Characteristics of Ambient-Noise in the Shallow Coastal Area.

천해 연안역에서의 수중소음의 특성

Jungyul Na* Jaewan Kim* Jinhyuk Choi**

나 정 열* 김 재 완* 최 진 혁**

ABSTRACT

The noise levels measured at two different depths in shallow water where the ship traffic noise are prevalent show a higher level on the lower depth at frequencies less than 100 Hz. The seasonal change in noise level depends on the propagation condition. The spectra shape is very close to the one previously reported by Urick(1986) for the area of high shipping density.

요 약

선박소음이 우세한 해역에서 측정된 수중소음의 크기를 분석한 결과 100Hz 미만에서는 깊은 수심에서의 소음크기가 낮은 수심에서보다 크게 나타나고 있다. 한편 계절적인 소음크기의 변화는 음파전달조건에 좌우되며 일반적인 spectrum shape은 Urick(1986)의 선박소음이 우세한 경우의 spectrum과 매우 유사하다.

I. Introduction

The sources of shallow-water noise are known to be highly variable in time since the noise background is a mixture of shipping noise, wind noise and biological noise(Urick, 1986). In particular, if the measurement site is located close to busy harbors the dominant noise source will be ship traffic so that greater variability and higher noise levels can be expected(Perrone and King, 1975).

However, only a rough indication has been given of the levels at offshore coastal locations where the ship traffic noise is prevalent. It has been assumed that locally generated noise such as a nearby ship traffic does not show depth effect on the noise level in shallow water except low frequency shipping noise originating at a distance (Ross, 1976).

On the other hand, if the water mass undergoes seasonal change that results in a different sound velocity profile, propagation condition may affect the depth dependence of the noise level(Piggott, 1964).

In order to verify the depth dependence of noise levels and to identify the causes, the noise measurements were made at a fixed site which is about 15 miles offshore in the Korea Strait. The noise samples were taken hourly for 30 minutes over 48 hours in every other month.

* Department of Earth and Marine Sciences, Hanyang University.
** Agency for Defense Development, BOX 18, Chinhae.

Two omni-directional hydrophones located at 10m and 70m depth respectively were moored from the ship at 100m depth of water. Wind and current speeds were also observed over the same period. The number of ships within the area of 12 mile radius was recorded from the ship's radar.

Ⅱ. Data Selection

Among the data set collected every other month over one year period, data from the months of May and November were selected since they represented typical propagation conditions in terms of the sound velocity profile. Also, they reflect the period of stable wind speed and about the same number of ships within the area of 12 mile radius.

Fig. 1 shows the temperature profiles across the strait which were taken at the time of the noise measurement. Station F1 is located very close to the busy harbor and the measurement site is close to the station F3. In May the water was rather weakly stratified compared to the one of November in which a strong thermocline was formed at two different depths, one near the bottom and another near the surface. Propagation effects due to these temperature profiles will be discussed later. In order to minimze the tidal effect that includes a strong tidal current of speed of 1 knot, the time of observation was selected around 1600 hour(local time) which was very close to the high tide. The number of ships was also considered at the same time to have similar background noise. The average number of ships during the period of measurement turned out to be about five.

Ⅲ. Ambient-Noise Spectra

Fig. 2-3 show the ambient-noise spectra averaged over 30-min period at two different depths (10 and 70 meters) for May and November in

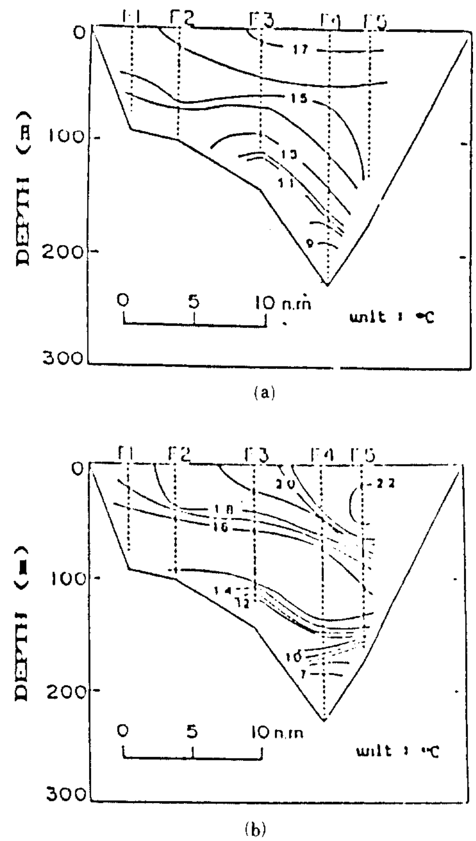


Fig. 1. Vertical temperature distributions across the strait in May(a) and November(b).

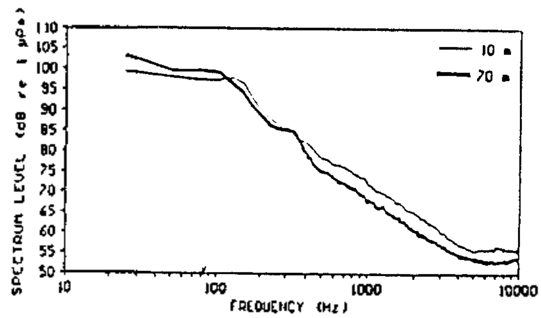


Fig. 2. Representative ambient-noise spectra in May for the indicated hydrophone depths (1-Hz frequency resolution, 30-min integration time).

25 Hz-10 kHz band.

From both figures it is clearly seen that at frequencies less than 100 Hz the noise-levels measured by 70m-hydrophone are dominant over the noise-levels at 10m-hydrophone. At frequencies greater than 100 Hz, the noise-levels at 10m -

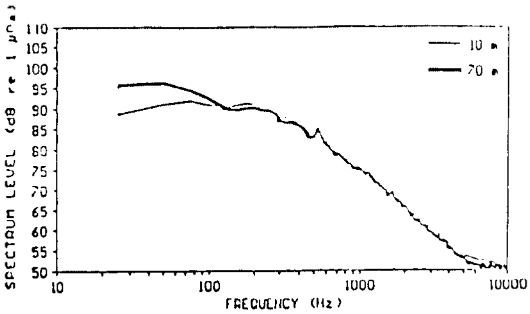


Fig. 3. Representative ambient-noise spectra in November for the indicated hydrophone depths (1 Hz frequency resolution, 30 min integration time).

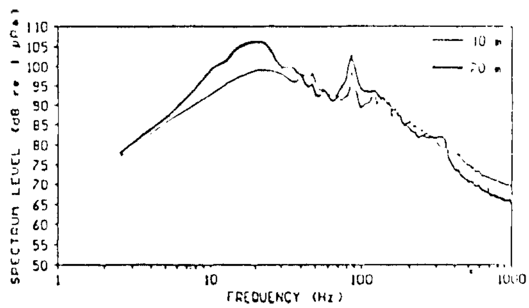


Fig. 5. Ambient noise spectra in May for the indicated hydrophone depths for lower frequenoies (2.5-1000 Hz, 1-Hz frequency resolution and 30 min integration time).

hydrophone are higher than those measured at 70m except at the tonal frequencies. The average wind for both May and November was 4-knot over its entire observed period, therefore locally generated wind noise did not contribute much to explain the difference. The difference in noise-levels exists between May and November for the upper and the lower hydrophones. In May the levels are higher at frequencies less than 200 Hz but they become lower than November for frequencies between 200 Hz and 5 kHz. The slope of the spectrum at frequencies greater than 200 Hz appears to be independent of depth and season and averages -7dB / octave.

Since the dominant noise sources are ship traffic, spectrum levels for frequency band of 2.5-1000 Hz are shown in Figs 4-5. The tonal components clearly indicate that the spectrum levels are dominated by the local ship-traffic noise that gives the maximum of the spectra a more peaked appearance near 20-30 Hz band. This type of spectrum was presented as an idealized ambient noise spectrum(Urick, 1986) due to shipping and present spectrum corresponds to the case of heavy shipping. The most unusual aspect of ship traffic noise in this area is that the noise levels at the lower hydrophone always exceed the levels of upper hydrophone. For two different size of ships, 50 ton fishing vessel and 20000 ton cargo ship, the radiated noise spectra(Fig. 6-7) also show the higher levels at the lower hydrophone with the maxima at 20 Hz indicating that the effects of ship size on the spectrum level are not significant at all.

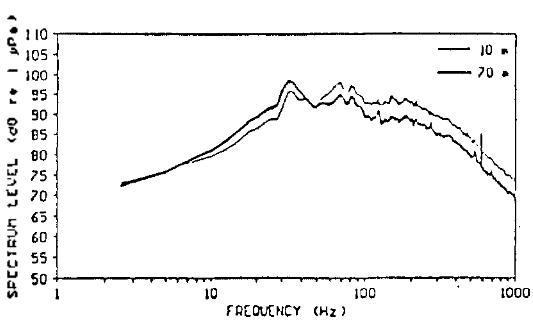


Fig. 4. Ambient-noise spectra in November for the indicated hydrophone depths for lower frequencies (2.5-1000 Hz, 1-Hz frequency resolution and 30 min integration time).

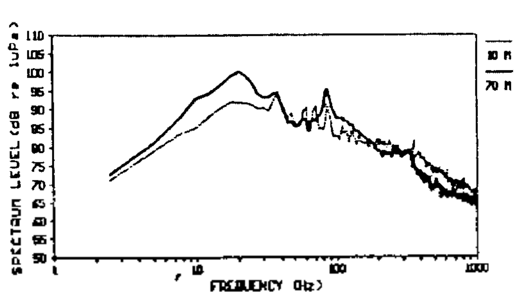


Fig. 6. Radiated noise spectra for 20000ton cargo ship measured at 2mile range for the indicated hydrophone depths(1-Hz frequency resolution, 1 min integration time).

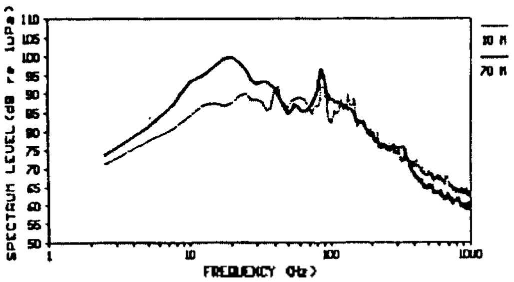
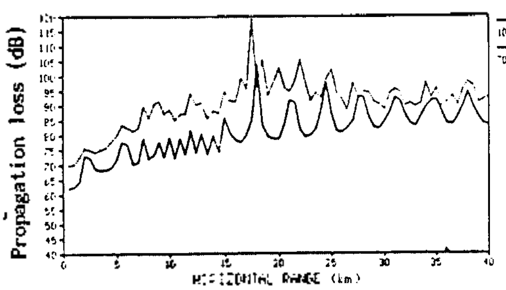


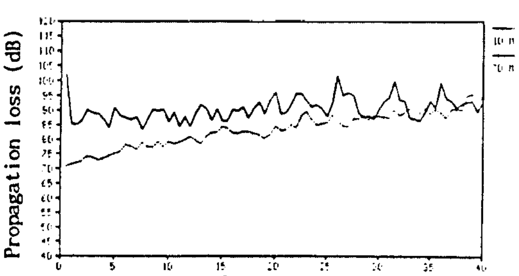
Fig. 7. Radiated noise spectra for 50ton fishing vessel at 2-mile range for the indicated hydrophone depths (1-Hz frequency resolution and 1 min integration time).

It is interesting to note that when Figs. 6-7 are compared to Fig. 4 the spectral shapes are very similar. This may indicates that the noise source of distant ships is dominant at the measurement site.

Fig. 8-9 present the propagation loss calculated based on the observed sound velocity profiles for 10 Hz and 300 Hz using IFD(Lee and McDaniel, 1988), and the progagation condition is better in

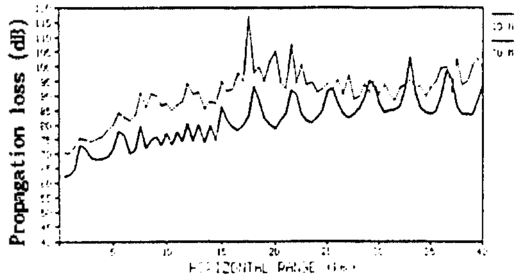


(a)

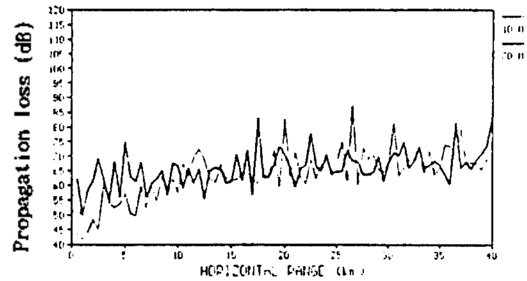


(b)

Fig. 8. Range-depth distribution of the propagation loss in May for two frequencies, 10Hz(a) and 300Hz(b), for source at 7m.



(a)



(b)

Fig. 9. Range-depth distribution of the propagation loss in November for two frequencies, 10Hz(a) and 300Hz (b), for source at 7m

November than in May.

The sources are assumed to be located at zero range which is shallow coastal area and the hydrophones are located between 15 km-20 km range at which the propagation loss of 10 Hz at the lower hydrophone depth appears to be always less than that of upper one. However, it is quite clear for 300 Hz in that the propagation loss is greater at the lower depth. This explains the differences in levels presented in the figs 4-5.

As seen in Fig. 8-9 the propagation condition seems to affect the depth dependence in such a way that a negative gradient in the sound velocity profiles causes the sound wave refracted and interacted with bottom. Presence of the thermocline in November actually increases the grazing angles at the bottom causing more propagation loss resulting less noise at the deeper hydrophone(Fig. 9(b)). Also the shift of maximum spectrum level toward lower frequency in May(Fig. 4-5) is suggested as a result of different propagation condi

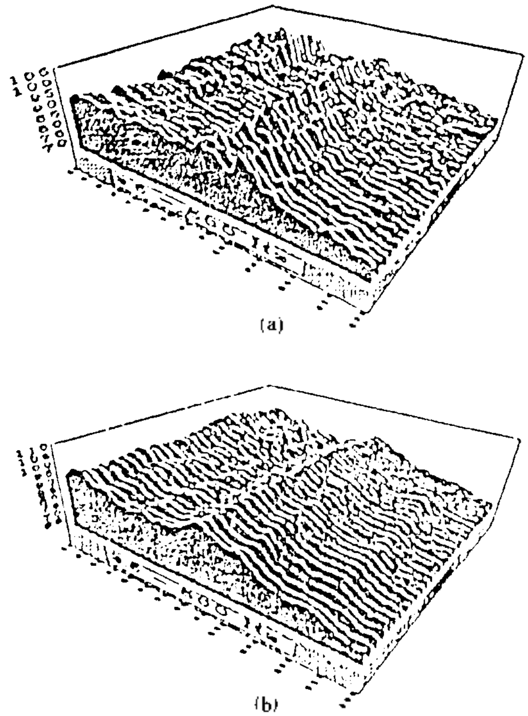


Fig. 10. Time variations of ambient noise spectra for 14 frequencies (tonals) in May for 10m(a) and 70m (b) hydrophone depths.

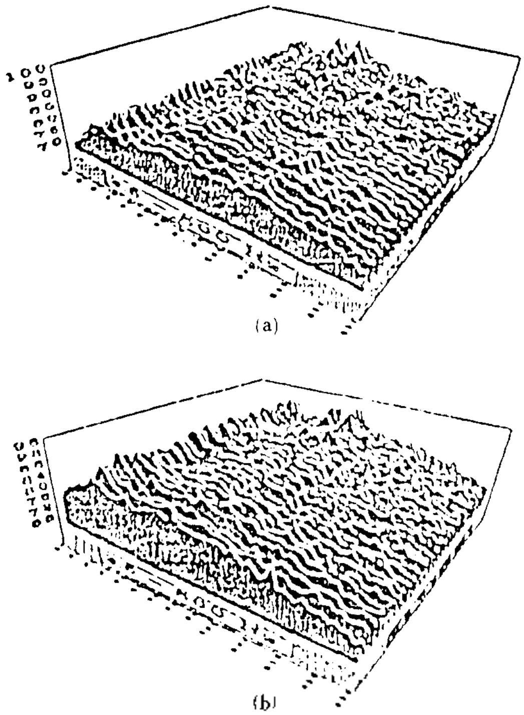


Fig. 11. Time variations of ambient-moise spectra for 14-frequencies (tonals) in Novemer for 10m(a) and 70m(b) hydropone depths.

tion. However, the cutoff frequency, which is between 9-10 Hz does not seem to influence the spectral changes.

The time variability of ship traffic noise has been known to be dependent on the number of tones, or lines, occuring in the bandwidth of the analyzer. For 14-lines, or 14 frequencies, one-minute averaged spectrum has been plotted over 30-min period(Fig. 10-11). The spectra levels of 14-lines seem to be quite steady especially on the lower hydrophone in May, but in November it fluctuates very much over the same period of time. As presented before(Fig. 6-7) the spectra shape is independent of ship size and the number of ships observed is same during the period of measurement in May and November.

Therefore, this variability may be due to the difference in tonal frequencies as well as the horizontal directionality of noise sources that has not been measured. The propagation condition or different propagation path of noise is another factor that could influence the variability.

Ⅳ. Summary

It has been shown that the noise levels measured by shallow and deep hydrophones in shallow water where the ship traffic noise is prevalent are strongly depth-dependent at frequencies less than 100 Hz.

The depth dependency of noise level is such that the levels are always higher on the deeper hydrophone. Seasonal changes in noise level show that at frequencies greater than 200 Hz it becomes significantly pronounced at the lower hydrophone.

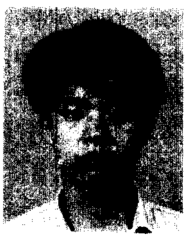
The depth variation of noise levels has been explained in terms of propagation conditions.

It was also shown that the spectra shape is very close to the one presented by Urick(1986) for high shipping density. The time variability of spectrum seems to be dependent upon the directionality of noise sources and it was remarkably steady in May. Tides, wind and long-term variability have not been considered, however, it may not change the average spectra shape that is caused by the ship traffic noise.

References

1. Urick, R. J., Ambient Noise in the Sea, Peninsula Publishing, 1986.
2. Perone, A. J. and L. A. King, Analysis Technique for Classifying Wind and Ship-Generated Noise Characteristics, JASA 58, 1186, 1975.
3. Ross, D., Mechanics of Underwater Noise, Pergamon Press, New York, 1976.
4. Piggott, C. L., Ambient Sea Noise at Low Frequencies in Shallow Water of the Scotian Shelf, JASA 36, 2152, 1964.
5. Lee, D. and McDaniel, S. T., Ocean Acoustic Propagation Finite Difference Methods, Pergamon Press, New York, 1988.

▲Jaewan Kim



Date of Birth Mar. 3. 1966.
1986. 3. Dept. of Earth and Marine Seiences, Hanyang Univ.(B.S)
1990. 2. Graduate Student, Dept.of Earth and Marine Sciences, Hanyang Univ.

▲Jung Yual Na Professor, Dept. of Earth and Marine Sciences Hanyang Univ.(Vol.8. No.6)

▲Jin Hyuk Choi Data of Birth(ID No.) : 1952. 6. 17(520617-1004817)

Education :

Mar. 1982 ~ Aug. 1990 Seoul National University of Korea. Ph.D. in Marine Geology
Mar. 1978 ~ Aug. 1981 Seoul National University of Korea. M.S. in Marine Geology
Mar. 1971 ~ Feb. 1978 Seoul National University of Korea. B.S. in Oceanography

Work Experience :

May. 1985 ~ Present Senior Researcher in Oceano-

Geology division, Korea Ocean Research and Development Institute of Korea.

Aug. 1981 ~ Dec. 1981 Research Assistant in Marine Geology division, Korea Ocean Research and Development Institute of Korea. raphic and Acoustic Division, Agency for Defense Development of Korea.

Aug. 1984 ~ Aug. 1985 Lecturer in Department of Oceanography, Chungnam National University of Korea.
Apr. 1983 ~ May. 1984 Secretary Tresurer in the Oceanological Society of Korea.
Apr. 1983 ~ May. 1984 Assistant in Department of Oceanography, Seoul National University of Korea.
Aug. 1982 ~ Dec. 1982 Research Assistant in Marine