Studies on the Underwater Sound - II
On the Diurnal Variation of the TEMPURA NOISE in the Coastal Waters of Nagasaki Prefecture

Akira TAKEMURA

In the coastal waters of Nagasaki Prefecture, 24-hour observations were made for the sound level of TEMPURA NOISE (frying noise) at 6 stations with less traffic noise. It was revealed that the TEMPURA NOISE level shows diurnal variations and high peak values at sunrise and sunset being 3 - 5 dB higher than that in daytime or nighttime. There was observed no characteristic difference in noise level between the daytime and the nighttime, but it was observed that the noise level of daytime is sometimes higher than that of nighttime and vice versa. The level of the noise varied by the quality of the bottom materials, and variation was remarkable in the sea area of sandy mud bottom. The variation of noise level was considered to be caused by the sudden change in brightness of the sunbeam at sunrise or sunset, and not so much to be influenced by the factors of the tide and so on. It seems that the frequency characteristics of the noise is variable by the bottom condition and the biological noise at any station depends on the life of the sea at the station. The range of the noise level was about 65 - 85 dB (2×10^{-4} μ bar).

Introduction

The cause of the crackle or TEMPURA NOISE which is heard in the sea were reported by JOHNSON, EVEREST and YOUNG[1,3], DOBRIN[2], VOLZ[4], BUSNEL and DZIEDZIC[5], FISH[6], WENZ[7], and so on. TAKEMURA and MIZUE[8] stated that the TEMPURA NOISE at the coastal waters of Japan would be mainly caused by the snapping shrimp.

BUSNEL and DZIEDZIC[5] had similarly measured the diurnal variation of the frying noise at the surrounding of Corsica on the Mediterranean Sea and reported the results with many data. According to the above report, the level of the frying noise at the rocky coastal waters becomes higher at sunset ane becomes lower at sunrise, the variation of noise level being abing about 10 dB; the noise level at the coastal region is within the range of 70 - 80 dB; the diurnal variation of underwater sound (crackle) produced by the barnacleinthe of the Atlantic Ocean (*Balanus perforatus*) is similar to the above variation and varies by the brightness;

the local difference in the noise level is little observed if the sea condition is the same but the noise level increases according to the condition of the sea bottom as it goes from offshore toward shore.

EVEREST, YOUNG and JOHNSON[1,3] described the diurnal change in wide band

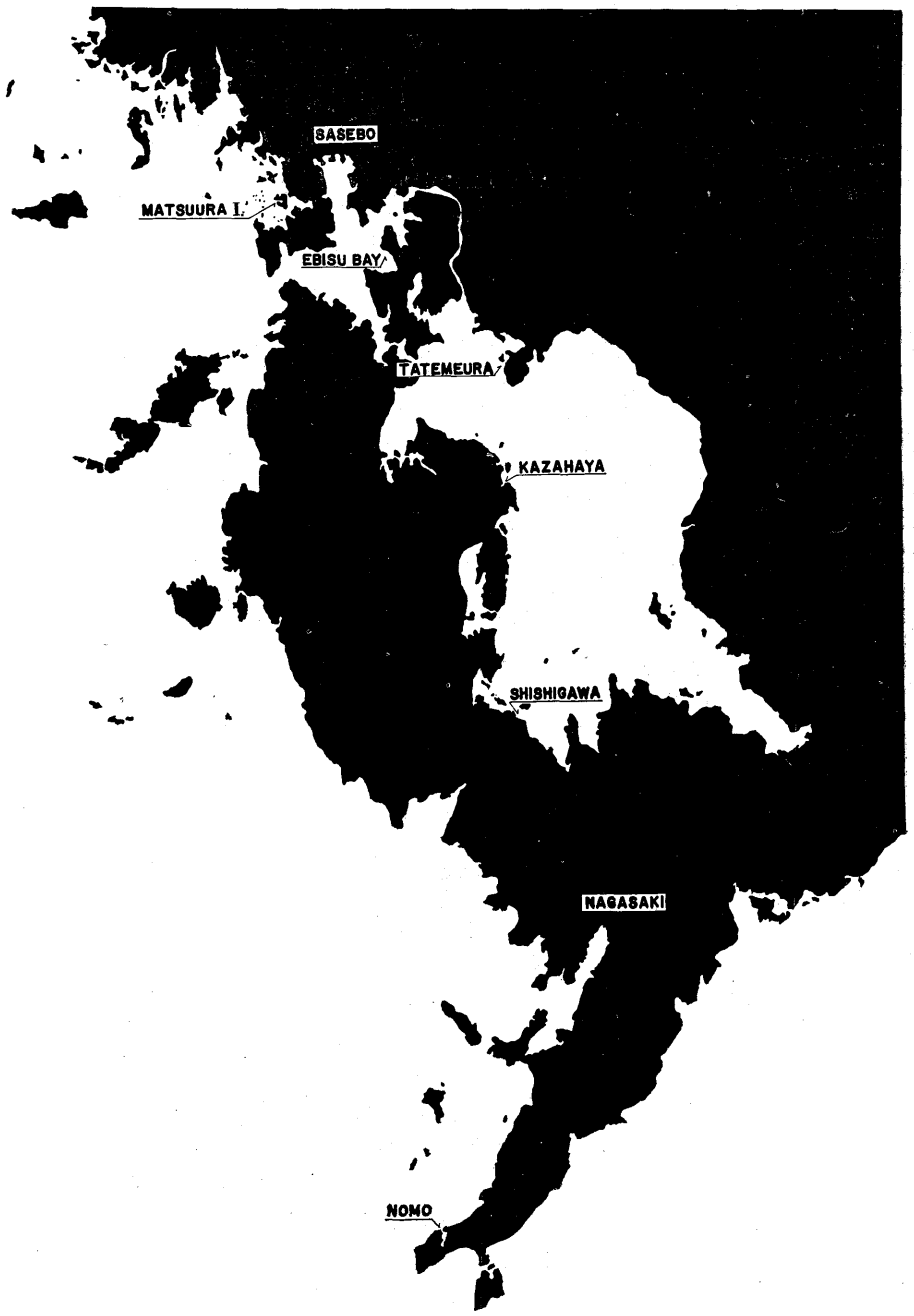

Fig. 1. Location of observation.

shrimp noise at the Pacific coast of the United States and at the neighboring area of islands in the Pacific Ocean. According to the described figure, the noise level of daytime is lower than that of nighttime, and it seems that the slight peak value is indicated before sunrise and after sunset, and the value is 3 - 6 dB higher than the level of daytime; the average spectrum of frequency shows a broad peak of above 2 kHz and the shape is not uniform.

Table 1. Environmental condition of stations.

Station	NOMO	SHISHIGAWA	KAZAHAYA	TATEMEURA	EBISU BAY	MATSUURA I.
Condition						
Bottom materials	SAND (mud, pebblestone)	PEBBLESTONE (sand, mud, seaweeds)	MUD (sand, seaweeds, pebblestone)	SAND (pebblestone, mud)	MUD (pebblestone, sand)	MUD (sand)
Circumstance	STONE WALLS	STONE WALLS SMALL CREEK	STONE WALLS COVE	SEA BEACH OF PEBBLESTONE COVE	STONE WALLS SMALL INLET	ROCK UNINHABITED ISLAND
Depth of water (m)	7	5	8	9	6	5

DOBRIN [2] reported that the noise level at Wolf Trap during the summer indicates a symmetrical peak at about 8:30 P. M. ; at Beaufort and Fort Macon in June, the peak is observed at 12 : 30 A. M. each night; and the cause is not definite but it may be related to the feeding activity at the bottom.

EVELEST and GALES [9] described that the daytime level of crackling noise is lower than the nighttime level but the difference is not so large, and the peaks at sunrise and sunset are quite interesting characteristics of these variations.

It is properly considered that these noises, especially at the coastal waters, influence greatly upon the utilization of the underwater sound. Accordingly, in order to study the underwater noises in further detail, the observation of the diurnal variation in the coastal waters of Nagasaki Prefecture was carried out.

Methods

As it has been understood from the previous studies that the underwater noise is caused by biological factors, 6 coastal stations were selected on the coastal waters in Nagasaki Prefecture where the influence of traffic noise upon the observation was as little as possible. No station, however, was entirely free from some traffic

noise. Therefore, in order to avoid the influence of natural and artificial noise from physical and chemical factors except for the noise from biological factors, the observation was subject to a great time restriction resulting in some extent of delaying or hastening. The selected 6 stations were Nomo, Shishigawa, Kazahaya, Tatemeura, Ebisu Bay, and Matsuura I. as shown in Fig. 1 and a total of 10 measurements were carried out at those stations. The environmental conditions of the stations are shown in Table 1.

At each station, all mechanisms of the research vessel which would utter noise such as engine, generator, and invertor were brought to a stop and 24-hour investigation of the noise level was carried out.

The instruments used for this investigation were a hydrophone (OKI ST 65-01), pre-amplifier (OKI for ST-65), precision sound level meter (RION), taperecorder (NAGRA III) and sound spectrograph (RION). The hydrophone submerged to about 5m of depth was sustained by a float and the noise was amplified to about 30 dB by the pre-amplifier and then the noise level was measured by the precision sound level meter. The level was measured by the JIS methods for measurement of

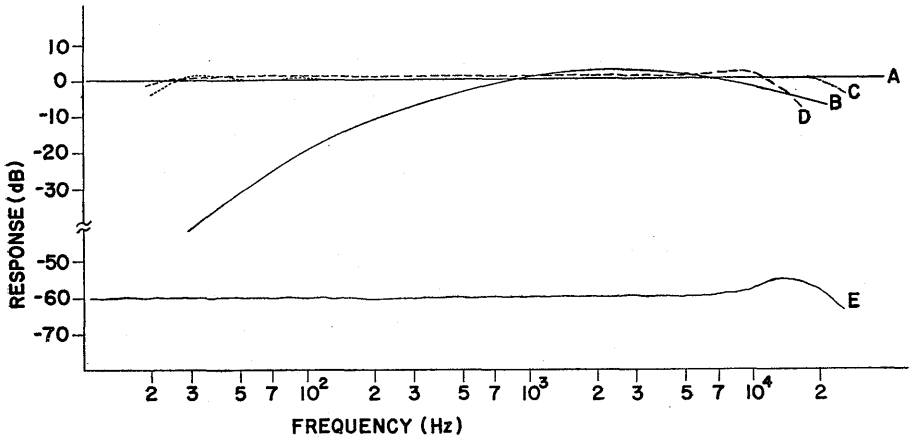

Fig. 2. Characteristics of these instruments.
A ; 5Hz-characteristic B ; A-characteristic curve of precision sound level meter C ; Tape recorder D ; Sound spectrograph
E ; Hydrophone

sound level[10] for A-characteristic (medium value and 90% range) even for flat characteristic above 5 Hz (medium value and 90% range) and was recorded by the tape recorder. The frequency characteristics were studied by the sound spectrograph. The characteristics of these instruments are shown in Fig. 2. The atmospheric pressure, air temperature, water temperature, tide and other factors at the time were also measured to determine whether or not they have any influence upon the TEMPURA NOISE.

Observations and results

1) Diurnal variation of the noise level

Twenty-four-hour measurement of the underwater noise was carried out at 6 stations except for Ebisu Bay where measurement was not done in the daytime on account of traffic noise. These results are shown in Figs. 3 - 7. In the figures, the vertical solid line and the dotted line show 90% range of the sound level variations excluding the upper and lower 5% ranges and the mark (O) shows the medium value. The solid line shows the value measured by the flat characteristic in the range above 5 Hz and the dotted line shows the value measured by the A-characteristic for the revision of the auditory sense.

Fig. 3 shows the variation of noise level at Ebisu Bay. As has been stated, the noise level after 8:00 A.M. is influenced by the traffic noise and the noise level at night is 3 - 5.5dB lower than the peak value at sunset and sunrise, and the level of A-characteristic is higher than that of 5Hz-characteristic. The level at nighttime is almost constant and is about 70dB (0 dB = 2×10^{-4} μ bar). The TEMPURA NOISE before and after the peak value was so strong that each noise was clearly audible.

Fig. 4 shows the variation of noise level at Kazahaya from 10th to 11th of

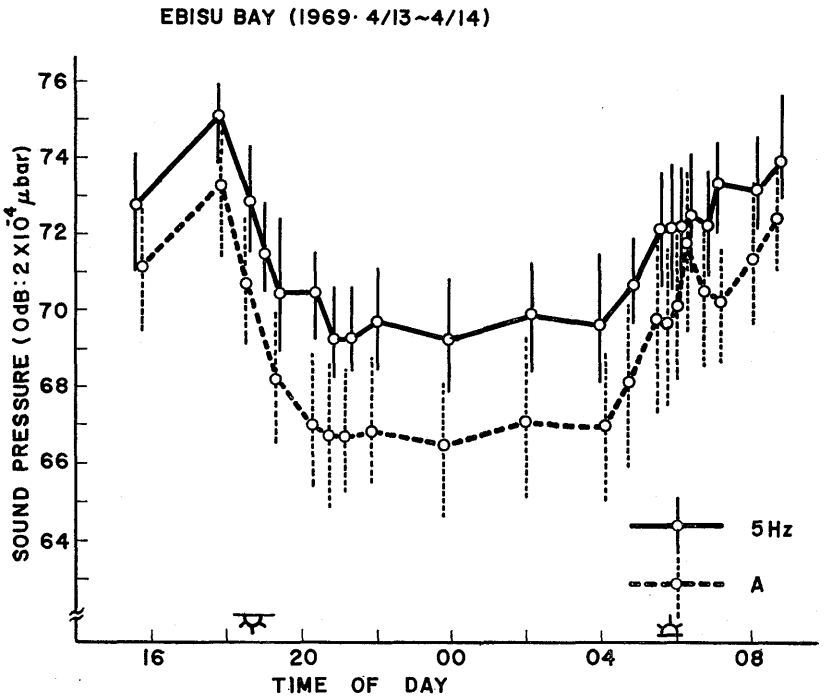

Fig. 3. Diurnal variation of noise level at Ebisu bay.

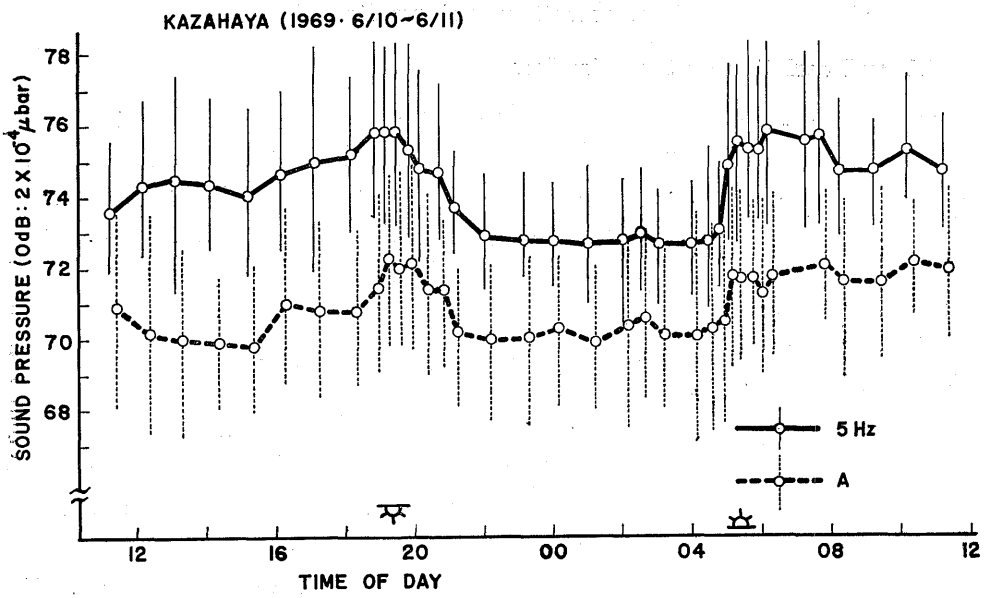

Fig. 4. Diurnal variation of noise level at Kazahaya.

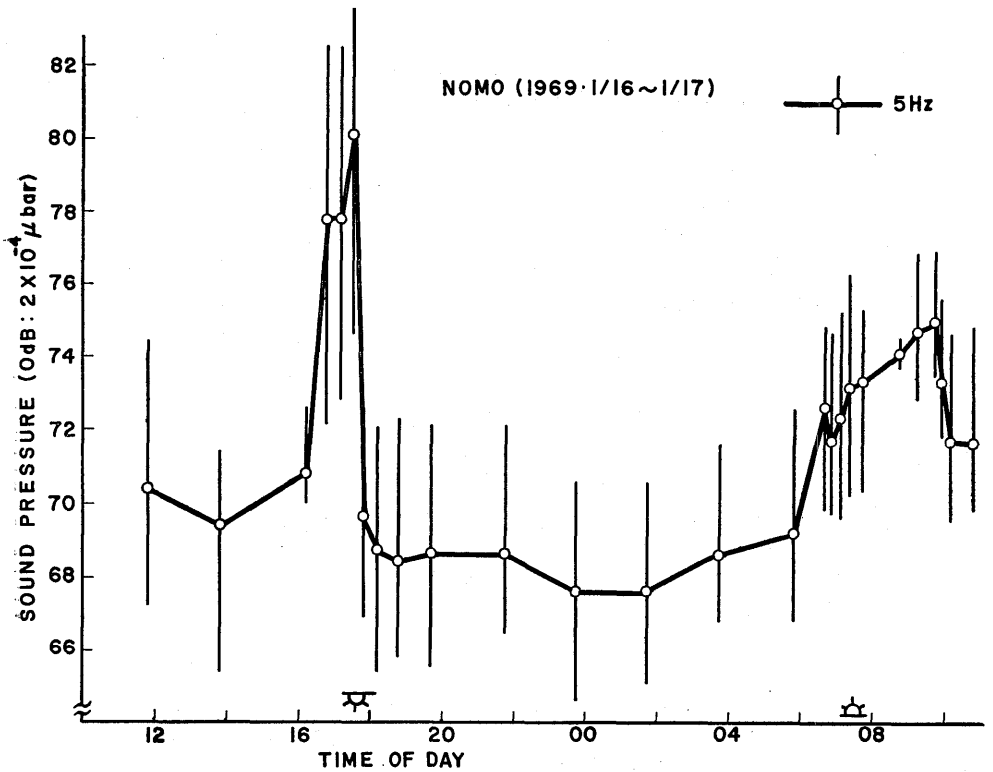

Fig. 5. Diurnal variation of noise level at Nomo.

June in 1969. The noise level reached the peak at sunrise and sunset, and decreased by about 3 dB at nighttime as observed at Ebisu Bay. The noise level at daytime is rugged being disturbed by the traffic noise from far away and is lower than the peak value at sunrise and sunset similarly to the one obtained at night. These results indicate to be slightly different from the above-mentioned foreign paper and

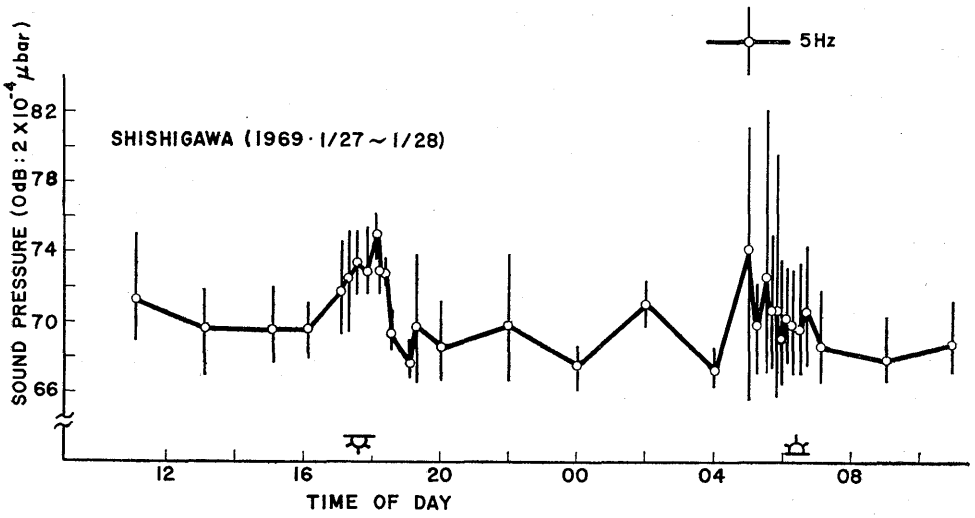

Fig. 6. Diurnal variation of noise level at Shishigawa.

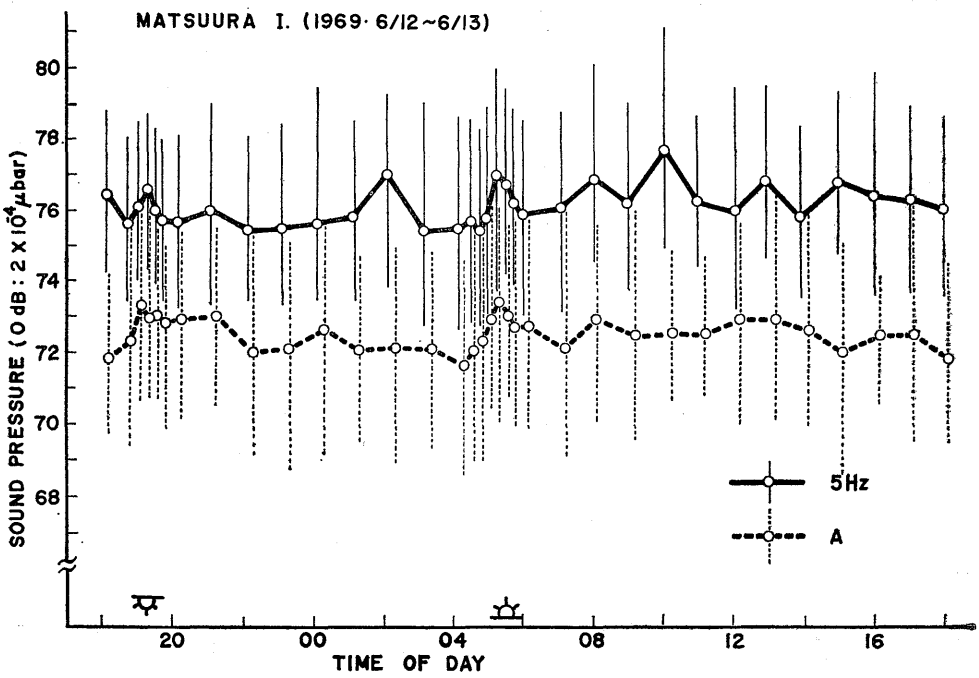

Fig. 7. Diurnal variation of noise level at Matsuura Island.

the variation of A-characteristic is smaller than that of 5Hz-characteristic.

The result of investigation at Nomo Bay is shown in Fig. 5. In this figure, there is a powerful peak value (about 10 dB) at sunset. The investigation was made together with the observation of the tide which was considered to have some relation to the noise level, but no difference was noted. This fact indicates that the sessile animals of the tidal zone either in ebb or flow have little influence upon the noise, and the cause of the TEMPURA NOISE is rather the benthic animals than the sessile animals in the tidal zone.

Fig. 6 shows the variation of noise level at Shishigawa.

Fig. 7 shows the result of the investigation on the variation of the noise level from 12th to 13th of June in 1969 at the Matsuura I. In this area, the noise level is constant measuring about 76dB (0 dB = 2×10^{-4} μbar) without any significant variation.

Observation at Tatemeura was impeded by rough condition of the sea and no result was obtained.

After all, the locality of the sea area had a great influence upon the diurnal variation of the underwater noise level and it was considered that observation must

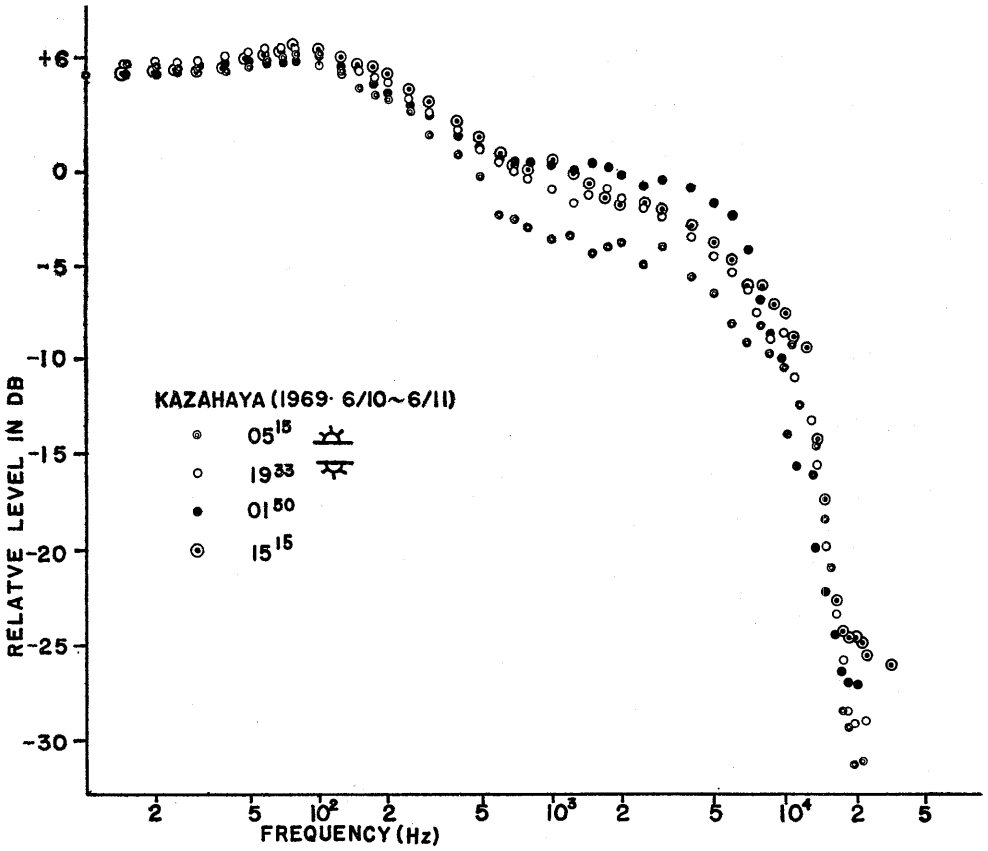

Fig. 8. Diurnal change in TEMPURA NOISE spectrum at Kazahaya.

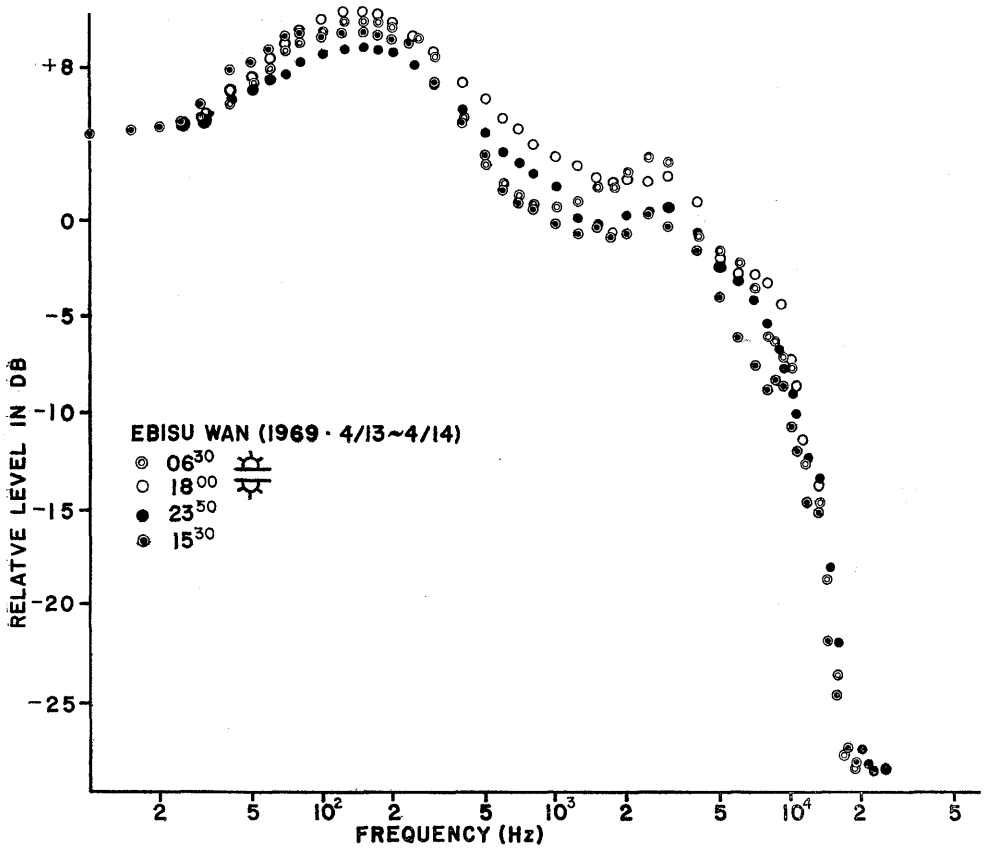

Fig. 9. Diurnal change in TEMPURA NOISE spectrum at Ebisu bay.

be carried out not only for a specific species but also for the entire marine life. There is, however, no denying that the underwater noise is mainly caused by the snapping shrimp. There was observed no definite relationship between the underwater noise and atmospheric factors such as barometric pressure, air temperature, water temperature, and so on.

2) **Spectrogram of the underwater noise**

Figs. 8 and 9 show the spectrograms of the underwater noise at nighttime, daytime, sunrise, and sunset. The spectrograms vary more or less by the condition of the sea area showing its distinguished characteristic especially at about 3 kHz. The noise variation unlike at Kazahaya is all equal the same at any frequency value at Ebisu Bay that shows a large peak value at about 3 kHz. It seems that this is caused by different condition of the bottom and the lives that live under this condition. Whereas the TEMPURA NOISE is caused chiefly by Genus *Alpheus* as stated in the previous paper, it may also be influenced by other subjects living in the region. This noise abates suddenly at 8 - 9 kHz and hardly reaches up to 15 kHz.

These spectrograms are similar to that of the report[1,3] about snapping shrimp by EVEREST, YOUNG and JOHNSON.

Summary

1) The diurnal variation of the underwater sound was investigated 10 times at 6 stations on the coastal waters of Nagasaki Prefecture from January to September in 1969.

2) The underwater noise level reached to the peak value twice a day (at sunset and sunrise) being 3 - 5 dB higher than that in nighttime and daytime.

3) The noise level in daytime was sometimes higher than that in nighttime and sometimes equal with the latter. No obvious difference in the noise level was observed between the nighttime and the daytime.

4) The noise was influenced even by the condition of the bottom materials, for example, the noise at the bottom of sandy mud was the hugest.

5) This variation was caused chiefly by sudden change of brightness and it did not seem that the variation was influenced by the tide, water temperature, air temperature, atmospheric pressure, and so on.

6) The frequency distribution of the underwater noise was somewhat different by the condition of the bottom materials and the underwater life in the area, and the considerably powerful noise level was observed between 1 and 4 kHz at sunrise and sunset in the area where many snapping shrimps might possibly live as mentioned in the previous paper.

7) The sound pressure level was about 65 - 85 dB.

8) It was not likely that the sessile animals which adhere to the tidal zone are the main cause of the TEMPURA NOISE.

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