Sounds produced by individual white whales, *Delphinapterus leucas*, from Svalbard during capture (L)

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Recordings were made of the sounds produced by white whales during capture events in Storfjorden, Svalbard, in the late autumn. Only four of eight captured individuals produced sounds. Four subadults, one female and three males, between 330 and 375 cm long, did not produce sounds during handling. The four animals that produced sounds were as follows: a female subadult of 280 cm produced repetitive broadband clicks; a solitary calf produced harmonic sounds, which we suggest may serve as mother–calf ''contact calls,'' and a mother–calf pair were the two animals that produced the most sounds in the study. The mother produced ''crooning'' broadband clicks and frequently moved her head toward her calf while producing underwater sounds. The calf produced three types of frequency-modulated sounds interspersed within broadband click trains. No sounds were heard from any of the animals once they were free-swimming, or during *ad lib* recording sessions in the study area, even though groups of white whales were sighted on several occasions away from the capture net. [DOI: 10.1121/1.1528931]

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I. INTRODUCTION

White whales, *Delphinapterus leucas*, produce a wide range of variable underwater sounds (e.g., Sjare and Smith, 1986a, b; Bel'kovich and Sh'ekotov, 1992, 1993). These sounds have been shown to vary according to behavioral context (e.g., Sjare and Smith, 1986a, b; Bel'kovich and Sh'ekotov, 1992, 1993); a variety of studies have linked individual signals with specific behaviors and group contexts (Morgan, 1979; Bel'kovich and Sh'ekotov, 1992, 1993). However, few studies have studied the sounds produced by individual whales (e.g., Au and Nachtigall, 1997). Given the complexity of white whale sounds, further investigations of this kind are necessary to improve our understanding of sound usage in this species. White whales are thought to alter their calling behavior in response to the presence of vessels (Finley *et al.*, 1990; Lesage *et al.*, 1999) and a variety of cetacean species have been shown to produce ''contact calls'' during stressful situations (Caldwell *et al.*, 1990). The aim of this study was to investigate the sounds produced by individual white whales during capture.

II. METHODS

This study was carried out between 17 and 23 October 2001 at Wichebukta in Storfjorden (78°31′N, 18°55′E), eastern Spitsbergen. White whales were captured using a net set from the beach and the sex and age of all individuals were determined [see Lydersen *et al.* (2001) for more details]. The whales were captured for the purpose of deploying satellite transmitters. During the handling process continuous recordings were made of the sounds of each captured whale. A hydrophone was placed 0.5 m deep in the water in front of the head of each individual and recordings were made of any sounds that were produced during handling and upon release. Recordings of the sounds were made using a High Tech Inc. hydrophone (model HTI-96-MIN, sensitivity: −170 dB, flat frequency response: 5 Hz to 30 kHz; add ±1.0 dB) and a digital audio tape recorder, Sony TCD-D8 (frequency response 5 Hz to 22 kHz ±1.0 dB). The recordings were digitized and displayed as spectrograms (fast Fourier transforms, dt: 10 ms, df: 102 Hz, FFT size: 512) using the BatSound analysis PC software program (Pettersson Elektronik A.B., 1996).

Sounds were divided into two broad categories, broadband clicks and narrow-band frequency-modulated sounds. Frequency-modulated sound types were defined according to variations in their spectral contours. Only high-quality records, where all sound contours were distinctly measurable on the spectrograms, were used for these analyses. Two sound parameters were measured for burst pulses and narrow-band frequency modulated sounds: (1) total duration (s) and (2) frequency with the greatest energy, Fmax (kHz). For broadband clicks four measurements were made: (1) the duration of the click train (s); (2) the interclick interval ICI (s), (3) number of clicks per seconds, and (4) the interval between one click train and the next, BCI (s). Measurements were restricted by the upper limit (22 kHz) of the recording equipment.

Ad lib recordings were made each day during the study period, from a zodiac that was adrift several hundred meters offshore in the bay in which the net was set.

III. RESULTS

Eight whales were captured during the study period: five were subadults, one mother–calf pair was captured, and one solitary calf. Four of the five subadults (one female and three males) did not produce any sounds. These animals were all

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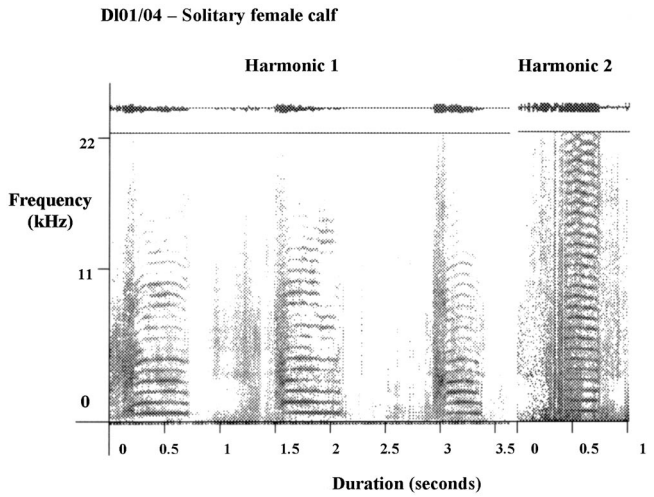

FIG. 1. Spectrograms of the harmonic sounds 1 and 2 produced by the solitary female calf (fast Fourier transforms, dt: 10 ms, df: 102 Hz, FFT size: 512). The gaps in the time scale on the x axis represent the start and end of each spectrogram.

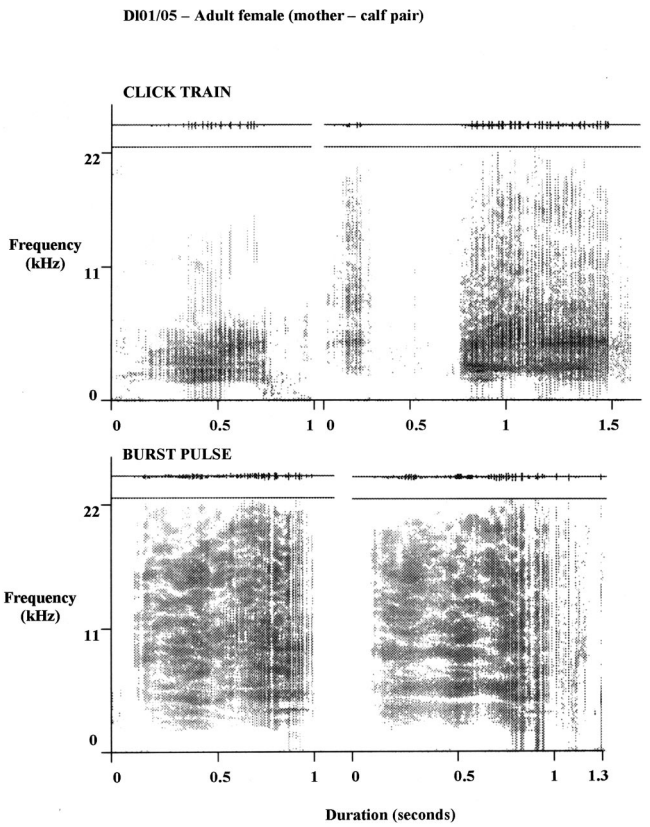

FIG. 2. Spectrograms of the broadband clicks and burst pulsed sounds produced by the adult female from the mother–calf pair (fast Fourier transforms, dt: 10 ms, df: 102 Hz, FFT size: 512). The gaps in the time scale on the x axis represent the start and end of each spectrogram.

more than 320 cm in length. A mother–calf pair, a solitary calf and, a subadult that was 280 cm long each produced sounds. All of these whales were females.

Sounds produced by the solitary calf were distinct from all other sounds recorded in this study, in that they contained frequency-modulated calls. There were two distinct sounds, harmonic 1 and 2 (Fig. 1). The calf produced sounds for 66% of the handling time ($n=24$ min). Harmonic 1 ($n=108$) had a mean duration of 0.7 ± 0.01 SE s, with a mean Fmax of 3.3 ± 0.07 SE kHz. Harmonic 2 ($n=39$) had a mean duration of 0.4 ± 0.01 SE and a mean Fmax of 1.5 ± 0.2 SE. During production of this sound air was expelled by the calf through its blowhole.

The mother–calf pair were kept in close contact with one another throughout their handling time. The mother produced sounds 79% of the time and the calf produced sounds 43% of the time ($n=35$ min). The sounds produced by the mother were composed of repetitive click trains that varied greatly in duration (mean 1.9 ± 1.3 SE s, $n=339$) (Fig. 2). ICI varied from 0.46 to 0.012 s in duration with a mean of 27 clicks produced per second ($n=241$). The mean BCI was 1.5 ± 1.1 SE s ($n=235$). The click trains produced by the mother had a distinct audible ''crooning'' sound. The female frequently moved her head toward the calf while producing underwater sounds. The calf from the mother–calf pair produced click trains ($n=206$) and occasional frequency-modulated sounds within the click trains ($n=32$) (Fig. 3). The calf's click trains had a mean duration of 0.6 ± 0.5 SE s. ICI varied from 0.5 to 0.09 s in duration, with a mean of 18 clicks per second. The mean BCI was 6.5 ± 1.3 SE s ($n=153$). This calf produced three types of frequency-modulated sounds, all of which occurred with either one or no harmonics (Fig. 3): a flat contour ($n=18$), an upsweep ($n=9$), and a variable contour ($n=5$). The mean duration of the flat contour whistle was 0.4 ± 0.05 SE s, with the mean frequency of the first harmonic at 7.6 ± 0.3 SE kHz and the second harmonic of 15.1 ± 0.1 SE kHz. Upsweep whistles were 0.3 ± 0.03 SE s in duration and 7.9 ± 0.02 SE kHz in the first harmonic and 15.0 ± 0.08 SE kHz in the second harmonic. Variable contour whistles were considerably longer in duration (mean of 1.2 ± 0.9 SE s), but had a comparable Fmax of 7.7 ± 0.3 SE kHz in the first harmonic and 15.1 ± 0.3 SE kHz in the second harmonic. The subadult female produced only click trains (Fig. 4). A total of 37 min were recorded for this animal, during which the subadult produced sounds 28% of the time. The click trains had a mean duration of 0.3 ± 0.08 SE s ($n=89$). ICI varied from 0.41 to 0.03 s in duration with a mean of 22 clicks per second. The mean BCI was 11.5 ± 2.7 SE s ($n=153$).

A total of 7 h of *ad lib* recordings were made from a drifting zodiac. Even though whales passed close to the boat on several occasions, no white whales sounds were recorded from any free-swimming individuals.

IV. DISCUSSION

This study has shown that individual white whales produce a variety of different sounds during a similar, stressful situation. Surprisingly, subadults of more than 320 cm in length did not produce any sounds under 22 kHz, while being held in a net and manipulated. Although it is possible that subadults produced ultrasonic sounds, during this and in other studies, the majority of sounds produced by white whales have either a part or the whole component that occurs below 22 kHz (e.g., Sjare and Smith, 1986a, b; Bel'kovich and Sh'ekotov, 1992, 1993). Among the subadults that did

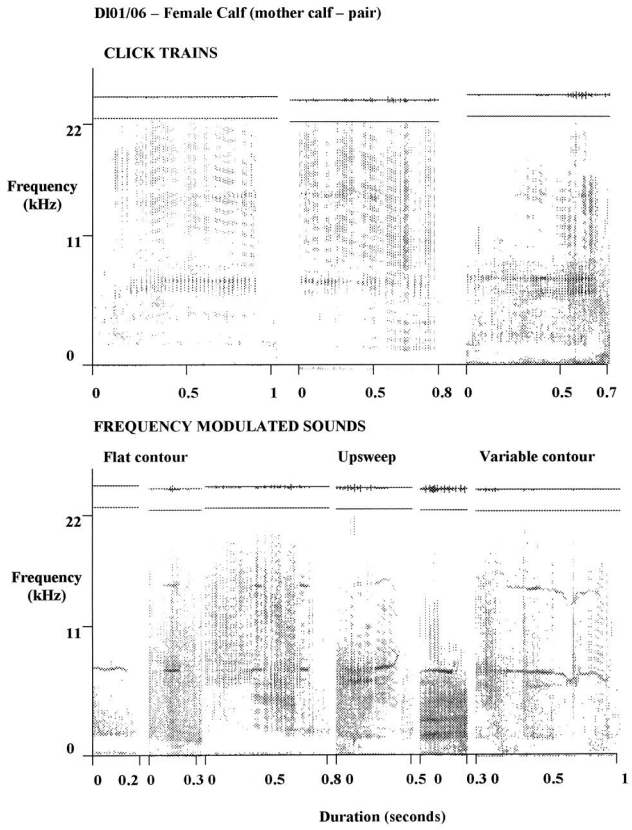

FIG. 3. Spectrograms of the broadband clicks and the flat, upsweep and variable contour frequency modulated sounds produced by the female calf from the mother–calf pair (fast Fourier transforms, dt: 10 ms, df: 102 Hz, FFT size: 512). The gaps in the time scale on the x axis represent the start and end of each spectrogram.

not produce sounds, there were one female and three males, therefore it is unlikely that this result is related to variation in sex. It is more likely that it is related to age. The single subadult that did produce sounds was 280 cm in length, suggesting it was between three and four years of age (Heide-Jørgensen and Teilmann, 1994). The sounds that it produced were solely broadband clicks. Click series, as defined by Sjare and Smith (1986a), are used most frequently during ''socially interactive'' or ''alarm situations.'' The click series produced by this individual in this study resembled the broadband clicks observed in Sjare and Smith (1986a).

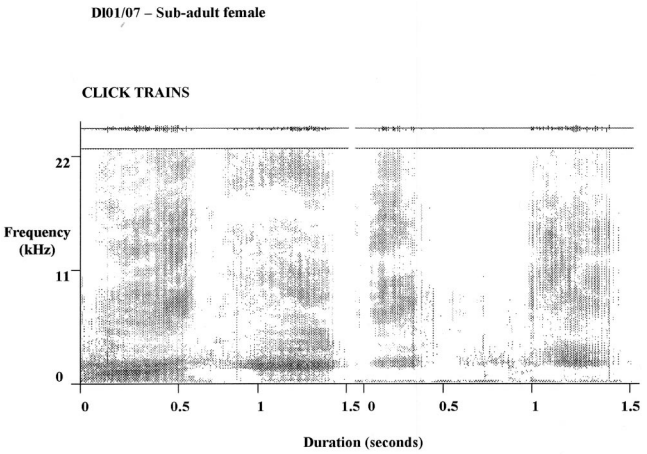

FIG. 4. Spectrograms of the broadband clicks produced by the subadult female (fast Fourier transforms, dt: 10 ms, df: 102 Hz, FFT size: 512). The gaps in the time scale on the x axis represent the start and end of each spectrogram.

The solitary calf produced sounds that were different from those recorded for other individuals. Similar sounds to this harmonic call have been documented in the repertoires of wild ranging white whales (Sjare and Smith, 1986a; Bel'kovich and Sh'ekotov, 1992, 1993). The size of this individual suggests that it was one to two years old and therefore still likely to have been dependent on its mother. Mother–calf whistles are produced in *Tursiops sp.* and have been shown to facilitate reunions between mother–calf pairs (e.g., Smolker *et al.*, 1993). It is possible that the sounds produced by the calf were a mother–calf contact call produced during separation. The adult female of the mother–calf pair produced broadband clicks. The behavior of the mother suggested that these sounds were directed toward her calf. Bel'kovich and Sh'ekotov (1992) show spectrographs of sounds produced by mother–calf pairs, some of which resemble those produced in this study. However, the sounds used by the mother–calf pair in this study differ significantly from the whistles reported in many delphinid mother–calf contact behaviors (Smolker *et al.*, 1993).

The fact that only young animals and members of a mother–calf pair produced sounds during capture suggests that previously described ''alarm calls'' (Finley *et al.*, 1990; Lesage *et al.*, 1999) may actually be contact calls between mothers and dependent young. No sounds were recorded from free-swimming whales, although groups were sighted in the area where boats were operating. Additionally, no sounds were produced from males or large juveniles that were captured, presumably in a ''stressful'' situation. Unlike many delphinid species (Caldwell *et al.*, 1990), the white whales in this study did not produce a standard ''contact call.'' The sounds produced by individual animals during handling were variable, but the age/status of animals emitting calls and their structure suggest that it is likely that they all served as ''contact calls.''

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