Persistent, Long-Range, Autonomous Under-Ice Observations of Arctic Change

Key Project Contact(s):
Rich Camilli, Woods Hole Oceanographic Institution, rcamilli@whoi.edu (PI, vehicle systems design)
Ted Maksym, Woods Hole Oceanographic Institution, tmaksym@whoi.edu (Co-I, sea ice observations)
Brian William, Massachusetts Institute of Technology, williams@csail.mit.edu (Co-I, mission planning)

Project Website URLs & Social Media Accounts:
https://www.youtube.com/watch?v=JaIWi0HgdkA
https://www.whoi.edu/news-insights/content/navigating-the-changing-arctic/

Project Objectives: Build and trial a low cost, long-range hybrid autonomous vehicle for sustained under-ice operation. This includes key technological and operation advancements, including:

- Terrain-aided navigation during long-duration under ice operations without GPS or the need for acoustic beacons.
- Capability of operating in water with currents in excess of 1 m/s or rapidly changing ice cover
- Continuously optimized vehicle velocity enabling energy-efficient use of adaptive propulsion.
- Automated risk-aware mission replanning to rapidly adapt to evolving environmental conditions
- Low cost operation without need for icebreaker support, or acoustic transponder networks.

This will provide capability for:

- Continuous observation of ice-ocean interactions such as the seasonal ice advance and retreat
- Characterization of ice thickness variability along transects up to hundreds of kilometers
- Coincident observation ice thickness, waves, and upper ocean variability
- Eventual goal of sustained operation under ice over thousands of kilometers.

Broader Impacts – has involved several WHOI summer student fellows, 2 grad-students, and been incorporated into WHOI Summer Introduction to Engineering and Scientific Research (SIESR) for high school students in underserved communities.

Keywords: Hybrid underwater glider, sea ice, upper-ocean, sustained autonomous observations

Progress to Date/Future Plans:

- Vehicle built and sea trialed; mission planning computer installed; new nose cone with scanning sonar built; improved thruster designed and in production
- Demonstrated terrain-aided navigation during cruises of opportunity (simultaneous localization and mapping using Doppler sonar at Eastern Pacific shelf margin in Dec 2018 and within an active volcano in the Eastern Mediterranean Nov 2019)
- Completed initial lab and field testing for sonar detection and classification of ice (presence, thickness, and composition) as well as wave spectra (frequency, amplitude, and direction). This is important for science data gathering, surfacing for communication with satellites, and vehicle survivability.

Highlights or Expected Outcomes:

- Demonstrated unattended adaptive AUG operation in regions containing obstacles.
- Demonstrated improved AUG navigation (more than 10X decrease in navigation uncertainty).
- Demonstrated the ability of an automated process to quantify ice thickness to 2cm resolution, and ability to characterize marginal ice (ice floes in the presence of ice free areas) as well as frazil ice. This process is currently being integrated into the vehicle's onboard interpreter & mission planner to autonomously adapt mission plans in response to environmental state.

NNA Community Collaboration and Research Coordination: Currently funded for development and testing; science deployment will require subsequent funding. Are there marine projects we could leverage to expand scope of test deployment opportunities? Could provide some limited observations in return. Target is late summer 2020 in Beaufort/Chukchi, but flexible.

Advice for Overcoming NNA Project Challenges: Challenges in completing engineering and test deployments with COVID-19 restrictions.