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Snapping shrimps sounds in the Black sea

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We have recorded an ambient noise at several sites at the Black Sea shelf zone. In all these sites, in the absence of a strong swell or storm, the recorded signal was almost entirely due to the activity of snapping shrimps, apparently belonging to the species Alpheus dentipes. We used different recording equipment, but in all cases we tried to provide a wide band of frequency analysis. In contrast to the data obtained in tropical waters, the rate of the most intense clicks was comparatively low, which allowed us to analyze their shape in detail and estimate the distance from the animal to the audiorecorder by analyzing the echo delay from the water surface. Qualitatively, the signals in different habitats were identical. However, the type of recorded signal depended on the nature of the bottom surface and the presence of reflections. We revealed the existence of a pair of pulses emanating from the same object from the same position. The use of high-frequency equipment suggests that the high-frequency edge of the snapping shrimps click spectrum can reach 300 kHz.

Keywords: snapping shrimps, Black sea, shelf sounds

1. INTRODUCTION

Global warming has significantly changed the geographic range of many species. This is especially true of marine invertebrates, who must adapt to changing ambient temperature to survive. Decapod crayfish belonging to the family *Alpheidae,* called snapping shrimps, in particular have spread rapidly from the tropics and subtropics to temperate zones. Their activity has already been recorded in several points of the Mediterranean (1), as well as in Ireland at latitude 51.5^0 (2). In the 1990s, we recorded and investigated the clicks emitted by snapping shrimps in the Peter the Great Bay (Sea of Japan) at latitude of 42.5^o (3). In the past few years, we have observed and studied snapping shrimps clicks at several points on the shelf zone of the eastern and northern shores of the Black Sea. We gathered the most data of this activity at Sukhum Bay. The results obtained in the course of this work were partially published (4). Also preliminary studies of this activity were carried out in the area of Blue Bay near the Gelenzhik city and at the T.I. Vyazemsky Karadag scientific station (Nature Reserve of the RAS). The results from each studied location are worth examining.

2. RESULTS

2.1 Sukhum cape

At Sukhum bay (42.979N,40.973E) snapping shrimp signals were first recorded in 2013. We used a laboratory room located at piles on the distance of 10–17 m from the coast. At the place where clicks were recorded, the seafloor had a slope of about 30^o south from the

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coast - so the depth of the seafloor increased from 5m to 10m. The surface of seafloorwas covered with pebbles and topped with a layer of dead mussel shells. We performed acoustical monitoring of this site over several years. We recorded acoustic activity with a Brüle and Kjar hydrophone (uniform frequency response up to about 200 kHz), placed 30-40cm above the bottom. For long routine monitoring we recorded ambient noise in the 10-40 kHz frequency range, but we conducted short-term recordings at a quantization frequency of 196 kHz.

Since the sizes of pebbles and mussel shells are comparable with the wavelength of the most high-frequency components of a click, the calculation of thedirection and the form of actual recorded signal turns out to be rather complex.

In contrast to the acoustical activity of these animals that was recorded in tropical waters (1) at Sukhum bay the rate of high-intensity clicks was low, which allowed us to analyze the amplitude and shape of individual impulses in detail. In some cases the amplitudes of individual clicks exceeded the noise level by more than two orders of magnitude (Fig. 1)

In many cases, we very clearly observed an echo from distinct click. The response phases were inverted, indicating that the signal had been reflected from the sea surface. As a result we were able to estimate the distance from the point of radiation to the point on the seafloor where the hydrophone was located. For the example illustrated in fig 1, considering the slope of the bottom and assuming that the emitter is situated closer to the shore than the receiver, we obtained an estimate of the distance along the bottom surface of around 1.5 meters. Since the amplitude of the signal was high, it is reasonable to conclude that we obtained a valid recording and that the emitter and receiver were in close proximity.

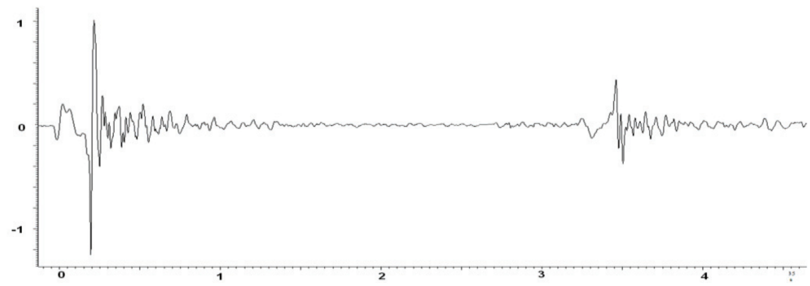

Figure 1 – This is a snapping shrimp click recorded with evident echo signal reflected from the water surface. Abscissa - the time in ms, ordinate –sound pressure in relative units.

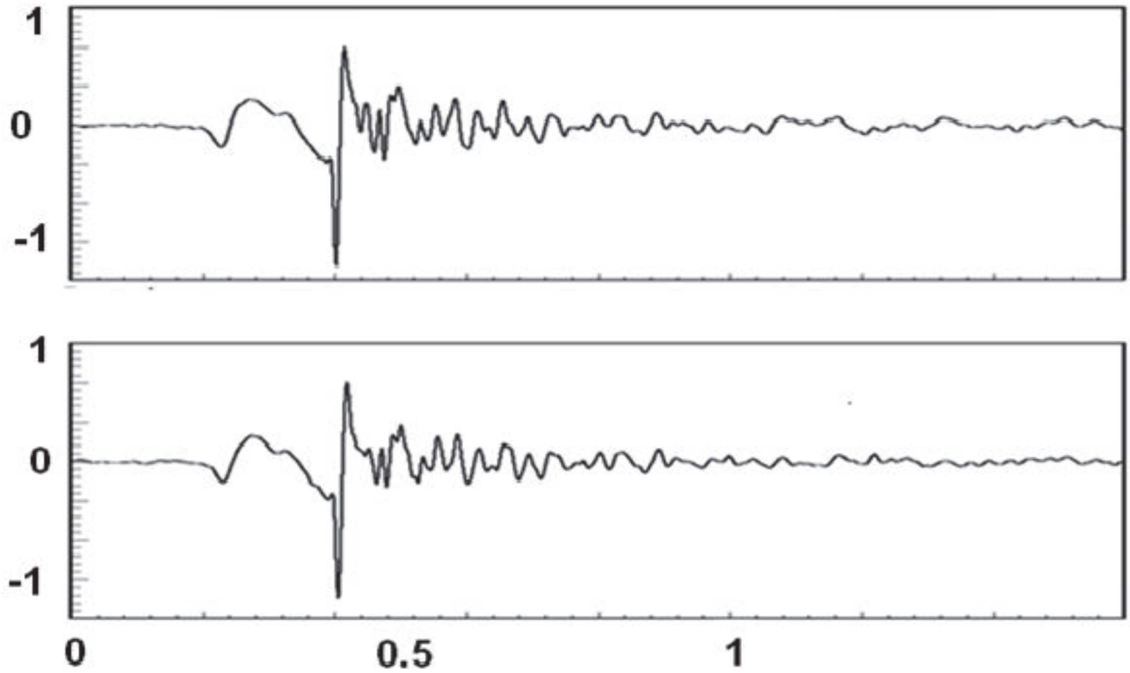

Figure 2 – Two snapping shrimp clicks which were recorded at 8:02 pm with an interclick interval of 0.84s. Abscissa - the time in ms, ordinate –sound pressure in relative units.

Several times we observed very interesting events – a double click of the same animal emitted from the same place with an interval of about 1s. An example of such an event is presented in the fig 2. The shapes of the two clicks with all their peculiarities are virtually identical.

2.2 Blue bay

At the point with coordinates (44.575N, 37.982E) we recorded snapping shrimp signals using the hydrophone with an upper frequency limit around 200 kHz and with a sampling rate of 500 kHz.

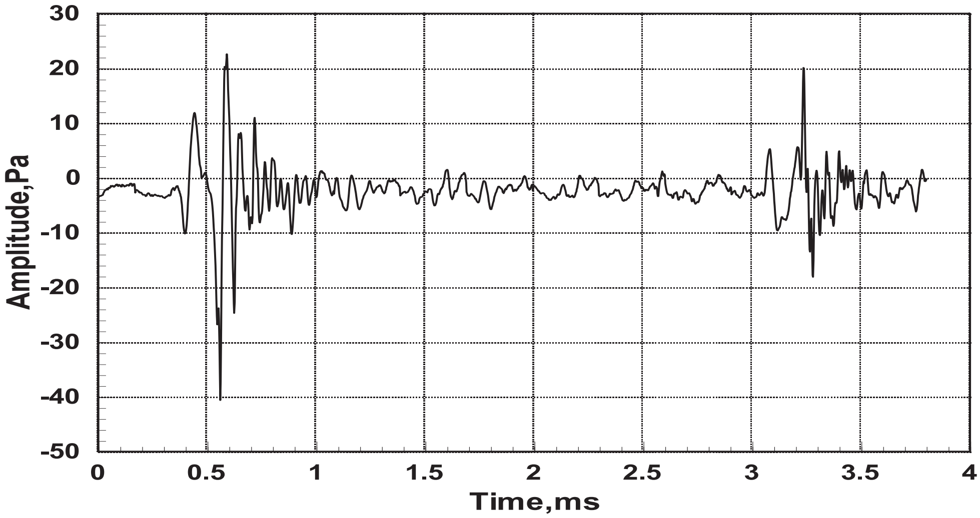

Figure 3 – This is snapping shrimp click recorded with evident echo signal reflected from the water surface. Abscissa - the time in ms, ordinate –sound pressure in Pa. 29.06.2018, 6 h 30 m.

The hydrophone, descended from the pier, was located approximately 2.5 m below the water surface. The seafloor at this site was sandy and silty. Its surface at a depth of 4 m was relatively flat. The delay between the emitted signal and the echo indicated that the sound was emitted approximately 3m from a point of the bottom just below the suspended hydrophone.

2.3 Karadag scientific station

In the T.I.Vyazemsky Karadag scientific station (Nature Reserve of the RAS) (44.911N; 35.202E) we recorded bioacoustic signals using the TC4014-5 hydrophone (RESON, 480 kHz resonance region), equipped with a miniature preamplifier located on the ceramic sensor. The frequency band of the amplification path was 1 MHz, and the quantization frequency was 5 MHz (14 bits). The analog to digital converter E20-10 has a low pass filter of 1.25 MHz and allow us to record of any digital information to a computer via the USB channel.

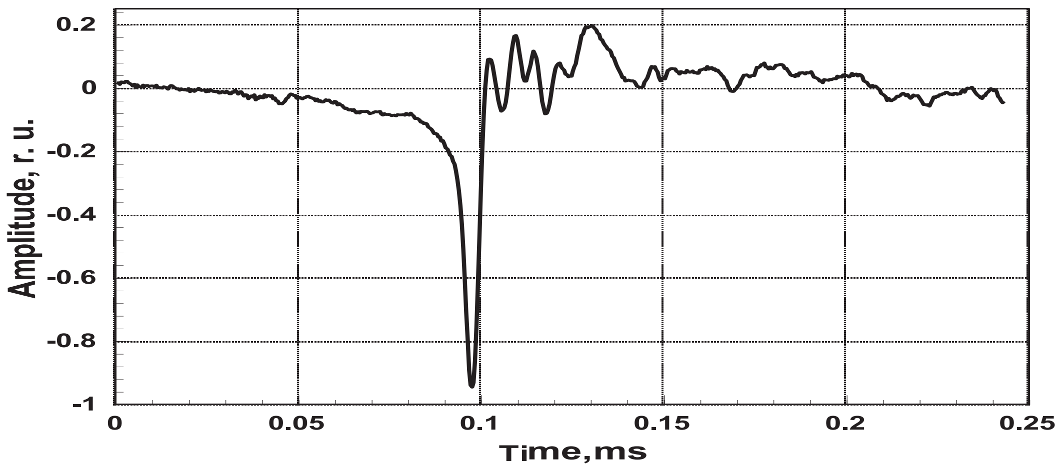

Figure 4 – This is a snapping shrimp click waveform recorded by a high frequency hydrophone. Abscissa - the time in ms, ordinate – sound pressure in relative units.

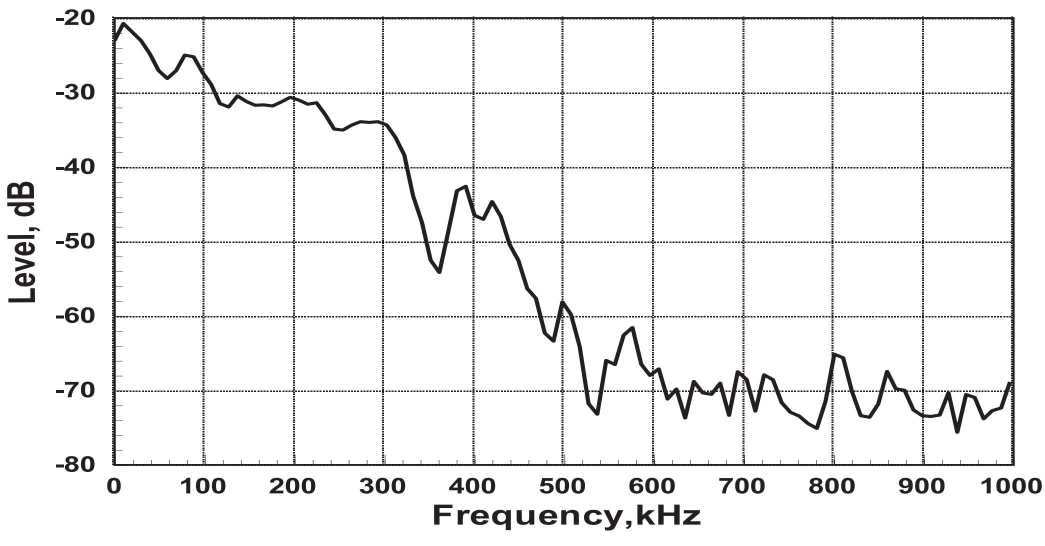

Figure 5 – Spectrum of the snapping shrimp click recorded by high frequency hydrophone. Abscissa - the frequency in kHz, ordinate – spectral level in dB in relative units.

At the site where snapping shrimp clicks were recorded, the seafloor was relatively flat and covered with sand, stones, and algae. The hydrophone was placed less than one meter from the surface and three meters above the seafloor. At this location only a few individual clicks were recorded.

The recorded clicks were very short with very high amplitude. Unfortunately we were unable to measure its value in Pa, due to the lack of accurate gain calibration. The duration of the click was less than 10 mks (fig. 4). We estimated the spectrum of this signal. We found that the upper limit of a fairly high spectral power of the click reached 300 kHz (see fig. 5).

3. DISCUSSION AND CONCLUSIONS

The activity of snapping shrimps in temperate waters of the northern hemisphere differs significantly from their activity in tropical waters. In more habitual and long ago mastered places (tropical waters of Australia, Asia and America) individual pulses of animals belonging to different species often overlap. They also mix with other bioacoustical signals (5, 6). Snapping shrimps have began to inhabit the Black Sea relatively recently. At all points where we performed our recordings, high-amplitude single pulses were emitted with a comparatively low rate (less than once per second). According to (7) and our preliminary observations, only one species of snapping shrimp (*Alpheus dentipes*) lives in the Mediterranean basin and in particular in the Black Sea at present. This is confirmed by the fundamental similarity of the shape of clicks recorded at different points.

Other bioacoustical sounds were recorded very rarely. Almost the only sound events that could be confused with shrimp clicks were echolocation pulses of dolphins. However, upon careful offline examination of the recordings, these signals were excluded based on the lack of a lower-frequency precursor. In addition, dolphin's echolocation pulses were almost always emitted in series with small interpulse intervals.

Regarding the spectral parameters of the emitted clicks, they are determined primarily by the characteristics of the recording system and, to a lesser extent, by the distance from the emitting source to the registration site. Interestingly, higher frequency hydrophones yelding recorded higher-frequency clicks, we found, suggesting that data obtained with using low frequency hydrophones significantly underestimate the complexity of click's spectrums. Under favorable conditions (see Figure 5), the high-frequency edge of the click spectrum reached 300 kHz.

The presence in many cases of a pronounced inverted echo signal from the surface of the water allowed us to determine the distance from the transmitter to the recording hydrophone. Using the records from several hydrophones located in different sites on the seafloor it is possible to achieve a strict localization of the emitter. Such techniques allow both an investigation of the behavior of individual animals, and monitoring of small shrimp populations *in situ*. Obviously, such monitoring could be productive both for assessing population dynamics and for identifying environmental factors, including anthropogenic influences that may affect the shelf ecology.

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