Hydrophones for Acoustic Exploration of the Extreme Depths of the Ocean

M. J. Buckingham
Marine Physical Laboratory, Scripps Institution of Oceanography
University of California, San Diego
9500 Gilman Drive, La Jolla, California 92093-0238, USA
tel: (858) 534-7977; fax: (858) 534-7461; email: mjb@mpl.ucsd.edu

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LONG-TERM GOALS

Characterize the spatial and temporal statistics of the ambient noise field from the sea surface down to the greatest depths in the ocean.

OBJECTIVES

The objective of the deep ambient noise project is to develop and deploy a broadband (0.01 - 40 kHz), multi-sensor system, designated Deep Sound, which is capable of monitoring sound to the deepest depths (11 km) in the ocean. Deep Sound will return depth profiles of the noise spectral level and the vertical and horizontal coherence, along with environmental data and system data.

APPROACH

A Vitrovex glass sphere of approximately 0.5 m internal diameter contains data acquisition and storage electronics along with a control CPU (essentially a stripped down PC). Throughputs connect external hydrophones and CTD sensors to the interior of the sphere. As the system descends into the ocean under the influence of gravity at a terminal speed of about 0.5 m/s, the broadband (0.01 - 60 kHz) ambient noise is detected on a suite of HTI deep-diving hydrophones, with vertical and horizontal separations. At a pre-assigned depth, which may be as deep as 11 km, a drop weight is released via a burn wire, and the system returns to the surface under its own buoyancy. Recovery is achieved with the aid of an Argos antenna, an RF locator beacon and a high-intensity strobe light.

WORK COMPLETED

Two versions of Deep Sound have been designed and built, the Mk. I and Mk. II, the latter having more hydrophones in horizontal as well as vertical configurations and a number of enhanced features which improve performance significantly. The Mk. I version made three descents in the Philippines Sea in May 2009, to depths of 5,200 m, 5,500 m and 6,000 m, and in all three cases was recovered after a six-hour return trip with little difficulty. These deployments returned unique ambient noise data sets, supported by environmental measurements (CTD) and system-monitoring information. Since the Philippine Sea experiments, new open-pore foam boots have been fitted to the hydrophones to reduce interference from hydrodynamic fluctuations (turbulence), which leads to a dramatic improvement in the acoustic recordings (see Fig. 1). The HTI hydrophones are rated by the
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manufacturer to a depth of 7.5 km, but our requirement is more demanding, since we aim to descend to the bottom of the Challenger Deep in the Mariana Trench. Accordingly, we have performed our own static-pressure tests on the hydrophones to 18,000 psi, equivalent to a depth of approximately 12 km, which is deeper than any part of the ocean.

RESULTS

The effect of the new open-pore foam boots on acoustic performance is illustrated in Fig. 1, showing before-and-after noise spectra, taken in the waters off the coast of southern California. The greatly improved quality of the recording from the shielded hydrophone is clearly evident.

![Fig. 1. Ambient noise spectra from HTI hydrophones, taken in the ocean off the coast of southern California. a) Unshielded hydrophone, as used on Deep Sound in the Philippine Sea experiment. b) A similar hydrophone fitted with an open-pore foam boot, which acts as a flow shield, keeping turbulent fluctuations away from the active surface of the sensor.](image)

With regard to our pressure testing of the HTI hydrophones, they came through with flying colors. The acoustic performance of the hydrophones was satisfactory under a static pressure of 18,000 psi (see Fig.2), which represents an equivalent depth of some 12 km. The sensitivity of the hydrophones varied with pressure, but only weakly, and no irreversible damage was inflicted.
Fig. 2. Pressure gauge indicating maximum static pressure (18,000 psi) to which we subjected the HTI hydrophones.

IMPACT/APPLICATIONS

The extreme depth capability of Deep Sound opens up a number of potential applications, in addition to recording ambient noise. For example, the system could be used to investigate the acoustic properties of hydrothermal vents, which are typically found at depths around 5000 m, well below the performance limit of most hydrophones. Another interesting possibility is the exploitation of the steady descent and ascent rates to provide a synthetic aperture in the vertical. A synthetic vertical aperture of 1 km, say, could yield enhanced signal detection while the system remained entirely covert.

TRANSITIONS

It is too early for a transition, since the deep ambient noise system was only recently conceived and is still under development.

RELATED PROJECTS

None at present.
PUBLICATIONS

Journal Articles & Chapters in Book


**Conferences, Workshops and Seminars**


**PATENTS**


HONORS/AWARDS/PRIZES


My graduate students have been awarded seven “best student paper” prizes for presentations at international acoustics conferences.

3. Eric Giddens, 1st Prize for “Sound from a light aircraft for underwater acoustic applications”, 144th Meeting of the Acoustical Society of America, Cancun, Mexico, 2-6 December 2002.