Nereid under-ice vehicle is a powerful new tool for polar science

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Nereid Under Ice is remotely operated by pilots aboard a surface ship via a lightweight, micro-thin, fiber-optic tether, which relays in real time environmental data, including high definition imagery of what the vehicle "sees" as it explores, maps, and gathers data beneath undisturbed sea-ice away from the disruptive impact of an ice-breaking research ship. Credit: Chris German, Woods Hole Oceanographic Institution

Scientists studying the harsh and rapidly changing Arctic environment now have a valuable new tool to advance their work—an innovative

robot, designed and built at the Woods Hole Oceanographic Institution (WHOI) that is changing the way scientists can interact with and observe the polar environment.

Over the past 30 years, the Arctic has warmed more than any other region on Earth. As sea ice continues to thin and melt, understanding the rapid changes going on in this sensitive part of the world and its ecosystems becomes even more crucial.

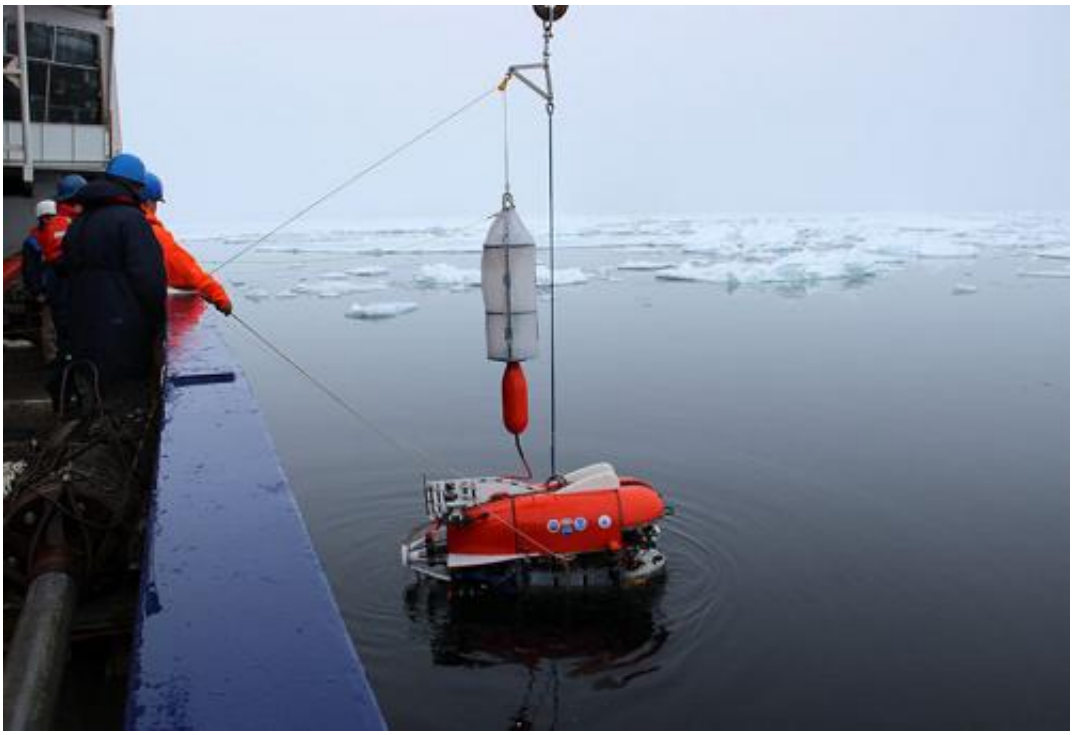
The new vehicle, called Nereid Under Ice (NUI), is remotely operated by pilots aboard a surface ship via a lightweight, micro-thin, fiber-optic tether, which relays in real time environmental data, including high definition imagery of what the vehicle "sees" as it explores, maps, and gathers data beneath undisturbed sea-ice away from the disruptive impact of an ice-breaking research ship. This real-time view allows scientists to direct the vehicle's path and collect data of interest based on their visual feedback.

The approximately $3 million vehicle, which was developed with major funding from the National Science Foundation and WHOI, was tested in July 2014 on a scientific expedition aboard the Alfred Wegener Institute's ice-breaker Polarstern, which has the ability to access thick ice.

"We already know the Arctic is changing on an unprecedented scale, and now we have a proven vehicle that provides a completely new way of looking at that system," said Chris German, one of the project's principal investigators at WHOI and the lead scientist for the NUI dives in the Arctic.

A key piece of enabling technology is the lightweight, thin fiber-optic tether—similar in diameter to a human hair. "The fiber-optic tether permits NUI to travel farther from the ship than a conventional tether

would allow," said Andy Bowen, Director of the National Deep Submergence Facility at WHOI and the lead principal investigator for the project to design and build the vehicle. "The tether enables the vehicle to reach heavier ice cover away from the ship, or to move closer to the calving front of a glacier while still remaining under direct human control."



The Nereid Under Ice vehicle is launched from the Alfred Wegener Institute's ice-breaker Polarstern during an expedition last summer. Credit: Chris German, Woods Hole Oceanographic Institution

If the tether breaks or becomes entangled, NUI is designed to operate as a free-swimming, autonomous vehicle. As part of its 'come home' control system, the vehicle routinely reports its status to the ship via underwater acoustic telemetry.

"Its human operators can then remotely pilot NUI back to the ship by sending it a series of vehicle motion commands to enable the vehicle to safely return to the ship," said Louis Whitcomb, Professor of Engineering at Johns Hopkins University who is both a principal investigator on the vehicle design-and-build project and sailed to the Arctic with NUI this summer.

Without an ice-capable robot, past Arctic studies have primarily relied on samples gathered from lowering instruments off the side of an icebreaker research ship.

"Icebreakers are extremely powerful ships, which they need to be in order to make their way through the ice. But they also behave like floating mixmasters, which is an issue if you're trying to study biological activity immediately under the ice," said Sam Laney, a biologist at WHOI and a member of this summer's Arctic science team. "With this vehicle, we are able to get far enough away from the ship to be in undisturbed areas, so that we can really survey biological phenomena under the ice like never before."

During its trials off the Polarstern this summer, the vehicle made four dives, to a maximum depth of 45 meters. More importantly, the distance of the dives ranged up to 800 meters away from the ship and NUI completed up to 3.7 kilometers of track-line surveys under moving sea ice. The dives provided scientists with an abundance of optical, physical, chemical, biological and visual data, which will be the focus of continued study, particularly looking at the extent to which photosynthesis can occur in an ice-covered ocean and how that varies as melt-ponds form and the ice thins.

One of the surprises the team noted about the dives was the unexpectedly high amount of biological productivity found under the ice. They observed large concentrations of algae (single-celled

organisms), copepods (tiny, shrimplike crustaceans), ctenophores (comb jellyfish), and larvaceans (transparent, gelatinous animals).

"One of the big needs for better understanding the fate of polar life in a warming Arctic is to be able to look for it under the melting ice," said Antje Boetius from the Alfred Wegener Institute Helmholtz Center for Polar and Marine Research and Chief Scientist for this summer's Polarstern expedition. "There are no other adequate methods available to science at this time: satellites cannot see through ice, and research vessels stir up the under-ice environment. The robot NUI is a real innovation in this regard. It allows us to extend our senses into this fascinating extreme habitat: the cryosphere. It provides impressions and data from an area that could be completely different in a few decades from now."

The tethering system for Nereid Under Icewas originally developed during the design of the unmanned deep-sea robot Nereus, which made a historic dive in 2009 tothePacific Ocean's Mariana Trench—the deepest part of the ocean. Nereus, which was also designed and built by a team of engineers at the Deep Submergence Facility at WHOI and counted among its successes helping to explore the world's deepest vent-sites on the Mid Cayman Rise (2009-2013), was lost in May 2014 while working as part of a mission to explore the ocean's hadal region from 6,000 to nearly 11,000 meters deep.

Major funding for this summer's expedition aboard the Polarstern was provided by the National Oceanic and Atmospheric Administration's Office of Ocean Exploration and Research and the Alfred Wegener Institute (AWI). The expedition was also part of the Helmholtz Alliance program called the Robotic Exploration of Extreme Environments (ROBEX).

Provided by Woods Hole Oceanographic Institution