

Preliminary findings on the mass strandings of melon-headed whale *Peponocephala electra* on Boavista Island in November 2007, with notes on other cetaceans from the Cape Verde Islands

KOEN VAN WAEREBEEK^{1,2}, CORNELIS J. HAZEVOET³, PEDRO LÓPEZ SUÁREZ⁴, MANUEL SIMÃO DELGADO RODRIGUES⁴, GABRIELLA GATT⁴

¹ Conservation & Research of West African Aquatic Mammals (COREWAM-Senegal), Musée de la Mer à Gorée, IFAN, Université CAD, Dakar, BP 206, Senegal. Email: corewam.senegal@yahoo.co.nz

² Scientific Counsellor for Federal Public Service Public health, Food chain security and Environment, Multilateral and Strategic Affairs, Eurostation building (DG5), Place Victor Horta 40, box 10, Room 02C368, B-1060 Brussels, Belgium.

³ Museu Nacional de História Natural, Rua da Escola Politécnica 58, 1250-102 Lisbon, Portugal

⁴ Projecto Naturalia (EU Interreg IIIB), C.P. 100, Sal Rei, Boavista, Republic of Cape Verde

Abstract

On 17-19 November 2007, two mass stranding events of melon-headed whales *Peponocephala electra* occurred in western Boavista, Cape Verde Islands, concerning 265 and 70 animals respectively. Only ca. 65 individuals could be successfully returned to the sea. Dead animals were immediately buried in a mass grave on the beach which however impeded necropsies and sampling. A study visit from 9-17 January 2008 attempted to reconstruct events, collect biological data and liaise with local stakeholders for improved documenting of future stranding events. Despite advanced decomposition, 16 specimens were exhumed. Samples collected include: skulls (n=9), stomach contents (n=3) and tissue samples (n=12). Screening of photographic evidence showed tightly grouped live-strandings, with many refloated individuals beaching again. The live-strandings and the total absence of tell-tale injuries associated with fishing gear excluded fisheries interactions. Good body conditions and indications of antemortem feeding were also inconsistent with epizootic infectious disease. Finally, nothing suggests that biotoxins or chemical contamination were involved, and the cause of the strandings remains unknown. The presence of submarine *USS Annapolis* in Cape Verde waters, apparently coinciding temporally with the strandings, led some to raise questions about the use of active sonar. Once identified, abundant squid beaks and fish otoliths found in fore- and main stomachs will provide valuable data on the feeding ecology of melon-headed whales in the eastern Atlantic. Study of cranial and genetic variation will help delineate population structure. A cursory examination of skeletal material of other small cetaceans, including pilot whales, did not support the occurrence of long-finned pilot whale *G. melas* in Cape Verde.

Resumo

Dois arrojamentos colectivos envolvendo respectivamente 265 e 70 baleias-cabeça-de-melão, *Peponocephala electra*, foram registados na zona oeste da ilha da Boavista, em Cabo Verde de 17 a 19 de Novembro de 2007. Apenas cerca de 65 indivíduos puderam ser devolvidos ao mar com sucesso. Os animais mortos foram imediatamente enterrados numa vala comum aberta na praia, facto que impediu a realização de necrópsias e de qualquer amostragem. Numa visita realizada de 9 a 17 de Janeiro de 2008 tentou-se reconstruir os acontecimentos, recolher dados e estabelecer ligações com parceiros locais de modo a tentar melhorar a intervenção em futuras situações de arrojamentos. Apesar do avançado estado de decomposição foi possível exumar 16 animais. As amostras recolhidas incluem: crânios (n=9), conteúdo estomacal (n=3) e amostras de tecidos (n=12). A análise do registo fotográfico mostrou a ocorrência de arrojamentos colectivos de grupo de compactos animais e que muitos dos animais encaminhados de volta ao mar voltavam a arrojar. Os arrojamentos de cetáceos vivos e a total ausência de ferimentos compatíveis com aparelhos de pesca excluíram a interacção com artes de pesca como causa provável da mortalidade registada. Por outro lado a boa condição física dos animais, bem como a existência de indícios de alimentação recente são incompatíveis com um quadro epizootico de doença infecciosa. Finalmente, não há qualquer indicação da existência de contaminação química ou por biotoxinas, pelo que a causa deste arrojamento permanece desconhecida. A presença do submarino *USS Annapolis* em águas de Cabo Verde, aparentemente coincidindo temporalmente com os arrojamentos registados, levantou a questão do eventual envolvimento do sonar activo como causa directa dos arrojamentos. A grande quantidade de bicos de cefalópodes e de otólitos de peixes encontrados nos estômagos dos cetáceos necropsiados fornecerão importantes dados sobre a ecologia alimentar das baleias-cabeça-de-melão no Atlântico Oriental. O estudo das variações craniométricas e genéticas permitirá definir a estrutura populacional. A análise de material ósseo proveniente de outros pequenos delfínidos não permitiu confirmar a presença da baleia-piloto, *G. melas*, em Cabo Verde.

Résumé

Deux échouages en masse de 265 et 70 péponocéphales *Peponocephala electra* respectivement ont eu lieu dans l'ouest du Boavista, Cap Vert, du 17 au 19 novembre 2007. Seulement *ca.* 65 individus ont pu être retournés à l'océan. Les cétacés morts ont été immédiatement enterrés dans une fosse commune sur la plage qui a toutefois entravé des nécropsies et l'échantillonnage. Une visite d'étude effectuée du 9 au 17 janvier 2008 a tenté de reconstituer les évènements, de recueillir des données biologiques et d'assurer la liaison avec les acteurs locaux pour améliorer la documentation de futurs échouages. Seize spécimens ont été exhumés, en dépit de leur décomposition avancée. Les échantillons suivants ont été recueillis: crânes (n= 9), contenu estomacal (n= 3) et tissus (n=12). Les évidences photographiques ont démontré les échouages d'animaux vivants étroitement groupés et de nombreux individus renfloués qui retournent s'échouer de nouveau. Les échouages de cétacés vivants et l'absence de blessures typiques d'engins de pêche excluent une interaction avec les pêcheries comme cause possible. La bonne condition physique des péponocéphales et des indications d'alimentation antemortem ne sont pas cohérentes avec une épizootie de maladie infectieuse. Enfin, rien ne suggère que des biotoxines ou des contaminants chimiques soient impliquées. La cause des échouages reste donc inconnue. La présence du sous-marin *USS Annapolis* au Cap-Vert, apparemment coïncidant temporellement avec les échouages, a amené certains à remettre en question le sonar actif. Des abondants becs de calmars et otolithes de poissons trouvés dans les estomacs fourniront des données uniques sur l'écologie alimentaire des péponocéphales dans l'est de l'Atlantique. L'étude de la variation craniométrique et génétique permettra de définir la structure de populations. L'examen de crânes de quelques autres petits cétacés, dont des baleines pilotes, ne pouvait confirmer la présence du globicéphale commun *G. melas* au Cap-Vert.

INTRODUCTION

Two mass stranding events of, respectively, 265 and 70 (65 of which survived) melon-headed whales *Peponocephala electra* (Gray, 1846) occurred with about a day interval on western Boavista Island (Ilha da Boavista) in the Cape Verde Islands from 17-19 November 2007 (Figures 1 & 2). Local authorities immediately buried dead animals in a mass grave on the beach, which unfortunately impeded necropsies and postmortem sampling.



Fig.1. Mass stranding of *ca.* 265 melon-headed whales at Praia da Chave, Boavista, photographed on 18 November 2007, the day after the initial stranding (Photo Projecto Naturalia).

Although overdue, a study visit to the Cape Verde Islands by two of us (KVW, CJH), from 9-17 January 2008, attempted to reconstruct events, collect biological information and liaise with local stakeholders as to support their initiatives towards improved documenting in the future. Determining the cause of cetacean strandings can be very difficult, even when not dealing with decomposed carcasses (Geraci and Lounsbury, 1993; Perrin and Geraci, 2002). Considering the seven week postmortem period, no causal explanation was anticipated

as a result of this mission. Here we report on our preliminary findings.

MATERIAL AND METHODS

Field work was carried out on Boavista Island from 10-13 January 2008, with exhuming and sampling of melon-headed whale carcasses done at Praia da Chave (16°06'N, 22°56'W) on 10 and 11 January, seven weeks postmortem. All buried and several exposed carcasses were in an advanced state of decomposition (standard condition code 4; Hare and Mead, 1987; Geraci and Lounsbury, 1993). In total 16 specimens were exhumed, but sampling attempts were futile in several as muscles and organs had acquired a pasty texture. Carcasses disintegrated when manipulated, hence few body lengths could be taken. A few surface-lying carcasses were in an early phase of mummification thanks to intense solar radiation, drying (due to strong trade winds) and a salty environment. In these, many organs, including those of the digestive tract, although decomposed by autolysis, were clearly recognizable. In three specimens, contents could be retrieved from fore and main stomachs over a metal sieve (1mm²), rinsed and stored in 96% ethanol. Fish otoliths, squid beaks and fish lenses were dried, counted and photographed (Figure 3). Squid beaks were returned to an ethanol solution to avoid cracking.

Dr. Tony Booth (University of Cape Town, South Africa) has been contacted for help with the identification of fish otoliths, while Dr. Uwe Piatkowski (Leibniz-Institut für Meereswissenschaften, Universität Kiel, Germany) agreed to identify squid beaks.

Soft tissue samples, or teeth, of 12 specimens were collected and kept in dimethylsulfoxide (DMSO) saline solution for later DNA extraction. Due to concern about inadequate preservation, samples were transferred to 96% ethanol base within hours. They were brought to

São Vicente and deposited at the Instituto Nacional de Desenvolvimento das Pescas (INDP)¹ in the care of Mrs. Vanda Marques da Silva Monteiro, who will facilitate export to the Laboratory of Evolutionary Genetics, directed by Prof. Michel Milinkovitch.² Very little is known about the species' genetics (Jefferson and Barros, 1997).

Nine *P. electra* heads were collected at Praia da Chave, flensed, tagged (plastic-protected numbers inserted in foramen magnum) and deposited in half-open plastic bags in a shipping container (Figure 4) to allow further tissue removal by dermestid beetles and, ultimately, specimen preparation for a craniometric study at a later date.

Another eight dried heads and skulls of melon-headed whales, collected from various earlier strandings, and stored in the shipping container (for lack of alternatives) were prepared for long-term clean storage. Hardened tissues were removed after soaking the heads in seawater for 1-2 hours. Subsequently, skulls were cleaned, dried, numbered (see below), photographed and stored in a lockable plastic container designed for water-storage.

Boavista biological reference collection

An informal Boavista biological reference collection (BVRC) has been maintained at Sal Rei for some years. It currently includes skeletal remains of 22 cetaceans: 17 skulls (two with complete skeleton) of *Peponocephala electra*, short-finned pilot whales *Globicephala macrorhynchus* (n=2), false killer whale *Pseudorca crassidens* (n=1), rough-toothed dolphin *Steno bredanensis* (n=1), and common minke whale *Balaenoptera acutorostrata* (n=1).



Fig. 2. Mass stranding of ca. 70 melon-headed whales on Praia de Boca da Salina, Boavista, 19 November 2007. Some 65 specimens were successfully refloated and headed to deeper water (Photo Projecto Naturalia).

Specimens examined at Praia da Chave

Specimen BV001 *Peponocephala electra*

Date examined: 10.01.2008. Skin sample (FB182).

¹ Instituto Nacional de Desenvolvimento das Pescas, C.P. 132, Mindelo, São Vicente, Republic of Cape Verde.

² Laboratory of Evolutionary Genetics, Institute of Molecular Biology and Medicine, Université Libre de Bruxelles (ULB), cp 300, Rue Jeener & Brachet, 12, B-6041 Gosselies, Belgium.

Estimated length 234cm (compensated for rostrum cut-off).

Specimen BV002 *Peponocephala electra*

Date examined: 10.01.2008. Standard length (SL) 242cm, i.e. adult size. Teeth collected as tissue sample (FB002); epidermis decomposed. Skull collected.



Fig. 3. Otoliths (right), squid beaks (left) and fish eye lenses (in cup) collected from the fore and main stomachs of melon-headed whale specimen BV009 (Photo by KVV).

Specimen BV003 *Peponocephala electra*

Date collected: 10.01.2008. No length measurement, but adult size. Very decomposed; no soft tissue, but some teeth (FB152) and skull collected.

Specimen BV004 *Peponocephala electra*

Date collected: 10.01.2008. Juvenile (epiphyses of posterior lumbar vertebrae detached; mandibular symphysis unfused). No length measurement. Tissue sample FB181 (2 teeth and some skin).

Specimen BV005 *Peponocephala electra*

Date collected: 10.01.2008. No length measurement, but estimated adult size. Tissue sample (FB197).

Specimen BV006 *Peponocephala electra*

Date collected: 10.01.2008. Adult size (SL 235cm). Some teeth as tissue sample (FB171). Probably female (genital slit morphology). Skull collected.

Specimen BV007 *Peponocephala electra*

Date collected: 10.01.2008. Adult, estimated length 232cm (rostrum cut off). Good skin sample (FB217). Skull collected.

Specimen BV008 *Peponocephala electra*

Date collected: 10.01.2008. Estimated length 224cm (rostrum cut off). Adult size, female (genital slit morphology). Skin sample (FB186). Partially collected fore and main stomach contents (in EtOH). Liquid in forestomach. Otoliths (19), squid beaks (20) and eye lenses (10) collected.

Specimen BV009 *Peponocephala electra*

Date collected: 10.01.2008. Confirmed female (genital slit morphology). Estimated length 246cm (rostrum cut off). Many healed scars on body. Skin sample (FB232). Forestomach and main stomach contained liquid contents, many otoliths (n=175) and squid beaks (n=63) (Figure 3).

Specimen BV010 *Peponocephala electra*

Date examined: 10.01.2008. Estimated length 230cm

(rostrum chopped off for teeth). No tissue sample (advanced decomposition).

Specimen BV011 *Peponocephala electra*

Date examined: 11.01.2008. No length estimate, but subadult size (rostrum cut off). Male (penis extruded). Small testes, ca 6cm length. Tissue sample (FB 127). Epiphyses not fused in lumbar vertebrae. Stomach contents: liquid, otoliths, squids in fore and main stomachs (collected).

Specimen BV012 *Peponocephala electra*

Date examined: 11.01.2008. Recovered from mass grave. Juvenile skull collected. No sex, length or other data.

Specimen BV013 *Peponocephala electra*

Date examined: 11.01.2008. Recovered from mass grave. Adult skull collected. No sex, length or other data.

Specimen BV014 *Peponocephala electra*

Date examined: 11.01.2008. Recovered from mass grave. Adult skull collected. No sex, length or other data.

Specimen BV015 *Peponocephala electra*

Date examined: 11.01.2008. Surface specimen. Adult skull collected, with teeth and tympano-periotics. No sex, length or other data.

Specimen BV016 *Peponocephala electra*

Date examined: 11.01.2008. Surface specimen. Subadult skull collected. No sex, length or other data.



Fig. 4. Dilapidated shipping container in Sal Rei, Boavista, functioning as temporary holding space for unprocessed cetacean and sea turtle skeletal specimens. While it keeps specimens safe from dogs, people may have access (Photo by KVW).

Other melon-headed whale specimens examined³

Specimen BV017 *Peponocephala electra*

Probably originates from a mass stranding at Praia de Roque, eastern Boavista. Date examined: 13.01.2008. Calvaria (subadult), no tympano-periotic bones (TP) nor teeth.

Specimen BV018 *Peponocephala electra*

Probably originates from a mass stranding (>30 individuals) at Praia Abrolhal, northern Boavista, in August 2001. Date examined: 13.01.2008. Skull (adult); no TP or teeth.

Specimen BV019 *Peponocephala electra*

Probably same origin as BV018. Date examined: 13.01.2008. Skull (adult), no TP or teeth.

³ For all specimens, dorsal and ventral cranial photo-identification images were taken.

Specimen BV020 *Peponocephala electra*

Probably same origin as BV018. Date examined: 13.01.2008. Skull (adult); no TP or teeth.

Specimen BV021 *Peponocephala electra*

Probably same origin as BV018. Date examined: 13.01.2008. Skull (adult); no TP or teeth.



Fig. 5. Adult *Peponocephala electra* skull (BV 018). Dorsal and ventral high-resolution images of skulls allow specimen recognition independent from numbering (Photo by KVW).

Specimen BV022 *Peponocephala electra*

Probably same origin as BV018. Date examined: 13.01.2008. Skull; TP and teeth available. Some teeth sampled in ethanol (FB157).

Specimen BV023 *Peponocephala electra*

Probably same origin as BV018. Date examined: 13.01.2008. Complete skeleton (physically mature); teeth available. Some teeth sampled in ethanol (FB166).

Specimen BV024 *Peponocephala electra*

Probably same origin as BV018. Date examined: 13.01.2008. Complete skeleton (physically mature); teeth available.

Other cetacean species

Short-finned pilot whale *Globicephala macrorhynchus*

Two calvariae present in the BVRC collection were confirmed to belong to short-finned pilot whale because of distally expanded premaxillae covering the maxillae anteriorly, wide alveoli and a short and broad rostrum (cf. van Bree, 1971).



Fig. 6. One of two calvariae of short-finned pilot whale *Globicephala macrorhynchus*. Lens cover scale is 60mm diameter (Photo by KVW).

One skull (Figure 6) was collected by PLS on the northern coast of Santa Luzia Island in February 2001, first encountered there during an expedition in October 1999. An unknown number (> 3) had been involved in a stranding on the island. The other skull was collected by Mr. G. Torda at Ponta Calheta Negra, NE coast of Boavista, in September 2003, from a mass stranding of more than 20 animals that took place before 1999.



Fig. 7. Dorsal view of rough-toothed dolphin *Steno bredanensis* skull (BV026). Lens cover scale is 60mm in diameter (Photo by KVV).

Rough-toothed dolphin *Steno bredanensis*

One calvaria (No. BV026; Figure 7) examined on 13.01.2008 is kept in the BVRC. No data accompany the specimen, but it originates from either Boavista or Santa Luzia. Five beach-worn teeth are available, but no tympano-periotic bones.

A mandible without number, kept at INDP, was positively identified as *S. bredanensis* based on the elongated mandibular symphysis and rough-surfaced, conical teeth. Unfortunately, its origin was not indicated.

False killer whale *Pseudorca crassidens*

The right mandible of a false killer whale (BV 025) was retrieved from an indeterminate beach on Boavista a few years ago and placed in the BVRC. No further details are available.

RESULTS

Narrative of *P. electra* mass stranding events

The first live mass-stranding of ca. 265 melon-headed whales was noticed by locals at Praia da Chave, just north of Ponta Morro de Areia (Figure 9), late in the evening of 17 November 2007 and the Boavista Police Department was notified at 22:30h. Rescue efforts were organised at night from 01:00 to 04:00h and from 06:00 to 13:00h (18 November). The whales that approached the shallow littoral zone remained tightly grouped throughout the event. Despite repeated refloating attempts and wetting of beached animals by volunteers (including two of us, MSDR and GG), the cetaceans refused to swim away, consistently returning to the beach, and died. Carcasses were buried around 16:00h on 18 November in a mass grave on the beach.

A second wave of ca. 70 melon-headed whales approached the beach at Praia de Boca da Salina (16°07'N, 22°55'W) in front of Hotel Riu Karamboa (under construction), some 5km north of the first stranding site, in the early morning of 19 November 2007. It was communicated at ca. 06:00h. High mortality was averted thanks to a large number of volunteers among locals and holidaymakers. Beached animals were pulled into the sea, escorted towards deeper water by swimmers

and a small boat between 09:00 and 10:00h. Five individuals remained grounded and died. No specimens were collected, but one was examined (see below). The main group was not seen again and, presumably, escaped offshore.

Necropsy results and pathology

On 23 November 2007, i.e. four days postmortem, PLS performed an *in situ* necropsy of a 260cm adult male on Praia de Boca da Salina, with findings as follow. Body condition was good with normal blubber thickness and no signs of emaciation. No external traumatism was visible, apart from some tooth rakes from social interactions, and no external parasites. No macroscopic pathological lesions were found, while tissue damage was congruent with normal postmortem autolysis of internal organs. Abdominal organs examined included liver, pancreas, spleen, some mesenteric lymph nodes, testes, kidneys and gastrointestinal tract. No internal hemorrhages nor other gross pathologies or abnormalities were evident. Stomachs and different sections of the intestine were opened and some unidentified nematodes were seen attached to the gastric mucosa. A few squid beaks were collected, but otherwise no food remains were found in the various sections of the intestinal tract. In the thoracic cavity, accessed through the diaphragm muscle, heart and lungs (apical lobes) appeared normal. At the request of INDP, a sample of skin, blubber and muscle from the dorsal region of the animal was collected for the local environmental authorities.



Fig. 8. Right mandible (BV 025) of a false killer whale *Pseudorca crassidens*. Note the 8 large, circular alveoli (oval in killer whales) and the tooth row extending for almost half the length of the mandibula (about 1/4 in short-finned pilot whale) (Photo by KVV).

During necropsies performed in January 2008 (by KVV), few organs and tissues were sufficiently intact to allow distinction between normal morphology and pathology. In buried carcasses many organs were beyond recognition and disintegrated at touch, but partially exposed specimens were appreciably less decomposed. In four of the latter no gross pathological conditions were seen. Blubber thickness (ca. 15mm) was considered normal relative to body size. Also, perusal of more than 100 images of the live stranded animals in Boavista (Projecto Naturalia archives) revealed no individuals with depressed neck regions, visible ribs or other symptoms of emaciation.



Fig. 9. Map of Boavista, Cape Verde Islands, with place names of stranding sites mentioned in the text.

A few individuals showed crater scars of cookie-cutter shark *Isistius brasiliensis* bites (Figure 10). Some scars were semi-circular as the bite had been unsuccessful. These small sharks seem to be common in Cape Verde waters (cf. Moore *et al.*, 2003) and may attack a wide range of cetacean species. Cookie-cutter shark predation on *P. electra* has been reported before in other oceans (Barron and Jefferson, 1993; Gasparini and Sazima, 1996) and once from South Africa (Best and Shaughnessy, 1981).

One specimen was infested with several tens of commensal stalked barnacles *Conchoderma auritum*, apparently attached to abnormally exposed teeth in both left and right mandible (Figure 11). Clarke (1966) indicated that *C. auritum* requires a hard substance to attach, in odontocetes typically exposed teeth. This is the first known record of *C. auritum* in the melon-headed whale.

Feeding

The identification of squid beaks and fish otoliths to species, genus or family level (in progress) will provide, for the first time, data on the feeding habits of melon-headed whales in the Northeast Atlantic Ocean. The collected samples are the only stomach contents available for this region, and are therefore valuable.

DISCUSSION

Melon-headed whales

Distribution and status of eastern North Atlantic stock

Melon-headed whales are found in tropical and subtropical waters worldwide (Jefferson and Barros, 1997; Perryman, 2002), but very little is known about them in the eastern Atlantic. The species has been documented from the Bijagós archipelago⁴ in Guinea-Bissau (Van Beneden and Gervais, 1880), Senegal (van Bree and

Cadenat, 1968), Houtbaai, South Africa (Best and Shaughnessy, 1981), at 17°N 38°W in the mid-Atlantic⁵ (Pilleri, 1982), Cornwall (Mikkelsen and Sheldrick, 1992), Cape Verde Islands (Reiner *et al.*, 1996; Hazevoet and Wenzel, 2000), Mauritania (Robineau and Vély, 1997) and Ghana (Ofori-Danson *et al.*, 2003; and Figure 12). No global abundance estimates are available, but the species is not thought to be common. A western North Atlantic stock is proposed by NOAA⁶, implying the existence of an eastern (North) Atlantic stock. However stock structure is hypothetical. Very few specimens from the eastern North Atlantic have been studied, emphasizing the importance of sampling as performed during this mission. The addition of 17 skulls from Boavista should allow a preliminary study of morphological variation. Also, tissue samples will hopefully permit estimation of genetic variability if DNA of sufficiently good quality can be extracted.

Unknown cause of strandings

P. electra is most often found in offshore, deep waters and nearshore sightings are generally from areas where deep oceanic waters are found near the coast (Perryman, 2002). It is one of several species of highly gregarious 'blackfish' known to mass strand (as reviewed in Jefferson and Barros, 1997).



Fig. 10. Oval, scar-forming incisive trauma on a melon-headed whale stranded at Praia da Chave, indicative of cookie-cutter shark bite (Photo Projecto Naturalia).

The first mass stranding of melon-headed whale reported from the Atlantic Ocean was of about 240 animals in northeastern Brazil (Lodi *et al.*, 1990), the cause of which could not be determined. Mass strandings that occurred in the Cape Verde Islands will be reviewed by some of us in another paper (Hazevoet *et al.*, in preparation).

Predictably, in view of the extended postmortem period, the cause(s) of the November 2007 melon-headed whale mass strandings at Boavista also remain(s) obscure. However, some common causes of mass-strandings (see Perrin and Geraci, 2002) can be excluded with some

⁵ some 870 nautical miles west of Boa Vista.

⁶ Melon-headed whale: Western North Atlantic stock (November 2005). See www.nmfs.noaa.gov/pr/pdfs/sars/ao2003whmh-wn.pdf

⁴ Van Beneden and Gervais used the old spelling "Bissagos".

confidence or were unlikely. There were no indications of a fisheries-related interaction: all individuals stranded alive, in two compact groups, and no animals were seen with injuries or marks suggesting fishing gear (see Hare and Mead, 1987). Neither was there any hint that infectious disease or biotoxins were involved, and these were deemed unlikely causes. No animals from other species and taxa had died and stranded⁷. Blubber thickness and overall body condition of the examined melon-headed whales were normal. From direct observations and photographs, no specimens showed signs of emaciation. The fore and main stomachs of three of the four individuals examined contained liquid and abundant fish otoliths, fish eyelenses and squid beaks, the fourth individual's stomachs contained squid beaks, indicating that at least some of the melon-headed whales had been feeding relatively shortly antemortem. Pursuing prey typically requires sustained, energetic movements, implying that dolphins need to be healthy in order to forage successfully.

Predation or harassment by killer whales is unknown in both melon-headed whales and their aggressive look-alikes, pygmy killer whales *Feresa attenuata* (Jefferson *et al.*, 1991; Jefferson and Barros, 1997). Moreover, killer whales are rarely sighted off the Cape Verde Islands (see Hazevoet and Wenzel, 2000). Large shark predation neither is reported and considering that more than a day passed between the first and second wave of strandings, suggests that shark predation is an unlikely cause.

The nuclear-powered attack submarine *USS Annapolis* (SSN760) called at Praia (São Tiago Island) on 17 November 2007⁸ and reportedly at the port of Mindelo (São Vicente Island) on 18 November⁹, raising suspicion in the media about a possible connection of the strandings with the use of active sonar. Fact is, no causal relation with the submarine's presence was demonstrated in the recent Boavista melon-headed whale strandings. However, the hasty burial left little material for study and, as to be expected, the exhuming of carcasses seven weeks postmortem revealed little about causes. According to J.P. Pham⁸ 'the Annapolis's historic visit came as part of U.S. Sixth Fleet's Africa Partnership Station (APS) initiative which involves training teams from various Navy, Marine, and Coast Guard commands, as well as personnel from several European allies, collaborating to enhance regional partnerships and support sustained, focused training aimed at building up African maritime capacities.' It is possible, indeed likely, that other active sonar-equipped navy vessels (surface or submarine) were present in Cape Verde waters when *USS Annapolis* visited.

⁷ When biotoxins emerge in an ecosystem's food web through harmful algal blooms (HABs), typically multiple species and taxa suffer mortality and strand or wash ashore.

⁸ J. Peter Pham, 'Cape Verde: a Rare African Success, in World Defense Review: Strategic Interests; 21 February 2008.

See <http://worlddefensereview.com/strategicinterests.shtml>

⁹ S. St.Aubyn Mascarenhas, 'Melon head whales stranding in Cape Verde'; 1 Dec 2007, message on MARMAM list, see: www.mail-archive.com/marmam@lists.uvic.ca/msg01349.html

Stranding circumstances on Boavista were reminiscent of an averted mass stranding of 150-200 animals of the same species that occurred in the shallow waters of Hanalei Bay, Kaua'i, Hawaii, on 3-4 July 2004 (Southall *et al.*, 2006). The latter well-documented event was spatially and temporally correlated with Rim of the Pacific Exercises (RIMPAC). Sonar training and tracking exercises were held and six naval surface vessels transiting to the operational area on 2 July 2004 intermittently transmitted active sonar, as reported by NOAA (Southall *et al.*, 2006).



Fig. 11. Rostrum of a melon-headed whale infested with stalked barnacles *Conchoderma auritum*. These commensals are uncommon in delphinids and are often associated with congenital or acquired deformations where the mouth cannot be properly closed and teeth remain permanently exposed (Photo Projecto Naturalia).

Thanks to human assistance, the Hawaiian melon-headed whales were successfully returned to deeper water when sonar transmission had ceased. The single animal left dead in a full necropsy did not show any evidence of disease or internal trauma (Southall *et al.*, 2006). The deep-diving beaked whales (Ziphiidae) are reported to suffer gas and fat embolic syndrome (Fernández *et al.*, 2005) leading to lethal strandings after military sonar exposure (reviewed in Brownell *et al.*, 2004). From a study of cetaceans stranded during military exercises in Taiwan in 2004 and 2005, Wang and Yang (2006) concluded that there is some evidence that pelagic delphinids like pygmy killer whale *Feresa attenuata* may show internal injuries to structures associated with or related to acoustics or diving. Little is documented on diving behaviour in *P. electra*, but mostly mesopelagic prey items suggest that feeding takes place deep in the water column (Jefferson and Barros, 1997). Evaluation of bathymetric distribution of prey species collected in Boavista may shed some light on diving behaviour in this region.

It is plausible also that military sonar could cause panic and induce a flight reaction. The melon-headed whales may, for instance, have sought shallow water in an attempt to escape disturbing levels of noise, or stampeded and accidentally entered nearshore waters (see also Brownell *et al.*, 2005; Morton and Symonds, 2002). Due to their naturally pelagic character (Jefferson and Barros,

1997), melon-headed whales may not navigate well in unfamiliar shallow areas, unaware of the risks of grounding. Also, in schooling species, like *P. electra*, care-giving behaviour engendered by tight social bonds are thought to be a factor in strandings (Perrin and Geraci, 2002). Indeed, refloated individuals may refuse to leave towards deeper water and may ground again if group members are still alive on the beach, as was observed in the first (17-18 November) stranding event, but not in the second (19 November).

Feeding habits

Squids appear to be the preferred prey of *P. electra*, but also small fish and shrimps (Jefferson and Barros, 1997). The only information on the diet in the eastern Atlantic is the finding of *Loligo reynaudi*, an ommastrephid squid and *Merluccius* sp. in the stomach of one stranded specimen from South Africa (Best and Shaughnessy, 1981). The Cape Verde samples demonstrate that several species of both squids and fish constitute important prey in the Northeastern Atlantic. Identification of beaks and otoliths will provide important insights into the feeding ecology of *P. electra* in this ocean province.

Utilization

Reportedly some of the melon-headed whales that died were utilized for food, which is a common habit throughout coastal West Africa (see Clapham and Van Waerebeek, 2007; Ofori-Danson *et al.*, 2003), but also in northern Brazil (e.g. Lodi *et al.*, 1990). The rostra of at least five specimens had been cut off to extract teeth for locally made jewelry, for sale in tourists shops at Sal Rei.



Fig. 12. Three melon-headed whales landed in a Ghana port and sold for human consumption (Photo CMS/WAF CET-3 project).

Pilot whales

Besides the authenticated presence of short-finned pilot whale *Globicephala macrorhynchus*, also long-finned pilot whale *G. melas* has been presumed to occur in waters of Cape Verde archipelago (e.g. Lagendijk, 1984; Hazevoet and Wenzel, 2000; Moore *et al.*, 2003). However, until now no evidence for the occurrence of the latter species has been presented.

We examined photographic evidence of skulls and carcasses for several tens of pilot whale individuals from Boavista, all of which were *G. macrorhynchus*. Skulls of juvenile and subadult individuals of *G. macrorhynchus* show limited lateral broadening of the premaxillaries (cf.

van Bree, 1971), which perhaps may have led to confusion with *G. melas*. Until voucher material becomes available, the presence of *G. melas* in Cape Verde waters should be regarded as unconfirmed.

Recommendations

(1) The melon-headed whales were buried by local authorities just hours after death. This impeded much-needed necropsies and sampling. It is recommended that small cetaceans stranded on remote beaches in arid zones (like most of the Cape Verdes) not be buried until they have been examined by scientists. Carcasses may be pulled above the high-tide line and left to dry in the sun. Unpleasant smells will fade away quickly with natural mummification processes setting in. In contrast with live (or freshly dead) animals where zoonotic transmission of pathogenic microorganisms may constitute a health risk, saprophytic bacteria that decompose carcasses are of significantly lesser concern. Generally, the risk of disease is low for persons who are healthy and free of disease conditions or medications that lower resistance to infection (Geraci and Lounsbury, 1993).

Many tourists clearly regarded the Boavista strandings as interesting events rather than a nuisance and many visited the beaches despite the main site, where animals were buried, not being easily accessible.

(2) Set-up of a permanent Boavista environmental centre to educate and inform local people as well as the increasing numbers of visiting tourists about Boavista's biodiversity and the need for more conservation efforts and scientific research. Simultaneously, such a centre could function as a safe deposit for biological specimens and a convenient base for ecotourism services.

(3) Organisation at Boavista (as well as on other islands) of an introductory marine mammal training course for interested officials and others, on how to deal with cetacean strandings, biological sampling protocols, and the recognition of species and the various types of mortality.

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