IR NO. 69-14

INFORMAL REPORT

SPERM WHALE ACOUSTIC CHARACTERISTIC MEASUREMENTS FROM THE ASWEPS AIRCRAFT

JANUARY 1969

INFORMAL REPORT

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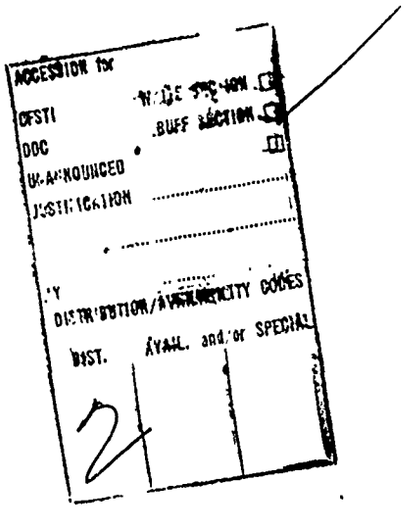

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ABSTRACT

Target strengths of a target believed to be a sperm whale, Physeter catodon, were measured. Source level measurements of echolocation clicks are presented together with sonograms and descriptions of three different types of sounds recorded.

LT. J. LAWRENCE DUNN

Acoustical Oceanography Branch
Exploratory Oceanography Division
Research and Development Department

APPROVED FOR RELEASE: R. A. Winokur
Acting Director
Exploratory Oceanography Division

DATE: 31 January 1969

ACKNOWLEDGEMENTS

The author is grateful to E. E. Davis who provided the data tape and to P. J. Perkins of the Narragansett Marine Laboratory and W. E. Evans of the Naval Undersea Warfare Center who provided helpful suggestions during the preparation of this report.

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INTRODUCTION

A continuing effort of the Acoustical Oceanography Branch of the Naval Oceanographic Office's Research and Development Department has been the acquisition of acoustic characteristics of marine organisms suspected of being false sonar targets. During the course of routine airborne volume reverberation measurements south of Bermuda (31°N 65°W) in December of 1968, NAVOCEANO personnel recorded sounds and echoes from an unseen target identified by its sounds as a solitary sperm whale (Physeter catodon).

MEASUREMENT TECHNIQUES

The measurement techniques employed have been explained in detail by Davis (1968). Briefly they are as follows: A modified AN/SSQ-41A sonobuoy is dropped from the aircraft at the desired location; upon striking the water the sonobuoy's hydrophone sinks to a depth of 60 feet and the radio transmitter section of the buoy transmits to the aircraft the waterborne sounds picked up by the hydrophone. On board the aircraft the sonobuoy's transmissions are received on an AN/ARR-52 receiver and recorded on a Lockheed 7 channel tape recorder. Periodic calibration pulses from the buoy permit the recording of absolute levels. After recording the ambient noise for several minutes the aircraft then returns over the sonobuoy and drops a MK 61 SUS charge (1.8 pounds of TNT). The explosion of this charge insonifies the water column and the resultant volume reverberation is recorded. Echoes of individual targets possessing sufficient target strength can be heard above the noise and reverberation level. Ordinarily three SUS charge drops are made.

RESULTS

1. Target Strength

Figure 1 is a one-third octave, 1 kHz center frequency, Sanborn grapnic recording of a bomb drop sequence. Spike A is a sperm whale echolocation click and Spike B is believed to be the echo from the whale. The range to this echo is 3070 yards. On the two successive drops, 5 and 10 minutes later, similar echoes were present at 3280 yards and 3210 yards, respectively. The SUS charges are usually dropped within 100 yards of the sonobuoy and for purposes of these calculations the distance between the sonobuoy hydrophone and exploding SUS charge is ignored.

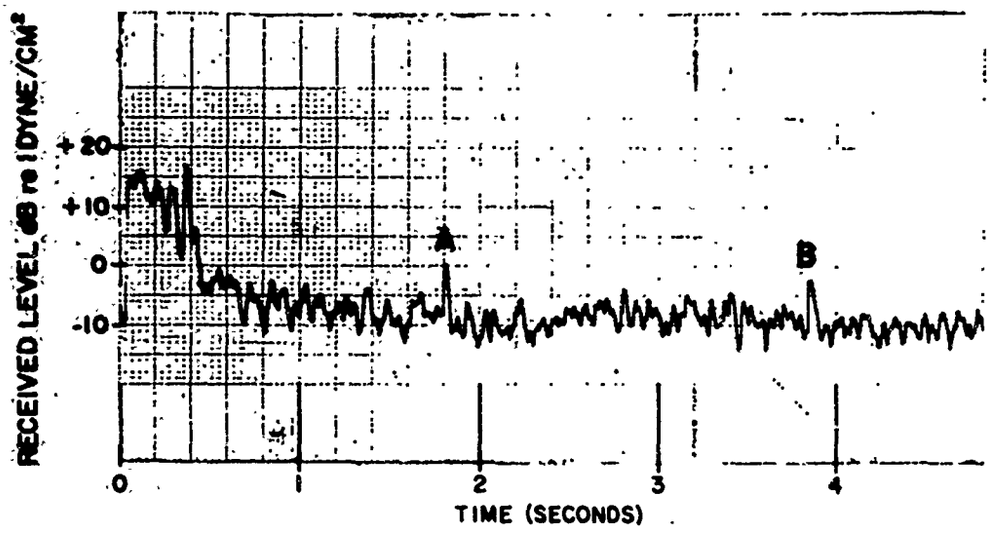

FIGURE 1. TYPICAL EXPLOSIVE SEQUENCE

Using the equation:

$$E = SL - 40 \log R - 2 \alpha R + TS,$$

where: E = Corrected Echo Level,

SL = Source Level of SUS charge (144 dB re 1 dyne/cm^2 @1 kHz),

R = Range from hydrophone to target,

TS = Target Strength of target, and

α = Attentuation Coefficient [Thorp (1967)],

the 1-kHz target strengths of the echoes recorded on each of the three SUS charge drops are -6.0 dB, -7.2 dB, and -6.6 dB re 1 dyne/cm^2. If these are bow aspect target strengths beam aspect target strengths might be expected to be of the order 0 to + 10 dB.

2. Source Level

Three different types of sounds were recorded, the most prevalent of which was the characteristic echolocation click reported by Perkins, Fish and Mowbray (1966), Backus and Schevill (1966), and others.

Using the equation:

$$S = SL - 20 \log R - \alpha R,$$

where: S = Corrected Signal Level of sperm whale click,

SL = Source Level of sperm whale click, and

R = Range from hydrophone to whale (for this calculation R is assumed to be 3150 yards).

the average source level for 148 echolocation clicks in the one-third octave 1 kHz band is 73.9 dB with a standard deviation of 3.51 dB re 1 dyne/cm^2. This figure is considerably higher than that reported by Corcella and Green (1968). Even if the assumed range to the whale were considered to be 100 yards the source level would be 45 dB, 10 dB higher than the level reported by Corcella and Green.

Little is known of the directionality of the echolocation clicks of sperm whales, however, studies by Norris et al. (1961) indicate that the Atlantic Bottlenose Dolphin, Tursiops truncatus, a smaller relative of the sperm whale, almost certainly utilizes directional sound transmission when echolocating. In addition, Norris and his colleagues postulate that the site of directional sound transmission in Tursiops is located in the upper jaw and in the melon, thus allowing excellent echolocation forward and above the jaw line. It is probable that the whale in question was oriented towards the sonobuoy thus transmitting maximum energy in that direction, whereas the whales producing the clicks studied by Corcella and Green may not have been oriented towards the bottom mounted hydrophone.

ANALYSIS OF SOUNDS

Figures 2, 3, and 4 are sonograms produced on a Kay Electric Sonograph, Sound Spectrum Analyzer, Model 7029A. Figure 2 shows a typical series of echolocation clicks. The intensity increase around 3 kHz is characteristic of sperm whale clicks. The decrease in intensity above 4 kHz is due to a combination of factors, not the least of which is the fact that the present sonobuoy system frequency response falls off rapidly above 4 kHz.

Figure 3 is the sonogram of a sound quite similar to the so-called "hyena" sound of Tursiops. No other Tursiops like sounds were recorded and Tursiops has never been reported in this deep mid-ocean area. No definite identification of the source can be made; however, the possibility that the sound was emitted by the sperm whale cannot be overlooked even though such a sound has not previously been reported from large Odontocetes. If in fact the sound originated from the sperm whale its source level in the 1 kHz one-third octave band is approximately 74 dB re 1 dyne/cm^2, strikingly close to the average level of the echolocation clicks in the same band.

Figure 4 shows a rapid repetition of echolocation clicks. These clicks were produced 280 milliseconds after the sound from the number 2 explosion was calculated to have reached the whale. This amount of time is within the range of normal acoustic response reaction times of cetaceans (W. Evans personal communication).

SUMMARY

Analysis of echoes believed to be those of a sperm whale shows 1 kHz target strengths of -6.0, -7.2, and -6.6 dB. The source levels of 148 echolocation clicks ranged from 66.6 to 83.6 dB with an average of 73.9 re 1 dyne/cm^2.

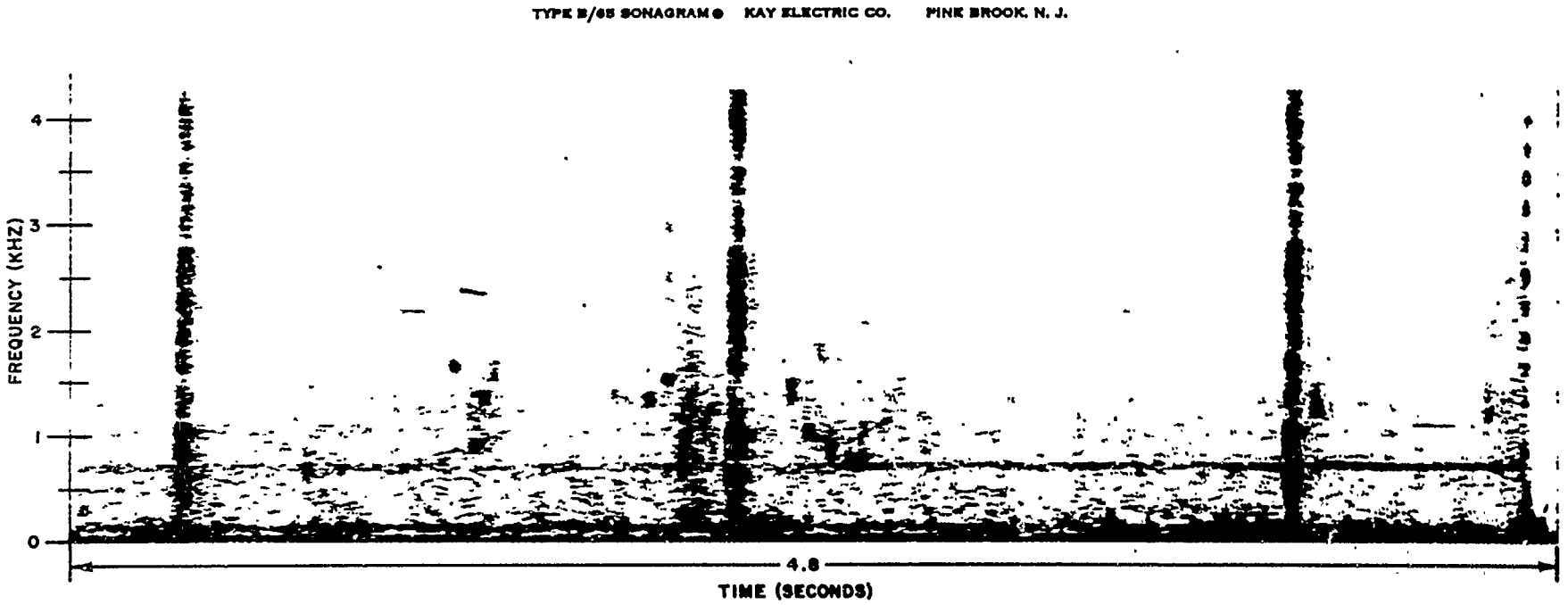

FIGURE 2. SPERM WHALE ECHOLOCATION CLICKS

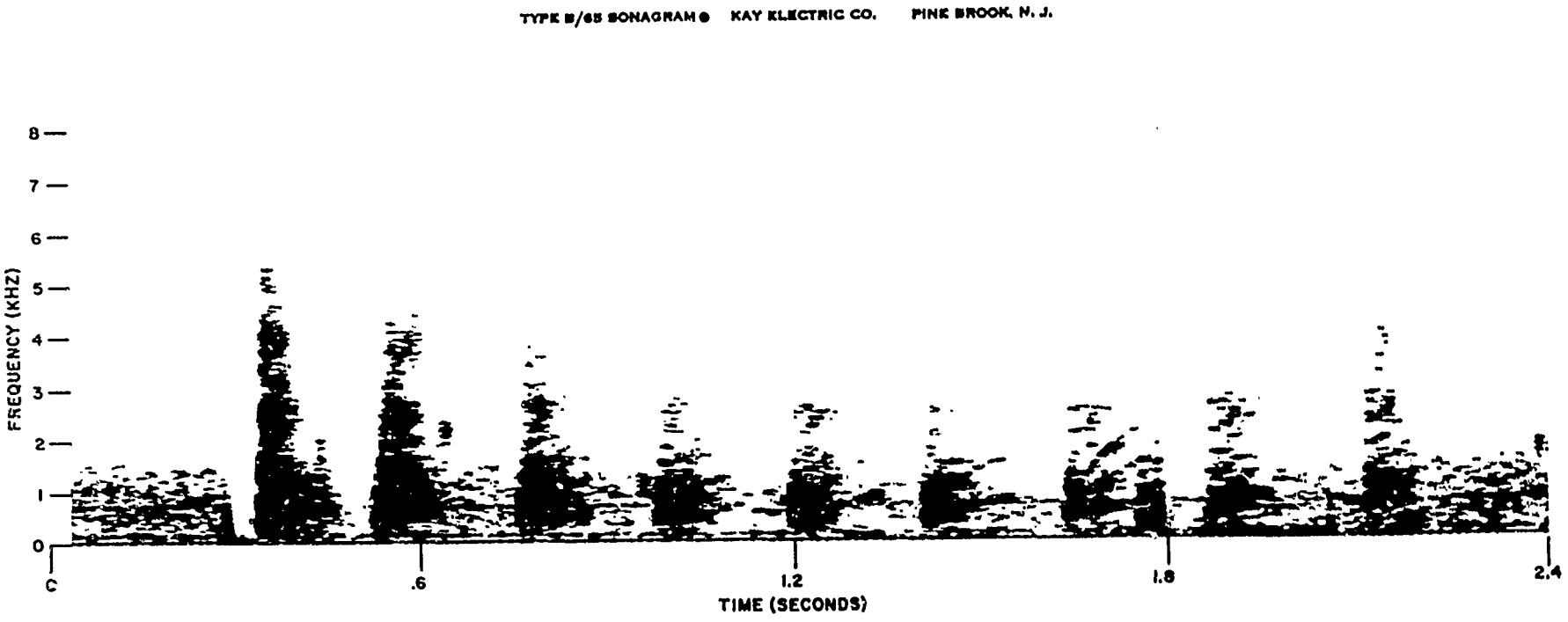

FIGURE 3. SOUND OF INDETERMINATE ORIGIN

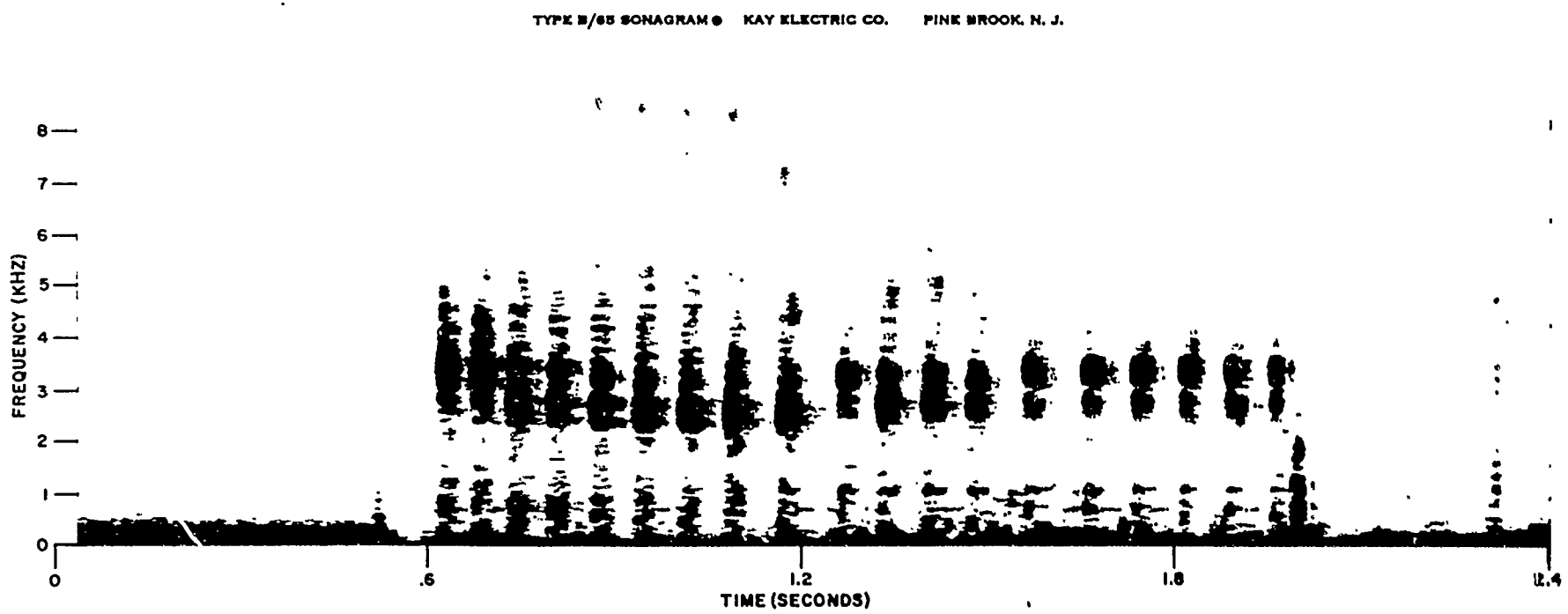

FIGURE 4. RAPID BURST OF ECHOLOCATION CLICKS

Directionality of sound emission from the sperm whale is proposed as a possible explanation for the large difference in source levels reported by this author, and those levels previously reported by Corcella and Green. Two additional sounds were recorded; a rapid series of clicks following the detonation of charge 2 and sounds similar to the "hyena" sound of Tursiops.

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. NAVAL OCEANOGRAPHIC OFFICE	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

SPERM WHALE ACOUSTIC CHARACTERISTIC MEASUREMENTS FROM THE ASWEPS AIRCRAFT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Informal Report

5. AUTHOR(S) (First name, middle initial, last name)

Lt. J. Lawrence Dunn

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1969	12	6

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. HF 05-552-301	IR NO. 69-14
c. 709-FD-FCR	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
SPERM WHALE ACOUSTIC CHARACTERISTIC MEASUREMENTS FROM THE ASWEPS AIRCRAFT						