SHALLOW SURVEY 2015

The 7th International Conference on High-Resolution Surveys in Shallow Water

Plymouth University
14-18 September 2015

Conference Abstracts
14 - 18 September 2015
Roland Levinsky Building, Plymouth University

www.shallowsurvey2015.org
An Analysis of the Effectiveness and Efficiency of the Swathe Bathymetry Systems Utilised For the 2015 Common Dataset

Session 2: The 2015 Common Dataset
Time 11:10
Presenter Luke Elliott, Plymouth University/UKHO
Authors Luke Elliott, Plymouth University/UKHO

Abstract Nine datasets make up the Common Dataset acquired by Edgetech, Kongsberg, Teledyne Reson and WASSP in 2014. This paper aims to assess the ability of the systems to detect objects using both visual and statistical analysis. The paper will present the findings of the authors dissertation.
SHALLOW SURVEY 2015 PAPERS

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<th>Title</th>
<th>A visual and statistical comparison of the Shallow Survey 2015 Common Data Sets</th>
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<tr>
<td>Presenter</td>
<td>Peter Hogarth, Kongsberg Maritime</td>
</tr>
<tr>
<td>Authors</td>
<td>Peter Hogarth, Kongsberg Maritime</td>
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Abstract: Following on from an informal presentation in Plymouth a decade ago, in this paper, a comparison of the different data sets will be presented. 50cm mean binned grids derived from all available xyz files will be compared. The visual comparisons will use identical areas of interest and equal sun illumination settings, with brief objective comments on coverage, sources and types of error, and some reference to effect on image and final grid quality. This will be linked to a statistical analysis of the differences between all combinations of pairs of grids. The importance of three dimensional sound velocity variations when considering wide swath coverage will be highlighted, and the very large (order of magnitude) differences between sound speed regimes which are characteristic of Plymouth will be discussed for the different data sets. Conclusions will be drawn for both multibeam and phase measurement systems when used in complex estuarine conditions and recommendations will be made for best survey practice.
Intercomparison of the Shallow Water Survey datasets and combined data interpretation of backscatter and bathymetry

Title
Intercomparison of the Shallow Water Survey datasets and combined data interpretation of backscatter and bathymetry

Session
2: The 2015 Common Dataset

Time
12:00

Presenter
TBC

Authors
Tim Le Bas, National Oceanography Centre
Andrew Colenutt, Channel Coastal Observatory

Abstract
The shallow water surveys of 2014 have provided a unique opportunity to compare and contrast 6 swath bathymetry systems. The systems were deployed over two areas, all providing gridded maps of bathymetry and some (but not all) backscatter mosaics. New backscatter mosaics were created where raw data was available.

Intercomparison of different bathymetric datasets show the variation in the map from the bathymetric surveying process. Individually each survey would be validated and acceptable for publication and the errors would be hard to detect. With multiple datasets difference maps show where systems correlate and where the standard deviation is high.

It has been widely accepted that much improved data interpretation is gained when using the backscatter imagery in conjunction with the bathymetric features. Expert interpreters then use the feature boundaries that are seen on these maps and digitise boundaries to delineate changes in substrate. Unfortunately this can be a slow process, usually is very subjective, non-repeatable and unquantifiable. A new method has been developed to speed this process up by mimicking human interpretation. Object Based Image Analysis (OBIA) is where the objects are defined as distinct segments of an image with characteristics of in spatial, statistical and temporal scales. There are two main aspects to OBIA: Segmentation and Classification. Homogeneous groups of pixels are identified and form objects or segments which can have different sizes and shapes (polygons). From the pixel value statistics, the geometry and texture of the objects, an interpreter can define statistical models to generate a defined classification. This mimics how human experts work and provides objective, repeatable and measured data interpretation.

OBIA is available in commercial software packages, but these are expensive and require extensive user training. The RSGIS library of analysis and classification routines has been created (Bunting et al., 2014) to provide a Linux open source software platform for the processing of remotely sensed and GIS datasets. It gives access to many of the techniques needed. However, as many users use the Microsoft windows and ArcMap environment, we have converted it to a Windows based python library, and therefore making it available within ArcGIS. This will lead to a better integration of the OBIA methodology in many habitat and interpretation mapping workflows.

Input to the segmentation process is a multi-layered raster imagery, such as derivatives of bathymetry, e.g. slope and rugosity, together with backscatter imagery. The size and number of polygons in the segmentation are set by the user and are dependent on the imagery used. The polygons are defined by a region growing algorithm, thus finding areas, their edges and any lineations in the imagery. Attached to each polygon are the characteristics of the imagery such as mean and standard deviation of the pixel values, within each polygon.

The segmentation process for each of the datasets will be presented and compared (where backscatter imagery are available). Improvements in consistency of data quality, coverage, availability and interpretation of coastal and marine-related spatial data directly contribute to multi-disciplinary baseline conditions, providing a more robust scientific evidence base for policy.
**Title**  
Collection, processing and interpretation of seafloor backscatter from various coastal seafloor types using a high- & multi-frequency multibeam echosounder

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**Presenter**  
Dimitrios Eleftherakis, Institut Français de Recherche pour l’Exploitation de la Mer (Ifremer)

**Authors**  
Dimitrios Eleftherakis, Ifremer  
Jean Marie Augustin, Ifremer  
Laurent Berger, Ifremer  
Naig Le Bouffant, Ifremer  
Sophie Loyer, Service Hydrographique et Océanographique de la Marine (SHOM)  
Xavier Lurton, Ifremer  
Anne Pacault, Ifremer  
Christophe Vrignaud, SHOM

**Abstract**  
The latest generation of multibeam echosounders (MBES) shows a clear progress in functionalities. For example, the recent Kongsberg EM2040 features several frequencies (nominal 200, 300 & 400 kHz), and a variety of transmission modes. Ifremer uses EM2040’s in various configurations (coastal or high-sea vessels, AUVs). Actions have been conducted for calibration (in tank and at sea) and logging a collection of seafloor data under controlled conditions.

The EM2040 of coastal RV Thalia has been operated for a series of surveys in the Bay of Brest (10-30 m), on various seafloor types (from rock to coarse deposits, sands, and estuary soft mud), preselected by geoscience specialists and completed in situ by ground-truthing operations. A set of well-documented data was gathered over three years. Regarding calibration, the angle response compensation resulted from a statistical analysis [1] of the field data, and subtracted from the measured backscatter. Absolute levels were obtained by the use of a calibrated single-beam echosounder as reference. Dedicated acquisitions were conducted to document the sounder response variation with transmit mode and pulse duration.

The datasets are available from several areas (documented by video and grab samples), at three frequencies, and for various azimuth angles. The BS average values from the various seafloor types show dispersion over a 15-dB range; azimuth dependence is observed only for certain types of organized seafloor roughness. Ground-truthing showed for most configurations coarse granular components (mineral or biological), and a strong biological content (shells, worms, brittle-stars). Only a minority of the sediment facies were found to be describable by the current theoretical models of physical backscatter. The angular responses were described according to a heuristic description of backscatter strength proposed in [1], providing for each area three descriptor sets (one per frequency) such as the average BS at oblique angles, the fall-off rate at grazing angles, the existence and value of a cut-off angle, the specular return level. Classification analysis is performed based on principal component analysis and k-means clustering for each frequency separately in order to assess the classification potential of the descriptors. Moreover, the potential of multi-frequency imaging on improving the classification discriminating performance is investigated.

### Title  
Practical trade-offs and recommendations in choosing high-resolution backscatter collection modes

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<tr>
<td>Presenter</td>
<td>David Finlayson, Chesapeake Technology, Inc.</td>
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<tr>
<td>Author</td>
<td>David Finlayson, Chesapeake Technology, Inc.</td>
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| Today, most MBES and PMBS systems on the market produce georeferenced imagery using at least two if not more complementary data formats, including beam-averaged amplitudes, beam time-series (Snippets), angle-amplitude time series and binned amplitude/angle time series. Each mode of operation makes trade-offs in terms of data resolution, data volume and georeferencing that must be balanced against survey requirements and costs in both time and resources. 

In this presentation, we will compare the various backscatter modes employed by each sonar in the Shallow Water dataset against the same sonar systems operating in alternative modes. What were the additional costs in storage and processing time for collecting beam-time series data vs beam-averaged data and was the final acoustic image noticeably improved? Is the improvement in the across-track resolution compromised by an along-track resolution that is an order of magnitude lower? Finally, while the beam-time series format (Snippets) has emerged as a defacto industry standard for high-resolution MBES backscatter, can this format be improved to ease georeferencing and reduce data redundancy? |
Title: Definition of Guidelines and Recommendations for Seafloor Backscatter Measurements using Hydrographic Multibeam Echosounders, by the GeoHab Backscatter Working Group

Session: 3: Backscatter
Time: 14:50
Presenter: Xavier Lurton, Ifremer, France

Abstract:

The Marine Geological and Biological Habitat Mapping (GeoHab) group gathers a community of geoscientists and biologists around the topic of marine habitat mapping, with a strong technological component. During its 2013 annual meeting, a workshop dedicated to multibeam seafloor backscatter concluded the need for better coherence and common agreement on acquisition, processing and interpretation of data. Subsequently, the GeoHab Backscatter Working Group (BSWG) was created, with the mandate of proposing best practices for the acquisition and processing of seafloor backscatter, and providing recommendations for further development of backscatter acquisition systems and processing software.

The group brings together researchers, end-users, sonar manufacturers and software developers, with the goal of producing realistic guidelines and providing feedback on how hardware and software tools can be improved. Co-written by specialists of the various fields involved, the guide, now available on line (May 2015), covers five main topics:

• sonar backscatter fundamentals;
• user needs;
• seafloor backscatter measurements;
• acquisition best practices;
• backscatter data processing.

Designed to reach a wide audience of scientists, engineers, operators and stakeholders all using sonar backscatter for seafloor-mapping applications, the BSWG report proposes fundamentals of the topic, a state-of-the art of techniques, and a number of recommendations for future systems and processing.

This presentation will give a quick overview of the project, and will then concentrate on the issues related to field acquisition, to processing, and to recommendations to sonar constructors.
### The Generation of 3D Models from Multibeam & Laser Data for the Structural Monitoring of Wrecks

<table>
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<th>The Generation of 3D Models from Multibeam &amp; Laser Data for the Structural Monitoring of Wrecks</th>
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<tr>
<td>Presenter</td>
<td>TBC</td>
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</table>
| Authors | Andrew Stanley, MMT (UK)  
Chris Bulford, MMT (UK)                                                                 |

#### Abstract

March 2015 marks the 70th anniversary of the sinking of the Liberty Ship the S.S. James Eagen Layne. The ongoing deterioration of a key sport diving site has prompted a group of enthusiasts to launch the Liberty 70 project to record and document the wreck site and all the elements of the vessel’s fascinating history before it is totally lost.

The wreck of another liberty ship which was lost the previous year has received much more attention from the UK Government. Laying in the Thames Estuary, the wreck of the S.S. Richard Montgomery has been a hazard to navigation for the past 70 years and has been subjected to repeated surveys in order to determine its structural integrity.

The combined use of multibeam sonar and laser scanning technology enables the generation of 3D models which have been used to conduct comparative analyses of the wreck at a range of scales. Each annual snapshot of the Richard Montgomery provides a vital overview of the ongoing deterioration of the vessel’s structures.

This presentation details the methodologies developed by MMT (UK) to acquire, process and examine the detailed 3D models of the S.S. Richard Montgomery. Discussed are the different systems, software and data products employed to determine the areas of the wreck which show evidence of degradation and collapse relative to the historical datasets.
**Title** | High Resolution Multibeam Sonar for Monitoring Shipwreck Degradation  
--- | ---  
**Session** | 4: Wreck Surveys  
**Time** | 16:10  
**Presenter** | TBC  
**Authors** | Peter Holt, The SHIPS Project  
| Gwyn Jones, Plymouth University  
| Robert Stone, University of Birmingham  

**Abstract** | For the last seven years the SHIPS Project in conjunction with Plymouth University has been monitoring the degradation of a steel shipwreck sunk in WWII. The Liberty ship S.S. James Eagan Layne was beached in Whitsand Bay near Plymouth in March 1945 and since 2010 has been the subject of a wide ranging study by the SHIPS Project. As part of this study, high resolution multibeam sonar has been used to create a number of 3D models of the ship which form a record of her structural collapse. The results of the survey work are now being used by the HIT Team at the University of Birmingham to create a 4D virtual reality model which shows the site formation process.
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<td>Presenter</td>
<td>Vitad Pradith, HYPACK, Inc.</td>
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| Authors | Vitad Pradith, HYPACK, Inc.  
Brad Barr, NOAA  
Matthew Lawrence, NOAA  
Lisa Brisson, EdgeTech, Inc. |

**Abstract**

In August 1871, 40 whaling ships from Hawaii, New England, and California arrived at an area northwest of Wainwright Inlet along the Chukchi Sea coast of Alaska in pursuit of the bowhead whale. 33 of these ships were trapped and subsequently lost when pack ice moved unexpectedly toward shore. As a result, the disposition of the “lost whaling fleet” is a mystery laying in an area that is largely unexplored and inadequately mapped.

With the prospect of increased maritime commerce along the area, an expedition was launched by the National Oceanic and Atmospheric Administration (NOAA) Office of National Marine Sanctuaries during the month of August 2015 (144 years later) to map and document the area. NOAA, along with their technology partners at HYPACK, Inc. and EdgeTech proceeded to explore and map the area using an array of contemporary hardware and software technologies to conduct acoustic and magnetic surveys. This mode of operation allowed NOAA to utilize non-invasive shallow water mapping technologies to search for the remains of the ill-fated fleet. The focus of this paper discusses the challenges and advantages/disadvantages of the sensor deployment architecture and integrated software data acquisition and processing environment in a shallow water regime.
**Title**  
Satellite Derived Bathymetry (SDB) as Source Data for Navigational Charts

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<tr>
<td>Presenter</td>
<td>Austin Capsey, United Kingdom Hydrographic Office</td>
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</table>
| Authors | Andy Talbot, United Kingdom Hydrographic Office  
Austin Capsey, United Kingdom Hydrographic Office |

| Abstract | Deriving depths from satellite imagery has been possible since the late 1970’s, but recent advances in technology - such as increased resolution and positional accuracy - have brought this technology to the interest of the UKHO, as well as to the wider surveying and environmental monitoring industry.  
Whilst SDB promises to be a useful asset for quickly and economically surveying large areas, with claims by both academia and industry that depths down to as much as 30m can be measured, from a navigational charting perspective its suitability has yet to be fully proven.  
In September 2013 the UKHO embarked on a trial to investigate the quality characteristics of SDB though detailed comparison of a number of commercially contracted SDB datasets against a high accuracy, high resolution multibeam survey gathered concurrently in an area where conditions were expected to be favourable to SDB.  
The results indicated the inherent level of uncertainty in the SDB datasets, allowing the UKHO to make an informed decision as to its potential use within the navigation sector and to develop a strategy to guide future SDB data gathering programs.  
This paper describes the methodology and findings from the UKHO trial and the subsequent work on developing a method for charting SDB data.  
The first SDB dataset is expected to be included on a British Admiralty nautical chart due for publication later this year. |
**Satellite Derived Bathymetry – A user’s perspective**

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<tr>
<td><strong>Presenter</strong></td>
<td>Andrew Waddington, LW Partners Ltd</td>
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<tr>
<td><strong>Author</strong></td>
<td>Andrew Waddington, LW Partners Ltd</td>
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**Abstract**

Recent developments in satellite hardware have created an opportunity to gather ever higher definition imagery and hyperspectral data of the oceans using remote sensing. The wide area coverage, revisit frequency and relatively low cost of data acquisition would seem to offer a great opportunity to fill in the gaps in our knowledge of bathymetry around the world particularly in optically clear waters which often coincide with some of the areas with the poorest data coverage. Yet SDB continues to have more detractors than supporters and uptake of the bathymetric products of spaced based earth observation remains largely academic. So why isn’t SDB more widely accepted? This paper will look at SDB from a user’s perspective and will consider recent developments in the production of bathymetric data derived from space based observation, examine bathymetric data derived from satellites in recent trials and ask what it is that we, the hydrographic community, want from space-based observation.
## Approaches, their capabilities and common standards for Satellite Derived Bathymetry

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Approaches, their capabilities and common standards for Satellite Derived Bathymetry

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<tr>
<td>Presenter</td>
<td>TBC</td>
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</table>
| Authors       | Thomas Heege, EOMAP GmbH & Co. KG  
Knut Hartmann, EOMAP GmbH & Co. KG |

### Abstract
Satellite derived bathymetry (SDB) measurements from multispectral imagery can play an important role to fill the significant information gaps in depth for extended shallow water areas globally. SDB capabilities support mapping of huge and remote areas in a short time and to a fraction of costs, compared to other approaches, and decreases significantly risks in unexplored areas. However, clients need to understand the different approaches of SDB, their capabilities and limitations, and should be supported by standards.

Basic technical differences of the passive optical imaging approach to echo-sounding or to the active Lidar system result in differences in many product details. For physical reasons, SDB product qualification measures do not fit into the given categories of e.g. the hydrographic standards in S44 (or of other standard classes), as these were once developed based on the technical capabilities of active sensor systems: SDB can meet e.g. Order 1b only in few exceptional cases for restricted areas.

The central requirement for the usability is the provision of an independent error specification for each single point measurement. This is all the more important, as SDB uncertainties vary with a number of environmental and sensor parameters, not only from one record time to another, but also from one point measurement (pixel) to the adjacent one inner one image. Validation or calibration with in situ-data applied in one part of the scene is therefore not necessarily meaningfully for another part. Therefore, a quantitative error model, which reflects main uncertainty sources, can be expected as one of several mandatory element when talking about standards.

The different capabilities of various technical approaches to retrieve SDB maps shall be addressed in the presentation, as well as a proposal of qualified standard definitions to support hydrographic and marine industry users with relevant product information to evaluate SDB solutions within their application.
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<th>Title</th>
<th>A look into the performance of bathymetric lidar systems</th>
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<tr>
<td>Presenter</td>
<td>Christopher Macon, USACE - JALBTCX</td>
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<tr>
<td>Author</td>
<td>Christopher Macon, USACE - JALBTCX</td>
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**Abstract**
For the past two decades, the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) has been utilizing bathymetric lidar along the world's coastlines. In addition to performing surveys, the JALBTCX has helped improve the coastal mapping capabilities by developing new sensors and utilizing commercial services. Much of the development and commercial service providers have been limited to a select few. In the past few years there has been dramatic change in the bathymetric lidar landscape. New sensors have flooded the market and they have even rapidly evolved in their short time frame.

This summer the JALBTCX is testing a handful of these sensors. The testing includes the traditional broad beam, shallow water narrow beam, and single photon counting systems. This presentation will focus on the various sensors and their performance in a variety of water conditions.
Integrating Multi-Source Bathymetry Data in a Comprehensive Bathymetric Information System: a Washington State Test Case

Session 6: Geographic Information Systems
Time 11:10

Presenters
Meredith Payne, State of Washington Department of Natural Resources Division of Aquatic Resources
Caitlyn Raines, Esri

Authors
Meredith Payne, State of Washington Department of Natural Resources Division of Aquatic Resources
Caitlyn Raines, Esri

Abstract
The State of Washington’s Department of Natural Resources (WADNR) is tasked with managing over 2.6 million acres of state-owned aquatic lands as a trust for the people of Washington. In order to better manage the natural resources on state-owned aquatics lands, the WADNR Division of Aquatic Resources (AQR) needs accurate cadastral boundaries for aquatic lands at three tidal datums. In order to generate shorelines based on those datums, AQR assembled approximately 1,000 datasets from various federal and state agencies with which they designed and populated a bathymetric information system (BIS) based on Esri’s ArcGIS for Maritime: Bathymetry solution. Since the data were originally intended for diverse project-specific uses, they were acquired in several vertical datums. Thus, WADNR was challenged with finding a way to facilitate their conversion to a common vertical datum for assimilation. To that end, AQR, in collaboration with Esri, developed a workflow which uses NOAA’s VDatum transformation methods within ArcGIS. This workflow allowed AQR to automate the datum transformation process. The final result can be continually updated to take advantage of the most recent and accurate information made available as the Washington State bathymetric data inventory grows.
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<tr>
<td>Presenter</td>
<td>Robert Kinnear, Maritime and Coastguard Agency</td>
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<tr>
<td>Authors</td>
<td>Robert Kinnear, Maritime and Coastguard Agency, André Cocuccio, Maritime and Coastguard Agency</td>
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**Abstract**

This paper discusses how, using a suite of GIS tools, the MCA Hydrography Unit are able to ensure that the UK Civil Hydrography Programme targets the highest priority SOLAS areas and is delivered at the best value for money.

In the UK, the Maritime and Coastguard Agency (MCA) is responsible for implementing the Government’s maritime safety policy. The MCA Hydrography Unit is responsible for ensuring that UK waters are surveyed to a standard commensurate with safe navigation and to ensure compliance with international treaties and conventions. This duty is undertaken through the “Civil Hydrography Programme (CHP)”.

A suite of GIS tools developed by the MCA form a GIS-based Civil Hydrography Management Tool. A Survey Costing Tool (CT) is capable of producing accurate, repeatable estimates of the time and cost required to survey user-specified areas of seabed. A Prioritisation Tool (PT) manages the process of setting hydrographic survey priorities including the selection of annual survey areas on a risk and cost basis. The output identifies and prioritises those areas around the UK of greatest hydrographic risk to the mariner.

The tools make use of the latest developments in geospatial processing to analyse a suite of marine and maritime datasets. The work supports annual survey planning under the CHP, ensuring that commissioned surveys continue to focus on those key and often critical high priority areas on the UK continental shelf.
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<th>A Marine Object Manager for Detected and Database-stored Features</th>
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<td>Presenter</td>
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</table>
| Authors | Giuseppe Masetti, Center for Coastal and Ocean Mapping & Joint Hydrographic Center, University of New Hampshire  
Brian Russel Calder, Center for Coastal and Ocean Mapping & Joint Hydrographic Center, University of New Hampshire  
Matthew J. Wilson, NOAA Office of Coast Survey, Atlantic Hydrographic Branch |

## Abstract

The combination of information present in bathymetric and imagery-based products is a key requirement for any modern feature-detection approach that aims to be adopted in coastal areas whereas the seafloor is deep enough that optic means are not reliable. If the data sources and the processing involved are correctly weighted in a fusion algorithm, the detection task can be extended beyond a simple binary (presence/absence) decision to provide a meaningful metric that evaluates confidence in the presence of new features. In combination with other existing information (such as that present in ENCs), this metric can become a proxy for areas with high probability of change (for features to be either added or removed) with respect to the baseline knowledge of the area. The dual, and partially contradictory, goals of such a system are to highlight areas with high probability of change, and to use the existing nautical documentation as a spatial filter to reduce resource consumption on known features. Determining an appropriate balance between these is an interesting challenge.

Based on such considerations, this work describes an approach for how to effectively assist data analysts in combining the results of different target detection algorithms, as well as in comparing such results with existing features present on ENCs and geographic databases (e.g., spatial DBMS). The main goal is to help the analyst in focusing on specific areas (with higher likelihood of new features), prioritizing them on safety-of-navigation criteria and reducing the common pitfall of subjectivity in the processing workflow. Although mainly aimed at reducing the “ping-to-chart” time, the approach is also well suited for different scenarios such as rapid response to the short-term increase in marine debris deposition related to major events like hurricanes and floods.

These concepts are tested and demonstrated by a Marine Object Manager application prototype that uses real acoustic data products, existing nautical documentation, and publicly available geospatial services to support analyst decisions. The application also supports a schema-based mechanism for consistent data exchange and content validation.
**Variable Resolution Surfaces in Practice**

**Session**: 7: Data Visualisation  
**Time**: 14:00  
**Presenter**: Mark Masry, CARIS  
**Authors**: Mark Masry, CARIS  
Bill Lamey, CARIS

**Abstract**

Digital Elevation Models (DEMs) represent geographic surfaces using a set of nodes, each with a specific position and elevation value. Raster surface models, in which the surface nodes are arranged in a regular grid, are perhaps the most common type of DEM. The distance between neighbouring nodes is given by the raster's "resolution" and governs the level of detail at which the DEM can represent a given spatial feature.

Raster DEMs are relatively simple to store, query and visualize. They can also be partitioned easily, and scale well to large numbers of nodes. While they are in wide use, they are not well suited to cases in which some features or areas must be represented at a higher level of detail than others. These occur, for example, when the density of the data used to construct the surface model varies across space or when the resolution at which an area should be modeled is an operational constraint.

Triangulated Irregular Networks (TIN) address some of these issues by allowing a surface to be constructed over an irregular set of nodes, but are more challenging to store, partition and scale than raster DEMs. It can also be difficult to represent data holidays in a TIN.

CARIS has developed a Variable Resolution (VR) surface model, which provides a hybrid approach: areas with different resolutions are modeled within a single continuous surface by constructing a partitioned triangulated mesh dynamically over a set of semi-regular or irregular nodes. The resulting surface model scales well to billions of nodes while still allowing fast 2D and 3D visualization.

This paper presents the creation and processing of VR surfaces as part an efficient hydrographic processing workflow, both as a QC tool and as an end product from which vector features can be generated. Examples using real-world data will be presented.
Making Sense of a Sea of Sensors: Understanding the Littoral Environment

Session 7: Data Visualisation
Time 14:25
Presenter Ben Drinkwater, Helyx SIS Ltd
Authors Ben Drinkwater, Helyx SIS Ltd
Simon Fitch, Helyx SIS Ltd

Abstract
With the rise of high resolution surveys, the statement “Swimming in Sensors, drowning in data” sums up the all too real situation where the amount of data produced by new sensor technology, and the lack of coherence between these datasets threatens to over burden the analyst with data management and processing tasks before any value can be derived for decision making purposes.

In recognition of the benefits of improving consistency between datasets in order to enable further exploitation, Helyx have developed a methodology for the UK Hydrographic Office (UKHO), Defence Maritime Geospatial Intelligence Centre (DMGIC) that enables merging and integration of multiple bathymetric, terrain and imagery datasets in order to create a seamless surface model of the littoral zone. The increasing availability and coverage of data such as bathymetry, LiDAR and imagery makes the fusion of this type of information all the more important. It allows an improved understanding of complex and interrelated environments such as the littoral zone, which can only truly be analysed based on an understanding of the whole environment.

Using Plymouth Sound as a case study, Helyx have demonstrated the benefits of the seamless surface model through the creation of a 3D visualisation which provides the user with greatly enhanced situation awareness in a port entry scenario.

This paper will seek to demonstrate the methodology developed by Helyx by analysing and integrating the Shallow Survey datasets within the existing seamless surface model. The benefits of this process will be highlighted through the benefits a single surface model generates, such as 3D visualisation, Go/No-Go visualisation, change detection and visualisation of key features such as wrecks. The paper will conclude that it is possible to build upon the foundations laid by this research to further develop the model to assist the needs of a wide range of stakeholder groups who perform tasks such as planning, change detection and legacy data integration in the marine environment.
**Title**
Interactive 4D Visualization, Processing and Analysis of Multi-Sensor, Multi-Resolution Data Sets

**Session**
7: Data Visualisation

**Time**
14:50

**Presenter**
Lindsay Gee, QPS US

**Authors**
Lindsay Gee, QPS US
Larry Mayer, Center for Coastal and Ocean Mapping, UNH
Maurice Doucet, QPS US
Duncan Mallace, QPS
Jonathan Beaudoin, QPS Canada

**Abstract**
This paper follows on from others of a similar title presented at the previous Shallow Water Survey Conferences. Using the common dataset, it will present recent developments in the processing, visualization and analysis of the ever-increasing volumes and variety of data emerging from shallow water sensors.

The advancement of sensor technology and the ability to map the seafloor and the water column have continued to advance at a rapid pace, and this is clearly shown in the volume and diversity of the common datasets provided since the first conference in 1999. The advance has provided an ongoing challenge requiring new developments to process and analyze the data.

The presentations from the previous conferences also illustrate the evolution of the software and tools. This ranges from what is now seen as the simple combination of bathymetry DEMs and draped sonar images in the 3D environment, through the implementation of the CUBE algorithm for processing, to the more rigorous backscattering processing and the industry use of water column data from multibeam sonars.

This year’s presentation of the common dataset sees the continued push for automation and simplification of the workflow, to improve efficiency, accuracy and understanding of the seafloor morphology and processes. This allows the user to concentrate on their primary production or analysis from the data, rather than having the majority of their time occupied with data cleaning and quality control.
### Wobble Analysis - The search for errors in each system

<table>
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<td>Time</td>
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<td>Presenter</td>
<td>TBC</td>
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</table>
| Authors | Duncan Mallace, QPS  
Jonathan Beaudoin, QPS |

#### Abstract

Installing multibeam systems on vessels of opportunity is invariably thwart with difficulty. Artefacts in the data caused by the different survey components being mis-aligned or mis-measured are hard to calculate. This paper examines the setups for each of the different multibeam systems by analysing the common dataset using the wobble tool and ancillary sensor information in Qimera and will present the findings.
Title | Improvements to Shallow Water Surveying – Rapidly Identifying Patterns and Problems in Multibeam Datasets
---|---
Session | 9: Data Quality & Calibration
Time | 09:25
Presenter | TBC
Authors | Lawrence Haselmaier, NAVOCEANO
Anna Manning, NAVOCEANO
Matthew Thompson, NAVOCEANO

Abstract
Naval Oceanographic Office (NAVOCEANO) utilizes a diverse suite of survey assets to collect high resolution hydrographic data in shallow water areas all over the globe. These assets maintain a high operation tempo resulting in extremely large volumes of hydrographic data. The success of these hydrographic data collection efforts depends on the quality of collection systems and the ability of personnel to rapidly identify and correct errors. The Hydrographic Department at NAVOCEANO has developed methods, leveraging NAVOCEANO’s C-Band data transfer capability, to provide in-house personnel the ability to review hydrographic data during collection, and rapidly identify abnormalities and troubleshoot issues. These methods provide the opportunity for the survey parties to resolve problems in the field, before substantial recollection or rework is required. This document will discuss these methods, the tools developed to identify and repair issues within the multibeam datasets, and how these techniques have been implemented throughout NAVOCEANO to help improve the quality of shallow water datasets and their resulting products. Examples of these techniques will also be showcased using the common datasets highlighting their utility for revealing valuable information typically undocumented within the survey logs, reports, or metadata.
**Title**
Analysis of SVP variability and its implications on sounding uncertainty, from the INFOMAR multi-annual baseline mapping programme.

**Session**
9: Data Quality & Calibration

**Time**
09:50

**Presenter**
Hannah McCann, Geological Survey of Ireland

**Authors**
Hannah McCann, Geological Survey of Ireland
David Hardy, Geological Survey of Ireland
Ronan O'Toole, Greenlight Surveys
Ágúst Magnússon, Atlas Professionals

**Abstract**
INFOMAR is the Irish state’s seabed mapping program and has focused on mapping near shore, shallow waters (<30m) in recent years. This has employed a fleet of three dedicated multibeam (MBES) survey vessels and a rotating survey team of ~25. A key challenge identified early in this work program was the impact of SVP (sound velocity profile) control on data quality.

Previous studies have illustrated the result of incorrect SVP input on MBES data and software tools exist to highlight the influence of SVP uncertainty on the Total Propagated Uncertainty (TPU) used to assess statistical data quality. Whilst many of the other variables contributing to a soundings TPU value (tide, positioning, attitude accuracy etc.) have been minimised due to improved instrumentation & system integration – constraining the impact of SVP uncertainty remains largely dependent on staff experience/understanding and survey procedures.

This paper will retrospectively assess our attempts to sufficiently constrain SVP variability during routine survey operations and over a 4 year period (2011-2014). A new approach to visualising SVP data has been developed; where previous displays commonly superimpose SVP casts on a single graph, this new approach computes the difference in SV between successive casts for a given depth – these differences are then plotted for greatly improved legibility.

A toolkit has been developed to automate the more tedious aspects of this analysis. This will enable such assessments to be performed on-board on a smaller scale, as an ‘end-of-day’ task – with the goal of further refining our SVP control. The toolkit will also be made available to any interested third parties who find it beneficial.

Preliminary investigations indicate that 77% of discrete SV readings are within 1m/s in comparison to temporally adjacent casts; 92.4% are within 2m/s; while 99.3% are within 4m/s. Based on available analysis, the magnitude of variation between successive SVP’s is seen to reduce over the period 2011-2013; 2014 shows a measurable increase in variability, potentially related to crew rotation and experience levels.

These values provide a realistic input for TPU computation and a simple metric for survey crews to achieve.
## SHALLOW SURVEY 2015 PAPERS

<table>
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<th>Title</th>
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<tr>
<td><strong>Presenter</strong></td>
<td>Eric Maillard, Teledyne-RESON, Inc</td>
</tr>
<tr>
<td><strong>Authors</strong></td>
<td>Eric Maillard, Teledyne-RESON, Inc Jesper Christoffersen, Teledyne-RESON, A/S</td>
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</tbody>
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**Abstract**

“Collect once, process many times” is a concept that is gaining popularity in the bathymetric survey community. The ultimate input to “process many times” is the collection, storing and archiving of the whole water column signals produced by the acoustic sensor. The latest generation of multibeam echosounders is high-resolution, wide-band, wide coverage, dual head... The amount of data these systems produce is increasing extremely fast, so does the survey storage requirement. In this paper we present the latest refinements of a simple concept for data selection through multiple target detection applied to water column signal from a multibeam echosounder. The underlying paradigm is to store the water column signal only when something of potential interest is present. The concept is explained in the first part of the paper and examples from the common data set and other sources are presented in the second part.
Title: Assessing Resurvey Priority for a Chart Portfolio

Session: 10: Policy, Planning & Collaboration
Time: 11:10
Presenter: Brian Calder, CCOM/JHC, University of New Hampshire
Author: Brian Calder, CCOM/JHC, University of New Hampshire

Abstract: Many, if not most, hydrographic offices are responsible for a chart portfolio larger than their ability to resurvey continuously. An important activity each year is therefore to determine which area of the charting responsibility should have resources expended on it from a usually limited budget. In some cases, this is obvious. For example, if there has been a recent change in bathymetry due to natural disaster, or bigger ships are expected to be coming in to an expanded container port, an area might be given higher priority. In other cases, however, the choice might not be so clear, and in many, if not most, cases the decisions are only made subjectively.

As an alternative, this paper proposes a model that may be used to assess the potential gain in the knowledge of the bottom configuration of an area that might be achieved through the conduct of a modern survey. This is argued to be a proxy for the benefit derived from the survey so that it can be used as a means to determine where to resurvey first. In essence, the area with the greatest potential benefit should be the highest priority. Applied objectively to a chart portfolio, this method has the potential to rank the various areas of charting responsibility as to their resurvey priority, taking into account such issues as the a priori knowledge of the bathymetry based on previous surveys, the geological context of the area, time-varying changes in the bottom configuration, and the type, frequency, and dimensions of the shipping in the area.

The paper describes the methodology applied in the model, and illustrates its use in the Shallow Survey area, and elsewhere, as a priority estimator. The paper also addresses calibration issues for the model, which can be significant, and efficiency of computation, particularly in a parallel system.
<table>
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<th>Title</th>
<th>Challenges and opportunities surveying the UK’s remote Overseas Territories</th>
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<td>10: Policy, Planning &amp; Collaboration</td>
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<tr>
<td>Presenter</td>
<td>Koen Vanstaen, Cefas</td>
</tr>
<tr>
<td>Authors</td>
<td>Koen Vanstaen, Cefas</td>
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**Abstract**

The UK’s overseas territories comprise some of the most remote parts on the planet. Access by sea is often key to the local economy and increasingly tourism is looked at to stimulate economic growth. Despite the reliance on sea access, nautical charts in the UK’s Overseas Territories are often still largely based on 19th century observations.

For these small island communities, updating hydrographic charts is often limited by the budgets available for this task within single departments. In 2014 the Centre for Environment, Fisheries and Aquaculture Science (Cefas), the United Kingdom Hydrographic Office (UKHO) and National Parks Trust of the Virgin Islands (NPT) started a project to demonstrate the opportunities presented by greater collaboration across departments through the “collect once, use many times” principle. The project brought together stakeholders with a hydrographic, shipping, environmental, fisheries and disaster management interest. A survey area was identified which was of interest to all stakeholders and a survey team and equipment was mobilised in July 2014. Undertaking a survey to meet multiple requirements meant that some deviations from traditional hydrographic survey practice had to be implemented, to ensure the end product would be fit for purpose for all end-users.

This talk will introduce the project and challenges facing the UK’s Overseas Territories. The talk will go on by discussing the challenges faced undertaking the survey in a remote location and to ensure the resulting data was fit for purpose for all end users. This included ensuring bathymetry and backscatter data quality were maintained at all times, whilst meeting recognised standards. Despite these efforts, issues were still experienced post-survey due to hardware and software compatibility and the lag in software catching up with advances in hardware developments. This talk will therefore identify some of the barriers that need to be addressed by the survey community to ensure surveys meet hydrographic as well as other needs. Despite the challenges, the survey products have successfully demonstrated the benefits and opportunities presented by collaboration across end-users. Examples of advances in environmental and fisheries management will be used to illustrate this.
Crowd-sourced Bathymetry and Open-access Bathymetric Data

Session 10: Policy, Planning & Collaboration
Time 12:00
Presenter David Wyatt, International Hydrographic Organization
Author David Wyatt, International Hydrographic Organization

Abstract

Recognizing that much of the world’s seas and navigable waters are still either unsurveyed or poorly surveyed, the IHO Member States at their 18th International Hydrographic Conference decided:

“... to progress whatever actions are required to improve the collection, quality and availability of hydrographic data worldwide, monitor and rectify possible deficiencies and shortcomings, cooperate with other international organizations and stakeholders as necessary, and to keep Member States informed on progress on this issue. ... “.

Crowd-sourced bathymetry (CSB) is seen by the IHO as one way to improve the currently unsatisfactory situation.

The author will explore the background of the IHO’s new crowd-sourced bathymetry programme which aims to increase the quantity of bathymetric data being collected, particularly in the remote and currently unsurveyed areas of the globe, as well as in those busier sea areas seen to be of lesser national priority. Details of the infrastructure being put in place and the mechanisms planned to be established by the IHO to develop the supporting guidance will be presented.

The author will highlight the on-going development of the IHO’s long-standing Data Centre for Digital Bathymetry which is now being developed as an open-access web-based digital bathymetry reference data store in which trusted contributors may upload data or metadata as their contribution to the Global Marine Spatial Data Infrastructure.

Details will be provided on how the scientific and commercial surveying communities can contribute to the development of the IHO CSB programme by making their data more easily discoverable, thereby avoiding unnecessary duplication of effort and making a significant contribution towards filling in some of the white space that currently dominates many of the world’s nautical charts, bathymetric maps and databases.
Integration of Multibeam Beam Steering and Vessel Dynamic Positioning to Minimise the Duration of Shallow Water Surveys

**Session**
11: Data & Systems Integration

**Time**
14:00

**Presenters**
James Riordan, SonarSim Ltd
Francis Flannery, SonarSim Ltd

**Authors**
James Riordan, SonarSim Ltd
Francis Flannery, SonarSim Ltd

**Abstract**
This talk will demonstrate a pre-survey use scenario and post-survey sea trial results of SonarSim's Multibeam AutoPilot (MAP) software for automated survey optimisation; firstly, the pre-survey planning and performance prediction capabilities of MAP Onshore will be demonstrated using a Multibeam Survey Simulation scenario constructed from the 2014 Common Dataset of Plymouth Sound and secondly, the results of ship trials of MAP Offshore aboard Geological Survey of Ireland (GSI) vessels during their 2015 survey season will be presented.

The varying topography, tight positioning tolerances, and platform motion perturbations of the shallow water survey paradigm can impose overwhelming levels of manual system readjustment on the onboard Hydrographer and Helmsman; continuous on-the-fly recalculation and deviations from pre-planned vessel waypoints are required to maintain desired coverage overlap between successive runlines. The impact on survey efficiency is predictable but difficult to control and post survey analysis of datasets indicates 10-15% of survey time is lost through a combination of infill line elimination of holidays and coverage redundancy in areas of overly tight runline spacing.

MAP is an end-to-end software-based workflow solution for shallow water Multibeam operations which solves this problem. Following on from a successful INFOMAR pilot project conducted by the GSI and SonarSim in 2012, which developed and ship trialled an automated onboard tool for vessel runline planning, the extended MAP framework now also leverages the pre-survey training, planning, and prediction capabilities of SonarSim’s high-performance SONAR simulation framework. The MAP Offshore source code received a major upgrade in early 2015 and is again scheduled for ship trials through June-September on the Geological Survey of Ireland vessels (which are equipped with Kongsberg EM2040(D) Multibeams). Key technical developments include the addition of advanced point and surface data filtering and analytics modules to accurately deal with noisy data, and 3D visualisation of workflow stage outputs for improved operator quality control and supervision during data collection. A unique feature of MAP Offshore is that it integrates dynamic SONAR beam steering with dynamic vessel positioning. Without MAP, the vessel autopilot (waypoint following) and dynamic beam steering control (attitude stabilisation) are decoupled and operate without coordination. MAP performs real-time processing of the Multibeam data as it is collected, as well as the position and attitude information, to realise an intelligent feedback path between extracted real-time coverage analytics and the survey control duopoly. Through real-time automation, the Multibeam dynamic beam-steering and the vessel autopilot positioning now work in unison to achieve tighter line spacing, eliminate data gaps, and generate higher quality uniform coverage within prescribed coverage overlap requirements. The enshrined innovations are also the focus of the SonarSim led European Commission H2020 Blue Growth instrument project SONAR INtegrated Advanced Navigation (SINANN) as an initiative to help double the profit margins of European coastal zone survey fleets, expensive capital investments typically operating on single digit margins.
The Onshore and Offshore modules create a synergy whereby intelligent adaptive survey control is driven by exhaustive Simulator based survey pre-planning. SonarSim’s computational acoustics modelling framework underpins the most powerful SONAR Simulator in existence. It is a multi-purpose platform capable of supporting personnel training, survey performance prediction, and pre-mobilisation interconnect testing. Amongst others, it is used by the Saudi Arabian General Commission for Survey to deliver enhanced IHO Cat A & B accredited Multibeam and Sidescan SONAR training courses, and in the European Commission FP7 SUPPORT project it was used to determine the most cost-effective fit-for-purpose equipment configuration, surveillance strategy, and machine vision algorithm suite for a novel Port & Harbour diver detection system based on an AUV deployed Forward Looking SONAR. By enabling exhaustive “what if” analysis the most effective mapping regimes for a given vessel configuration & required survey standard can then be determined by distilling the generated performance analytics. Simulator scenarios can be created based on geometry and reflectivity information extracted from existing bathymetry databases and a demonstration incorporating the Plymouth Sound dataset will be presented, incorporating representative platform motion disturbance, tide, and vessel manoeuvrability characteristics extracted from the raw data files. Integration of the Simulator HPC capabilities with the smart closed loop survey controller in MAP Offshore unlocks the intelligent survey automation which is required to minimise the duration of a survey, while preserving data quality. In summary, MAP will improve operational safety and vessel productivity by reducing fatigue and shifting the task focus from low level manual intervention to high level quality control and process supervision.
<table>
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<th>3D Integration of Hydrographic, Geophysical and Geotechnical Data</th>
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<tr>
<td>Time</td>
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<tr>
<td>Presenter</td>
<td>Brian Critchley, University of Southampton</td>
</tr>
<tr>
<td>Author</td>
<td>Brian Critchley, University of Southampton</td>
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**Abstract**

With the continuing development of hydrographic and geophysical instruments, providing higher resolution seabed and sub-seabed data, it is important to be able to use the complementary nature of these data sets to inform and further improve ground modelling accuracy.

Geo-4D incorporate all relevant historical and current cultural, water column, hydrographic, geophysical and geotechnical data, and infrastructure into a single 3D space, with full processing and interpretation capability.

Water column data is being requested more frequently, and is being used to supplement bathymetric data, identifying greater seabed/anthropogenic detail and the existence of seabed seeps and fish activity. We are able to process and interpret huge water column data sets, with the benefit of also being able to analyse the bathymetry and seismic data in the same 3D view.

The compilation of all relevant data into a single 3D space enables rigorous data QC and makes best use of the all data sets to inform seabed and sub-seabed conditions. We are also able to extract 2D GIS deliverables from the 3D ground model.

The presentation will include construction of the ground model using all relevant data formats, generation of GIS deliverables and detail applications.
### Calibrated side scan images from a phase measuring bathymetric sonar: another tool for shallow water seabed monitoring.

**Session**  
11: Data & Systems Integration

**Time**  
14:50

**Presenters**  
Francisco Javier Gutierrez, Kongsberg Maritime  
Duncan Tamsett, Kongsberg Maritime

**Authors**  
Francisco Javier Gutierrez, Kongsberg Maritime  
Peter Manley-Cooke, Kongsberg Maritime  
Duncan Tamsett, Kongsberg Maritime

**Abstract**  
Co-registered hydrographic quality bathymetry and side scan data have been collected using a calibrated phase-measuring bathymetric sonar. This technology facilitates the production of calibrated acoustic reflectivity images of the seafloor.

This work will briefly describe the calibration process, the various factors involved in the measurement of the reflected acoustic signal and how the measured intensity of the acoustic echo can be processed to deliver seabed backscatter intensity in absolute values. The results will be illustrated using data collected with a GeoSwath Plus system processed using GeoTexture software. This software is able to account for sonar calibration information, range and absorption in the water column, transducer directivity, vessel movement (roll), angular backscatter response and the slope of the seafloor. This enables the generation of high-quality normalised seafloor images with minimal artefacts as well as absolute backscatter intensity levels. This has a direct use in seabed monitoring application in shallow waters, and will allow changes in the composition of the seafloor in absolute terms to be quantified and included in the geomorphology of the area under study.
The Naval Oceanographic Office (NAVOCEANO) has put considerable effort and resources into developing a Concept of Operations, acquiring an equipment pool, training personnel, and transitioning to operational capability for use of Unmanned Undersea Vehicles/Unmanned Surface Vehicles (UUV/USV). This capability supplements traditional manned collection assets and makes significant contributions to a broad range of survey missions through autonomy, thereby reducing risk to personnel, equipment, and mission. The use of the Littoral Battlespace Sensing Autonomous Underwater Vehicles (LBS-AUV) extends the operational effectiveness of the survey ships and Hydrographic Survey Launches (HSLs) in the littoral areas. This paper will describe how NAVOCEANO is integrating the LBS-AUV operations into hydrographic survey missions and developing techniques to meet hydrographic data accuracy standards in the shallow water environment.

Perhaps the most important consideration for the use of LBS-AUV for hydrography is how to achieve required International Hydrographic Organization (IHO) Order 1 specification for positioning and target detection without the deployment of an underwater acoustic Long BaseLine (LBL) navigation system. This paper will discuss some of NAVOCEANO’s operational and developing techniques for achieving an appropriate level of uncertainty, such that the data are acceptable, for use in traditional hydrographic products. This paper will also describe the LBS-AUV operational workflow, from data download to data integration, and generation of attributed multibeam data files, the sounding reduction, and generation/validation of the bathymetric surface for use in products.
Assessing Horizontal Uncertainty in AUV Generated Bathymetry

Session 12: Maritime Autonomous Systems
Time 16:10
Presenter Val Schmidt, University of New Hampshire
Authors Val Schmidt, University of New Hampshire
John S. Byrne, Leidos
Oyvind Hegrenas, Kongsberg
Steve Brodet, Hydroid

Abstract Hydrographic surveys from autonomous underwater vehicles (AUVs) can provide higher resolution datasets in deep water, added efficiency to manned operations with little increase in personnel and when appropriate, clandestine opportunities for seafloor mapping. Navigation requirements set forth by the International Hydrographic Organization (IHO) apply equally well to these surveys and it remains incumbent on hydrographers to estimate the navigation uncertainty of the AUV and subsequent bathymetry. Modern inertial and doppler velocity log (DVL) based navigation systems provide estimates of AUV position uncertainty as a function of time during the survey. However experience has shown these estimates to often over-estimate the true position uncertainty of the vehicle. Overestimation of navigation uncertainty has critical impacts on mission design as it limits the effective duration at which the AUV may continue mapping without external aiding, either by returning to the surface for a GPS fix or by acoustic means. Here we assess the navigation drift of a REMUS 600 operating in shallow water in the vicinity of the Portsmouth Harbor 2008 Shallow Survey data set, by matching bathymetric features in overlapping survey lines. The navigation drift is compared to the estimated uncertainty of the vehicle’s navigation system and recommendations are given for improving the vehicle’s horizontal position uncertainty estimation.
Title: Reducing Ping-to-Chart Time through Onboard Data Processing in Autonomous Underwater Vehicles

Session: 12: Maritime Autonomous Systems

Time: 16:35

Presenters: Michael Redmayne, CARIS
Steve Brodet, Hydroid

Authors: Michael Redmayne, CARIS
Steve Brodet, Hydroid

Abstract: In a traditional hydrographic survey workflow, data can be acquired, accessed and processed during a survey by the personnel working on the vessel or launch. Data processing tools have reduced the ratio of acquisition to processing time significantly in the past 10 years, so that there is no longer a significant processing backlog after acquisition.

With the increasing use of autonomous platforms for hydrographic survey operations, this backlog has become evident again. Without a human in the real time feedback loop, the platform must gather the data and await post processing when it is recovered. This method has significant disadvantages, most notably a lack of assurance that the data collected is within required specification and an increased turnaround time before the platform can be re-deployed.

This paper will describe a new method of acquiring and processing data autonomously whilst the survey is underway, and the benefits that can be gained from using this method when employed with an Autonomous Underwater Vehicle.