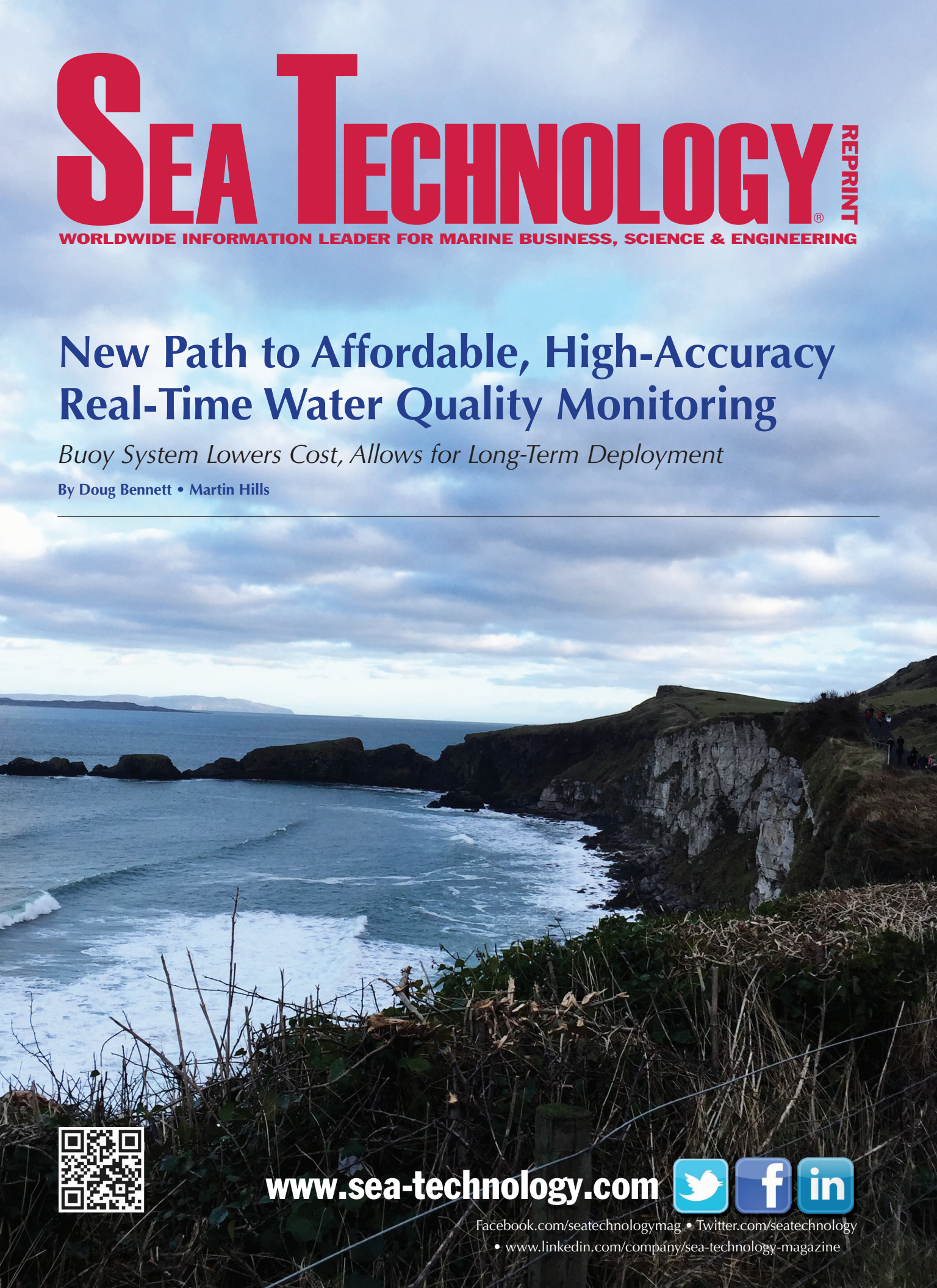
SEA TECHNOLOGY REPRINT
WORLDWIDE INFORMATION LEADER FOR MARINE BUSINESS, SCIENCE & ENGINEERING

New Path to Affordable, High-Accuracy Real-Time Water Quality Monitoring

Buoy System Lowers Cost, Allows for Long-Term Deployment

By Doug Bennett • Martin Hills



www.sea-technology.com
Facebook.com/seatechnologymag • Twitter.com/seatechnology
• www.linkedin.com/company/sea-technology-magazine

New Path to Affordable, High-Accuracy Real-Time Water Quality Monitoring

Buoy System Lowers Cost, Allows for Long-Term Deployment

By Doug Bennett • Martin Hills

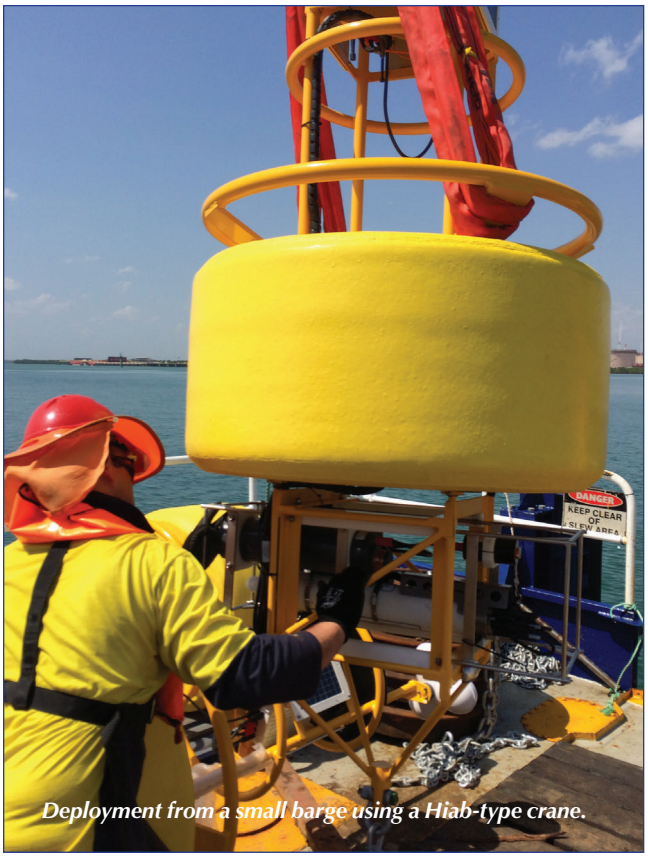
A new, real-time water quality monitoring system was deployed in October 2014 in support of INPEX Australia's Ichthys LNG project. INPEX (Perth, Australia) contractor AEC Environmental (Adelaide, Australia) collaborated with Imbros Pty. Ltd. (Moonah, Tasmania) and Soundnine Inc. (Kirkland, Washington) to build and deploy an array of eight data buoys throughout Darwin Harbor. AEC will operate the system for the life of the multiyear project to monitor changes to the predredging baseline water quality within the estuary.

AEC and Imbros worked closely to develop a specification for the data buoys that carefully considered the unique monitoring requirements and environmental conditions of Darwin Harbor, and could be economically sustained long term. Budget objectives were met by leveraging the unique features of Soundnine's (S9) DANTE System with Imbros's own simplified buoy design, as well as using instrumentation that minimized the need for on-site service. The result is a surprisingly affordable, robust and highly capable monitoring system, tailored to the project requirement for high-accuracy measurements and affordable long-term operation.

Site Challenges

The deployment site challenges are significant. The large tidal variation, monsoon conditions and remote buoy locations require a robust mooring and buoy system, capable of surviving cyclones. Timely buoy retrieval ahead of or following a storm would be impossible. The potential combination of tides and storms creates the real possibility that buoys could be dragged off station by floating debris after rain storms or pulled several meters underwater by storm surge. Imbros engineers and consultants designed the buoy specifically for the proposed instrument suite and the worst predicted conditions. The buoy structure and mooring were modeled using wind and swell data obtained during Cyclone Tracy, which devastated Darwin in 1974.

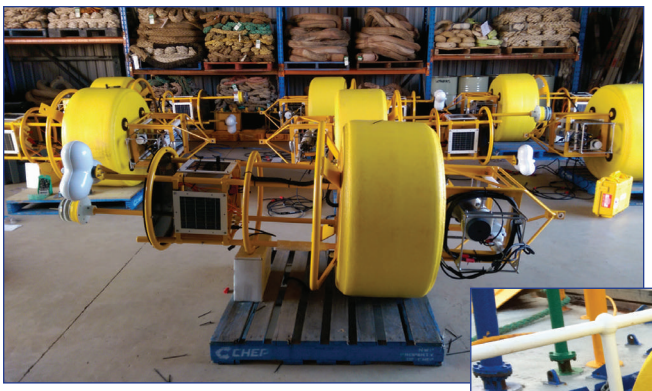
The remote mooring sites require satellite telemetry of the real-time data. Each buoy monitors water temperature, conductivity (salinity), pressure, dissolved oxygen, turbidity and pH. The long (90-day) service intervals keep operating costs down, but require sensors able to maintain accuracy in warm surface water conducive to fouling. The completed system reports scientific-quality data in engineering units directly to the end-users. Automated email alerts are also sent if measurements are out of acceptable ranges, such as in high-turbidity, low-pH or anoxic conditions.

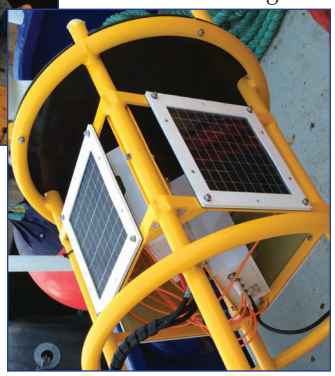


Deployment from a small barge using a Hiab-type crane.

System Design

The S9 DANTE System enabled a simpler, smaller, less costly buoy design. The modular DANTE components (controller, PowerPack and solar panels), with pre-engineered connectivity and small, tightly integrated submersible housings, eliminated the need for a waterproof compartment on





(Top) The final assembly of the eight-buoy system, performed in warehouse, was accomplished with approximately two man hours per buoy. (Middle) Instrument cage installed in the buoy substructure. (Right) DANTE Buoy Controller, PowerPack and solar panels are bolt-on, plug-in modules.

the buoy structure. The buoy design is also modular, consisting of tower, float, underwater substructure and instrument cage. The DANTE components were installed in the tower, instruments were installed in the protective cage, and the eight-buoy system was shipped compactly; each buoy in three compact modules, which saved shipping cost and enabled quick, on-site, bolt-together and plug-in assembly.

The buoys are powered by the DANTE PowerPack. It provides two 90-watt-hour batteries with independent charge controllers and four solar panel inputs. Its lithium-iron phosphate rechargeable batteries are safer and lighter than sealed lead-acid batteries, and they do not emit hydrogen gas. The PowerPack can be shipped by common carriers with no hazardous materials warnings.

Scientific-grade instrumentation from Sea-Bird (Bellevue, Washington), WET Labs (Philomath, Oregon) and Satlantic (Halifax, Canada) incorporate multiple anti-fouling mechanisms and deployment strategies for each sensor, providing unmatched initial accuracy and measurement stability, particularly in the warm estuary. The instrument cluster sits directly under the float at a water depth of 50 centimeters. It is housed in a stainless steel cage designed for easy installation and removal and is locked into place with two clamps. Cabling runs through the center of the Surlyn foam float to the DANTE Buoy Controller, where each instrument connects to its individual communication port. The substructure frame is made from 16-millimeter galvanized steel rod and galvanized steel angle stock. This provides a strong mounting point for the mooring and a sturdy housing for the instrument cluster frame. It also works well as a ballast to keep the buoy upright. Currents in the estuary are modest, so drag was not a significant concern in this design.

The simple mounting of the DANTE components allowed for a lightweight, strong and easy-to-service top structure (tower). This saved time and money during the manufacturing process. All metal components were manufactured locally, allowing more control over the quality of the end product. Made from light alloy tubing, the tower holds the navigational light, radar reflector, DANTE Buoy Controller, PowerPack and solar panels.

The DANTE Controller design eliminated failure-prone antenna mounts on the buoy tower and external RF cabling because the GPS receiver, Iridium satellite radio (modem) and antennas are all built into the waterproof controller enclosure. In fact, the entire system reduced cabling to the minimum required: one cable per solar panel, one SubConn (North Pembroke, Massachusetts) wet-mateable power cable from the PowerPack to the DANTE Controller, and one from each of the three underwater instruments to the controller.

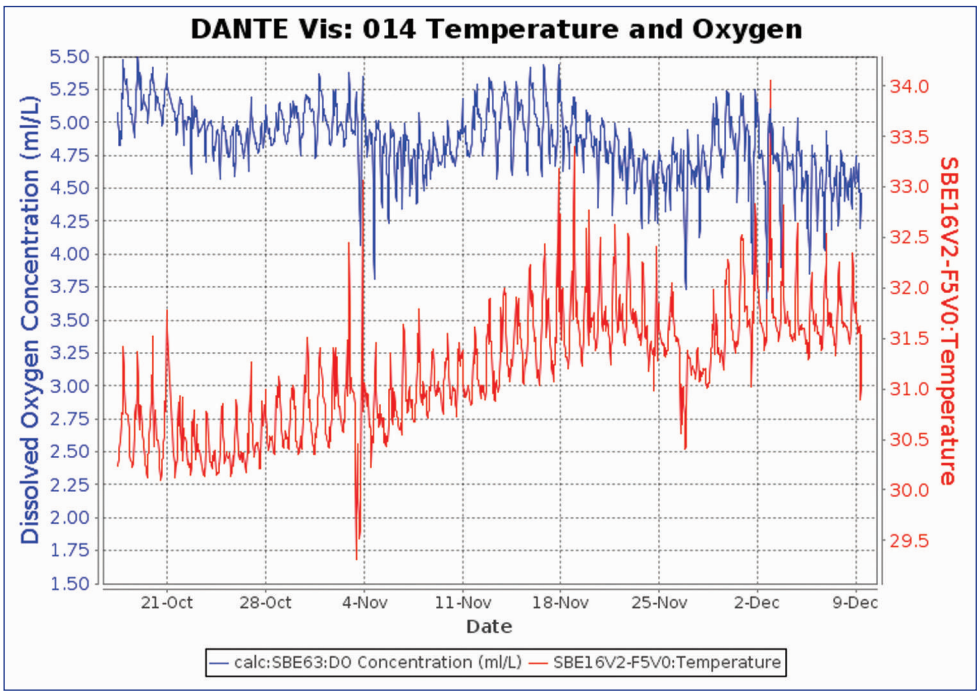
The DANTE Buoy Controller and Solar PowerPack modules are securely mounted via threaded holes in their enclosures to a sliding plate for easy access to connectors during initial instrument installation and on-site maintenance. The 5-watt solar panels fabricated by Soundnine are flexible (no glass), nonmetallic, immune to immersion and corrosion, and supplied with IP69k-rated stainless M12 connector cables that plug in securely to the PowerPack. The panels have mounting holes for easy bolt-on installation. The 12-volt, 14-ampere-hour PowerPack easily maintains full charge with two solar panels, although four panels were used for redundancy. A fully-charged battery provides reserve capacity for approximately 30 days of operation without charging.

When the sensor sampling details are known in advance, Soundnine preconfigures each DANTE Controller before shipment, allowing a true plug-and-play experience. In this case, the DANTE Controllers were delivered to Imbros before the sensor sampling setup was finalized.

Soundnine helped test instrument connections, configure sensors and write sensor driver scripts through a few remote computer log-in sessions with Imbros staff. This proved quite efficient, although S9 staff would have been happy for the chance to visit Tasmania for more in-depth training.

The controller runs a simple driver script for each sensor every time it takes a sample. Sensor communication is both logged on a memory card and forwarded to another internal processor for parsing and data transmission. The integration process was completed with a firmware update, including parsers for new data formats.

The buoys transmit a data packet of 100 bytes every hour using Iridium short-burst data. These packets include all sensor data and system status (battery voltage and current, charging voltages and currents, subsystem power consumption, housing internal humidity and temperature). Data packets are encrypted for security and to prevent spoofing. Packets are received from the Iridium network by redundant DANTE servers at a data center in Sydney, Australia. Messages are decrypted, archived and parsed on the DANTE



A seven-week time series shows increasing average temperature with corresponding decrease in dissolved oxygen.

servers, then distributed by email and published to a database for convenient and secure access. The DANTE servers also perform range tests on the data with automatic email alerts when parameters are out of range.

The free DANTE Vis software package provides data access, conversion and plotting and provides secure end-user control over DANTE server alert thresholds, email addresses and data delivery options. Server configuration can be downloaded directly from each server, modified, saved to local files and uploaded again to DANTE servers with no assistance from Soundnine.

Integration, Testing

Imbros was very happy with the help and support from Soundnine during the integration and testing phase. In the initial online meetings and training sessions, Imbros staff quickly gained working knowledge of how to operate the DANTE system, modify the basic settings for each sensor and configure the communication settings. The DANTE Controller provides clear commands and responses via DANTE Config software to ensure the correct setup. After training, Imbros staff has found the DANTE Vis software easy to navigate and use.

During Imbros's initial testing after connecting the sensor suite, it was noted that the Sea-Bird dissolved oxygen sensor (SBE 63 ODO) and WET Labs turbidity sensor, both integrated with an SBE 16plus SeaCAT CTD, only output voltage or counts, and that the DO sensor serial number was not included in the 16plus output data. This would have required the inconvenience of applying calibration coefficients after raw data were transmitted to shore. Also, the omission of DO sensor serial numbers from the SeaCAT output meant there was no automated way to know which DO sensor was integrated with which SeaCAT. This created an intractable data housekeeping burden, particularly over the multiyear life of the project as sensors were swapped in the field for calibration or maintenance and integrated with different SeaCATs over time. Soundnine solved the problem quickly and without additional cost by adding features to DANTE Vis enabling users to enter calibration coefficients and serial numbers in a report configuration file that in turn enabled DANTE servers to convert the raw data to engineering units in real time and include the DO sensor serial number in the data report.

Results

Imbros reported: "By the time the complete system was delivered to the end-customer, the DANTE Controllers were literally a plug-and-play device. The data coming into the designated email addresses are informative and simple to understand. DANTE status information, which automatically appears in the data reports, is also a nice touch. Knowing the GPS position, battery voltage, solar charge current and internal temperature and humidity of the DANTE Controller assures us the buoy is in the correct location and functioning as expected."

The DANTE System contributed to cost savings in hardware, shipping and integration in two ways: It allowed the local fabrication of simpler, less-expensive buoys than would otherwise have been possible, and it contributed to fast, easy integration and assembly.

As a result, more of the monitoring budget was allocated to deploying science-grade instrumentation with the high accuracy and long-term stability needed to ensure data integrity over a much longer time scale than previous efforts were able to produce. ■

Doug Bennett is vice president of Soundnine Inc. He has 30 years of international oceanographic instrumentation sales, marketing and product development experience, with technical specialties in temperature, conductivity (salinity) pressure, dissolved oxygen, current and water quality instrumentation, and their application to measurement platforms, including ships, buoys, seafloor observatories, AUVs and gliders.

Martin Hills is the technical director of Imbros Pty Ltd., with 36 years of experience in the marine technology field. He oversees the Marine Sales and Engineering Divisions for Imbros. Hills is known for his passion and innovation in applying oceanographic equipment, both in supporting customers and as part of Imbros's in-house research and development projects.

©Copyright 2015 by Compass Publications Inc. *Sea Technology* (ISSN 0093-3651) is published monthly by Compass Publications Inc., 1600 Wilson Blvd., Suite 1010, Arlington, VA 22209; (703) 524-3136; oceanbiz@sea-technology.com.
All rights reserved. Neither this publication nor any part of it may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of Compass Publications Inc.