Design and Deployment of a Deep-water Seafloor Sound Source

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Introduction

With funding from DOE-NETL, the Naval Research Laboratory's deep-towed acoustic geophysics system (DTAGS) was outfitted to be set directly on the seafloor with the intent of more efficiently generating shear wave energy in the seafloor. We altered the existing DTAGS by adding a releasable landing shoe, and a geophone array that used existing data telemetry.

The modified system was deployed in March of 2010 in about 900m of water near the site of the University of Mississippi's gas hydrate observatory in lease block MC118. DTAGS produced signals with several different waveforms within the 220-1000Hz range while in contact with the seafloor at three separate locations in lease block MC118. The experiments were performed in conjunction with a series of other measurements (Bottom Loss Underwater Exercise 2010, BLUE10) where only the DTAGS source was towed through the water column and used to ping to EARS (Environmental Acoustic Recording System) buoys in a measure of the anisotropy of the bottom loss in this region.

Design Strategy

We assumed that when lowering DTAGS to the seafloor, small amounts of drift by the ship as well as any currents in the water would cause the geophone array cable to lay down along the seafloor, possibly dragging slightly, before the DTAGS itself came to rest on the seafloor. At this point excess cable would be let out so as not to tug at the system while it was on the seafloor (see Figure 1, left). Floats were placed on the tow-cable to prevent it from contacting the seafloor and potentially wrapping around DTAGS. The source was to be on the seafloor for many minutes at a time, actively pinging to increase fold and therefore improve the signal to noise ratio.

We constructed a landing shoe for DTAGS consisting of a solid aluminum plate (with drain holes) and a short riser to prevent mud from coming in contact with the Helmholz resonator. The shoe was designed with an acoustic release on the back end. If the pull-up tension on the cable was greater than about a few thousand pounds, the acoustic release could be activated from the ship and would free the back end of the shoe. The shoe would pivot on the front edge, so that the full strength of the pull up could be focused on the front edge and the system could be peeled off of the seafloor. During our three deployments there was never any trouble lifting DTAGS off the seafloor, and the acoustic release was not used.

We also outfitted DTAGS with a two-element array, each 10 and 20 m away from the source. We used three-axis accelerometers instead of geophones both for ease of use and because their small mass (about 1 kg) would ensure that they would couple to the seafloor at the frequencies of interest, about 200-300 Hz. The accelerometers were suspended with braided cable in rigid frames to de-couple them from any motion of the array cable (Figure 2, right). The far geophone (at

20m) was also outfitted with a hydrophone to aid in interpreting the recorded signals.

Deployment

Because bringing DTAGS into contact with the seafloor was deemed to be inherently riskier than towing it through the water, the seafloor landings where performed on the last day of the cruise, 7 April 2010. We suspect that the station keeping was actually more accurate than we had anticipated, so that both of the geophones were very near the DTAGS source.

Also, although the tow-cable specifications include torsion balancing, we suspect a twist developed such that instead of a bend in the tow-cable (Figure 1) there was actually a loop in the tow-cable. When DTAGS was raised from the seafloor a kink formed in the cable, possibly damaging the cable.

Results

DTAGS was placed on the seafloor three times. While on the seafloor the system was activated with several different waveforms, all 250 ms in duration.
The hydrophone records for each of the three landings (Figure 3) show greater amplitude than when the array was suspended in the water column. We suspect this is due to less flow noise around the hydrophone, and less mechanical noise (rattling or strum) from the array cable. Figure 3 shows the direct arrival for each of the three landings. Several attempts were made to cross-correlate the signals with estimates of the source waveform, but the results indicated no discernable features in the sediment column. Data from the third landing exhibited the greatest signal to noise ratio (SNR), but this was still only about 25 dB. The expected SNR for DTAGS signals at this range is over 80 dB. Note that when the system was suspended in the water column, even the amplitude of the direct wave was largely below the amplitude of the noise.

Figure 4 shows the data from the first channel of accelerometer 1. The slanted, high amplitude stripes between the landings are cross talk from compass telemetry. The SNR of the accelerometer data during the landings is even lower than that of the hydrophone. Only a slight indication of the direct wave is visible and only in a portion of the records (arrow at about 0.03 s in Figure 4). An expanded view of this signal, with all three channels displayed with shaded area is shown in Figure 5 (left). The direct signal is the horizontal event at 0.033 s.

Conclusions

In general the signal level was quite low, 40-60 dB less than expected. This was almost certainly due to an electrical short in the source. Because neither the reflected P-wave nor S-wave energy is discernable in our data, we were unable to determine how effectively shear-wave energy can be generated by this source on the seafloor.

Upon post-cruise disassembly in the shop, we discovered electrical arcing within the source that destroyed a portion of the piezo-ceramic ring responsible for generating the sound. The arcing shorted the system, apparently draining power from the rest of the rings. After the cruise, the damaged ring was replaced with a spare, (a major operation that cannot be performed at sea).

As of late 2010 the source has been repaired, re-sealed and tested. The dielectric Mylar between the rings was replaced at double the original thickness, to help prevent arcing in the future.

Figures

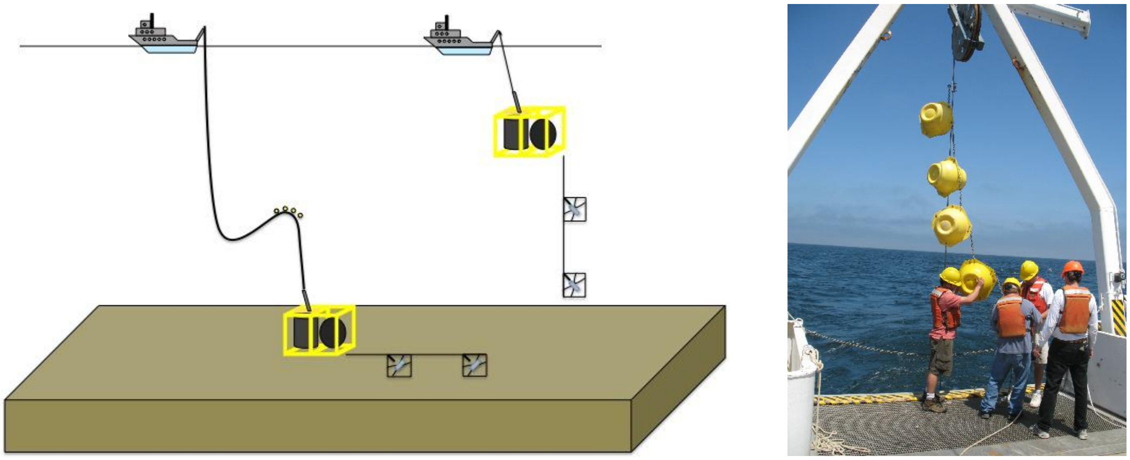

Figure 1 (left) The accelerometer array and DTAGS were slowly laid on the seafloor and extra cable let out. (right) Floats were deployed to suspend the cable in the water column, creating a bend so as to de-couple DTAGS from ship motion.

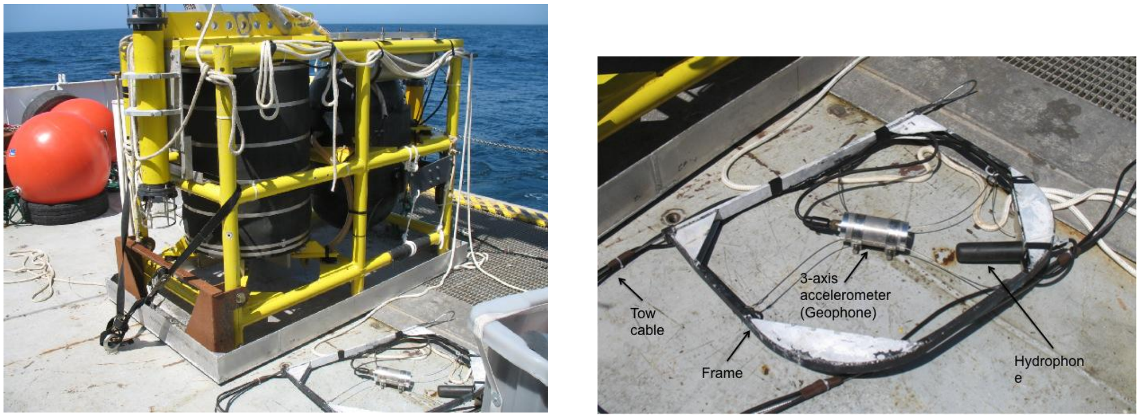

Figure 2 (left) DTAGS on the deck of the R/V Cape Hatteras outfitted with landing shoe. (right) the far accelerometer frame with hydrophone.

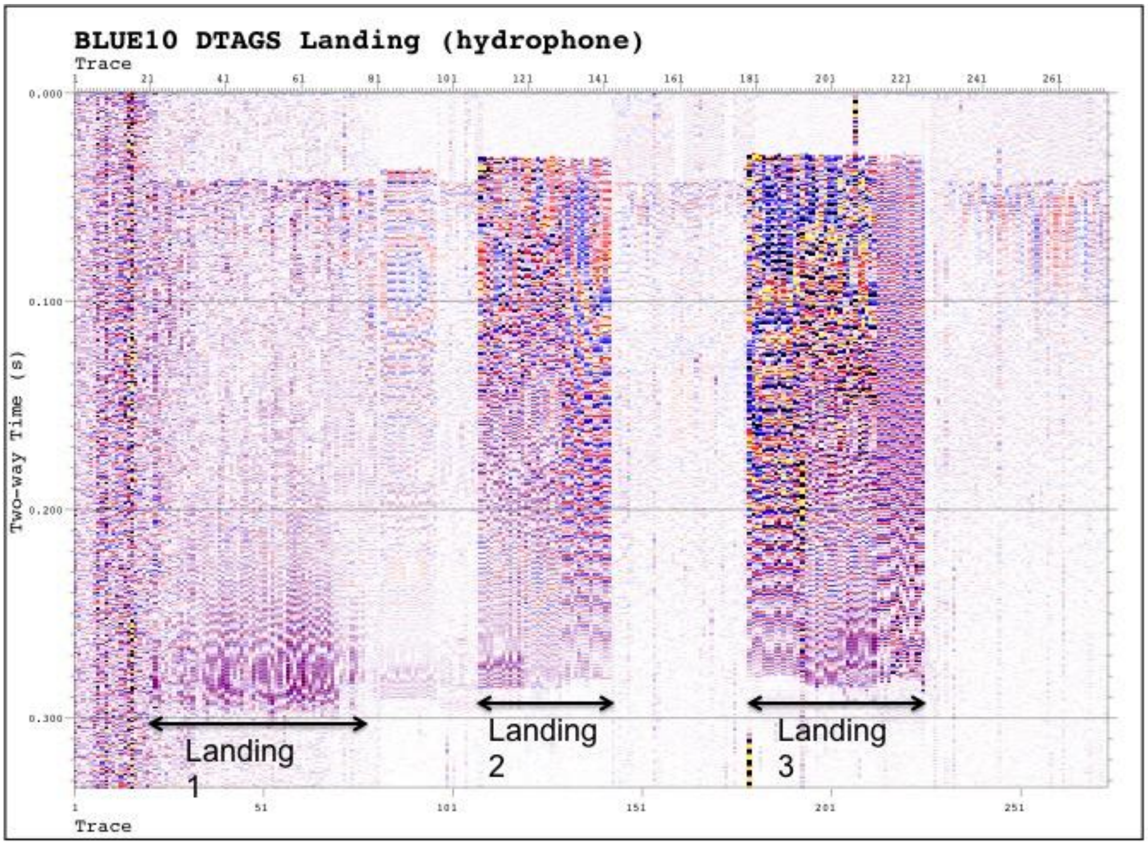

Figure 3. The hydrophone records for the three landings show that the source fired as expected. Each source fire lasted 250ms.

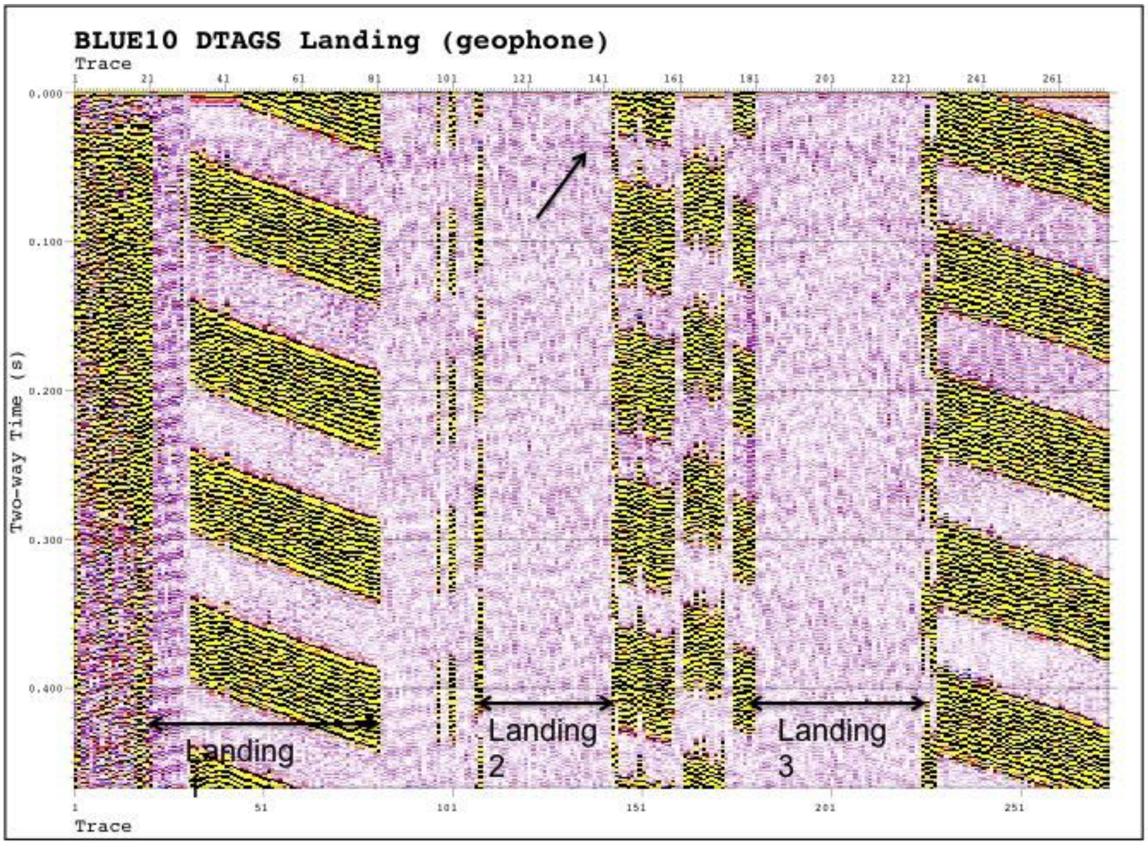

Figure 4. The records on all 3 channels of both geophones were similar. The high amplitude parallel bands are likely an artifact generated by telemetry signals. Only very weak signals are visible at about 0.03 s (arrow).

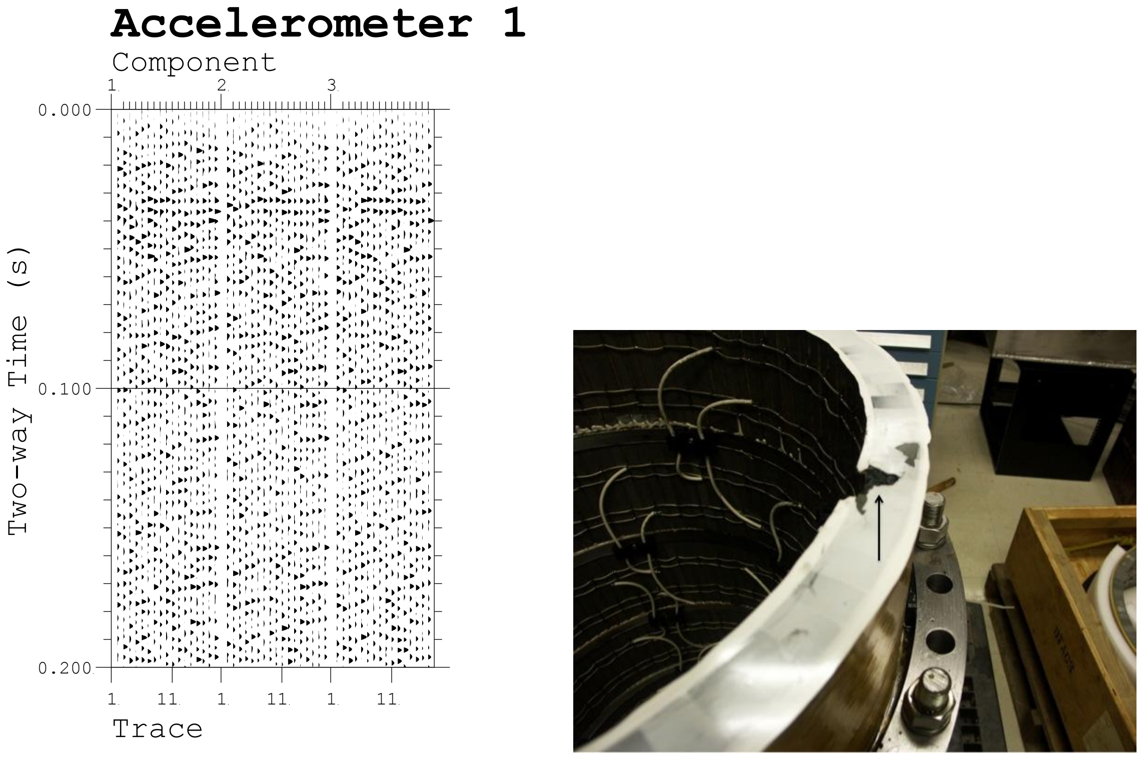

Figure 5. (Left) The weak signals from the accelerometer are shown here for all three accelerometer axes. The direct wave arrives at about 0.033 s. It is not possible to distinguish between the pressure-wave and shear wave on the basis of this signal. (Right) The source of the signal weakness – a transducer ring burned (arrow) from electrical arcing.