US Hydro 2017 Technical Session Schedule w/ Abstracts

Tuesday, March 21, 2017

Multiple Uses of Hydrographic Data		Session Chair: Jonathan Beaudoin
Multibeam Water Column Data Processing Techniques to Facilitate Scientific Bio-Acoustic Interpretation	**10:00 am**	**Presented by Ian Church**

One component of the Gulf of Mexico Research Initiative's (GoMRI) CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) project is focused on examining water column acoustic return data from a Reson Seabat 7125 SV2 within the Mississippi Bight. The multibeam system was mounted on board the RV Point Sur, and data was collected at three times of year (fall, spring and summer). The goal was to identify and map spatial and temporal variations in biomass throughout the region by correlating the water column data with imagery from a towed profiling high resolution in situ ichthyoplankton imaging system (with CTD, dissolved oxygen, PAR, and chlorophyll-a fluorescence). There are many technical challenges associated with correlating the two datasets, as the multibeam data are in three dimensions, and they operate on different temporal and spatial scales. Overcoming issues with receiver sidelobe interference and developing a filtering algorithm to identify objects and signal patterns of interest, which might normally be considered noise, is investigated. The development of these filtering algorithms allows the water column data to be correlated to the reference imagery data from the ISIIS, and other sensor information, expanding the usefulness of the dataset.

Setting the Stage for Multi-Spectral Acoustic Backscatter Research	**10:20 am**	**Presented by Craig Brown**

The establishment of multibeam echosounders (MBES) as a mainstream tool in ocean mapping has facilitated integrative approaches towards nautical charting, benthic habitat mapping, and seafloor geotechnical surveys. The combined acoustic response of the seabed and the subsurface can vary with MBES operating frequency. At worst, this can make for difficulties in merging results from different mapping systems or mapping campaigns. At best, however, having observations of the same seafloor at different acoustic wavelengths allows for increased discriminatory power in seabed classification and characterization efforts. Here, we present results from early trials of a multispectral multibeam system (R2Sonic 2026 MBES) in the Bedford Basin, Nova Scotia. In this system, the frequency can be modified on a ping-by-ping basis, that can provide multi-spectral acoustic measurements with a single pass of the survey platform. We demonstrate how this capability provided improved seafloor discrimination at this site based on the different frequency responses and seafloor sediment characteristics at the site. These innovations offer tremendous potential for application in the area of seafloor geological and benthic habitat mapping

Steps Towards a True Crowd, Collecting Bathymetry via Electronic Navigation Systems	**10:40 am**	**Presented by Adam Reed**
. Strained resources and budgets for hydrographic offices have resulted in increased scrutiny for the acquisition of hydrographic data and the clear need to acquire data from non-traditional sources to complete their charting mandates. Crowdsourcing bathymetric data has been listed as a priority issue by the International Hydrographic Organization (IHO) as an important source contributing to the future of nautical charting. The IHO's Crowdsourced Bathymetry Working Group in partnership with NOAA's Office of Coast Survey and Rose Point Navigation Systems established a citizen science program to provide publicly available crowdsourced bathymetry data. This follows a successful 2015 pilot project to harvest crowdsourced bathymetry from Electronic Navigation Systems. The program incorporates efforts to minimize cost barriers to entry for contribution, expand the vessel demographics participating, and present a publicly available crowd solution. In this paper we will discuss the methods used for data collection, the location and formats in which the data is available, what quality has been observed, and the lessons learned.		
Arctic Charts: Cold, Hard Facts	**11:00 am**	**Preseneted by Denis Hains, CHS**
Navigating in the Arctic is risky… Planning is critical, especially for mariners cruising in areas where sufficient and modern hydro data is lacking… Grounding is an ever-present possibility… Up to date Charts and Publications with Notices to Mariners and Notices to Shipping are safety essentials … …and Lessons Learned in Canada…		

Multiple Use of Hydrographic Data Lightning Round 1	Starts at 11:40am	Tuesday March 21, 2017

David Bernstein: MANAGEMENT AND ANALYSIS OF SIDE SCAN SONAR DATA WITH ESRI'S RASTER MOSAIC DATASET

Hydrographic datasets serve a variety of purposes across many disciplines. Specifically, side scan sonar data is commonly used for object detection, habitat mapping and environmental monitoring. These data are traditionally distributed as a combination of point, line and polygon features and mosaicked images, resulting in a final product that is limited for further analysis. As these data are commonly collected with 120-200% coverage, the combination of mosaicking options specific to each user can be overwhelming to processors, requiring significant training to achieve customer satisfaction. To create an end product that still retains the complete footprint of each individual line, these data can be mosaicked and viewed in an ESRI Raster Mosaic Dataset. End-users can then store, manage and query 100% of the processed data, providing the ability to generate products best suited for their needs. As many organizations currently implement ESRI GIS environments, this approach may provide a solution for preserving the posterity of side scan data. Now, with ArcGIS 10.5, publishing services create new opportunities to rapidly share results both internally and with clients, without transmitting data. Additionally, Maritime Chart Service can be combined with these image map services, bringing ENC and side scan sonar products together for analysis.

Chris Malzone: The GIS based user guided workflow: Acquisition, Processing, Visualization and Sharing of Hydrographic Based Data

Advancements in Hydrographic based applications are leading to the incorporation of Geographical Information Systems & user guided workflows at every stage of the Hydrographic workflow. This allows for rapid adjustments during a variety of operations (eg hydrography, fisheries, Oil & Gas) while improving accuracies and reducing poor decisions through the automation of mundane, human-error prone tasks. This paper will outline the evolution of the GIS based user-guided workflow from Acquisition to deliverable with case studies presented.

Starla Robinson: Ping Once Use many times: NOAA Wilmington NC 2016 Field Season

NOAA Coast Survey and The National Centers for Coastal Ocean Science (NCCOS) collaborated during the 2016 Field Season to map the continental shelf near Wilmington, North Carolina for habitat analysis and the safety of navigation.

The Wilmington project has epitomized the Integrated and Coastal Ocean Mapping (IOCM) effort within NOAA: from data discovery and communication of mapping priorities between stakeholders; to the sharing of expertise and data; doing more with limited resources. Past habitat surveys were refined for charting. Scientists from Coast Survey, NCCOS, and UNH JHC/CCOM came together to share best practices. A bottom camera attached to the grab sampler prototype developed by UNH JHC/CCOM scientists was tested. Bottom photos, sediment samples, backscatter, and bathymetry were collected, to meet both habitat analysis and charting needs. This opportunity has opened discussions on how we can collect data that meets multiple needs, and how to serve that data to our stakeholders.

The hydrographic community wears many hats: we are sailors, scientists, and explorers. We muster considerable resources, face a considerable risk, to gather data to see the world better. For the safety of navigation; for solving environmental problems; and to model our world, we work together.

Katrina Wyllie: NOAA's Arctic Survey Initiatives

Rapidly emerging needs, limited operational windows, and the vast scope make fully surveying U.S. Arctic waters an imposing responsibility. To tackle this challenge in a systematic way, NOAA prioritized areas of higher navigational risk, based on depth, survey vintage, and vessel traffic. Refinements to survey specifications and advancements in survey planning procedures, like satellite derived bathymetry and AIS analysis, augmented by communication with local mariners, then aided in the determination of the survey coverage technique to be employed. Survey coverage techniques include: complete coverage multibeam, side scan sonar, set line space multibeam or opportunistic multibeam acquisition. This paper reviews the lessons learned from NOAA's hydrographic survey efforts in the Arctic from 2015 to 2016, including a U.S. Coast Guard-proposed transit corridor, to determine best practices for planning and executing future survey efforts in the Arctic.

Johnson Oguntuase: EXTENDING THE RANGE OF POST-PROCESSED KINEMATIC POSITIONING FOR AIRBORNE LIDAR SYSTEMS (CZMIL)

The preferred method of positioning Coastal Zone Mapping and Imaging Lidar (CZMIL) and typical ALB systems is the Post-processed Kinematic (PPK) method with tight integration of Inertial Measuring Unit (IMU) data to provide the smooth best estimate of trajectory (SBET). This method has been shown to have centimeter order uncertainty; however, there are limitations in terms of the maximum distance the aircraft can travel relative to the ground Global Navigation Satellite System (GNSS) receivers used for kinematic positioning. In the case of Single Base PPK (SBPPK), a maximum distance of 20 km is recommended while for Network PPK (NPPK), otherwise referred to as IN-Fusion Smart Base in Applanix POSPac MMS (a mobile mapping suite); receivers must be within a network of at least four GNSS receivers with baseline separations up to 70 km [1].

The foregoing methods limit the operation range of ALB systems and planning logistics can be expensive, time-consuming and excruciating. This paper, therefore, justifies the use of the Precise Point Positioning (PPP) method, tightly coupled with IMU data for positioning CZMIL and allied systems. The comparison of PPP and NPPK solutions in this study showed that the two-sigma (2σ) uncertainty in the elevations of flight trajectory was less than 0.14m while the uncertainty in the 2D positions was not greater than 0.05m.

Tuesday, March 21, 2017		
Coastal Management Through Hydrography		**Session Chair: Jack Riley**
A Preliminary Report on the Hydrographic Health of the United States and a Proposed Method of Reporting a Survey's Return on Investment	**1:10pm**	**Presented by Christy Fandel**

The National Oceanic and Atmospheric Administration (NOAA) is mandated to acquire hydrographic data to support the safe navigation of maritime commerce throughout the substantial 3.4 million square nautical miles of the United States' Exclusive Economic Zone (EEZ). While a complete hydrographic survey of the nation's waters would maximize navigational safety, the large areal extent, coupled with constrained resources in time and money make this infeasible. NOAA recently implemented a risk-based model of Hydrographic Health throughout the EEZ to systematically prioritize areas for survey. The Hydrographic Health model incorporates both the desired state of hydrography for a given area, as well as an estimate of the depreciated state of the last known survey. This paper presents the nationwide results of the Hydrographic Health model and how proposed survey areas were subsequently identified. In addition, preliminary reporting metrics that strive to communicate and quantify the justification and potential return on investment of a proposed survey are discussed.

Coastal Zone Mapping and Monitoring – An example of needs, equipment, methods, and applications from Washington State	**1:30pn**	**Presented by George Kaminsky**
This paper will present efforts of the Washington State Department of Ecology, Coastal Monitoring & Analysis Program to map selected shorelines of the Washington State and monitor their physical changes over time for coastal management applications. First, the efforts will by motivated by coastal management needs for need for high-resolution mapping across the landwater interface. Second, the design and outfitting of the survey vessel, R/V *George Davidson*, will be described, including installation of a mobile laser scanner and a dual-mount, dual head multibeam sonar system. Third, the methodology used to capture seamless topobathymetric coverage across the coastal zone will be presented, including integration of boat-based mapping with land-based RTK-GPS topographic surveys. Finally, example survey results and applications will be discussed. This paper will expand on the Dual-head Mapping article featured in the August 2016 issue of xyHt.		
Seamless Topo-Bathy Surveys In Support of Shoreline Coastal Management: Emerald Isle, North Carolina	**1:50pm**	**Presented by Ben Sumners**
Managing coastal development and environmental resources near tidal inlets is complicated by rapid shoreline change and must be tightly coupled with an understanding of inlet dynamics through intelligent monitoring practices. Shoreline erosion/accretion patterns are often amplified with proximity to inlets, and significantly impacts infrastructure, recreational and commercial navigation, tourism, and coastal resource management. In 2005, Emerald Isle, NC was experiencing a rapidly eroding shoreline caused by a migrating inlet channel that was encroaching on homes and infrastructure. To mitigate these concerns, the inlet navigation channel was relocated ~3,500ft to the west within the Bogue Inlet floodway. A monitoring plan was developed by Geodynamics and the Town to understand long-term inlet and shoreline trends and support coastal managers with a data-centered understanding of the migrating tidal inlet. Biannual monitoring surveys are conducted according to a design allowing for a seamless integration of shoreline topography and inlet bathymetry at this dynamic land-water interface. The goal of this ongoing monitoring effort is to measure various inlet/shoreline interactions over time through comparison of shoreline DEM surfaces, surveyed and processed with an accurate and repeatable methodology. These data are critical to understanding the current rate of inlet migration, spatial-sediment volume changes, and MHW shoreline evolution.		
Bathymetric X-Band Radar at Beaufort Inlet for Detection of Shoal Movement, Dynamic Shorelines and Near-Shore Bathymetry	**2:10pn**	**Presented by Kenneth Vierra**
Navigation channels and coastlines are in constant motion due to waves and currents which drive sediment transport. Bathymetric X-band radars persistently monitor these areas for change, thereby reducing costs and improving efficiency. Bathymetric radars will aid NOAA and other stakeholders in maintaining waterways and assuring maritime safety. Beaufort Inlet is a great example of a dynamic shoreline and shoals and the constant fight to maintain a navigable channel. Under a NOAA SBIR Phase II program, we successfully collected continuous bathy radar data at Beaufort Inlet for two and a half months. This provided an opportunity to validate the bathymetry retrieval capability, but also a chance to begin looking at other derived products. For example, the radar data clearly show migration of subsurface sand waves and shorelines. An extended program to operate the radar and provide products through a web page will allow stakeholders to begin using bathy radar products in their planning and operations.		

Coastal Management Through Hydrography Lightning Round 2	Starts at 2:30 pm	Tuesday March 21, 2017

Abigail Hode: Inferring nearshore sediment transport via non-bathymetric LiDAR

Recurring, high resolution scans can be utilized to make inferences regarding nearshore sediment transport. In this study, near-shore bathymetric data was collected using a land-based non-bathymetric LiDAR system in conjunction with an Applanix POS/LV Inertial Measurement Unit (IMU). Scans were collected along the Bay Saint Louis and Waveland, Mississippi public beaches during times of low tide. Changes in sandbar and shoreline morphology were examined from processed and aligned scans collected at various times between December 2015 and July 2016 to coincide with suitable low tide events. Uniform sandbars were identified with an alongshore orientation, and minute changes in sandbar shape and location were registered near areas of concentrated storm run-off with initial scans from December 2015 through February 2016. An additional scan was collected in July 2016 which revealed larger changes in morphology when compared to earlier scans. A long term study is being conducted to continue collection of bathymetric data in the study area to further an understanding of seasonal and inter-annual trends and potential applications of this method.

Evan Martzial: Mapping the Estuarine Seafloor with Vessel-Based Acoustic Instruments: The Shallowest Water Survey

Estuaries are among the world's most productive ecosystems and mapping the estuarine seafloor can provide useful information with regards to benthic habitats, ecosystem state, sediment transport and other biological and physical characteristics and processes. Turbid waters in many estuaries prevent optical methods, such as lidar, from being used. In addition, lidar, as of yet, provides only elevation information, though experimental data layers similar to acoustic backscatter imagery are in the early stages of development.

A series of vessel-based acoustic surveys onboard a custom-built, shallow draft pontoon boat using an EdgeTech 6205 Multi Phase Echo Sounder and Sidescan Sonar in a very shallow, tidally-restricted estuary were conducted in June 2016. The instrument collects coincident, dual-frequency, side scan imagery (op. freq. 550/1600 kHz) and swath bathymetry and backscatter (op. freq. 550 kHz). This yields four distinct, yet co-located data sets. Underwater video and grab samples were collected to ground-truth the imagery and improve our understanding of the seafloor. The instrument could map in high salinities, fresh water and the transition zone with little to no loss in data quality. This instrument/platform combination makes vessel-based acoustic mapping in these types of systems more feasible, efficient, and desirable.

Kandice Gunning: Observing spatial and temporal variations of an oyster reef in the Pass Christian Mississippi using the Edgetech 4600

Geological and biological discrimination in the ocean environment has been improved by assessing different acoustic backscatter datasets. As part of a research for the development of angular response curves for oyster reefs using relative backscatter solution on phase differencing sidescan sonar system in the Mississippi Sound this project highlights the procedure and present results leading to the completion of the study. To conduct the research, a three component approach is considered; 1) Bathymetric model; 2) signal analysis for the development of backscatter angular response curves and 3) spatial and statistical analysis for monitoring acoustic diversity for the survey region.
Spatially registered measurements extracted from the Edgetech 4600, an interferometric sonar system, is compared to previous surveys of that region to investigate the quantitative change of the realized acoustic diversity over time in the Western Mississippi Sound. The study is intended mainly to map the acoustic diversity, distribution and evolution of the oyster reef, and to a lesser extent map the reef system as a whole.

Coastal Management Through Hydrography Lightning Round 2	Starts at 2:30 pm	Tuesday March 21, 2017
Denis Hains (CHS) The Canadian Hydrographic Service adopted a new 2016-26 Vision and Focus towards a Data Centric, Client-Driven and Innovation Organization. This focus requires a review of the CHS Toolbox and way of operating for the next decade.		

Tuesday, March 21, 2017		
Oilfield Hydrography		**Session Chair: Guy Noll**
Deepwater Hydrocarbon Seep Detection: Tools and Techniques using Multibeam Echosounders	**3:30pm**	**Presented by Garrett Mitchell**
Despite steep declines in Oil and Gas market expenditures, demand for hydrocarbon seep surveys continues to grow. Hydrocarbon seep features are ephemeral, small, discrete, and often difficult to sample on the seafloor. Locating geologic and biologic features created by the upward ascent of petroleum fluids such as authigenic carbonate deposits, chemo-synthetic fauna, pockmarks, mud volcanoes, and other fluid expulsion features are greatly aided by the use of multibeam echosounders (MBES). Datasets created by multibeam echosounders (bathymetry, seafloor, backscatter, and midwater backscatter) can quickly and efficiently detect and locate hydrocarbon seeps. As frontier exploration surveys migrate into deeper waters in search of oil and gas reserves, it is desired to examine the acoustic frequency responses of multibeam sonars to seep features in deep water. Fugro has conducted over 50 seep hunting campaigns globally since 2001 and include single exploration blocks to multi-client "mega surveys" in Indonesia, Brazil, and most recently Mexico. In total, over 2 million square km of seafloor has been mapped with modern multibeam systems specifically in search for Hydrocarbon Seeps. This presentation will provide an overview of seep detection methodologies and provide some hydrographic results from the recently completed "Mega Survey" in Mexico.		
Investigating regional seafloor hazards using NOAA multibeam data and the relationship of these detected seafloor hazards with oil and gas installations in Mississippi Canyon	**3:50pm**	**Presented by Erick Huchzermeyer**
A study was conducted to reprocess and interpret NOAA *Okeanos Explorer* cruise EX1105's multibeam, backscatter, and water column data in the Mississippi Canyon Protraction Area. High gradient (>10°), detected water column seeps, and higher reflectivity areas were interpreted as seafloor hazards and their positions and shapes were added to a GIS system. Federal regulations in the form of NTLs (Notice to Lessees) prescribe avoidance radiuses for certain seafloor hazards and these avoidance radiuses were added to the interpreted GIS shapes. The ratio of seafloor hazard per lease block in the survey area was calculated. The highest ratio seen was 72.1% of a lease block unavailable to bottom disturbing activities. Additionally, BOEM well and pipeline data was plotted on the survey area. No wells exist in the seven leased blocks with greater than 44% seafloor hazard. The author's hypothesis is that the level of seafloor hazard impacts the decision to drill in these blocks well after the blocks have been leased – at great cost to oil and gas operators. It is postulated that future rounds of leasing might benefit from a regional bathymetric survey similar to the one conducted by the *Okeanos Explorer*.		

Machine Vision based Data Acquisition, Processing & Automation for Subsea Inspection	**4:10pm**	**Presented by Adrian Boyle**

Industrial machine vision refers to the use of computer based image processing techniques to perform an assessment of a specific condition of an object , normally as a quality control for a product on a manufacturing line. Usually , this happens in a well controlled environment such as a conveyor belt. Subsea, building a robust system that will reliably perform detection of events and anomalies requires careful design that considers both the "uncontrolled" environment as well as the challenges of ensuring data quality allows reliable machine processing. Generally, data is collected from ROV or AUV.
This presentation describes a multi source subsea machine vison system that acquires image, laser and a range of local navigation and external sensor metadata so that this data can then be processed using machine vision algorithms for geometrical and planar data analysis. The specific areas covered in this presentation include

- Speed and Quality of data acquisition using sequences of images
- Image quality assessments and closed loop control in real time and while the vessel is on location
- Pre - processing steps to assess data quality in situ and machine vison readiness
- Full machine vision processing of 2D and 3D laser and image
- Data considerations

The presentation will focus on linear pipelines and structures.

Latest pipeline inspection techniques	**4:30pm**	**Presented by Ole Kristensen**

The oil and gas industry is constantly improving the operation workflow – with focus on cost and quality optimisation. The development in sensor technologies means a shift from profiling sonars, via multi-beam echo sounders to now subsea laser, photogrammetry, photo and video mosaics, etc. On the software processing side, automation of processing is in focus, reducing man time through automation of free span detection, boulder identification, advanced Kalman filtering to improve pipe tracker and other data to best position pipes, etc.

This presentation covers the latest software available, giving examples of how the latest 3D and 4D technologies have been used across a number of customer cases to assess the development over time across many surveys.

Why the inertia on the adoption of AUVs in the Oil & Gas industry?	**4:50pm**	**Presented by Len Ricketts**

The current downturn in the oil and gas industry should have brought AUV services to the fore. AUVs are ready to take up the technical and commercial challenge, but why the inertia from the industry?
Presently companies that own the larger survey class AUV submarines are heavily invested in ROV assets creating strategic confusion for business development. This is typical of a market that is in transition from one technology to another.

AUVs first entered the commercial market due to a requirement to solve the challenges posed by deep water survey. Demand for AUV surveys are now being fueled by quality demands. Data quality and resolution are seen as the major contributing factors in de-risking projects starting from FEED stage.

AUVs have developed to such a degree that reliability figures match or even exceed that of ROVs.
Pricing has become a major determining factor for the inspection market. AUVs can be easily mobilized onto 3rd party vessels even utilizing the client's own long term charter vessel. AUVs can survey at up to 4 knots and do not need the host vessel to be in DP mode – lowering fuel costs. AUVs ARE cheaper!

Quality of data is a huge advantage when surveying with an AUV. Survey class AUVs carry a full suite of payload sensors tagged to a single time source. Surveys are easily tailored to client specification by adjusting altitude, speed and line spacing. The single time source allows for highly accurate data visualization and data fusion. AUV data ARE better!

Acoustic pipeline surveys are slowly but surely being executed by AUVs rather than ROVs due to the speed and quality that AUVs provide. The same precise survey can be repeated because the pipeline is the navigation guide when doing automatic pipeline tracking. This will eventually lead to technologies such as difference mapping and auto eventing.

Nowadays, AUVs have become so reliable that the bottleneck has moved to issues such as file sizes related to higher resolution data. Data management and data storage become significant considerations going forward. So the AUV industry is saddled with (dare I say it) dated ROV post processing technology AND the personnel that go with it.

Inertia stymies technology development, it also creates short term technologies like fast survey ROVs that will never be able to cope, commercially at least, with multiple AUV or ASV/AUV surveys.
But are AUV service suppliers entirely innocent? AUV surveys are cheap enough, why do we drive down the decision based on cost per kilometer? Do we do enough to educate the client? Does the project based business model disallow technical discussion to deliver the best value project rather than the cheapest one?

Oilfield Hydrography **Lightning Round 3**	**Starts at** **5:10 pm**	**Tuesday March 21, 2017**

Taylor Brown: Cheaper, Faster, Higher Resolution Pipeline Inspection Surveys – Advanced AUV Platforms and Sensors for Cost-Efficient Asset Integrity

AUVs are becoming the platform of choice to acquire high-resolution geophysical data for greenfield site characterization surveys. As the suite of navigation and sensor technology available for these platforms is improving, AUVs are becoming an attractive, lower-cost option for pipeline inspection as well. With pipe trackers, laser scanners, ultra-high resolution cameras, and methane detectors among the vast number of sensor options now available, AUV pipeline inspections become a cheaper, faster option compared to costly ROV surveys. This presentation will examine how subsea asset integrity programs can use AUV platforms fit with state of the art survey sensors to conduct more efficient, cost effective pipeline inspection surveys.

Burns Foster-Michael Redmayne: Simplifying Multibeam Backscatter Processing

Traditional methods of processing backscatter are often complex, and involve a great deal of user input to obtain a satisfactory result. As a consequence, it is often the case that backscatter data is gathered during survey operations but not subsequently processed unless absolutely needed. With the hydrographic survey industry moving to a more data centric model, there is a need for a more streamlined approach to processing backscatter data whilst maintaining the quality of the final product. This presentation describes the methods used to simplify the process of generating backscatter products and how it has been implemented in CARIS HIPS & SIPS.

Anand Hiroji: Radiometric Compensation Strategy for Multispectral Backscatter Data

Acoustic backscatter data from multibeam sonars are increasingly being used for seafloor classification. In order to improve the classification one emerging trend is to use multifrequency backscatter data (for example in this case 40 kHz to 300 kHz). While this ideally should reduce ambiguities in seafloor classification, it requires data collection by either simultaneous operation of multiple sonars or operation of a single sonar simultaneously at multiple frequencies. For a given configuration multiple sectors and swaths are used to maintain motion stabilization and to obtain an even sounding density. Furthermore as the sensor altitude varies, all of the pulselength, sector spacing, and center frequency changes. All of these add complications in removing the radiation overprint on the backscatter data.

In this study, strategies for radiation pattern removal from multispectral backscatter data are analyzed. The dataset utilized was collected using new EM710 and EM2040 multibeam sonars on the NOAA ship Thomas Jefferson. Different methods to remove radiation patterns are tested on the dataset and their relative impact on the fidelity of seafloor classification is assessed. Examples of improvements in seafloor discrimination using multispectral backscatter data are presented and suggestions for standardized field procedures for the data collection are put forward.

Steven MacDonald: Using Multibeam Backscatter In Offshore Surveys For Seabed Classification

Advancements in multibeam acoustic backscatter processing and recent developments in the GeoCoder Correction have led to increased quality products to support seafloor characterization and small object identification. The improvements in the processing and analysis tools for multibeam backscatter have paved the way for use of this data in place of side scan sonar in some applications.

Data from a survey off the Northeast coast of the US was examined to compare the results of the multibeam backscatter versus simultaneously acquired towed side scan sonar for seafloor characterization. Ground truth sampling was completed at selected sites to aid in accuracy of the sediment classification. Though the use of the ground truth samples, it is possible to “teach” the processing software to automatically detect areas with similar acoustic energy reflection properties. This method reduces the previous necessity for high level interpretation of the entirety of the data set.

The multibeam backscatter GeoCoder processing takes into account the beam geometry, sonar settings and seafloor bathymetry, while filtering for image speckle removal. These processes along with the absence of a prominent nadir zone found in side scan sonar allow for improved uniformity between adjacent survey lines and overall data product quality.

Wednesday, March 22		
Hydrographic Mapping Initiatives		**Session Chair: Karen Hart**
Latest Generation Multibeam Echo Sounder Application and the Evolution From Bathymetry to More Complete Ocean Mapping	**8:00am**	**Presented by Lindsay Gee**

Recent years has seen the evolution in use of multibeam echo sounders from primarily bathymetric mapping, to observing backscatter variations for characterizing the seabed, and most recently imaging the water column. The overall use as ocean mapping sensors broadens their application with new users continuing to develop and adapt the processing and analysis of the data.

Survey standards and processes for bathymetry are well established, however they continue to evolve for both backscatter and water column data. Seabed backscatter data are commonly used for seabed geological interpretation. However it was only recently that the GeoHab BSWG generated guidelines for best practice in the acquisition and processing of backscatter data.

Initial hydrographic use of water column data was to allow comparison against the bathymetry from conventional bottom detection over wrecks to ensure least depth determination over protruding structures like masts. The use of tools developed for this purpose also proved useful in assessing and optimizing sonar performance.

There has been significant broader use in geophysical surveys for research and oil and gas exploration where integrated mapping of the seabed and water column has provided a more complete view of the geologic processes in a region. This paper will examine the use of this integrated approach to mapping with the EM302 multibeam sonar during a number of surveys undertaken by Exploration Vessel (E/V) Nautilus during the 2016 expedition season off the US Pacific Coast.

Coherent Refraction "Noise" in Multibeam Data Due to Oceanographic Turbulence	**8:20am**	**Presented by John Hughes Clark**

Oceanographically-driven variations in sound speed have long been understood to be a significant source of error in multibeam bathymetry ("smiles and frowns"). The usual assumption, however, is that the water mass changes relatively slowly so that around the vessel the lateral structure can be assumed to remain uniform (i.e. no horizontal gradients).

In the presence, however, of significant vertical current shear, there may in fact be rapid horizontal variations in the sound speed structure resulted in locally tilted and rapidly oscillating veloclines. Under these conditions, the sloping velocline will distort the refracted ray path. Because these slope variations are related to the width and height dimension of turbulence at the shear boundary, a false roughness is projected onto the seafloor reflecting that scale.

While most sound speed sensitivity studies have focused on perturbations of strong veloclines, under such conditions the density gradient actually suppresses turbulence. In contrast at weak veloclines, the Richardson number may be low enough that turbulence is enhanced. Thus, somewhat counterintuitively, often these short-wavelength refraction-related distortions are actually worse in weakly stratified watermasses.

Field examples of interface turbulence, visible in water column imaging, are shown to correlate well with the pattern of refraction-generated false seabed roughness.

Passive and Active: Remote Survey Solutions for the Nearshore; an Integrated Approach	**8:40am**	**Presented by Don Ventura**

Emphasis on nearshore, shallow water surveys and the immediate coastal hinterland has increased over the past few years. This has been generated by concerns over various issues, including: sea level rise due to climate change and directly-attributable man-made issues such as land subsidence through extraction of valuable mineral and water resources; growth of, and reliance on, a seaborne Blue Economy delivering goods as efficiently as possible; concerns over erosion or damage to nearshore ecosystems necessitating additional focus on habitat mapping and environmental surveys in general; and an increasing percentage of the world's human population residing in close proximity to the coast which places extra emphasis on baselining and monitoring of this specific margin. At the same time, economic pressures on a great many of the world's advanced and developing nations alike bring the need for cost-effective methods of garnering geospatial data in the nearshore into sharp focus. Clearly, mapping of the land-sea interface requires the adoption of a broader approach to hydrographic surveying techniques and technologies to augment that already well surveyed with traditional methodology. This presentation will illustrate an integrated solution to this survey paradigm through the pragmatic use of satellite derived bathymetry and airborne topo- and bathymetric techniques.

Determining Survey Scope and Priority by Understanding Hydrographic Risk	**9:00am**	**Presented by John Riding**

We have interest in participating in this conference and we have both developed and have experience of a new risk based method to determine where hydrographic survey and charting updates should be undertaken. This GIS based risk methodology was originally developed by Marico Marine for LINZ in New Zealand. It was trialled in the waters of Vanuatu, where the connection of traffic risk to sea areas adjacent to locations providing :-
· Cultural importance; · Ecological importance; · Economic importance; · Coastal Utility importance.
And linking this to:- · Bottom coverage; · Charting standards; · Navigational difficulty (confined waters, high tidal zones, exposed coastlines, breaking reefs); · Growth predictions,
provides a new way for hydrographers and decision-makers to scope survey requirements, that has justification well beyond the decision-making based on professional perceptions. After further work in Tongan Waters, then the waters of the Cook Islands, the Hydrographic Risk Analysis system has been applied to the whole of the waters of the New Zealand EEZ. The system provides a representative output of areas to prioritise by hydrographic risk, but it additionally provides a charting Benefit Assessment to determine where charting reorganisations may be appropriate, differentiated from the conduct of new hydrographic surveys. The IHO have now formally endorsed the methodology and this approach at their 2015 assembly meeting in Monaco.

Enabling Technology: Development of a Remotely Operated Vessel for Pier Inspection	**9:20am**	**Presented by Jonathan Marshall**

In order to expediently survey marine structures such as large piers, bridges, and harbor facilities, a 6ft unmanned surface vessel was integrated with mechanically scanning multi-beam sonar, 360-degree lidar and high-definition photography. Combining point cloud data from all systems generates a high quality, above and below water, three-dimensional (3D) model of the target structure. The integration of a high precision positioning system was required for surveying in areas where GPS signal could be lost or degraded. HYPACK® survey software was used to operate all sensors as well as integrate the time and positioning signals. The small platform provides agile maneuverability among complicated structures with low overhangs and tightly spaced structural members. The goal in developing this unit was to create a fully-integrated survey tool that will allow a small team with minimal equipment to survey a pile supported marine structure and produce high quality data products in 24 hours.

Hydrographic Mapping Initiatives Lightning Round 4	Starts at 9:40 am	Wednesday March 22, 2017

Patrick Debroisse: Vessel Mounted Lasers for Shoreline Feature Acquisition

NOAA uses LIDAR derived bathymetry for charting applications where available and has interest in further developing LIDAR technology to increase accuracy, efficiency, and safety. NOAA's Hydrographic Systems and Technology Branch along with NOAAS *Fairweather* have recently experimented with vessel mounted laser scanners for the acquisition and determination of shoreline features.

The system tested and in use is the Velodyne VLP-16: a small, 16 channel laser scanning system. During testing in SE Alaska, it was found that acquisition by laser is as fast as the traditional method, but could be up to 300% faster if given prior bathymetry. It was also found that feature processing was at least as fast as the current methods. Through collaboration with software providers, the time to post process can be shortened significantly by automating various processes. Additionally, the safety of vessels and surveyors is increased because the use of lasers does not necessitate working in close proximity to dangerous features. The increase in accuracy of the laser system over leveling was found to be significant while comparing acquired locations of a known point by both methods.

Andrew Orthoman: ASV Deployment Leads to Production Gains on Bering Sea Hydrographic Project

TerraSond Limited, a hydrographic services company based in Palmer, Alaska (USA), used a C-Worker 5 (CW5) unmanned Autonomous Surface Vessel (ASV) in conjunction with a 105' research vessel in 2016 on a major hydrographic survey in the Bering Sea region of Alaska. The ASV served as a force-multiplier, collecting multibeam and towed sidescan data alongside the larger vessel, which surveyed adjacent lines simultaneously. The 18' (5.5 m) ASV collected 2,275 nautical line miles of the project total of 5,200 nautical miles, achieving an industry-first in terms of data production rates utilizing ASV technology, especially in the Arctic. Challenges encountered and addressed included project logistics in a remote region of Alaska, integration and operation of relatively complex sensors including towed sidescan on the unmanned vessel, adverse weather conditions for vessel operations, and safe launch and recovery of the unmanned vessel at sea.

Don Ventura for José Martínez Díaz: Multi-sensor surveying perspectives for hydrographic charting

In the summer of 2016 Fugro was contracted by NOAA Office of Coast Survey to conduct hydrographic surveying services in Penobscot Bay, Maine. The survey project encompassed approximately 370 square kilometers over an area characterized by a vibrant lobster fishing industry and high vessel traffic.
Aspects of coastal survey operations in the coast of Maine exposed the difficult complexities of the region: risk of uncharted submerged rocks and high number of lobster traps gear. Both circumstances were clear factors that would affect the efficiency and productivity of the survey caused for the conservative approach to shallow rocky coastline transiting and the constant need of avoidance maneuvering.
In an effort to gain efficiency, reduce costs and risks, and exploit the benefits of sensor technology, Fugro developed a survey plan that involved integrated MBES and Airborne Lidar Bathymetry (ALB). ALB technology allowed to obtain least depths on shallow waters less than 8 meters, thereby providing safe and efficient MBES survey vessel operations into safe water, while providing data coverage at the required specifications.
The ability to mobilize multiple survey sensors from multiple platforms and process data into a diverse range of data products and derivatives, surpasses the expectations of focused hydrographic surveying for nautical charting updates, while fueling other applications requiring baseline mapping products at large scale over large area extents.

Stephen Parsons: Advanced Water Column Monitoring in Support of CHS Airborne LiDAR Bathymetry (ALB) and MBES Shallow Water Mapping Operations in Pictou Harbour and Northumberland Strait, Nova Scotia

Successful airborne bathymetric LiDAR (ALB) operations are highly dependent on environmental factors such as weather and water clarity. Providing accurate in-situ information to LiDAR flight crews and operators is vital in determining flight windows and predicting the likely hood of successful flight sorties. In August 2016 CHS conducted ALB surveys with Leading Edge Geomatics (LEG) in the Pictou Nova Scotia area of the Northumberland Strait using a Chiroptera bathymetric LiDAR system. Coincident water column observations were also taken using radiometric, water sampling, secchi disk observations and real-time turbidity measurements. The results of these observations, their correlation to MODIS satellite observations and the impact of the water column data on project planning are reviewed. Comparisons to the observed ALB and concurrently measured multibeam and water column data collected using an EM2040D compact system are also presented as a part of this comprehensive shallow water mapping project.

David Hericks: 3D Structural Mapping of Rugged River Channels, Canyons and Dams using a USV-Mounted Multibeam Echosounder, Mechanically Scanning Sonar and Terrestrial LiDAR Scanner

Performing hydrographic surveys in rugged river channels, deep canyons, and near waterfalls and hydroelectric dams is often impractical because of the lack of boat access, risk to personnel, lack of GNSS satellite visibility and other technical challenges. High-resolution surface mapping above and below water in these difficult locations is important for assessing rock slope stability, evaluating design options and developing three-dimensional geological and hydrodynamic models. A unique unmanned surface vessel (USV), incorporating a multibeam echosounder (MBES), north-seeking inertial navigation system, high-bandwidth telemetry and a remote-controlled propulsion system was fabricated and utilized for hydrographic surveys in a rugged river channel at the bottom of mountain ravine and in a deep canyon downstream of a hydroelectric dam. Tripod-mounted mechanically scanning sonar and terrestrial LiDAR scanners (TLS) were also employed to map the above and below water surfaces in high-detail. Erosional undercutting and underwater tunnels were measured with the UAS and mechanically scanning sonars. The above-water TLS recorded centimeter-scale rock structure used in rock slope stability analyses and the combined bathymetric, topographic point-clouds were used to develop stunning 3D visualizations. These new hydrographic survey tools, deployed in difficult conditions with innovative methods are an integral part of the future of hydrography.

Firat Eren: Investigation of potential relationship between Airborne Lidar Bathymetry measurement uncertainties and seafloor characteristics

Depth measurements measured by Airborne Lidar Bathymetry (ALB) systems are typically calculated from waveform observations by measuring the time difference between the water surface and the bottom (seafloor) returns. In this study, the ALB bottom return waveform was analyzed spatially (i.e., area and geometry contributing to the bottom return) and temporally (i.e. the shape of the bottom return with respect to time) for seafloor characterization. Environmental factors that can potentially contribute to error in ALB bottom detection included: slope, grain-size of the sediments, vegetation, and mineral composition of the seafloor. A system-agnostic approach was developed in order to distinguish between the spatial variations of different bottom characteristics. The ALB data collected in the Merrimack River Embayment, Gulf of Maine was used as the proof of concept. The results demonstrated good correlation to acoustic backscatter which was collected in the same area.

THSOA Annual General Meeting	10:30 am 11:30 am	Wednesday March 22, 2017

Vector and Raster Nautical Charting: the Wave of the Future Lightning Round 6	Starts at 11:30 am	Wednesday March 22, 2017

Christie Ence: Revision of NOAA's Nautical Chart Manual

The National Oceanic and Atmospheric Administration (NOAA) Nautical Chart Manual (NCM) contains policies and procedures used to guide cartographers for making charts. Over the years, the NCM has been split into three volumes that contain instructions for compiling Raster Navigational Charts (RNCs), Electronic Navigational Charts (ENCs), and chart symbol specifications. It has been a challenge to adapt the NCM to accommodate new products and deliverables with a uniform specification across all three volumes. We hope to create a new manual that can be easily understood by compilers with different levels of expertise and who are working in different geographic settings. In this paper, we present NOAA's effort to meet international standards and provide a "one-stop-shop" for compilers working on ENC and RNC products. The revised NCM will follow the structure of the International Hydrographic Office (IHO) S-4 chart specification publication and include references to the IHO S-57 and IHO S-101 documents. The new design will feature a web interface that will guide compilers and enable efficient searches.

Guillaume Auclert: Plan to Rescheme NOAA ENC Coverage

The scheme – or footprints – of NOAA ENCs are based on the footprints of the raster charts from which they were derived. As a result, changing current ENC coverage to incorporate additional survey data outside of the existing bounds is complex and poses a challenge. In addition, the scale ranges chosen for the ENC navigational usage bands differ from the International Hydrographic Organization's (IHO) recommendations. As part of the "ENC first" effort, an ENC rescheming approach was developed to provide a seamless, tiled coverage that can easily be segmented or extended based on geographic location, available data and scale. In this new regular gridded ENC coverage approach, only a limited number of chart scales are used (down from the current 131 different scales). The new ENC scales conform to IHO S-57 and IHO S-101 ENC format specification. The new scheme segments the ENC tiles into three geographic zones. All individual ENC cell limits within each zone are along even lines of latitude and longitude. At higher latitudes, the regular longitudinal width of cells is increased twice to account for the convergence of meridians at the poles.

Corey Allen: Using Vessels' Calculated Under-Keel Clearance to Estimate the Appropriate Level of Effort for Hydrographic Surveying

Over the past century, there has been a steady advancement in hydrographic surveying techniques. The evolution in technology from lead lines to single beam systems to multibeam sonars has led to increased seafloor sampling density and more accurate data measurements. Hydrographers now have the ability to understand the seafloor better than any other time In the past; however, that understanding comes with a potential cost of increased time (both in field acquisition and processing) and increased data storage. Rather than immediately conducting the best survey technologically possible, the hydrographer must first define the hydrographic needs of an area. This paper proposes a method of relating a vessel's computed under-keel clearance to the desired state of hydrography. A GIS-based approach was used to join vessel positions reported through the Automated Information System (AIS) with the U.S. Coast Guard's authoritative database of vessel drafts. These drafts were then compared to interpolated depths extracted from NOAA ENCs to identify the minimum under keel clearance for any given area. The closer a theoretical hull is navigating to the seafloor, the more stringent the survey requirements would be; thus ensuring only the appropriate level of resources are dedicated to a particular project.

Cameron McLeay: Advancing Cartography with Tools from the Past
This paper will discuss some recently developed new tools for cartography.

To assist hard copy production, inspiration has been drawn from traditional cartographic methods, replicating the layover ability of light tables to easily compare layered data in a digital form. Increased production is enabled by further time saving tools. Production of Nautical Publications has been streamlined by using a One Feature, One Time database, utilising source data shared with chart production. Output to a finished publication is eased with automated compilation and layout tools.

Development of the next generation of navigational and related products based on the S-100 standard is progressing. New tools and methods will be discussed for dealing with S-100 concepts like complex and multiplicity, and outputting to ISO8211 and S-100 GML formats. Data formats supported are rapidly growing with the use of open source I/O libraries and new abilities to transform data on import.

LCDR Hsu: The Development of Taiwan (R.O.C.) ENC – NOW and the FUTURE

ENC, a popular and widely used IT product for modern navigators with ECDIS, is more efficiently to understand the geographic complexity than the way in traditional use of paper charts when sailing at sea. In 2015, the Taiwan(R.O.C.) Ministry of the Interior and Navy METOC office started a joint ENC production for the popularization of ENC application in future. Up to now, 76 Cells have been successfully published and correctly applied in the ECDIS, and the life cycle(UPDATE) has been functioning by IHO S-65 specification.

Kurt Nelson: Implementing a Navigational Bathymetric Database Within the U.S. Office of Coast Survey
As NOAA plans for the future production of S100 products, there is a clear need to implement high-resolution navigation information into fully manageable databases from which the needs of a diverse customer base can be met. A fundamental requirement will be the easy management and distribution of authoritative bathymetric data. To meet this challenge, the Office of Coast Survey (OCS) is taking steps to implement such a bathymetric database with the goal of better understanding the technology, addressing critical issues involved with merging diverse source data, developing processes needed to maintain such a database, and providing output to support existing and new products and services. This paper will delve into some of the issues encountered in building the initial prototype of a navigational bathymetric database and the effort to spiral out to greater geographic coverage, leverage more diverse source data, and integrate with other OCS efforts to modernize navigational product development.

Wednesday, March 22		
Hydrographic Data Management and Processing Techniques		**Session Chair: Brian Calder**
What Can Variable Resolution Do For You?	**1:00pm**	**Presented by Burns Foster**

Variable Resolution technology is now available in a commercial product with the release of HIPS and SIPS 10.0. This new technology is intended to solve one of the most significant limitations in processing today, where multiple gridded products must be maintained when a survey area covers a large range of depths, and/or is surveyed using multiple platforms producing varying data densities.

This paper will explore the workflow changes involved in the use of variable resolution, and will quantify efficiency gains through the use of a single model for product generation. We will also touch on impacts to industry standards and deliverables, such as those under IHO S-44.

Sound Speed Manager: An Open-Source Initiative to Streamline the Hydrographic Data Acquisitions Workflow	**1:20pm**	**Presented by Giuseppe Masetti for Barry Gallagher**

The use of inaccurate sound speed data heavily affects all survey products, from the bathymetry to the backscatter mosaic through the water column imagery. Thus, sound speed profiling (SSP) represents a key element for any workflow that aims to collect high-quality echosounder data.

Historically, SSP has been handled by surveyors using a mixture of manufacturer-specific tools, spreadsheets, scripts and some manual hacking. Far from optimal, this approach carries a number of disadvantages like being error prone and inconsistent among different sound profile systems. In the past years, both NOAA Office of Coast Survey and University of New Hampshire CCOM/JHC have tackled this issue by developing tools such as Pydro's Velocipy, MAC SVP Editor, and HydrOffice SSP Manager. Leveraging such experience, a jointly-developed open-source initiative has been created to provide a long-term and reliable solution for SSP.

Sound Speed Manager has been designed to ease the integration in existing data acquisition workflow, and its open source license provides a neat way to understand the adopted processing solutions as well as to adapt the application to specific organization needs. This latter is eased by the modular design, with the NOAA-specific functionalities organized so that they can be easily deactivated. The main functionalities include: the large support of commonly-used sound speed formats in input and output, the full integration with existing data acquisition/integration applications (e.g., Kongsberg SIS), the profile enhancement based on real-time and climatologic models, and the database management of the collected data with built-in functionalities for analysis and visualization.

Advances in Hydrographic Data Processing: Time for a Paradigm Shift	**1:50pm**	**Presented by Jonathan Beaudoin**

Hydrographic data processing can be challenging, even for experienced users. The problem is often the human operator. Humans make errors when transcribing vessel configurations from one software application to another or from one coordinate frame convention to another. Humans make errors when importing ancillary data and then failing to associate it with the correct data files. Humans make errors when changing processing configurations and not then performing the appropriate reprocessing. Any error along the way leads to poor results in the final product and many wasted hours troubleshooting the source of the error. A paradigm shift is a fundamental change in approach or underlying assumptions. With the release of QPS Qimera, we are striving for a paradigm shift in that we are automating the mundane and error prone tasks for which computers are well suited but humans are not, for example data transcription, processing state management and job scheduling. Qimera isolates the stages for which a human brings value to the process, for example processing configuration management and data validation. In this paper, we explore the methods used by Qimera to guide the operator through data processing, simplifying what has traditionally been a convoluted process.

Finding Fliers: New Techniques and Metrics	**2:10pm**	**Presented by Matthew Wilson**

Anomalous grid data “fliers” are the result of spurious soundings negatively affecting gridded bathymetry. Their presence in final grid products represents an inaccurate portrayal of the seafloor. Traditional methods of grid quality control to ensure flier detection and removal may not be sufficient, as one report estimated nearly 25% of surveys received at NOAA had final grid deliverables affected by fliers. This scenario is far from ideal, as affected grids require high time and effort to fix, and the authenticity of the original field submission is lost in the recreation of the final survey products.

The newest version of Flier Finder, available in the HydrOffice project QC Tools, explores several new automated techniques geared toward flier identification, including those employing a Laplacian operator, Gaussian curvature, and multi-directional depth scanning to flag spikes; others are built to identify anomalous nodes detached from the grid. Recommended grid search parameters are generated automatically based on median grid depth, depth variability, and surface roughness, which alleviates subjectivity of the algorithm input while also adding a level of standardization to the tools.

The effectiveness of new automated techniques compared to traditional, manual methods of flier detection needs to be objectively quantified. To this aim, personnel were given a control grid with known fliers, which they attempted to identify using both manual and automated means. Important metrics are determined from the results, which include an assessment of the time required to find fliers and the success rate of known flier identification, for both experienced and junior personnel, using both manual and automated techniques. The results will suggest whether or not the new automated techniques represent a statistically significant advantage over manual methods, in terms of speed and accuracy of flier identification. Once identified as statistically significant, a flier identification technique could be integrated in the gridding algorithm, reducing the rate of fliers delivered on the created surfaces.

Methods for Artifact Identification and Reduction in Acoustic Backscatter Mosaicking	**2:30pm**	**Presented by Giuseppe Masetti**

Modern sonar systems provide high resolution measurements of acoustic backscatter that were unthinkable just a few decades ago. However, many aspects of the data acquisition can heavily affect these measurements, reducing the data quality in the output mosaic. This work first describes and compares different approaches and techniques to identify the presence of weather-related artifacts (e.g., bubble wash-down), then explores possible scenarios on how to reduce the lack of knowledge in such areas.

For seafloor characterization, these kinds of artifacts increase the risk of erroneous boundary identification between acoustic facies. Although such risk can never be totally removed, it can be decreased by modeling the expected types of artifacts and by acting on their identification in the early phases of the data processing workflow. For instance, the identification of ping-oriented artifacts is facilitated by working at a survey line level, and the presence of overlapping areas between survey lines (when available) can be used to improve confidence in the resulting characterization.

The simple removal of the affected pings and ping sectors from the output mosaic usually provides a boost in its general visual quality and eases human interpretation. However, we also attempt several exploratory reconstructions of the removed areas, ranging from a naïve interpolation at the image-processing level to a more sophisticated Bayesian model-based approach. Both the identification and the reduction methods are demonstrated with a data set collected over the Marianas Trench last October using a Kongsberg EM122 multibeam echosounder.

Hydrographic Data Management and Processing Techniques **Lightning Round 5**	**Starts at 2:50 pm**	**Wednesday March 22, 2017**

Caitlyn Raines: Vertical Coordinate System Harmonization

Harmonizing vertical coordinate systems (VCS) is a common challenge when working with different hydrographic surveys. While the "map once, use multiple times" idea is a particularly useful concept in a discipline where data collection is difficult, time intensive, and expensive, we have all seen different agencies and organizations use different VCS that are chosen for best fit for the purpose of their work. Anyone interested in using data from multiple agencies often has to reconcile the different VCS amongst the surveys to make a cohesive surface model. Over the past few releases, Esri has introduced functionality to perform VCS transformations that makes this process easier. This functionality works on global VCS models. However, there are areas in the world in which the tidal datum transformation is better represented with a local model. Esri has developed a methodology to perform lightweight, easy VCS transformation where local models are available. This paper will detail the commercial-off-the-shelf (COTS) functionality for VCS transformation included in the ArcGIS platform. It will also discuss how to use local transformation grids where available to supplement the global transformation models.

Jack Riley for Janice Eisenberg: Implementing Variable-Resolution Gridding Technology for Hydrographic Surveying

NOAA's Office of Coast Survey (OCS) has long been collaborating with academia and industry to enable the variable-resolution representation of bathymetric data for hydrographic surveying, and is finally poised to consider the implementation of variable-resolution grids for the 2017 annual hydrographic field season. This paper examines the infrastructure that is currently being built to enable adoption of variable-resolution gridding technology for nautical charting, including the expansion of existing tools, workflows and deliverable requirements, as well as the challenges and work ahead. Notably, variable-resolution gridding technology has the potential to foster a paradigm shift from depth-based to density-based resolution estimation methods for producing navigation surfaces, which may have upstream and downstream implications for current workflows. The impact of variable-resolution gridding technology on the overall efficiency of data processing workflows will also be examined, as will implications for data archiving and the formulation of bathymetric surface product specifications (e.g., BAG 2.0, S-102). As is the case with the implementation of any new and innovative technology, we acknowledge the potential for "unknown unknowns" - things we don't know that we don't know about variable-resolution implementation - that may result in unforeseen consequences or value added.

Ole Kristensen: Automation of hydrographic processing

The hydrographic sector is working with increasing amounts of data due to sensor development as well as the operation of multiple unmanned assets with a smaller and smaller crew. This changes the way we work and places new challenges onto the design and capabilities of hydrographic software packages.

In the past, a single vessel mounted survey spread required processing speed of better than 1:1 (acquisition time vs processing time for final product). The development in sensors and unmanned assets requires processing speeds of 1:10 or better – and data volumes 10 to 100 times larger than before. In order to be able to handle the large amount of data, the highest possible performance is necessary and achieved with tools that automate as much as possible of the process – leaving quality review and error correction to be the focus of the data processor.

This presentation covers detailed examples of typical hydrographic workflows with a focus on process optimisation, ie where the individual steps of the workflow has been measured in terms of performance, and tools have been implemented to automate as much as possible of the data processing task, and ensuring that the data processor has the necessary overview of status, progress, and errors that need to be addressed.

Dean Moyles: Operational efficiencies on challenging marine surveys

In support of NOAA's Office of Coast Survey charting program, Fugro was contracted to provide hydrographic surveying services in Penobscot Bay, Maine. The survey plan over the highly complex coastline and shallow waters was challenged by the peak of lobster season.

To gain operational efficiencies, reduce cost, and reduce field personnel; Fugro utilized various in-house technologies which included Fugro's Back2Base; which are a set of technologies and processes that enable survey data to be reliably and economically transferred between work locations (terrestrial remote office or survey vessels) to the terrestrial reporting office, via an internet link such as land based high speed internet, satellite or mobile broadband. Fugro also developed a survey plan that involved an integrated multibeam echosounder (dual head Reson 7125 utilizing the 7030 installation parameters record) and Airborne Lidar Bathymetry (ALB).

To compliment this Fugro incorporated the CARIS Onboard software suit, where large volumes of data are automatically imported into HIPS and SIPS. Onboard generates a HIPS project and can be easily configured to output other products. All of which are kept up to date as new data is processed. By the time the survey platform has completed its daily operation a fully geo-referenced DEM, along with a HIPS project, are available for final quality control and use in survey deliverables.

With these technologies, along with many other in-house utilities, the survey was completed in a timely fashion while reducing cost and onsite field staff.

Jack Riley: Determination of Possible Errors in Geoid Models via the Ellipsoid-Referenced Hydrographic Datum

In ellipsoid-referenced surveys (ERS), a vertical datum transformation or "separation model" (SEP) is used to express hydrography (depth and heights) relative to a tidal datum, such as mean lower low water (MLLW); e.g., SEP = NAD83 – MLLW. The dominant signal in the SEP is attributed to the geoid height or undulation which describes how the orthometric datum—the basis for measurements relative to "sea level"—varies in space. Non-ERS hydrography inherently includes the spatial variability of the local mean sea level (MSL) per the character of the geoid, for the simple fact that depth and height measurements are reckoned relative to the sea surface; i.e., via survey vessels afloat. Water level observations at fixed points in conjunction with a propagation model describe the spatiotemporal relationship of the in situ sea surface—and hence the non-ERS hydrography—to tide datum and otherwise MSL. Given a (validated) SEP, such a tide model is not required for ERS work; indeed, a principal motivating factor for using ERS is to decouple the requirement for water level observations simultaneous to hydrography (replace "tide corrections" with the *a priori* tide datum SEP). However, if "tides" are available during the ERS, we can build an observed-SEP grid for comparison to an (un-validated) SEP model. We discuss how this SEP comparison may be used to determine the veracity of the geoid model in the latter. SEP comparisons are shown for ERS data, including 2016 survey work in north Kodiak, Alaska, where a localized geoid undulation exists in the NOAA hybrid and gravimetric models but is not present in our observed SEP.

Uchenna Nwankwo: Ellipsoidal referenced tidal datum at an offshore buoy in the Mississippi Bight using PPK and PPP GPS processing and tidal datum transfer.

As part of a program, by the Hydrographic Science Research Center at the University of Southern Mississippi, to extend the length over which GPS baselines could be utilized in the marine environment for precise positioning using either Real-Time Kinematic (RTK) or Post-Processed Kinematic (PPK) techniques, a buoy was deployed with a survey grade receiver in the Mississippi Bight in late 2004. PPK processing of the buoy data with data from nearby GPS basestations was conducted until the basestations were destroyed by hurricane Katrina in late August of 2005. Subsequent to Katrina, the Precise Point Positioning (PPP) technique was developed, which is an absolute processing method because only data from one GPS receiver is used. This made it possible to process the data collected through the entire storm. The Modified Range Ratio datum transfer method was used to transfer tidal datums (Epoch 1983-2001) from the NOAA National Water Level at Waveland, Mississippi (Station ID 8747766) to the buoy. These results could be incorporated into NOAA's VDatum tool to improve the ellipsoid-tidal datum models/surfaces further offshore, allowing for an improved ability to reduce ellipsoidally referenced hydrographic surveys in the region to chart datum

Wednesday, March 22		
Vector and Raster Nautical Charting: the Wave of the Future		**Session Chair: Rachel Medley**
NOAA's MSDI Approach for Delivering Information to Mariners	**3:50pm**	**Presented by Richard Brennan**

The office of Coast Survey is working towards an "ENC first" approach that includes re-scheming charts and providing a charting product with coverage defined by the end user. However, there are currently two issues that hinder this process; 1) How data is archived and not easily available for exploitation, and 2) the current process to do this for each specific product is entirely manual and time consuming. With the advent of the IHO's S-102 gridded bathymetry product specifications, it possible to harmonize the bathymetry and disseminate it in a gridded format. In this paper, we present NOAA's Marine Spatial Data Infrastructure (MSDI) approach. By using NOAA's source bathymetry as an authoritative database, it is possible to meet both our vector and gridded products demands. In addition, it is possible to incorporate more outside source data (OSD) that are useful to update the charts but do not meet IHO's S-44 survey standards. The goals of NOAA's MSDI database is to deliver information to mariners quickly and third-party services to pick and choose the information (feature class or a specific object) from charts (ENC or RNC) for their application or use the MSDI data as a seamless product based on existing chart scales.

Automating the Ping-To-Chart Workflow	**4:10pm**	**Presented by Burns Foster**

The production of a nautical chart, pipeline inspection map, sediment map or any similar products involves many complex steps between data collection and final delivery. At the same time, these complexities are generally well understood and well defined in the industry, which makes these tasks ripe for automation.

Teledyne CARIS has introduced a new automation tool called Process Designer, part of a larger effort to bring comprehensive, intuitive automation to their product line. Process Designer allows the user to capture business logic, i.e. their standard processing steps, as a series of automated tasks to be executed on incoming data. Designed with flexibility in mind, this new model will allow users to automate the generation of clean, production-ready data during acquisition with CARIS Onboard, as well as their post-processing analysis and product compilation tasks performed in HIPS and SIPS and BDB on the desktop.

A harbour survey dataset will be taken from raw sensor data through to a nautical chart to show the benefits of using the Process Designer to automate the Ping-To-Chart workflow, while still allowing human input at critical stages.

Coming! New, mobile-friendly NGA Nautical Chart data for mobile devices	**4:30pm**	**Presented by Chuck Nichols**

Learn how NGA will meet the growing demand for nautical chart data in a mobile-friendly data format. Sailors, soldiers, and airmen will be able to use Digital Nautical Charts (DNC), Electronic Navigation Charts (ENC), and other geospatial data in the new, mobile-friendly geopackage data format on their tablets and smartphones in an unconnected environment. This overcomes the significant hurdles that mobile technologies encounter with the potpourri of existing geospatial data formats.

Enterprise Geospatial Enablement of Hydrographic Department Resources	**4:50pm**	**Presented by Matthew Thompson**

The Naval Oceanographic Office's Hydrographic Department (NP4) is tasked with collecting, processing, and providing hydrographic and bathymetric data to the National Geospatial-Intelligence Agency for map and chart production. While the primary purpose and overarching requirement of NP4's data flow is safety of navigation (SoN), these data are utilized in a variety of other products to enhance the situational awareness of the Warfighter. NP4's current data management strategy causes extensive time for data discovery, conversion, and visualization. NP4 scientists must access multiple databases, each having a separate interface and output, to ensure all available data are considered. Databases are queried, results are then converted to common formats, and all are brought into a GIS interface for analysis and exploitation. These steps of data mining, preparation, and loading are a significant time sink. By organizing these data sources into a concise database solution accessed using standard GIS software and web services, NP4 can streamline it's workflow. A concise geodatabase solution that allows efficient discovery and visualization of NP4's current structured and ad-hoc hydrographic and bathymetric database resources is under development. This solution will allow NAVOCEANO to continue supporting the Navy's navigation information and data requirements, while positioning it to support the **Naval Meteorology and Oceanography Command (COMNAVMETOCCOM),** as they develop a GIS-based operations center.

Developing a Method to Validate the Navigational Bathymetric Database	**5:10pm**	**Presented by Katrina Wyllie**
NOAA's Office of Coast Survey (OCS) is implementing a high-resolution navigational bathymetric database (NBD) with the goal of providing authoritative bathymetry data for current and future nautical chart products and services. A prototype NBD was created for the Puget Sound area in early 2016 so initial testing could begin. This paper will discuss the methods used to validate the diverse source suppression rules, traceable metadata attribution, and extracted sounding and contour output. Where and why the NBD output differs from current nautical chart products will be discussed. Lessons learned from the validation methods used in the Puget Sound prototype NBD will help to refine and develop automated validation tools needed as larger regions are incorporated into this system.		

Thursday, March 23		
Hydrographic Education Opportunities		**Session Chair: Leslie Sautter**
Estimating Rates of Subsidence Using Sedimentation Over the Trinity River Incised Valley, Galveston Bay, Texas	**8:00am**	**Presented by Andrew Pekowski**
I propose to investigate the role differential compaction plays in relative sea level rise in Texas estuaries. The Texas estuaries are situated over incised Pleistocene channels up to 30 m deep filled with unconsolidated Holocene sediment. The Galveston Pier 21 tidal gauge has a 100 year record which has recorded a relative sea level rise rate 3 times the global average which has been considered a regional rate. However, Pier 21 resides over the Trinity River incised valley and if differential compaction has enhanced the rate, then this rate only represents a localized phenomenon creating an overestimation of the regional rate. The project will first determine the extent of the valley using a CHIRP sub bottom profiler. Analysis of the CHIRP seismic survey grid will provide locations for sediment cores to be taken outside and down the length of the valley, providing sediment for geochronological analysis leading to the quantification of localized subsidence.		

Advancement in the Estimation of Gas Seep Flux from Echosounder Measurements	**8:20am**	**Presented by Elizabeth Weidner**
Gas seeps can be precisely located utilizing multibeam echosounders (MBES) and split-beam echosounders (SBES). Beyond establishing seep location, understanding bubble fate and flux of gas into the water column and atmosphere is an important aspect of climate studies and determination of gas leakage from fossil fuel production sites. Can we advance our acoustics methodologies further, towards estimation of gas flux? A key to determining gas flux acoustically is estimation of seep bubble size distribution. Traditionally bubble size distribution is determined via empirical measurements using remotely operated vehicles. We describe an experiment carried out in the Arctic Ocean, establishing a methodology for quantifying seep flux remotely from acoustic measurements. This experiment used a calibrated, broadband SBES. The SBES's extended bandwidth (16-29 kHz) provided excellent discrimination of individual targets, allowing for identification of single bubbles in many seeps. In these cases, bubble target strength (TS) values were obtained using phase-angle data to compensate for beam-pattern effects. Bubble size distributions were determined by modeling the relationship between bubble size and TS. Coupling the acoustically-derived bubble size distributions with rise velocity, seep flux can be constrained. As acoustic methodologies advance, we hope to generalize the SBES methodology to other calibrated echosounders, including MBES.		

The Training & Development of Naval Hydrographer in Taiwan	**8:40am**	**Presented by Ming-Jer Huang for Yung-Da Sun**
Hydrography provides necessary information on nautical chart for navigation safety to vessels and ships sailing around any channel of the port, coastal area, and the open sea. Because the navigation safety is extremely important to national economic development, the quality of hydrographic surveyor also indirectly affects a national infrastructure and economy. In my context, the history and work of Taiwan Naval METOC hydrographic surveyors are introduced, and then its training program and IHO certification system are presented. I proposes a future framework for position development in navy. The scope of Naval METOC system is presented in the last.		

Application of High-Resolution Multibeam Sonar Backscatter to Guide Oceanographic Investigations in the Mississippi Bight	**9:00am**	**Presented by Lauren Quas**
Hydrographic survey data, while incredibly valuable on its own, can also be used to guide oceanographic and scientific investigations. The theory of “map once, use the data many times” is the driving force behind the multibeam surveys conducted during the Gulf of Mexico Research Initiative’s (GoMRI) CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) project. Reson Seabat 7125 SV2 acoustic backscatter data was collected along three observational corridors in the Mississippi Bight. The acoustic response of the seabed across a variety of grazing angles provides an indication of seabed scattering and, therefore, an estimate of sediment grain-size distributions. These characteristics, along with multibeam bathymetry, can be used to inform numerical model development, like the high-resolution biogeochemical/lower trophic level model being developed as part of CONCORDE. Sediment grab sampling and grain-size analysis were performed to constrain the backscatter data, produce acoustically-derived sediment distribution maps, and provide sediment type input parameters for the biogeochemical model. The model simulations are used to asses sediment transport in the study region on hourly to daily timescales. Future work on the backscatter dataset will involve multi-spectral acoustic analysis and development of additional inputs for the biogeochemical model, such as spatially varying drag coefficients.		

Mapping Active Mudflow Features off Southwest Pass, Louisiana, Gulf of Mexico	**11:00 am**	**Presented by Nikki Galloway**

In 2014, Oceaneering was contracted by NOAA to collect hydrographic survey data in the Gulf of Mexico off Southwest Pass, Louisiana in support of nautical charting. One hundred percent multibeam data coverage enabled an unprecedented view of the mudflow features on the Mississippi Delta front. Positional differences of mudflow sediment blocks were observed within a three month survey season. Mainline data were collected in November of 2014 and an investigation over the same area was performed in January of 2015 which indicates downslope sediment block migration. Wind speed from a weather station off the Southwest Pass mouth indicates normal winter storm events during this time with maximum wind speeds of 34 knots and gusts of 37 knots. High resolution multibeam bathymetry and backscatter data indicate the mudflow features morphology changes during short time periods and during periods of normal weather. This presentation will not only demonstrate the ability of multibeam to map significant seafloor features in high spatial resolution, but also shows the need for high temporal resolution for survey areas with a dynamic geomorphology.

Hydrographic Education Opportunities Lightning Round 7	**Starts at 9:20 am**	**Thursday March 23, 2017**

Julia Wallace: Detecting Bathymetric and Ecosystem Changes by Shoreline Alteration and Restoration Using Multibeam Sonar Technology

In recent years, local organizations have moved to restore the anthropogenically-altered shorelines of the Salish Sea. Changes to the beach and intertidal have been observed, however little research has recorded effects on the subtidal. This region is home to several species including eelgrass (*Zostera marina*), an important species in the Salish Sea often used to indicate ecosystem health. This research utilizes multibeam sonar bathymetric data to analyze changes to subtidal seafloor structure in response to shoreline modification and investigates potential subsequent ecosystem consequences. Two Washington state study sites were analyzed, Seahurst Park in Burien, and the Snohomish County Nearshore Restoration Project in Everett. Multibeam data was acquired using a Kongsberg EM 2040 system and post-processed in Caris HIPS to generate a base surface of sub-meter resolution. The data detected eelgrass beds in addition to revealing bathymetric changes. ArcGIS was used to generate descriptive and pattern metrics such as total elevation change, percent area changed, surface roughness, and Bathymetric Position Index. Data revealed small but noticeable changes in bathymetry and the presence of eelgrass following shoreline alteration. The changes observed could indicate that restoration may have negative consequences for *Zostera* populations and may potentially affect other organisms using the sublittoral habitat.

Ryan Sim: The First Two Years: Navigating through the waters of the CHS Multidisciplinary Hydrographer Professional Development and Apprenticeship Program

For over 130 years, the Canadian Hydrographic Service (CHS), as part of Fisheries and Oceans Canada (DFO) has been the primary organization responsible for charting the world's largest coastline. CHS has been a world leader in the adoption of hydrographic survey technology, techniques and technical training programs. As such, CHS offers a Multidisciplinary Hydrographer (MDH) *Professional Development and Apprenticeship Program (PDAP)* in order to ensure its employees maintain high standards of skills and technical expertise (for junior staff). The program is unique, as it offers on-the-job learning interspersed with formal training modules and academic courses presented by both internal and external collaborators.

The following paper is designed to highlight Canada's Professional Development and Apprenticeship Program, which is in alignment with FIG/IHO/ICA guidelines. The MDH PDAP is discussed in detail and is presented from the perspective of a new employee mid-way through their progression.

Matthew Birkebak: Examining the Effects of Surface Waves on ALB Measurements
The geometry of the air-water interface is an important factor in optical ray-path calculations for applications such as Airborne Lidar Bathymetry (ALB), and optical communication through the water surface. Previous studies on lidar laser beams refracting through a complex water surface have been dependent solely on theoretical models and simulations. However, these studies lack validation from empirical measurements that were conducted under well-controlled conditions. This work presents an empirical approach using a 6x6 array of photodiodes as a spatial detector unit to perform laser beam diagnostics below the surface of the water. Beam patterns that resulted from intersection between the underwater laser beam light field and the detector array were modeled and used to calculate changes in beam position and orientation at various water surface conditions. In this study, the effects of small capillary and capillary-gravity waves with wavelengths less than 10 cm were considered. Results of the study were compared to ALB ray-path geometry calculations and corrections over a flat water surface. In addition, uncertainty attributed to the air-water interface was evaluated and implemented in total propagated uncertainty (TPU) models for ALB measurements.

Maxwell Williamson: Using multibeam sonar water column backscatter to examine physical oceanography variability in the coastal environment of the Northern Gulf of Mexico
Water column data collection has become a useful hydrographic survey tool for determining least depths over sunken vessels and obstructions, but the data has useful applications in other scientific fields. As part of a Gulf of Mexico Research Initiative (GoMRI) consortium Spring 2016 cruise aboard the R/V Point Sur, a Reson Seabat 7125 SV2 multibeam sonar was operated to collect water column and bathymetry data to investigate the mixing of pulsed freshwater plumes, from Mobile Bay into the Mississippi Bight. The stratification generated by the plume, between the fresh and saltwater layers, creates a strong acoustic impedance contrast that is apparent in the water column backscatter. This stratification/mixing layer in the water column has an effect on sound speed variability, which can have a negative impact on multibeam depth accuracy. A profiling CTD was towed behind the vessel allowing for comparison of salinity and temperature variations to the multibeam water column signal. In this project the structure of the mixing layer is examined, including turbulence and thickness of the mixing, using multibeam sonar water column data. The ability of multibeam water column data to provide insight into areas where the sound speed field is not properly captured is investigated.

Maxim van Norden Challenges in Establishing an Undergraduate Degree Program in Hydrographic Science
The International Hydrographic Organization (IHO) and *Hydro International* magazine have reported a severe shortage of hydrographic surveyors world-wide. In fact, *Hydro International* reports that vacancies and demands for personnel at sea have made hydrographic surveyors the most wanted profession in the offshore world. While The University of Southern Mississippi (USM) and the University of New Hampshire (UNH) each graduate a dozen or so highly qualified hydrographers annually at the Category A level with a M.S. degree, both programs do not address industry needs for many more hydrographers with a practical hydrographic skill set. Due to this need by the offshore industry, the Blue Economy on the Mississippi Gulf Coast, the Federal Government, and the Department of Defense, Southern Miss initiated a 4-year undergraduate degree program in Marine Science with an emphasis in Hydrography in Fall 2015. This degree program is receiving financial support from the Office of Naval Research (ONR) STEM Outreach and Workforce Program. One objective is to obtain International Board recognition for Category B in 2018. This presentation will address the challenges in establishing a new degree program in a U.S. public university that meets international standards and with marketing this unknown career to the Millennial Generation.

Paul Brett: Canadian Ocean Mapping Research and Education Network (COMREN)
The Canadian Ocean Mapping Research and Education Network (COMREN) is a newly established network within Canada, Its focus designed to provide a collaborative environment for research interests and collaboration, share educational curriculum, and collaborate on key research questions of interest to the hydrographic, and ocean science community. COMREN looks to promote increased capacity in Canada and internationally. Its members bring unique educational opportunities and research themes to the

network that will complement and enhance the programs of the individual members.
COMREN adheres to a vision to find improvements in ocean mapping systems, methods, data processing and management tools, to address challenges of ocean mapping for the benefit of environmental protection, economic development, and safety of navigation and in support of other marine activities. The emphasis will be on developing national expertise to meet the challenges of Canada's ocean mapping challenges.
The initial signatories to the founding MOU include the: Interdisciplinary Centre for the Development of Ocean Mapping (**CIDCO**), Nova Scotia Community College (**NSCC**), Marine Institute of Memorial University of Newfoundland (**MI**), University of Laval (**ULaval/SCG**) and the University of New Brunswick (**UNB**). Discussions are underway to extend this network to other research and education institutions across Canada, these include, British Columbia Institute of Technology (**BCIT**), University of Ottawa (**UOttawa**) and York University (**YorkU**).
Each member of the network bring unique expertise, capacity and equipment to the Network and the sum of its parts is far greater than the individual contributions The network intends to work as a single unit to collaborate on research questions. Collectively it forms a formidable research capacity with common vision, interests, and goals. The networks focus will provide value to industry, government, and scholarship, through primary research, applied research and development and most importantly training highly qualified personnel to address the ongoing needs of ocean mapping community.

Thursday, March 23		
The Future of Hydrography		**Session Chair: Dave Wells**
On Testing of Complex Hydrographic Data Processing Algorithms	**10:30am**	**Presented by Brian Calder**

Modern hydrography relies, more and more, on complex algorithms to resolve the soundings generated by remote sensing modalities, and to process those soundings into chartable products. Algorithm quality assurance is therefore critical to the integrity of the hydrographic effort.

At best, the algorithms used might be described in a published paper, or possibly be available as a research code-base. More often, however, they are integrated deep in proprietary code and cannot be tested or verified without great effort. For algorithms transitioned from research in one organization to operations in another, there is no guarantee that the algorithm implemented is the algorithm that was designed. And each new software release demands effectively *ab initio* testing effort.

Using the CHRT code-base as an example, a testing structure is proposed. The structure consists of an XML-based definition which packages the required data with the desired tests, and allows for exact or approximate matching of results, with control over tolerances. The XML-based output provides hierarchically aggregated summaries of test success to assist in reporting with level-of-detail control. Although intended for end-user testing, the structure has obvious benefits for developers, and acts, effectively, as the algorithm's definition: any implementation that passes the conformance suite.

A Cloud Based Solution in Hydrographic Data Processing: The Shift to a Web-Centric Software	**10:50am**	**Presented by Dan Wright**

Currently available hydrographic data processing software is mostly limited to on premises installations, requiring annual licenses and a significant investment in hardware and data storage. This imposes hardware limitations on both the speed and capacity of processing large datasets. By leveraging the tools available through cloud computing, a Software as a Service (SaaS) data processing model is proposed. As implemented, many of the limitations imposed by on premises architecture are eliminated, but many new challenges are expected in bringing a SaaS processing solution to the field of hydrographic data processing.

Using academically proven Open Source API's to build the conversion engine and create the requisite Bag output files, we will show how a cloud based solution accomplishes these tasks more efficiently and with a significant reduction in both time and cost over traditional on premise software. The model requires rigorous testing methodologies as well as the development of a secure and reliable web based interface. It will also be shown that the cloud architecture provides additional opportunities for the use of aggregated data to satisfy the evolving needs of chart producing organizations.

With these concepts in mind, it is intended to demonstrate the functionality and benefits of the proposed processing system.

2030: Ocean Stewardship and Initial Industry Contributions	**11:10am**	**Presented by David Millar**

The world's oceans are critical to sustaining life, controlling climate and providing economic wealth. Despite this and the fact that over seventy percent of the Earth's surface is covered by oceans, our understanding of the ocean and seafloor processes is limited in part to the absence of ocean mapping data.

To this end, the GEBCO - Nippon Foundation established the Seabed 2030 program to compile a high-resolution openly available Digital Bathymetric Model portraying the World Ocean seabed at the highest resolution possible from the coast to the deepest trenches by the year 2030. To achieve Seabed 2030, existing data must be identified and the remaining gaps mapped.

Fugro has been involved in the development of the Seabed 2030 roadmap and has been leading industry participation in the program. As the world's largest offshore survey companies, Fugro operates a fleet of multibeam equipped survey vessels and collects ocean floor mapping data around the globe. While much of these data are commercially sensitive and owned by our customers, lower resolution versions of these datasets could be made available to GEBCO in support of the Seabed 2030 project. Fugro has initiated this dialog with our customers and has started to contribute "crowdsourced" MBES data acquired by our vessels as they are re-positioned and move from project to project. This presentation will briefly describe the Seabed 2030 project and Fugro's initiatives to support it.

Synthesizing Bathymetric Data for Analysis and Dissemination	**11:30am**	**Presented by Caitlyn Raines**

For over a decade, Esri has been supporting the oceanographic and hydrographic communities, and the challenges they face such as sea level rise, ocean acidification, and coastal resiliency to name a few. The ArcGIS platform has a rich toolset for visualization, data management and analysis.
This presentation will outline the modern production cycle of a bathymetric survey using the Esri Living Atlas content program as an example. Esri's Living Atlas is the foremost collection of authoritative, ready-to-use, global geographic information ever assembled. The presentation will :

- Demonstrate how Esri synthesizes multiple data sources using Esri's bathymetric data management tools for the Esri Ocean Basemap, including a new basemap in beta testing.
- Cover the development and publication of ocean-related content in Esri's Living Atlas, notably the World TopoBathy elevation service.
- Discuss how to supplement the Living Atlas content with an organization's own data.
- Use Esri's templates and tools to create outreach and communication products for both public and scientific audiences.

Arctic Regional Marine Spatial Data Infrastructure (MSDI) Work	**11:50am**	**Presented by Sebastian Carisio**

Hydrographic Offices (HOs) have traditionally operated under a product-centric model: creating and maintaining individual, navigational chart products. Of course, these products will remain to support Safety of Navigation (SoN) around the world, but the modern HO is transitioning to a data-centric production environment where a centralized data store can serve any desired output. Consequently, these offices are transforming their original role as a chart provider to a hydrographic data provider. With about 5% of the data housed by the HO ultimately represented on a finished navigational product intended for use by mariners only, these raw hydrographic datasets have an additional potential to contribute to the development of other societal realms (e.g., natural resource exploration, scientific research, fisheries management, emergency management). In order to promote this data to the broader user base, the establishment of a Marine Spatial Data Infrastructure (MSDI) is generally accepted as the solution to assist the HO in assisting these new users of HO data.

A MSDI is a framework established at a common level (e.g., national, regional, international) in which people and organizations develop the proper policies/governance to allow marine geospatial data to be released through the harmonization of technical standards and information systems. A MSDI stimulates standardization, management, and interoperability of data to allow its efficient sharing and discoverability across boundaries. Furthermore, it serves as the marine dimension to the broader Spatial Data Infrastructure (SDI) which may include data from various other geospatial authorities.

In October 2016, Member States (MS) of the International Hydrographic Organization (IHO) Arctic Regional Hydrographic Commission (ARHC) established a working group under the ARHC named the Arctic Regional MSDI Working Group (ARMSDIWG). The ARMSDIWG is comprised of HO representatives from the ARHC MS that are working towards the implementation of a MSDI for the Arctic through SDI-related activity monitoring in the region, considering policies and data contributions of Arctic maritime authorities, and by working closely with open standards organizations and related projects including the Open Geospatial Consortium Marine Domain Working Group and the Arctic Spatial Data Infrastructure (Arctic SDI). The Arctic SDI is an organization of the "8 National Mapping Agencies of the Arctic countries" all operating under a Memorandum of Understanding. In its first year of existence, the ARMSDIWG has been coordinating with the Arctic SDI to explore future areas of collaboration to strengthen the overall SDI for the region.

The Future of Hydrography Lightning Round 8	Starts at 12:10 pm	Thursday March 23, 2017

Jeppe Nielsen: Future of hydrographic software

The hydrographic industry is among one of the most tradition-bound segments, yet it is influenced by the technological development in a number of adjacent industries.

This presentation covers the dominant trends seen from a hydrographic software producer that comes with extensive experience from offshore construction and similar segments.

The trends covered are 3D/4D technologies including virtual reality, sensor development including laser/mosaics/stereovision/photogrammetry, large and big data and the challenges and possibilities they represent, unmanned vehicles and how they change the way we operate, and reducing cost and the need for embracing cloud/parallel/automated processing. The trends are covered using numerous highly visual examples across a number of customer projects.

Vegard Haugen, Mark Amend: Maritime Broadband Radio – Expanding Operations Over the Horizon

Autonomous platforms have been increasing in number and sophistication in recent years for both military and civilian applications in the marine sector. Maritime autonomy platforms are generally intended for the acquisition of data from many sensors to be used together to inform decision makers, either in real-time or post-mission. With each platform design are common goals of efficiently utilizing robotics for an overarching task, either as a replacement (labor cost reduction), an extension (the 'force multiplier' concept), or as an expansion of capabilities (doing something new). By focusing on the capabilities within the overarching task, the platform manufacturers can be sure the sensor payloads will adequately meet the needs of the end-user. On the other hand, questions of scale can't simply be answered with more platforms. The simplicity of network interfacing across multiple platforms, already in wide use among sensor manufacturers on a single platform, allows for the shared use of real-time data to expand autonomous operations. In the development of multiple platform operations, current telemetry methods are limited by range, bandwidth, and cost. In this paper we present examples illustrating the potential of a phased array smart antenna to maximize coordination amongst manned, semi-autonomous, and fully autonomous platforms. Utilizing a flexible, long-range, high bandwidth solution empowers integrators and end-users to expand the capabilities of their platforms in single or multiple operational modes.

Val Schmidt: Autonomous Surface Vessels for Hydrographic Survey

The Center for Coastal and Ocean Mapping at the University of New Hampshire has begun a research effort to explore the fielding autonomous surface vessels (ASVs) for marine science and, in particular, production hydrographic work. The effort was begun in earnest in 2016 with the procurement of a "C-Worker 4" ASV from ASV Global Ltd.. The C-Worker 4 was the result of a design collaboration between the Center and ASV Global to manufacture a platform capable of full work-day operations in the open ocean, supporting a full suite of state of the art navigation and sensor packages in a small (4m) form-factor to ease deployment and retrieval for research operations. In addition, through the Center's industrial partnership program, the center has been provided a Teledyne Oceanscience "Z-boat", out-fitted with survey grade positioning systems and Odom CV100 single beam echo-sounder. The Z-boat provides rapid two-person deployment and retrieval for quick testing of new algorithms and sensors, as well as shallow water mapping capability. In this paper we discuss our thinking on the use of ASVs for hydrography, our ongoing collaboration with NOAA's Hydrographic Systems and Technology Programs, our experience with these vessels thus far and our ongoing research.