Wavegliders for Arctic Surface Observations and Navigation Support (DURIP)

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LONG-TERM GOALS

The long-term goal of this project is the development of a Wave Glider-based autonomous surface platform for use in supporting Arctic Ocean research, in particular the ONR Marginal Ice Zone (MIZ) Departmental Research Initiative (DRI). The use of ships in the Arctic Ocean, even during the summer, is expensive and there are very few to choose from, so the employment of unmanned systems is potentially very attractive. The Wave Glider, commercialized by Liquid Robotics Inc. (LRI) after it was developed for marine mammal monitoring, is a general-purpose platform that can be outfitted with different sensors. The long-term science that this work supports includes measuring surface processes such as weather and waves, and also (in the future) monitoring surface temperature and other parameters in the upper few meters of the ocean.

OBJECTIVES

The near-term objectives of the program are the use of the Wave Glider for the ONR Marginal Ice Zone (MIZ) Departmental Research Initiative (DRI) as a platform for sensors and navigation sources. The sensors include devices to monitor weather and wave conditions, while the navigation sources will augment the beacons deployed on the ice from Banks Island in April 2014. The Wave Glider, because it is mobile, will allow positioning the sensors and the acoustic sources as close to the ice as practical during the period where there is no research vessel in the area. In addition, the Wave Gliders augment the SWIFT buoys deployed by Jim Thomson (an oceanographer at APL-UW who is also part of the ONR MIZ program), which are likely to drift to the west with the prevailing currents and winds.

APPROACH

The DURIP included funds for the purchase of two Wave Glider model SV-3s (Figure 1) with meteorological sensor and wave measurement capability, plus the installation of a custom acoustic source to complement the ice-based acoustic navigation buoys.

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Figure 1. Wave Glider components: Float and sub separated by a 4 m umbilical

Liquid Robotics Wave Glider. The model SV-3 is new as of 2013 and is a larger and more capable version of the SV-2, which has been sold commercially for more than five years by Liquid Robotics. At the time the DURIP was awarded LRI offered a deal where the SV-3 was available for the same cost as the SV-2, so the decision was made to purchase the newer model. The only sensor that was purchased along with the vehicle was the Airmar WeatherStation PB200 which includes wind speed, wind direction, temperature and pressure, plus an auxiliary GPS receiver.

The wave measurement capability was added at no cost because it is now a software-based sensor that uses the stock vehicle GPS input and an algorithm developed by Jim Thomson. The wave data is sent back over the Iridium telemetry link as part of the vehicle data stream, and available on the LRI-provided web-based interface called WGMS.

Acoustic Navigation Source. The navigation source is similar in most respects to that on the buoys, but packaged differently. See the annual report for "Acoustic Communications and Navigation for Mobile Under-Ice Sensors", N00014-12-I-0176 and N00014-12-I-0225 for additional details. The electronics is divided into two pieces, the source on the sub, and the GPS and Iridium terminal on the float. The challenge posed by the separation was routing the GPS timing signal to the transmitter, which was overcome by multiplexing it onto the data communications wires used to connect the subsea electronics to the float.

WORK COMPLETED

The SV-3 was procured and delivered to WHOI early in 2014 and tested for basic functionality. The sound source subsystem, fabricated as a separate module, fits on the bottom of the sub as shown in Figure 2.

The gliders were shipped to the University of Washington and then on to Prudhoe Bay, Alaska in advance of the planned field operations in July of 2014. The deployment was performed using the R/V Ukpik operating out of the West Dock area within the BP lease in Prudhoe Bay.

Operations of the R/V Ukpik were constrained by ice that collected along the coast of Alaska because of prevailing currents and winds. It was not possible to transit directly north through the coastal islands and into the Beaufort Sea, but instead it was necessary to drive east to Kaktovik (a village on Barter Island), about 100 miles, then proceed north into open water off the continental shelf. Fortunately, the NOAA US National/Naval Ice Center (NIC) made available RADARSAT-2 imagery which showed the location of the coastal ice for this phase of the project. The NIC images were also used later for piloting the Wave Gliders close to the ice edge.

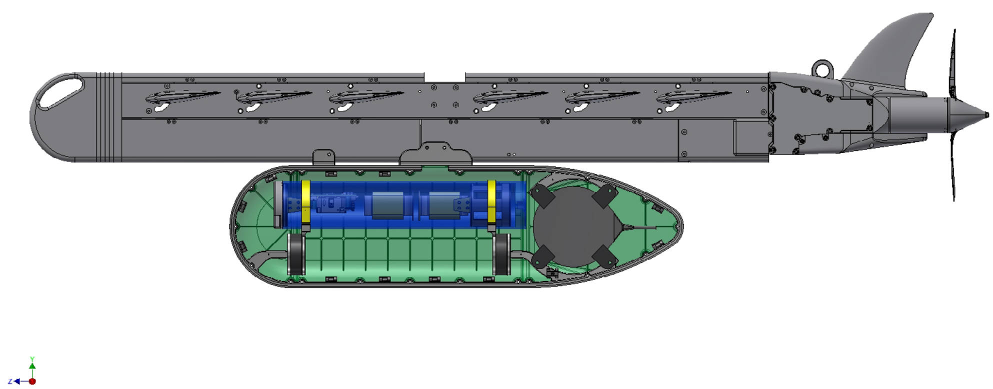

Figure 2. Waveglider sub side view showing the pod containing the electronics housing (blue cylinder), and the low-frequency (900 Hz) source (black disk).

RESULTS

The Wave Gliders were launched 150 km offshore in open water and piloted to waypoints where their basic functionality was checked (Figure 3). The speed of the Wave Gliders depended on the local sea state, which varied depending on the wind and swell, but typically was up to 1.5 kt. This speed allowed the Wave Gliders to make relatively good time when it was desired to pilot them another 60 miles toward the ice edge to stay close to the Seagliders.

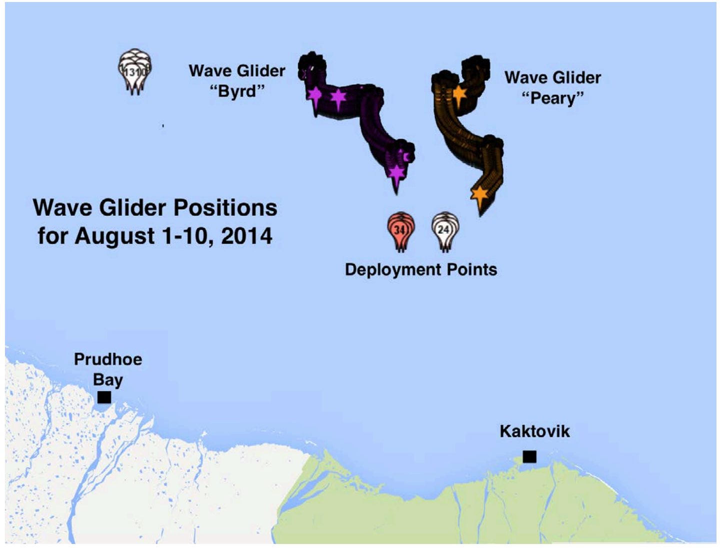

Figure 3. Deployment locations and partial tracks for the Wave Gliders in August 2014.

One of the concerns early in the deployment was whether there would be sufficient energy to supply the glider and payload with power through September when they were to be recovered. The concern about energy was quickly alleviated by monitoring the solar input and power draw, which showed that the solar cells were able to fully recharge the batteries on many days, depending on the cloud cover. The situation changed by mid-September, when a combination of less sunlight, a lower solar angle and increasing clouds greatly reduced the watt-hours per day that were available for battery recharging.

The lack of reserve energy meant that all of the non-essential subsystems had to be turned off in order to preserve energy to operate the core vehicle functions such as steering and telemetry.

While the weather sensor on one of the units failed, the other one operated throughout the mission until the time where it had to be turned off to conserve energy. An example of the data from the weather station is shown in Figure 4 where two weeks of temperature and wind speed are shown. This data was important for the program because it was taken in open water where there was no other platform present. Further, it was taken coincident in time and space to where the waves data was sampled.

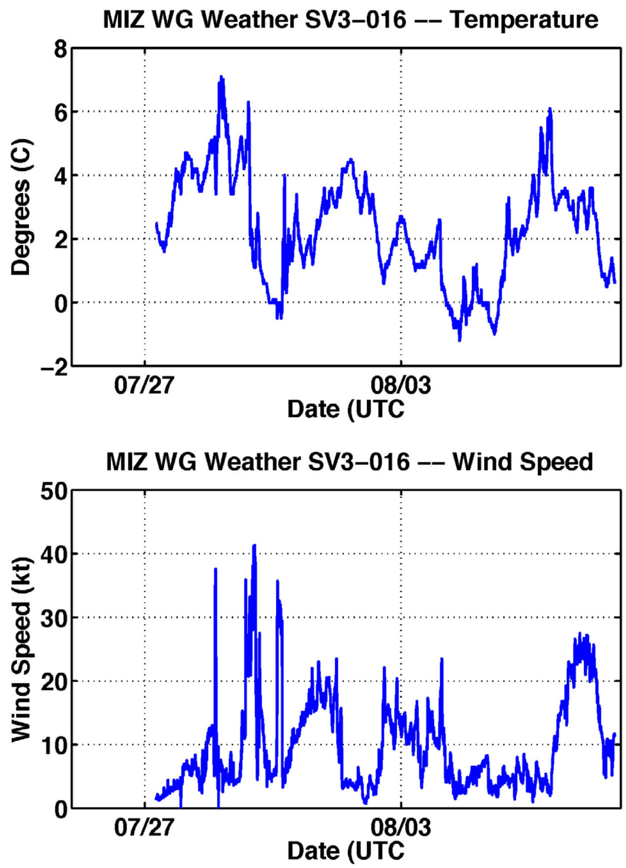

Figure 4. Data from Airmar weather sensor.

Example wave data is shown in Figure 5, with the significant wave height from each of the two systems. The distance between the two Wave Gliders was between 20 and 50 km during this period, and the two measurements are highly correlated from 9/8 through mid-day on 9/9. At this point Wave Glider Peary encountered a small region of concentrated ice and became trapped within it, damping motion due to ocean waves. The data shown was sent back in real-time, and it will be used by Jim Thomson in his study of waves, fetch and ice in the MIZ.

The use of the Wave Glider as an acoustic source had mixed results. The UW Seagliders regularly received acoustic receptions from the Wave Gliders, but the ranges were not as great as with the buoys on the ice. The most likely reason is that the sound speed profile where it was possible to operate the Wave Glider (tens of kilometers away from the ice) included multiple warm shallow layers that prevented the sound from reaching the Seagliders

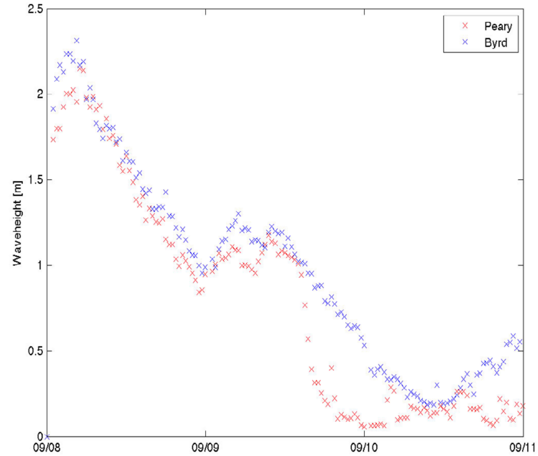

Figure 5. Wave height over time as measured and reported in real-time by the GPS-based wave software on the float. Peary was stuck in the ice starting on approximately Sept. 10 (courtesy Jim Thomson, APL-UW).

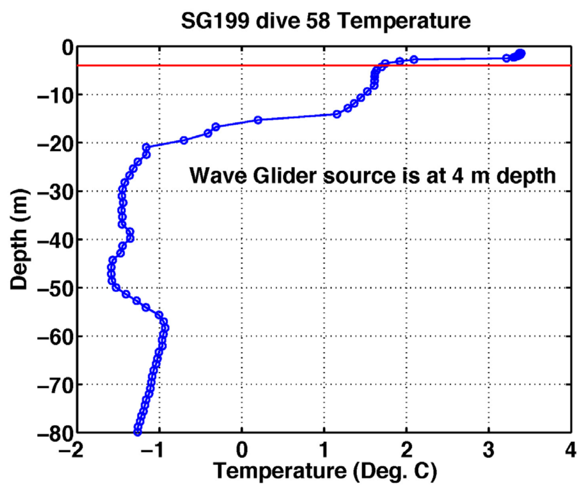

Figure 6 Temperature profile taken by a Seaglider during its transit to the ice edge. The surface temperature is more than 4 degrees, showing the heating that has already occurred in open water.

The temperature profile taken by a Seaglider is shown in Figure 6. There is a very warm layer at the top (to about 3 m), then another from 15 to 20, then the lower layer of Pacific water at 50 m. The modeled transmission loss using this profile (Figure 7) shows that indeed the sound tended to refract away from 50 m layer, trapping the sound high in the water column where it interacts with the surface and ice as it propagates to the Seagliders in the MIZ.

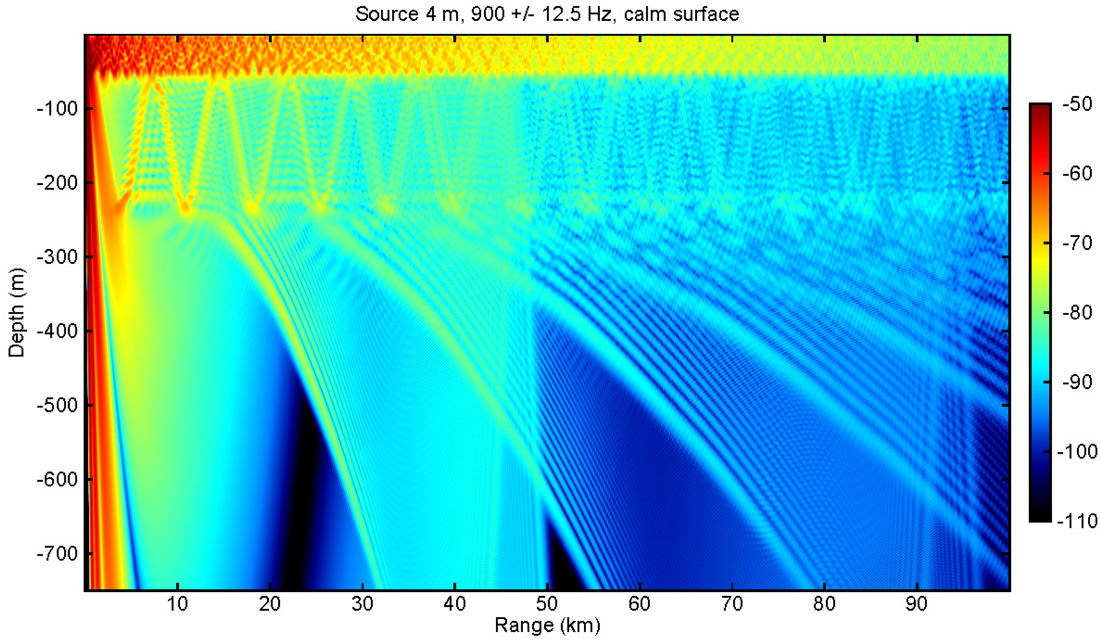

Figure 7. Modeled transmission loss for an acoustic source at 4 m computed using the Seaglider CTD profile.

Unfortunately, the Wave Glider Peary that was stuck in the ice was lost after it stopped reporting its position, most likely because it was crushed or over-topped by ice in September just two weeks before it was to be recovered. The second Wave Glider was recovered without incident during the Norseman II recovery cruise that was lead by Jim Thomson. That cruise also included the recovery of the UW Seagliders and some of the SWIFT wave measurement buoys.

IMPACT/APPLICATIONS

The use of a Wave Glider for Arctic Ocean operations allows for monitoring of ocean surface conditions, waves and weather as the ice melts back in the spring. Ice breakers do not typically transit north of Alaska until later in the year, while the ice goes out in the area off Prudhoe Bay and Kaktovik in July, sometimes quite early. Deployment of the Wave Gliders can be done from a small coastal vessel, obviating the need to get an ocean-going craft around Point Barrow, which may not happen until late July. Thus Wave Gliders may offer a new way of making observations in the Beaufort Sea early in the melt season when it is not otherwise possible.

TRANSITIONS

While no transitions are presently planned, the demonstration showed how Wave Gliders can augment moorings and sensors fixed to the ice for Navy scientific observations.

RELATED PROJECTS

WHOI also supports on-going use of Wave Gliders as mobile acoustic modem gateways for ONR and other organizations.