AUVs in the Bay '09

NOAA's Chesapeake Bay Office Holds Workshop To Promote the Use of AUVs in Classrooms, Research

By Lauren Masterson
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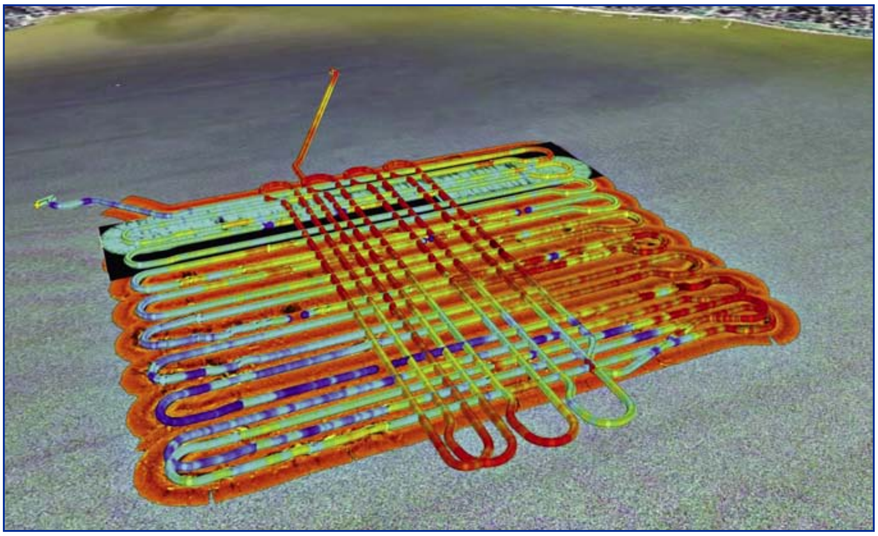
At the recent three-day autonomous underwater vehicle (AUV) workshop, AUVs in the Bay '09, *Sea Technology* had the opportunity to experience the capabilities of this technology firsthand, seeing the vehicles' design up close, their deployment and the data they collected.

This involvement with technology was exactly the purpose of the event, according to organizer Doug Levin of NOAA's Chesapeake Bay Office (NCBO). He emphasized that hands-on experience with technology is one of the best means of getting students engaged and excited about science, technology, engineering and mathematics (STEM) learning.

"We've got to make this stuff neat for kids to use," Levin said.

Held on June 16 through 18 at the Philip Merrill Environmental Center in Annapolis, Maryland, the event was designed as a means to display and demonstrate emerging technologies in the field of AUVs and, in particular, ways to get these technologies and the scientific opportunities they offer into the classroom. Attendees ranged from representatives of companies like Hydroid (Pocasset, Massachusetts) and YSI Inc. (Yellow Springs, Ohio) to educators from major research universities, local high schools and programs teaching science to at-risk students. Teledyne RD Instruments (Poway, California) helped sponsor the workshop.

In addition to introducing educators to the potentials of this technology in the field of education, the workshop was also intended to demonstrate the benefits AUVs could provide to researchers studying the Chesapeake and other estuaries, according to the organizers.



Color plot of temperature information overlaid on 900-kilohertz side scan sonar images from the Gavia. A single line of gridded bathymetry data (light blue and turquoise on a black background) is also included. (Image courtesy of Dr. Art Trembanis, CSHEL)

"What surprises me is that this stuff continues to advance rather quickly, in terms of not only the technology, but the applications," Peyton Robertson, director of NCBO, said. "Some of the technology you're going to be exploring here gives us even more opportunities to explore the bay."

AUV Launch

The first day saw the launch of the four participating AUVs: a YSI EcoMapper, a Hafmynd ehf (Reykjavik, Iceland) Gavia owned by the University of Delaware's Coastal Sediments Hydrodynamics and Engineering Laboratory (CSHEL) and two Hydroid remote environmental monitoring units (REMUSs), one owned by Rutgers and the other by the U.S. Naval Academy (USNA).

The vehicles had each been assigned their own 0.5-square-kilometer mission areas, and their operators had configured them to collect data that would suit their particular capabilities.

A familiar sight on the bay caused concerns from the start. The crab boats floating just offshore and their networks of pots under the surface presented a maze of lines for the AUVs to navigate around.

Obstacle avoidance is still a relatively weak point of the vehicle technology, the experts warned, and operators worried that their AUVs could get tangled in a line, aborting the mission and leav-

The Rutgers Hydroid REMUS waits on the beach for deployment. (Photo courtesy of John Higinbotham, Emergent Space Technologies)

ing them with the unenviable task of locating the devices under the waves.

Weather was also an issue—it was an unusually chilly day with a good amount of wind. The vehicles bobbed up and down in the surf, giving some operators concerns that they might be pushed off course or suffer interference with their communications to shore.

Despite these issues, the launch continued as planned. The Gavia was first to hit the waves, deploying from a NOAA Zodiac (Paris, France) Hurricane rigid-hull inflatable boat (RHIB).

CSHEL's Gavia—the development of which was originally funded by the Icelandic government to assess the impact of trawl fishing on the nation's seafloor—was equipped for International Hydrographic Organization (IHO)-quality bathymetric mapping. It features a Doppler velocity log-aided inertial navigation system, a 900/1,800-kilohertz Marine Sonic Technology (White Marsh, Virginia) side scan sonar, a GeoAcoustics Ltd. (Great Yarmouth, England) 500-kilohertz GeoSwath phase-measuring bathymetric sonar and a bottom-looking camera that snaps images of the seafloor.

The next AUV in the water was the REMUS, operated by Rutgers. Unlike the Gavia, it was launched from the beach, with two people carrying it into the water and lowering it in. In addition to benthic mapping, the REMUS was uniquely equipped for water-quality monitoring, featuring sensors to measure dissolved oxygen; conductivity, temperature and depth; dissolved colored organic matter; and chlorophyll a.

The EcoMapper was next to deploy. Weighing about 50 pounds, it could have been launched from the beach by a single person, but due to the hazards of the choppy seas and the maze of unseen crab pots, the YSI representatives chose to launch it from the Hurricane. This also allowed the vehicle to conserve battery power, since it did not have to travel as far to reach its mission area. Like the Rutgers REMUS, it was also equipped to measure water-quality parameters such as pH, conductivity and temperature, dissolved oxygen, turbidity, chlorophyll and blue-green algae.

The USNA's REMUS was the fourth and final AUV to be deployed, but the team grappled with technical issues. The AUV hit a snag when the team realized their vehicle was having problems with its propeller. After the team swapped it out with a new part, it seemed the vehicle could go ahead with its mission. Unfortunately, once the team got the REMUS in the water, it still would not start, and the mission could not be completed.

Expert Talks

After the launches, the technology experts on hand stressed the benefits that AUVs offer to various fields of ocean research.

The potential of AUVs for water-quality monitoring was discussed, with Levin suggesting the vehicles could be an asset to the Chesapeake Bay buoy monitoring system, transiting between the buoys to drop off their data and power up as they monitored much broader swaths of the bay.

Other presenters from academic institutions, industry and government agencies demonstrated the various AUVs' capabilites with data and images from research around the world.

Mission Results

On the second day, the teams announced the results of their missions in short presentations.

Gavia. The Gavia AUV completed the entire planned mission of more than 18 kilometers with a run time of about 3.5 hours. The vehicle completely covered the survey grid in a series of 19 north-south trending lines with alternating spacing of 30 and 15 meters to allow for overlap of the side scan and swath bathymetry sonar footprints.

The mission was executed in a terrain-following behavior whereby the robot maintained a standoff from the seabed of four meters. In addition to the 19 north-south lines, an additional set of 10 parallel east-west lines was run through the mission grid area to provide additional coverage and cross-calibrating data for the bathymetry sonar system. At the end of the mission, the vehicle came up just at the planned end point for the awaiting RHIB.

Upon recovery of the AUV dockside, the team transferred more than two gigabytes of bathymetry data, 200 megabytes of side scan sonar data and tens of thousands of discrete observations of water-quality parameters (i.e., temperature, salinity and turbidity) from the AUV mission logs.

When reviewing the data, the team noted that their fears about the shallow depth and choppy surface had not been unfounded. There had been a surprisingly large number of emergency brake maneuvers triggered by the forward-looking obstacle avoidance sonar on the nose cone of the vehicle, they said, meaning that the AUV had periodically stopped and floated upward to avoid the potential obstacle before continuing on the mission.

Ecomapper. The YSI EcoMapper collected data once every second as it covered the 0.5-square-kilometer area and stored them in a log file in its computer.

The vehicle made eight passes through the mission area. The operators programmed the AUV to undulate through the water column, from the surface down to a roughly 15-foot depth. After following this pattern for most of the mission, it performed two passes just at the lowest point of its pattern. Once the EcoMapper completed the mission, it stayed in a park set up on the surface in a five-meter circle until it was picked up.

The team found that as the vehicle dove to 15 feet, the dissolved oxygen dropped, from 9.9 milligrams per liter on the surface to 8.2 milligrams per liter at the lowest depth. When the vehicle came back to the surface, the same change was captured with the dissolved oxygen sensor. This trend was seen throughout the mission as the undulation continued.

REMUS. Unlike the other two AUVs that were able to complete their missions, Rutgers' REMUS 100 did not operate on a preplanned lawnmower pattern, but instead relied on dead reckoning (DR) as its primary navigational mode. This was mainly due to the fact that multiple ranging transducers (of unknown frequency and coding structure) were in use by other participants in the demonstration area, producing a potential risk of navigation signal collision.

This use of DR, meaning not deploying REMUS's ranging units and disallowing the use of transducer fixes in the REMUS program, mitigated this risk, the team said.

Playback of the resulting mission demonstrated that the use of DR was, in this case, adequate for hydrography description, benthic characterization and safe mission navigation, but that an unusual amount of navigational error (judged against past DR missions) caused unacceptable lack of precision for the purpose of geolocating benthic targets. This was likely due to a crew action when getting a local compass calibration, the team said, and could have been further mitigated by obtaining surface calibration fixes using the global positioning system more often.

Despite this level of drift, the team explained that the results still showed that DR should be seriously considered as a navigational option for AUV missions that do not require high navigational precision, such as some types of hydrographic or fisheries missions. Especially for high aspect ratio mission paths, DR can greatly decrease complexity during operations because of the reduction in ranger mooring risk and deployment, initial programming and predeployment adjustments to the program's ranger coordinates, they said.

The team concluded that REMUS was able to maintain a constant and steady height above the bottom with little pitch or yaw associated with towed packages, so that the 600-kilohertz Marine Sonic side scan had a stable platform near the bottom. This allowed the Rutgers team to collect clear, detailed echogram images of the bottom and showed the AUV's applicability to both mapping and fisheries missions.

Conclusions

All in all, the AUVs in the Bay '09 event gave educators, researchers and governmental decision makers a chance to see these vehicles in action and observe the data they are capable of collecting, in the hope that this technology may become a better tool not only in research, but in federal initiatives like marine spatial planning and STEM education from the grade school to university levels, the organizers stressed.

Larry Mayer, director of the University of New Hampshire's Center for Coastal & Ocean Mapping/Joint Hydrographic Center, may have best summed up the workshop's goals in his presentation on the use of AUVs in marine mapping. He pointed out that humans have mapped the dark side of the moon much more throughly than the vast majority of the ocean.

"We do have the technology to do it, and you see it in these four vehicles," he said. "We just have to have the will to do it." ■

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