Hydroacoustic Field Lake Trial Using High Performance Fiber Distributed Acoustic Sensing System

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The exploration of marine oil resources has gained great attentions in recent years. Among several methods, the acoustic detection is a relatively common method for offshore oil logging. Consequently, it is important to set up underwater acoustic sensors with high reliability and sensitivity. Owing to the advantages of great convenience, low cost and distributed detection, fiber distributed acoustic sensing (DAS) has been served as an attractive means for large-scale detection. In this work, a high sensitive fiber DAS system based on the distributed microstructured optical fiber (DMOF) and coherent detection is proposed to perform the hydroacoustic sensing. The calibration experiment of acoustic pressure sensitivity is conducted, in which the fiber is demonstrated with a high sensitivity of -140.22dB (*re* 1rad/μPa). Besides, the hydroacoustic field lake trial is carried out successfully, including source directivity tracking, long-distance direct wave test and underwater target location, which fully indicated that our fiber DAS has great potential for applications in the underwater hydrophone network.

Several experiments are performed to demonstrate the underwater sensing performance of our fiber DAS. As illustrated in Fig. 1(a), the acoustic pressure sensitivity of -140.22dB (*re* 1rad/μPa) is linear fitted through the calibration between the standard hydrophone and optical fiber. Then the lake trial is carried out to verify the underwater performance of our DAS system. In the field test, the direct waves respectively emitted by monopole and dipole sources are detected successfully, which verifies the practicability of our system. Specifically, the hydroacoustic signal of the monopole source as far as 2.3km away can be detected, demonstrating an excellent sensitivity of the DAS system. And the directionality of the hydroacoustic source is also tested, which appears a good “8” shape as shown in Figs. 1(c) and 1(d). Moreover, the direct wave and reflected wave can be obtained simultaneously. As illustrated in Fig. 1(e), by calculating the time difference between the direct wave and reflected wave, the location of the underwater target can be obtained. As the hydroacoustic velocity is 1500m/s, the distance between the reflector and fiber sensor is calculated to be 54.75m, which is basically consistent with the actual installation (55m). Besides, the propagation of the hydroacoustic signal is tracked by six fiber sensors composed of different DMOF segments as shown in Fig. 1(f), which demonstrates the distributed detection ability of the sensor system. Benefiting from the convenient deployment, high sensitivity and large-scale detection, our fiber DAS system could be further applied in the area of underwater geological and resource exploration, such as the remote cross-hole seismic tomography.

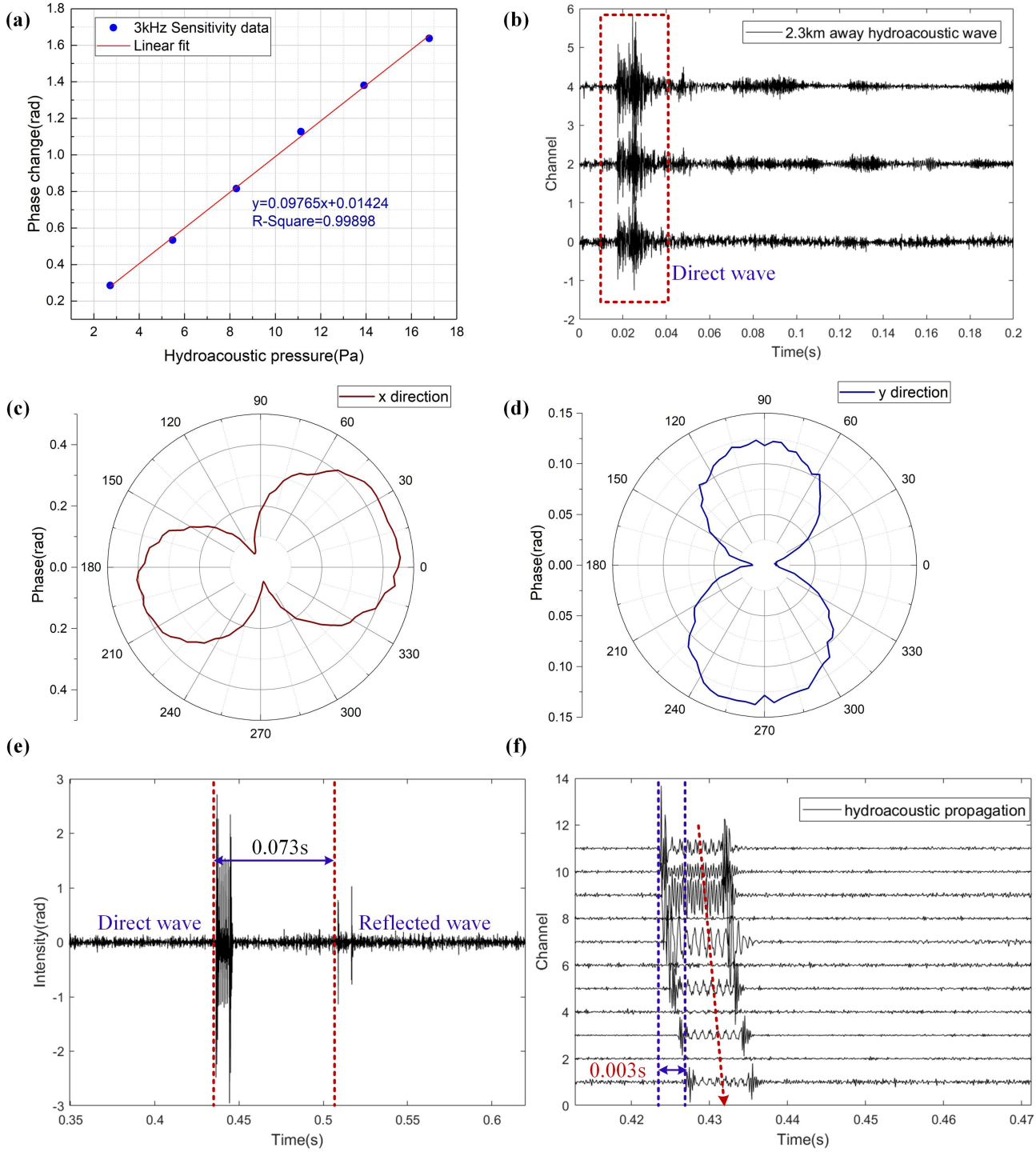

Fig.1. Experimental results; (a). Sensitivity at 3kHz; (b). 2.3km away direct wave; (c). X direction tracking of dipole source; (d). Y direction tracking of dipole source; (e). Direct wave and reflected wave detected by the fiber sensor; (f). Distributed detection of hydroacoustic wave.