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Indication of lethal interactions between a solitary bottlenose dolphin (*Tursiops truncatus*) and harbor porpoises (*Phocoena phocoena*) in the German Baltic Sea

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Abstract

Background: Aggressive interactions between bottlenose dolphins (*Tursiops truncatus*) and harbor porpoises (*Phocoena phocoena*) have been reported in different parts of the world since the late 1990s. In the Baltic Sea, harbor porpoises are the only native cetacean species, while bottlenose dolphins may appear there temporarily. In the fall of 2016, a solitary male photo-identified bottlenose dolphin stayed in the German Baltic Sea of Schleswig-Holstein for 3 months. During that time, the necropsies of the stranded harbor porpoises revealed types of trauma of varying degrees in six animals, which is unusual in this area. The purpose of this study was to determine if the appearance of the bottlenose dolphin could be linked to the trauma of the harbor porpoise carcasses.

Results: Pathological findings in these animals included subcutaneous, thoracic and abdominal hemorrhages, multiple, mainly bilateral, rib fractures, and one instance of lung laceration. These findings correspond with the previously reported dolphin-caused injuries in other regions. Moreover, public sighting reports showed a spatial and temporal correlation between the appearance of the dolphin and the stranding of fatally injured harbor porpoises.

Conclusion: Despite the fact that no attack has been witnessed in German waters to date, our findings indicate the first record of lethal interactions between a bottlenose dolphin and harbor porpoises in the German Baltic Sea. Furthermore, to our knowledge, this is the first report of porpoise aggression by a socially isolated bottlenose dolphin.

Keywords: Cetaceans, Interspecific aggression, Porpicide, Blunt trauma, Mortality, Stranding

Background

The distributions of bottlenose dolphins (*Tursiops truncatus*) and harbor porpoises (*Phocoena phocoena*) overlap in several areas of the Northern Hemisphere [1, 2]. In one of these areas, namely the Moray Firth, Scotland, aggressive bottlenose dolphin interactions with harbor porpoises were originally reported [3]. Four witnessed dolphin attacks resulted in multiple skeletal fractures and damaged internal organs in harbor porpoises. Moreover, tooth marks were found as several parallel wounds on the skin of some of the carcasses. The spacing of these so-called rake marks were determined to be specific for bottlenose dolphins. Similar cases were noticed in Cardigan Bay, Wales, but without any rake marks on the skin of harbor porpoises [4]. Dolphin attacks were also witnessed in Monterey Bay, California, USA. On

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these occasions, the deaths of a total of 44 porpoises were inflicted by dolphins, so-called porpicide, the carcasses showing rake marks and severe blunt trauma. Witnessed attacks identified all known aggressors as males [5]. Moreover, an aggressive interaction with bottlenose dolphins was mentioned as the potential cause of death in harbor porpoises in North Carolina, USA [6].

Aggressive inter- and also intra-species interactions have been noticed in various species of odontocetes in different parts of the world. Relatively harmless incidents were observed where Guiana dolphins (*Sotalia guianensis*) were scared away by bottlenose dolphins in southern Brazil [7]. Furthermore, Atlantic spotted dolphins (*Stenella frontalis*) and bottlenose dolphins were reported pushing and chasing each other in the Bahamas [8]. In southern Brazil, a Guiana dolphin calf was attacked by three bottlenose dolphins [9]. In the Haro Strait, Washington State, USA, a neonatal harbor porpoise was attacked by two Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) [10]. The healed rake marks made by white-beaked dolphins (*Lagenorhynchus albirostris*) on two juvenile harbor porpoise carcasses also exemplified aggressive interactions in the southern North Sea [11].

Some of the previous observations offered possible explanations for the motive of such aggressive behavior. For example, a bottlenose dolphin attack on a harbor porpoise calf was regarded as object-oriented play [10]. On another occasion, an aggressive interaction was witnessed in a regular feeding aggregation of bottlenose and Commerson's dolphins (*Cephalorhynchus commersonii*). Here, three adult bottlenose dolphins attacked Commerson's dolphins, most probably in order to defend a juvenile [12]. Aggressive interactions owing to food competition were assumed between short-finned pilot whales (*Globicephala macrorhynchus*) and Risso's dolphins (*Grampus griseus*) [13]. Moreover, sexually-driven aggression between bottlenose dolphins and Atlantic spotted dolphins was reported [8]. Additionally, there are several reports of infanticide among bottlenose dolphins [14–17]. Furthermore, there has been the assumption that bottlenose dolphins may attack harbor porpoises to hone their skills for infanticide [14].

In the Baltic Sea, harbor porpoises are the only native cetacean species [18]; they are especially abundant in the western part [19]. Although bottlenose dolphins are rare visitors in the German area of the Baltic Sea, three temporary inhabitants were reported in 2015 and 2016, one pair and the solitary male. The present study describes the first cases of lethal interactions between a solitary male bottlenose dolphin and harbor porpoises in German waters. Post-mortem findings were correlated with public social media postings that provided a spatio-temporal connection between dolphin sightings and harbor porpoise strandings.

Results

Of the 159 harbor porpoise carcasses that stranded on the Baltic Sea coast of Schleswig-Holstein in 2016, six animals (3.8%) were diagnosed as potential dolphin victims. All six animals were found dead. Stranding dates are the dates when the animals were found and retrieved. It is to note that the stranding locations were not necessarily the locations of the attack as the porpoises may not have died directly during the attack. Moreover, carcasses can drift due to wind and current. The six carcasses showed, for this region, unusual blunt trauma in varying degrees. These animals (five females [case No. 1, 2, 4, 5, 6] and one male [case No. 3]) were found stranded dead between September 22 and October 31, 2016. They included two calves (cases No. 4, 6), and four adults (cases No. 1, 2, 3, 5), with their total lengths varying from 98.5 to 167 cm. One animal (case No. 6) was in good, four animals (case No. 2–5) in moderate, and one animal (case No. 1) had poor nutritional status (Table 1). Table 2 summarizes the potential dolphin-related pathological findings.

Case No. 1 displayed extensive subcutaneous hemorrhages on the left thorax and focal subcutaneous hemorrhages at the right thorax. On the right side, seven ribs were fractured, associated with serosal and pulmonary lacerations (Fig. 1). A pneumothorax was not detected. On the left side, one fractured rib was found. All of the

Table 1 Stranding date, sex, nutritional status, age class, dental age, body length and state of decomposition of harbor porpoises (*Phocoena phocoena*) with blunt trauma, recovered from the Baltic Sea coast of Schleswig-Holstein in 2016

Case No.	Stranding date	Sex	Nutritional status	Age class	Age (yrs)	Body length (cm)	State of decomposition
1	2016/09/22	female	poor	adult	14–15	167	advanced
2	2016/09/23	female	moderate	adult	5–6	166	advanced
3	2016/10/08	male	moderate	adult	17	148	fresh
4	2016/10/26	female	moderate	calf	n. d.	98.5	fresh
5	2016/10/26	female	moderate	adult	9–10	152	fresh
6	2016/10/31	female	good	calf	n. d.	105.5	fresh

n. d. not determined

Table 2 Pathomorphological findings potentially associated with a dolphin attack in the six harbor porpoises (*Phocoena phocoena*)

Case No.	1	2	3	4	5	6
Hemorrhages in the blubber	+	+	+	+	+	+
Hemorrhages in the musculature	–	+	+	+	+	+
Hemorrhages in/around internal organs	–	–	+	–	–	+
Hemothorax/−abdomen	+	–	–	+	–	–
Rib fractures unilateral	–	–	+	–	–	–
Rib fractures bilateral	+	+	–	–	–	+
Lung laceration	+	–	–	–	–	–
Hyphema	–	–	–	+	–	–
Fractured mandible	–	–	–	–	+	–

+ = lesion present; – = lesion not present

rib fractures were closed fractures. Hemorrhages were seen around the fractured ribs, but only mildly in the area of the laceration in the lung. Additionally, there was less than 20 mL of blood in the thoracic cavity. Hemorrhages were also found in the intercostal *rete mirabile* and around the left kidney. A long straight cut in a caudodorsal direction of the left flank, perforating the abdominal wall with the stomach and intestines partly hanging out, was regarded as a post-mortem event. The histopathology of its wound margin did not show any hemorrhages or cellular infiltrations. Furthermore, non-trauma related findings included an ulceration in the first stomach compartment and a mild parasitic infestation in the second compartment with focal gastritis. Cardiovascular failure in association with post-traumatic shock, multiple rib fractures, lung laceration and mild hemothorax was assumed to be the cause of death. In addition, a pneumothorax leading to suffocation could not be completely excluded.

In case No. 2, extensive subcutaneous hemorrhages were found around the thorax. Seven ribs on the left side and one rib on the right side had a closed fracture. No pneumothorax was detected. In the surrounding tissue of the fractured ribs, only mild hemorrhages were seen. Cardiovascular failure due to post-traumatic shock and breathing difficulties were the assumed cause of death.

In case No. 3, subcutaneous hemorrhages were observed in the blubber and the musculature bilaterally along the thorax with extensions of approximately 20 × 30 cm. On the left side, closed fractures of four ribs occurred (Fig. 1), but these were without any discernible hemorrhages. Macroscopic findings included pinhead-sized white nodules and interstitial emphysema in the whole lung. Histopathology revealed severe, acute hemorrhages in the blubber and musculature, a complete focal epidermal separation from the underlying fibrous tissue, and mild acute hemorrhages in the brain. Additional findings included pulmonary endoparasitosis with a pronounced secondary bacterial suppurative bronchopneumonia, moderate tracheitis and mild focal encephalitis as well as parasitic hepatitis, pancreatitis, enteritis

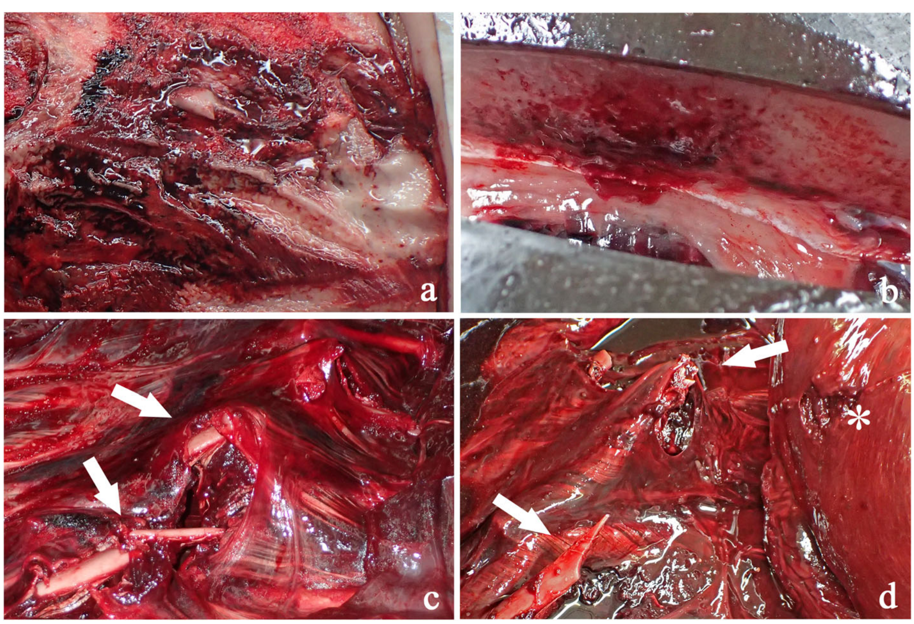

Fig. 1 Macroscopic findings in the harbor porpoise carcasses included extensive hemorrhages in the blubber along the thorax (case No. 4) (**a**), focal hemorrhages in the thoracic blubber (case No. 5) (**b**), fractured ribs with serosal laceration and mild hemorrhages (case No. 3) (arrows) (**c**), fractured ribs with serosal (arrows) and corresponding lung laceration (asterisk) (case No. 1) (**d**)

and lymphadenitis. The severity of the pathological changes in the lungs was regarded as extensive enough to cause an impairment of lung functions. Cardiovascular failure due to post-traumatic shock, associated with pulmonary insufficiency, was determined as the assumed cause of death.

Case No. 4 had extensive hemorrhages along the left thoracic wall (Fig. 1). Histopathology revealed a focal defect of epidermis and blubber with mild acute cutaneous and severe muscular hemorrhages. In addition, multifocal hemorrhages were present in the acoustic fat. The left eye showed a hyphema. Furthermore, around 120 mL of reddish free fluid was present in the abdominal cavity. Additional findings included mild lymphoplasmacytic and eosinophilic enteritis with eosinophilic lymphadenitis of the mesenteric lymph node and severe alveolar pulmonary edema. The cause of death was assumed to be cardiovascular failure of unknown origin.

In case No. 5, a focal hemorrhage measuring $5 \times 3 \times 2$ cm was found in the blubber along the right thorax (Fig. 1). Histopathology revealed moderate, acute hemorrhages and hyaline degeneration in the musculature of the thoracic wall. The left mandible had a closed fracture without any corresponding hemorrhages, indicating a post-mortem change. A straight long cut of approximately 20 cm in length in a ventrocaudal direction in the left flank perforated the abdominal wall, causing a partial protrusion of the stomach and intestines. The wound margins were irregular, but did not show hemorrhages, thereby once again indicating a post-mortem change. Additional findings included severe alveolar edema with copious amounts of white foam in the trachea and bronchi. Furthermore, histopathology revealed chronic cholangitis and pericholangitis with oligofocal chronic hepatitis, mild to moderate gastritis in the glandular part, and parasitic granulomatous inflammation of the pulmonary and mesenteric lymph nodes. Cardiovascular failure of unknown origin was the assumed cause of death.

Case No. 6 had extensive hemorrhages in the blubber and musculature along the entire thoracic and abdominal circumference. On both sides, all ribs were fractured adjacent to the articulation with the vertebral column. Two ribs lacerated the thoracic serosa, but did not cause lung laceration. All other rib fractures were closed. Severe subserosal hemorrhages were present along the dorsal inner thorax wall and in the dorsal intercostal musculature, the dorsal diaphragm, the periaortal fatty tissue and the *rete mirabile*. Additional hemorrhages were seen in the acoustic fat lining the lower jaw. Histology revealed multiple shallow defects of the epidermis without any cellular reactions. Additional findings included severe hyperemia of the lung with mild alveolar histiocytosis. Cardiovascular failure due to post-traumatic shock and breathing difficulties was assumed to be the cause of death.

In addition, three animals (cases No. 4, 5, 6) had externally a few mild, presumably traumatic, skin lesions around the head including abrasions, small cuts, and defects of unknown origin without any reactive changes like intravascular adhesion of granulocytes or emigration. Only in case No. 4, were hemorrhages found to be associated with these abrasions. Dolphin-specific rake marks on the skin were not found in any of the investigated animals.

Case number 4 (calf) and 5 (adult female) stranded on the same day around 10 km apart, hence constituting a potential mother-calf pair. Genetic analysis on nuclear microsatellites however rejected a parent-offspring relationship between the two animals (mismatch at 4 out of 14 microsatellite loci).

From September 9 to December 3, a solitary bottlenose dolphin stayed in the Baltic Sea of Schleswig-Holstein, mainly in the Kiel Firth and Eckernförde Bay, Germany. The dolphin was given two different names by the public, Freddy and Fiete, and was identified as male by divers. It had five recognizable, eyelash-like scars rostral of the left eye by which it was photo-identified (Fig. 2a). Furthermore, there are at least four vertical cuts caudal of the left eye (Fig. 2a) and several recognizable scars on the left side of the blowhole (Fig.

Fig. 2 Pictures of the bottlenose dolphin showing eyelash-like scars rostral of the left eye and vertical cuts caudal of the left eye (**a**) as well as recognizable scars on the left side of the blowhole (**b**). Picture by courtesy of Philipp Hoy

2b). Dolphin sightings were posted by the public on the Internet for almost 79% (71/90 days) of its stay in the German Baltic Sea. During the stranding of the six harbor porpoises (between September 22 and October 31) sighting data was available for 95% (38/40) of the days. The movement patterns of the bottlenose dolphin were reconstructed by mapping those sightings. The dolphin sightings showed a temporal and spatial correlation with the strandings of all six harbor porpoises (Fig. 3). The dolphin was seen in the respective area for at least 6 days before each stranding. Focusing on all strandings of harbor porpoises during the presence of the bottlenose dolphin in the German Baltic Sea, a total number of 92 such stranding incidents were recorded along the Baltic Sea coast of Schleswig-Holstein, with six of those cases (6.5%) showing a lesion pattern suggestive of a dolphin attack.

Discussion

The pathological findings, combined with the spatio-temporal correlation of stranding of the harbor porpoises and sightings of the bottlenose dolphin, indicate six cases of fatal dolphin-related trauma in the Kiel Firth and Eckernförde Bay, Germany. The findings described here were previously rarely seen in this area. Database research over a period of almost 30 years showed that of a total of 1410 necropsied harbor porpoises, only six additional animals, found in 1996, 2006, 2013 and 2014, displayed similar blunt trauma of unknown genesis. This indicates the rarity of the six current cases. Although some of their injuries seemed to be caused post-mortem, others occurred most likely intra vitam, resulting in the death of the six animals. The described traumatic lesions are similar to previously reported blunt trauma caused by bottlenose dolphins in different parts of the world [3–5, 15, 20]. Bilateral bruising and hemorrhaging in the subcutis and underlying muscles as well as multiple rib fractures seem to be typical lesions in this context. Internal hematoma, lung lacerations, internal bleeding, and fractures of the mandible and the skull had been previously documented [5, 15, 20]. However, none of the described cases showed

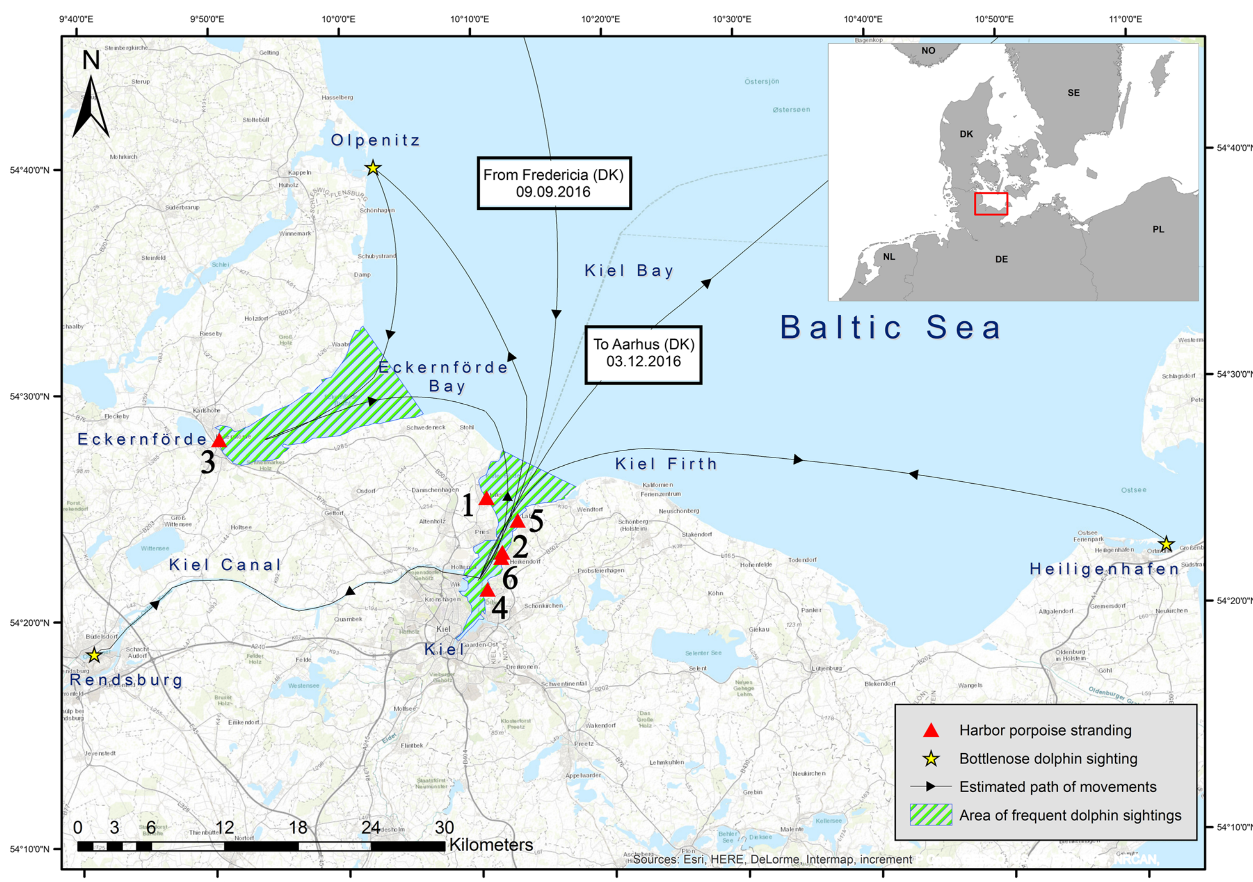

Fig. 3 Sighting locations of the solitary male dolphin and stranding locations of the six harbor porpoise carcasses found with blunt trauma during the presence of the dolphin. Shaded zones show the main areas where the dolphin was sighted on consecutive days. Case numbers 1–6 are marked next to their stranding location. The first sighting of the bottlenose dolphin in German waters was on September 8, the last sighting was on December 3. The map was created using ArcGIS for Desktop 10.5 (©ESRI, Inc., USA)

specific rake marks as often noticed in other incidents [3, 5, 14, 20]. Externally, only mild skin abrasions and small single skin cuts were detected. In none of the histologically examined cuts, except one, were hemorrhages found, which may indicate a post-mortem or stranding-related cause. The case with mild hemorrhages (case No. 4) did not show a cellular inflammatory reaction to the injury, thus indicating that this developed shortly before death. Therefore, it may be either dolphin-associated or caused during a potential live stranding. The observed post-mortem skin lesions may be caused by scavenging birds or pushing of the carcasses over the seabed and ashore by the current or breakers. The long straight cut in the flank of two animals (case No. 1, 5) most likely occurred post-mortem as there was no histological evidence of vital skin reactions.

In case No. 1, the injuries were regarded as sufficiently severe to lead directly to death. Here, multiple rib fractures corresponded with a hemothorax and a probable intravital lung laceration, leading to severe respiratory insufficiency. Furthermore, a possible pneumothorax might have caused suffocation. In the other five cases, the cause of death could not be determined with certainty. Case No. 5 is the only one that showed severe alveolar edema; it also only had few injuries. The pathological findings cannot exclude asphyxiation in this animal. It is, however, completely speculative whether the dolphin drowned this porpoise by pushing it under water. Although net marks are missing, by-catch cannot be completely excluded. In the other animals, as far as lesions could be assessed due to post-mortem changes, a post-traumatic shock, associated with respiratory insufficiency due to rib fractures and/or pre-existing pulmonary diseases (case No. 3), is likely to have resulted in fatal cardiovascular failure.

The affected harbor porpoises varied in terms of the age class and length. A preference for females (5/6) and animals in moderate or poor body condition (5/6) might be supposed, but it could not be proven with the present small sample size. In a study in northern California, the sex ratio of harbor porpoise victims was distributed equally between males and females [21].

Other potential causes, such as boat strikes or fatal interactions with odontocete species other than the bottlenose dolphin, appear to be unlikely in the presented cases. A collision with a boat might cause similar blunt trauma but would be expected to be mainly unilateral. Especially subcutaneous hemorrhages would be limited to the impact site [22]. In the present study, four of six carcasses had hemorrhages on both sides of the trunk. Furthermore, seasonal incidents of boat strikes have been associated with a temporary boat traffic increase [23]. September and October, the months in which the harbour porpoise strandings took place in the Baltic Sea, are not typical for high boating activities in the respective area. Other cetacean species, except the native harbour porpoise, are only sporadic, short-time visitors in the Baltic Sea. Besides bottlenose dolphins, occasionally occurring odontocetes mainly include white-beaked dolphins and common dolphins (*Delphinus delphis*) [24]. In addition, within the last 20 years one northern bottlenose whale (*Hyperoodon ampullatus*), one Risso's dolphin, one orca (*Orcinus orca*) and two long-finned pilot whales (*Globicephala melas*) were reported as strandings from the Danish Baltic Sea coast [24, 25]. Of these, also white-beaked dolphins and killer whales have been shown to cause blunt trauma to other marine mammals, including harbour porpoises [11, 26]. As the German and Danish Baltic Sea coast is characterized by a high human population density, a high number of recreational boats and an intense commercial shipping, sightings and reports of exceptional cetaceans are very likely [27]. Those sightings are often shared via social media and/or picked up by the local press. During the occurrence of the presented incidences, no other unusual cetacean sightings than the single bottlenose dolphin were reported.

In the Moray Firth, Scotland, an area where both harbor porpoises and bottlenose dolphins appear all year round, up to 63% of the stranded harbor porpoises were recorded to have died due to bottlenose dolphin attacks [3]. Unlike the Moray Firth, harbor porpoises are the only native cetacean species in the Baltic Sea [19, 28, 29]. The rare sporadic occurrence of dolphins in the German Baltic Sea is further reflected by five recorded cases of stranded individuals that have been necropsied during a 30-year period (1987–2016). These include three common dolphins, one white-beaked dolphin and one bottlenose dolphin. Therefore, interactions between dolphins and harbor porpoises are rare events in the German Baltic Sea.

By correlating the sighting data from public postings on social media and local news channels, the above-reported porpoise deaths coincided with the presence of a solitary male bottlenose dolphin. The dolphin could be identified in photographs and underwater videos due to recognizable scars. Interestingly, the presence of an unidentified dolphin pair at the beginning of 2016 did not result in any known harbor porpoise death along the German coasts. In contrast, attacks on porpoises in Denmark were observed both by the same individual (identified through photo ID) as well as by a dolphin pair which may or may not be the same one as that sighted in German waters (personal communication by Magnus Wahlberg, Marine Biological Research Center, University of Southern Denmark, Hindsholmvej 11, 5300 Kerteminde, April 2017). Interestingly, anecdotal reports indicate that harbor porpoise sighting frequencies were reduced while the dolphin was sighted in an area (personal communication by Stephan Thomsen, private videographer, Auf dem Löwenberg 9, 24,943 Flensburg, Germany, May 2018). This observation corresponds with earlier findings using T- and C-PODs (porpoise click detectors), which showed that the auditory presence of the harbor porpoises clearly decreased when bottlenose dolphins appeared. However, those studies could not clarify whether the harbor porpoises left the area or just reduced their acoustic activity [30, 31].

The motive for the attack and killing remains unknown. There have been several assumptions explaining the reason for this behavior and there could be several factors, depending on the specific situation and the individuals involved. Interspecies territoriality, defense of group members, food competition, feeding interference, object-orientated play, including practicing infanticide or fighting, sexual frustration, and aberrant behavior have been discussed in this context [3–5, 15, 20]. Interestingly, in Monterey Bay, California, USA, photo-identified bottlenose dolphins were witnessed attacking harbor porpoises and all known aggressors were males [5]. The dolphin in the Baltic Sea was also identified as male by divers to whom the dolphin displayed mating behavior with a visible penis (personal communication by Thorsten Peuster, Tauchen & Meer, Jungfernstieg 69, 24,340 Eckernförde, Germany). In northern California, where the main breeding season of bottlenose dolphins is estimated to be in summer, the porpoise attacks mainly occurred during the fall [5, 21, 32]. This might lead to the assumption that the attacks are linked to mating behavior and/or sexual frustration when female bottlenose dolphins are not in estrus anymore. In this context, it is to note that the highest distribution overlap of harbor porpoises and bottlenose dolphins in that area occurs during summer, because during these months harbor porpoise come close to the shore, entering the range of the coastal bottlenose dolphin population [5]. In the Baltic Sea, the lethal interactions also took place in the fall. Conversely, in the UK, where the ranges of both species overlap during the whole year, cases of porpoises being killed by dolphins occurred all around the year but with a peak in June [3]. Thus, most of the attacks occurred before the main breeding season between July and September [33]. It can be speculated that the solitary male dolphin from the Baltic Sea belongs to the permanent bottlenose dolphin population of the Moray Firth because it is the nearest.

Noteworthy is also that this is the first report of a socially isolated bottlenose dolphin attacking harbor porpoises. Witnessed attacks reported in the literature were either committed by a group of dolphins [3, 5] or by a dolphin which belonged to a group nearby [5]. Dolphins are typically highly social animals living in groups. However, some individuals are solitary animals and in addition, some of these animals are known to socialize with humans [34].

The reasons behind the attacks in Kiel and Eckernförde can only be speculated. The behavior of the bottlenose dolphin was reported by various social media postings and local press reports as being extremely friendly toward swimmers and divers; it even actively searched for physical contact. However, to determine the motive for the aggressive behavior toward the harbor porpoises, more information would be needed concerning the social status, sexual activity, and the hormone status of the aggressor as well as the specific situation itself.

Conclusion

Lethal aggression of bottlenose dolphins towards harbor porpoises has been reported in different parts of the world. The current study depicts the first incidents of this behavior in the German Baltic Sea where harbor porpoises are the only native cetacean species and dolphins are only temporary inhabitants. Moreover, this is the first report of a socially isolated male dolphin committing porpicide. Besides the unusual traumatic lesions found in this area, in six harbor porpoise carcasses, sightings posted on social media were used to show a spatial and temporal correlation with these six harbor porpoise stranding locations and the appearance of the dolphin.

Methods

As part of the German stranding network of Schleswig-Holstein, stranded marine mammals are retrieved and routinely necropsied at the Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover, Foundation. In 2016, 159 harbor porpoises were found stranded dead on the Baltic Sea coast of Schleswig-Holstein. Six of these porpoises (cases No. 1–6) showed blunt trauma. Four of these animals were necropsied freshly, while two with an advanced decomposition status had been previously frozen. A full post-mortem examination was performed on the four fresh carcasses (cases No. 3–6), as described previously [35], while the examination of the other two (cases No. 1, 2) was limited due to decomposition. In the four adult animals, six teeth from the left lower jaw were removed for estimating their age by counting the annual growth layers [36]. The two calves were estimated to be aged 3–4 months based on their stranding dates and known birth periods in the Baltic Sea [37]. The carcasses were macroscopically examined externally and internally. Their nutritional status was judged based on the blubber thickness and the state of muscles [35]. Depending on the decomposition status, histopathological samples were taken routinely from various organs and any tissue showing morphological changes. For histopathology, the samples were fixed in 10% buffered formalin, embedded in paraffin wax, sectioned at 3 μm and stained with hematoxylin and eosin. In keeping with the findings, bacteriological, virological and parasitological samples were taken and investigated as described previously [35]. Genetic analysis was performed for case numbers 4 and 5 to determine whether they were a mother-calf-pair by genotyping part of the mitochondrial Control Region and 14 autosomal microsatellites [38, 39]. As all research was conducted on deceased animals, no ethics approval was required.

A map was created to illustrate the spatial and temporal connection between the stranding of these six harbor porpoises and the sighting of a solitary bottlenose dolphin that was present in the German Baltic Sea during that period. Using ArcGIS (ESRI, Version 10.4), the stranding locations and dates were added to the data on dolphin sightings. Information about the occurrence of the identified bottlenose dolphin was taken from the sighting reports posted on the Internet [34–38].

Abbreviations
Yrs: Years; cm: Centimeter; n. d.: Not determined

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Authors' contributions
SG collected and analyzed the data, designed and wrote the manuscript. PC collected and analyzed social media sighting posts and created the ArcGIS map. PW performed the histological examinations, analyzed, and interpreted the histological data and substantially revised the manuscript. TK, JL, AR and MR performed necropsies and contributed to writing and revising the manuscript. RT performed the genetic analysis. US initiated this study and substantially revised it. All authors read and approved the final manuscript.

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Availability of data and materials
All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate
All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. As all research was conducted on deceased animals, no ethics approval was required.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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