Injuries in cetaceans in the Strait of Gibraltar: an update for the period 2016–2020

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ABSTRACT

The Strait of Gibraltar is an important habitat for seven regularly occurring cetacean species. These waters are heavily used for fishing and therefore experience extraordinary levels of shipping traffic. Photography provides a valuable and non-invasive tool to monitor the health of cetacean populations, where external injuries may indicate specific anthropogenic impacts, such as vessel strikes or fishery interactions. We manually screened 27,866 photos taken during whale-watching operations between 2016–20 for human-induced injuries. Injuries of potential anthropogenic origin were detected in 228 cases. The severity of these injuries ranged from superficial linear marks to severe traumas that may affect survival and fitness. Severe injuries included a gunshot wound, vessel-related traumata and abrasions, signs of previous severe entanglements and deep lacerations which could stem from recreational fishery activities or propellor cuts and occasionally served as an entry point for dermal infections. In 2007, Spanish legislation introduced regulations on how to approach cetaceans by boat, but recreational fishery vessels have been commonly observed to disregard this law. We therefore urge stricter control and enforcement of existing laws and collaboration between the Spanish and Moroccan authorities to mitigate the human impact on cetaceans in this region.

KEYWORDS: CETACEANS; STRAIT OF GIBRALTAR; HUMAN IMPACT; WOUNDS; LACERATIONS; ENTANGLEMENT

INTRODUCTION

The nutrient-rich waters (Wierucka *et al*., 2014) in the Strait of Gibraltar are an important habitat for seven regularly occurring cetacean species: common dolphins (*Delphinus delphis*), striped dolphins (*Stenella coeruleoalba*), common bottlenose dolphins (*Tursiops truncatus*), long-finned pilot whales (*Globicephala melas*), killer whales (*Orcinus orca*), hereafter called orcas, sperm whales (*Physeter macrocephalus*) and fin whales (*Balaenoptera physalus*). This region is under intensive anthropogenic impact and carries a high potential for conflict between humans and marine mammals.

The Strait is an international shipping lane, with approximately 60,000 ships in transit every year.[3] Additionally, fast ferries are operated all year round, connecting the Spanish mainland with Morocco and the Spanish enclave Ceuta, with up to 156 ferries crossing the Strait during the main season.[4] To protect cetaceans from vessel-induced injuries, the Spanish Government recommended a 13-knot speed limit in 2007, but compliance remains low (Silber *et al*., 2012).

The Western Mediterranean Sea is intensively fished. Most fishery methods have been shown to lead to interactions with marine mammals and incur a risk of injury and entanglement (FAO, 2018). The Western

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[4] Phone enquiry to Algeciras Port Authority (27 July 2023): *https://www.apba.es/#*

Mediterranean fleet is mainly composed of polyvalent vessels, though bottom trawlers, trawlers and purse seiners are also common (FAO, 2018; 2020). On the coast of Andalusia, industrial fishery methods are mainly deployed in the bays of Almería, Málaga and Marbella, and target a variety of fish species, such as European hake (*Merluccius merluccius*), European pilchard (*Sardina pilchardus*) and European anchovy (*Engraulis encrasicolus*) (García-Tiscar, 2009). The Strait of Gibraltar itself is mostly targeted by artisanal and commercial longline fisheries (García-Tiscar, 2009) where blackspot seabream (*Pagellus bogaraveo*) and swordfish (*Xiphias gladius*) are commercially important species (Abid *et al*., 2019; Burgos *et al*., 2013). Passage through the Strait is an important milestone in the yearly migration of bluefin tuna (*Thunnus thynnus*) which are caught using droplines or in a traditional trap fishery called the Almadraba (Esteban *et al*., 2016; Cort *et al*., 2019).

Illegal, unregulated and unreported fishing also occurs. Drift net fishing caused worldwide concern in the 1990s (Silvani *et al*., 1999). The low species-selectivity of this technique is responsible for high bycatches of vulnerable species (Richards, 1994; Tudela *et al*., 2005). Large-scale drift nets which target large pelagic species have been banned in the Mediterranean Sea since 2002 but this technique is still used illegally by both European and Moroccan vessels (Tudela *et al*., 2005).

The Strait of Gibraltar is a popular holiday destination and recreational fishing a widely enjoyed activity. Spanish legislation (Royal Decree 1727/2007) established protective measures for cetaceans in 2007 (Ministerio de la Presidencia, 2008). The Decree regulates how closely cetaceans can be approached by boat, but recreational fishery vessels have been commonly observed to disregard this law. These boats are reported to drive into schools of cetaceans as these animals indicate the presence of tuna (Herr *et al*., 2020; Limón, 2021). Fish caught recreationally cannot be sold, but illegal activities may still be lucrative. There have been reports of recreational vessels catching tuna for the market.[5]

Local cetacean populations therefore face a variety of anthropogenic threats and have been classified as 'vulnerable' and 'critically endangered' (Azzolin *et al*., 2020; Bearzi *et al*., 2003; 2008; Carpinelli *et al*., 2014; Castellote *et al*., 2012; Esteban *et al*., 2014; Verborgh *et al*., 2016). Photography is a valuable tool to monitor external traumata. Visible injuries may indicate specific anthropogenic impacts, such as vessel strikes or fishery interactions (Luksenburg, 2014). A previous study used photographs to assess human-induced injuries in cetaceans in this region covering the years 2001–15 (Herr *et al*., 2020). This paper aims to provide an update for the years 2016–20. Long-term monitoring can provide valuable information on major threats and help shape the implementation of conservation measures. The occurrence of different injury patterns over time may indicate newly arising anthropogenic threats and the efficacy of mitigation measures. This work also provided a unique opportunity to follow up some of the individuals documented by Herr *et al*. (2020).

MATERIALS AND METHODS

Data collection

A total of 27,866 photographs (2016: n = 6,001; 2017: n = 3,814; 2018: n = 3,492; 2019: n = 9,882; 2020: n = 4,677) were opportunistically collected during whale-watching operations in the years 2016–20. The same data were used to assess the occurrence of epizoa, ectoparasites, dermal diseases and emaciation. The results are published in a separate article which further elaborates on the data collection process (Hanninger *et al*., 2023).

Photo-identification

Due to the opportunistic nature of these data, photo-identification was only possible for a limited number of individuals. Notches in the dorsal fin are a reliable tool for photo-ID (Bertulli *et al*., 2015) and were used as the main distinctive feature. Scars and pigmentation patterns were also used (Auger-Méthé *et al*., 2007). High-quality photographs were processed using Darwin 2.22.[6]

[5] Aguilera Garcia, C. E., 2015, European Parliament: *https://www.europarl.europa.eu/doceo/document/E-8-2015-003860_EN.html* (accessed 27 July 2023)

[6] Darwin Research Group, 2022: *http://darwin.eckerd.edu/?page=photo_identification.html* (accessed 27 July 2023).

Data analysis

The photographs were screened for conspicuous features. Low-quality pictures (blurred or overexposed) were excluded. The prevalence of injuries was not subject to statistical analysis. Images were taken opportunistically and are therefore likely to include a bias towards animals with conspicuous features.

Observed injuries were identified as 'likely of natural origin', 'likely anthropogenic' or 'unclear'. The literature was consulted to assess whether observed injuries may be attributable to specific human impacts. Encircling marks around the rostrum, head or appendages indicate entanglement in gillnets (Mazzariol *et al*., 2015; Moore and Barco, 2013; Moore *et al*., 2013; Read *et al*., 2000). A series of parallel incisions indicate sharp trauma inflicted by propellor blades (Byard *et al*., 2012; Elwen *et al*., 2010; Hill *et al*., 2017; Schoeman *et al*., 2020). Boat propellors might also provide a plausible explanation for appendages which have been severed linearly (Luksenburg, 2014; Moore and Barco, 2013; Van Waerebeek *et al*., 2007). Linear amputations may also stem from an interaction with fishery gear (Kiszka *et al*., 2008; Luksenburg, 2014; Moore and Barco, 2013). The ability to detect fine features from photographs is limited. The suspected aetiologies have therefore been reported as far as possible. The data also include sightings of four injured carcasses. The colouration of surrounding tissue was used to determine whether an injury occurred ante- or post-mortem. Ante-mortem wounds are associated with haemorrhage (Read *et al*., 2000).

RESULTS AND DISCUSSION

Photo-identification

Common and bottlenose dolphins, pilot whales, orcas and individual sperm whales are assumed to be at least seasonally present in the Strait of Gibraltar (De Stephanis *et al*., 2008; Esteban *et al*., 2016; Verborgh *et al*., 2009). No common dolphins were re-sighted. The same individual striped dolphin was re-sighted twice. The same individual fin whale was re-sighted twice. For all other species, several individuals were re-sighted within at least two years of the study period (*T. truncatus*: n = 47; *O. orca*: n = 12; *G. melas*: n = 56; *P. macrocephalus*: n = 10). These re-sightings provided valuable insights into life-history features.

Photo-ID was also conducted for individuals shown in the previous study's gallery which reported multiple injured individuals for the period 2001–15 (Herr *et al*., 2020). Six injured animals were re-identified in the current data. The low number of re-sightings may be explained by the limitations of photo-identification. Recent photographs of the re-sighted animals can be seen in Figures 1–4.

An adult bottlenose dolphin with a linear abrasion or scar at the cranial base of the dorsal fin was previously documented (Herr *et al*., 2020: Fig. 8C). The scar is still visible and served as a feature for photo-identification. In 2019, this animal was re-sighted with a potential cranial net-mark (Fig. 1A).

Herr and colleagues documented one fin whale with a scar perpendicular to the body axis (Herr *et al*., 2020: Fig. 5A). The animal was re-sighted once and re-identified using the scar (Fig. 1B).

An adult male orca was previously documented with tooth rake marks and various other marks on the back (Herr *et al*., 2020: Figs 7A and 8A). This individual was re-sighted in all five years. These previously reported injuries appeared to be rather superficial and had healed without permanent scars. The animal presented new vertical linear impressions or abrasions (Fig. 2A).

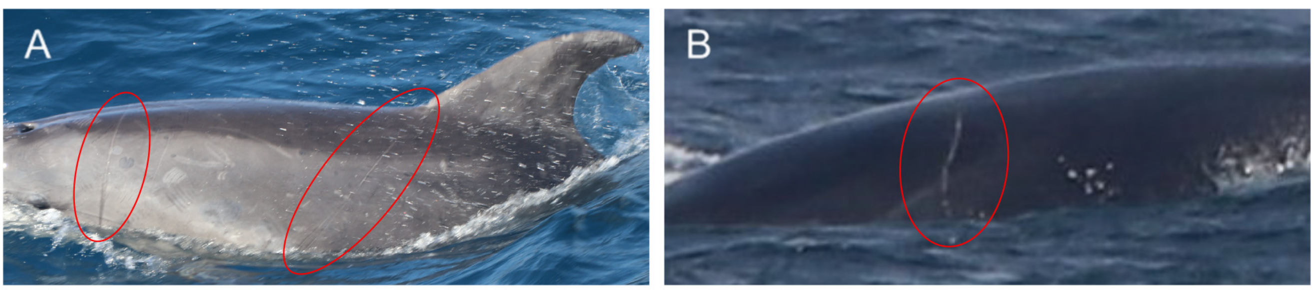

Fig. 1. Recent photographs of animals previously documented by Herr and colleagues. A) Adult bottlenose dolphin with a linear scar or abrasion at the cranial base of the dorsal fin and a potential cranial net-mark. B) Fin whale with a scar perpendicular to the body axis.

A female orca was previously reported with severe injuries assumed to originate from fishery interactions. This animal is known to have a severed pectoral fin and a deep laceration at the caudal base of the dorsal fin (Herr *et al*., 2020: Fig. 21). The animal was re-sighted in multiple years, always accompanied by a calf. While a picture of the pectoral fin was not available, the laceration at the caudal base of the dorsal fin appeared to have healed, but the animal was re-sighted in 2016 with an open wound close to the scar tissue (Fig. 2B). In the same year, the individual also exhibited various linear marks on the other side of its body (Fig. 2C).

An adult pilot whale was previously reported with cuts on the dorsum, presumably inflicted by fishing lines or a collision (Herr *et al*., 2020: Fig. 10B). This animal was re-sighted in several years. The cuts are still clearly visible (Fig. 3A). In 2017, the animal also had small open wounds on top of the scar tissue (Fig. 3B).

One adult pilot whale was documented with a partial linear amputation of the dorsal fin, possibly inflicted by fishing lines or a collision (Herr *et al*., 2020: Figs 12A–B). This animal was re-sighted in 2017. The amputation wound had healed, but the animal presented multiple new disorders. The animal was photographed with a hump at the peduncle (Fig. 4A), multiple open ulcerations (Fig. 4B) and a severe wound at the base of the dorsal fin (Fig. 4C). The partial linear shape of the wound may indicate a traumatic origin. The animal has not been re-sighted since 21 October 2017.

Fig. 2. Recent photographs of orcas previously documented by Herr and colleagues: A) Adult male orca sighted in all five years. The animal was sighted with multiple, vertical linear marks. B) and C) Female orca with a deep laceration at the base of the dorsal fin. The animal was resighted in all five years and presented an open wound on top of the scar tissue and multiple vertical linear marks.

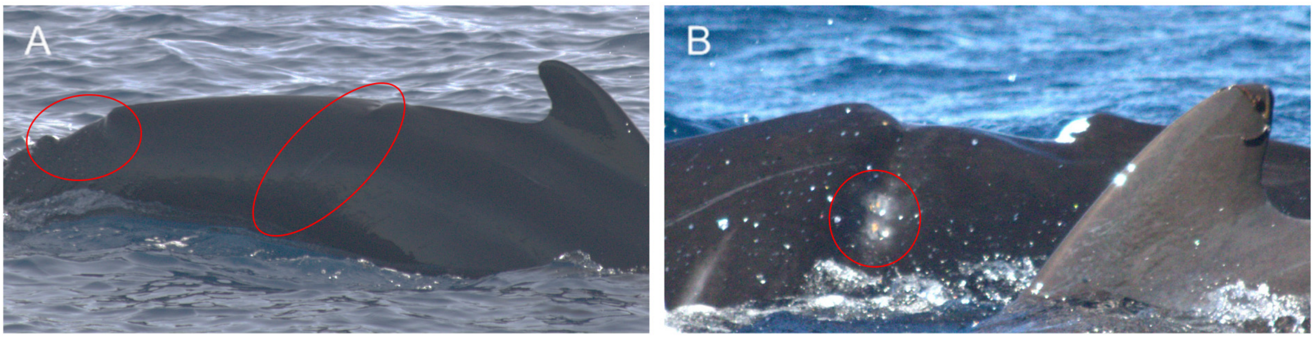

Fig. 3. Recent photographs of an adult pilot whale previously documented by Herr and colleagues: A) Adult pilot whale with cuts on the dorsum. The animal was resighted in several years. B) In 2017, the animal presented open wounds on top of the scar tissue.

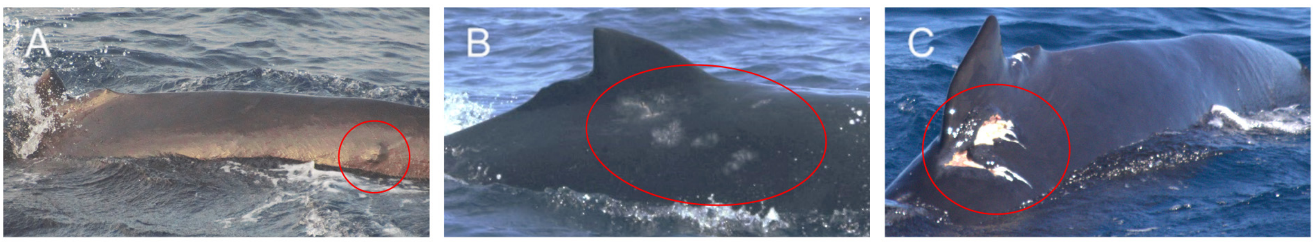

Fig. 4. Recent photographs of a pilot whale previously documented by Herr and colleagues: A)–C) Adult pilot whale with a previously documented partial linear amputation of the dorsal fin. The animal was resighted in 2017 with a hump at the peduncle, multiple open wounds and a severe excision-like wound at the base of the dorsal fin.

Likely naturally induced injuries

The observations included tooth rake marks (narrowly spaced, parallel linear marks) inflicted by the teeth of conspecifics or predators (Ashe *et al*., 2021; Elwen *et al*., 2014; Lee *et al*., 2019; Scott *et al*., 2005), skidding marks (Fig. 5A) (Bertulli *et al*., 2012; Nichols *et al*., 2011) and injuries potentially inflicted by squid (Herr *et al*., 2020). Abraded fin tips were only detected in bottlenose dolphins and seem to consist of dense tooth rakes. In some individuals, elongated notches (Fig. 5B) or round cuts (Fig. 5C) were detected on the trailing edge of appendages. These injuries were classified as likely naturally induced (Kügler *et al*., 2014; Luksenburg, 2014).

Fig. 5. Likely naturally induced injuries: A) Juvenile pilot whale with skidding marks dorsally (large red circle) and *Xenobalanus spp.* attached to the dorsal fin (small red circle). B) Adult striped dolphin with an elongated notch on the trailing edge and old, broadly spaced tooth rake marks on the lateral surface of the dorsal fin. C) Adult striped dolphin with a round cut on the trailing edge of the dorsal fin.

Table 1

Overview of detected cases of injuries.

	Number of cases with regard to stage of healing		
Anatomical location and description	Fresh	Healed	Not determinable
Appendages			
Linear amputations	1	8	–
V-shaped or linear lacerations	–	–	–
– Into the trailing edge of the dorsal fin	9	101	–
– Into the leading edge of the dorsal fin	–	1	–
– Into the base of the dorsal fin	2	–	–
Obtuse short notches in appendages	1	2	1
Linear impressions	2	–	10
Potential netmarks	–	–	8
Abrasions of the leading edge	5	–	–
Potential tagging scar	–	1	–
Potential gunshot injury	1	–	–
Cranial/rostral or located at the lower jaw			
Linear lacerations cranially	2	–	1
Potential netmarks	–	–	6
Potential hooking injuries	–	2	–
Body			
Linear impressions or abrasions	2	–	38
Linear lacerations into the peduncle	2	–	-
Linear or V-shaped scars dorsally		18	
Parallel, linear cuts	1	1	1
Oblique cut into the peduncle	1	–	–
Total	**29**	**134**	**65**

Injuries of possible anthropogenic origin

Signs of human interaction were detected in 234 cases (injuries: n = 228; entangled gear: n = 5; entangled debris: n = 1). Observed injuries are summarised in Table 1. The stage of healing was not determinable from photographs which meant we only distinguished 'fresh' and 'healed' injuries where possible. Injuries to appendages were commonly detected.

Nine animals were sighted with partial linear amputations (Fig. 6) (dorsal fin: n = 5; fluke: n = 4) which may stem from boat propellors or fishery gear (Kiszka *et al*., 2008; Luksenburg, 2014; Moore and Barco, 2013; Panigada *et al*., 2006; Van Waerebeek *et al*., 2007). Most of these injuries had healed. A fresh amputation was detected in one common dolphin (Fig. 6A). The injury was not completely clean-cut, with tissue rests still attached. This injury was therefore assumed to most likely stem from fishery gear.

Multiple individuals were sighted with healed V-shaped or linear lacerations on the appendages (dorsal fin: n = 87; fluke: n = 15). Most of these injuries were located on the trailing edges (n = 101). Some of these injuries may persist for a longer period. V-shaped lacerations might be caused by a propellor hit or fishery gear (Luksenburg, 2014; Baird *et al*., 2014). Parallel V-shaped lacerations (Fig. 7A) have been interpreted as a sign of interaction with boat propellors (Bonneville *et al*., 2021; Luksenburg, 2014). Single linear injuries (Fig. 7B), often located at the base of the dorsal fin, most likely stem from fishery equipment, such as longlines or big game fishing lines (Baird *et al*., 2014; Herr *et al*., 2020; 2023). Luksenburg (2014) suggests that V-shaped or linear injuries accompanied by linear scars (Fig. 7C) are also likely to be caused by fishery gear interaction.

Fresh linear or V-shaped lacerations were detected on nine animals (Figs 8A–C). In each case, the laceration was located at the trailing edge, occurred solitarily and did not show any opposing marks. Similar injuries have been previously reported in this region and assumed to be caused by big game fishing lines (Herr *et al*., 2020). Recreational fishery vessels have been observed to illegally approach cetaceans and drag their lines over the bodies of cetaceans in the hope that these animals indicate the presence of tuna (Herr *et al*., 2020; Limón, 2021; Olaya-Ponzone *et al*., 2020). These observed lacerations were occasionally surrounded by patches of pale skin (Fig. 8A) and may have served as an entry point for a dermal infection (Van Bressem *et al*., 2015). Big game fishing lines could also be responsible for other observed injuries, such as abrasions to the leading edge of the dorsal fin (n = 5) (Fig. 8D) and two cranial linear lacerations (Figs 8E–F).

Obtuse short indentations were commonly detected on the trailing edges of appendages. These injuries might stem from either an interaction with conspecifics or fishery gear (Kügler *et al*., 2014; Luksenburg, 2014). Many

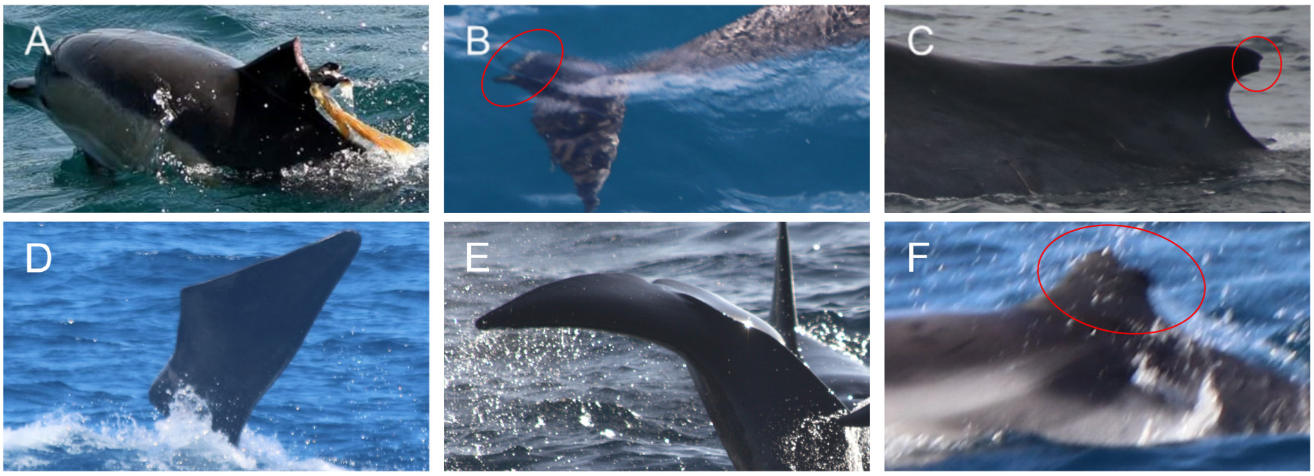

Fig. 6. Linear amputations: A) Common dolphin with a partially severed dorsal fin. The cranial part of the injury is linear, while the caudal part is irregular in relief and some subcutaneous tissue is still attached. B) Subadult pilot whale with a partial, linear amputation of the fluke. C) Fin whale with a linear chopped fin tip and *Pennella balaenopterae* attached. D) Sperm whale with a healed, linear severed fluke. E) Adult orca with a healed, partial amputation of the fluke. F) Adult striped dolphin with a partial amputation of the dorsal fin.

Fig. 7. Healed linear or V-shaped lacerations: A) Adult striped dolphin with two parallel V-shaped cuts on the trailing edge of the dorsal fin (red arrows). B) Adult pilot whale with a deep, healed laceration into the trailing edge of the dorsal fin (large red circle) and two *Xenobalanus spp.* attached (small red circle). C) Juvenile bottlenose dolphin with a healed V-shaped cut on the trailing edge of the dorsal fin. The injury is accompanied by linear scar tissue.

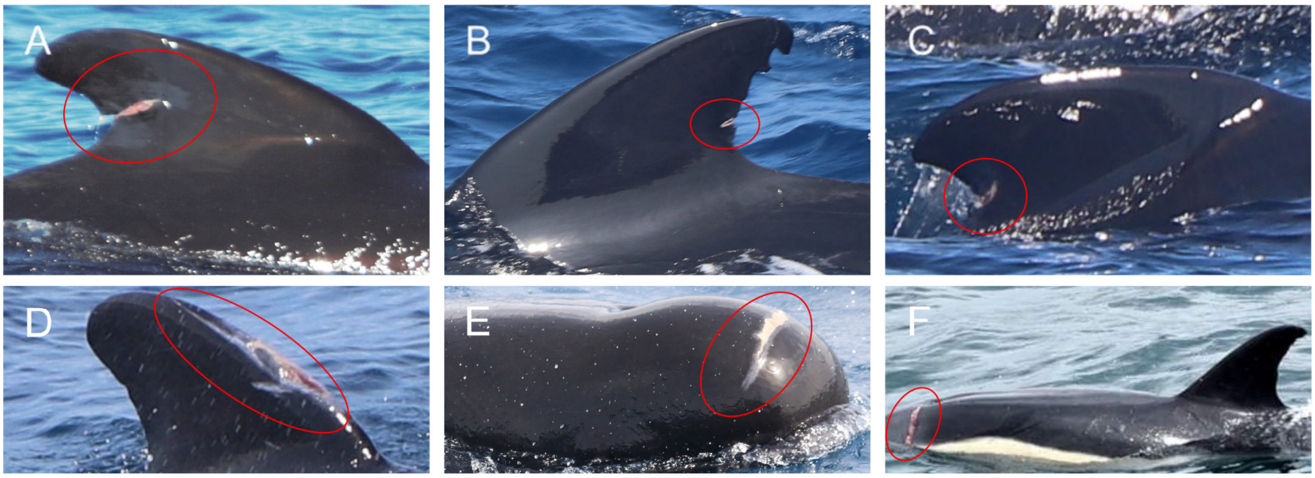

Fig. 8. Fresh lacerations and abrasions: A)–C) Adult pilot whales with deep lacerations on the trailing edge of the dorsal fin. In picture A, the injury is surrounded by patches of pale skin. D) Adult pilot whale with an abrasion of the leading edge. The injury is accompanied by a linear indentation. E) Adult pilot whale with a linear cranial laceration. F) Adult common dolphin with a linear cranial laceration.

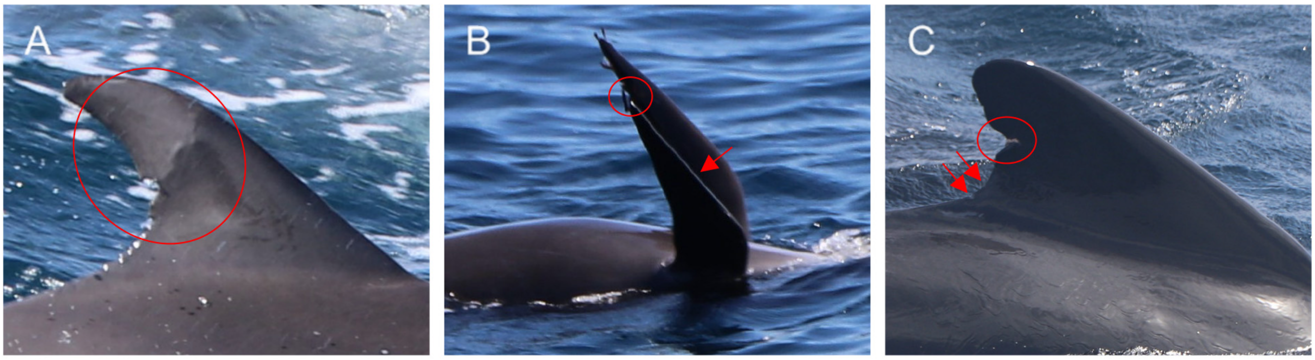

Fig. 9. Obtuse, short indentations: A) Adult bottlenose dolphin sighted with two obtuse, short notches in the trailing edge. One notch is connected to a linear scar at the lateral surface of the dorsal fin. B) Adult pilot whale with *Xenobalanus spp.* attached to the pectoral fin and an obtuse indentation on the trailing edge (red circle). A single strand of nylon is still attached (red arrow). C) Adult pilot whale with two short, obtuse indentations (red arrows) on the caudal base of the dorsal fin and a linear laceration on the trailing edge of the dorsal fin (red circle).

individuals exhibited multiple notches that were already healed and could not clearly be attributed to a source. Healed notches have been listed as likely human-induced if they are accompanied by linear scars (Fig. 9A; n = 1; Luksenburg, 2014) or fishery gear appears to be attached (Fig. 9B; n = 1). One fresh notch was detected on the trailing edge of the dorsal fin of a pilot whale. The injury occurred solitarily and did not show any opposing marks. A fishery interaction was assumed (Luksenburg, 2014). Another pilot whale was sighted with two recently acquired short obtuse notches located at the caudal base of the dorsal fin (Fig. 9C). This injury was similar to the 'sawed edges' described in bottlenose dolphins off the coast of Ecuador which may potentially be caused by gillnets (Félix *et al*., 2018b). The affected pilot whale acquired these notches in April 2019 and was re-sighted in June with a fresh laceration to the trailing edge of the dorsal fin. This laceration is likely to stem from a further fishery-related incident. An interaction with big game fishing lines is assumed (Herr *et al*., 2020).

Twelve animals were sighted with non-encircling linear impressions or scars to the trailing or leading edges of appendages (Fig. 10) that were potentially caused by lines or twine (Moore and Barco, 2013; Moore *et al*., 2013). In one case, multifilament twine was suspected (Fig. 10A) as the linear impression seemed to be composed of three narrow straight furrows (Moore and Barco*,* 2013). Two orcas were sighted with fresh lacerations at the caudal base of the dorsal fin (Fig. 11A) which were potentially caused by contact with lines (Moore and Barco, 2013; Moore *et al*., 2013).

Fresh injuries located on the bodies of animals included vertical linear abrasions or impressions (Figs 2A–C, 11B–G; peduncle: n = 4; body: n = 34; dorsal: n = 2) and two cases of a linear laceration (Fig. 11H; peduncle: n = 2). These linear marks may have been caused by contact with lines (Gilman *et al*., 2006). Most vertical linear

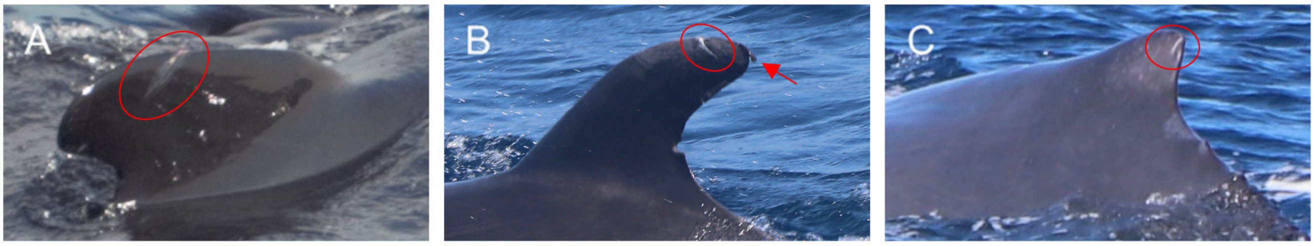

Fig. 10. Linear impressions or lacerations: A) Adult pilot whale with a linear impression at the leading edge of the dorsal fin. The impression seems to be composed of three straight, narrow furrows. B) Adult bottlenose dolphin with a linear impression at the leading edge (red circle) of the dorsal fin and one *Xenobalanus spp.* (red arrow) attached. C) Adult sperm whale with a linear scar on the trailing edge of the dorsal fin.

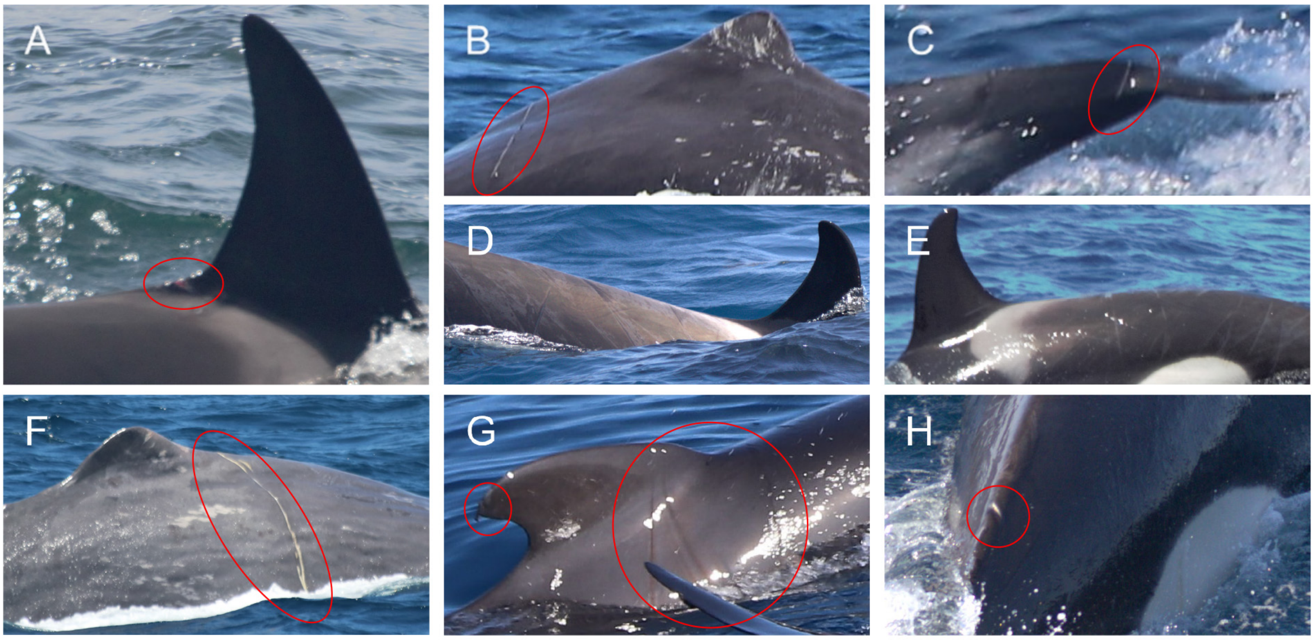

Fig. 11. Linear lacerations, impressions, or abrasions: A) Adult orca with a fresh laceration at the caudal base of the dorsal fin. B) Adult sperm whale with a lateral linear impression or abrasion. C) Adult striped dolphin with a linear impression at the caudal peduncle. D) Adult orca with multiple linear impressions or abrasions at the peduncle. The marks are surrounded by patches of pale skin. E) Adult orca with approximately eleven vertical, linear marks. F) Adult sperm whale with a potential case of piebaldism and two vertical lacerations or abrasions. G) Pilot whale calf with multiple vertical, linear marks in the middle of the body (large red circle) and *Xenobalanus spp.* attached to the dorsal fin (small red circle). H) Adult orca with a linear laceration on the dorsal peduncle.

marks were found in orcas (n = 27) which are known to depredate tuna from the Moroccan drop-line fisheries (De Stephanis *et al*., 2002). These animals often showed multiple marks that could stem from repeated contact with the deployed lines.

Four sperm whales (Fig. 12) and one pilot whale (Fig. 9B) were observed to be entangled with fishing gear. In all cases, it appeared to be a single strand of nylon, potentially stemming from longlines (Moore and Barco, 2013) or recreational fishery activities. Multiple individuals were sighted with signs of previous entanglement. Potential net marks were detected in 14 cases (Figs 1A and 13; cranial: n = 2; flipper: n = 2; snout: n = 1; dorsal fin: n = 6; rostrum: n = 3) (Mazzariol *et al*., 2015; Moore and Barco, 2013; Read *et al*., 2000).

Two bottlenose dolphins were sighted with linear scars at the lower jaw which might be a sign of hooking entanglement (Fig. 14A) and indicate an interaction with longlining gear (Moore and Barco, 2013). No gear was present to confirm this assumption. Longline fleets have significant potential to inflict deep wounds as cetaceans are attracted to the baited hooks of this fishing technique (Gilman *et al*., 2006; Read, 2008). A severe trauma was documented in one sperm whale sighted with a deep cut-like laceration and a cranial impression (Fig. 14B). This injury is assumed to stem from a previous entanglement (Cassoff *et al*., 2011; Rolland *et al*., 2016). Eighteen animals were sighted with linear dorsal scars (peduncle: n = 17; caudal of the blowhole: n = 1). These scars were rather shallow in 14 cases (Figs 14C–F) and potentially caused by a previous entanglement (Basran *et al*., 2019; Félix *et al*., 2018a; 2018b; Feyrer *et al*., 2021; Herr *et al*., 2020; Ramp *et al*., 2021). On four animals, the scars were V-shaped

Fig. 12. Entangled fishery gear: A)–C) Adult sperm whales with monofilament twine attached to the fluke.

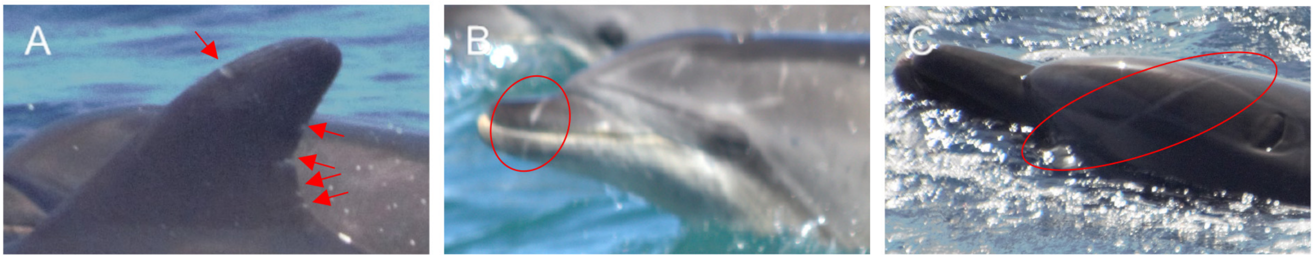

Fig. 13. Potential net-marks: A) Adult bottlenose dolphin with four healed linear lacerations into the trailing edge of the dorsal fin and one opposing linear scar on the leading edge. B) Adult bottlenose dolphin with a linear, potentially encircling impression at the snout. C) Adult bottlenose dolphin with a linear, potentially encircling cranial impression.

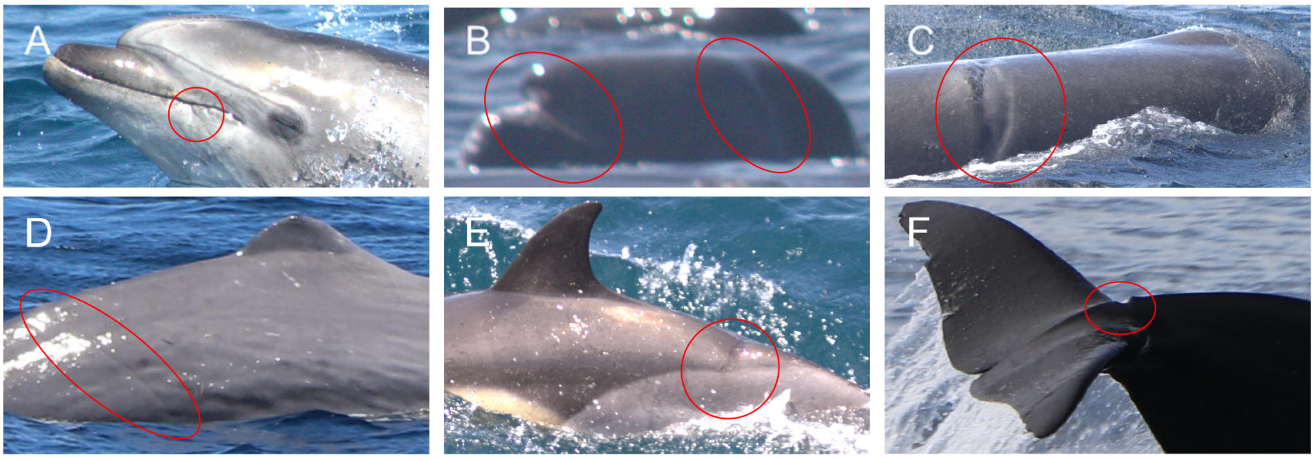

Fig. 14. Potential signs of previous entanglement: A) Adult bottlenose dolphin with two linear scars at the lower jaw. B) Sperm whale with a deep cut-like laceration and a linear cranial impression. C) Adult sperm whale with a dorsal scar. D) Adult sperm whale with a healed linear scar on the peduncle. E) Adult common dolphin with a linear scar on the dorsal peduncle. F) Adult pilot whale with a healed, blunt laceration into the caudal peduncle.

and penetrated deeply into the muscle (Fig. 15). These injuries could also have been caused by boat propellors (Félix *et al*., 2018b; Feyrer *et al*., 2021; Herr *et al*., 2020; McGuire *et al*., 2021; Visser, 1999; Wells *et al*., 2008).

Incision-like parallel wounds were detected in one sperm whale and one adult orca. These wounds are indicative of sharp trauma caused by propellor blades (Byard *et al*., 2012; Elwen *et al*., 2010; Hill *et al*., 2017; Moore and Barco, 2013; Moore *et al*., 2013; Schoeman *et al*., 2020). The sperm whale was sighted with two healed dorsal incisions (Fig. 16) and the orca presented injuries that stemmed from two different vessel incidents. The orca was sighted multiple times and clearly identifiable from both sides of the body due to a small notch on the trailing edge of its dorsal fin. The animal was photographed on 2 August 2020 with two parallel cuts to the right side of its body (Fig. 17A).

This individual was photographed for the first time in the whale-watching season of 2020. It is therefore not determinable when the animal sustained its injuries. Between 3 August 2020 and 21 August 2020, the animal was involved in another vessel incident. On 3 August 2020, no injuries were visible on the left side of the body

Fig. 15. Injuries caused by entanglement or boat collision: A) Adult pilot whale with a healed, deep V-shaped cut on the dorsum (large red circle). Additionally, the animal presented a healed V-shaped cut on the trailing edge of the dorsal fin (small red circle). B) Adult pilot whale with a deep, healed cut on the dorsum. C) Adult pilot whale with a deep dorsal scar (red circle). The dorsal fin is mildly colonized by *Xenobalanus spp.* (red arrow).

Fig. 16. Potential propellor injuries: Adult sperm whale with two deep, dorsal incisions.

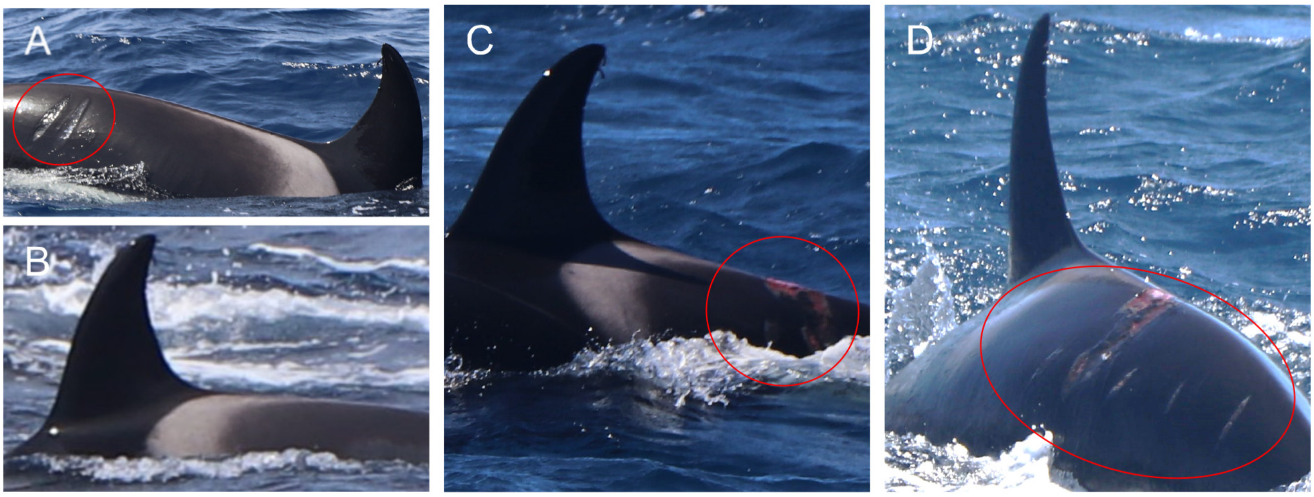

Fig. 17. Female orca named 'Gladis Blanca': A) The individual was sighted on 2 August 2020 with two parallel wounds on the peduncle. B) The left side of the body photographed on 3 August 2020. C) and D) Photographs of the animal on 21 August 2020 and 23 August 2020: Five parallel wounds and a dorsal abrasion are present.

(Fig. 17B). On 21 and 23 August 2020, the animal was re-sighted with a dorsal abrasion and five parallel wounds on the left side of the body (Figs 17C–D). This orca was identified as an adult female named 'Gladis Blanca' (R. Esteban, pers. comm.). Since May 2020, there have been reports of orca interactions with vessels along the Iberian Peninsula. Some orca individuals approach the vessels before striking and turning the rudders (Esteban *et al.*, 2022a; 2022b). These interactions occur most frequently with sailing boats and often lead to damaged rudders. 'Gladis Blanca' is known to engage in vessel interactions (R. Esteban, pers. comm.). There are multiple hypotheses as to what may have caused this disruptive behaviour: it might have been triggered by a previous vessel incident (Esteban *et al.*, 2022b). We cannot determine the timing of the first propellor injury and do not know whether it might be related to any behavioural changes, but it remains worrying that the individual appears to have been involved in two vessel incidents in 2020.

The orca population in the Strait of Gibraltar is classified as 'critically endangered' (Esteban *et al.*, 2014). Due to the increased risk of injuries, concern was raised that the disruptive behaviour of these orcas may become a conservation issue (Esteban *et al.*, 2022b). This concern is strengthened by our observations. Another severe trauma was documented in an adult orca. The animal was sighted on one occasion with a severe cut into the peduncle (Fig. 18). The cut was oblique, parts of the skin were not completely severed, but the aetiology remains unclear: it could stem from a line being dragged over the body or a sharp agent. Propellor injuries are typically a series of multiple parallel incisions with a vertical orientation (Moore and Barco, 2013; Moore *et al*., 2013). We cannot exclude the possibility that this injury could also have been inflicted by an act of human mutilation, particularly as conflicts between fishermen and orcas have been reported due to the depredation of tuna (De Stephanis *et al*., 2002).

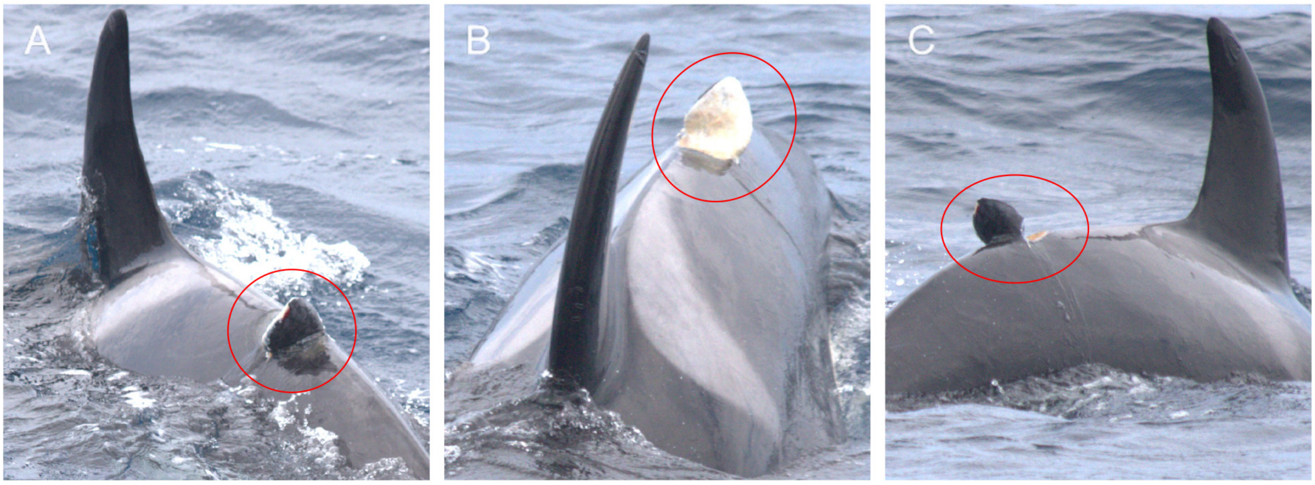

Fig. 18. Adult orca sighted on 30 June 2018: A–C) Photographs of an oblique cut into the peduncle.

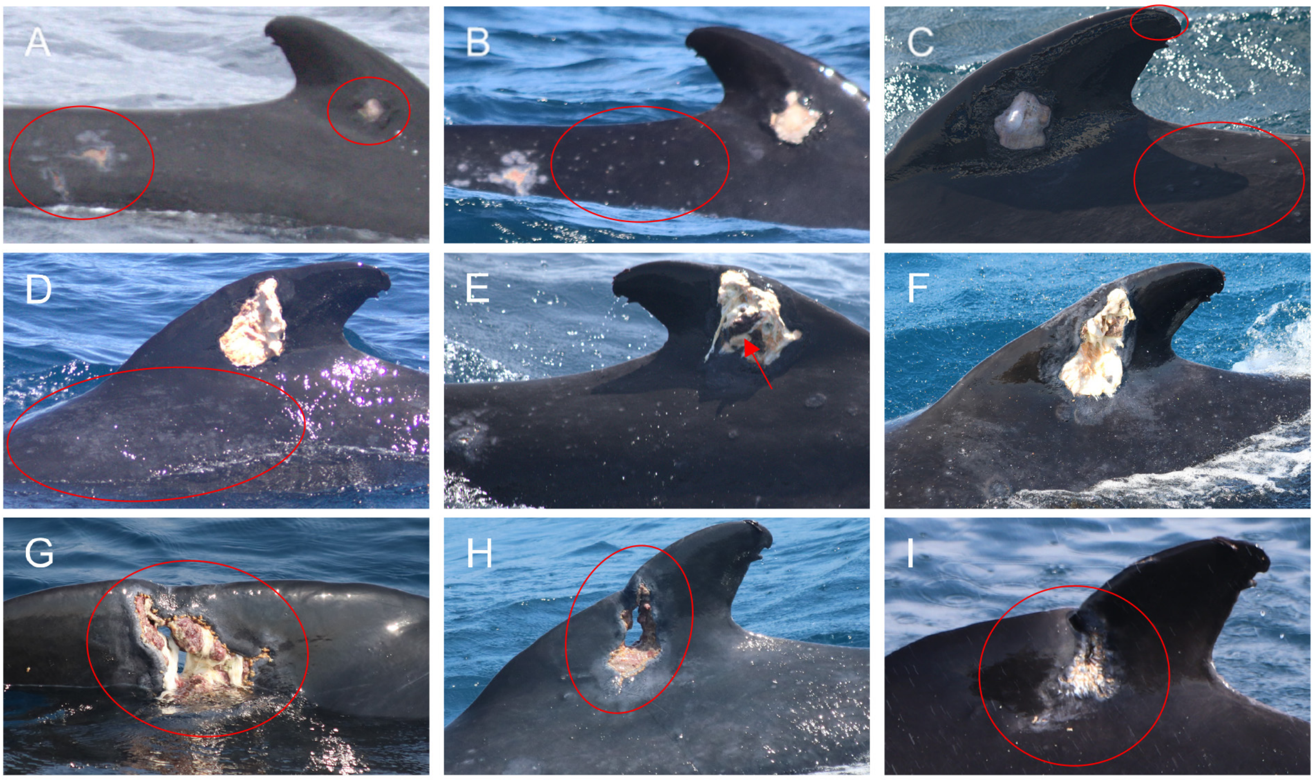

Fig. 19. The fate of an adult pilot whale: A) Adult pilot whale sighted on 24 May 2018 with a potential bullet wound in the centre of the dorsal fin and an open wound at the peduncle. B) By 6 June 2018, the bullet wound had enlarged and the animal appeared to have multiple grey, cutaneous nodules laterally (red circle). C) A photograph of the other body side taken on 11 June 2018 showed that the bullet had gone through the dorsal fin. Grey cutaneous nodules are also visible on the other half of the body (large red circle) and the dorsal fin is mildly colonized by *Xenobalanus spp.* (small red circle). D) By 1 July 2018, the wound had enlarged and degenerated and some patches of pale skin had appeared on the body (red circle). E) and F) By the end of July 2018, the gunshot wound had enlarged further and the centre of the gunshot injury had become dark-pigmented (red arrow) and possibly necrotic. G) In early August, the tissue in the centre of the injury had broken away. The wound was colonized by cyamids. H) On 25 August 2018, the wound seemed to have stabilized. I) By April 2019, the hole in the centre of the injury had closed and the animal seemed to have recovered; however, this was the last sighting of this individual.

An adult pilot whale was sighted with a circular wound in the centre of the dorsal fin (Fig. 19). The wound was visible on both sides of the dorsal fin and is assumed to be caused by a gunshot (R. L. Brownell Jr., pers. comm.). The animal also showed additional dermal disease, potentially caused by an impairment to the immune function. The animal was sighted with an open wound at the peduncle (Fig. 19A), multiple grey cutaneous nodules (Figs 19B–C) and patches of pale skin (Fig. 19D). The peduncle wound resembled a case of a potentially open vesicular lesion (Brownell *et al*., 2007). This assumption cannot be confirmed as there are no pictures showing the lesion at an earlier point of time. The aetiology remains unclear. One potential agent might be a calicivirus which cause vesicular lesions that erode quickly and leave shallow ulcers (Smith *et al*., 1983), but calicivirus infections have not been reported in free-ranging cetaceans (Van Bressem *et al*., 2008) and occur mainly on the dorsal side of fins (Mazzariol *et al*., 2015). This animal was re-sighted multiple times in 2018–19. The gunshot wound was deteriorating and had been colonised by cyamids (Fig. 19G; Lehnert *et al*., 2021). In April 2019, the health of this individual appeared to have stabilised, but the animal was not seen again.

A potential tagging scar was detected in one pilot whale (Fig. 20A). This scar might originate from a research project that used LIMPET SPOT5 tags in 2010–11 (Verborgh, 2015). Entangled debris was observed on one occasion. An adult bottlenose dolphin was sighted with plastic debris attached to the dorsal fin (Fig. 20B). The entangled litter appeared to be a single-use bag. The Mediterranean Sea is a global hotspot for plastic pollution (Fossi *et al*., 2018; Van Sebille *et al*., 2015). A global ocean litter analysis revealed that single-use bags, bottles and food-to-go items are among the most common macro-plastics found in the oceans (Morales-Caselles *et al*., 2021). This reinforces the need for a total ban on single-use plastics.

We reported a broad range of injuries. Most of these were classified as rather superficial. Based on the extent of tissue damage, anthropogenic trauma was classified as potentially severe in 26 animals, including seven cases of partially amputated appendages, deep V-shaped or linear lacerations to the dorsal fin (fresh: n = 3; healed: n = 6), severe signs of entanglement in one sperm whale, deep V-shaped scars on the dorsum of four animals, three cases of potential propellor injuries, an oblique cut to the peduncle of an orca and a potential gunshot wound in one pilot whale.

Other injuries

Injuries were listed as 'other' if they could not clearly be attributed to a specific cause. Examples of observed injuries are short horizontal scars or lacerations (Fig. 21A; n = 9), curved injuries (Fig. 21B; n = 8) or other irregularly shaped wounds (Fig. 21C; n = 9). This category also included abrasions located on the cranium or peduncle (Figs 21D–F; n = 7). Blunt vessel strikes may cause internal injuries with either no or subtle visible external lesions (Moore and Barco, 2013). External lesions occasionally include swellings, non-linear abrasions and lacerations, but a blunt vessel trauma cannot be confirmed from photographs. The bottom topography of the Strait is characterised by a rocky seabed (De Mol *et al*., 2012) so that the observed injuries may also potentially stem from rubbing over other hard substrates, such as the sea floor (A. Read and D. Waples, pers. comm.).

We further observed nine animals with excised integuments of the skin (Figs 4C and 22). The aetiology of these injuries remains unclear. Similar injuries have been previously reported in this region (Herr *et al*., 2020), indicating the possible presence of specific agents that repeatedly cause such wounds. Six wounds were classified as severe based on size. One animal was not re-sighted and may be deceased (Figs 4A–C). One wound was classified as chronic after having been first documented in 2019 (Fig. 22A) and enlarged in 2020 (Fig. 22B).

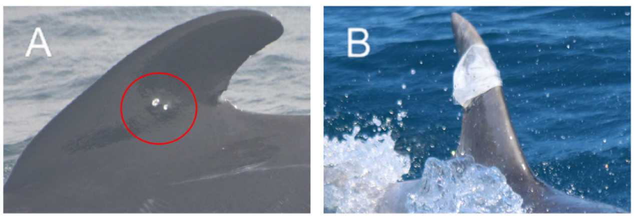

Fig. 20. Other signs of human interaction: A) Adult pilot whale with a potential tagging scar. B) Adult bottlenose dolphin with plastic debris attached to the dorsal fin.

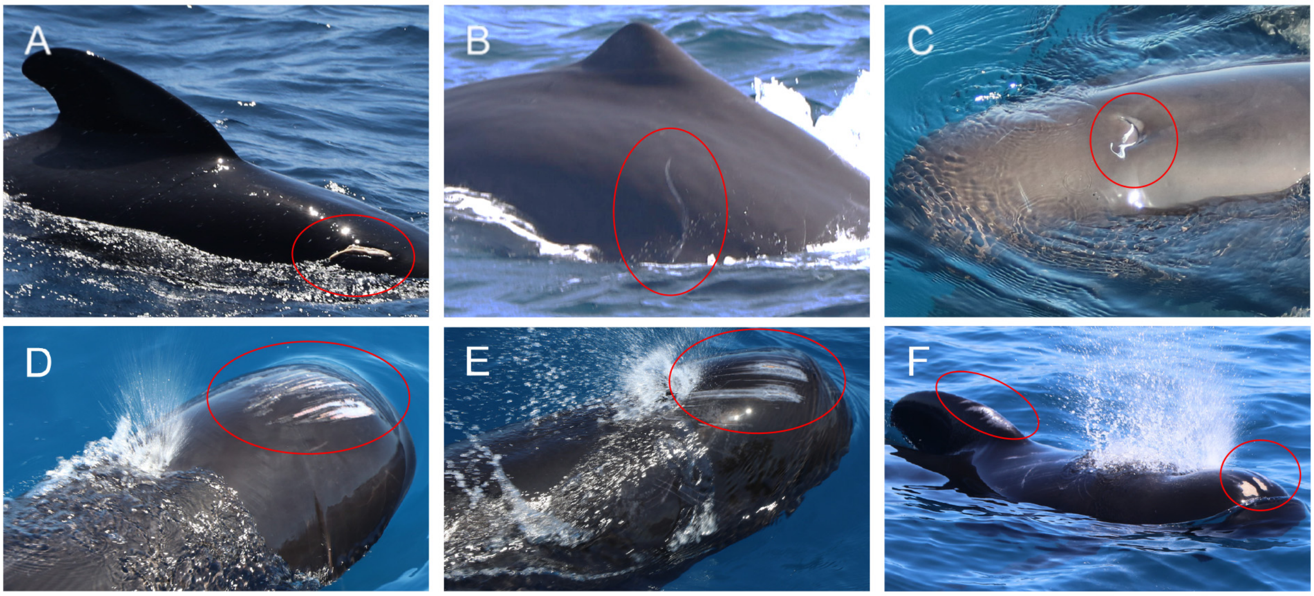

Fig. 21. Injuries with unclear aetiology: A) Adult pilot whale with a dorsal laceration. B) Adult sperm whale with a curved lateral scar. C) Juvenile pilot whale with two scrapes of tissue attached to the blowhole. D) and E) Adult pilot whales with cranial abrasions. F) Adult pilot whale with abrasions on the cranium and at the leading edge of the dorsal fin.

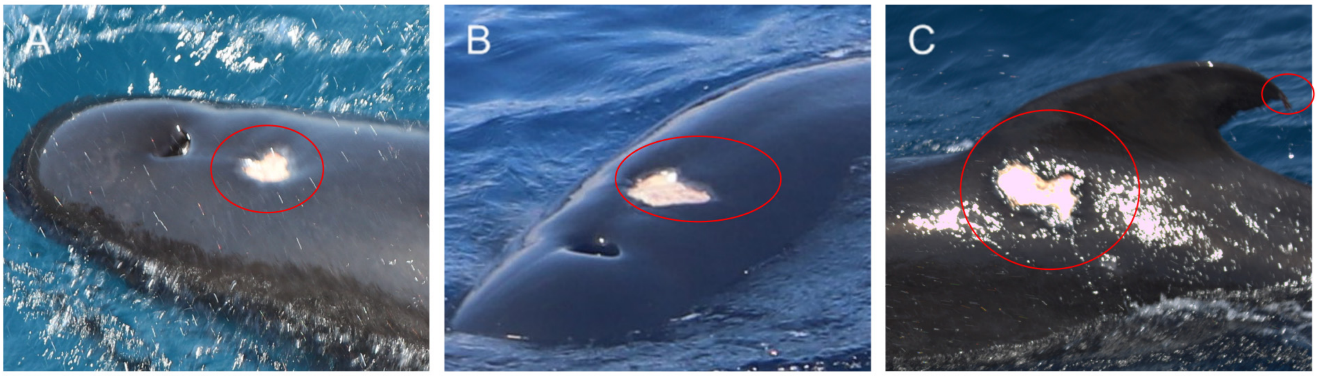

Fig. 22: Excised integuments: A) and B) Adult pilot whale sighted in 2019 with an excision-like dorsal wound. The wound has enlarged slightly when the individual was resighted in 2020. C) Adult pilot whale with an excised integument at the cranial base of the dorsal fin (large red circle). The dorsal fin is mildly colonized by *Xenobalanus spp.* (small red circle).

Carcasses

The data included sightings of three dead floating animals and one beached carcass (Fig. 23) in 2016 (n = 1) and 2019 (n = 3). The species could not be identified but could be common or striped dolphins. Animals killed in drift nets often become severely entangled and fishermen occasionally remove their appendages to facilitate disentanglement (Read *et al*., 2000). These animals can further present small puncture wounds which may stem from fisherman gaffs, an instrument used by fishers to retrieve animals from the water (Moore and Barco, 2013; Moore *et al*., 2013; Read *et al*., 2000). Such wounds were detected in two carcasses. One animal was sighted with a clean-severed fluke (Fig. 23A). This injury did not seem to be associated with haemorrhage and is assumed to have occurred post-mortem (Read *et al*., 2000). The other animal was found beached in a state of moderate decomposition (Fig. 23B) (Moore and Barco, 2013). The skin was peeling off and the extremities were decomposing. Both lobes of the fluke had been severed and the animal presented a puncture wound below the eye. Some haemorrhage was visible close to the puncture wound but restricted to a small area. It is not clear whether these injuries occurred post-mortem. Clean-severed appendages and puncture wounds are considered to be consistent with but not diagnostic of entanglement in drift nets (Read *et al*., 2000). Evidence of entanglement in the form of net-marks was not detected in the available pictures (Read *et al*., 2000). Therefore, final conclusions on the source of these injuries cannot be drawn. However, illegal drift nets continue to impact

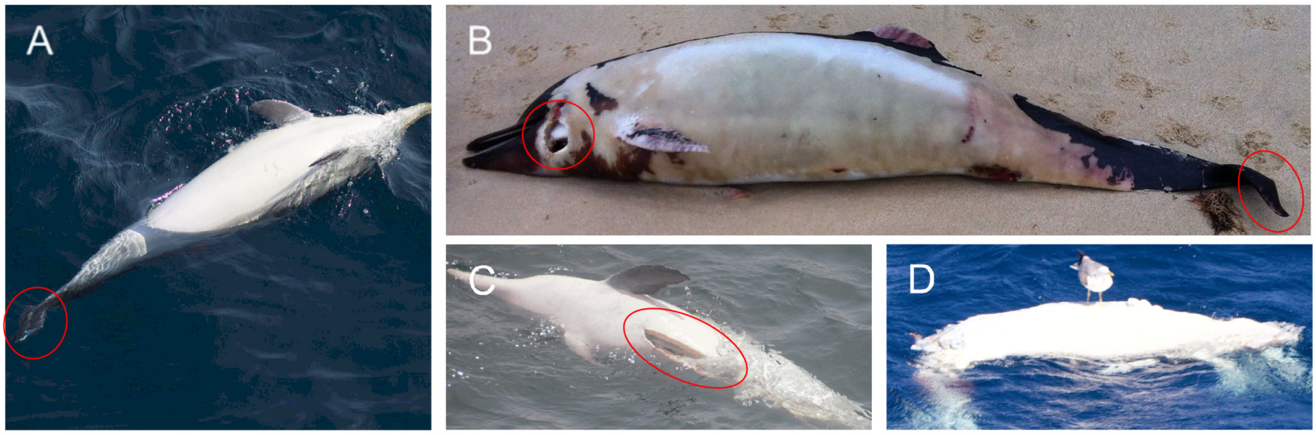

Fig. 23. Stranded or drifting carcasses: A) Unidentified dolphin sighted on 21 July 2019. Both paddles of the fluke are cleanly severed. The injury does not seem to be associated with haemorrhage. B) Unidentified dolphin found stranded on 7 November 2019 in a state of moderate decomposition. The skin is peeling off and the extremities are decomposing. Both paddles of the fluke are severed and the animal has a puncture wound below the eye. C) Unidentified dolphin sighted drifting on 29 August 2016. The animal has a linear, clean-cut abdominal incision. This wound does not seem to be associated with haemorrhage. D) Unidentified dolphin sighted drifting on 15 April 2019 with a broken tail stock. The abdominal cavity seems to be open, with the intestines exposed.

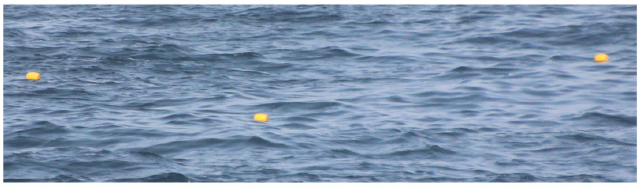

Fig. 24. Yellow buoys photographed in 2016. These buoys are commonly used in drift net fishing and can be observed in the Strait of Gibraltar when driftnets are damaged by ships.

cetaceans in the Strait of Gibraltar (Tudela *et al*., 2005; Tydeman *et al*., 2012). These nets are occasionally damaged by ships and remnants can regularly be observed in the Strait (Fig. 24; Herr *et al*., 2020).

A further carcass was sighted with a longitudinal abdominal incision (Fig. 23C). This is assumed to have occurred post-mortem and might be a case of human mutilation (Read *et al*., 2000). Abdominal incisions are occasionally inflicted by fishers who commonly believe that such an incision prevents the carcass from floating and washing ashore (Read *et al*., 2000). A fourth carcass was seen drifting with a broken tail stock (Fig. 23D) with the intestines apparently exposed. This picture is unfortunately blurred which means we cannot be sure whether the animal died from a massive trauma or if the injuries occurred post-mortem (e.g., due to a propellor strike).

CONCLUSIONS

This study provides an update on traumata among cetaceans in the Strait of Gibraltar. Unfortunately, our observations are in agreement with the previous report by Herr *et al*. (2020) who identified recreational fishery activities and the use of illegal drift nets as major threats. We detected similar patterns of injury in the time frame from 2016–20. Big game fishing lines continue to cause severe lacerations. In some cases, these wounds served as an entry point for dermal infections. In addition to intense fishery pressures, the Strait of Gibraltar is one of the busiest shipping lanes in the world. This dense traffic imposes a severe threat of injuries and death. Mariners do not always adhere to the recommended speed limit of 13 knots. We documented sharp traumata that are likely to have been caused by propellor blades. Blunt vessel traumata cannot be confirmed from photographs, but some individuals exhibited abrasions that may indicate a blunt vessel interaction.

Overall, local cetacean populations continue to face a variety of anthropogenic threats. Herr *et al.* (2020) emphasised the need for an area-wide management plan to mitigate these observed human impacts. Even though protective measures were established by Spanish legislation in 2007, we recorded similar injury patterns as Herr *et al.* (2020). Our work is not able to provide statements on injury prevalence. Further studies are urgently needed to quantify the anthropogenic impact and evaluate the efficacy of these current protective measures. We stress the importance of continued surveillance, improved monitoring and enforcement of existing legislation, which requires collaboration between the Spanish and Moroccan authorities.

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AUTHORS' DECLARATION

This work was conducted in conformity to Spanish legal requirements.

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