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QuantifyingAcoustic Uncertainty Due to Marine Mammals and Fish Near the Shelfbreak Front off Cape Hatteras

James F. Lynch
MS #11, Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-2230 Fax: (508) 457-2194 e-mail: jlynch@whoi.edu

Glen Gawarkiewicz
MS#21, Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-2913 Fax: (508) 457-2181 e-mail: gleng@whoi.edu

Ying-Tsong Lin
MS #11, Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-2329 Fax: (508) 457-2194 e-mail: ytlin@whoi.edu

Arthur E. Newhall
MS #11, Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-3317 Fax: (508) 457-2194 e-mail: anewhall@whoi.edu

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LONG TERM GOALS

The long term goals of our work on acoustic uncertainty due to fish and marine mammals are to: 1) understand the nature of low-to-medium frequency (100-2000 Hz) acoustic scattering (specifically reverberation and attenuation) by fish schools and larger marine mammals, 2) advance our acoustic methods of quantitatively imaging fish schools and tracking vocalizing marine mammals, and 3) understand the correlation between the detailed physical oceanography and the biology and acoustics.

OBJECTIVES

Our primary objectives this year were: 1) complete analysis of our "year two" major experiment data (taken off Cape Hatteras, N.C. to measure the acoustics, biology, and physical oceanography of fish schools) and 2) finish publishing our results.

APPROACH

The basic tools/methodology employed in our "year two" major cruise consisted of a combination of: 1) an AUV mounted acoustic source, 2) moored multi-element SHRU acoustic receiver arrays, 3) a shipboard acoustic resonator, 4) fish-attraction devices (FAD's), 5) a three-AUV fish-field mapping effort (employing sidescan sonar plus optics) and 6) ScanFish, ADCP, and moored sensor oceanographic field mapping. The day-to-day experimental plan was to: 1) survey the oceanography at night to find the shelfbreak front and other features that might attract fish, 2) survey for fish during the day based on the oceanography survey results, 3) given a good fish population "target", deploy the SHRU receivers and FAD's and perform REMUS vehicle operations to both map the fish school and examine its 500-2000 Hz scattering characteristics.

Our post cruise approach is simply to simultaneously analyze the acoustic, biologic, and physical oceanographic data to see the correlations between the three areas.

WORK COMPLETED/ACCOMPLISHMENTS

A suite of signal processing programs was developed over the past three years to allow data extraction from the SHRU recorders, matched filter processing, pulse compression and frequency analysis. These programs were used to analyze the 2012 acoustic data, and we now have results that show the attenuation from the fish and the scattering from the medium and direct arrivals that competes with scattering from the fish. We now have one paper in review and are in the process of finishing a second peer-reviewed manuscript.

RESULTS

The acoustic model has been further refined. To obtain a better estimate of source positions, the navigation data of the source AUV (Snoopy) was corrected using the GPS fix obtained when the AUV surfaced. The estimated positions of the source AUV were verified by comparing its surveyed topographic map to another independent map obtained from the second AUV (Edgar) equipped with an inertial navigation system. Both of the topographic maps show a 6-m deep scour at the ship wreck site, along with other seafloor features consistently observed by both AUVs (see Figure 1). With the improved source position estimates, numerical acoustic models of eigenrays and broadband arrival patterns were constructed using a time series of water column sound speed profiles measured in the experiment area. The eigenray tracing shows some, but not significant, scattering from the scour (see Figure 2). The simulated arrivals from a high-order broadband PE model agree with the data very well in terms of the arrival time and pulse spread durations (see Figure 3). Sea surface roughness scattering was estimated, and when added to bottom roughness spread, the combination was adequate to explain the scattering pattern is observed experimentally.

Co-PI Grothues worked to quantify the position and identity of fishes from high frequency (600 &900 kHz) side scan sonar and video imaging in support of calculations for determine fish scatter from low frequency sonar, and for application to understanding scattering organism distribution in pelagic environments per se. A paper was submitted to the Canadian Journal of Fisheries and Aquatic Sciences and is currently under peer review.

IMPACT/APPLICATIONS

The impact of our experiment should be: 1) an increased understanding of the scattering of sound through fish schools, which can help discriminate fish schools as "false targets" for sonars, 2) improved methods for mapping fish populations and schools, which is important in that the "biological field" is often an unknown for both experimental studies and Navy applications, and thus could be quantified, and 3) a beginning understanding of how climate change may be affecting shallow water acoustics, both through the fish, and perhaps more importantly, through the ocean temperature field.

TRANSITIONS

Being able to model the acoustics of fish schools will allow them to be discriminated against as false targets ion sonar systems. Also, in the case of larger shoals, the effective attenuation due to the fish can be estimated. Further, the ability to incorporate fish and climate change into Navy models could be a useful payoff.

RELATED PROJECTS

This work is related to the work of K. Benoit-Bird and her work off the west coast of the United States as well as T. Stanton and D. Greenbaum who are working on theoretical aspects of fish school behavior and the scattering of sound within fish schools. This work also relates to efforts to quantify uncertainty in acoustic propagation from the Quantifying, Predicting, and Exploiting Uncertainty DRI.

PUBLICATIONS

A. Recent Publications (refereed)

Thomas M. Grothues, Arthur E. Newhall, James F. Lynch, Kaela S. Vogel, Glen G. Gawarkiewicz. (2015) High Frequency Side Scan Sonar Fish Reconnaissance by Autonomous Underwater Vehicles. Canadian Journal of Fishers and Aquatic Sciences. [Submitted]

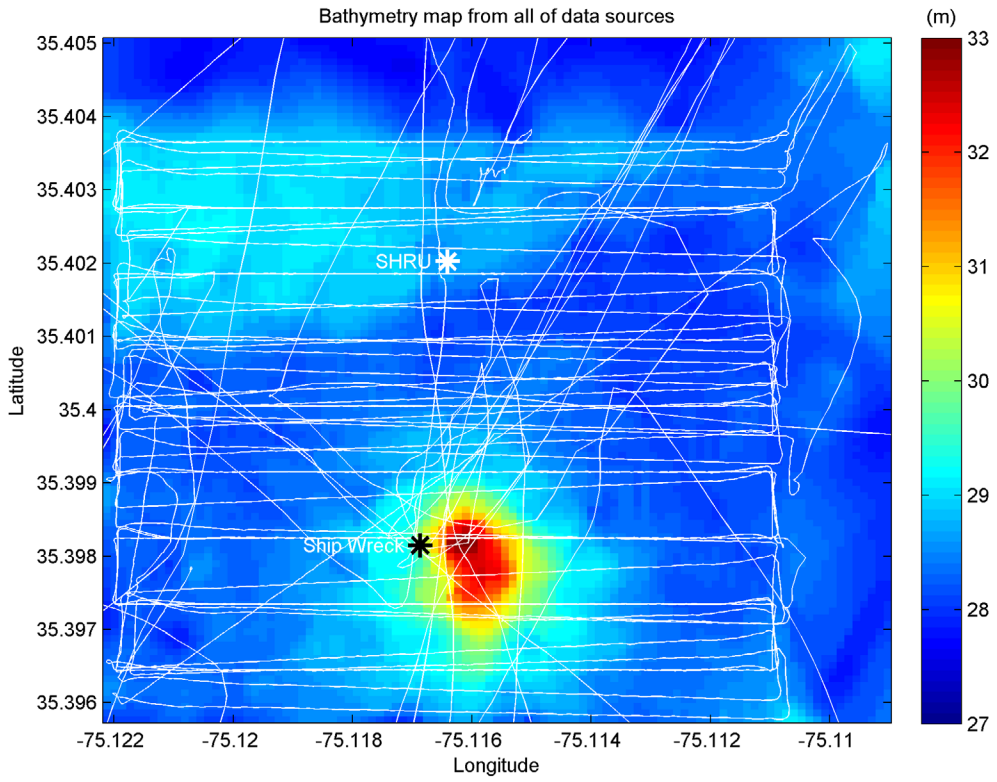

Figure 1. Bathymetric map created using all data sources. Scour pit near shipwreck is a prominent feature.

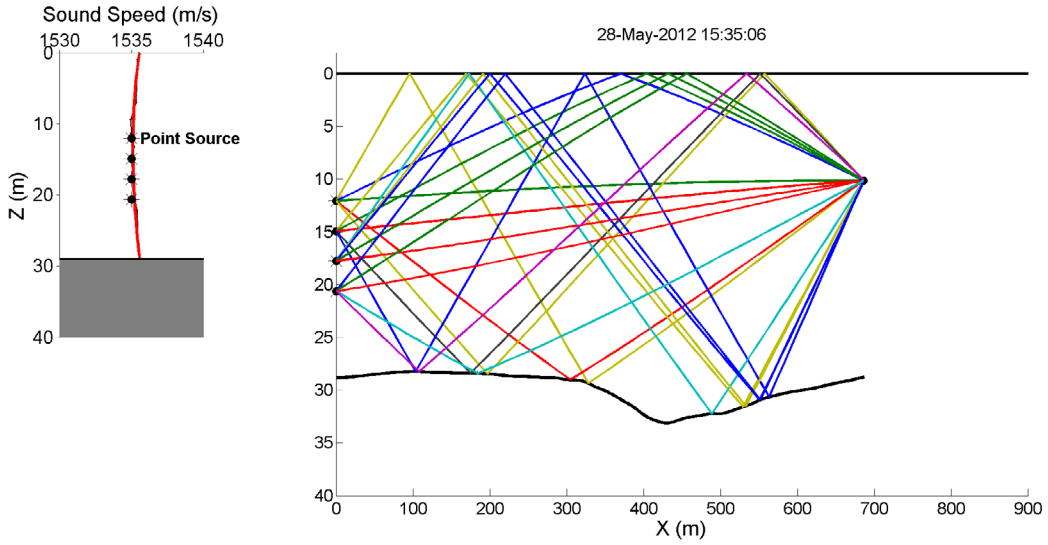

Figure 2. Soundspeed profile and eigenrays for a typical source to receiver range and azimuth.

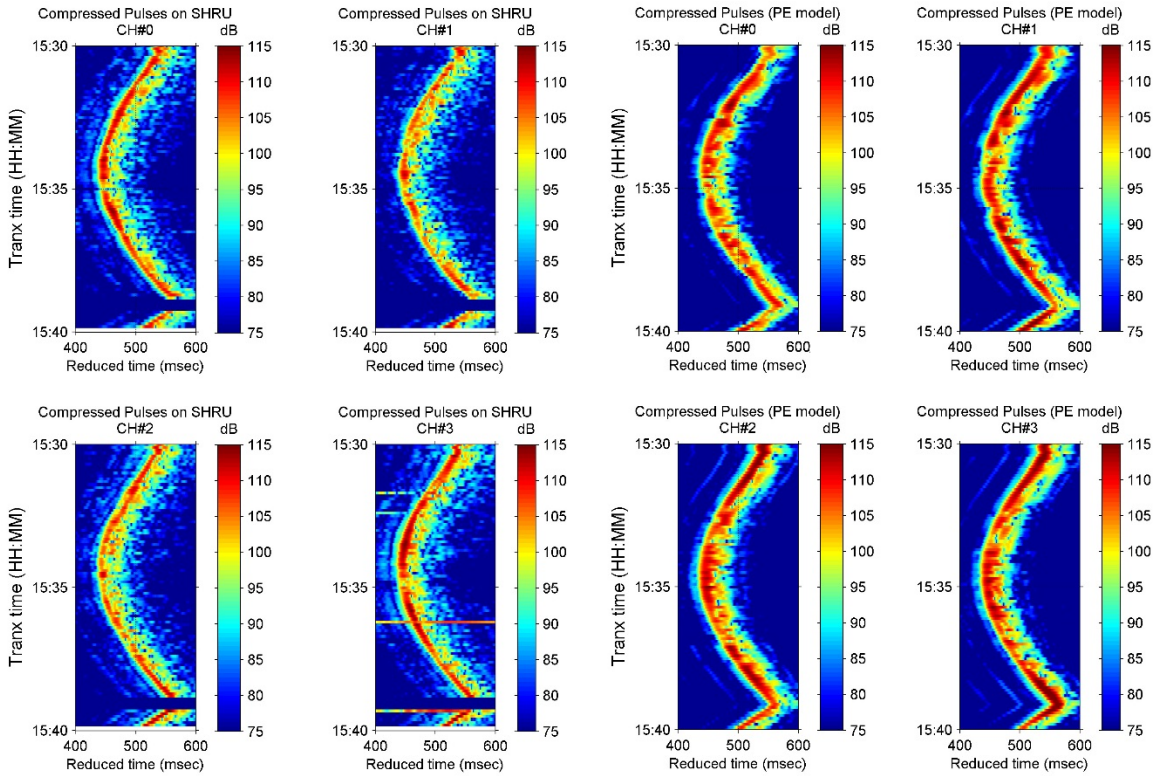

Figure 3. Arrival pattern, showing spread due to bathymetric scattering.