TPG4190 Seismic data acquisition and processing
Lecture 2: Receivers

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Overview

1. Receiver system (sec. 2.8)

Receiver system

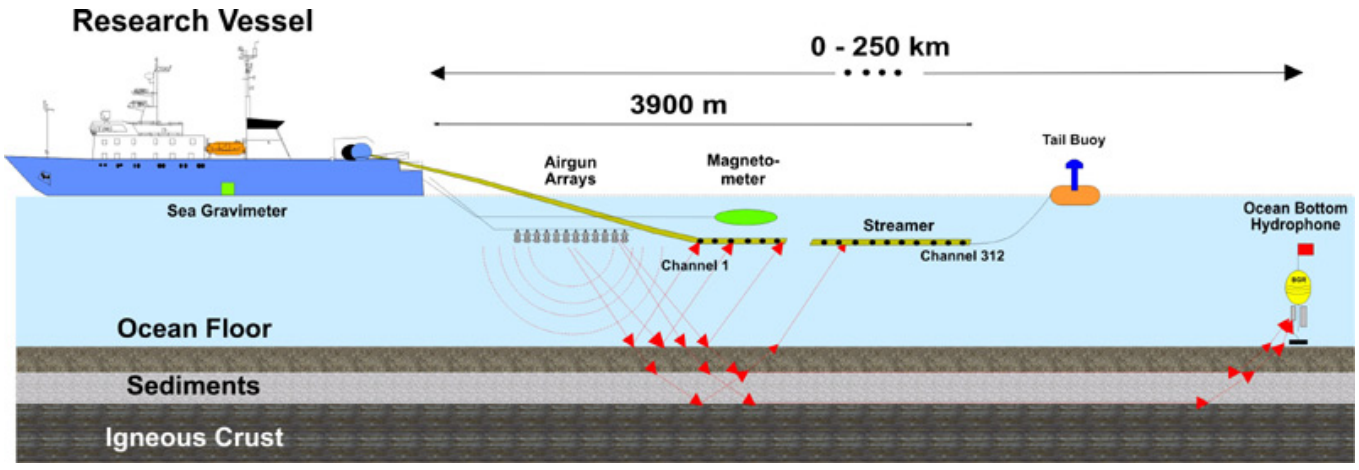

Figure: Marine seismic setup

- Each channel is a group of hydrophones (10-20) connected together
- Distance between each group is typical 12.5m or 6.25m
- Hydrophones are pizzo-electric devices sensitive to pressure

Receiver system

A single group of hydrophones are summed together as

$$\sum_{j=0}^{N-1} a(x_j,), \tag{1}$$

where $x_j = i\Delta x$ and Δx is the distance between hydrophones and N is the number, while $a(x_j)$ is the amplitude measured at position x_j. Formally, this is the same as

$$g(x) = \sum_{j=0}^{N-1} \int_0^{x_j} dx\, \delta(x_j - x) a(x) \tag{2}$$

The expression inside the sum can be recognized as the convolution of $a(x)$ and $\delta(x_j - x)$. The Fourier transform of the convolution of two functions is equal to the product of the Fourier transform of each function. Hence we have

$$G(k) = A(k) \sum_{j=0}^{N-1} \Delta(k, x_j) \tag{3}$$

Receiver system

where Δ is the Fourier transform of the delta function

$$\Delta(k) = \exp(ikx_j) = \exp(ikj\Delta x) \tag{4}$$

Hence we have for the Fourier transform of the sum of the hydrophones

$$H(k) = \sum_{j=0}^{N-1} \exp(ikj\Delta x). \tag{5}$$

This is a geometric series and the sum is equal to

$$\sum_{j=0}^{N-1} \exp(ikj\Delta x) = \frac{1 - \exp(ikN\Delta x)}{1 - \exp(ik\Delta x)}. \tag{6}$$

The right hand side is rewritten as

$$\frac{\exp(ikN\Delta x/2)\left[\exp(-ikN\Delta x/2) - \exp(ikN\Delta x/2)\right]}{\exp(ik\Delta x/2)\left[\exp(-ik\Delta x/2) - \exp(ik\Delta x/2)\right]}. \tag{7}$$

Receiver system

which is recognized as:

$$H(k) = \frac{\sin(kN\Delta x/2)}{\sin(k\Delta x/2)} \tag{8}$$

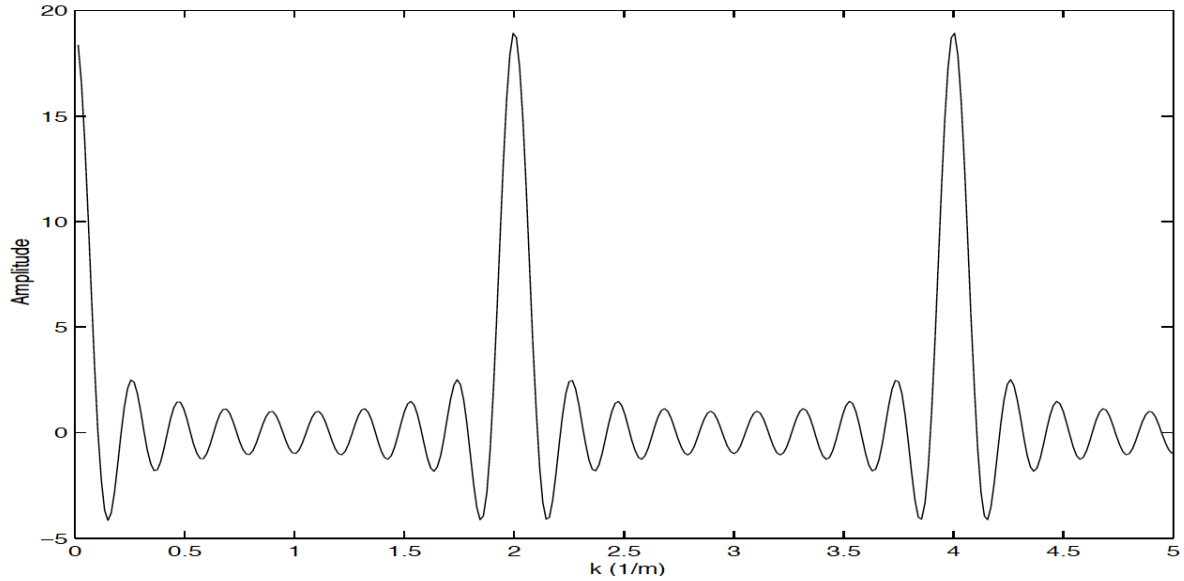

Figure: Receiver group array spectrum

Receiver system

- Dynamic range of seismic data: 1μbar - 1 bar
- Seismic data often low-pass filtered at 125Hz
- Old data often High-pass filtered at 3-5Hz
- Temporal aliasing not a problem
- Spatial aliasing almost always problematic

Spatial aliasing

- Spatial aliasing: Spacing between receivers is too large to capture rapid variations of the data

$$\Delta r < \frac{v}{2f \sin(\theta)}. \tag{9}$$

where

- Δr : Spacing between receiver (groups)
- v : Velocity at the receiver
- θ : Angle between vertical and direction of wave

Receiver system

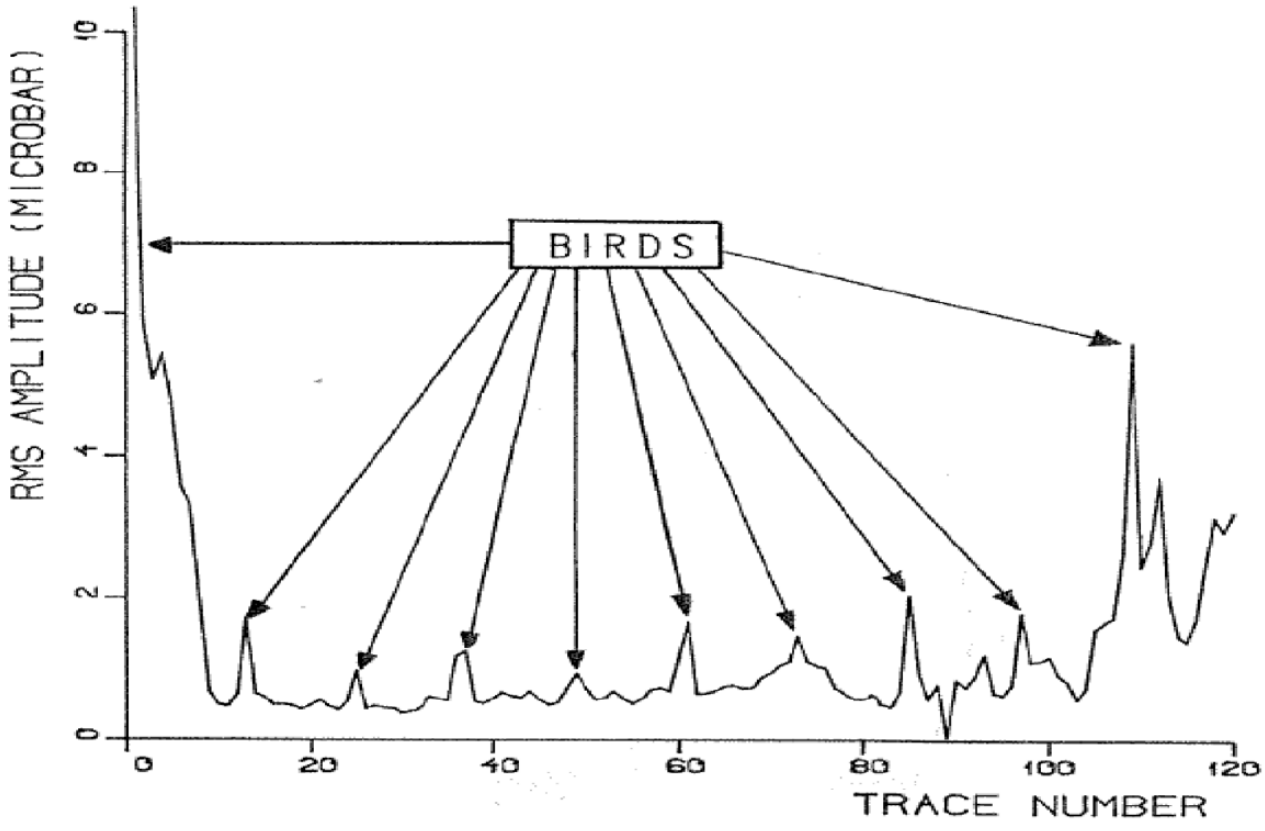

Figure: Streamer ambient noise

Receiver system

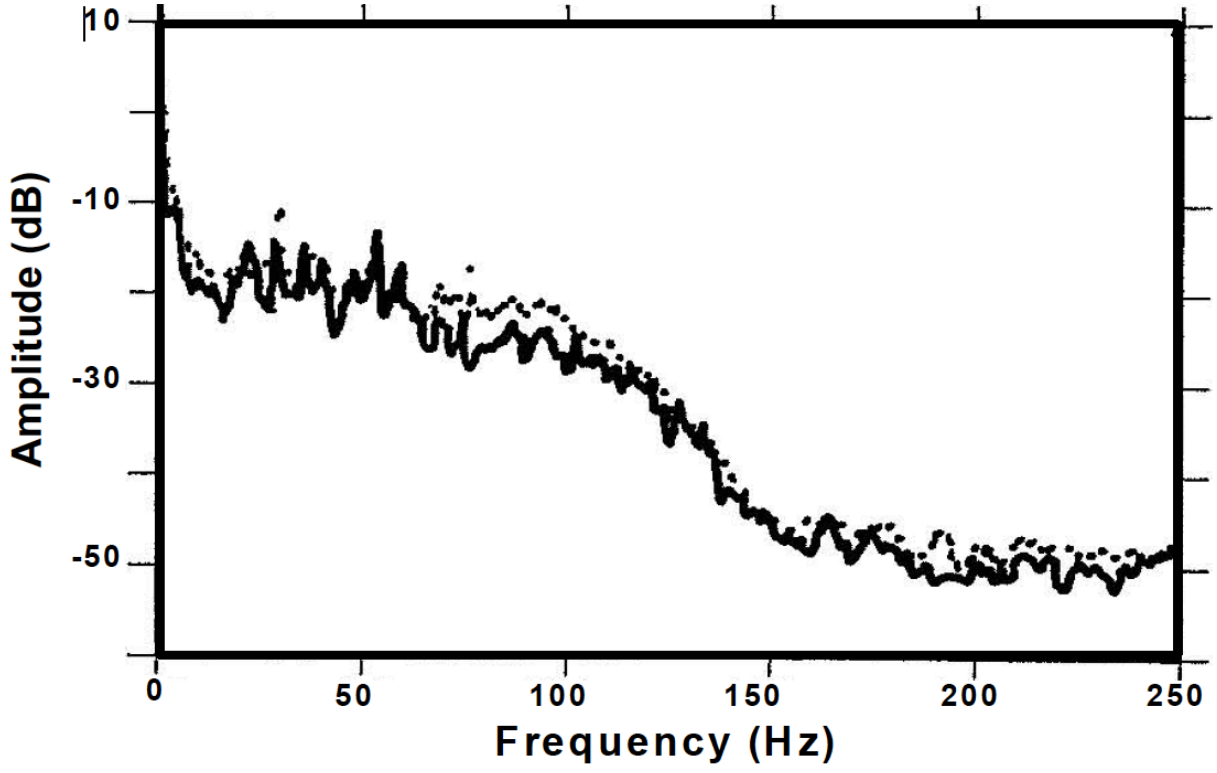

Figure: Noise record for two different sources

$$P_{db} = 20 \log \left(\frac{P}{P_{ref}} \right) \tag{10}$$

Receiver system

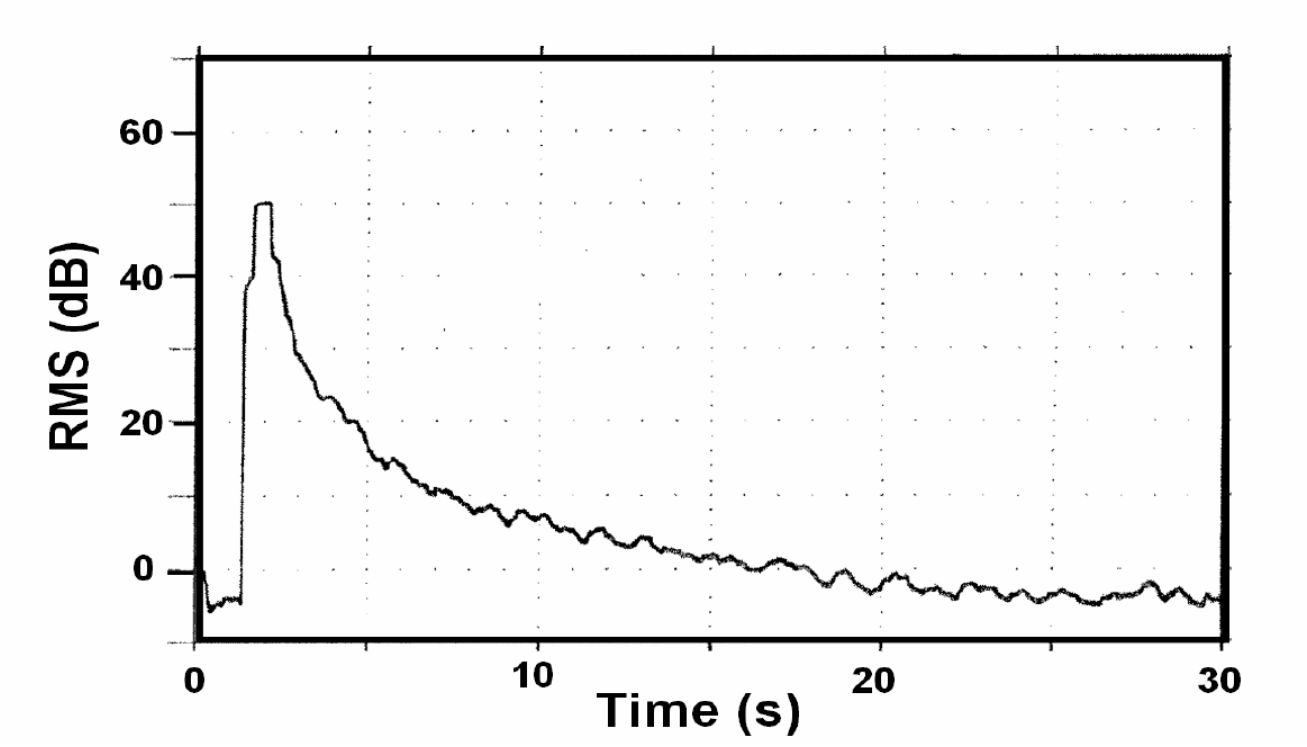

Figure: Noise record for single shot