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First Stranding of Cuvier's Beaked Whale (*Ziphius cavirostris*) on the Danish North Sea Coast

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Abstract

Herein, the biometrics, body condition, and veterinary findings from the first stranding of a Cuvier's beaked whale (*Ziphius cavirostris*; Cuvier, 1823) in Denmark are described. It was an adult male with a single tooth (the right was missing). The animal appeared to be well fed and had a body length of 581 cm and a total weight of approximately 2,500 kg. During dissection, we recorded the mass of the bones, blubber, muscle, and organs, which to our knowledge are the first to be published for this species. The back was covered with linear, parallel scarring likely caused by male–male competition. In addition, scattered scars were found in the skin derived from cookiecutter shark (*Isistius brasiliensis*) bites. Multiple small abscesses were found in the blubber, probably due to parasites. Histopathologically, the lungs were characterized by mild purulent pneumonia, and the liver revealed hepatic steatosis. *Clostridium sardiniensis* and *Paeniclostridium sordellii* were observed in the lungs and liver. The gastrointestinal tract contained only traces of food and two smaller pieces of plastic in the first stomach chamber. Nematode parasites were found in the intestines. Sexual organs indicated full maturity. Both kidneys showed moderate infestation, with the nematode *Crassicauda crassicauda* forming calcified granulomas. The exact cause of death was unknown, but the whale was ill with purulent pneumonia and an agonal septicemia. We did not find any evidence of gas or fat emboli. Furthermore, it can be speculated that storms or noise exposure may have led the whale astray, eventually causing its stranding within the so-called "North Sea Trap." The stranding reported contributed to a pattern of increased Cuvier's beaked whale strandings in the North Sea area, suggesting a recent northerly shift of its range, perhaps due to the climate-induced range shift of its squid prey.

Key Words: stranding, necropsy, North Sea Trap, Cuvier's beaked whale, *Ziphius cavirostris*

Introduction

Cuvier's beaked whale (*Ziphius cavirostris*; Cuvier, 1823) is a meso- and benthopelagic, teuthophageous toothed whale (Heyning, 1989; Praca & Gannier, 2008). The species is distributed throughout the world's tropical, subtropical, and warm temperate waters. In the Northeast Atlantic, it is more commonly found off the west coasts of Ireland and Scotland and in the Bay of Biscay (Reid et al., 2003). In the North Sea, strandings are mostly confined to the southern tidal areas (the Wash, UK, and the Dutch Wadden Sea area), and only a few strandings have been reported from the greater North Sea area, although there seems to have been an increase since 2000 (Malm, 1870; Duguy, 1981; Van Waerebeek et al., 1997; Sabin et al., 2003; Robinson & MacLeod, 2009; Bachara & Øien, 2017). The last 50 years of mid-frequency sonar use has induced a series of mass and single strandings of Cuvier's beaked whales and other beaked whale species (Simonis et al., 2020), and these may trigger more frequent intrusions of the species into the North Sea, which is considered a trap for pelagic cetaceans (MacLeod, 2000; IJsseldijk et al., 2018). The mechanisms behind these sonar-induced strandings are still unknown, but available evidence points to strong anti-predator responses

with a dramatic change in diving behaviour that may lead to decompression sickness (Hooker et al., 2011). Given that information on naval sonar use is often classified, it is inherently difficult to determine if a stranding happens due to natural causes or as result of mid-frequency sonar use. Either way, strandings of Cuvier's beaked whales are rare and, hence, every opportunity should be exploited to learn more about these elephant-sized deep diving predators. We report herein on the biometrics, body condition, and veterinary findings of an adult male individual stranded on the island of Rømø in the Danish part of the Wadden Sea.

Methods

A dead whale was initially observed on 13 February 2020 off the coast on Lakolk Beach (Rømø, Denmark). The following day, the whale was washed ashore at this location and was subsequently transported to the Fisheries and Maritime Museum (Esbjerg, Denmark) where it was stored until the external examination (16 February 2020) and necropsy (17 February 2020). The species of the whale was determined, the decomposition condition code (DCC) of the carcass was assessed (Kuiken & Hartmann, 1991), and standard cetacean body measurements were recorded. The whale was examined for external scars and injuries as well as external parasites. The blubber thickness was measured ventrally, laterally, and dorsally, extending from the pectoral fins and down to the anus. The head was inspected for injuries/trauma, cut off, and frozen until further examinations (data not included).

At necropsy, the blubber was cut off into strips and traversed crosswise (squares of approx. 15 × 15 cm) with a knife to examine for the presence of parasites and pathologies. Body blubber and muscles were weighed separately (the head not included). The internal organs were examined for the presence of parasites, palpated, removed, and weighed. Incisions for the identification of pathology and parasites were made in all the organs, except the heart, which was secured for an ongoing project on whale heart anatomy (data not included). The lungs were separated from the trachea, bronchi, and bronchioles and examined for parasites. The stomach chambers and intestines were cut open, and each compartment was examined separately for plastic and food remains. Standard samples were taken from the integument, blubber, muscle, brain stem, lung, liver, and kidney; fixed in neutral buffered 10% formalin; and embedded in paraffin for histopathological examination. Samples for microbiology included the lung for morbillivirus (by RT-PCR as previously described by Trebbien et al., 2014), and the muscle and liver for bacteriology. In addition, a few cm of the spinal cord were collected and frozen at -18ºC for later examination for virus. Any parasites observed were collected in 70% alcohol for macro- and microscopic morphological species identification. A faeces sample was analyzed microscopically for the presence of parasite eggs by a modified McMaster technique according to Roepstorff & Nansen (1998). The genitalia were visually examined for determination of sex and sexual maturity. The skeleton was cut free from the soft tissue and preserved at the Natural History Museum of Denmark. The remaining soft parts were destroyed.

Results

Species Identification and External Characteristics

The whale was identified as an adult male Cuvier's beaked whale measuring 581 cm in total body length. Additional measurements are shown in Table 1. Only the left tooth was present; the right tooth was missing. The body of the animal was marked by multiple linear, parallel scars (Figure 1). The scars were most prevalent on the back dorsal and lateral side of the animal, while there were fewer scars on the ventral side. Some of the parallel scars were > 1 m long and

Table 1. Body dimensions in cm

Total standard length	581.0	Fins	
Beak to anus	408.0	Pectoral fin (length)	55.5
Beak to dorsal fin (top)	400.0	Pectoral fin (width)	10.5
Beak to dorsal fin (cranial)	351.0		
Beak to belly button	251.0	Dorsal fin (length)	48.0
Beak to max g-max	162.0	Dorsal fin (width)	22.5
Beak to pectoral fin (caudal)	152.0		
Beak to pectoral fin (cranial)	116.0	Standard curve measures:	
Beak to ear	85.0	Pectoral fin	300.0
Beak to eye	58.0	G-max	300.0
Beak to blow hole	58.0	Umbilical scar	280.0
Beak to corner of mouth	42.0	Genital slit	236.0
Beak (total length)	18.0	Anus	198.0

Figure 1. The back of the Cuvier's beaked whale (*Ziphius cavirostris*) was covered with linear, parallel scarring caused by other males' teeth from combat. Furthermore, scattered scars were found in the skin after bites from cookiecutter sharks (*Isistius brasiliensis*).

Table 2. Organ weights in kg

	Lungs				Kidney		Blubber and		
Heart	Left	Right	Liver	Spleen	Left	Right	integument	Muscle	Bones
15.88	24.02	21.90	20.20	0.25	6.43	5.00	488.00	642.00	192.00

Note: Blubber, muscles, and bones were weighed without the head. Furthermore, the gastrointestinal tract and several other organs were not weighed.

ran crosswise. Between these scars, small stellate scars were found placed diffusely in the skin.

Internal Body Observations

The weight and the gross examination of the genitalia clearly indicate full maturity. The total weight of the animal was approximately 2,500 kg, with the weight of some individual organs, blubber, and muscle listed in Table 2 (not all organs included). The stomach was divided into ten contiguous chambers between the end of the esophagus and the start of the duodenum. Two small pieces of plastic were observed in the first stomach compartment: one piece was flat, approx. 5 × 8 cm, while the other was a ribbon approximately 2 × 35 cm in size (Figure 2). The length of the intestines was 15.5 m.

Veterinary Findings

The blubber thickness varied from 20 to 70 mm (Table 3), and fatty fringes were present on the lung surface. In addition to the scars already described, multiple, small, deep-lying abscesses were observed in the blubber on the back. The small abscesses revealed histologically deep, epithelial-covered pockets filled by cellular debris. Neither bacteria nor parasitic elements were revealed.

Both the lung and liver showed only mild autolytic degradation together with the brain stem, which appeared unaffected. When palpated, the lung tissue was uniform without pneumonic consolidation. Cut open, the bronchial system appeared normal and without parasites. The lungs, however, were histopathologically characterized by mild suppurative pneumonia, including large mononuclear cells within the alveolar lumen as shown in Figure 3. An interstitial infiltration was not prominent, and the bronchi seemed to be unaffected. Within the alveolar debris, small basophilic, coccoid bacteria were revealed together with a few slender rods. Microbiologically, samples of the lungs showed no growth aerobically; but anaerobically, the lungs exhibited a mixed infection with *Clostridium sardiniensis* and *Paeniclostridium sordellii* (*Clostridium sordellii*). The lungs were negative for distemper virus.

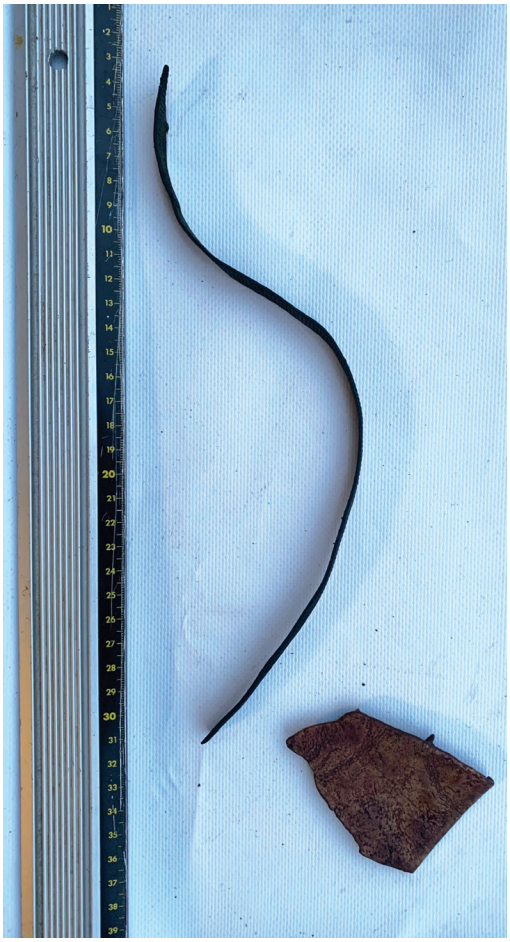

Figure 2. Two pieces of plastic were found in the first stomach compartment: a flat piece of plastic, about 5 × 8 cm, and a ribbon of about 2 × 35 cm.

The liver had a normal texture and color. Microscopically, the liver showed uniform, large hepatocytes within a normal lobular pattern and with normal gall ducts. Hepatocytes with single medium to large cytoplasmic lipid droplets were present revealing mild hepatic steatosis. As with the lungs, samples of the liver showed no growth

Table 3. Blubber thickness in mm

	Pectoral fin (caudal)	At maximum circumference (G-max)	Umbilical scar	Genital slit	Anus
Dorsally	40	40	50	60	50
Laterally	55	55	70	30	50
Ventral	20	20	35	50	30

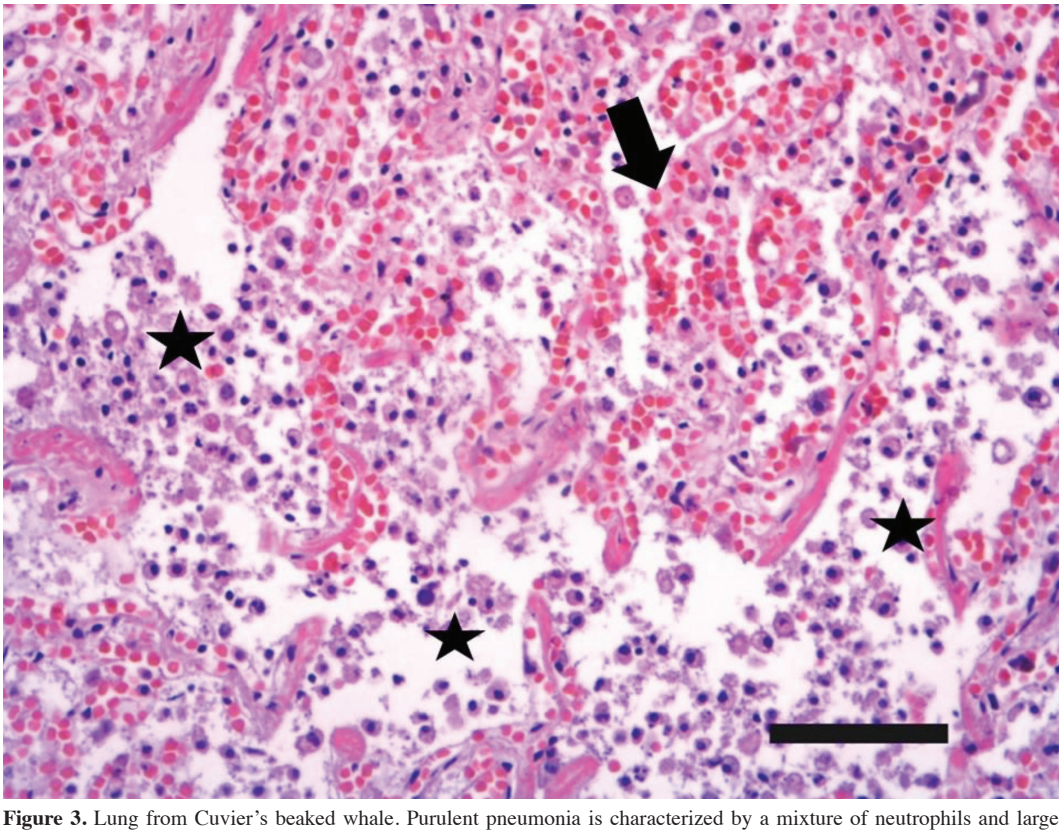

Figure 3. Lung from Cuvier's beaked whale. Purulent pneumonia is characterized by a mixture of neutrophils and large mononuclear cell in the alveoli (stars). The alveolar capillary vessels are congested (arrow). H&E stain; bar = 100 µm.

aerobically; but anaerobically, *Clostridium sardiniensis* was identified.

The gastrointestinal system was nearly empty, containing only traces of food. In the upper gut, light to moderate numbers of nematodes (the species was not determined) were observed. The intestines were too autolytic for histologic evaluation. The faeces sample was negative for parasite eggs and oocysts.

Both kidneys revealed moderate infestation with the nematode identified as *Crassicauda crassicauda* involving approximately 1/3 of the lobules, although a uremic odor was not noticed. The affected lobules were severely mineralized, with many nematodes enclosed in the calyx of the lobules. In addition, several of the nematodes were enclosed in completely degenerated lobules with fibrous connective tissue where they formed approximately 1- to 2-cm large granulomas. However, several nematodes were calcified, and the nematodes extended into the ureter.

Discussion

Herein, we describe the first stranding of a Cuvier's beaked whale in Denmark, the third beaked whale species to be registered in the country. Beaked whales are known for their extremely deep and prolonged dives (Tyack et al., 2006) and are, therefore, not native to the relatively shallow North Sea with its average depth of 100 m. In frequency of occurrence among stranded beaked whales, the northern bottlenose whale (*Hyperoodon ampullatus*) had 14 events of 20 individuals since 1785, and Sowerby's beaked whale (*Mesoplodon bidens*) had 10 single strandings since 1880 in Denmark (Kinze, 1995, 2007; Kinze et al., 1998, 2018).

The veterinary findings cannot explicitly explain the cause of death of this beaked whale, but the whale was affected by purulent pneumonia and hepatic steatosis. The identified anaerobic bacteria from the lung and liver are not known as respiratory pathogens but are suggestive of an agonal septicemia. Although the kidneys were chronically infested by *C. crassicauda*, no uremic odor was noticed; thus, it was of no clinical importance. The whale was in what we consider a normal to well-fed condition. However, the lack of food in the gastrointestinal system indicated that the whale had not eaten at least during the several hours prior to death. It is unlikely that the two small pieces of plastic found in the animal's stomach had had any health impact on the whale as they had not created reactions in the gastric mucosa or blocked the passage of food.

In contrast, a necropsy of a Cuvier's beaked whale in neighbouring Norway showed large amounts of plastic, likely leading to its death (Lislevand, 2017). The parallel scarring on the whale's back is likely caused by interactions with other males' teeth during male–male competition, whereas we suggest that the scattered scars in the skin are derived from cookiecutter shark (*Isistius brasiliensis*) bites. The multiple, small, deep-lying abscesses in the blubber on the back are probably due to *Crassicauda* infestations. In general, the whale appeared to be without serious pathological disorders, and we found no signs of trauma caused by ship collision or bycatch. We cannot rule out that the stranding was induced by a flight response to an unknown navy sonar exposure, although no evidence of gas or fat emboli were observed, making direct mortality from such exposure less likely. The stranding event took place after weeks in which there were periods of storms in the North Sea, and these poor weather conditions could have played a contributing role in the stranding.

Given that the Wadden Sea region is shallow-watered and characterized by strong tidal cycles, we can speculate that this animal made a navigational error and ultimately was caught in shallow water. The Wadden Sea and the southern North Sea in particular have been described as the "North Sea Trap," a unique phenomena that is due to the frequent strandings of oceanic cetaceans there. For instance, in 1996 and 1997, large groups of sperm whales (*Physeter macrocephalus*) stranded at the same location as the Cuvier's beaked whale described herein, namely on the island of Rømø (Kinze et al., 1998); in 2014, two sperm whales stranded at Henne Beach, immediately north of Rømø (Hansen et al., 2016); and in 2016, as many as 30 sperm whales stranded in the southern North Sea along the coasts of Denmark, Germany, the Netherlands, France, and the United Kingdom (IJsseldijk et al., 2018). Some of the recent strandings of Cuvier's beaked whales around the North Sea could possibly be explained in the same manner.

In their assessment of Ziphiidae strandings, MacLeod and coworkers (2004) reported a total of 63 Cuvier's beaked whale strandings in the United Kingdom in the period 1800 to 2002. These exhibited a strong seasonal trend in strandings, with peaks in winter and summer; they almost exclusively occurred on the Atlantic coast. In contrast, the Sowerby's beaked whale and northern bottlenose whale strandings reported in the study mainly occurred on the North Sea coast. Interestingly, of the 11 known Cuvier's beaked whale strandings since

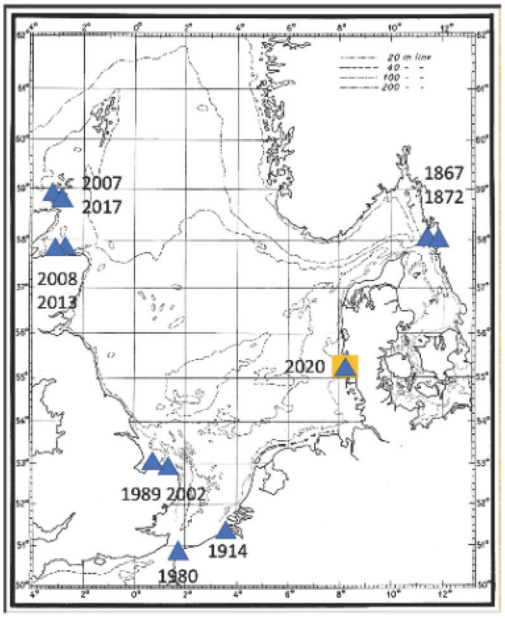

Figure 4. Overview of 11 previously stranded Cuvier's beaked whales in the North Sea area during the period 1867 to 2020. Note that six of them have stranded within the last 20 years. The present whale is the one from 2020.

1867 in the North Sea, we show that more than half stranded in the last 20 years (Figure 4). This indicates that this first Danish stranding is part of an emerging pattern of increasing frequency pushing the species' distribution limit further north than suggested by MacLeod et al. less than two decades ago. Little is known about the population structure and putative migration movements of Cuvier's beaked whale (Dalebout et al., 2005). Thus, it remains to be understood if this rise in cases is, indeed, related to an increasing northerly distribution of Cuvier's beaked whales and, if so, whether this range shift is driven by a climate-induced northern shift in squid and/or if it is related in part at least to human noise pollution at sea (Aguilar Soto et al., 2006; DeRuiter et al., 2013). Cuvier's beaked whales are, like the sperm whale, a pelagic species with potentially similar navigational shortcomings of its biosonar in shallow water. With increasing numbers off the Scottish coast, more individuals are expected fatally to enter the North Sea. The increased number of Cuvier's beaked whale strandings in the North Sea call for studies on their distribution, abundance, and population connectivity in the Northeast Atlantic, and a closer monitoring of habitat changes from rising sea temperatures and acute effects of human encroachment via navy sonars, seismic exploration, and increased vessel traffic.

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