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What We Thought We Knew About the Arctic Is Wrong **30**

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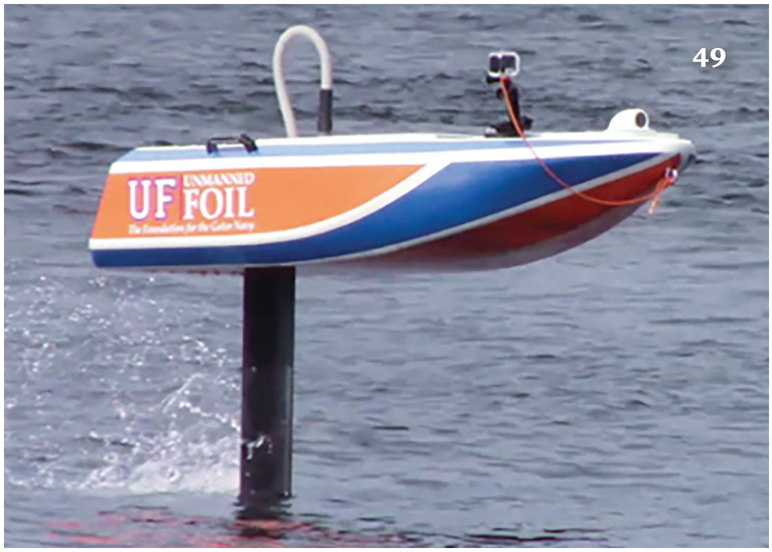

FEATURES & NEWS

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TECHNICAL PAPERS

ON THE COVER

The aurora borealis over Ice Camp Seadragon during Ice Exercise (ICEX) 2020. ICEX 2020 is a biennial submarine exercise which promotes interoperability between allies and partners to maintain operational readiness and regional stability, while improving capabilities to operate in the Arctic environment.

U.S. NAVY PHOTO BY MASS COMMUNICATION SPECIALIST 1ST CLASS MICHAEL B. ZINGARO/RELEASED

Dynamic Environment Has Changed Drastically Since End of the Cold War

Diminishing Ice Reveals an Astonishing Fact: What We Thought We Knew about the Arctic Is Wrong

By CAPT Edward Lundquist, USN (Ret.)

AS THE ARCTIC ICE IS DIMINISHING, interest in the region, the once foreboding icy high north, so hostile to humans, now seems to be extending a warm welcome to people, whether for defense, commerce, fishing or tourism.

The U.S. Navy and its NATO allies long considered the Arctic as a potential sanctuary and battlespace for nuclear powered submarines that can safely and covertly maneuver under the ice for extended periods of time. The Soviets had the same idea. That's why so much research was conducted to build and maintain a foundational knowledge of the dynamic ocean, ice and atmospheric environment. As the Cold War tensions thawed, the research was reduced. Now, thirty years later, relations between Russia and NATO have turned frigid again.

The Department of the Navy release of "A Blue Arctic-A Strategic Blueprint for the Arctic," in January, emphasized the urgency . "In the decades ahead, rapidly melting sea ice and increasingly navigable Arctic waters – a Blue Arctic – will create new challenges and opportunities off our northern shores. Without sustained American naval presence and partnerships in the Arctic Region, peace and prosperity will be increasingly challenged by Russia and China, whose interests and values differ dramatically from ours. Competing views of how to control increasingly accessible marine resources and sea routes, unintended military accidents and conflict, and spill-over of major power competition in the Arctic all have the potential to threaten U.S. interests and prosperity. These challenges are compounded by increasing risk of environmental degradation and disasters, accidents at sea, and displacement of people and wildlife as human activity increases in the region."

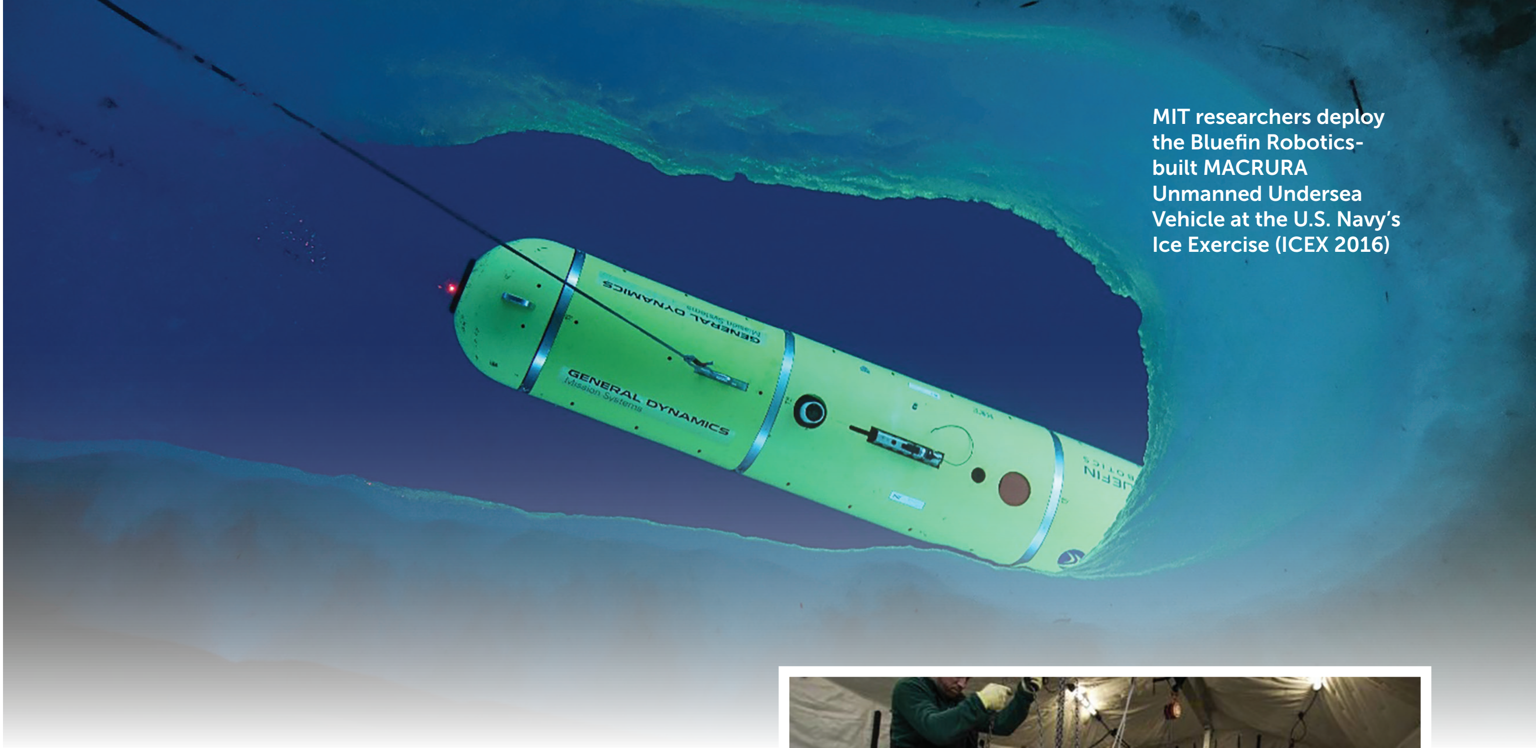
The Blue Arctic document coincided with the release of a report from the Congressional Research Service (CRS) on "Changes in the Arctic," which acknowledged that the diminishment of Arctic sea ice has led to increased human activities in the Arctic, and has heightened interest in, and concerns about, the region's future. Resurgence of Russia's military, which has a significant presence in the Russian Arctic, and especially the growing numbers and quality of Russian submarines, means the region's strategic importance has also increased.

According to the U.S. Navy's Strategic Outlook for Arctic, issued in January 2019, "Current scientific evidence indicates the character of Arctic continues to change. The composition of the sea ice is trending thinner and younger and sea ice coverage is still decreasing. Though sea ice extent has declined at a rate of 13% per decade in the summer and 3% per decade in the winter, understanding and accurately predicting both the inter-annual variability and regional ice coverage remains challenging."

Neil Barton, Ph.D., Global Modeling Section Meteorologist at the U.S. Naval Research Laboratory Marine Meteorology Division in Monterey, Calif., said the main challenge in modeling the earth system in the extreme poleward latitudes in the scarcity of observations to initialize and diagnose their models. "Obtaining and maintaining in situ observations is difficult because of harsh conditions. In addition, many satellite observations have more difficulties observing meteorological and ocean conditions compared to lower latitudes due to the cold surface, a surface with a high albedo (referring to how much radiation from the sun is reflected or absorbed by the surface), and low amounts of moisture in the atmosphere."

In addition to observation scarcity, Barton said that the surface processes at the polar latitudes are complex due to the tight connection between the ocean, sea ice, and atmosphere. Changes in the sea ice are greatly related to changes in the atmosphere and ocean.

What scientist have learned is that the Cold War physics models for ambient noise, currents and salinity are today obsolete. The models that were so painstakingly developed during the Cold War to faithfully predict underwater acoustic properties for sonar, are no longer valid. That means layers and channels that could be used in the past to detect and track submarines are no longer there, or have changed.



MIT researchers deploy the Bluefin Robotics-built MACRURA Unmanned Undersea Vehicle at the U.S. Navy's Ice Exercise (ICEX 2016)

PHOTO CREDIT: MIT, GENERAL DYNAMICS

U.S. NAVY PHOTO BY MASS COMMUNICATION SPECIALIST 2ND CLASS TYLER THOMPSON

New ice age

That's one of the big reasons that the Navy and allied navies, academia and industry and other partners conduct the biennial Ice Exercise (ICEX) operations to collect meteorological and oceanographic data and validate computer models in real under-ice conditions with unmanned underwater vehicles (UUVs), which are increasingly becoming important to both naval warfighters and researchers.

The three-week long ICEX 2020 included the construction of a temporary ice camp, named Camp Seadragon, and the arrival of two U.S. Navy fast-attack submarines last March. The Seawolf-class fast-attack submarine USS *Connecticut* (SSN 22) from Bremerton, Washington, and the Los Angeles-class fast-attack submarine USS *Toledo* (SSN 769) from Groton, Connecticut, conducted a North Pole surfacing and other training evolutions while in the region, as well as breaking through the ice at Camp Seadragon.

In recent year, ICEX events have focused on the development, refinement and experimentation of technical capabilities in extreme conditions and in the undersea environment. In 2020, a joint research effort, led by the Laboratory for Autonomous Marine Sensing Systems (LAMSS) at the Massachusetts Institute of Technology (MIT), and included participants from the Navy's Arctic Submarine Laboratory (ASL), Unmanned Undersea Vehicle Squadron (UUVRON), GobySoft LLC, Woods Hole Oceanographic Institution (WHOI), and General Dynamics Mission Systems (GDMS) Bluefin Robotics, focused on ways to improve positioning, navigation, situational awareness and understanding the Arctic undersea environment, while also enhancing the performance of operators and platforms using autonomous UUVs under the ice.

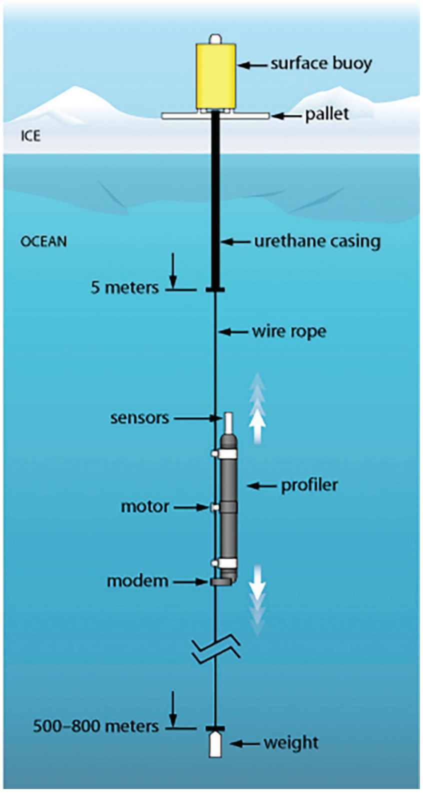
"Some of the data collected and reported by autonomous systems cannot be gathered any other way, and it helps us better understand the long-term environmental changes in the air, ice coverage, and throughout the entire water column," said Dr. Henrik Schmidt, director of LAMSS at MIT and leader of the ICEX team.

There are many challenges involved with deploying UUVs in and around ice in polar regions. One of the limitations in the high north is the lack of land-based communications or satellite coverage. For systems that update their location using frequent GPS fixes, the lack of coverage becomes problematic.

To demonstrate new technologies that can help unmanned underwater vehicles (UUVs), know where they are, the team used MIT's *Macrura* UUV based on the General Dynamics Mission Systems Bluefin Robotics 21-inch (diameter) vehicle.

To overcome the limitations of persistent ice cover, which prevents surfacing to take a GPS fix, the team demonstrated an integrated communication and navigation-aiding framework known as the ICEX tracking range—or icex-tracker—to provide accurate positioning using network of surface buoys linked by radio communications to Camp Seadragon, equipped with small acoustic modems and transducers suspended beneath the ice.

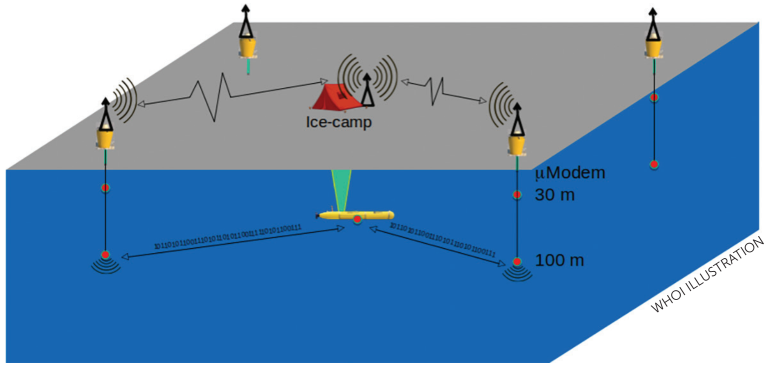
"For ICEX 2020, our science team experimented with the MIT Macrura to navigate precisely while conducting a submerged mission," said Lieut. Cmdr. Dan Goodwin, a



WHOI ILLUSTRATION

naval officer and master's candidate in a graduate program jointly run by MIT and WHOI. "We can drill a hole in the ice and drop in an ice-tethered profiler that's anchored in the surface ice and has a suspended sensor below at predetermined depths that measures temperature and salinity versus depth. We can also attach modems to the tether that can communicate with a UUV.

We used four buoys about 2,000 meters apart, the same buoys that the submarines used, with micro modems at both 30- and 100-meters depths to compensate for the temperature and salinity differences in the water that affect acoustic propagation. This allowed the UUV to adaptively switch between modems depending on the depth of and range to the vehicle to ensure the most coherent acoustic communication. The travel time of those signals provided acoustic aided navigation for the UUV. The system was also able to compensate for currents, which can vary in in direction and intensity at different depths."



According to Goodwin, the system is completely scalable. "We could use more buoys to provide wider coverage, and provide positioning to all types of UUVs."

Remarkable recovery

Goodwin said launch and recovery of UUVs is tricky. In thick ice, it is especially challenging. The team had to cut a "hydro hole" 3 feet wide and 15 feet long in the 6-foot-thick ice, removing 8 tons of ice in order to make a hole large enough to place Macrura in the water. "We were able to demonstrate under-ice navigation to near-GPS quality. The *Macrura* vehicle knew where it was, and we knew where it was."

In fact, at one point during the operation the vehicle stopped under the ice, and efforts to recover the vehicle were put on hold for a major ice storm. "Days later, we were able to go directly to where it was, cut a hole in the ice, and extract the vehicle," said Goodwin.

"The recovery wouldn't have been possible without the incredible accuracy of the navigation system which was improved further using the in-situ environmental model," added Schmidt.

Sounds different

Schmidt said he has been going to the Arctic since the 80s, operating from ice camps, doing underwater research, particularly in relation to underwater sounds, ambient noise, propagation of sound. As scientists come back to the Arctic, they have found that much of what they knew from before has changed. "It's very, very different from what we saw when we were last up there back in the late 80s and early 90s."

"We compared the ambient noise– the noise created by the ice – that we got back in 1994 with what we got in 2016 and 2020, at the same location and same time of year. The sources of the sound have changed. We used to have 4-meter-thick pack ice when we were up there back in the 90s, and most of the noise was created by these ice floes grinding against each other. The ice would fracture, but not break. Today the ice is thinner, and when stressors develop because of wind and current, then the ice breaks," Schmidt said. "So not only did we see that sound propagating differently because of this oceanographic feature, but also the ambient noise is dramatically changed because of the much thinner ice. Today we have a lot of noise in the Arctic, generated by ice fracturing and ice flows grinding against each other."

Schmidt and his fellow scientists recognize that the environment is evolving for anyone using underwater sound, whether it's for navigation, communications, sensing marine mammals. "It's dramatically changing the way we can do things," he said. "That's one reason why scientists and navies are interested again."

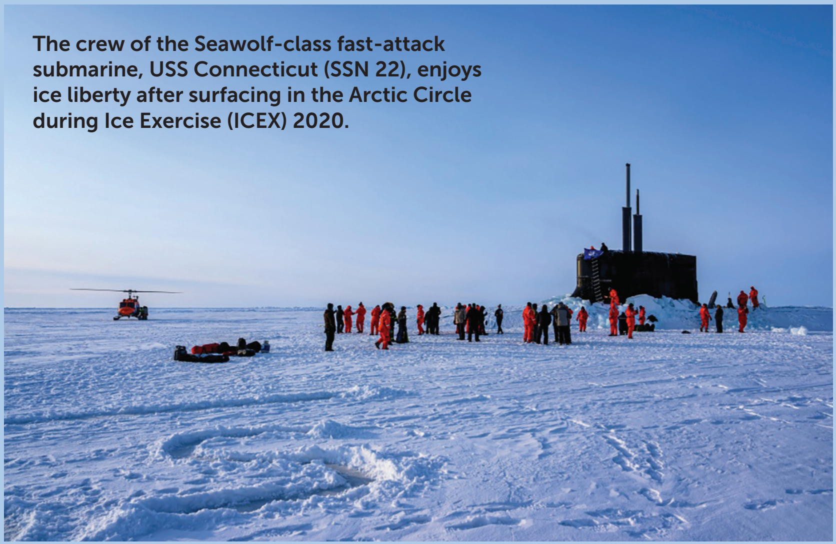
ICEX 2020: Navy sets up camp on 6 feet of ice in minus 27 degrees weather. Perfect for polar research.

By Edward Lundquist

The U.S. Navy's biennial Ice Exercise (ICEX) in the Arctic Ocean is more than a demonstration of its ability to operate in the extreme latitudes, it's also a unique opportunity to do science.

Led by Commander, Submarine Forces (COMSUBFOR), ICEX 2020 brought together various Navy commands and activities, other services, allies and partner nations to enhance our collective abilities to operate in the harsh polar environment.

The Navy's Arctic Submarine Laboratory (ASL) in San Diego led the coordination, planning and execution for three-week exercise in March involving five nations, two submarines and more than 100 participants. The Seawolf-class fast-attack submarine USS Connecticut (SSN 22) from Bremerton, Washington, and the Groton, Connecticut-based Los Angeles-class fast-attack submarine USS Toledo (SSN 769) conducted multiple Arctic transits, a North Pole surfacing and other training evolutions while in the Arctic ocean. The submarines surface next to Camp Seadragon, a temporary outpost constructed on an Arctic ice floe 200 miles north of the Alaska coast in the Beaufort Sea. Named for the Skate-class nuclear powered attack submarine USS Seadragon (SSN 584), which helped pioneer navigation in and under the Arctic Ocean, the temporary camp provided a stable platform for the command-and-control center, tracking range, sensors, communication equipment and facilities for 45 personnel at a time, who were responsible for the submarine operations and under-ice navigation exercises.



The crew of the Seawolf-class fast-attack submarine, USS Connecticut (SSN 22), enjoys ice liberty after surfacing in the Arctic Circle during Ice Exercise (ICEX) 2020.

U.S. NAVY PHOTO BY MASS COMMUNICATION SPECIALIST 1ST CLASS MICHAEL B. ZINGARO/RELEASED

Preparation for the event begins years in advance from building an operational plan with research goals to the months before tracking ice flows with satellite imagery to determine which multi-year ice-flow is best to support building the ice-camp. Once some tentative areas were identified, flights out of Prudhoe Bay were conducted to determine feasibility of the camp.

The high north is a foreboding environment. Even as the climate is changing, and the multi-year Arctic ice cover is diminishing, there is still plenty of ice, making it inaccessible for much of the year. But there is more seasonally open water now, and that's inviting commerce, resource exploitation, and tourists. Travelling from Asia to Europe by the polar route is much shorter, and in shipping, time is money.

"The Arctic is a potential strategic corridor—between Indo-Pacific, Europe, and the U.S. homeland—for expanded competition. The Submarine Force must maintain readiness by exercising in Arctic conditions to ensure they can protect national security interests and maintain favorable balances of power in the Indo-Pacific and Europe if called upon," said Vice Adm. Daryl Caudle, commander, Submarine Forces. "ICEX 2020 provides the opportunity for the Submarine Force to demonstrate combat and tactical readiness for sustained Arctic operations in the unique and challenging Arctic environment."