepared using the Data Management Plan Tool available at https://dmp.cdlib.org. This tool is provided by the University of California Curation Center of the California Digital Library, and is intended to answer all of the relevant questions associated with the management of digital data.

H.1 General Description of Data to be Managed

- **Name of the Dataset or data collection project.**
  IOCM Research in support of Super Storm Sandy Disaster Relief

- **Keywords that could be used to characterize the data**
  Lidar, Bathymetry/Topography, Elevation, Backscatter, Reflectance, Sidescan, Remote Sensing, Marine Debris

- **Summary description of the data to be generated.**
  Lidar, sonar, and optical data from multiple sensors that will be used to generate derivative products for IOCM research in support of Super Storm Sandy disaster relief. All data designated for release from this research will be reviewed, checked for errors, and documented.

- **Anticipated temporal coverage of the data.**
  2012 to present. Coverage varies from location to location—some areas feature multiple surveys while other areas have no coverage.

- **Anticipated geographic coverage of the data.**
  Coastal regions of U.S. east coast states (partial coverage) affected by Super Storm Sandy.

- **What data types will you be creating or capturing?**
  Topography/Bathymetry grids (ESRI GIS Grid Files and ASCII Files), Maps (JPEGs and/or PDFs), GIS Shapefiles, Documentation and Reports (PDFs), Metadata (XML), GML Based Interoperable Databases (Geography Markup Language)

- **How will you capture or create the data**
  CCOM will make use of raw and processed data, to generate said products, from many organizations and services including: NOAA’s Integrated Ocean and Coastal Mapping Processing Center, NOAA’s National Geodetic Survey (NGS), NOAA’s Remote Sensing Division, U.S Geological Survey (USGS), U.S. Army Corp of Engineers’ National Coastal Mapping Program (NCMP), and Digital Coast

- **Will the data contain Personally Identifiable Information or any information whose distribution may be restricted by law or national security?**
  No

H.2 Points of Contact

- **Who can, or could, represent this data collection project on NOAA’s Data Management Integration Team (DMIT)?**
  N/A

- **Who is the overall point of contact for the data collection?**
Data Stewardship

- What quality control procedures will be employed?
  All data will be fully examined and validated following a standard quality-control review procedure.

- What is the overall lifecycle of the data from collection or acquisition to making it available to customer?
  Data products will be generated as time and resources permit.

Data Documentation

- Which metadata repository will be used to document this data collection?
  Metadata will be made available through the following: CCOM Website and Data.gov

- In addition to discovery-level metadata, what additional metadata or other documentation is necessary to fully describe the data and ensure its long-term usefulness? How will that metadata be collected and updated?
  Is there a requirement to document this data collection in other metadata repositories?

  Metadata records contain both discovery and use information. Additional documentation (linked to from within the metadata) will be available through the CCOM website.

  Metadata will be reviewed as necessary.

  There are no requirements to document the data in any other metadata repositories other than those already mentioned in 4.1.

- What standards will be used to represent data and metadata elements in this data collection?

  Currently CCOM metadata is being written in the FGDC CSDGM format. However, work is underway to have future records written using the ISO 19115 format.

Data Sharing

- Will the data be made available to the public? If so, what is the expected date of first availability? Is this a one-time data collection, or an ongoing series of measurements? Will there be a Principal Investigator hold or other delay between data collection and publication, and if so for how long?
The data will be made available to the public.
This is an ongoing project that is updated as resources permit.
Expected first release of data will happen during Q1, FY14.
There will be no hold on generated products beyond the period of time necessary for quality control and metadata generation.

- If the data are not to be made available to the public, explain why and under what authority distribution may be restricted. NOAA policy states that Environmental data will be visible, accessible and independently understandable to users, except where limited by law, regulation, policy (such as those applicable to personally identifiable information or protected critical infrastructure information or proprietary trade information) or by security requirements.

  N/A

- Will users be subject to any access conditions or restrictions, such as submission of non-disclosure statements, special authorization, or acceptance of a licensing agreement?

  No

- What data access protocols will be used to enable data sharing? The use of open-standard, interoperable, non-proprietary web services is recommended (for example, OPeNDAP, or Open Geospatial Consortium (OGC) web services).

  Open standards are used for data sharing. The data may be accessed via web pages, ftp sites, and web services.

- In what catalogs will these services or data be made registered to enable discovery by users and other Catalogs?

  Data.gov
  ArcGIS.com

H.6 Initial Data Storage and Protection

- Where and how will the data be stored initially (i.e., prior to being sent to a long-term archive facility)?

  Data will be stored at CCOM.

- How will the data be protected from accidental or malicious modification or deletion? Discuss data back-up, disaster recovery/contingency planning, and off-site storage relevant to the data collection.

  The data will be protected using standard security practices
  The data will be backed up on a regular schedule
  Copies of the data will be held off site per disaster recovery requirements

- If there will be limitations to data access, how will these data be protected from unauthorized access? How will access permissions be managed? What process is to be followed in the event of unauthorized access?

  N/A

H.7 Long-Term Archiving and Preservation

- In what NOAA Data Center (NODC, NCDC, NGDC) will the data be archived and preserved?

  The data will be archived at NGDC
If you have not identified a NOAA Data Center, what is your long-term strategy for maintaining curating, and archiving the data?
N/A

How will the costs of long-term data archiving be provided and maintained?
N/A

What transformations or procedures will be necessary to prepare data for preservation or sharing? (e.g., quality control, format conversion, anonymization of personally-identifiable information, etc.). What related information will be submitted to the archive to enable future use and understanding of the data [e.g., metadata, references, reports, research papers, algorithms, audio or video codecs, special character sets or fonts, etc.]).

There are no additional requirements necessary for preservation

Data for archiving is submitted with all existing documentation including metadata
I. Data Sources

I.1 Redbird Artificial Reef Site

The approximately 1.5 km² survey area is located ~30 km off the coast of the Delaware shore (Figure I.1). The dataset consists of co-located multibeam (Reson SeaBat 7125) and PMBS (500 kHz GeoAcoustics GeoSwath Plus) data. These data will be used to evaluate the optimal acoustic surveying data acquisition procedures in response situations, investigate new and innovative techniques to process interferometric data, and assess the applicability of multibeam and interferometric for assessing storm impacts.

Figure I.1: An example of data from the Redbird site (data collected by Reson SeaBat 7125), post-Super Storm Sandy.

I.2 Lidar surveys (coastal areas of NY and NJ)

Three main lidar dataset will be used for the study: 1) EAARL-B surveys conducted over the NJ coastline and Barnegat Bay, NJ, acquired directly from the USGS, 2) Pre- and post-Sandy ALB surveys (CHARTS and CZMIL) collected through the USACE’s National Coastal Mapping Program [NCMP] over coastal New Jersey and New York and maintained on NOAA’s Digital Coast website (Figure I.2) and, 3) Riegl surveys conducted over Barnegat Bay, NJ, acquired directly from NOAA NGS. The lidar data will provide bathymetry and intensity information that will be used for lidar processing that include: generating new IOCM multi-use data products, extracting enhanced information from lidar waveforms, shoreline change analysis, analysis of erosion and deposition, bathymetric mapping in adverse conditions, assessing seagrass habitat change, and benthic habitat classification and analysis.
Figure I.2: An example for available USACE lidar datasets (data collected by the CZMIL ALB) data through NOAA’s Digital Coast.

1.3 Aerial imagery (coastal areas of NY and NJ)

Pre- and post-storm impact aerial imagery over the New Jersey and New York coastlines will be used for identifying changes in the shoreline and seafloor morphology. The aerial imagery will be also used as a visual reference for studies using lidar and satellite multispectral imagery. The aerial imagery includes optical and near-infrared images collected through the coastal mapping program in Remote Sensing Division at NOAA/NOS/NGS (http://ngs.woc.noaa.gov/storms/sandy/), USGS’s Digital Orthophoto Quarter Quads (DOQQs) and High Resolution Orthoimagery data (http://earthexplorer.usgs.gov/), and USDA’s National Agriculture Imagery Program (NAIP) (http://earthexplorer.usgs.gov/). An example is reported in Figure I.3.

Figure I.3: An example for available aerial imagery (NAIP imagery at 1m resolution) through USGS’s EarthExplorer.
I.4 Satellite imagery (coastal areas of NY and NJ)

Multi-spectral satellite images (such as WorldView 2 and Landsat 7/8) of the Sandy-impact region acquired from service providers and servers such as DigitalGlobe, GeoEye’s GeoFUSE, USGS’s EarthExplorer and ResMap. This spectral imagery will allow characterization of the water column and the seafloor for habitat studies. Time series from these datasets will allow identification of natural trends that can be separated from the impact of the storm. Multi-spectral satellite imagery is available from as early as 1999 (Figure I.4).

![Figure I.4: An example for multi-spectral satellite imagery (Landsat 7 from 1999) through USGS’s EarthExplorer.](image)

I.5 Portsmouth, NH Site

This approximately 500 m² survey area is located ~1 km off the coast of New Hampshire. The dataset consists of co-located multibeam (Kongsberg EM 2040) and PMBS (Klein HydroChart 5000) data. These datasets may be used to investigate the optimal acoustic survey acquisition procedures necessary to maximize acoustic data acquisition efficiency in response conditions (should other data in the area more directly impacted by Super Storm Sandy be unavailable).
### Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ALB</td>
<td>Airborne Lidar Bathymetry</td>
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<td>ALBTCX</td>
<td>Airborne Lidar Bathymetry Technical Center</td>
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<tr>
<td>ASPRS</td>
<td>American Society for Photogrammetry and Remote Sensing</td>
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<tr>
<td>AUV</td>
<td>Autonomous Underwater Vehicle</td>
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<tr>
<td>CCOM</td>
<td>Center for Coastal and Ocean Mapping</td>
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<td>CEI</td>
<td>Coastal Engineering Index</td>
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<tr>
<td>CHRT</td>
<td>CUBE with Hierarchical Resolution Techniques</td>
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<tr>
<td>CMECS</td>
<td>Coastal and Marine Ecological Classification Standards</td>
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<tr>
<td>COTS</td>
<td>Commercial Off-The-Shelf (typically software or hardware)</td>
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<tr>
<td>CVI</td>
<td>Coastal Vulnerability Indices</td>
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<tr>
<td>CZMIL</td>
<td>Coastal Zone Mapping and Imaging Lidar</td>
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<tr>
<td>CUBE</td>
<td>Combined Uncertainty and Bathymetry Estimator</td>
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<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
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<td>DRA</td>
<td>Disaster Relief Appropriations Act</td>
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<tr>
<td>EAARL-B</td>
<td>USGS Experimental Advanced Airborne Research Lidar</td>
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<td>EFH</td>
<td>Essential Fish Habitat</td>
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<td>ERMA</td>
<td>Environmental Response Management Application</td>
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<td>FFO</td>
<td>Federal Funding Opportunity</td>
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<td>FGDC</td>
<td>Federal Geographic Data Committee</td>
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<td>FMGT</td>
<td>Fledermaus GeoCoder Toolkit</td>
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<td>FOV</td>
<td>Field of View</td>
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<td>GIS</td>
<td>Geographic Information System</td>
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<td>GML</td>
<td>Geography Markup Language</td>
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<tr>
<td>IOCM</td>
<td>Integrated Ocean and Coastal Mapping</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>JALBTCX</td>
<td>Joint Airborne Lidar Bathymetry Research Center of Expertise</td>
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<td>JSON</td>
<td>JavaScript Object Notation</td>
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<td>LIDAR</td>
<td>Light Detection and Ranging</td>
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<td>MBES</td>
<td>Multibeam Echosounder</td>
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<td>MGDS</td>
<td>Marine Geoscience Data System</td>
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<td>MHW</td>
<td>Mean High Water</td>
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<td>MLLW</td>
<td>Mean Lower Low Water</td>
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<td>NCMP</td>
<td>National Coastal Mapping Program</td>
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<td>NGDC</td>
<td>National Geophysical Data Center (Boulder, CO)</td>
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<td>NGS</td>
<td>National Geodetic Survey</td>
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<td>NIST</td>
<td>National Institute of Standards and Technology</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<td>PMBS</td>
<td>Phase Measuring Bathymetric Sonar</td>
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<td>PPMS</td>
<td>Potentially Polluting Marine Site</td>
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<tr>
<td>R2R</td>
<td>Rolling-deck to Repository program</td>
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<tr>
<td>REST</td>
<td>Representational State Transfer</td>
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<tr>
<td>RTK</td>
<td>Real-time Kinematic (positioning)</td>
</tr>
<tr>
<td>RULET</td>
<td>Remediation of Underwater Legacy Environmental Threats</td>
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<tr>
<td>RUST</td>
<td>Resources and UnderSea Threats database</td>
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<tr>
<td>SAV</td>
<td>Submerged Aquatic Vegetation</td>
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<tr>
<td>SOAP</td>
<td>Simple Object Access Protocol</td>
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<td>SONAR</td>
<td>Sound Navigation and Ranging</td>
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<td>SOP</td>
<td>Standard Operating Procedure</td>
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<td>Total Propagated Uncertainty</td>
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