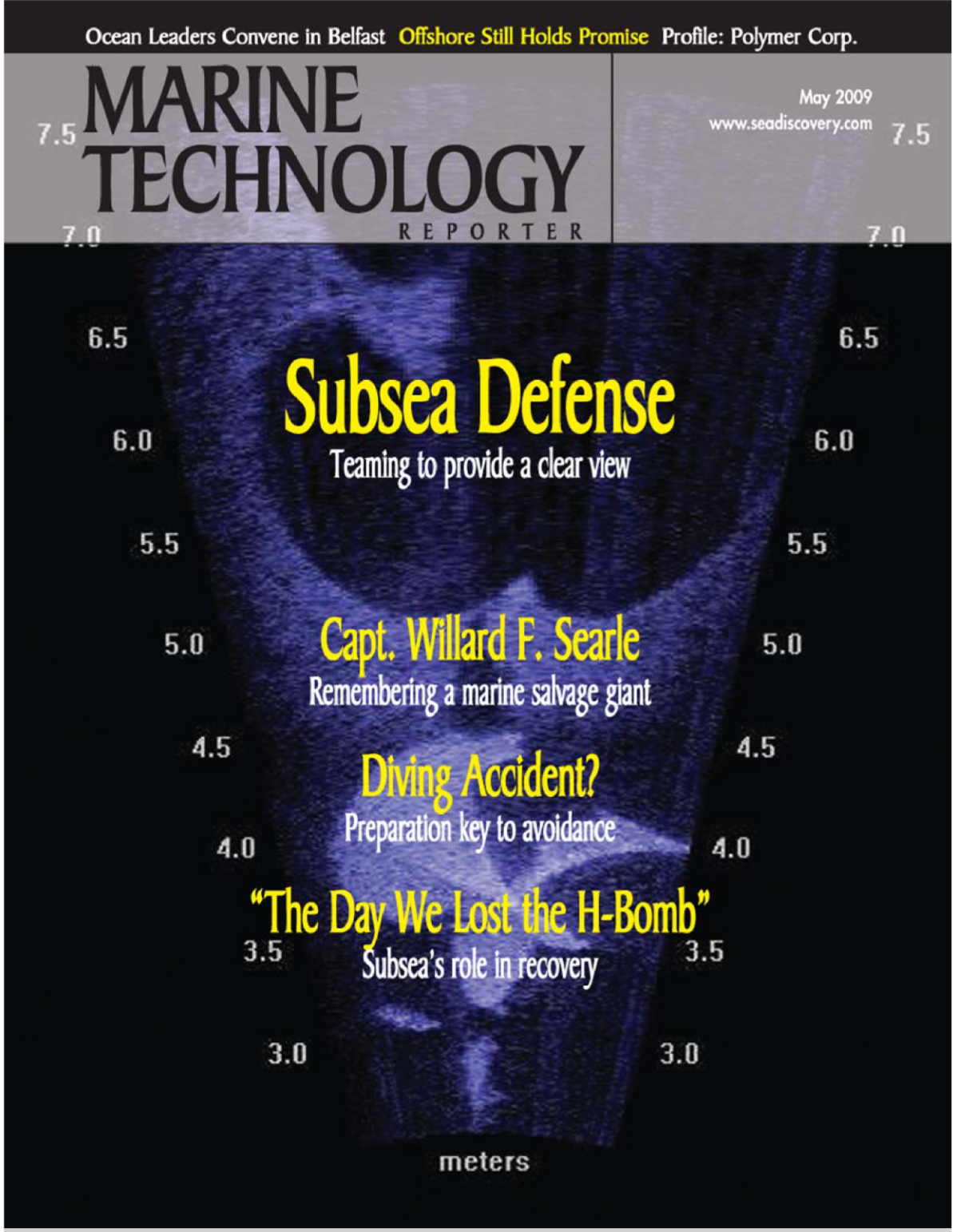


Bluefin

HAUV Makes its Mark

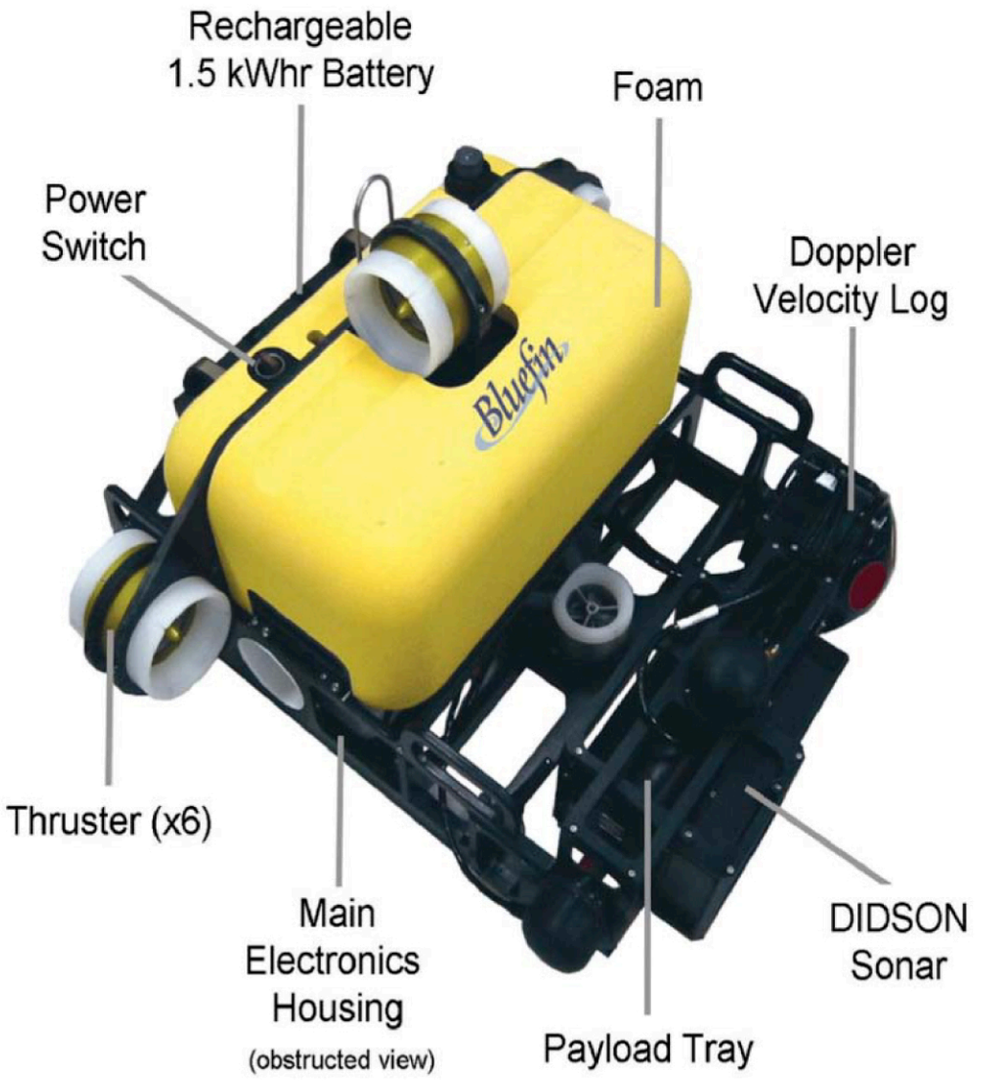
by Greg Trauthwein, Editor

Advances in subsea vehicle technology are rapidly evolving to keep pace with market demand ..or ..is rapidly evolving market demand driving advances in subsea vehicle technology? Both could be convincingly argued, and regardless of your position, technology and demand seem to be running in a dead-heat. MTR had the opportunity to garner the insights of one of the market's technological leaders, David Kelly, President of Bluefin Robotics, who discussed the seven-year evolution of his company's HAUV – the Hovering Autonomous Underwater Vehicle.

Like so many other stories of great technological innovation, the story of the Hovering Autonomous Underwater Vehicle – or HAUV – starts from academia, entails investment from the military, and includes a collaboration of private and public entities.

Bluefin Robotics was born from the halls of academia, founded in May of 1997, formed from a core team of the Sea Grant Autonomous Underwater Vehicles Laboratory at the Massachusetts Institute of Technology, with which it is still closely associated. Along the path to 2009, Bluefin has become a diversified corporate entity, providing a broad scope of technologies, from concept to finished product, across the scientific, commercial and military markets globally.

"The Hovering Autonomous Underwater Vehicle (HAUV) has been under development for seven years," said David Kelly, president and CEO, Bluefin Robotics, and its origination and development was driven by the Navy's need for a truly efficient, autonomous hull inspection system. In short, the Navy wanted to develop a sys-



The Bluefin Hovering Autonomous Underwater Vehicle (HAUV2) is equipped with a DIDSON Sonar mounted on an independently controlled payload tray enabling 100% coverage of the hull. DIDSON is manufactured by Sound Metrics Corp.

The HAUV2 is two-man deployable. HAUV2 being deployed in the summer of 2008.

tem that made a tough, mundane, dangerous but important task more efficient and safe.

Now in its "second-generation," Bluefin's HAUV is currently under evaluation by the Navy for procurement for its stated goal: an efficient fully autonomous hull inspection tool.

While the HAUV is stamped with the Bluefin name, Kelly is quick to commend a long list of partners in the project, partners that include:

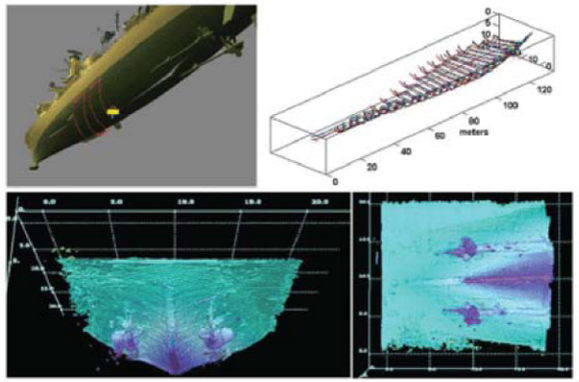
- MIT (feature based navigation & control)
- Florida Atlantic University (high speed acoustic communications)
- the University of Michigan (video feature-based navigation, as well as mosaicing)
- Seebyte (automated target recognition, control around complex areas and real-time mosaicing),
- Acoustic View (mosaicing under EOD HULS contract)
- Sound Metrics Corp. (DIDSON Sonar) and
- ScienceGL (3D rendering)

To date, four vehicles have been built for the Office of Naval Research and the Explosive Ordnance Disposal Hull Unmanned Localization System (EOD HULS), and have performed well in eight demonstrations from San Diego to Italy "From a developmental view, we have gone from proof of concept into an engineering model which is ready to go into a production run," said Kelly. "The US Navy is fully committed to the program; ONR on the development side and the PMS-EOD office on the user side. We are currently in Phase 2 of the EOD HULS program."

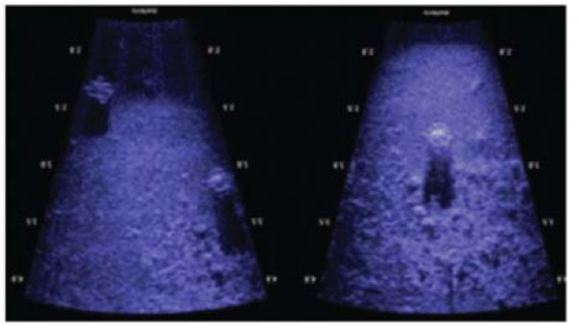
Chart 1

Demonstration	Location	Date	HAUV1A	HAUV1B	HAUV2	Target Ship
EOD/SPAWAR	Quincy, MA	6/2005	✓			Heavy Cruiser
HULSFest	San Diego, CA	2/2006	✓			Research Vessel
NATO HPT	La Spezia, Italy	4/2006	✓			Submarine
AUVFest'07	Panama City, FL	6/2007	✓	✓		Barge
EOD HULS Demo	San Diego, CA	8/2007	✓			Cruiser
AUVFest'08	Newport, RI	5/2008	✓	✓		Aircraft carrier
EOD HULS RTC&E	San Diego, CA	12/2008			✓	Seaplane tender
Trial KONDARI	Sydney, Australia	2/2009		✓		Landing ship

HAUV provides a stable platform for sensors to capture high quality data images of subsea objects. This mosaic of seafloor debris was provided generated with AcousticView.



HAUV provides precise, accurate and persistent positioning ideal for change detection applications. Top Left: A representative track of a hull survey. Top Right: Trackline data of an actual hull survey. Bottom: 3D profiling of a hull survey rendered by ScienceGL, Inc.



At AUVFest 2008, a 200 x 4 meter area of the USS Saratoga hull was surveyed in approximately 15 minutes. Several mine-like objects were successful recognized, as shown in this raw DIDSON Sonar data.

While the primary focus of the vehicle has been for a specific military purpose, Kelly said that there has been serious interest in the vehicle for a wide variety of military, port and harbor security, as well as commercial duties.

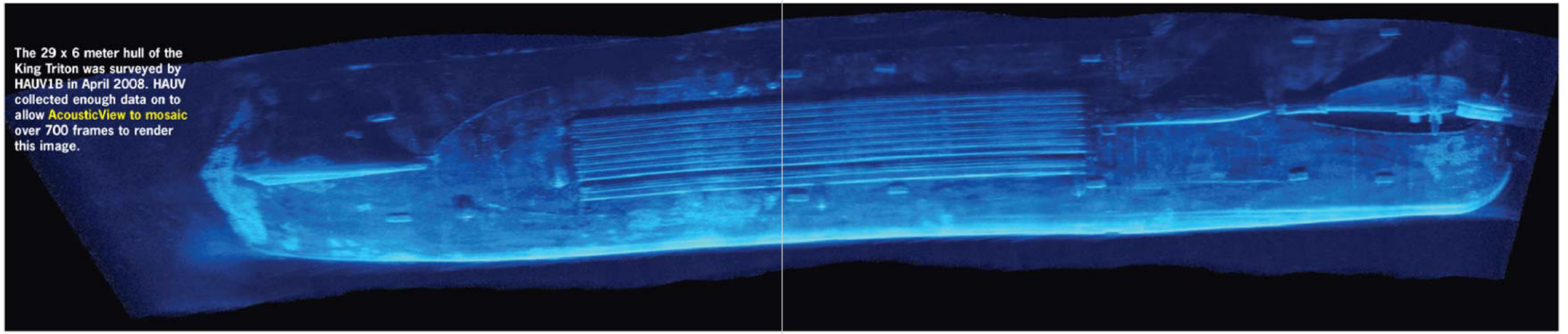
"Based on the platform's original design objective, the HAUV is capable of rapidly and accurately surveying the hull of a ship removing the diver from mundane and/or dangerous situations," Kelly said. He noted that the HAUV is designed, and has proven time and again through testing and demonstration, to be able to survey the hull – both the straight, flat easy portions, as well as the complex areas around the shafts, propellers and rudders, helping to minimize the need for diver in laborious, mundane and occasionally dangerous situations.

But while ship hull survey has been the driving force in the development of the HAUV, "many other applications have emerged as well."

To illustrate its functionality, Kelly points to HAUV's performance at a recent demonstration, where a 200 meter long structure was survey in just 15 minutes.

Beyond performing ship hull inspections, the HAUV – which is designed to offer superior performance in low visibility and/or dangerous areas while performing long and/or mundane tasks – will be suited to accomplish a variety of jobs in the mainstream commercial market, including: ship hull inspections; industry Inspection Repair Maintenance (IRM) missions for offshore rigs; high value commercial vessels, port facilities and offshore structures such as LNG mooring systems; underwater inspection in lieu of dry docking (UWILD); as well as dockside, pier and harbor bottom survey. Importantly, the vehicle is outfitted with the sensors and capability for change detection, a crucial capability in both security and maintenance surveys.

While the current vehicle is suitable for commercial applications, Kelly said it would be more reasonable to outfit the vehicle with different, more commercially suitable sensors for specific missions. Bluefin is currently working on its own commercial demonstrator HAUV, which is scheduled to be ready for demonstrations to the



The 29 x 6 meter hull of the King Triton was surveyed by HAUV1B in April 2008. HAUV collected enough data on to allow AcousticView to mosaic over 700 frames to render this image.

commercial market in the second half of 2009.

The Vehicle

The HAUV is an ROV-form-factor UUV that is a self-propelled, unmanned underwater vehicle, able to be deployed by two people. It weighs 78 kg and measures 42 x 40 x 25 cm, and is made up of the following components:

- six hubless bi-directional DC brushless thrusters
- a main electronics housing containing core electronics
- a pressure tolerant, rechargeable, 1.5 kWh lithium polymer battery
- an independently controlled payload tray mounted with a DVL and a DIDSON Sonar
- a 1200 kHz RD Instruments DVL
- Sound Metrics DIDSON imaging sonar
- flotation foam
- ballast weight

Data transmission between the vehicle and the operator station is through a fiber optic tether, though the tether is only needed if the operator requires immediate data and visual feedback. Otherwise, the vehicle is able to operate free from physical connection, recording data for download upon retrieval.

Central to the HAUV's capabilities is its ability to achieve full hull-relative navigation control, meaning that the vehicle can be operated without having to install any equipment on or around the hull.

While designed to work autonomously, the operator can, with a tethered HAUV, take control via joystick and steer the vessel for a closer look at objects of interest.

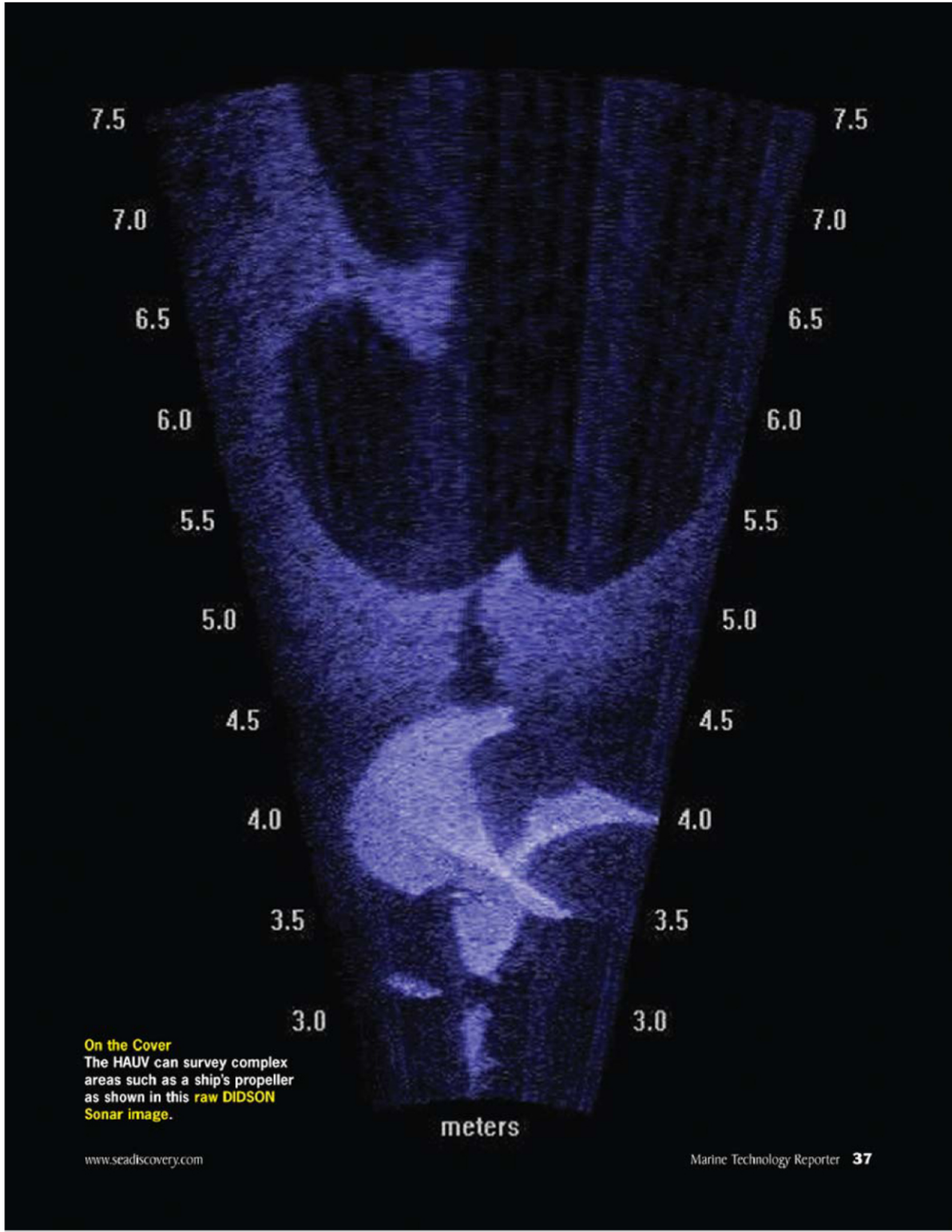
"You toss the vehicle in the water and it goes," Kelly said. The vehicle senses the hull by DVL, and relative navigation and control is via DVL, IMU and depth sensors. The vehicle maintains a consistent and safe distance away from the hull, and six thrusters provide control as the vehicle navigates its survey path.

"The capability requirement is to do the job without having any 'a-priori' knowledge of the hull to be surveyed," Kelly said. Using DIDSON provided by Sound Metrics, the HAUV consistently provides a video quality picture in turbid or dark water.

The vehicle is designed for ease of operation, and according to Kelly one of its main advantages is the fact that a trained ROV operator is not needed to run a mission. Before deploying the vehicle, the operator needs to simply answer five questions (such as stand-off distance, spacing between passes, etc.) in the Bluefin Operator Software Tool Suite; place the vehicle in the water and drive it close to the hull, on the surface, under operator control. The operator then, on the computer, clicks "auto", the vehicle senses the hull by DVL, and the vehicles six thrusters provide control as it navigates a survey path a consistent and safe distance from the hull. Data from the DIDSON sonar is viewed in real-time via the fiber optic tether, or, when in operation in full autonomous mode, the data is recorded and retrieved with the vehicle.

While the vehicle is fully autonomous, the operator can take control of the vehicle via a joystick to revisit a particular area of interest. Even in this mode, however, the vehicle maintains an optimum altitude and position from the hull.

According to Kelly, achieving hull-relative navigation and control with limited prior knowledge of the hull was one of the greatest challenges in creating the HAUV, but ironically, with the vehicle's success, this challenge has essentially become a strength of Bluefin Robotics.



On the Cover
The HAUV can survey complex areas such as a ship's propeller as shown in this raw DIDSON Sonar image.