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A Note on Clicks Recorded from Free-Ranging Indo-Pacific Humpback Dolphins, *Sousa chinensis*

John C. Goold[1] and Thomas A. Jefferson[2]

[1]*Institute of Environmental Science, University of Wales Bangor, Robinson Building, Deiniol Road, Bangor, Gwynedd. LL57 2UW UK*
[2]*Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA Fisheries, 8604 La Jolla Shores Drive, La Jolla, CA 92037 USA*

Abstract

Opportunistic recordings of Indo-Pacific humpback dolphin clicks were made from a group of approximately ten humpback dolphins in the waters off Lantau Island, Hong Kong. Clicks were typically delphinid in waveshape, especially the click onsets, with spectral energy extending up to at least 200 kHz. Pulse durations were a few tens of microseconds. There appeared to be bimodality in the click spectra, an observation consistent with the hypothesis of asymmetric phonating lips. Due to the opportunistic nature of the recordings and the uncontrolled recording conditions, click waveforms captured here are unlikely to be representative of on-axis signals, so the spectrum of the recorded signals may differ from those that would be recorded directly in front of the animals.

Key Words: Acoustics, behavior, echolocation, Hong Kong, Indo-Pacific humpback dolphin, *Sousa chinensis*

Introduction

Humpback dolphins (*Sousa chinensis*) occur in coastal waters throughout much of southern Asia, northern Australia, and eastern Africa (Jefferson & Karczmarski, 2001). This species tends to occur in shallow, nearshore waters, particularly around the mouths of large rivers. In Hong Kong, these dolphins are concentrated in the waters north of Lantau Island, in the estuary of the Pearl River (Jefferson, 2000).

A number of papers have described the sounds of humpback dolphins (Schultz & Corkeron, 1994; Van Parijs & Corkeron, 2001a, 2001b; Zbinden et al., 1977), although these works have been restricted to human audio, or at best low ultrasonic, recordings. Potential ultrasonic components of humpback dolphin clicks, therefore, have not been reported. Ultrasonic recording in the field can be quite challenging and requires the use of either high speed tape recording or high speed digital sampling. The latter, in particular, is now becoming more accessible due to advances in computer hardware. We report here on opportunistic high speed digital recording of humpack dolphin clicks made in the waters north of Lantau Island, Hong Kong.

Materials and Methods

Data Collection

A group of approximately ten Indo-Pacific humpback dolphins was encountered during a line-transect survey north of Lantau Island, Hong Kong, on 24 March 2000. During this particular survey, a towed hydrophone with a broad bandwidth recording system was used as part of a data collection exercise for the finless porpoise project (Goold & Jefferson, 2002). Since the hydrophone was deployed and active, the encounter was taken as an opportunity to record a small sample of echolocation clicks from the humpback dolphins. The survey vessel idled at low speed while the dolphins circled in the vicinity. The dolphin behavior was primarily slow and wide circling; their precise activity was indeterminate. The hydrophone output was monitored through headphones during this time to determine when dolphin sounds were present. Clicks were the primary dolphin sounds heard, although whistles were also heard.

The hydrophone was an HS150 towed unit, based around a 12.7-mm piezoceramic sphere and 30-dB front-end preamplifier. The unit was towed on 50 m of cable behind the survey vessel—a 17 m chartered ferry. The hydrophone signal was high pass filtered at 30 kHz, to prevent dynamic range saturation from low frequency noise and audio click components, and was sampled at 500 kHz on an *IOTech Wavebook 512*. The sample data from the wavebook were recorded in near real time on the hard disk of a laptop computer. Due to the high sample rate of the recording system, the data had to be buffered into RAM before writing to the hard disk; therefore, sampling was not performed in a long continuous stream. Sampling was performed in 10-sec bursts during bouts of dolphin clicking, as monitored through the headphones. The input signal was not low pass filtered just below the nyquist frequency; therefore, aliasing is possible but unlikely to be significant at these high frequencies.

Data Analysis

Sampled waveform data were imported into MATLAB and inspected for individual clicks. Transients were marked automatically by a cross-threshold scanning routine, and then each auto-marked piece of the waveform data was manually inspected by eye to ascertain (1) that it indeed contained a dolphin click rather than a noise spike and (2) that the click waveform was undistorted during sampling (i.e., not clipped through dynamic range saturation). Due to the proximity of the dolphins to the hydrophone on some occasions, a good many of the click waveforms showed clipping. The markers from the clipped signals were discarded, and only those markers for waveform sections that were clearly unclipped dolphin signals were retained for exploratory analysis.

Given uncertainties about the number of dolphins producing clicks at any given moment in time, inter-click intervals were not measured. Exploratory analysis concentrated on inspection of waveshapes and spectral content of clicks. Click waveforms were extracted and plotted to illustrate the general waveshape. Clicks were analyzed for their spectral content, using a 256 point (512 μs) FFT window that comfortably enveloped the entire signal. Dolphin click spectra were stored in matrices and displayed in waterfall plots.

Results

Figure 1 shows a waveform of a humpback dolphin click. The waveshape is typical of a delphinid, showing a sharp onset, although the decay is fairly extended and suggests reverberation. The total pulse duration is a few tens of microseconds. Spectral energy in the humpback dolphin click spectrum is present from the lower end of the pass band around 30 kHz, to as high as 200 kHz, and in some cases beyond (Figure 2). There is some evidence of spectral rippling in the waterfall cascades of Figure 2, which displays approximately 100 individual click spectra. There is also some evidence of bimodality in the click spectra, as illustrated in the waterfall cascades of Figure 2. Figure 2(a) is particularly suggestive of

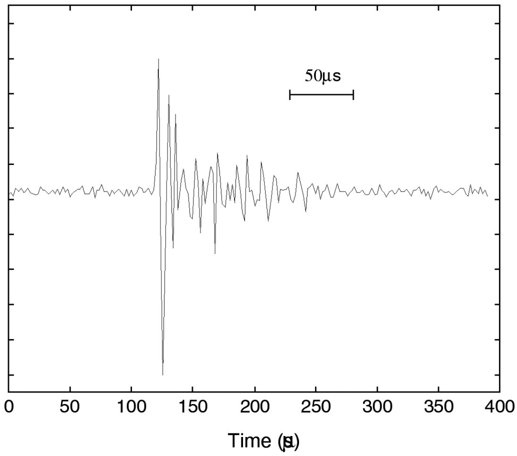

Figure 1. Waveform of a humpback dolphin click, as recorded opportunistically during an encounter in the waters off Lantau Island. Timebase and scale bar are in microseconds.

this, with spectral modes occurring at approximately 100 kHz and 180 kHz, respectively.

Discussion

The type of rapid onset pulse presented here is characteristic of dolphin clicks in general, and it tends to produce a broadband spectral signature. Such clicks contrast with the narrowband signals typically produced by phocoenids (Goold & Jefferson, 2002; Kamminga et al., 1996; Møhl & Anderson, 1973; Verboom & Kastelein, 1995), and even some small delphinids (Dawson, 1988; Evans et al., 1988). It is highly likely that each humpback dolphin click analysed here is a multipath composite (primarily direct path and surface reflection) of the actual click waveform emitted by a dolphin. The transducer of the towed hydrophone would have been close to the water surface (within 5 m), although the precise depth is unknown. Reverberation was clearly present and can be seen in Figure 1. Although reverberation creates extension at the tail end of the click, at the front-end the multipath reflection will overlay an echo of the initial broadband spike of the click, delayed by just a few microseconds behind the direct path onset. This is a sufficiently small delay for both pulses to fall into the same FFT window and induce spectral rippling. This corruption of the recorded click signals, combined with the fact that orientation of the animals with respect to the hydrophone was not known during recording, is an inevitable consequence of the opportunistic and uncontrolled manner of the recordings. The general pattern of spectral bimodality is interest-

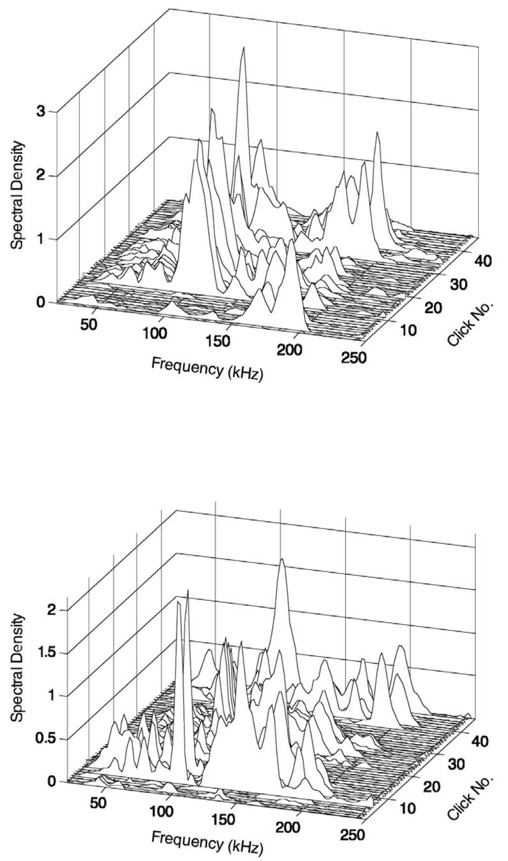

Figure 2. Waterfall plots of two humpback dolphin click series spectra. Spectral density is measured in arbitrary waveform units and is presented on a linear scale.

ing as it fits with the hypothesis of Cranford et al. (1996) regarding sound production from paired, but asymmetric, phonating lips within the nasal complex of delphinids. It would be interesting to work with a larger sample size of clicks, preferably recorded under more controlled conditions, to investigate this aspect further.

Clearly, we are not able to report the idealized click waveform and spectrum of the humpback dolphin click as would be recorded under controlled conditions at a point close to source and on-axis with respect to the dolphins forward transmission beam; however, our data are sufficient to demonstrate that humpback dolphin clicks are at least generally of a typical delphinid form, with broadband energy of up to at least 200 kHz.

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