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ORIGINAL ARTICLE

Larynx strangulation in a resident bottlenose dolphin (*Tursiops truncatus*) from the Northern Adriatic Sea, Croatia

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Abstract: Marine environments worldwide are affected by various anthropogenic activities, and many cetacean populations face increasing human pressures, especially those in coastal habitats. The key threats affecting common bottlenose dolphins (*Tursiops truncatus*) today are fishery interactions, prey depletion, habitat disturbance, pollution and climate change. The Mediterranean basin is one of the areas subjected to enormous pressure from human activities, in particular the Adriatic Sea, where bycatch represents the most frequent cause of dolphin mortality related to fisheries, followed by larynx strangulations, long-term tail entanglement and presence of fishing gear residue in the stomach. In this study, we present the first published case of a resident bottlenose dolphin from the Adriatic Sea population with a known observation history and confirmed cause of death observed in the Croatian part of the Adriatic Sea. By comparing the photographs of the dolphin's dorsal fin taken during the *post mortem* examination with those obtained from boat-based surveys, we were able to identify the individual L_1834, which has been observed since 2018 along the eastern coast of the northern Adriatic Sea. Over three decades of monitoring live bottlenose dolphins and their systematic mortality surveillance in Croatian waters enabled us to gain insight into the ranging and residency pattern of the dolphin stranded in 2023 due to larynx strangulation with fishing net parts.
Keywords: bottlenose dolphin; larynx strangulation; photo-identification; Adriatic Sea; dolphin - fisheries interactions

Sažetak: STRANGULACIJA GRKLJANA KOD REZIDENTNE JEDINKE DOBROG DUPINA (*Tursiops truncatus*) NA PODRUČJU SJEVERNOG JADRANA. Morski ekosustavi diljem svijeta pod utjecajem su raznih antropogenih čimbenika, a mnoge populacije kitova u priobalnim staništima suočavaju se sa sve većim pritiscima. Interakcija s ribarstvom, iscrpljivanje plijena, uništavanje staništa, onečišćenje i klimatske promjene, prepoznati su kao ključne prijetnje s kojima se danas suočavaju dobri dupini (*Tursiops truncatus*). Sredozemno more jedno je od područja pod ogromnim pritiskom ljudskih aktivnosti, osobito Jadransko more gdje je prilov najčešće zabilježen uzrok uginuća dupina povezan s ribarstvom, nakon čega slijede strangulacija grkljana, dugotrajno zaplitanje u ribolovni alat i njegovo gutanje. U ovom radu predstavljamo prvi objavljeni slučaj rezidentnog dobrog dupina iz populacije Jadranskog mora s potvrđenim uzrokom uginuća i utvrđenom povijesti opažanja tijekom terenskih istraživanja na području hrvatskog dijela Jadranskog mora. Usporedbom fotografija leđne peraje dupina snimljenih tijekom postmortalnog pregleda s onima dobivenim tijekom opažanja živih jedinki s broda, uspjeli smo identificirati jedinku L_1834, koja je praćena od 2018. godine duž istočne obale sjevernog Jadrana. Više od tri desetljeća praćenja živih jedinki dobrog dupina i sustavnog praćenja njihove smrtnosti u hrvatskim vodama, omogućili su nam uvid u obrasce kretanja i obitavanja dupina pronađenog 2023. godine, čiji je uzrok uginuća bila strangulacija grkljana dijelovima ribarske mreže.
Ključne riječi: dobri dupin; strangulacija grkljana; foto-identifikacija; Jadransko more; interakcije dupina i ribarstva

INTRODUCTION

The common bottlenose dolphin (*Tursiops truncatus,* hereafter: bottlenose dolphin) is a cosmopolitan cetacean species within the group of toothed whales (Odontoceti) that inhabits temperate and tropical zones (Reeves *et al*., 2002), and the only cetacean species regularly inhabiting the entire Adriatic Sea (Bearzi *et al*., 2024). The species is protected under the Nature Protection Act (Republic of Croatia, 2013) in Croatia and is included in Annexes II and IV of the Directive of the EU Habitats. Moreover, the Mediterranean subpopulation is listed as "least concern" (LC) according to the latest IUCN assessment (Natoli *et al*., 2021).

The abundance of bottlenose dolphins in the Adriatic Sea was estimated at 5700 individuals (95% CI=4300-7600) from aerial surveys conducted in 2010 and 2013 (Fortuna *et al*., 2018), and at 10350 individuals (95%

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CI=5896-18166) from an aerial survey conducted in 2018 (Panigada *et al*., 2024). However, these estimates are not corrected for perception and availability bias, thus, the actual abundance is expected to be higher. Along the Croatian Adriatic coast, the population is structured into distinct communities with relatively low migration rates between them (Pleslić *et al*., 2019). One such community resides in the area of Kvarnerić (north-eastern Adriatic), where dedicated boat surveys have been conducted since 1987 to study the spatial and temporal distribution of bottlenose dolphins, site fidelity, demographic parameters, behaviour and their interactions with human activities (Bearzi *et al*., 1999; Fortuna, 2006; Pleslić *et al*., 2015, 2019). The abundance of bottlenose dolphins in Kvarnerić was estimated to vary annually between 112 and 310 individuals in the period from 2004 to 2011 (Pleslić *et al*., 2015), with numerous individuals showing long-term residency in the area (Rako-Gospić *et al*., 2017; Pleslić *et al*., 2019). Additionally, mortality monitoring has been carried out over the last three decades in the whole Croatian Adriatic Sea according to the national Protocol for reporting of injured/sick or dead protected marine animals (sea turtles, marine mammals, sharks) (Đuras *et al*., 2021).

Bottlenose dolphins living in coastal habitats are generally subjected to various human pressures that can affect their abundance and distribution (Natoli *et al*., 2021). Ongoing threats to this species in the Mediterranean Sea include epizootic outbreaks, fishery-related mortality and other fishery-related disturbance, prey depletion, boat traffic and acoustic disturbance, intentional killing, marine pollution, and climate change (Bearzi *et al*., 2008; Natoli *et al*., 2021). This pattern is also observed in the Croatian part of the Adriatic Sea, where dolphin-fisheries interactions appear to play a significant role in bottlenose dolphin mortality since bycatch, larynx strangulation with fishing net parts, chronic entanglements and fishing gear residues in the digestive system were recorded in 32% of *post mortem* examined bottlenose dolphins found in that area (Đuras *et al*., 2021).

Larynx strangulation with fishing net parts has been described as the result of a specific dolphin-fisheries interaction where dolphins tear off a part of the set net during depredation (Đuras Gomerčić *et al*., 2009). Such a fishing net part may surround the larynx and cause severe injuries to the laryngeal wall, or it may lead to death due to asphyxia (Đuras Gomerčić *et al*., 2009). This pathological condition is unique to toothed cetaceans due to the specific anatomy of the larynx, which was acquired during evolution as an adaptation to aquatic life. Namely, the larynx in odontocetes forms orally and dorsally a specific tubular extension whose tip lies ventral to the choanae. It remains in an elongated position during deglutition when the food is swallowed through wide lateral channels. The larynx position provides a direct passage for air to reach the trachea and lungs (Reidenberg and Laitman, 1987; Brzica *et al*., 2015). Because of its position in toothed cetaceans, it is subject to foreign body injuries, especially during depredation from fishing nets (Đuras Gomerčić *et al*., 2009).

Our study describes a case of a bottlenose dolphin, resident in the north-eastern Adriatic Sea, which died because of larynx strangulation with a part of a fish net. The peculiarity of this case is that the individual was identified during boat surveys and monitored over several years before it was found dead in 2023. It represents one of the rare cases of bottlenose dolphins in the Adriatic Sea with data on its ranging during life, stranding location and cause of death.

MATERIAL AND METHODS

Sightings of the bottlenose dolphins were recorded during boat-based surveys conducted in the Kvarnerić region since 1987, the island of Vis region since 2007, and the North Dalmatia region since 2013. These areas are also part of the "Northern Adriatic and Dalmatian Archipelago Important Marine Mammal Area (IMMA)" designated for bottlenose dolphins (IUCN-MMPATF, 2017). A sighting was defined as the continuous monitoring of an individual dolphin or a group of dolphins (Shane, 1990; Mann and Smuts, 1999). Behaviour data were collected at the beginning and throughout the observation period, defined as the behaviour exhibited by more than 50% of individuals within the observed group. Behavioural categories were established based on the classifications proposed by Bearzi *et al*. (1999) and Lusseau (2006). A detailed description of each behaviour category is provided in Table 1.

A Samsung Tab A 10 tablet computer with a GPS receiver and NaviLog application was used to record the location, time, behaviour, size and age composition of the group. A standard, non-invasive photo-identification protocol (Würsig and Jefferson, 1990) was used to collect photographs of present individuals using professional grade cameras, the Canon EOS R5 and EOS 7D equipped with Canon EF 70–200 mm F/2.8 L USM lenses.

Individuals in the photographs were identified based on natural markings (notches, cuts and deformities) by cross-referencing the dorsal fin reference catalogue of the Blue World Institute, according to Pleslić *et al*. (2015). Following the *post mortem* examination, photographs of the dorsal fin with well-preserved natural markings were analysed and compared with the dorsal fin reference catalogue to determine whether the carcass could be matched to a previously identified and monitored individual. Sighting data of the stranded dolphin were extracted from the database and used to determine its sighting locations, behaviour and check for evidence of previous interactions with fisheries. Following the criteria of Gubbins (2002) and Chen *et al.* (2011), dolphins were classified as resident if they were observed on ten or more occasions and at least once *per* year. Furthermore, its sighting locations were used to estimate

Table 1. Behaviour categories adapted from Bearzi *et al.* (1999) and Lusseau (2006).

Behaviour	Definition
Dive (D)	Pattern characterized by cycles of single long dives (>1 min) spaced by clusters of a relatively regular number of ventilations; group stays within the same area.
Dive-travel (DT)	Single long dives (>1 min) accompanied by a pattern of clustered ventilations; groups move in a certain direction.
Travel (T)	Individuals resurface in irregular and short intervals (<1 min); consistent directional movement of dolphins.
Travel slow (TS)	Individuals are travelling in a direction, but are moving significantly more slowly than during other behaviours.
Travel fast (TF)	Individuals are travelling at high speed in a direction, mostly at the surface. Travel fast is characterised by animals horizontally leaping in the direction of travel, splashing up water in the process.
Social travel (ST)	Individuals resurface in irregular and short intervals (<1 min), moving steadily in one direction, while socializing intermittently.
Socialise (S)	Display of surface behaviour (jumps, leaps, rolling, tail slaps, etc.); group stays within the same area.
Surface feeding (SF)	Feeding activities performed near the water surface; fish jump from the water; individuals jump for fish.
Milling (M)	Individuals move slowly below the surface with occasional surfaces; group stays within the same area.
Active trawler follow (ATF)	Following wake of operating trawler, at about 100 – 300 m stern; regular single long dives for several minutes (>2 min) are followed after several short-interval surfaces.
Passive trawler follow (PTF)	Following the wake of an operating trawler, at about 100 – 300 m stern; individuals resurface in irregular and short intervals (<1 min).
Purse seiner follow (PSF)	Individuals are located up to 300 m from the purse seiner, dive in different directions, occasionally approaching the vessel, and dive significantly longer (> 1 min).
Mixed behaviour (MIX)	Different behaviours are performed inconsistently by different individuals or subgroups.
Not available (N/A)	Not possible to determine the group behaviour.

home range using a non-parametric, utilization distribution estimator, the 95% fixed-kernel density estimator (KDE) with smoothing parameters calculated using the reference bandwidth (Worton, 1989).

Navigation data were analyzed using ArcMap 10.4 (ESRI, 2013). Adobe Photoshop Lightroom Classic 10.2 (Adobe Inc., 2021) was used for organizing and assigning the dolphin identity and navigation data to photographs. The 95% KDE was calculated using R 4.2.1 Statistical Software (R version 4.2.1 (2022-06-23 ucrt); R Core Team, 2022) with adehabitatHR (v0.4.21; Calenge and Fortmann-Roe, 2023) and sf (v1.0.16; Pebesma and Bivand, 2023) R packages.

From October 1990 to July 2023, *post mortem* examinations of marine mammals found dead in the Croatian part of the Adriatic Sea were carried out by the Faculty of Veterinary Medicine, University of Zagreb, under the supervision of the National Institute for Environment and Nature Protection, with the current annual permit No. UP/I-352-04/23-08/92, 517-10-1-2-23-4 granted by the Ministry of Economy and Sustainable Development, Republic of Croatia. *Post mortem* examinations were performed following a standard necropsy protocol modified according to Kuiken and García Hartmann (1991). For each specimen, stranding circumstances, date, and location of stranding were recorded. Species and sex were determined according to morphological features. The carcass's condition code was assigned based on the criteria outlined by Ijsseldijk *et al.* (2019). According to their findings, seagulls and both terrestrial and marine predators may begin attacking live stranded dolphins, particularly targeting the eyes, skin, blubber at the jaw, and body openings, possibly already injured from contact with rocks or shells during the stranding event. Consequently, external damage may be evident prior to death. Additionally, dehydration of the skin, eyes, and

exposed mucous membranes should not be considered a reliable indicator of the *post mortem* interval, as tissues submerged in water often retain a vital appearance for an extended period. It is also important to note that the coding system does not provide a specific gradation for dorsal fin decomposition, offering only general descriptions related to skin condition. Body mass and external measurements were taken according to Perrin (1975). Gross observations were recorded during necropsy and photographed. Depending on the decomposition code, tissue samples were collected for histopathological examination, genetic and toxicological analyses. If present, stomach content was analysed by gross examination. Tissue samples, skeletons, reports and photographs were deposited at the Department of Anatomy, Histology and Embryology of the Faculty of Veterinary Medicine, University of Zagreb, Croatia.

RESULTS

The stranded dolphin was first identified during a boat survey on July 19, 2018, as an adult and assigned the code L_1834 (Fig. 1). In the period from July 2018 to June 2023, this dolphin was observed on 20 occasions (Table 2). The 95% KDE home range of L_1834 was estimated to be 1859,4 km^2 (Fig. 2). Individual L_1834 was categorized as a resident because 1) it was observed on ≥10 occasions (Table 2); 2) it was seen at least once each year (Table 2) and 3) it had a relatively small home range (Fig. 2).

Overall, 372 photographs of this individual were examined. Except for the natural markings obtained during the social interactions (Fig. 1), there were no visible injuries that would indicate previous interaction with fishing gear. The number of individuals in the groups where L_1834 was observed ranged from 1 to 40 bottlenose dolphins. The mean group size was 11.4 (SE=2.1). Group compositions were a mix of age classes and sexes. Of the 20 recorded sightings of this individual, two occurred in association with a purse seine and one with a bottom trawler. In these instances, the dolphin was observed following the respective fishing vessels. However, no direct evidence of foraging behaviour or prey capture was documented (Table 2).

A total of 14 hours and 58 minutes were spent observing the behaviour of this individual across all sightings, of which it spent 68.1% engaged in feeding-related behaviours (DT, D, PSF, ATF). To a smaller extent of time (15.7%), the individual was engaged in activities indicating resting or socialising (M, TS, ST, S), whereas travelling (T) was observed in 16.2% of total time (Fig. 3 and Table 1).

On July 13, 2023, a dolphin carcass was found on the beach in the village of Košljun (44°23'53'' N; 15°4'36'' E), island of Pag, Croatia (Fig. 4), and it was transported to the Faculty of Veterinary Medicine, University of Zagreb, Croatia. The carcass was in the advanced stage of decomposition, i.e., the epidermis was peeled off from most of the body, the penis and eyeballs were prolapsed. Furthermore, the dorsal fin exhibited partial loss of the epidermis, which is considered indicative of advanced decomposition according to Ijsseldijk *et al*. (2019). The external examination of the dead dolphin showed that it was a male, 308 cm long and in good body condition. One of the most notable external features observed on the carcass was a fragment of a fishing net hanging from the mouth. Pathoanatomical dissection revealed a fishing net part, 90 cm in length, that encircled the larynx of the dolphin. The mucosal lining of the external surface of the epiglottic and arytenoid cartilages showed

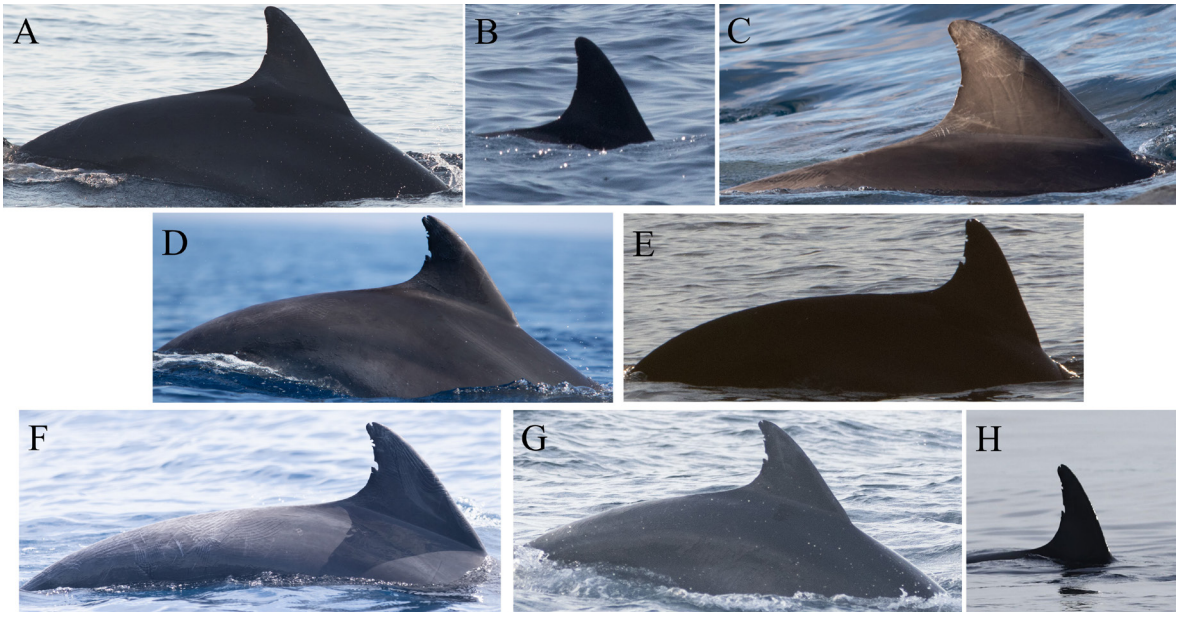

Fig. 1. Natural markings identified on photographs of the bottlenose dolphin L_1834 recorded in 2018 **(A, B, C)**; 2021 **(D, E)**; 2022 **(F, G)** and 2023 **(H)**.

Table 2. Overview of dates, times, locations and group sizes of the sightings of bottlenose dolphin L_1834 (*- sighting behind purse seiner, **- sighting behind trawler).

Sighting	Date	Time	Lat	Lon	Group size
1	19/07/2018	7:14:46	44°13’29” N	14°44’23” E	1
2	20/07/2018	13:59:37	44°27’58” N	14°39’43” E	40
3	16/08/2018	15:22:34	44°27’51” N	14°39’41” E	16
4	16/08/2018	15:02:24	44°28’22” N	14°39’56” E	11
5 *	09/11/2018	7:02:25	44°24’8” N	14°31’44” E	21
6	10/06/2019	11:52:18	44°21’35” N	14°39’41” E	6
7	19/06/2019	11:12:27	44°26’56” N	14°40’11” E	8
8 **	13/09/2020	10:51:17	44°28’8” N	14°35’48” E	29
9	14/09/2021	13:00:29	44°12’5” N	14°31’15” E	10
10	02/10/2021	16:56:12	44°27’33” N	14°41’54” E	10
11	07/06/2022	13:39:19	44°23’57” N	14°43’52” E	9
12	25/06/2022	13:51:17	44°32’59” N	14°33’51” E	2
13	25/06/2022	16:32:33	44°33’0” N	14°33’52” E	10
14	29/06/2022	16:25:19	44°29’0” N	14°32’57” E	4
15	01/07/2022	13:39:50	44°37’33” N	14°36’51” E	4
16	01/08/2022	13:33:25	44°30’3” N	14°37’49” E	6
17	08/08/2022	11:32:44	44°20’15” N	14°48’58” E	16
18	20/09/2022	11:43:02	44°26’39” N	14°27’35” E	13
19 *	25/11/2022	7:43:59	44°25’47” N	14°29’57” E	4
20	14/06/2023	16:20:02	44°31’22” N	14°36’26” E	8

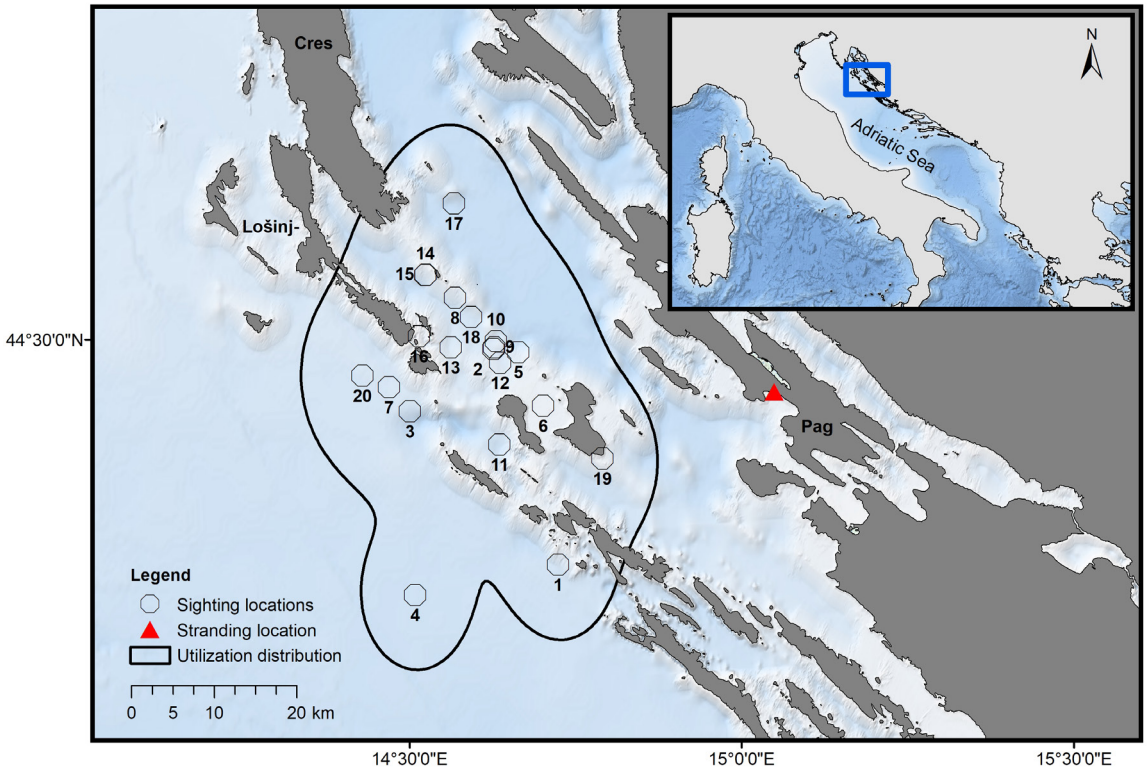

Fig. 2. Locations of sightings, estimated home range and the stranding location of bottlenose dolphin L_1834.

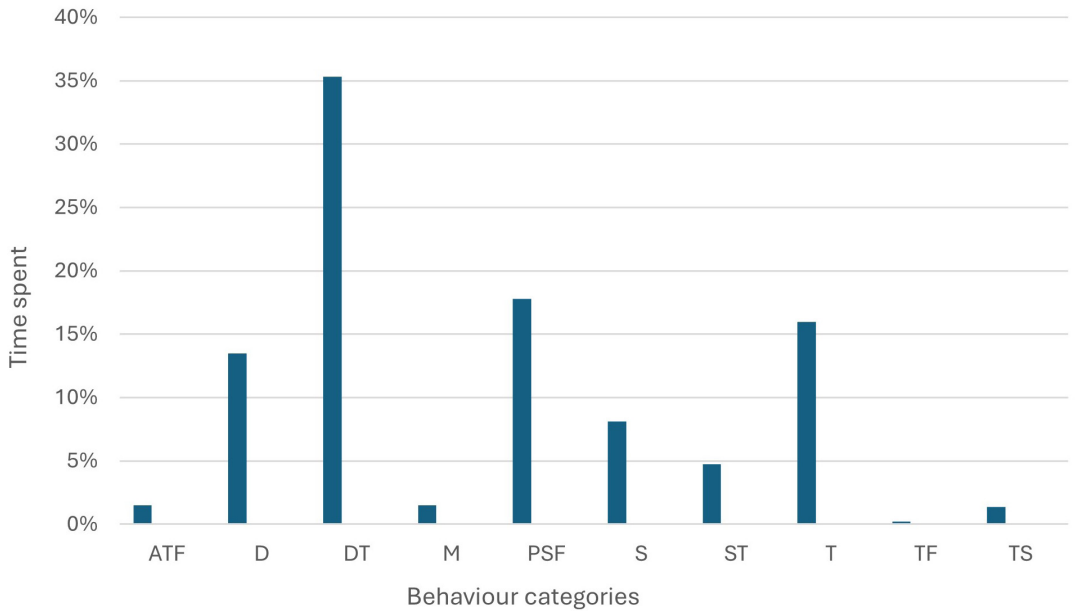

Fig. 3. Total behavioural budget (ATF: Active trawler follow; D: Dive; DT: Dive-travel; M: Milling; PSF: Passive trawler follow; S: Socialise; ST: Social travel; T: Travel; TF: Travel fast; TS: Travel slow).

two ring-formed lesions, one broad, proximal and another narrow, distal lesion. Those lesions reached the depth of the laryngeal cartilages. The third lesion of the laryngeal wall was detected on the caudal aspect of the intra-arytenoid fold. That lesion protruded up to the mucosal lining of the laryngeal cavity, however, a full perforation of the laryngeal wall was not recorded. No food remains were recorded in the stomach or along the intestine. There were no other detectable pathoanatomical changes, moreover, the tissues were not suitable for fur-

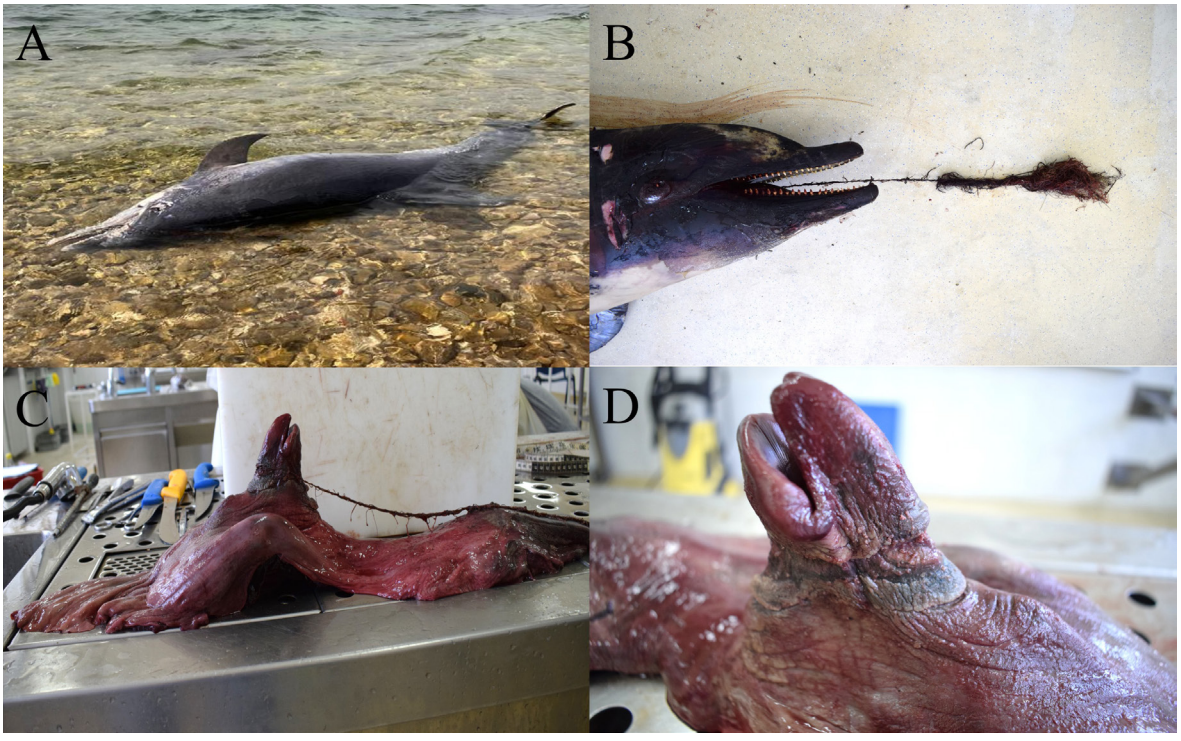

Fig. 4. Stranded bottlenose dolphin on the beach in Košljun, Pag, Croatia **(A)**; fishing net part hanging from the dolphin's mouth **(B)**; eviscerated larynx with the fishing net part **(C)**; two ring-formed lesions of the laryngeal wall, fishing net part removed **(D)**.

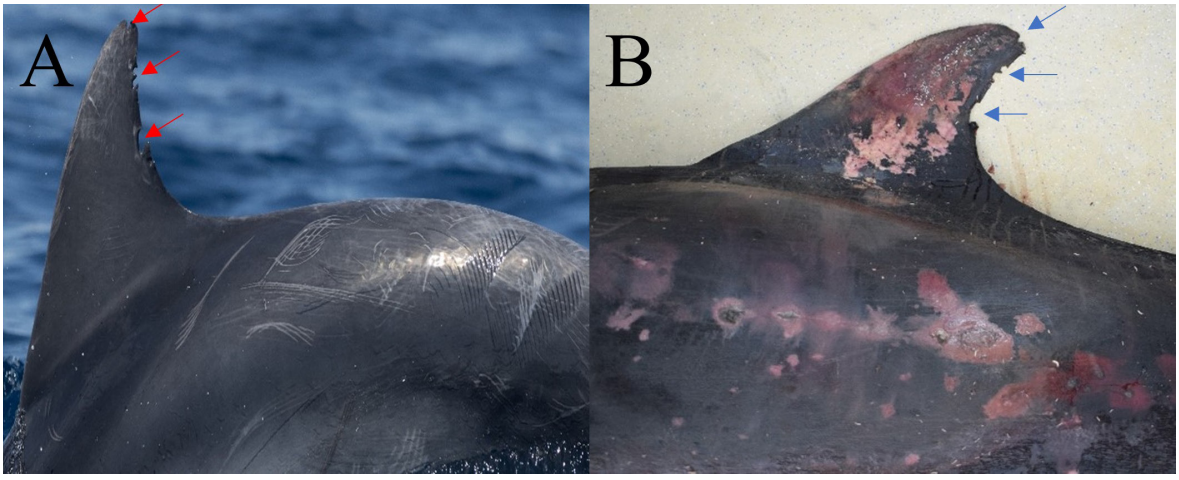

Fig. 5. Matching of the live **(A)** and dead bottlenose dolphin L_1834 **(B)** based on the natural markings on the dorsal fin.

ther histopathological examination due to the advanced decomposition.

Even though the carcass was classified as being in advanced decomposition, the notches on the trailing edge of the dorsal fin were well preserved, enabling comparison with the reference catalogue. Based on the shapes, sizes and relative positions of the notches, the individual was identified as bottlenose dolphin L_1834 (Fig. 5).

The stranding location of dolphin L_1834 was compared to its sighting locations while alive (Fig. 2). All the sightings were relatively close to the stranding location.

DISCUSSION

The monitoring of free ranging animals is a complex process that ideally includes observations and samplings of live animals in their habitat, along with detailed examinations of specimens and analyses of their tissues after their death to better understand their ecology and conservation status. In our study, the intensive monitoring of the bottlenose dolphin population enabled insight into the ranging and residency pattern of the stranded dolphin. This paper represents one of the few published cases of a bottlenose dolphin from the Adriatic Sea population with both a known observation history and a confirmed cause of death. Namely, Genov *et al*. (2016, 2019) reported two identified bottlenose dolphin carcasses of known origin, one of which was found entangled in fishing gear. In contrast, despite more than three decades of monitoring live bottlenose dolphins along the eastern Adriatic coast, combined with the systematic *post mortem* examinations, no previous identified matches between monitored individuals and stranded carcasses have been documented in the study area. We assume that one contributing factor is the fact that over 60% of carcasses are discovered in an advanced state of decomposition, by which time the identifying marks have disappeared due to decay.

The cause of death of dolphin L_1834 belongs to a type of dolphins-fisheries interactions previously described in bottlenose dolphins from the Adriatic Sea (Đuras Gomerčić *et al*., 2009). Larynx strangulation with a fishing net is a pathological condition known from coastal dolphins that inhabit areas where bottom set nets are frequently used for commercial fishing (Đuras Gomerčić *et al*., 2009; Carpentieri and Gonzalvo, 2022). It is presumed that resident dolphins depredate from fishing nets, to decrease efforts, whereby they tear off parts of the net with the fish, which can lead to entanglement and produce an incidental catch (Đuras Gomerčić *et al*., 2009; Carpentieri and Gonzalvo, 2022). The fate of the fishing net part may be as follows: 1) it may fall out of the mouth, which is the most favourable scenario for the dolphin; 2) it may be swallowed and end in the stomach, where it accumulates and represents a persistent foreign body; or 3) it encircles the larynx and might cause immediate death due to asphyxia or mild to severe injuries that may lead to acute or chronic health deprivation (Đuras Gomerčić *et al*., 2009).

However, larynx strangulation with the fishing net is not the only fatal dolphin-fisheries interaction recorded in the Adriatic Sea. Namely, between 1990 and 2019, as part of the mortality monitoring, 300 cetaceans found dead along the Croatian part of the Adriatic Sea were examined *post mortem* (Đuras *et al*., 2021). Fisheries interactions were identified in 32% of the cases, with bycatch representing the most frequently recorded interaction (19.7%). Larynx strangulations (5.3%), long-term tail entanglement (1%), and the presence of fishing gear in the stomach (7.3%) were classified as dolphins-fisheries interaction other than bycatch, although some of these cases were also designated as suspected bycatch (Đuras *et al*., 2021). This is in accordance with data obtained exclusively for the northern Adriatic coast, where the cause of death in 39% of dolphin carcasses documented between 2002 and 2020 was attributed to fisheries, either confirmed or highly suspected. Among these, by-

catch was confirmed as a cause of mortality in 17% of cases, while 22% were attributed to other fishery-related causes, including larynx strangulation and obstruction of the digestive tract (Genov, 2022; Evans *et al*., 2023).

In the case of L_1834, the strangulation was most probably caused by depredation on a bottom set net, based on the material the net was made of. Although *post mortem* examinations of bottlenose dolphins stranded along the Croatian coastline between 1990 and 2019 have provided clear, albeit circumstantial, evidence of interactions with fishing set nets (Đuras *et al*., 2021), direct observations of such interactions remain scarce, which prevents estimating the real rate and effect of such interactions on a (sub)population level. This is particularly concerning given that the distribution of bottlenose dolphins in the northern Adriatic Sea frequently overlaps with small-scale fisheries employing bottom set nets (e.g., gill and trammel nets) (Genov *et al*., 2008; Bearzi *et al*., 2024). Notably, depredation on bottom set nets appears to be a significant issue in both the northern and southern regions of the Adriatic Sea, particularly on a seasonal basis (Lauriano *et al*., 2009). This problem is especially pronounced in fisheries employing trammel nets, a widely used gear type for targeting various species of commercial interest, such as red mullet (*Mullus* sp.) and common cuttlefish (*Sepia officinalis*) (Lauriano *et al*., 2009). A recent pilot study confirmed that bottlenose dolphin foraging on trammel nets results in substantial economic losses for local fishers (Gonzalvo and Carpentieri, 2023). Furthermore, incidents involving the ingestion of net fragments and larynx strangulation of dolphins have been documented in gillnet fisheries within the same area (Gonzalvo and Carpentieri, 2023).

In addition to bottom set trammel nets and gillnets, commonly used in coastal Mediterranean fisheries, dolphins are also known to interact with trawl nets and small purse seines targeting pelagic schooling fish (Reeves *et al*., 2001). In our case, the dolphin L_1834 was previously observed engaging in such interactions: once following a bottom-trawler and twice a purse seine (Table 2). However, no direct evidence of foraging or prey capture was documented. As described by Bonizzoni *et al*. (2022), foraging in association with trawlers enhances prey accessibility and may, in certain cases, mitigate the effects of natural prey scarcity in areas affected by intensive fishing pressure or habitat degradation. In fact, the Kvarnerić area was found to have a notably higher rate of interactions with bottom trawlers (23.7%) compared to North Dalmatia (4%) and the island of Vis area (4.8%) (Pleslić, 2022). Furthermore, a study of Rako-Gospić *et al*. (2017) found that resident dolphins in this area utilize feeding behind bottom trawlers repeatedly, males more frequently than females. Dolphin L_1834 from our study was a male. However, the six cases of larynx strangulation in dolphins described by Đuras Gomerčić *et al*. (2009), resulting from interactions with set nets, were evenly distributed according to their sex, i.e., six males were affected, five females and one dolphin of unknown sex, thus, it seems that both sexes are at equal risk of fatal outcomes of fisheries interactions with set nets. Given that *post mortem* examinations have revealed interactions with various gear types, and that opportunistic feeding represents an important foraging strategy in the study area, resident individuals with relatively small home ranges, such as dolphin L_1834, are likely at increased risk of interacting with fisheries.

Depredation from fishing gear is the main cause of the negative attitude of fishermen towards dolphins. The negative attitude may lead to illegal actions such as deliberate killing of dolphins, which has been previously recorded in the Adriatic Sea (Đuras *et al*., 2021, 2024). Out of 209 fishermen interviewed in 2020 in different Italian and Croatian areas, 88% stated having observed the interaction between their fishing gear and dolphins, irrespective of the gear type (Li Veli *et al*., 2023). The fishing gears involved in that study included bottom trawls, set nets, longlines, and mid-water pair trawls. Reported damage to fishing gear varied across regions and seasons, with set nets being more frequently affected than other gear types, such as bottom trawls (Li Veli *et al*., 2023). Primarily, they reported damages to their catch (58.7%), followed by net depredation (56.1%) and fishing gear damage (22.5%). Overall, interactions between bottlenose dolphins and set nets appear to be increasing across the Mediterranean region (Carpentieri and Gonzalvo, 2022). These interactions may lead to a risk of bycatch, along with gear damage, catch depredation, and potentially notable economic impacts on fisheries (Carpentieri and Gonzalvo, 2022). Moreover, the compensation system for damaged fishing gear and catch loss due to dolphin depredation has been established, however, it seems not to be fully effective, at least in the Croatian part of the Adriatic Sea (Macan *et al*., 2021).

The current solutions to prevent or reduce interactions between marine mammals and fisheries include time-area closures, acoustic deterrent and exclusion devices, physical barriers, and other modifications to operations and fishing gear (FAO, 2021; Bonizzoni *et al*., 2022). While spatial closures and the implementation of codes of conduct are likely among the most effective measures for mitigating cetacean mortality (Tulloch *et al*., 2020), their application in open-ocean environments may be limited by practical and logistical constraints (Bonizzoni *et al*., 2022). Further research and development of strategies with innovative solutions are needed to minimize the interactions and conflicts, ensuring the conservation of these vulnerable species.

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