PACIFIC NAVAL LABORATORY

ESQUIMALT, B.C.

Reprint 67 - 1

AMBIENT NOISE UNDER SEA ICE AND FURTHER MEASUREMENTS OF WIND AND TEMPERATURE DEPENDENCE

by

A. R. Milne, J. H. Ganton and D. J. McMillin

DEFENCE RESEARCH BOARD
CANADA

30e 30 30a pb 30b

Reprinted from THE JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA, Vol. 41, No. 2, 525–528, February 1967

Ambient Noise under Sea Ice and Further Measurements of Wind and Temperature Dependence

A. R. MILNE, J. H. GANTON, AND D. J. MCMILLIN

Defence Research Board, Pacific Naval Laboratory, H.M.C. Dockyard, Esquimault, British Columbia, Canada

Measurements of underwater-pressure spectral density from M'Clure Strait (2–5 May 1966), the Beaufort Sea (31 July and 16 August 1965), and the Canada Deep (14 April 1965) are presented. The M'Clure Strait measurements, made under shore-fast sea ice, exhibited a variability related to air-temperature and wind-speed changes of a similar nature to those reported previously for midwinter under-ice noise. The great differences in the magnitude and variation with frequency of the ambient noise observed under sea ice is again illustrated with three sets of measurements obtained during 1965–1966. The noise observed under the shore-fast ice of M'Clure Strait in the springtime appeared to be governed by air-temperature and wind-speed changes in a similar manner to noise observed previously in the midwinter [J. H. Ganton and A. R. Milne, J. Acoust. Soc. Am. **38**, 406–411 (1965)]. On the other hand, measurements made under the moving ice cover of the Canada Deep in the springtime and of the Beaufort Sea in the summer appeared to be less amenable to description in terms of easily observable physical variables.

THE RECORDING SITE IN M'CLURE STRAIT (MAY 1966) WAS located (Fig. 1) on shore-fast ice composed of randomly distributed fields of broken and unbroken 2-yr ice cemented by leads and frozen pools of 1-yr ice 7 ft thick. Ambient-noise recordings were made using a hydrophone on the bottom in 451 m of water. During all 22 of the 6-min samples, records of air temperatures and recordings of wind speed at a height of 5 m were obtained. Pressure-spectrum measurements excluded infrequent biological noises consisting of occasional barks and long (5-sec) tones of slowly decreasing frequency that were heard during periods of low background noise. As observed during midwinter measurements, impulsive ice-cracking noise was produced when the air temperature decreased and slowly vanished with air-temperature increases.[1,2] This phenomenon is clearly seen in Fig. 2, which shows the air temperature (centigrade) and the root-mean-square pressure-spectral density in selected octave bands (decibels *re* 1 μbar^2·sec) plotted against time. As the air temperature declined, pressure-spectral densities in the frequency bands 120–960 Hz increased by as much as 30 dB. These increases in impulsive noise may be expected to occur diurnally since air-temperature changes in the springtime are roughly tied to the intensity of solar radiation. In higher- and lower-frequency bands, sound pressures were influenced by air-temperature changes but to a lesser degree. Sample spectra for this cooling trend are shown in Fig. 3. The progressive increase of noise pressure in the midband (0.1–1.0 kHz) during the cooling trend was produced almost entirely by an increase in the impulsive ice-cracking noise. During warming trends, however, the primary noise component showed Gaussian distribution in amplitude and had spectral densities shown in Fig. 4. These spectra were essentially "white" for frequencies of above 1 kHz and show a rough dependence on wind speed similar to that reported in Ref. 1. Figure 5 shows measurements of the spectral density of the Gaussian component of the noise in the 3.2–6.4-kHz band plotted against wind speed (meters/second). The dashed line is the assumed dependence of ambient noise vs wind speed from Fig. 8 of Ref. 1 for the midwinter. A roughly similar trend, but at lower sound pressures, is observed for the points representing the M'Clure Strait springtime measurements except for the anomalous spectral densities shown as circles in Fig. 5. These spectral densities were obtained from measurements made from 0920 h to 1700 h on 5 May and in a time sequence during which the Gaussian noise slowly diminished to an unaccountably low level despite a constant wind speed.

The recording site for the Canada Deep (April 1965) (Fig. 1) was on 10/10th springtime pack ice over water 2476 m deep. Figure 6 shows root-mean-square pressure-spectral densities in decibels (see above) for noise samples recorded during a 7-h cooling period ($-10.6°$ to $-18.3°$C) using an omnidirectional hydrophone at a depth of 91 m. Since long-distance sound propa-

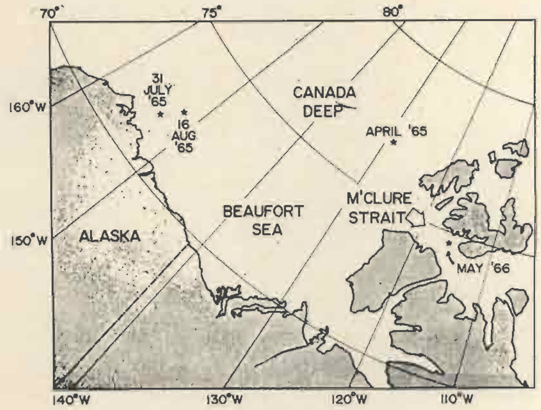

FIG. 1. Map showing sites of ambient-noise measurements.

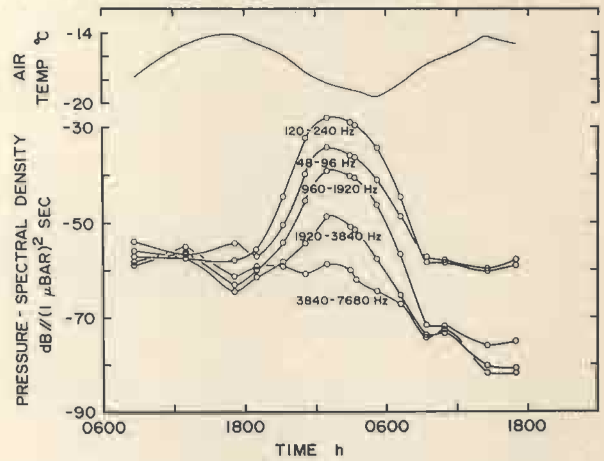

FIG. 2. M'Clure Strait, May 1966: changes of ambient-noise spectral densities and air temperature plotted versus time.

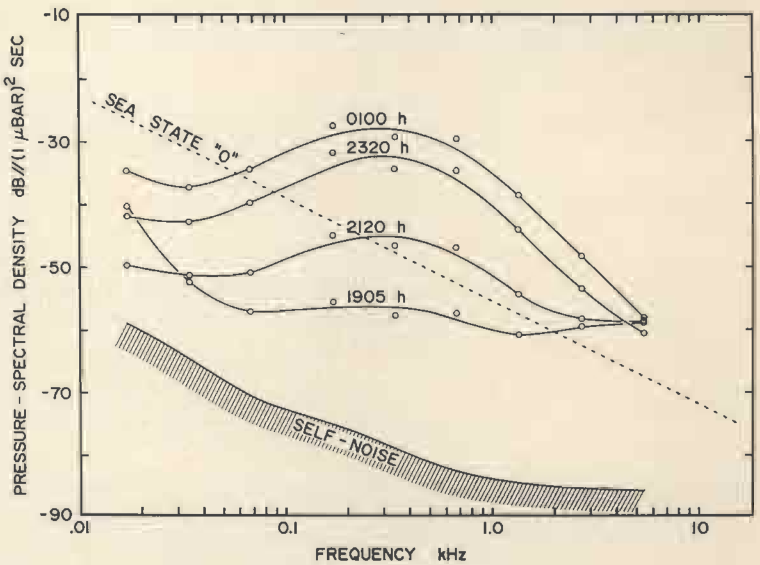

FIG. 3. M'Clure Strait, May 1966: Spectra for underwater ambient noise recorded during air cooling.

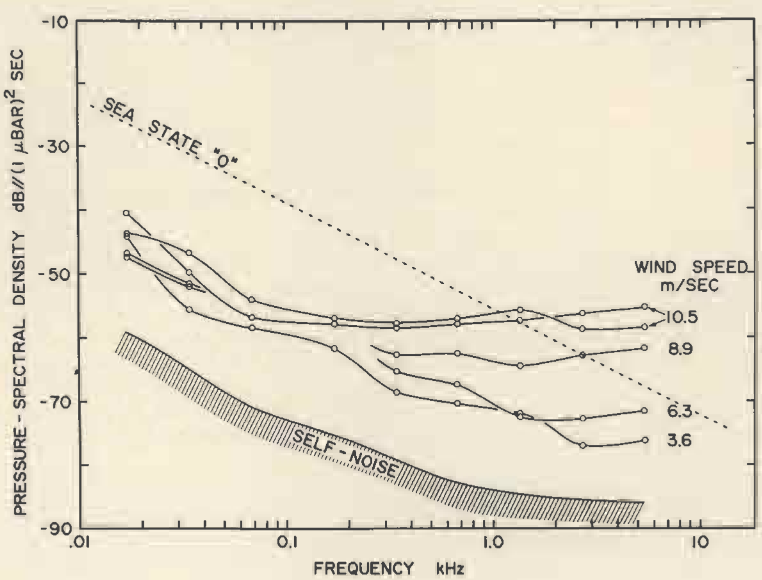

FIG. 4. M'Clure Strait, May 1966: Spectra for underwater ambient noise recorded during rising air temperatures.

gation in the deep water of the Arctic Ocean is progressively less efficient at higher frequencies, the high-frequency ambient noise was almost entirely the result of local, and therefore observed, conditions. The pressure spectra (Fig. 6) for frequencies of above 2 kHz show a uniform increase with the local wind speed, except for the two spectra plotted with a dashed line. For these spectra, the Gaussian wind noise was masked by impulsive ice-cracking noise.

Figure 7 shows root-mean-square pressure-spectral densities in decibels for two ambient-noise measurements made on 31 July (A) and 16 August (B) in the Beaufort Sea locations shown in Fig. 1. For Sample A, the water depth was 567 m, the ice cover was composed of 5%–10% polar floes and 85%–90% 1-yr ice, the wind speed was 2.6 m/sec, the air temperature was 6.7°C, and the depth of an omnidirectional hydrophone was 61 m. For Sample B, the equivalent conditions were: water depth, 585 m, ice cover, 9/10th polar floes and 1/10th decayed 1-yr ice; wind speed, 1.5 m/sec; air temperature, 1.1°C; and hydrophone depth, 122 m. Field observations of noise and subsequent observations during analysis showed that the noise in the higher-frequency bands (3.8–15 kHz) was more impulsive than in the bands at lower frequencies. The impulsive noise could best be described as more like

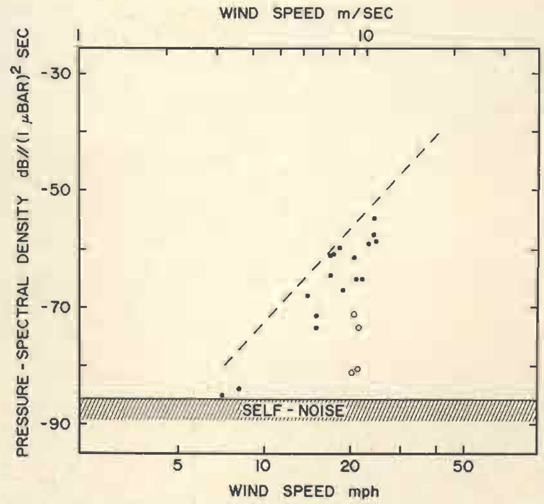

FIG. 5. M'Clure Strait, May 1966: Spectral densities in the 3.2–6.4-kHz band vs the wind speed 5 m above the surface of the ice.

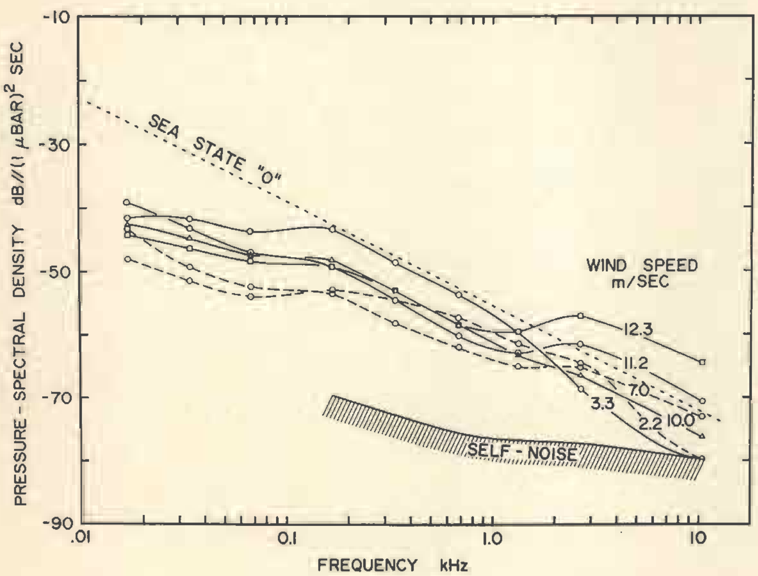

FIG. 6. Canada Deep, April 1965: Ambient-noise spectra.

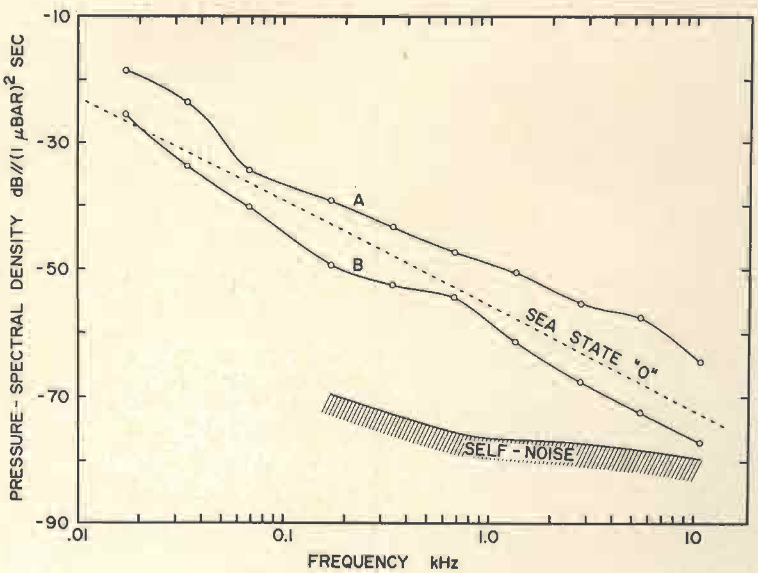

FIG. 7. Beaufort Sea, Summer 1965: Ambient-noise spectra.

that produced by bacon frying than by ice cracking. The mechanism of noise production under summer ice appears to be fundamentally different from that under winter or springtime sea ice (see Ref. 3, Part II, Discussion C).

This letter is published with the kind permission of the Chairman of the Defence Research Board of Canada.

[1] J. H. Ganton and A. R. Milne, "Temperature and Wind-Dependent Noise under Midwinter Pack Ice," J. Acoust. Soc. Am. 38, 406–411 (1965).

[2] A. R. Milne, "Statistical Description of Noise Under Shore-Fast Sea Ice in Winter," J. Acoust. Soc. Am. 39, 1174–1182 (1966).

[3] A. R. Milne and J. H. Ganton, "Ambient Noise Under Arctic Sea-Ice," J. Acoust. Soc. Am. 36, 855–863 (1964).