PACIFIC RIM NATIONS SYNCHRONIZE SHALLOW WATER ACOUSTICS STUDIES

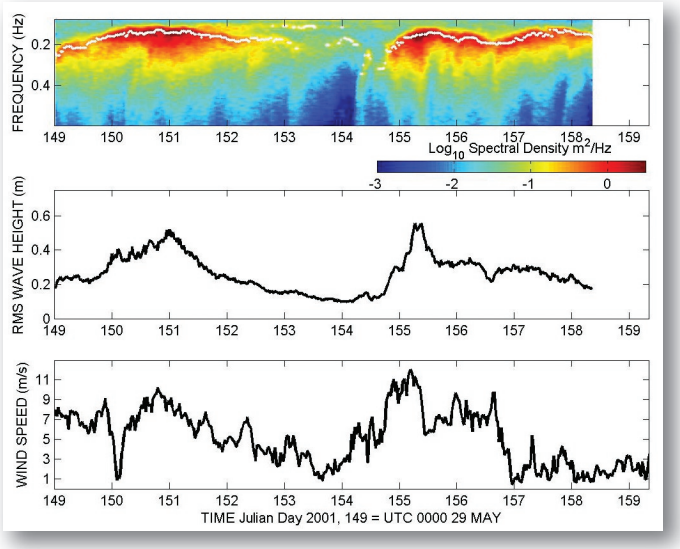
The fifty-mile trip up the Huangpu River—a tributary of the Yangtze—from the East China Sea to the port at Shanghai is a marvelous experience. APL-UW scientists and engineers looked on as the 170-ft R/V *Melville* was piloted amid the surges and flows of huge cargo vessels, fishing boats, and small live-aboard barges. After making their berth, a six-person uniformed contingent from the State Oceanic Administration of the People's Republic of China boarded to conduct an inquiry with the experiment's Chief Scientist Peter Dahl concerning the cruise's scientific measurements made during the preceding two weeks. After an initial misunderstanding about required documentation, the contingent's lead person and Dahl zeroed in on their common rudimentary knowledge of Japanese language and appreciation of haiku. Mutual compliments led to an efficient business exchange and thus the Asian Seas International Acoustics Experiment (ASIAEX) in the East China Sea was ended officially.

The APL-UW team aboard the R/V Melville *at Shanghai (from left to right): Russ Light, Eric Boget, Peter Dahl, Pete Sabin, Vern Miller, and DJ Tang*

The success of the ASIAEX field program, comprised of the experiments in the East China Sea and those of one month earlier in the South China Sea led by the Woods Hole Oceanographic Institution, was the culmination of five years of planning overseen by Jeffrey Simmen while he was the ocean acoustics program manager at the Office of Naval Research. The Asian marginal seas offer a unique shallow water laboratory in the world because their depth of a few hundred meters extends for hundreds of kilometers across the continental shelf. Scientists from eight Asian institutions from Korea to Singapore and eleven institutions from across the U.S. joined together to collect ocean acoustic, oceanographic, and geophysical data. This coordinated effort enabled underwater acoustics to be understood and modeled within the proper environmental context.

For ten days in May and June 2001, the APL-UW crew aboard the R/V *Melville* conducted ocean acoustic propagation and scattering experiments to understand the acoustic interaction with ocean boundaries as influenced by seabed properties and variable sea surface conditions. Sea surface data showed three-day periods of significant winds and seas alternating with calm balmy conditions during the ten-day observation window.

Dahl measured the influence of the changing sea surface on shallow water acoustic propagation using the APL-UW-engineered MORAY (MOored Receiving ArraY). The instrument received acoustic signals in the frequency range 2–20 kHz transmitted from the R/V *Melville* at a distance of 0.5–1 km from the MORAY. Upon receiving and



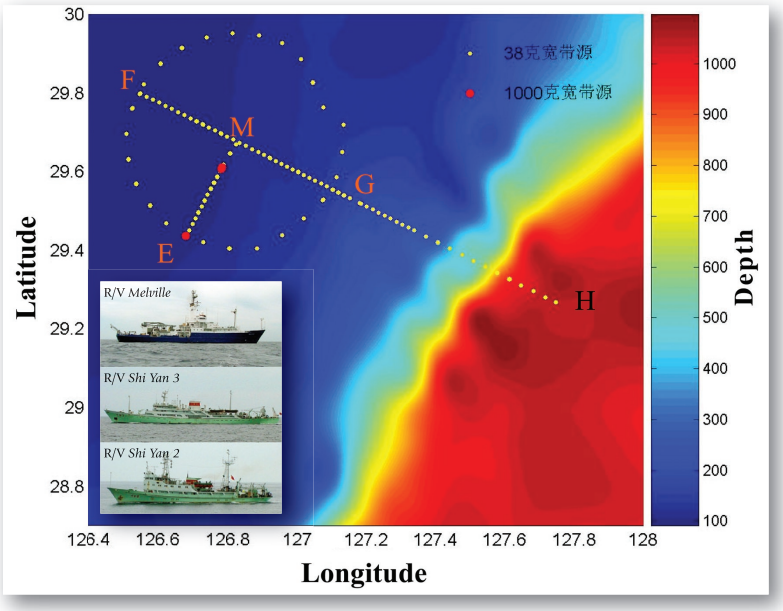
Surface wave properties and wind speed recorded in the East China Sea during ASIAEX. The top shows contour of wave frequency spectra measured every one-half hour between 29 May and 8 June. The red areas show the wave frequencies of the most energetic waves, with the peak frequency tracked by the white dots. (A peak frequency of 0.2 Hz corresponds to a wavelength on the sea surface of 39 m.) The middle shows the average waveheight, and the bottom shows the wind speed. Between 29 May and 7 June, wind speed varied from near 1 m/s to 13 m/s and RMS waveheight varied between about 0.1 m and 0.6 m, thus providing a wide range of sea state conditions for the ocean acoustic experiments. In this open-sea environment wind speed and waveheight show correlation, with maximum waveheight developing a few hours after maximum wind speed.

Deploying the IMP2 in the East China Sea

recording the signals, data were sent back to the *Melville* through an RF modem. Acoustic data obtained by the MORAY were used to study shallow water, short-range propagation and forward scattering from the seabed. Continuous measurements over two 24-hr periods were made to capture variability in environmental effects. The measurements in this frequency range are crucial to understanding underwater acoustic communication, detection, and imaging in littoral seas.

Senior Oceanographer DJ Tang collected seabed measurements in the study area with the IMP2 (In situ Measurement of Porosity, 2nd generation). This instrument, also engineered by APL-UW, resembles a 5-m-long sawhorse; it measures seafloor roughness at centimeter scales and seabed density at centimeter depth resolution. A conductivity probe is mounted on the IMP2 A-frame, which is equipped with horizontal and vertical motor systems. After each vertical measurement cycle is finished, the probe retracts to the starting position and the horizontal motor moves the probe to the next designated horizontal position, where the next vertical measurement cycle commences. Data collected by IMP2 are used as input for bottom acoustic scattering models.

A key phase of the cruise was the coordination of activities with two Chinese research vessels over five days. The service of three vessels covering a large geographic area was needed to study the mechanisms responsible for low-frequency reverberation in shallow water and how sound propagates across boundaries separating sediments of differing composition. The *Shi Yan 2* deployed 38-g and 1000-g explosive charges at 50-m depth along a set course up to 100 km away from the *Shi Yan 3* and *Melville*, which were recording the data on vertical line arrays.



The large-scale experimental site for ASIAEX, East China Sea, was a circle of radius 30 km. The yellow dots (above) are waypoints visited by the R/V Shi Yan 2 *for deployment of explosive sound sources. The R/V* Melville *and the R/V* Shi Yan 3 *held position at waypoint M and recorded acoustic transmissions from the deployed sources.*

ASIAEX collected an extraordinary set of synchronized acoustic, oceanographic, and marine geophysical data in Asian marginal seas. The work makes a significant contribution to understanding how variable seabed sediments and sea surface roughness in shallow water environments govern acoustic propagation and reverberation. Inverting acoustic propagation and reverberation field measurements across the frequency range of 10 Hz to 10 kHz has gone far to establish a unified geoacoustic description of the East China Sea's seabed.

The size and scope of the multinational effort created enormous logistical challenges, but all participants contributed to an increased understanding of the acoustic environment of the Asian littoral seas and appreciation of the people of the many Pacific Rim nations who came together to study it.