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Short communication

Postural instability and akinesia in a pantropical spotted dolphin, *Stenella attenuata*, in proximity to operating airguns of a geophysical seismic vessel

Howard Gray[a,*], Koen Van Waerebeek[b]

[a] *School of Biological and Biomedical Sciences, University of Durham, South Road, DH1 3LE, UK*
[b] *Cetacean Conservation Medicine Group, Centro Peruano de Estudios Cetológicos (CEPEC), Museo de Delfines, Lima 20, Peru*

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ABSTRACT

Aberrant behaviour including erratic locomotion was observed in a pantropical spotted dolphin 600 m ahead of an airgun array during 3D seismic explorations off Liberia in March 2009. The dolphin, presumably in acoustic distress, lifted its head and cervical region above the surface in an oblique, strikingly rigid posture during 5 min. Turbulent white-water evidenced a major propulsory thrust. Incremental postural instability and apparent exhaustion progressed to a catatonic-like state of akinesia as the dolphin rolled over onto one side, then its back before sinking virtually motionless close to the airgun array. Unless it recovered full locomotory control, asphyxiation was inevitable. Potential internal injury is discussed, both acoustic-mediated and from extreme exertion (exertional myopathy, rhabdomyolysis and myoglobinuric nephrosis). As behaviour was spatially and temporally closely associated with firing seismic airguns, we suggest a cause–effect relationship. Differential diagnoses of pre-existing morbidity, senescence, or intoxication are considered possible but unlikely.

Introduction

The negative effects of anthropogenic noise on cetaceans are generally well-documented (e.g. Gordon et al. 2003; Nowacek et al. 2007; Stone 2003; Weilgart 2007) and include avoidance behaviour (Goold 1996; Richardson et al. 1995; Stone 2003; Weir 2008), behavioural changes (Bowles et al. 1994; Southall et al., 2007), stress (Bateson 2007; Romano et al. 2004), migration route shifts (Richardson et al. 1999), physiological or auditory damage (Gordon et al. 2003; Ketten et al. 1993) and mortality (Fernández et al. 2004, 2005; Jepson et al. 2003) amongst others.

As highest acoustic energy levels by seismic exploration are produced at low frequencies of 10–200 Hz and overlap with mysticete signal frequencies of 16–500 Hz (reviewed in Weir 2008), mysticetes are thought to be more sensitive to seismic activities than odontocetes (Nowacek et al. 2007; Richardson et al. 1995; Richardson & Würsig 1997). However, Goold and Fish (1998) showed that incidental noise emissions during seismic surveys dominate the bandwidth within odontocete auditory range (200 Hz to 22 kHz) at distances of up to 2 km or more from the airgun source. Although behavioural effects of airgun sound on small odontocetes have been poorly studied (Weir 2008), dolphins observed from seismic vessels in operation are regularly seen moving away from the acoustic source (Bain & Williams 2006; Calambokidis & Osmek 1998; Stone 2003; Stone & Tasker 2006; Weir 2008; authors, personal observations). Encounter rates for several small odontocetes off the UK were significantly lower and distance to sightings was significantly higher during periods when air-guns were firing (Stone 2003). Goold (1996) suggested that within 1 km short-beaked common dolphins, *Delphinus delphis*, found the signals from a seismic source aversive. Striking short-term, short-range responses were reported for Atlantic spotted dolphins *Stenella frontalis* off Angola (Weir 2008). Groups occurred at a significantly greater distance from the airgun array ($p < 0.001$) during full-array operations than during guns-off periods, while positive-approach behaviour ($N = 9$) occurred only during guns-off periods (Weir 2008).

Case study

On 18 March 2009, an adult-sized pantropical spotted dolphin, *Stenella attenuata* (Gray, 1846) was closely observed during 3D seismic explorations by R/V *GeoBarents* between ca. 15–50 nm offshore Monrovia, Liberia from 27 February to 4 May 2009. The single dolphin of sighting HG-037 displayed aberrant behaviour, the circumstances of which are discussed below in an effort to elucidate the potential cause.

* Corresponding author.
E-mail address: howard_gray@btinternet.com (H. Gray).

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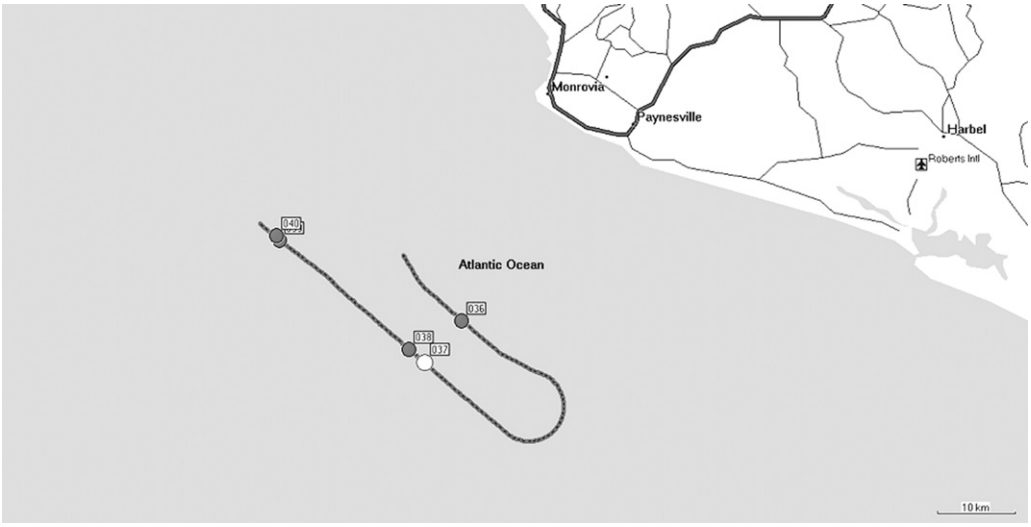

Fig. 1. Observation track log and location of cetacean sightings on 18 March 2009 off Liberia. HG-036, 08:06 h, 200 unidentified Delphinidae at N06.05122°, W010.90085°, airguns firing. HG-037, 13:31 h, 1 *Stenella attenuata* at N06.00240°, W010.94498°, airguns firing. HG-038, 13:52 h, 300 unidentified Delphinidae at N06.01798°, W010.96295°; airguns firing. HG-039, 17:01 h, 7 *Globicephala macrorhynchus* at N06.14442°, W011.11383°, airguns inactive. HG-040, 17:02 h, 200 unidentified Delphinidae at N06.1499°, W011.11675°, airguns inactive.

Table 1
Record of operations.

Line	Time soft start began	Time of full power	Time of start of line	Time of end of line	Time airguns stopped
Line 1	01:50	02:10	02:36	05:06	05:06
Line 2	07:21	07:41	08:06	08:47	08:47
Line 3	12:24	12:44	13:07	15:38	15:38
Line 4	17:21	17:41	18:05	20:24	20:24

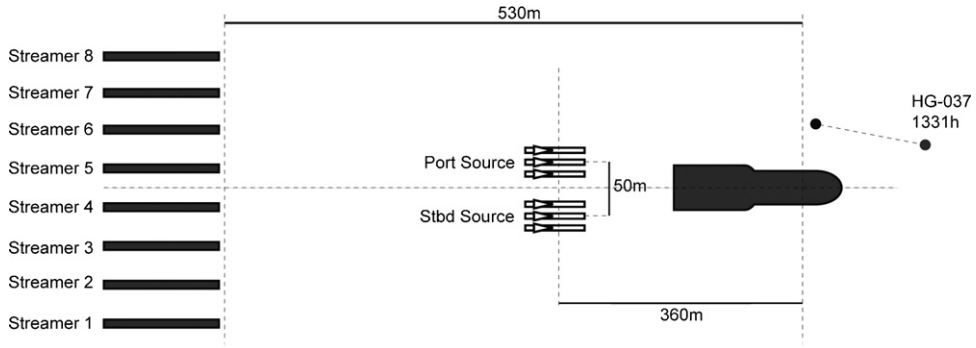

Fig. 2. Observed movement (dotted line) of pantropical spotted dolphin HG-037 relative to the port side of the vessel with layout of towed seismic array.

During 601 min on watch on 18th March, HG made five sightings of delphinids. The observation track-log, with sighting locations, is plotted in Fig. 1. The distance between adjacent survey lines was approximately 8800 m. In the course of the day, four 'infill' lines[1] were run (Table 1). A 30-min pre-shoot watch was conducted before every 'soft start' in daylight hours. Observer height was 11.80 m at the time of observation. The soft start was initiated more than 1 h before dolphin HG-037 was encountered at 13:31 h, position N06.00240°, W010.94498°, approximately 19 nm off the Liberian coast where water depth was 520 m. Fair weather conditions included a Beaufort sea state 3 and good visibility (>3 km). The vessel was traveling at approximately 4.0 kts and the deployed Sondera G-airguns in towed array (Fig. 2) were operating at full power during the observation. Their main specifications were: 2×3400 in.^{3} volume; air pressure 2000 psi; shot interval 25 m flip-flop (i.e. 50 m per source); source depth 6 m (±1.0 m) and source separation 50 m; peak–peak 166.4 bar m; P/b ratio minimum 29.5:1; maximum timing error ±1 ms. While no specific legislation exists in Liberia regulating mitigation of marine mammal disturbance during seismic surveys, the UK's Joint Nature Conservation Committee (JNCC) guidelines were followed (see www.jncc.gov.uk). JNCC does not require active measures after soft starts, the industry's standard gradual power ramping-up procedure, from minimal to full-power over a 20 min period, designed to allow marine mammals sufficient time to move away.

The initial sighting cue at 13:31 h consisted of dolphin HG-037 moving erratically at the surface, approximately 600 m ahead of the airgun array. Both initial posture and locomotion differed from any dolphin behaviour known to the authors. This individual slowly moved forward, non-directionally, while lifting its anterior body

[1] New tracklines designed for a second attempt at surveying in an area that was incompletely surveyed during a first pass-over, often due to some technical problem.