DETECTION OF TONE GLIDES BY THE BELUGA WHALE

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INTRODUCTION

Bullock et al. (1962), working with four species of delphinids, found that frequency-modulated (FM) pulses of 2-5 msec duration sometimes produced large electrophysiological responses compared to continuous frequency (CF) pulses in the same frequency range. They also found that in some cases an FM pulse swept upward in frequency was 10 dB more effective than a down swept-pulse and vice versa. The audibility of frequency swept pulses has been studied with human subjects without finding such dramatic results (Cullen and Collins, 1982, Van Bergeijk, 1964 and Nabelek, 1976). To study detection thresholds for tone glides in the beluga whale three types of tone pulses were used: continuous frequency (CF) tones, linear frequency modulated (LFM) tones, and linear period modulated (LPM) tones. These three pulse types can be expressed mathematically as follows (Kroszczynski, 1969).

\[ s(t) = A \sin(p), \]

\[ p = 2\pi f_0 t, \] for a CF tone,

\[ p = 2\pi (f_0 t + (a/2)t^2), \] for an LFM tone and

\[ p = (2\pi /b)(\ln(1 + (b/T_0)t)), \] for a LPM tone. In Eq. 3 "a" and in Eq. 4 "b" is the rate at which the frequency is swept, \( f_0 \) is the instantaneous frequency at the start of the sweep and \( T_0 \) is the instantaneous period \( (1/f_0) \) at the start of the sweep and \( \ln \) means the natural logarithm. The instantaneous frequency
Fig. 1. Energy spectra of the three types of pulses used. A, B and C refer to CF, LPM and LFM pulses, respectively. The upper, middle and lower plots are for pulse durations of 0.025 msec, 0.2 msec and 0.8 msec.