Transition Support of Meteorology and Oceanography (METOC) Technology to the Naval Oceanographic Office Warfare Support Center

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LONG-TERM GOALS

The long-term goal of this research is to support the transition of METOC technology to the Naval Oceanographic Office Warfare Support Center. Specifically, this includes the methodology for assimilation and adaptive sampling of in-situ data, collected from gliders (oceanographic) and mobile acoustic sources (acoustics), with fleet ocean and acoustic models, ultimately to be used by the fleet for improved system performance prediction. Also, this research seeks to refine, demonstrate and transition the probabilistic method for characterizing environmental acoustic uncertainty to the performance prediction methods used by the fleet and extend its application to AUVs and gliders which are suited to adaptive sampling of dynamical oceanography.

OBJECTIVES

The objectives of this effort are to: i) improve the capabilities of gliders for use in fleet tactical exercises, including the demonstration of a glider launch from a submarine, ii) demonstrate the use of the glider as a data truck and with a towed array to characterize the ambient noise field and acoustic uncertainty provinces, iii) continue development of the OMAS (OASIS Mobile Acoustic Source) in-situ acoustic system with application to a submarine, and iv) improve adaptive sampling tools and strategies that reduce uncertainty in ocean and acoustic models.

APPROACH

In fall 2005, OASIS (working closely with Webb Research Corporation and Woods Hole Oceanographic Institution) coordinated the launch of a 200m Slocum Electric Glider from the dry deck shelter (DDS) on USS BUFFALO. This was the first such launch from a submarine and was executed while the ship was at periscope depth in the waters off Barber's Point, Hawaii. The launch was performed by divers from Swimmer Delivery Vehicle Team One (SDVT-1) and was supported by the officers and crew off USS BUFFALO, Submarine Squadron One and the staff of Commander, Submarine Forces, U.S. Pacific Fleet (COMSUBPAC).

In spring 2006, OASIS (in cooperation with Webb Research Corp., Dinkum Software, Inc., Benthos Teledyne, Inc., Scripps Institute of Oceanography's Marine Physical Lab, and SPAWAR) worked with SDVT-1 to deploy an array of acoustic sensors for the purpose of detecting high-speed surface craft. The acoustic sensors included an OASIS-designed bottom line array, moored omni-directional buoys in the water column from Scripps Marine Physical Lab, and a Teledyne Benthos SM75 bottom-moored high frequency sensor and modem (See Fig. 1). In addition to the moored devices, a Teledyne Benthos

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ATM855 acoustic modem was integrated into a Slocum Electric glider, allowing the glider to act as a data shuttle between the SM75 and the glider command center. The proof of concept task for the Glider was to swim in over-the-horizon, actively ping for a response from the moored modem, establish a link when within range, remain in range while receiving acoustic detection data from the moored modem, come to the surface, and establish an Iridium link to transfer the data back to a surface vessel or shore node. In addition, the glider collected hydrographic (CTD) data to improve local three-dimensional characterization of the water column for ASW, MIW, or NSW purposes.

In summer 2006, OASIS, working with APL-UW, University of Hawaii (UH), Webb Research Corporation, Naval Oceanographic Office (NAVO), COMSUBPAC and COMTHIRDFLT, participated in RIMPAC, a biannual multi-national exercise held in the Hawaiian operating areas. Prior to commencement of the exercise, six gliders were deployed from the USNS PATHFINDER by a team made up of OASIS, Inc., APL-UW, and UH personnel. This fleet of gliders consisted of two Seagliders from APL-UW, two Seagliders from UH, and 2 Slocum Electric Gliders from OASIS/SPAWAR.

WORK COMPLETED

The fall 2005 submarine launch of the Slocum glider was completed successfully. The glider was carried free of the submarine by the divers and released, allowing it to come to the surface. Once at the surface, the glider remained there in quiescent mode (no motors running, just the RF modem), allowing the USS BUFFALO time to move away from the deployment site. When BUFFALO signaled that she was clear of the site, the Glider was given its mission instructions via RF modem by OASIS personnel onboard a nearby surface craft.

After launch, the submarine proceeded on with other missions while the glider spent four days gathering data (currents, CTD, PAR, fluorescence, 470 and 700nm backscatter, and acoustic) in support of a simulated NSW mission off the coast of Oahu. During the mission, the Glider data, with the exception of the acoustics, was transmitted via Iridium back to a shore control center. After recovery, the Glider dataset was downloaded to the NSW Mission Support Center in Coronado, CA.

In the spring 2006 test, in the interest of time, the glider was deployed from a surface vessel near the Teledyne Benthos acoustic modem buoy, so the over-the-horizon capability was not demonstrated, but this has been proven in other glider operations worldwide. All other aspects of the proof of concept were successfully demonstrated, including establishing a link with a moored modem and transferring data via an Iridium satellite link.

Initial testing for a glider towed array was also completed in the waters off Pearl Harbor. Tests were conducted using a neutrally buoyant "dummy" towed array in order to identify and correct flight and vehicle behavior/control issues associated with pulling an acoustic towed array behind the glider.

During the RIMPAC exercises in summer 2006, the Seagliders were piloted by APL-UW and the Slocums were piloted by OASIS. All were operated in support of the ASW portions of the RIMPAC scenario. OASIS worked together with APL-UW, SUBPAC and NAVO to plan and execute Glider flight paths in the exercise area. Waterspace issues and Glider flight plans were discussed by the Glider participants during daily teleconferences. Glider data were sent to NAVO daily, where they were ingested into MODAS for fleet use and displayed on an exercise website.

RESULTS

During the spring 2006 glider proof of concept, data transfer of up to 8 kB from the SM75 to the Glider was achieved at spatial separations of up to 1.25 miles. Further testing is needed to determine the limits of data transfer volume and effective range. An important observation was that currents near the island of Oahu are quite variable and can be as strong as 1.5 knots. This required skill in piloting the glider, which typically can make about 0.5 knots in calm water. In nearshore waters with significant wind-driven or tidal currents, or in strong boundary currents or associated eddies, accurate navigation of gliders may not be possible, although regional control would still be achievable by leveraging the currents to achieve general coverage patterns.

In the RIMPAC exercises, operating the gliders in this environment proved challenging, with important lessons learned for future multi-glider operations. Key glider placement concerns were 1) waterspace management with other participating submerged vehicles, 2) maximizing ASW impact by placing the gliders in and near the locations of key tactical events, and 3) the presence of strong currents associated with energetic eddies south of the Hawaiian Island chain, where all Gliders operated.

Despite some mechanical failures with some of the gliders, the multi-glider deployment is considered a success because substantial data were collected (see Fig. 2) to improve the quality of the MODAS picture being provided to the fleet. Also, raw glider data (not processed through MODAS) were provided to fleet users. The close coordination of activities by all of the groups involved in the Glider portion of the RIMPAC exercise allowed for the successful execution of our tasks. For example, coordination of a recovery and redeployment of the Slocum gliders midway through the exercise, to maximize ASW impact and avoid a potential waterspace conflict brought about by strong currents, involved all parties working closely together. In the end, a robust set of data is available to researchers at NRL, NAVO, OASIS, and elsewhere to facilitate the conduct of data assimilation, adaptive sampling, and ocean modeling studies, all aimed at advancing the utility of the glider data in terms of acoustic performance prediction for ASW. A further benefit of the RIMPAC glider deployment is an increased awareness of gliders on the part of both U.S. and coalition forces and an increasing call for gliders to characterize the water column in future exercises and operations.

IMPACT/APPLICATIONS

The submarine glider launch project successfully demonstrated the concept of launching UUVs from submerged submarines. A future project is envisioned by ONR, OASIS, and SUBPAC in which a glider, and a REMUS, are both deployed and recovered onboard the DDS, eliminating the need for a surface support vessel for the Glider. The DDS launch platform could be atop an SSN or SSGN.

Follow-on work with SDVT-1 to mature the acoustic network demonstrated with the moored modem and Iridium link and to explore various data exfiltration concepts is envisioned. From the glider perspective, one aspect of this future work will be a full evolution of the proof of concept beginning with the Glider(s) flying in from well offshore, perhaps where it was deployed by a submarine, to a specific location or set of locations where it would acoustically receive ACOMMS data, fly back offshore, and communicate to a command center.

Further work on the glider towed array is also planned in the fall of 2006, using the WHOI RV Tioga near Martha's Vineyard. Array issues to be addressed include determining electrical power requirements and analyzing the effect of glider ballast pump and tail fin radiated noise on the ambient noise field. Finally, the array will be used for transmission loss and ambient noise data collection.

The RIMPAC glider project points to the need for a shift from MODAS to adaptive sampling and predictive modeling with the capability of assimilating the high density of observations provided by gliders, as well as the need for tools that will allow the Navy to optimize (in terms of impact on the quality of acoustic performance predictions) the placement and movement of these sensors. Projects to achieve these ends are in the planning stages.

TRANSITIONS

Multiple transition opportunities have been discussed above as we are working closely with many agencies and organizations within the fleet.

RELATED PROJECTS

The Autonomous Wide Aperture Cluster for Surveillance (AWACS) program, sponsored by ONR is related to this program. AWACS will use the capabilities of an array towed from the glider as part of the cluster of other AUVs used for detecting quiet sources in complex shallow water.

PUBLICATIONS

Abbot, P.A., Gedney, C.J., Emerson, C.I., Dyer, I., and Corriveau, P.J., "Submarine-Launched Mobile Acoustic Source for In-Situ Transmission Loss Measurements." Submarine Technology Symposium, May 2006, (Secret). [published]

Abbot, P., Gedney, C., Morton, D., and Emerson, C., "Mobile Acoustic Source for Underwater Acoustic Measurements," OCEANS 2006, Boston, MA, September 2006. [published]

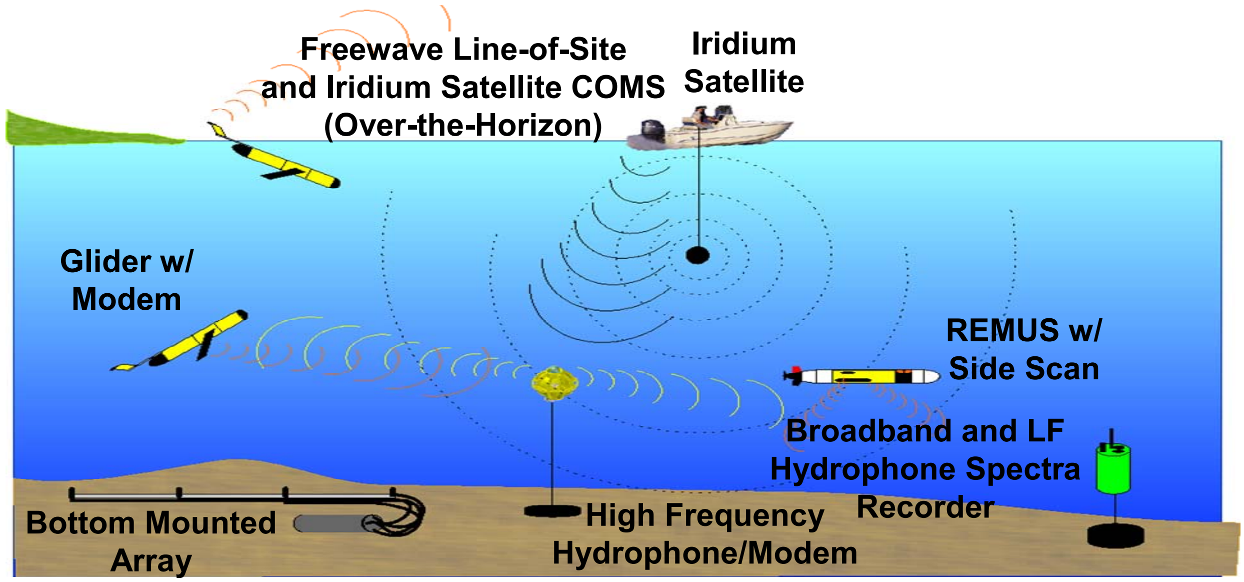

Figure 1: Schematic of the acoustic sensors used in HUSA to detect high-speed surface vessels.

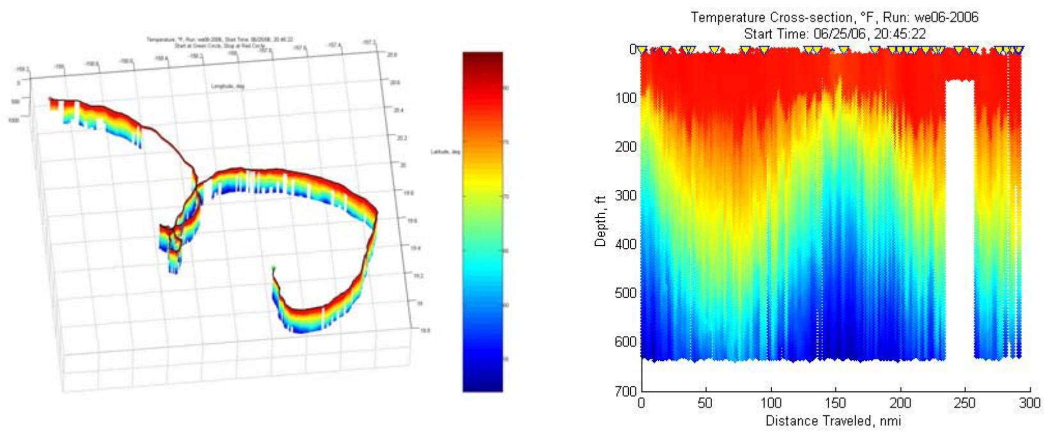

Figure 2: Temperature data June 25-July 15 from one of two Slocum gliders deployed during RIMPAC. The ribbon plot on the left shows the temperatures the glider encountered in relation to its latitude/longitude position. The composite plot on the right shows the same data but displayed as distance flown. In the right hand plot, note the shoaling of colder water near start and 150 km into the glider run, features associated with the glider's proximity to the center of a strong cyclonic eddy. The surface-only data seen in the ribbon plot and as a white space in the composite plot occurred when the Glider was flown near the surface to avoid a submerged waterspace conflict.