# Shelfbreak Acoustics: The ASIAEX Volume Interaction Experiment

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## LONG TERM GOALS

The long term goal of our work in the ASIAEX program is to understand the nature of low frequency (50-600 Hz) acoustic propagation through shallow water when strong oceanic variability in the form of fronts, eddies, boundary layers, and internal waves is present. We are also greatly interested in the effects of geological variability, which is just as important to acoustics as ocean variability in shallow water regions.

## OBJECTIVES

In the ASIAEX experiment, there were a number of specific objectives that we pursued. Specifically, we were interested in measuring: 1) horizontal array coherence in shallow water, 2) the frequency dependence of the shallow water acoustic field in the 50-600 Hz band, 3) the range dependent pressure field, and 4) the travel time and intensity fluctuations of the acoustic field. These goals both reinforced and extended the goals of the two predecessor experiments to ASIAEX, the 1995 SWARM internal wave experiment and the 1996-97 PRIMER shelfbreak front experiment. We also are interested in studying the oceanography and geology of the South China Sea (SCS) volume experiment region, in an interdisciplinary approach together with other ASIAEX investigators.

## APPROACH

Similar to the SWARM and PRIMER experiments, the ASIAEX SCS effort combined high-resolution physical oceanographic and geologic measurements with precise measurements of the acoustic field (see Figure 1.) Acoustically, the heart of our experiment was a combined vertical/horizontal aperture array, which listened to both moored and towed sources with frequencies from 50 Hz to 600 Hz. The moored sources enabled us to examine acoustic propagation time series both for a cross slope and an along slope geometry. The towed sources allowed us to study propagation loss versus range, a simple study that had been intended in previous experiments, but had never been accomplished due to time constraints. The oceanographic support for the acoustics was quite extensive, consisting of twenty-nine separate oceanographic moorings, a Sea Soar hydrography survey, a high frequency acoustic backscatter survey, satellite imagery (SAR and AVHRR), and numerous CTD casts. The geological support was also good, consisting of two high-resolution chirp sonar surveys along the stationary propagation paths, as well as the propagation loss tows. (We had hoped for somewhat more geological

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14. ABSTRACT
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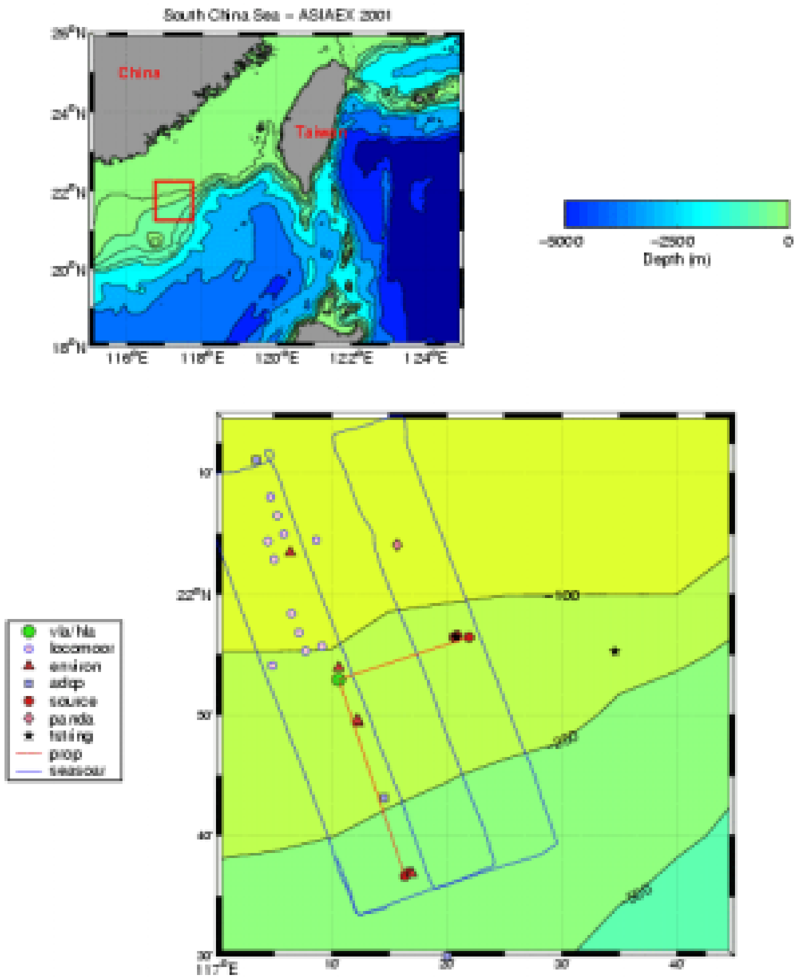


***Figure 1. Upper panel shows geographical location of ASIAEX SCS volume interaction experiment. Lower panel shows locations of moorings, as well as fixed acoustic paths and Sea Soar tracks.***

data, but area permission problems in the FY 2000 preliminary experiment precluded our obtaining all the data we desired.) Our experiment extended temporally over a three-week period, so that we were able to examine the effects of a full spring-neap tidal cycle on the acoustics transmissions.

## WORK COMPLETED

Our main accomplishment this year was the successful performance of the SCS volume interaction field experiment. WHOI led in the deployment of forty oceanographic and acoustic moorings, worked with numerous US and Pacific Rim nation's investigators as a team in doing the field work, and ultimately brought back the largest and best environmentally supported acoustic transmission data set to date on shallow water shelf and shelfbreak acoustics. We have recently prepared a technical report on the moored acoustics/oceanography component of the ASIAEX SCS effort, which will be distributed at the Hawaii workshop in late October.

## RESULTS

We have only just begun to digest the acoustic, oceanographic, and geologic results of the ASIAEX volume interaction experiment, which ended in May, 2001, but even the preliminary results are intriguing. We first spotlight the horizontal array component of our HLA/VLA receiver, as that was the biggest new feature of this experiment as compared with past efforts. Figure 2 shows the horizontal acoustic array geometry on May 5th, as measured by both light bulb implosion sources and long baseline navigation.

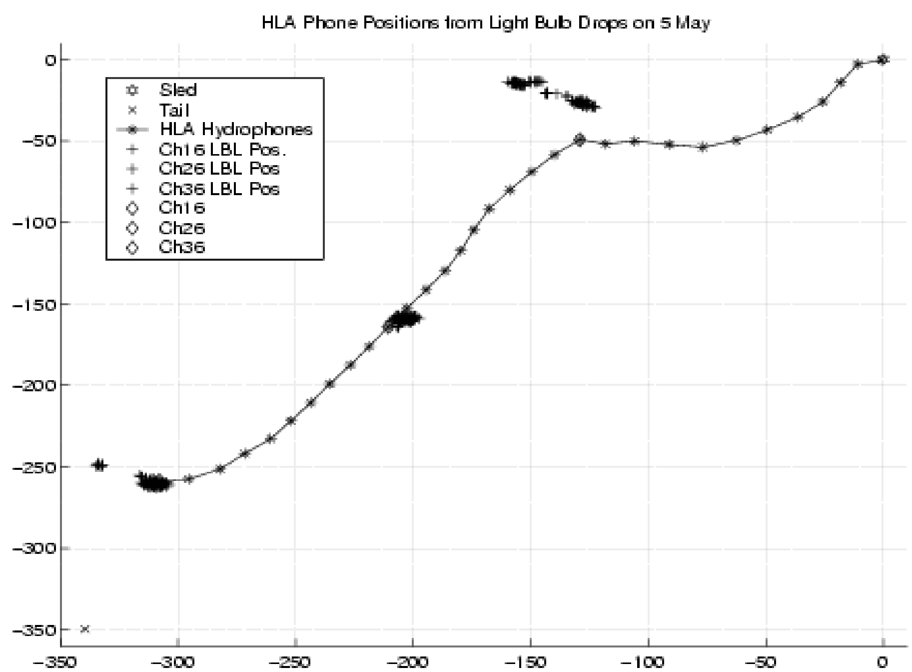


***Figure 2. Horizontal line array element positions on 5 May, 2001, computed using broadband light bulb sources and LBLN.***

One sees that the array is not a straight line, which was expected given the strong near-bottom currents in the region. We see that the light bulbs allow us to track the array, and that they agree well with the long baseline navigation (LBLN) system, which was employed continuously throughout the experiment. This indicates that, by using the lightbulbs, the LBLN and the environmental information, along with some of the multipaths from the moored sources for navigation, we can successfully locate the array elements to high accuracy.  This allows us to utilize whichever HLA beamforming algorithms we wish to. The acoustic data itself was of very high quality, with high SNR. An example of that data is shown in Figure 3. Note that the transmissions are diverse in nature, and fill the band from 50-600 Hz.

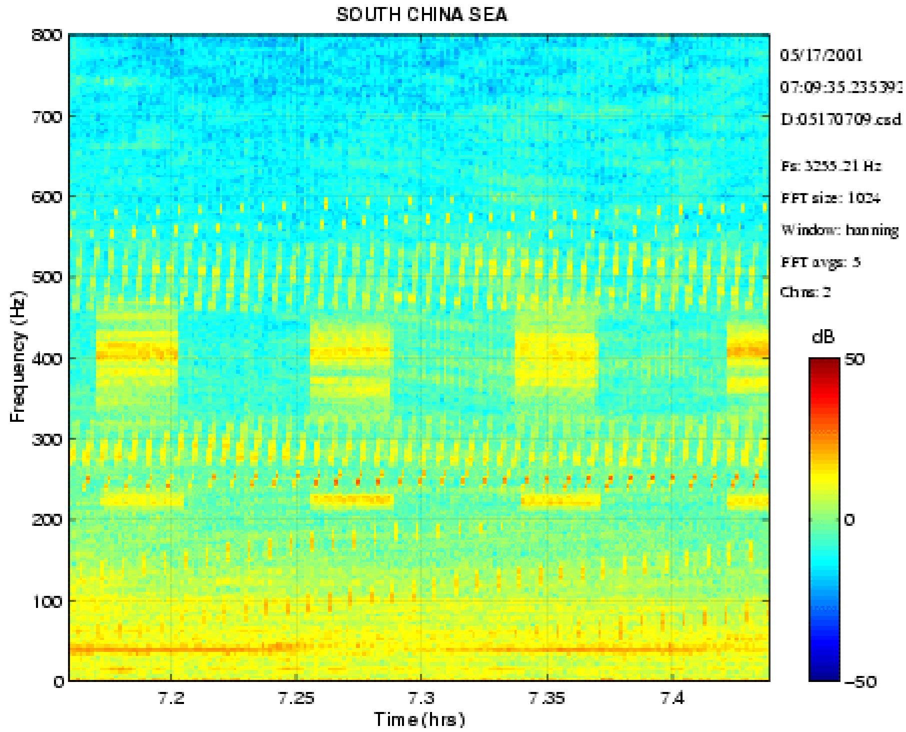


***Figure 3. Representative spectrogram of receptions on HLA hydrophones during the ASIAEX SCS volume interaction experiment.***

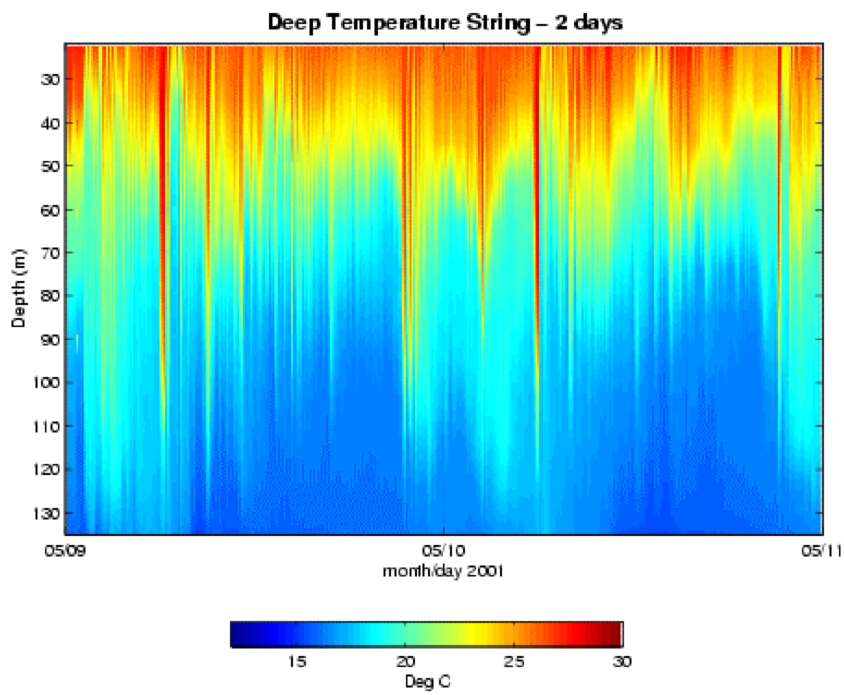


***Figure 4. Example of large amplitude solitons seen in thermistor string data.***

The oceanographic data that was taken by the moorings we prepared was also of great interest. Especially striking is the extremely strong soliton internal wave field seen in the area. In Figure 4, one sees internal waves of up to 120m amplitude in 136m of water.

## IMPACT

Probably the greatest impact that the ASIAEX volume interaction experiment will have is in seeing just how well we can predict the acoustic field and its variability/fluctuation level for a case where we can check the answers against ground truth. Additionally, we can directly examine important quantities such as horizontal coherence length and the frequency dependence of acoustic propagation for the ASIAEX region. Finally, the oceanographic data taken will be of great use in calibrating Navy models, such as MODAS.

## TRANSITIONS

One eventual transition of our data will be to ONR's Uncertainty DRI program, where the interest is in "the error bars" in ocean acoustic field and system performance prediction. Also, our ASIAEX data provide a unique database in a region where there are relatively few high-quality data.

## RELATED PROJECTS

The SWARM acoustics/internal wave study and the PRIMER acoustics/shelfbreak front study were direct predecessors of ASIAEX, and examined some of the same scientific issues, only with fewer measurement resources. The Uncertainty DRI is also a closely related project to ASIAEX, as it will use some of the data. Finally, the ASIAEX 2000 ECS preliminary experiment also included a small volume interaction component related to our SCS work.

## PUBLICATIONS (ASIAEX AND PRIMER)

J. Lynch, A.Newhall, B. Sperry, G. Gawarkiewicz, P.Tyack, and C.S. Chiu, "Spatial and temporal variations in acoustic propagation characteristics at the New England shelfbreak front", submitted to IEEE J. Oceanic Eng'g., 2001.

C.S. Chiu, S. Ramp and J. Lynch, "The ASIAEX 2000 preliminary experiment in the East China Sea (ECS)", Proceedings of the Beijing ICTCA meeting, May, 2001.