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PERIODIC VARIATIONS OF THE UNDERWATER AMBIENT NOISE LEVEL OF BI--ETC(U)

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This is a working paper giving tentative information about some work in progress at NEL. If cited in the literature the information is to be identified as tentative and unpublished.

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PERIODIC VARIATIONS OF THE UNDERWATER AMBIENT NOISE LEVEL OF BIOLOGICAL ORIGIN OFF SOUTHERN CALIFORNIA.

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(10) G. A. Clapp ~~(NEL Code 3190)~~

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ABSTRACT

Two distinct periodic variations of the underwater noise level have been observed in the coastal waters off San Diego. The first, called the "sunset chorus," appeared diurnally before sunset, and faded away within 3 hours. This variation was observed in the 100- to 1000-cycles per second (cps) band and raised the sound-pressure level 5 to 20 decibels (dB) above the normal background. During the winter months, the variation had a shorter period and was less intense than in summer. The effect was sometimes observed at dawn, although with reduced duration and amplitude. Two members of the croaker family, spotfin, Roncador stearnsi, and yellow-fin, Umbrina roncador, are believed to be responsible for the sunset chorus, as Johnson[1] concluded.

The second periodic variation is called the "cycling sound." It is observed only at night in the late spring and summer months. Its amplitude is commonly from 3 to 6 dB, but maximums of 16 dB have been noted. It is observed above the background in the 300- to 800-cps band with peak amplitude occurring at about 450 cps.

INTRODUCTION

Sources of underwater ambient noise, other than marine life, are now reasonably well-understood, and fairly reliable estimates of the noise levels can be made. However, the calculation of ambient noise levels in a given situation, especially in coastal waters, can be hampered by lack of knowledge of soniferous marine organisms. The variation of species, their density, and the environmental factors over small intervals of space and time complicate predictions.

A desirable technique for predicting the occurrence of underwater noise from biological life would provide information on (a) the species of marine life capable of sound production and (b) the environmental conditions under which soniferous species will produce noise. However, the results of studies of biological sound, are often described in a manner that makes it difficult to precisely identify the causative organisms. If the soniferous organisms remain unidentified, the observed acoustic output cannot be related to known biological behavior and the data are not utilized, as for example when the known habits of croakers and snapping shrimp have been deduced from their acoustical emissions. Some difficulties of identification in situ are (a) limited visibility; (b) lack of underwater observational mobility; (c) the stimulation of either silence or abnormal noise production on the part of organisms by observational equipment (such as underwater lights or television); and (d) the improbability of visual contact because of low species density.

Laboratory studies utilizing an aquarium and a single species of fish can provide identification of some biological sound sources. However, the alien aquarium environment may discourage the organism from making noise, and an attempt to induce sound production by the species could result in unusual or abnormal effects. The aquarium should simulate the natural environment as nearly as possible, but such parameters as tides, waves, and deep-water pressures are not easily reproducible. Laboratory aquaria large enough to study fish that produce noise as a group rather than as individuals are often not available. Aquarium studies, however, remain the best method for positively identifying soniferous marine life.

Any sounds heard in aquaria can be compared with those detected in the marine environment, but differences due to other environmental variables can be observed between the same fish in captivity and in the sea. Tavolga[2] reports that the timbre of fish sounds is affected by the size and insulation material of the aquarium.

The distance from the hydrophone is also an important parameter both in the natural and the artificial environments. Any harmonic analysis that does not take these variables into account is of limited value. An anechoic pool thus meets an essential requirement for the study of soniferous marine life, and the harmonic distortion caused by present aquaria would thereby be eliminated.

DISCUSSION

ENVIRONMENT

Most of the measurements presented in this report were made from the U. S. Navy Electronics Laboratory (NEL) Oceanographic Research Tower, located 0.8 mile off Mission Beach, San Diego, California, in 60 feet of water on a gently sloping, sandy bottom. The surface temperature ranges from 65 to 70° F during the summer to about 55 to 60° F during the winter. The bottom temperature is often 10 degrees lower than the surface temperature in summer months.

Since sea-floor vegetation is sparse in the area, there are few fish except in the immediate vicinity of the tower, the substructure of which is covered with a growth that supports a relatively stable population of many hundreds. These fish, mainly halfmoons, perch, and kelp bass, seldom wander more than 100 yards from the tower. No correlation has yet been established by closed-circuit television between these fish and various biological noises that can be heard. Shipboard observations, made within a mile of the tower, indicate no qualitative differences in biological noise. Thus, the tower habitat is not known to have attracted soniferous marine creatures.

DATA AND METHODS

Ambient noise measurements were made occasionally from June, 1960 and regularly from June, 1963 to July, 1964. A Noise Measuring Set PQM-1A, with a hydrophone mounted near a leg of the tower 10 feet from the bottom, was employed in data collection. All measurements were recorded continuously on a strip chart recorder. The graphic level data were supplemented by magnetic tape recordings on two occasions in May, 1964 and were later analyzed by a 1/3-octave filter system. Continuous anemometer records were available for the periods of data collection. Five local sea cruises, using the equipment described, were made during 1963 and 1964 to determine the geographic extent of the noise-level variations.

RESULTS

Two factors became evident from the initial recordings of the underwater noise level made in June, 1960. The first was a 15-dB rise in the noise level at sunset, with the maximum intensity occurring about 30 minutes afterward, termed the "sunset chorus." The second was a 3- to 6-dB oscillation in the noise level, with a period of 30 seconds, that occurred only during the early evening and night, called the "cycling sound." Figure 1 shows typical

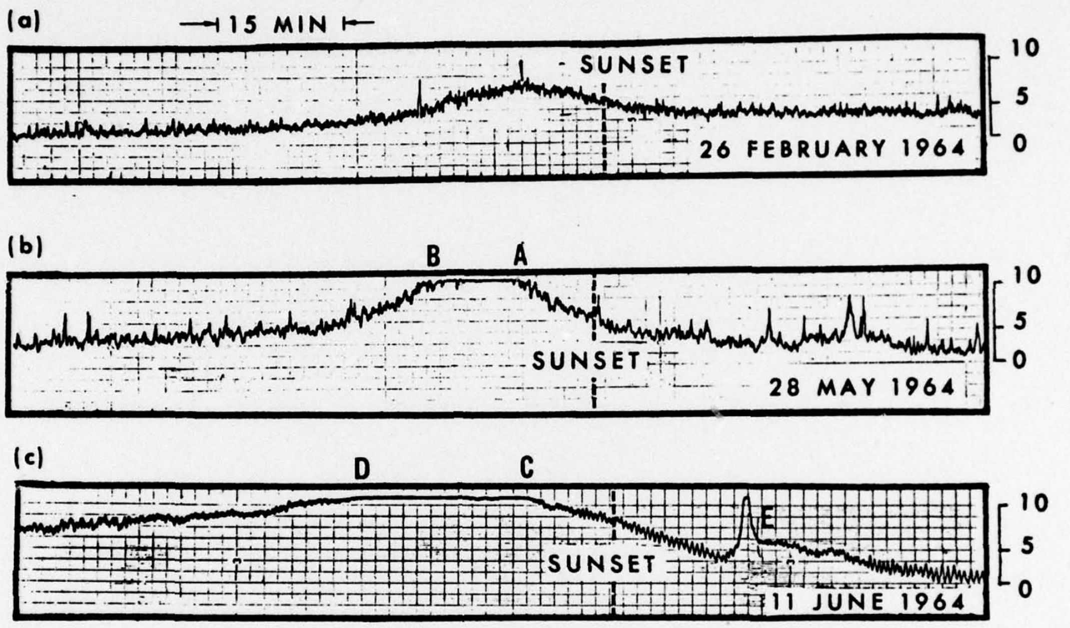

Figure 1. (a) Sample of sound pressure-level data near sunset on 26 February 1964; (b) Sound pressure-level data for 26 May 1964 (the readings are off-scale from A to B; (c) Sound pressure-level data for 11 June 1964 (the readings are off-scale from C to D).

The sharp rise at E represents noise from a motorboat passing near the tower. The cycling sound can be seen in the first 15 minutes of the data.

examples of data from February, May, and June. Both of these variations can be seen; the first 15 minutes on the bottom block shows the cycling sound and the sunset chorus can be seen in all three blocks. The rise at E on 11 June 1965 is noise produced by a motor boat.

SUNSET CHORUS

Biological noises near the NEL tower are heard as a chorus rather than as individuals. Few biologic noises are detected during the day except for shrimp-crackling. In June there is a general rise in the noise level and a slight increase in the amount of individual sounds heard as early as 1500. Most of the individual sounds are low-frequency grunts and knockings. The noise level continues to rise until shortly after sunset to about 15 dB above normal daytime level. The maximum intensity is attained 30 minutes after sunset and is followed by a decline for the next 3 hours of 3 to 5 dB above normal day levels. Sunset and its association with feeding time causes several species of fish, in this case the croakers, to increase their noise emission. The diurnal pattern of the croaker chorus is similar to that reported by Knudson in 1948 for Chespeake Bay.[3] It is also similar to the croaker chorus (primarily caused by Roncador stearnsi and Umbrina roncador) reported in the San Diego area in 1942 except that the duration of the chorus was shorter in 1942.[1,4] Figure 2 is the normal daytime spectrum and the sunset chorus spectrum and this figure shows that the sunset chorus is mainly in the 100- to 1000-cps band.

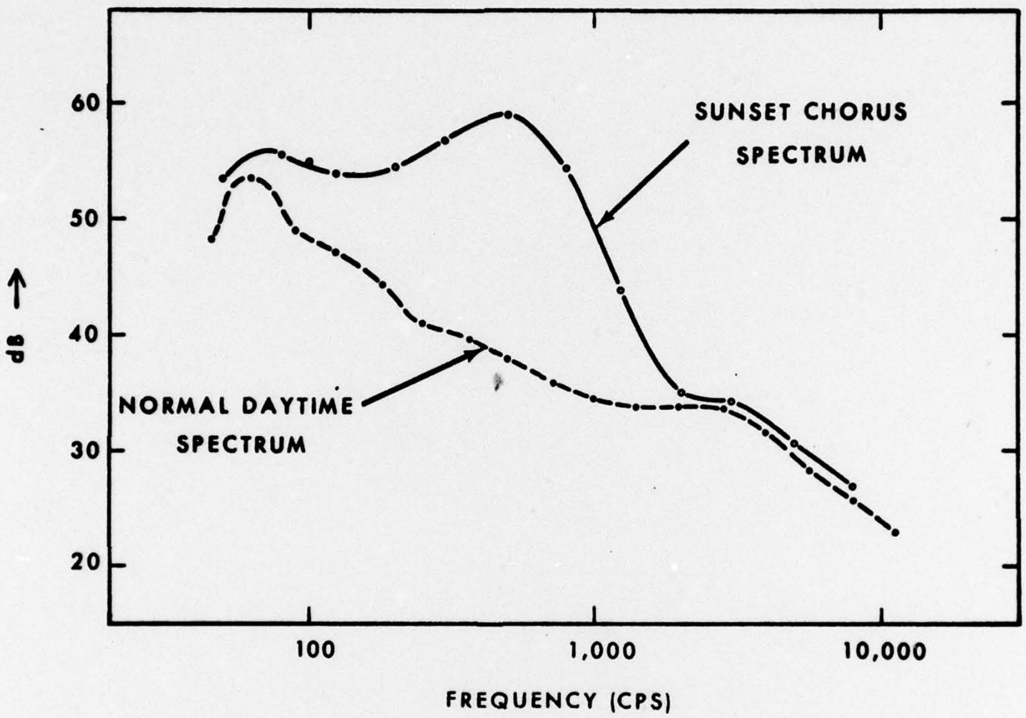

Figure 2. The sunset chorus spectrum level and the normal daytime spectrum level in June at the NEL Oceanographic Research Tower. The data points at 60 cps are about 5 dB low because of the frequency response of the system.

Knudson stated that the sunset chorus ends about the first of August, and Johnson noted its disappearance around 10 September. This investigation showed that, although seasonal differ ences exist, the sunset chorus occurred every night measurements were made throughout the year at the NEL tower location.

From January to the end of May the sunset chorus persists for 25 minutes to 2 hours, and the maximum intensity occurs about 20 minutes after sunset. During these months, the average maximum amplitude of the intensity of the sunset chorus declines about 2 dB per month. By June, the chorus begins as early as 1600 and ends as late as 2300 for a total of 7 hours. Maximum amplitudes are 10 to 15 dB above April levels and still occur around 25 minutes after sunset. In mid-August both the duration and amplitude of the evening chorus begin to decrease. The next month is characterized by irregularity; maximum amplitudes vary by as much as 10 dB from night to night. A peak in noise level is reached in summer and followed by a general decline in the autumn. Throughout the remainder of the year, the amplitude of the sunset chorus remains relatively low.

Figure 3 is a plot of the peak amplitude of the sunset chorus over an entire year. Each point represents one day. The solid line in June-September indicates a croaker chorus comparable to Knudson's and Johnson's observations. It is possible that during the remainder of the year the sunset chorus is caused by a source other than the croaker. Some 1943-44 data from Hawaii[6] indicate the presence of a sunset chorus throughout the year. Analysis of the Hawaiian data showed that the maximum amplitudes of the sunset chorus occurred during the summer at locations with sandy bottoms. The maximum amplitude around January is found in places with a different type of bottom. A preference for sandy areas is a characteristic of croakers.

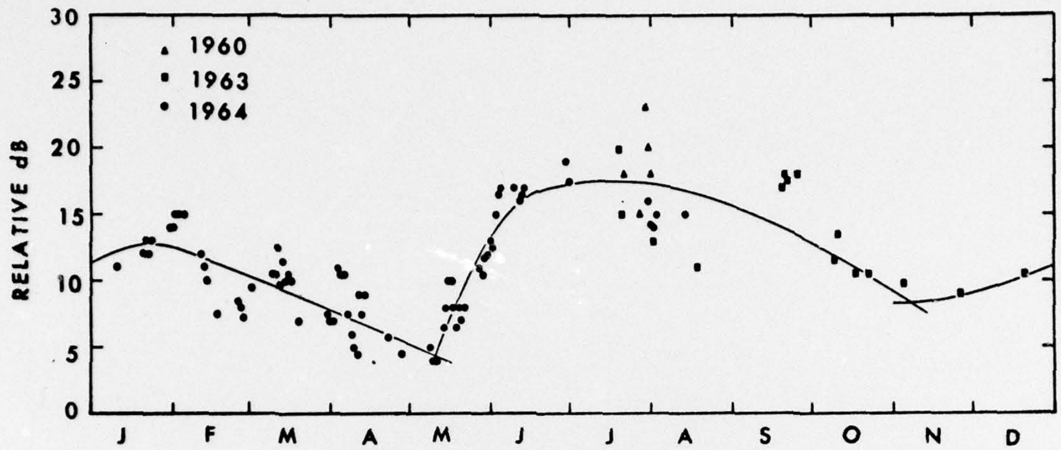

Figure 3. The peak amplitude of the sunset chorus relative to the background level for that day from data obtained in 1960, 1963, and 1964. The solid line from May to November represents the estimated monthly variation of the croaker noise. The solid line throughout the remainder of the year is the mean of the sunset chorus from an unidentified source.

The evening chorus in southern California is probably due to two separate biological sources. Croakers cause the evening chorus that persists for 3 or more hours in the summer months, which is centered at 500 cps, and occurs primarily over sandy bottom regions. The second organism not yet identified, produces an evening chorus of 2 hours duration or less at high frequency than the summer chorus, with a slight maximum that occurs in January or February, and does not seem to be confined to any particular environment.

Figures 4, 5, and 6 show the seasonal change of the sunset chorus and the cycling sound, and represent the smoothed noise level over a 24-hour period. The shaded area in each figure is the range of amplitudes of the cycling sound.

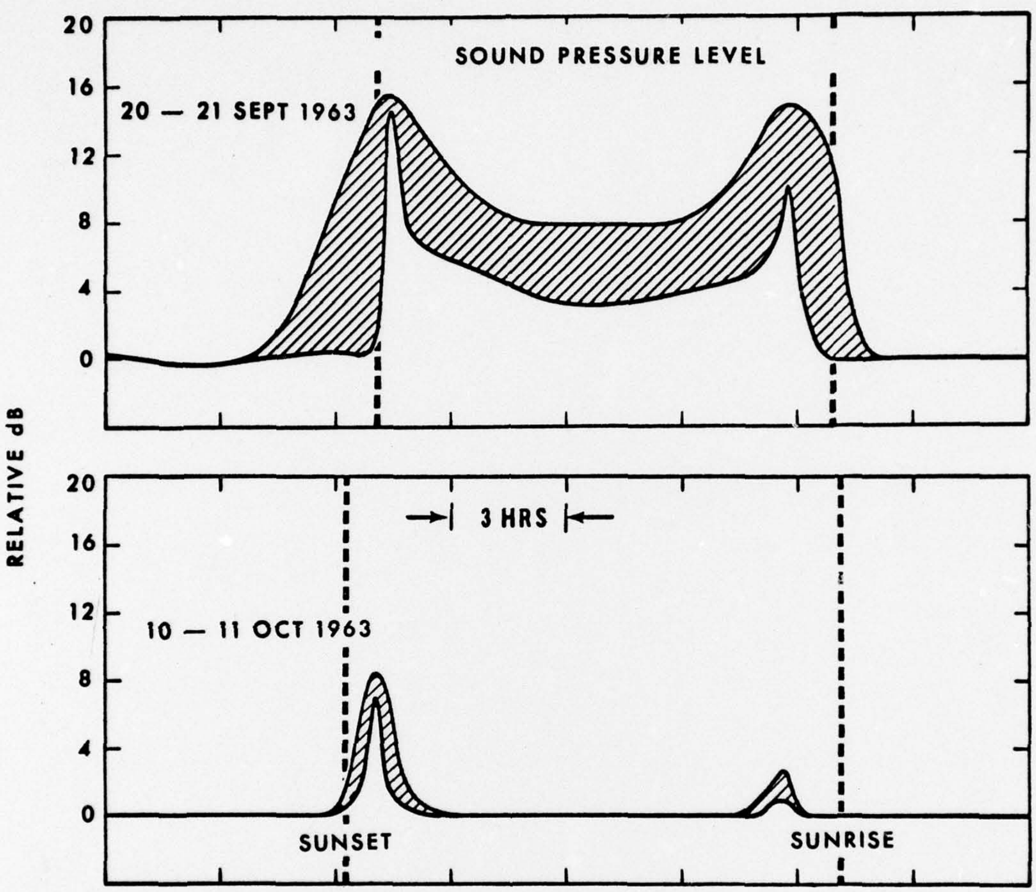

Figure 4. The smoothed sound pressure level in the range of 50 to 1000 cps for 2 days during September and October, 1963. The shaded area represents the peak-to-peak amplitude of the cycling sound. The minimum sound pressure levels during the night in June through September are higher than the daytime levels. Zero dB has been selected as the daytime level for each graph.

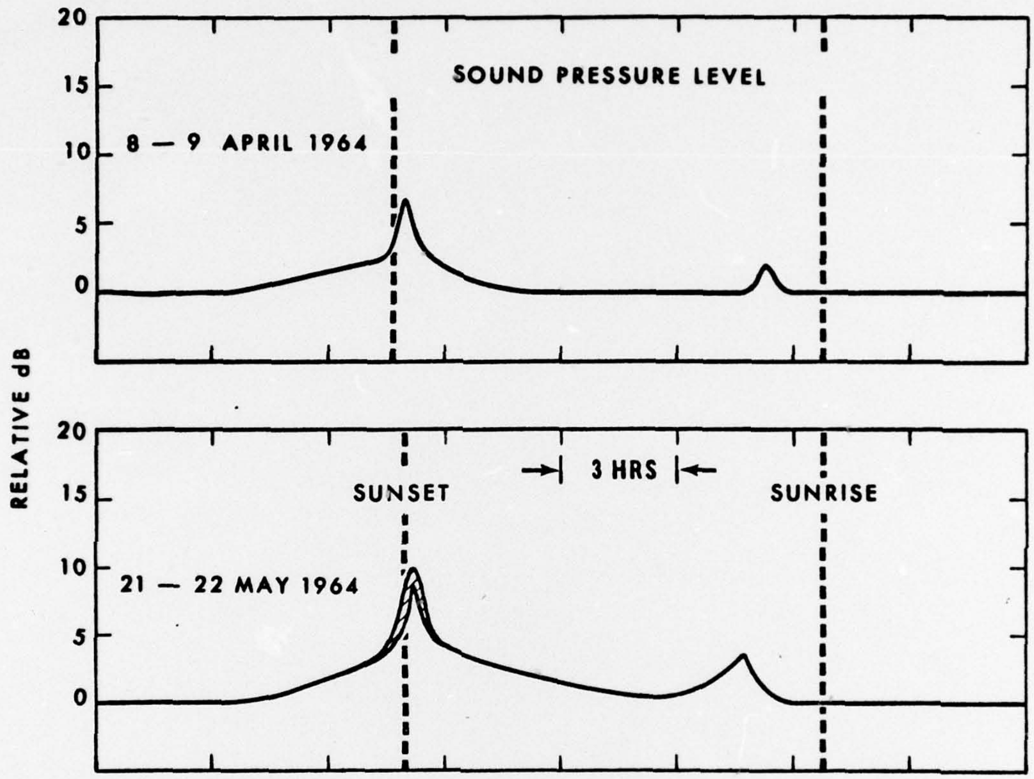

Figure 5. The smoothed sound pressure level in the range of 50 to 1000 cps for 2 days during April and May, 1964. The shaded area represents the peak-to-peak amplitude of the cycling sound. Zero dB has been selected as the daytime level for each graph.

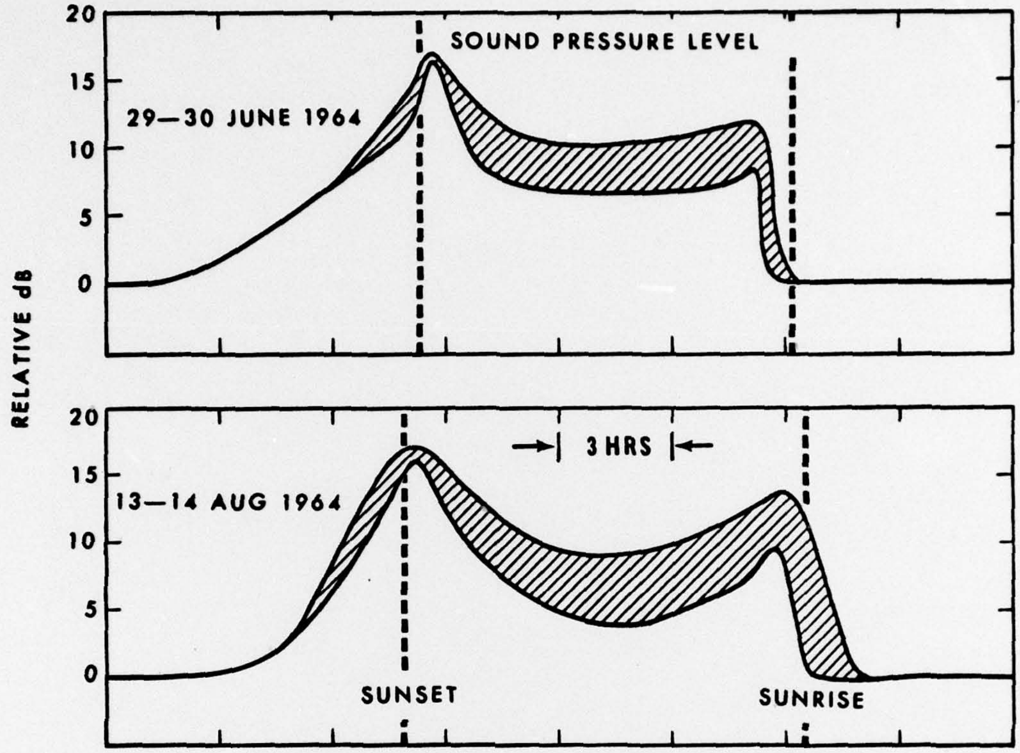

Figure 6. The smoothed sound pressure level in the range of 50 to 1000 cps for 2 days during June and August, 1964. The shaded area represents the peak-to-peak amplitude of the cycling sound. The minimum sound pressure levels during the night in June through September are higher than the daytime levels. Zero dB has been selected as the daytime level for each graph.

CYCLING SOUND

When the cycling sound in June is first heard, it gives the impression of being a general oscillation of the background noise level; no distinctive sounds can be noted. However, its composition becomes obvious in the summer when the cycling grows more intense and the sound is created by a large number of "carpenter fish" producing characteristic knocks in unison, so called because their individual knock sounds like a hammer tapping wood. A few separate knocks are first heard, then a great increase in the number, and finally so many that no specific knocks can be detected. The knocking quickly dies out. The composite of these is the cycling sound shown as the oscillations on figure 7, each lasting about 30 seconds. The cycling is analogous to the applause of an audience, where first is heard a few individual claps, then a general increase until few or no separate claps can be distinguished. Finally the applause subsides and only a few claps will be noted before silence. The cause of these "carpenter fish" making noise in unison throughout the night remains unknown. The cycling sound is observed above the background in the 300- to 800-cps band with a peak amplitude occurring at about 450 cps.

The period of the cycling is related to the background noise level. At low daytime levels, one cycle in one or two minutes is not unusual. At moderate background levels the period is usually from 30 to 40 seconds. When the sunset chorus augments the background level, the period of cycling decreases from 30 to 40 seconds to a minimum, sometimes as low as 15 seconds. As the background level increases further, the cycling becomes erratic and finally completely chaotic.

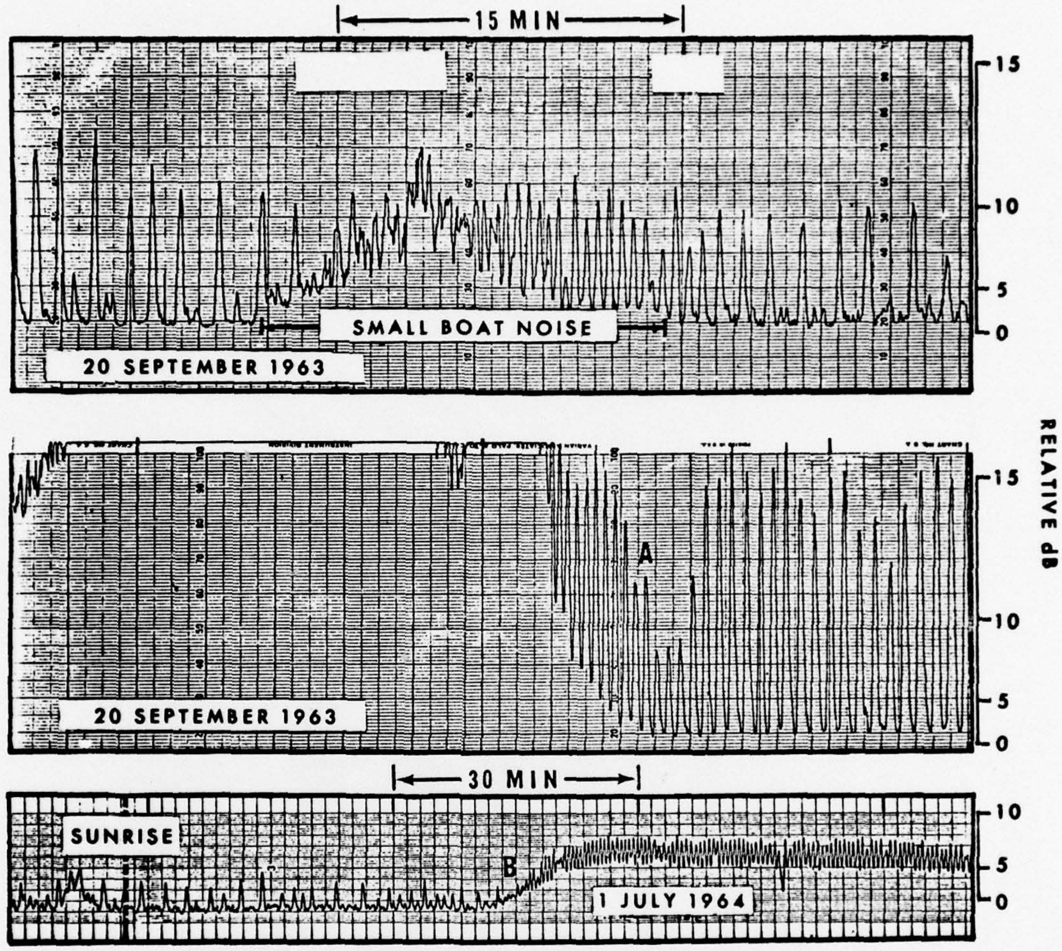

Figure 7. Three examples showing the effect of other sounds on the cycling sound: The decreasing period of the cycling sound as the other sound increases in intensity is obvious in each example. The first shows the effect of a small boat and the second shows the effect of the sunset chorus (A). The rapid drop in the sound pressure level (B) before sunrise, typical of data from late June through September, can be seen in the last record.

This relation between period and background noise level can be noted in regard to boat noise near the tower. As seen in the upper block in figure 7, when a small boat approaches the tower the cycling period becomes shorter and finally chaotic as the boat passes; the cycling becoming normal after the boat departs. The boat noise appears on the record at the same time that a change in the cycling occurs, and is measurable at 800 yards from the tower; presumably, this means that the soniferous animals are affected within the same radius.

Lights have less effect on the cycling than does sound. Underwater lights and surface spotlights directed into the water decrease both the background and the cycling levels by 1 to 2 dB. The inhibition of the cycling sound by turning on lights never endures more than 2 minutes.

Throughout the summer, the minimum night-time noise level is from 2 to 6 dB above the daytime level. This rise in the minimum night-time noise level occurs when the cycling sound is heard. The increase in night-time over daytime level may be a result of less-regular knocking by the source of the cycling sound. At periods of minimum noise in the pre-sunset cycling, nothing is heard except water noise; whereas, during the night, some sounds including knockings, can be detected when the cycling is at a minimum. The lower block in figure 7 shows the abrupt change from the night-time to daytime levels and a corresponding change in period of the cycling sound. Note that there is about 1 cycle per 30 seconds before position A and about 1 cycle per 2 minutes after position A.

Measurements made from 1960 to 1963 indicate that the average period of the cycling sound was usually near 30 seconds. In 1964 the average period was nearer 35 seconds and periods of 40 seconds were not uncommon. In order to examine the distribution of noise produced within the area, a relatively quiet ship was anchored at many local positions and ambient noise was recorded. Distinguishable individual knocks per second were the same throughout the area and from this information it is concluded that "carpenter fish" are approximately uniformly distributed. The background noise level did not change measurably during these years. A definite change of period can be seen in figure 7 when the background changes by as little as 2 or 3 dB. From this observation it can be seen that the "carpenter fish" are sensitive to this amount of sound pressure-level change. Since a high noise level corresponds to a short period of cycling sound (as deduced from Figure 7), the conclusion can be drawn that the population of "carpenter fish" decreased from the summer of 1963 to the summer of 1964.

The cycling sound has been determined to be seasonal in nature as its earliest appearance was in the middle of April and the first signs were irregular, low-amplitude oscillations occurring for about an hour during the time of the sunset chorus. By the first week in June, the population density of these fish became high enough to produce noticeable cycling throughout the entire night. At this time, the cycling began as much as 2 hours before sunset. The sunset chorus would occasionally continue up to 2 hours after sunrise. Throughout the remainder of the summer months there was little change in the pattern of the cycling sound. The magnitude of the pre-sunset and post-sunrise cycling increased slowly throughout the summer until mid-September when the former covered a peak-to-trough range of 14 dB and the latter a range of about 10 dB. The cycling terminated abruptly in the fall. Some of the most intense cycling of the year occurred during the last week of September 1963. Two weeks later, the maximum intensity of the cycling was only 4 dB and showed only for an hour near sunset, and again briefly at dawn. During the following week of October 20, there was no trace of the cycling sound. Figure 8 shows the intensity of the cycling sound, relative to sunset and sunrise throughout the year and represents the average of all data from 1960 through 1964.

These additional characteristics of the cycling sound and the "carpenter fish" were determined from four local sea trips. The cycling was heard only in coastal waters of generally less than 200 feet in depth. In a station in 1200 feet of water over Scripps Canyon, the cycling was smooth and regular, but weak, and no individual fish was heard, which indicated that the noise was coming from shallower water. The cycling was never heard in coastal areas with rocky bottoms or in areas of considerable kelp. In the long, sandy area north of La Jolla, and again in the sandy region from Coronado southward into Mexico, the cycling appeared to be more intense than at the tower site. This is probably attributable to the small area, less than a mile in each direction, that is suitable for the "carpenter fish" in the general location of the NEL Oceanographic Research Tower. The above characteristics, plus the diurnal and annual appearances of the cycling, suggest that the "carpenter fish" are members of the croaker family.

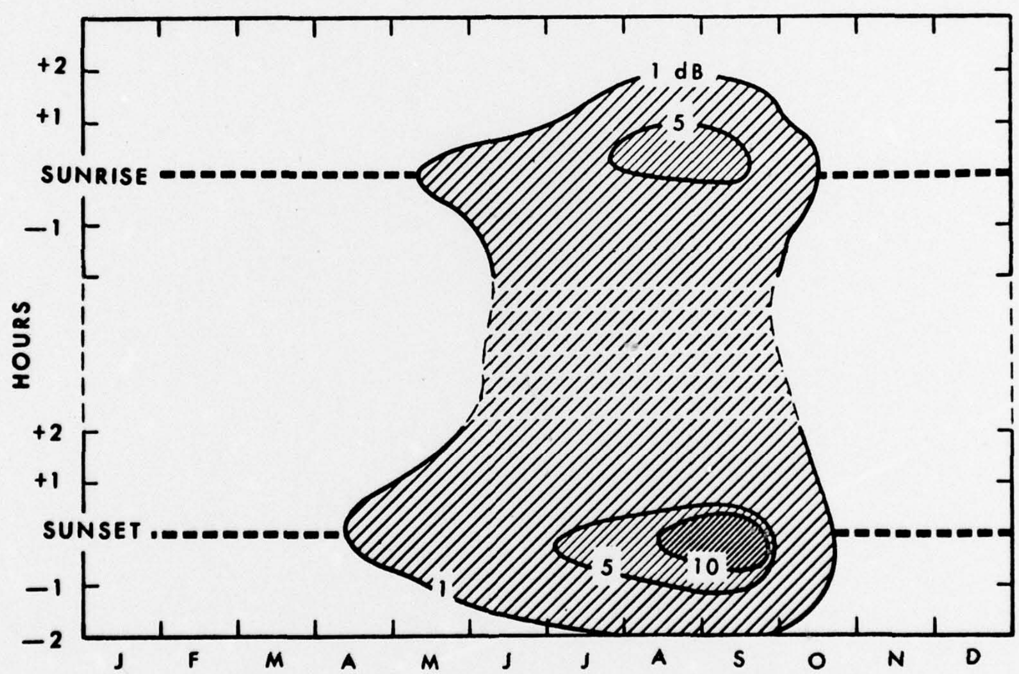

Figure 8. The mean range in dB of the cycling sound from data obtained in 1960, 1963, and 1964, relative to sunset and sunrise: Note that the cycling sound persists throughout the night from June through September.

REFERENCES

[1] Johnson, M. W., "Sound as a Tool in Marine Ecology, from Data on Biological Noises and the Deep Scattering Layer, Jour. of Marine Res., Vol. 7, No. 3, pp. 443-458, Nov. 15, 1948.

[2] Tavolga, W. M., Marine Bio-Acoustics, Pergammon Press, Oxford, 1964, pp. 200-203.

[3] Knudson, V. O., Alford, R. S., and Emling, J. W., "Underwater Ambient Noise," Jour. of Marine Res., Vol. 7, No. 3, p. 410, Nov. 15, 1948.

[4] Johnson, M. W., "Underwater Sounds of Biological Origin," UCDWR Report U28, Feb. 15, 1943.

[5] University of California, Division of War Research, "Underwater Evening Noise in the Hawaiian Area," UCDWR Report M299, March 1, 1945.