Sensory Abilities of Cetaceans

Laboratory and Field Evidence

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PURPOSEFUL CHANGES IN THE STRUCTURE OF ECHOLOCATION PULSES IN <u>TURSIOPS TRUNCATUS</u>

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In echolocation of obstacles and fish, dolphins normally rely on stereotyped pulses (Romanenko, 1974; Belkovitch and Dubrovsky, 1976). These pulses consist of 1-1.5 waves and their shape and frequency spectra are resistant to environmental changes. Even a considerable increase in the noise level in the ambient environment by means of sources distant from the dolphin causes no noticeable changes in pulse shape and frequency spectra.

Nevertheless, there are grounds to believe that a dolphin can manipulate the emitted pulse shape and frequency spectra in case noise sources are located in the immediate vicinity of the organ of hearing. To test this hypothesis, special experiments were carried-out; during these experiments intensive noise was generated alternately in the immediate vicinity of the sites on the dolphin's head of the possible reception of acoustic information (meatus acusticus externus, mandible and melon) (Romanenko, 1978). The noise level at these sites in OK frequency range made-up 120+6dB in re 0.02 mPa. The noise spectrum was constant in the frequency range from 5 to 30 kHz and it dropped by 6 - 7 dB per octave at higher frequencies. Two, 30 - mm diameter spheres of piezoelectric ceramics served as noise sources; they were fixed alternately with rubber suckers at the above mentioned sites (one sphere at each acoustic duct, on the right and left side of the mandible and both spheres near each other on the melon); they were fed by the same noise generator.

Echolocation pulses were received by miniaturized hydrophones, one of which was fixed on the anterior part of the melon (Fig 1), the second on the right or left side of the melon at equal distance between the first hydrophone and the blowhole. A third hydrophone was placed near one of the noise sources to monitor the noise level. Figure 1 shows a scheme of hydrophones and noise sources disposition. These are hydrophones: number one, two and three and noise sources: number one and two, which are placed near the acoustic duct.

The echolocation pulses were registered by a three-channel tape recorder, fixed on the dorsal fin of a dolphin together with a noise generator, a radiotelemetric system to turn on all the equipment. A light indicator made it possible to observe dolphin's movement in complete darkness. (The method of receiving the pulses on a dolphin's head was first proposed by Dierks and others, 1971).

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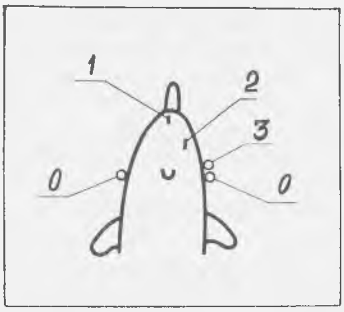

Fig.1. A scheme of noise sources (0) and hydrophones (1-3) positions.

The experiments were performed in a pool measuring 12.5 x 6 x 1.2 (depth). Initially the dolphin was placed at the starting position at one side of the pool. A fish was dipped with a splash on the opposite side of the pool. The fish was attached to a cotton thread and was moved noiselessly 2.5 - 3 m sideways. When hearing the splash, the dolphin would start to swim towards the fish, emitting echolocation pulses. A noise generator was switched on by radio when the dolphin was half way to the fish. The dolphin went on moving, echolocating to invariably locate the fish.

The dolphin's response to the switching-on of the noise generator in two ways: firstly: visual observation of changes of the luminous indicator trajectory, and secondly: by changes in echolocation activity.

When noise sources were placed near the external auditory meatus, a clear moving response was observed as indicated by a change of luminous trajectory. The dolphin gave a start when the noise generator was switched-on. Sometimes such experiments were carried-out in broad day light and one could clearly see that dolphin sharply moved his head when hearing the noise, trying to escape it, but soon calmed down.

When noise sources were placed near mandible and melon no moving activity changes were detected.

Analysis of the tape with the recorded signals showed the following: when noise sources were placed near the external auditory meatus, the echolocation pulses, which were received by all the hydrophones, were of stereotyped nature before exposure to noise (Fig.2, the first and the second pulse). After switching on the noise generator, the hydrophone

Fig.2. The stereotyped (1 and 2) and oscillatory (3) pulses.

fixed on the anterior part of the melon, received pulses of the same amplitude as the ones before the noise was generated, but they were oscillatory, with 4 - 5 periods, and displayed a higher-frequency, narrow spectra (Fig. 2, the third pulse). Transition from stereotyped pulses to oscillatory pulses took 200 - 300 ms. The second hydrophone received mostly stereotyped pulses with a 2.5 to 3 - fold amplitude. Occasionally, alongside with the stereotyped pulses, it recorded oscillatory pulses which were somewhat shifted in relation to the stereotyped pulses. The hydrophone, fixed near the external auditory meatus received emitted pulses as well as those reflected from the pool bottom, the water surface and the fish. The direct pulse, as well as those reflected from the pool bottom and water surface, were invariably stereotyped. By contrast, the pulses reflected from the fish were stereotyped prior to noise generation and became oscillatory when the noise started. In the case when noise sources were fixed on the mandible and melon no changes were recorded in the echolocation pulses after noise generator was started.

There is one other interesting fact. The pulses erradiated by dolphins when the noise generator is on, sometimes have a so called "forerunner" mentioned earlier by Zaslavsky (1974) and Dubrovsky (1975). We call "forerunners" pulses preceding each echolocation pulse. The intensity of "forerunner" changes in wide ranges and sometimes can run-up-to the intensity of the main pulse: the pulse becomes double. Nevertheless, the duration of a "forerunner" remains shorter than the main pulse.

The results of our experiments suggest that: (1) the dolphin probably can change the echolocation pulses spectra as the main means of overcoming the wide-range noise. (2) Stereotyped and oscillatory pulses can be emitted by different sources. (3) The acoustic information enters the internal parts of auditory system via the external acoustical meatus.

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