Robots to sniff out oil spills and algal blooms in the ice-covered Arctic

March 4 2020, by Lara Streiff

Engineers from MBARI and WHOI transport the LRAUV Polaris across the frozen surface of Bog Lake. Credit: Ben Yair Raanan © 2020 MBARI

Bundled in snow gear and wielding a chainsaw, a team of engineers cut a rectangular block from the solid ice underfoot, carving an entryway for their underwater robot. They plopped the torpedo-shaped vehicle, named Polaris, into the dark hole notched out of the surface of Bog Lake, Maine, and it slid smoothly into the water. The field trial—a collaboration between MBARI and Woods Hole Oceanographic Institute

(WHOI)—marked the first time an MBARI long-range autonomous underwater vehicle (LRAUV) had ever traveled beneath an ice sheet. But it won't be the last—Polaris or similar robots may eventually be used to sniff out oil spills and algal blooms in the ice-covered Arctic.

Autonomous underwater vehicles (AUVs) can carry a variety of instruments, including those that measure water temperature, collect water samples, or record sound underwater. Scientists and engineers generally deploy these robots off the side of a ship. The vehicle then navigates the surrounding waters on its own, and completes its mission within a day or two.

Polaris, however, is one of MBARI's long-range AUVs (LRAUVs), designed to stay out in the water for weeks at a time. Though other underwater robots can stay at sea for extended periods, the LRAUV carries all the essential sensors for long-term monitoring studies and is much more cost-effective than using a research vessel and crew to collect the same data.

"Long-range capabilities for AUVs are still relatively new," said MBARI Senior Software Engineer Brian Kieft. "All our LRAUVs were designed to eventually be able to operate with an overhead ceiling—such as an ice sheet—but this project is unique because, after almost 25,000 hours at sea, it's the very first time an LRAUV has actually been under the ice."

MBARI Engineer Brett Hobson helps prepare the LRAUV for a test run under the ice. Credit: Sean Whelan/WHOI

Most AUVs come to the surface periodically, using GPS to figure out where they are. But surfacing is not an option when operating below an ice sheet; instead, Polaris maneuvers through the water using its speed, heading, proximity to an acoustic beacon, and sonar to estimate its position continually.

While Polaris travels under the ice, scientists can keep tabs on the robot and download small amounts of data using an underwater acoustic transducer lowered into a hole in the ice. The LRAUV can detect and

locate such acoustic beacons up to five kilometers (over three miles) away. Researchers can expand the LRAUVs range by drilling additional holes in the ice and placing transducers in them. "That gives you five kilometers of range around each hole where you can still get data back and determine what's happening," explained Kieft.

At the end of its mission, Polaris needs to find and dock to a rope hanging through the ice—its docking station. The under-ice LRAUV is equipped with a special docking nose framed by two metal "whiskers" that help it latch onto this thin vertical line. By homing in on an acoustic beacon, the robot can return to the dock if there are any issues during deployment. "That's home sweet home," said Senior Mechanical Engineer Brett Hobson. "The dock is the only place where it can stop, the only place where it is safe."

Before going where no other LRAUV has gone before, Polaris was tested off the shores of sunny California. Two summers ago, MBARI scientists and engineers dispersed a plume of fluorescent-green biodegradable dye into the dark blue waters of the Pacific. The engineers then tested the robot's ability to track the plume's edges—a skill that could translate into detecting patchy oil spills or algal blooms. The tests in Santa Barbara and Monterey Bay, like those in Bog Lake, were funded by a grant to the University of Alaska's Arctic Domain Awareness Center (ADAC) by the US Department of Homeland Security.

Engineers from WHOI and MBARI reinstall fins and propeller on the LRAUV while keeping the vehicle's nose in the water so the mechanical parts don't freeze. Credit: Sean Whelan/WHOI

After conducting field trials in the below-freezing temperatures of northern Maine, the engineering teams can more fully appreciate the autonomous design of their vehicle. "In theory, once you drop the LRAUV in the water, you can go home," said Hobson. "It can be operated from a browser on a computer, which can be located anywhere in the world." This would be a very appealing option for Arctic deployments. But even the hardiest AUV is not immune to frigid temperatures. At Bog Lake, the engineers had to wrap the robot in heating blankets when it was not in the water, to prevent its mechanical components from freezing up.

As bad as conditions were in Maine, Polaris will soon face even harsher climates. Shipping traffic and oil exploration are increasing in the Arctic, leaving the Coast Guard concerned about an increased risk of oil spills. In the event of a major under-ice spill, an ice shelf's smooth white facade could completely conceal the oil from view as it spreads underneath, causing widespread environmental damage and making containment difficult or impossible.

"You can't really know what's happening under the ice with traditional observing methods," said Kieft. The ADAC research group hopes that by deploying LRAUVs equipped with instruments to measure concentrations of oil in water, they can rapidly map a spill, track its movement, and possibly even identify the source of the seepage.

Designing a robot that can dive beneath an ice sheet, track a plume, and find its way back required lots of on-site engineering. "We changed a lot of the behaviors of this robot," said Kieft. "Some of the technology, such as the docking capability that we've developed for this project, could have far-reaching benefits for scientists at MBARI, and hopefully scientists around the world, whether it's under the ice or in open water."

The next stop for the robot will be the Great Lakes in March, followed by Barrow, Alaska in July. The design of the LRAUV has been licensed to WHOI, which plans to build additional vehicles. Though MBARI will continue to provide support, Polaris has been officially handed over to the scientists at WHOI, who will operate it going forward.

Provided by Monterey Bay Aquarium Research Institute