Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER 507466
UNCLASSIFIED	

TITLE

VERTICAL NOISE COHERENCE MEASUREMENTS IN SHALLOW WATER USING LAGRANGIAN DRIFTERS

System Number:

Patron Number:

Requester:

Notes:

DSIS Use only:

Deliver to:

Vertical Noise Coherence Measurements in Shallow Water Using Lagrangian Drifters

Francine Desharnais*, Blair R. MacDonald† and Kenneth J. Mah†

**Defence Research Establishment Atlantic, P.O. Box 1012, Dartmouth, Nova Scotia, Canada, B2Y 3Z7 and*
†Seimac, 271 Brownlow Avenue, Dartmouth, Nova Scotia, Canada, B3B 1W6

Abstract: The vertical coherence of an acoustic noise field in shallow water (at frequencies dominated by sea surface noise) can be used to infer certain ocean bottom properties such as the compressional sound speed of the upper sediment layer. Three Lagrangian Ambient Noise Drifters (LANDs) were developed for vertical coherence measurements. The drifters (drogued at 15 m depth) follow the near-surface currents, and take hourly measurements of coherence from their two hydrophones located at 50 m depth. The hydrophone separation is 1 m, and the measurements are made over a useable frequency range of 100 Hz to 1 kHz. The drifters were deployed twice consecutively at Western Bank (Scotian Shelf, Canada) and drifted for a period of up to 2.5 days.

BACKGROUND

Coherence is a normalized measurement. As a consequence, the vertical coherence of an ambient noise field should be independent of background noise level, wind speed and/or sea state, and the measurement should remain stable over a wide range of environmental conditions. This stability is particularly useful when relating vertical noise coherence to seabed parameters, as described in (1).

The Lagrangian Ambient Noise Drifters (LANDs) were first designed under contract by Seimac as a tool to measure underwater ambient noise over long periods of time (2). The drifters are drogued at 15 m depth to follow near-surface currents, and are equipped with diverse instrumentation to measure ambient noise levels (in third-octave bands from 50 Hz to 12.8 kHz) at 100 m depth, as well as GPS buoy position, wind speed and direction, surface wave energy spectrum, water temperature at the surface and at 100 m depth. The information is relayed hourly to a land-based station via an ARGOS satellite link.

The LANDs have been successfully used in the Gulf Stream (3), and a few units were modified to measure vertical noise coherence in shallow water. For this purpose, the hydrophone was relocated at 50 m depth, and a second hydrophone was positioned 1 m below it. The electronics package was also modified to internally record, once per hour, the frequency noise spectra at both hydrophones and the cross-spectrum between them, over a useable frequency range of 100 Hz to 1 kHz. The coherence (or normalized cross-spectrum) of the noise field is later calculated from these spectra. The life cycle of the drifters was reduced from 14 to 5 days due to power limitations.

Five ambient noise LANDs and three modified LANDs (for coherence measurements) were deployed during a sea trial over Western Bank (Scotian Shelf, Canada) in September 1997. During a first deployment, the LANDs drifted for 2 consecutive days in the Northern shallow water area of the Bank. A second deployment occurred in the Western

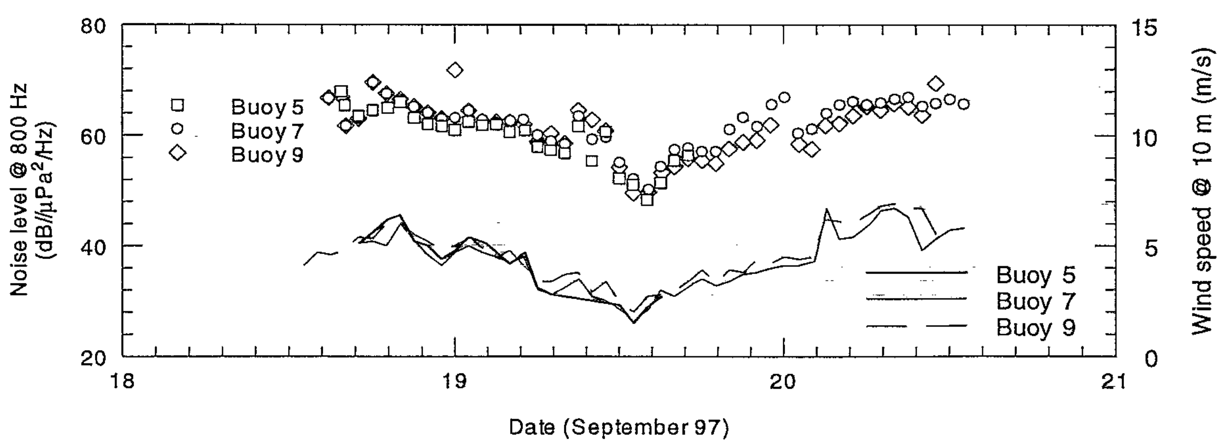

FIGURE 1. Noise level at 800 Hz (upper symbols and scale on left) and wind speed at 10 m (lower curves and scale on right) as a function of time (UTC) for drifters 5, 7 and 9 on the first deployment.

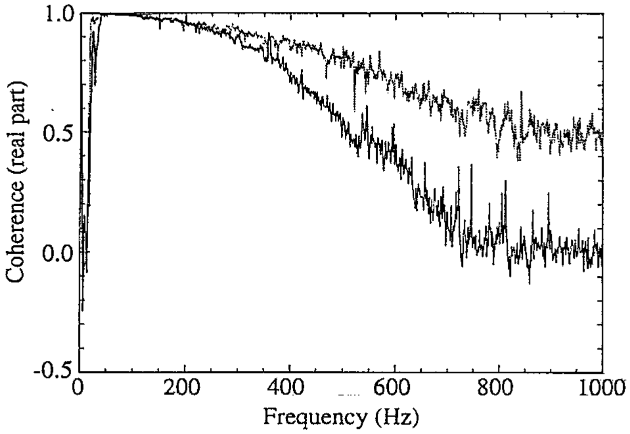

FIGURE 2. Real part of coherence with ship in area (pale line above), and with no ship in area (dark line below).

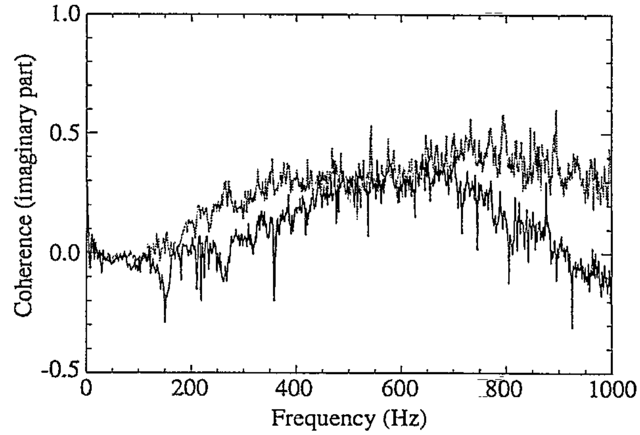

FIGURE 3. Imaginary part of coherence with ship in area (pale line above), and with no ship in area (dark line below).

Gully (between Western and Emerald Banks) and lasted 1 day. The wind varied from 2 to 13 m/s during the deployments, and the sea conditions varied from calm to 3-4 m waves.

EXPERIMENTAL RESULTS

Figure 1 shows the 800-Hz ambient noise levels (upper symbols and scale on left) and the wind speed at 10 m (lower curves and scale on right) as a function of time for the 3 coherence drifters over the 2 days of the first deployment. The noise levels are 5-minute averages over a third-octave band; the anemometers are located 1 m above sea level, and the readings are corrected to give an equivalent wind speed at a 10-m standard height. The wind speed cycles between 2 storm systems passing over the experimental location. The ambient noise levels (*NL*) correlate well with wind speed (v), and follow a relationship of the type $NL=B+20n\log v$, where B and v are frequency dependent.

Figures 2 and 3 show two samples of coherence data (real and imaginary parts) as a function of frequency. The samples were taken on 19 Sep 97 at 1300 and 1500 UTC. At 1500 UTC (dark line in both figures), no ships were observed in a 40 km radius from the drifters (except for the experimental ship with engines turned off). At 1300 UTC, one ship was sighted on radar at approximately 23 km from the buoys.

The real coherence at 1500 UTC (dark line in Figure 2) is similar to that measured in the same area on other occasions and with a different measurement system (1). The coherence was successfully modelled in (1) assuming a 38-m layer of sand over bedrock, which is typical of the Western Bank area. The low coherence at frequencies below 50 Hz is due to self noise on the hydrophones.

Even over 20 km away, one ship is enough to affect significantly the real and imaginary coherence (pale curves in Figures 2 and 3) of the noise field. During these measurements, however, the wind speed was at its minimum (2 to 4 m/s). For wind speeds above 5 m/s, local shipping is better masked by wind/sea state noise, and the variance of the coherence measurement (particularly the imaginary part) is reduced.

If vertical noise coherence is used to estimate bottom parameters (such as compressional and shear speed of the upper sediment layer), wind speeds above 10 kn can reduce the degree of uncertainty on the estimates. This is particularly true for shear speed estimates, which relate more closely to the imaginary part of the vertical coherence.

REFERENCES

1. Desharnais, F. and Chapman, D.M.F. "Modelling the vertical coherence of the shallow water ambient noise field," *Proceedings of Sea Surface Sound '97*, Southampton, UK, 111-118, 1997.
2. Carey, W.C., Fraser, I.A. and Leger, G.T. "Lagrangian Ambient Noise Drifter," *Proceedings of Oceans '94*, Halifax, NS, Canada, Vol. 3, 34-39,1994.
3. Fraser, I.A. and Carey, W.C. "Gray-scale visualization of wave spectra in an ocean eddy," *Proceedings of Oceans '97*, Halifax, NS, Canada,1203-1208,1997.

Vertical noise coherence measurements in shallow water using Lagrangian drifters. Francine Desharnais (Defence Research Establishment Atlantic, P.O. Box 1012, Dartmouth, Nova Scotia, CANADA, B2Y 3Z7, desharnais@drea.dnd.ca), Blair R. MacDonald (Seimac, 271 Brownlow Avenue, Dartmouth, Nova Scotia, CANADA, B3B 1W6), and Kenneth J. Mah (Seimac, 271 Brownlow Avenue, Dartmouth, Nova Scotia, CANADA, B3B 1W6)

The vertical coherence of an acoustic noise field in shallow water (at frequencies dominated by sea surface noise) can be used to infer certain ocean bottom properties such as the compressional sound speed of the upper sediment layer. As coherence is a normalized measurement, it is independent of background noise level, or wind speed/sea state, and remains a stable measurement over a wide range of environmental conditions. A set of three Lagrangian Ambient Noise Drifters (LANDs) were developed for vertical coherence measurements. The drifters (drogued at 15 m depth) follow the near-surface currents, and take hourly measurements of coherence from their two hydrophones located at 50 m depth. The hydrophone separation is 1 m, and the measurements are made over a usable frequency range of 100 Hz to 1 kHz. The drifters were deployed at Western Bank (Scotian Shelf, Canada) and drifted for up to 2.5 days. The sea conditions varied from calm to 3-4 m waves. The stability of the coherence data through the various sea states, and the impact of shipping noise on the measurements will be discussed.

Number of words in abstract: 180
Suggested Special Session:
Technical Area: Underwater Acoustics
(PACS) Subject Classification number(s): 43.30.Nb, 43.60.Cg
Telephone number: 902-426-3100, ext. 219 email address: desharnais@drea.dnd.ca
Send notice to: F. Desharnais. DREA, P.O. Box 1012, Dartmouth, Nova Scotia, Canada, B2Y 3Z7
Special Facility:
Method of Presentation: Prefer lecture

S07466