

LOW FREQUENCY OCEAN BASIN WALL REVERBERATION AND PSEUDO-PROPAGATION LOSS

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The noise level at a point in the ocean is the sum of the signals received from many different noise sources. The signal from each of these sources is usually computed from its known or estimated level and the propagation loss over the great circle route between source and receiver. However, as illustrated in Figure 1, there are also scattering or reverberation processes by which energy can be propagated to the receiver over other paths. It is of interest to estimate the magnitude of this contribution.

Impulsive sources, such as explosions, provide a convenient procedure for measuring this contribution. Figure 2 shows the received signal from a rather large underwater detonation. This signal can be divided into two parts. In Region I, signal has, broadly speaking, propagated over the great circle route. Propagation loss (PL) is frequently measured with explosive sources by comparing the energy (E_1) obtained by integrating over this time interval with the energy radiated at the source (E_0) with the result:

$$PL = 10 \log (E_0/E_1)$$

Signal in Region II has propagated over other paths and has been scattered to the receiver by interaction with the basin boundaries. As when measuring propagation loss (PL), a comparison of the energy (E_2), leads to a quantity which we have termed pseudo-propagation loss (PPL):

$$PPL = 10 \log (E_0/E_2)$$

The relative noise contribution over the two types of paths is then given by:

$$\Delta N = PPL - PL$$

From the standpoint of noise modeling PPL can be interpreted as the maximum value of PL which applies to a particular source. For example, if the great circle route is blocked, perhaps by an island, the received level is determined by the source level and PPL.

Explosive sources are convenient for making these measurements because the difference in travel time between the great circle path and the reverberent paths provides a natural separation of the two sets of arrivals. However, it is necessary to use high yields so

that the reverberent signal exceeds the ambient noise level, which must be accounted for when determining PL and PPL. An alternative procedure is to construct a model, test it against limited data, and use it thereafter for predicting PPL.

The coast and island chains bounding the ocean basin are represented by a series of line segments, Figure 3. The segments are selected to have about the same aspect angle and bottom slope over its length. An expanding ellipse with foci at the source and receiver intersects the segments determining the arrival time of the reverberent energy from each of them. The propagation loss from the source to the segment and from the segment to the receiver is assumed to be of the form:

$$PL = K + 10 \log R + \alpha R$$

where: K is a constant which determines the range for transition from spherical to cylindrical spreading (taken to be 10 nm for the ocean region under consideration).
 α is the absorption in dB/yard.
R is the range. (dB)

Energy scattered from the slope to the receiver is computed by propagating a ray up the slope, Figure 4. At each interaction with the bottom a loss is applied for forward propagation and a scattering strength applied for energy scattered to the receiver following the same path down slope as was followed up slope. An average sound velocity profile is assumed for the area, and the above process is repeated for several initial interaction points for each of several possible ray paths and the results averaged. The reverberent area is computed to be the product of the length of the ellipse across the segment, and a distance up the slope which is a function of the slope but never more than half the loop length. Timing corrections are applied for each of the bottom encounters.

This process is applied to each of the segments in turn, and the total signal at the receiver determined by summing in 10 second intervals.

Figure 2 shows a comparison between experimental and model results for one test case. The results in the time domain are reasonably good. More important for our purposes, the agreement in integrated energy for Region II is within several decibels for a number of test cases.

Several calculations of the pseudo-propagation loss (PPL) have been made with the results shown in Table 1. This should not be construed to be representative of all source-receiver combinations in this area, or of other ocean areas. (This work was sponsored by the U.S. Defense Nuclear Agency and the U.S. Naval Surface Weapons Center).

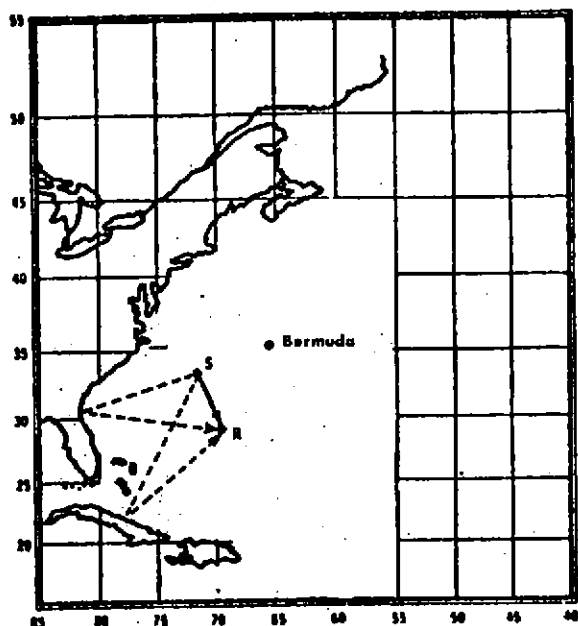


Figure 1
Paths from Source to Receiver

—→ Direct Path
- - -→ Reverberant Path

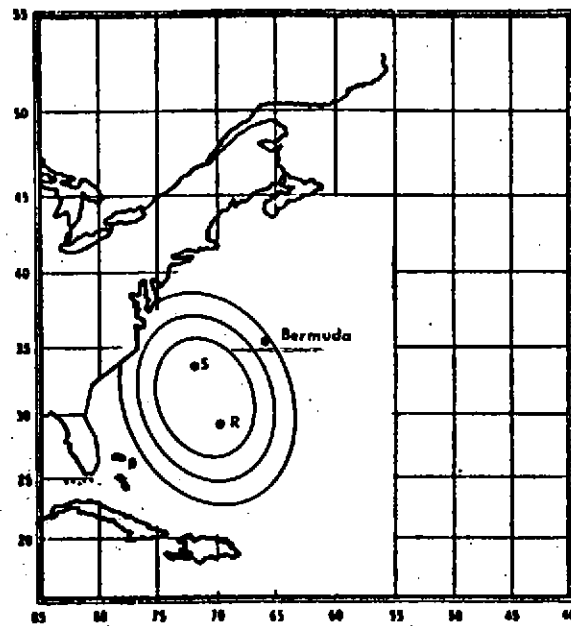


Figure 3
Boundary Segments and Equi-path Length Ellipses

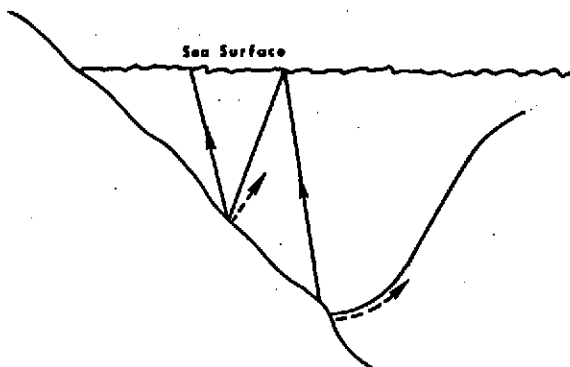


Figure 4
Upslope Propagation and Scattering

- - -→ Scattered Energy
—→ Upslope Propagation

Table I
Representative Values of PPL

<u>f (Hz)</u>	<u>PPL (dB)</u>
50	120-125
200	125-130

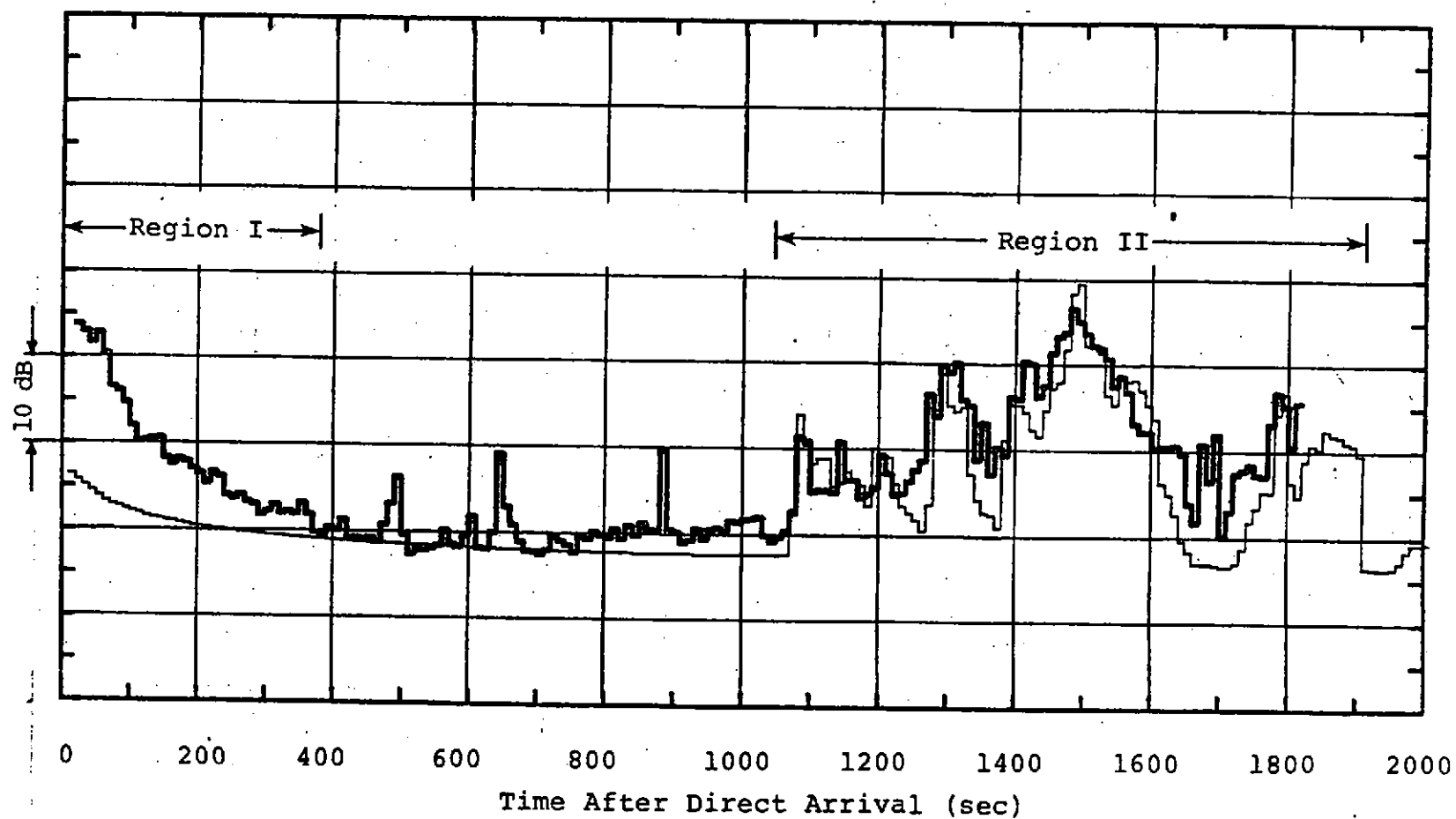


Figure 2. Comparison of Typical Model Computation (Fine Trace) with Experimental Data (Heavy Trace) in a 1/3 octave band centered at 50 Hz

Source to receiver separation distance is 106 nm