SnT 2021
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Hydroacoustic observations using Distributed Acoustic Sensing technology on a fiber-optic submarine cable

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POSTER

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ABSTRACT

A ship-based air-gun survey was conducted contemporarily with distributed acoustic sensing (DAS) observations using an abandoned submarine cable. Measurements were compared between DAS and co-located hydrophones on the seafloor. DAS measures the Rayleigh back-scattering variations along a fiber-optic cable, of the same kind as the IMS HA hydrophone stations' trunk cables, using incident laser light from the cable terminal. From this measurement, strain or strain rate are obtained. It is known that both spatially- and temporally-dense measurements are achieved with DAS technology, and therefore 50-km length DAS was performed with 10-m resolution and 500-samples per second (SPS). The submarine cable was on the seafloor, except for a 2-km buried section, and reaching 1000 m depth. Broadband frequency signals associated with the air-gun shots recorded by DAS agreed with recordings from co-located hydrophones. The amplitude of DAS strain rate is correlated to pressure at a frequency range above 2 Hz. We also investigated the capability of DAS to measure ocean microseismics (peak frequency ~0.1 Hz), which were identified along the entire submarine cable up to 50 km. Since DAS is performed along a fiber-optic cable of several tens of kilometers length, it can be used also for array observations.

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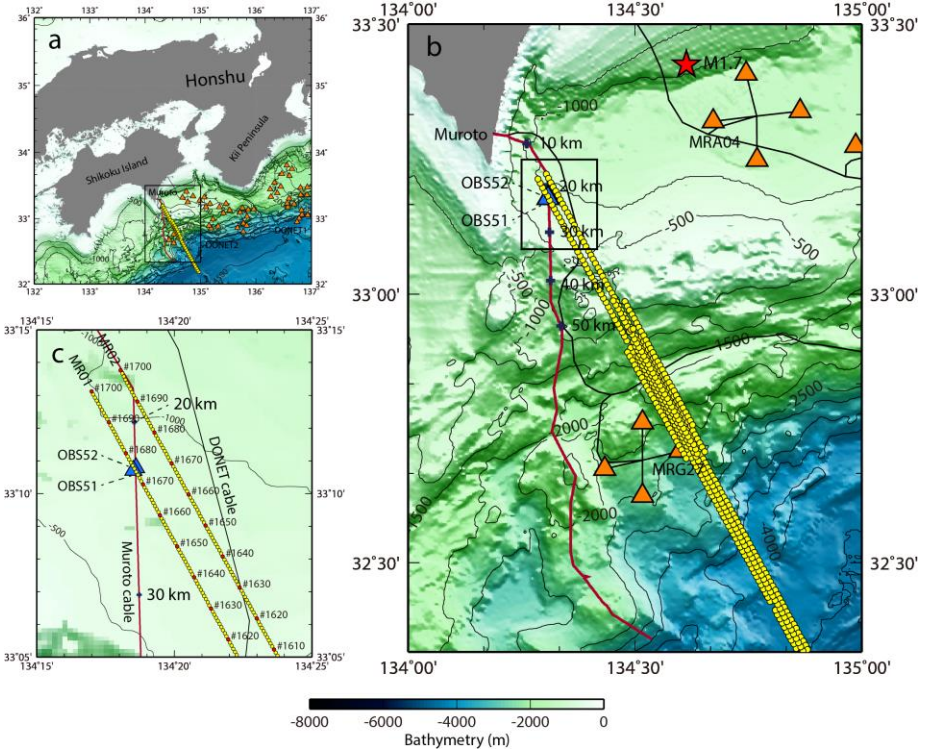
INTRODUCTION

The DAS experimental areas covered by the study. The locations of the Muroto cable (red line), the air-gun shot sites (yellow circles), two OBSs (blue triangles), and the DONET observatories (orange triangles) are shown. (a) The DAS experimental site is located off Shikoku Island, Japan, where the DONET observatories are deployed. (b) Detailed map of the Muroto cable and the surrounding area. The Muroto cable is 128 km long of which the cable section up to 50 km is used for the DAS measurement. Cable length is indicated by a blue cross at every 10 km. Two OBSs, i.e. OBS51 and OBS52, had been deployed near the Muroto cable temporally during the air-gun shots. The seismic survey lines with the air-gun shots were located over the Muroto cable and one DONET observatory, MRG27. (c) Detailed map of the air-gun shots near the Muroto cable. The numbers presented along two seismic survey lines, i.e. MR01 and MR02 are the shot identifications (IDs). The locations of the air-gun shot are represented by red circles every 10 shots for easier visibility. It is expected that the air-gun shots between #1670 and #1680 along the MR01 line were conducted over the Muroto cable and two OBSs.



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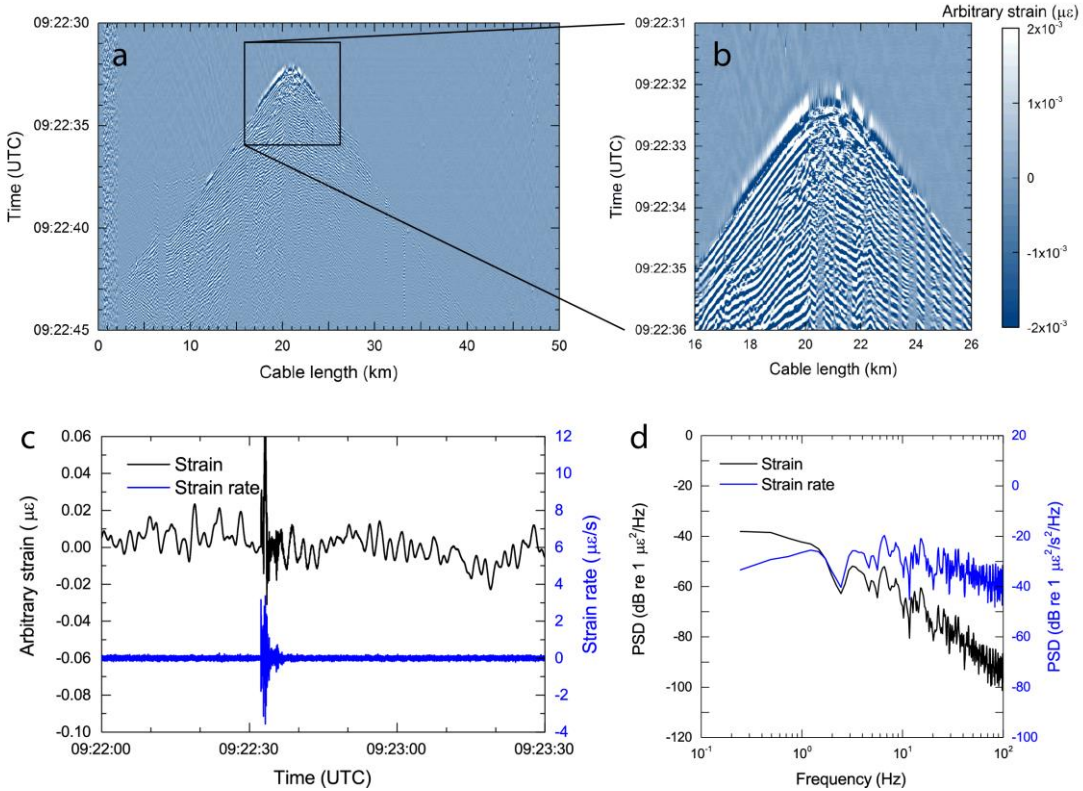
RESULTS

An example of the DAS recordings associated with the air-gun shot. The air-gun shot presented is number 1675 along the MR01 line. (a) 15 s-long recording (a period for 09:22:30 UTC to 09:22:45 UTC on 03 December 2019) of strain along the Muroto cable up to 50 km. A band-pass filter between 2 Hz and 60 Hz is applied to the strain dataset. (b) Enlarged figure focusing on the first arrival of the hydroacoustic signal at a cable section between 16 km and 26 km. Periodic strain fluctuations are observed at the both side. (c) Time series of strain and its conversion to strain rate recording the air-gun shooting at a cable length of 20.8 km. A de-mean value is subtracted from the original strain data. (d) Power spectral densities (PSDs) of strain and strain rate associated with the air-gun shooting.



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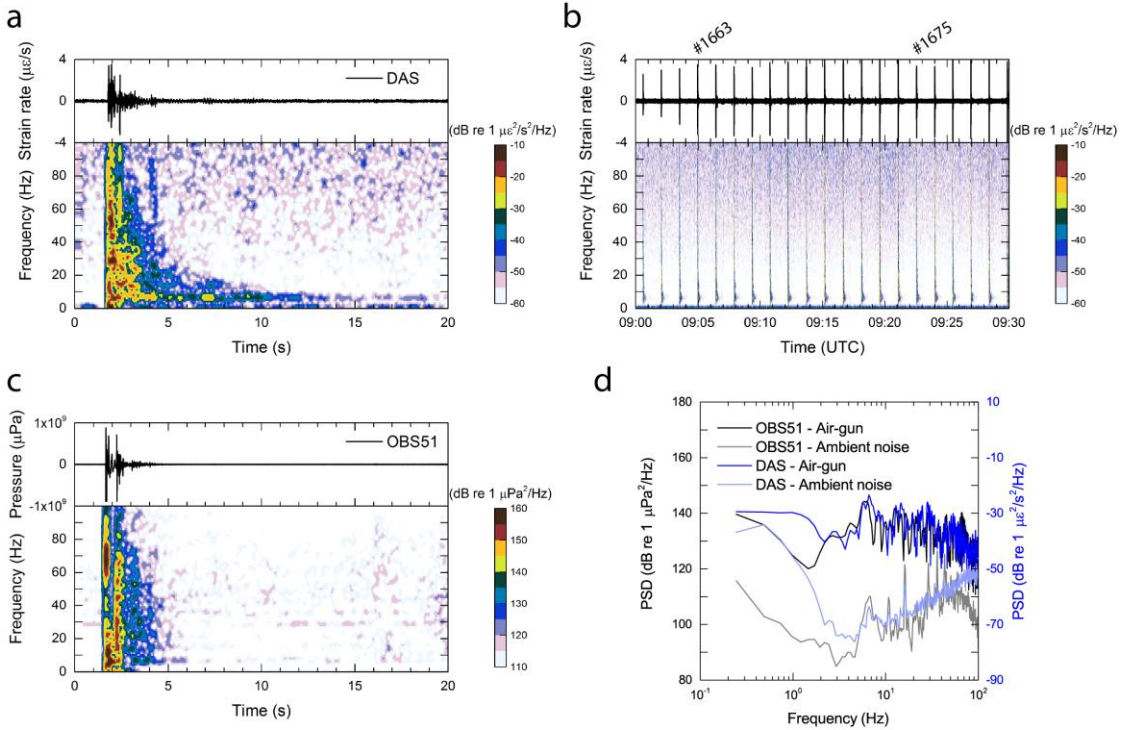
RESULTS

Comparison of hydroacoustic signals recorded by the DAS measurement and the co-located hydrophone. (a) Time series recording and its spectrogram of the DAS measurement at a cable length of 20.8 km, recording the air-gun shot number 1663 along the MR01 line. (b) A series of air-gun shots recorded by the DAS measurement at the same location of (a) at 09:00s UTC on 03 December 2019, when the ship approaching the Muroto cable and co-located two OBSs. A shot #1663 conducted at 09:04:56 UTC is magnified in (a). A following shot #1675 conducted at 09:22:32 UTC is also indicated. (c) Hydroacoustic signal originated from the same explosion of (a) recorded by a hydrophone of OBS51 displayed as the same form of (a). (d) Power spectral densities (PSDs) of the same signals of the DAS measurement and the hydrophone comparing with the ambient noise between the air-gun shots.



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CONCLUSIONS

Hydroacoustic signals originating in the water-column or near the water-surface were detected for the first time on DAS measurements using the submarine fiber-optic cable while conducting a marine active source seismic survey. Our examination of the unique dataset obtained by the DAS technique has provided insights into hydroacoustic monitoring in the ocean.

The raw dataset has been converted to strain rate along a submarine cable, so that hydroacoustics can be easily compared to standard sensors used in the present study.

The sensitivity of the DAS measurement for the hydroacoustic signals induced by air-gun shots has been investigated, and PSDs show a similar characteristic in frequency contents to the co-located hydrophones.