Development of an Under-Ice Ecosystem Observation Capability Using Autonomous Underwater Vehicle Technology

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Figure 1: Area of AUV operations including A) GLERL Lake Michigan Field Station, B) future AUV docking station, C) channel entrance, D) mapping area. Image upper right looking A to B; Saab AUV lower right.

Winter observations of ecology in the Great Lakes have been historically limited due to a number of challenges such as ice cover and ice formation on research vessels. At present Great Lakes research vessels are not designed for operations in ice cover and therefore are docked or stored during winter months. With support from NOAA Oceanic and Atmospheric Research (OAR), NOAA Great Lakes Environmental Research Laboratory (NOAA GLERL) conducts extensive sampling and monitoring during the open-water period, but winter observations are often limited to meteorological stations installed on a few permanent structures and some rudimentary mooring deployments. Recent studies have shown that some biological processes actually accelerate during winter months increasing the demand for winter observations. Fortunately, the advancements of autonomous underwater vehicles (AUV) may allow for collection of winter ecosystem data, even under ice.

The Mission Plan

NOAA/GLERL will deploy an AUV in phases, each allowing increased autonomy and increased observations, culminating with the development of an under-ice docking station. The deployment of the Saab Sabertooth AUV will be operated in collaboration with Hibbard Inshore. Phase I testing of the AUV is planned for the summer of 2021, at NOAA GLERL's Lake Michigan Field Station. The field station offers an ideal testing ground, with easy access to the Port of Muskegon highlighted in Figure 1. The Phase I demonstration will verify procedures, setup and navigation. The initial test will include multibeam sonar and video high-resolution imagery. Multibeam sonar will deliver both imaging and survey capabilities providing object detection, navigation and high density lake bed classification. The 1080P high definition video allows mapping of invasive Quagga mussels. All the collected data will be transferred to the GLERL Real-time Coastal Observations Network (ReCON). Funding and logistic support provided by the NOAA Office of Marine & Aviation Operations (OMAO) Uncrewed Systems Operation Center.

Phase II will occur during the early winter season and include the addition of a scientific echosounder for fish observation and classification. In the final stage of the project, Phase III, the AUV will be outfitted with an ice profiling sonar system in order to collect data regarding ice thickness and conditions. Phase III will also include the development of a docking station, (see Figure 1) equipped high-bandwidth data transfer.

The Platform

The Saab Sabertooth is a hybrid AUV and remotely operated vehicle (ROV) that has been in production for over eight years, demonstrating its design reliability. The platform can hover, stop and maneuver around points of interest, or provide a traditional survey. This range of control makes it perfect for maneuvering in and out of the channel while still being able to provide traditional survey data. The vehicle is rated to a depth of 1200 meters, a depth greater than any region of the Great Lakes. The small size, 3.7m long by 1.4m wide and 0.45m high, permits either small vessel launch or a shore launch for mission flexibility. Once deployed the battery provides approximately 10 hours of

operation at a speed of 1kt with a maximum speed of 4kts. In addition, the design allows for significant payload customization depending on desired application, as noted above by the additional sensing with each phase.

Initial navigation and mapping demonstrations (Phase I) are funded under the NOAA FY2020 request for proposals from the OMAO Uncrewed Systems Operations Center. Early winter demonstration and data collection (Phase II), including habitat mapping and fisheries acoustics will be funded under the Great Lakes Restoration Initiative.

Impact of Our Work

Winter observations are scarce in the Great Lakes. While NOAA/GLERL currently accomplishes open-water research cruises, sampling, and mooring deployments, these efforts do not provide the consistent integrated high resolution spatial and temporal coverage required to improve our understanding of winter ecosystems. Ice can cover large regions of the Great Lakes and shift quickly making winter research vessel cruises challenging or impossible. The addition of an under ice AUV will contribute to an enhanced understanding of the winter benthic and pelagic ecosystem in Lake Michigan, contributing to GLERL's long term research program. Developing the platform and procedures to deploy an AUV in winter under ice in Lake Michigan will provide valuable new insights into Great Lakes winter ecological processes. Methodologies developed using the Port of Muskegon as a testbed can be implemented throughout the Great Lakes as well as coastal ocean ice covered environments as well. Collecting winter data supports not only the Great Lakes Restoration Initiative to assess the health of the Great Lakes, but NOAA's mission to expand the application of uncrewed systems in every NOAA mission area by improving the efficiency, effectiveness, and coordination of UxS development and operations across the agency.