Autonomous Wide Aperture Cluster for Surveillance (AWACS) – WHOI Component

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LONG-TERM GOALS

Our long-term goal is to demonstrate the utility of collaborative autonomous vehicle-array systems in shallow water ASW. This necessitates the development of both advanced towed arrays and in-vehicle processing systems which include adaptive oceanographic sampling. This also necessitates at-sea testing of these components in realistic, shelfbreak environments.

OBJECTIVES

Over the past few years, we have been designing and building an advanced, very capable hydrophone towed array and also further demonstrating the capabilities of AUV towed array systems for environmental surveys and ASW work. Our near-term and long-term objectives are further extensions of those thrusts.

The near-term objectives of the acoustics research were: 1) to test and use the new digital towed array we have constructed, replacing the prototype array, 2) help develop and install the requisite processing for detection, localization, classification, and tracking (DCLT) in close collaboration with other AWACS PI's, 3) to continue to develop the environmental survey capabilities of the REMUS towed array (RTA) configuration, particularly as regards adaptive sampling of the ocean and seabed, and 4) to improve the abilities of this system to work in coordination with other vehicles as a "cluster system" ASW tool, specifically through at-sea tests.

The long-term acoustics objective is to develop, demonstrate, and quantify the performance characteristics, for both ASW and environmental surveying, of the REMUS and RTA system operating both alone and in collaboration with other systems.

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14. ABSTRACT
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APPROACH

Our approach this year was to first complete the construction of our digital array (the "NEDS" array) and also finish the initial development of adaptive oceanographic sampling algorithms. With these developments in place, we then performed coastal testing of the technology off nearby coastal waters. At that point, we proceeded to at-sea testing in a large scale oceanographic test off New Jersey, the so called "New England Sea Test II" or "NEST II" cruise. In this cruise, we used Scanfish surveys, AUV runs, CTD surveys, and mooring measurements to quantify the oceanography and test adaptive ocean sampling algorithms. We also deployed two REMUS 100 AUV's with towed arrays to track EMATT acoustic sources, acting as a 2-component cluster. One array was the older BU/WHOI array, our initial effort in the AWACS program, and the other was the newly completed and far more capable NEDS array. These tests were highly successful, as will be discussed below.

WORK COMPLETED

During this current fiscal year, we have made substantial progress on a number of fronts. Specifically, we have: 1) completed the construction of our new digital towed array, and are tested it both in nearby waters and at-sea, 2) performed a very successful at sea test of a "vehicle cluster" off the New England shelf, 3) began the at-sea testing of adaptive oceanographic sampling algorithms and methods, and 4)) studied winter cooling east of Cape Cod using REMUS surveys.

RESULTS

Our main new results were: 1) the completion and final testing of the new digital towed array, 2) the successful deployment of a cluster of AUV's in the New England Sea Test II experiment (NEST II) during May 28- June 6, 2008, 3) the successful initial implementation of adaptive ocean sampling algorithms and 4) studies of winter cooling east of Cape Cod using REMUS surveys.

Concerning acoustics during the NEST II experiment, a cluster of two REMUS AUV's was deployed multiple times (Fig 1), and was successful in detecting, localizing, and tracking two low source level EMATTS targets at over 10 km range. An example of the acoustic data we obtained from the NEDS array is shown in Figure 2.

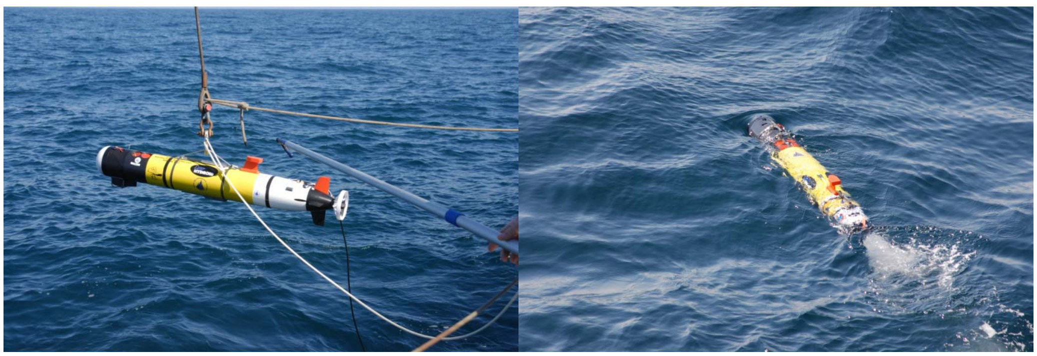

Figure 1. In left panel, REMUS 100 vehicle Snoopy is lowered from ship with leader of NEDS array behind it. In right panel, Snoopy moves away from ship towing array under command of deck box.

Mission 1 Power Spectrum Density
Steered to -8.5 degs and zoomed

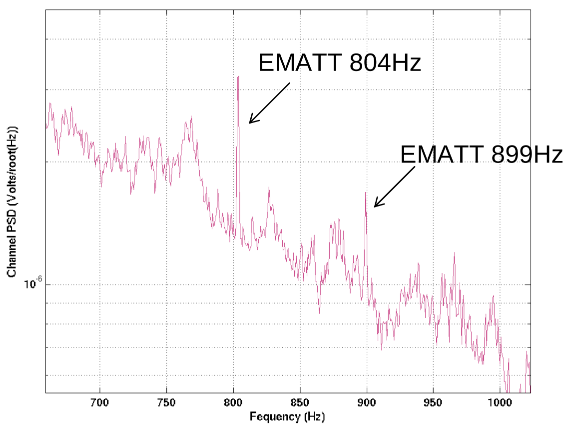

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Figure 2. EMATT source line detections by NEDS array during NEST II cruise.

Concerning the oceanography during the NEST II experiment, conditions encountered at the shelfbreak front were unprecedented. Offshore, there was a large amplitude Gulf Stream meander with imminent formation of a Warm-Core Ring (Figure 3). Note in Figure 1 that there was a streamer of shelf water which extended offshore to the north wall of the Gulf Stream. While streamers are common to the northeast of rings, where the ring flow is oriented offshore, the shelf water in this case was drawn offshore over an extremely broad area (100 km in the alongshelf). Associated with the offshore motion of shelf water in the surface layer was a shoreward retreat of the front below the surface layer (top 30 m). A cross-shelf CTD transect from the beginning of the cruise shows the offshore position of the Cold Pool at the 50 m isobath (Figure 4). While the foot of the front frequently retreats large distances shoreward, the extreme shoreward position of offshore edge of the Cold Pool has not been previously reported. During the NEST II cruise, we also performed autonomous Adaptive Sampling of the shelfbreak front using a REMUS 100 vehicle. G. Gawarkiewicz, in collaboration with S. Smith of Pro Sapien, Inc., successfully deployed the REMUS within the shelfbreak front and was able to identify the position of the front at a fixed depth.

Large-scale Setting- Large Gulf Stream meander

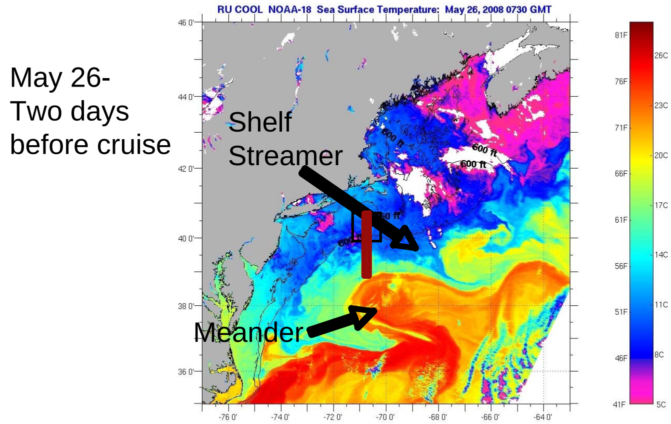

Figure 3. A satellite thermal image of the shelf and Gulf Stream south of New England. Note the large Gulf Stream meander as well as the broad shelf streamer extending offshore. An apparent counter-rotating eddy is present east of the meander. The red line along 71 Degrees West marks the position of the CTD transect in Figure 4.

CTD Transect over Shelf/Slope- Night May 28

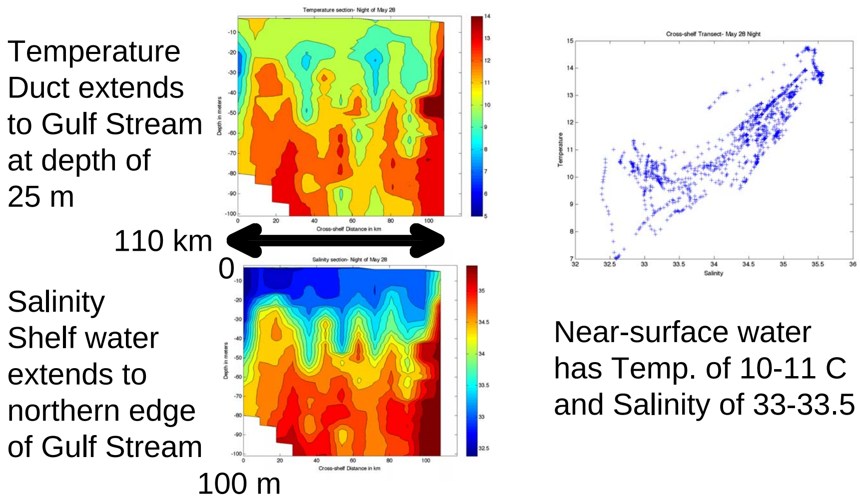

Figure 4. A CTD cross-shelf transect extending from the 50 m isobath over the shelf out to the north wall of the Gulf Stream. The top panel on the left shows the temperature and the lower panel shows the salinity. In the lower panel, note that the mean climatological position of the foot of the shelfbreak front is at the 100 m isobath, but that the foot of the shelfbreak front is not present in this section, nor is the Cold Pool present except at the most shoreward CTD station.

IMPACT/APPLICATIONS

The demonstration of the ability to deploy a cluster of AUV's that can survey the environment and perform the rudiments of an ASW mission against a low-level source shows that the technique has the potential for serious system development in the future.

RELATED PROJECTS

The AWACS project (now part of PLUS) is still being coordinated with the acoustics and physical oceanographic components of the SW06 experiment, and we are analyzing data common to these areas from the SW06 AWACS cruise on the R/V Endeavor. The AWACS effort also ties in well with the Uncertainty DRI's sponsored by ONR.

PUBLICATIONS

Shcherbina, A., and G. Gawarkiewicz, 2008b. A coastal current in winter. II: Wind forcing and cooling of a coastal current east of Cape Cod. J. Geophys. Res.-Oceans, 113, doi:10.1029/2008JC004750.

Shcherbina, A., G. Gawarkiewicz, C. Linder, and S. Thorrold, 2008. Mapping bathymetry and water mass distributions around Glovers Reef, Belize, with a REMUS Autonomous Underwater Vehicle. Limn. and Oceanogr., in press.