of time that data acquisition occurs is commonly between 30 and 40% of the total survey duration.

Engineering Surveys. Engineering seismic or high-resolution seismic surveys are site specific and cover small, localized areas to identify seafloor and shallow subsurface hazards. This information facilitates environmental and safety risk reduction.

WHY ARE SEISMIC SURVEYS REPEATED?

Repetition of a 3-D survey over the same area but at a later time allows for the detection of changes in fluid content of the reservoirs. Understanding how the distribution of reservoir fluids has changed after extracting petroleum from the reservoir for several years greatly increases the chances of optimizing future drilling to maximize production of the reservoir. Known as four-dimensional (4-D) seismic surveys, this technique is relatively new but has been used quite successfully to allow the petroleum industry to increase its production of hydrocarbons.

Increased computing capacity, improved imaging algorithms, and improvements in seismic acquisition hardware often necessitate repeating seismic surveys to allow petroleum companies to optimize the location and efficient production of needed energy supplies.

PARTICLE ACCELERATION NOISE GENERATED BY BOATS

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INTRODUCTION

The acoustic field consists of oscillating particles causing pressure fluctuations. Many aquatic organisms can detect the particle acceleration in the acoustic field and are therefore sometimes more susceptible to this component of the sound field rather than to the acoustic pressure (Kalmijn 1988). In this study, the particle acceleration generated by various boat types is measured using two hydrophones.

METHODS

Pressure gradient measurements were made in February, 2007, from 6 vessels (length ranging from 5 to more than 100 m) in the harbour of Bunbury, Western Australia. Water depth was 1-20 m and recording distance ranged from 5-500 m. Two B&K 8101 hydrophones (sensitivity −185.1 dB re V/μPa) were separated by 1-2 m radially or orthogonally relative the direction to the passing boat. Hydrophone depth varied between 0.5 and 2 m. The hydrophones were connected via a B&K 2804 power supply to an M-audio digital recorder (16 bits, 96 kHz). The recorded signals were digitally transferred to a laptop for analysis using Matlab 6.0 (Mathworks, Inc.).

The particle acceleration associated with the free-field acoustic pressure is given by

$$a = 2\pi fp/(\rho c)$$

where f is the centroid frequency, p is the sound pressure, and c is the speed of sound. The total acceleration of the medium is

$$a = -\Delta p/(\rho \Delta r)$$

where Δp is the pressure difference and Δr is the distance between the two hydrophones (Kalmijn 1988). Thus, from single hydrophone measurements, the acceleration caused by the acoustic pressure may be assessed, whereas two hydrophones are needed to obtain the total acceleration of the medium.

RESULTS

The largest difference between the free-field acoustic and total acceleration was found at a 5-m range from a smaller motor boat (Figure 1). At distances beyond this range, the acoustic and total accelerations were comparable in magnitude for all types of boats.

DISCUSSION

We estimate that the precision in the acceleration estimates to be better than 0.001 m/s^2 as computed from the hydrophone sensitivity and phase response.

Only within distances of 5 m from smaller boats at lower speed is the acceleration of the medium noticeably larger than what is anticipated from single-hydrophone measurements, as predicted from theory (Kalmijn 1988). For recordings of larger ships, no discrepancy

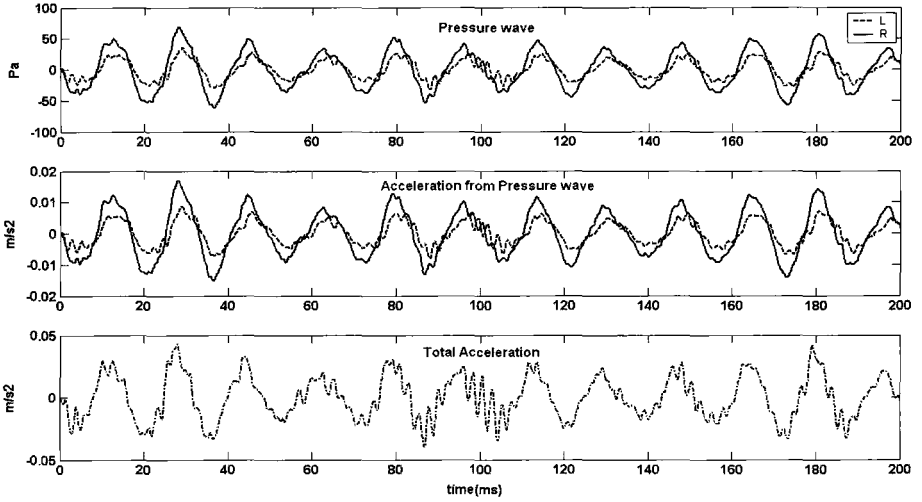

Figure 1. The pressure gradient created by a 5-m aluminum-hulled boat called "DDC" with a Yamaha 4-stroke 80 HP outboard engine, with a speed of 5 knots. The hydrophones were placed radially to the direction to the boat (hydrophone R is 2.21 m closer to the boat than hydrophone L) at a distance between boat and receiver R of 5 m. Top: calibrated sound pressure level from the two hydrophones (sampling rate 96 kHz). Middle: free-field "acoustic" acceleration. Bottom: total acceleration.

was found between the total and the free-field acoustic acceleration. However, measurements of larger boats were only made at ranges of more than 80 m and from boats moving at low speed. More acceleration measurements from different boat types in different bathymetries are needed before these findings may be generalized.

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REFERENCES

Kalmijn, A. D. (1988). Acoustic and hydrodynamic field detection. In *Sensory Biology of Aquatic Animals* (Ed. by J. Atema, R. R. Fay, A. N. Popper, & W. N. Tavolga), pp. 83-131. New York: Springer-Verlag.