Increasing numbers of ship strikes in the Canary Islands: proposals for immediate action to reduce risk of vessel-whale collisions

MANUEL CARRILLO[1] AND FABIAN RITTER[2]

Contact e-mails: canariasconservacion@yahoo.es; info@m-e-e-r.de

ABSTRACT

The Canary Islands, known for their extraordinarily high cetacean species diversity, have witnessed a rapid expansion in fast and high speed ferry traffic during the past few years. At the same time, ship strikes have been increasingly reported. 556 cetacean carcasses, found ashore, or reported, in the Canary Islands between 1991 and 2007, were examined. 59 strandings (10.6%) were found to involve vessel-whale collisions, the great majority of strandings (58%) occurred on Tenerife. Species most affected were sperm whales (*Physeter macrocephalus*, *n* = 24, 41%), pygmy sperm whales (*Kogia breviceps*, *n* = 10, 17%), Cuvier's beaked whales (*Ziphius cavirostris*, *n* = 7, 12%), short-finned pilot whales (*Globicephala macrorhynchus*, *n* = 6, 10%) and at least three baleen whale species (*n* = 9, 15%). Twenty six animals (44%, *n* = 42) were either calves or juveniles, and one was a newborn. The temporal distribution of strandings indicates that lethal strikes have increased in recent years. Most ship strikes, assumingly by large and fast moving vessels, probably resulted in the death of the animals, as indicated by severe injuries such as huge slashes, cuts, broken vertebrae or animals separated into halves. Given these numbers and the widely accepted fact that only a portion of ship strikes will be recorded due to under-reporting and carcasses drifting away or sinking, ship strikes appear to be a major threat to cetaceans in the Canary Islands, especially to sperm whales. Moreover, the issue is a matter of human safety, as crew and passengers are at risk of being harmed, too. In this situation, a number of measures to mitigate the risk of ship strikes are recommended as a matter of high priority. These include the placement of dedicated look-outs on fast moving vessels, the shift of ferry transects where feasible, a speed limitation for local high-risk areas where cetacean abundance is notably high, the introduction of an obligatory reporting system of vessel-whale collisions and the conduction of detailed studies dealing with this pressing issue.

KEY WORDS: CETACEANS; SHIP STRIKES; CANARY ISLANDS; NORTHERN HEMISPHERE; MEDITERRANEAN SEA; FAST FERRY TRAFFIC, MITIGATION; SPERM WHALE; PYGMY SPERM WHALE; CUVIER'S BEAKED WHALE; SHORT FINNED PILOT WHALE

INTRODUCTION

The worldwide number of collisions increased markedly from the 1950s onwards, which corresponds to the period of time when ships customarily began to reach maximum speeds of 14–15 knots or more (IWC, 2008; Laist *et al.*, 2001). During recent decades, with the rapid development of shipping traffic on a global scale, the situation in some parts of the world has become so critical that the issue by now is on the Agenda of the International Maritime Organisation (IMO, 2007; 2009).

Cetacean species affected include both large whales and small cetaceans such as dolphins and beaked whales (see review by Van Waerebeek *et al.*, 2007). However, certain species are especially vulnerable, namely those ones which swim slowly and stay at the surface for longer periods of time, for example right whales (*Eubalaena spp.*) and sperm whales (*Physeter macrocephalus*). Collisions with whales can also pose a threat to human safety, which is highlighted by the fact that considerable damage to ships has been reported (IWC, 2008; Laist *et al.*, 2001), as well as instances where sailors and ferry passengers have been hurt, including a case of human fatality in the Canary Islands (de Stephanis and Urquiola, 2006).

Although relatively little is known about the geographical distribution of collision cases on a global scale, a number of hot spots have been identified where ship strikes may affect the status of cetacean populations (ACCOBAMS, 2005; Pesante *et al.*, 2002). These include the east coast of the USA (Douglas *et al.*, 2008; Knowlton and Kraus, 2001), the northern Mediterranean Sea (Panigada *et al.*, 2006), the Strait of Gibraltar (de Stephanis and Urquiola, 2006), the Western Pacific (IMO, 2007) and the Canary Islands (de Stephanis and Urquiola, 2006; Ritter, 2010). These areas are characterised by a substantial overlap between high levels of shipping traffic and a known high density of cetaceans.

Where known, the types of vessels involved in collisions include a great variety of watercraft comprising large ships such as tankers, cargo or cruise ships, but also whale watching vessels, navy ships, yachts, hydrofoils and others (Jensen and Silber, 2004; Laist *et al.*, 2001; Ritter, 2009; Van Waerebeek *et al.*, 2007). Large high speed craft (HSC) have become a major concern, because they travel regularly at speeds of up to 35–40 knots, and collisions appear to be increasing (Ritter, 2010; Weinrich, 2004). These craft typically incorporate modern hull shapes like wave-piercing catamarans or trimarans.

Not surprisingly, fatality rates and severity of injury to whales struck by boats are related to size and speed of vessels. According to Laist *et al.* (2001), 89% of accounts in which the whale was seriously injured or killed occurred at speeds of 14 knots or more. Moreover, most lethal and serious injuries were caused by large ships of 80m length or more. Thus, speed appears to be a central factor with regards to collisions.

[1] *CANARIAS CONSERVACIÓN, Maya 8, 38204 La Laguna, Tenerife, Canary Islands, Spain.*
[2] *M.E.E.R. e.V., Bundesallee 123, 12161 Berlin, Germany.*

Table 1

Details of vessel-whale collision cases in the Canary Islands (1991-2007). Legend: TF = Tenerife, GC = Gran Canaria, LG = La Gomera, LZ = Lanzarote, LP = La Palma, FV = Fuerteventura, H = El Hierro, n.n. = not determined, MoD = Moderately decomposed, AD = Advanced decomposition. M = Male, F = Female.

Date	Species	Code	Island	Length (cm)	Sex	Condition	Age class	Notes
07/07/91	Sperm whale	Pm.070791	TF	n.n.	F	Fresh	Calf	Huge cuts. Collision with jet-foil (Company Trasmediterranea).
07/07/91	Sperm whale	Pm.070791	TF	n.n.	F	Fresh	Adult	Huge cuts. Collision with jet-foil (Company Trasmediterranea).
26/02/92	Short-finned pilot whale	Gm.260292	TF	340	F	MoD	Juvenile	Found floating on 22/02/92 with a large dorsal cut.
28/02/92	Undetermined	–	FV	1,200	–	–	–	Impact with ferry *Princesa Teguise*. Described as large cetacean of >12 m. Passengers: 1 injury and 18 with contusions.
30/05/92	Cuvier's beaked whale	Zc.300592	TF	550	M	MoD	Juvenile	Clear cut which separated the caudal peduncle from body. Cookie cutter marks and other shark bites.
12/07/95	Sperm whale	Pm.120795	TF	n.n.	–	Fresh	Calf	Only head of animal was found.
09/04/96	Sperm whale	Pm.090496a	GC	1,010	F	–	Adult	Ferry *Armas*.
09/04/96	Sperm whale	Pm.090496b	GC	680	M	–	Calf	Ferry *Armas*.
04/05/99	*Balaenopteridae*	B.040599	GC	n.n.	–	–	–	Collision observed by fishermen.
10/06/99	Short-finned pilot whale	Gm.100699	TF	n.n.	–	–	–	Collision with ferry *Gomera Jet*.
00/07/99	Fin whale	Bp.000799	TF	n.n.	–	–	Adult	Male of more than 20m. Press report in *La Gaceta* (18/09/99): *'¿Por qué mueren las ballenas?'*.
04/08/99	Sperm whale	Pm.040899	TF	n.n.	–	–	–	Head separated from body. Buried by technicians from Tenerife Council (Servicio de Recuperación Fauna).
06/08/99	Sperm whale	Pm.060899	TF	1,050	F	Fresh	Adult	Deep mediodorsal cut. Found floating and brought into harbour.
10/09/99	*Balaenopteridae*	B.100999	LG	n.n.	–	–	–	Rorqual tropical with a deep cut. Body was hauled off.
06/10/99	Bryde's whale	Be.061099	GC	1,200	F	MoD	Adult	Hematoms found all over the body.
20/01/00	*Balaenopteridae*	B.200100	LG	n.n.	–	–	–	Reported by passenger of ferry *Gomera Jet*.
09/06/00	Cuvier's beaked whale	Zc.090600	TF	n.n.	F	Fresh	Juvenile	Cut at the level of dorsal fin.
06/04/00	Sperm whale	Pm.060400	LZ	n.n.	M	MoD	Calf	Two cuts on head typical for propeller strikes.
12/06/00	Sperm whale	Pm.120600	TF	n.n.	–	Fresh	Juvenile	Head separated from body. Many plastic items found in stomach.
21/08/01	Sperm whale	Pm.210801	TF	600	F	Fresh	Calf	Large wound on posterior third of body: 600cm.
23/09/01	Sperm whale	Pm.230901	TF	n.n.	–	Fresh	Calf	Length of the head (which was separated from the body): 135cm.
24/09/01	Sperm whale	Pm.240901	TF	790	M	AD	–	Deep lateral cut lefthand side from lower jaw to dorsal fin.
07/02/02	Pygmy sperm whale	Kb.070202	TF	240	M	AD	Juvenile	Deep cuts mediodorsal and caudal.
18/04/02	Short-finned pilot whale	Gm.180402	TF	167	F	AD	Calf	Politraumatised on the skull, jaws, ribs and vertebrae, but without external marks.
21/06/02	Cuvier's beaked whale	Zc.210602	TF	525	M	AD	Adult	Medio-lateral cut at the height of the dorsal fin.
02/04/03	Short-finned pilot whale	Gm.020403	TF	1,60(+)	–	AD	Adult	Support from technicians of the 'Servicio de Fauna del Cabildo de Tenerife'. Only first third of body appeared.
28/04/03	Pygmy sperm whale	Kb.280403	TF	250	M	AD	Juvenile	Body cut at two locations: (1) at the height of the lung; (2) at the height of reproductive organs.
30/06/03	Pygmy sperm whale	Kb.300603	TF	238	M	AD	Juvenile	Deep cut from pectoral flipper to the vertebral column.
02/07/03	Pygmy sperm whale	K.020703	LP	300	–	AD	Adult	Deep sagittal cut.
05/07/03	Sperm whale	Pm.050703	TF	490	M	Fresh	Calf	Two traversing cuts: (1) from head to behind the blowhole; (2) deep cut close to dorsal fin.
11/10/03	Sperm whale	Pm.111003	H	953	M	AD	Juvenile	Deep dorsal cut (mid body).
14/11/03	Gervais' beaked whale	Me.141103	TF	282+	M	AD	Adult	Body cut off behind the genital area. Has been floating several days.
25/11/03	Sperm whale	Pm.251103	GC	1,200	–	–	–	Referenced in the press media.
15/04/04	Sei whale	Bb.150404	GC	n.n.	F	AD	Juvenile	Body cut into halves behind the dorsal fin.
06/05/04	Cuvier's beaked whale	Zc.060504	TF	n.n.		MoD	Adult	Animal cut at the onset of dorsal fin.
21/06/04	Pygmy sperm whale	Kb.210604	TF	188	M	AD	Juvenile	Appeared the day before at La Caleta, then drifted to harbour of Güimar. Partially sectioned in front of dorsal fin.
12/08/04	Sperm whale	Pm.120804	LG	n.n.	–	AD	Juvenile	Body cut in front of pectoral fin. Animal brought quickly to dumping site.
01/10/04	Sperm whale	Pm.011004	TF	1,050	F	AD	Adult	Cut at the height of cervical vertebrae.
31/12/04	Cuvier's beaked whale	Zc.311204	TF	620	M	AD	Adult	Hauled off by Guardia Civil but then resighted. Cut at the height of digestive apparatus.
15/02/05	Sperm whale	Pm.150205	TF	500	M	AD	Calf	Deep cuts at level of thorax. Numerous shark bites.
11/05/05	Sperm whale	Pm.110505	FV	686	F	Fresh	Calf	Numerous propeller cuts.
25/05/05	Balaenopteridae	B.250505	LG	1,000	–	AD	Juvenile	First seen floating off Tenerife, stranded on 22 May on La Gomera.
29/06/05	Short-finned pilot whale	Gm.290605	TF	115	M	AD	Calf	Floating body was accompanied by bottlenose dolphins up to the harbour of Alcalá. Head cut off.
20/07/05	Indeterminado	I.200705	FV	n.n.	–	–	–	Referenced in the press media. Probable collision with jet-foil.
27/09/05	Pygmy sperm whale	Kb.270905	GC	285	F	Fresh	–	Referenced in the press media/internet.
31/03/06	Pygmy sperm whale	Kb.310306	LG	280	F	Fresh	Juvenile	Found floating off LG. Full necropsy by veterenarians of the Las Palmas University. Hematoms present. No obvious markings.

Table 1 *continued*

Date	Species	Code	Island	Length (cm)	Sex	Condition	Age class	Notes
18/04/06	Pygmy sperm whale	Kb.180406	TF	274	F	AD	Adult	Foetus of 37 cm length. Skull destroyed.
27/04/06	Sperm whale	Pm.270406	TF	460	F	Fresh	Calf	Appeared 28/05/06 at Las Maretas. Longitudinal mediodorsal cut.
04/06/06	Cuvier's beaked whale	Zc.040606	LG	490+	M	AD	Adult	Deep cut which separated the tail stock.
05/07/06	Cuvier's beaked whale	Zc.050706	TF	400+	F	AD	–	Animal was observed 4 days floating in the area. No shark bites. Last third of body cut off at the level of genitals.
25/02/07	Fin whale	Bp.250207	GC	1,700	–	MoD	Juvenile	Animal wedged on the bow of monohull ferry (Company Trasemediterranea).
06/04/07	Pygmy sperm whale	Kb.060407	TF	275 (282)	F	SD	Adult	Dorsal and mediodorsal cuts of 15–30cm length and up to 12cm deep. Orca attack?
16/05/07	Sperm whale	Pm.160507	TF	325 (+)	M	SD	Calf	Animal cut at the level of the anus. Numerous shark bites.
04/06/07	Short-finned pilot whale	Gm.010607	TF	100 (+)	F	AD	Newborn	Animal cut at the end of the genital opening. Curved cuts 25–30cm length. Shark bites. Clearly visible foetal folds on right side.
20/03/07	Sei whale	Bb.200307	GC	1390	F	MoD	Adult	Fractured thoracic vertebrae. Hematoms (anterior region right side).
00/07/07	Sperm whale	Pm.000707	GC	n.n.	–	AD	–	Only part of the first third appeared.
20/06/07	Pygmy sperm whale	Kb.200607	GC	170 (+)	–	AD	–	Curved mediodorsal cuts. Stomach contents present.
08/07/07	Sperm whale	Pm.080707	H	n.n.	–	AD	–	Deep cut at the head. No skull present. Stomach contents present.
16/07/07	Sperm whale	Pm.160707	GC	1,300	–	AD	–	Deep cut at the level of cervical vertebrae. Head separated from body at the stranding site.

In this paper collision cases in the Canary Islands from 1991–2007, identified through the investigation of dead animals, are summarised. Ship strikes are related to the high density of fast and high speed inter-island traffic in the archipelago and the urgent need to introduce mitigation measures so as to preserve the integrity of the natural populations and to conserve the extraordinarily high cetacean species diversity found in the Canary Islands are discussed.

METHODS

This study investigated cetaceans which stranded between 1 January 1991 and 31 December 2007 on the coasts of the Canary Islands or were found floating dead at sea. Moreover, reports from eye witnesses, as well as those in the press and the internet, were analysed and included, as long as descriptions unambiguously pointed to a vessel-whale collision.

Direct investigation of carcasses included the determination of species and the state of decomposition. Sex and age class were identified as far as possible. External measurements, date and locality of the carcass were noted, and photographs were taken wherever feasible. Each stranding was assigned a unique ID code. All cases were entered into a database. Five categories were used for the state of decomposition: 1 = Fresh; 2 = Little decomposition; 3 = Moderate decomposition; 4 = Advanced decomposition; and 5 = Indeterminate (ECS, 1991). For the determination of age classes, the following length-based categories were used: 1 = Adult; 2 = Juvenile; 3 = Calf; and 4 = Newborn (compare Ritter, 2003). Carcasses were searched for indications of collisions with vessels. A collision event was identified if one or more of the following observations were noted: lesions including deep parallel cuts, usually dorsal, indicative of propeller strikes; large and/or deep slashes, sometimes cutting off large portions of the body; massive blunt trauma: broken bones such as vertebrae; jaws; etc.; or animals wedged on the bow of a vessel.

RESULTS

From 1991 until 2007, 556 cetacean carcasses were found stranded on the shoreline of the seven main Canary Islands, or were reported floating dead at sea. 59 animals, representing 10.6% of strandings, showed signs of collisions or were reported as being hit by a ship. The latter was the case nine times, whereas 50 animals were directly investigated by the first author and members of the Canarian Cetacean Stranding Network. One animal was found on the bow of a large vessel (see Table 1). Other sources of mortality included natural (54%), naval exercises (5%), interaction with fisheries (4%) and death related to waste (1%). In 141 animals (26%) the cause of death could not be determined.

The species primarily involved were sperm whales (*Physeter macrocephalus*, *n* = 24, 41%), pygmy sperm whales (*Kogia breviceps*, *n* = 10, 17%), Cuvier's beaked whales (*Ziphius cavirostris*, *n* = 7, 12%), short-finned pilot whales (*Globicephala macrorhynchus*, *n* = 6, 10%) and one True's beaked whale (*Mesoplodon europaeus*; see Fig. 1). At least three baleen whale species (*n* = 9, 15%) were found after being hit by a vessel: two fin whales (*Balaenoptera physalus*), two Bryde's whales (*B. brydei*) and one sei whale (*B. borealis*). Four balaenopterid whales could not be identified to the species level, and in another two genus and species remained unknown.

58% of cetaceans thought hit by vessels were found on Tenerife (*n* = 24) and 20% on Gran Canaria (*n* = 12). On La Gomera, six animals (10%) were encountered and three on Fuerteventura (5%). El Hierro accounted for two strandings, La Palma and Lanzarote one each. Some of the stranding locations are shown in Fig. 1.

Most animals were either juveniles (*n* = 13, 22%) or calves (*n* = 13, 22%). 15 animals (25%) were adults and one was a newborn. However, in almost one third of all strandings the age class remained indeterminate. Of those animals, where

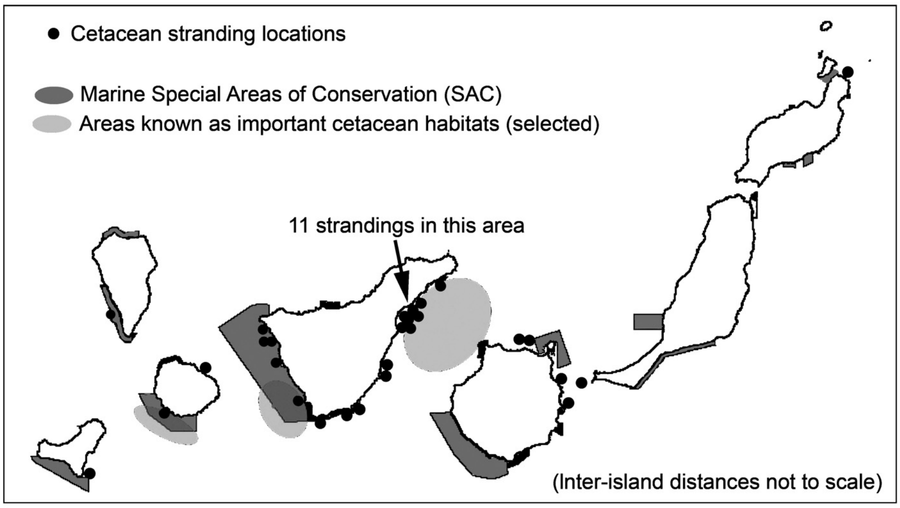

Fig. 1. Stranding locations of cetaceans showing signs of ship strikes, Canary Islands 1991–2007.

the sex could be determined (n = 36), 19 (53%) were females, and 17 (47%) were males. For 23 carcasses, the sex was not identifiable. For sperm whales, it was found that 8 animals were female, 7 were male and in 9 animals the sex could not be determined. 11 (46%) sperm whales were calves, 3 were juveniles, 4 were adults and in 6 animals the age class was not determined. Details on all strandings, together with remarks on the types of injuries encountered, are presented in Table 1.

DISCUSSION

The rate of strandings showing evidence of ship strike appears to have increased over the data collection period and indicates that the number of collisions has been at a consistently high level since 1999 (see Fig. 2). From 1991–98 the number of ship strikes recorded varied from 0 to 3, with an average of 1 per year. From 1999–2007, this number ranges from 3 to 9, averaging 6.4 per year. The effect of increased sighting effort can be ruled out as the Canary Island Cetacean Stranding network has not changed its mode of operation since it was established in 1991.

This study found that almost 11% of cetaceans stranded or found dead in the Canary Islands showed signs of collisions with vessels. Other studies have found similar percentages. Laist *et al.* (2001) reported ship strikes as possible or known cause of death in 16 out of 127 strandings (13%) on the French coast from 1972–1998, in 14 out of 407 strandings along the US Atlantic (1976–1993), and in 11 out of 55 strandings (20%) on the coast of South Africa from 1963–1998. In the Mediterranean Sea, Panigada *et al.* (2006) found that 16% (46 of 287) of cetacean deaths were caused by vessels. However, all of these areas are at least an order of magnitude larger than the spatial area described here.

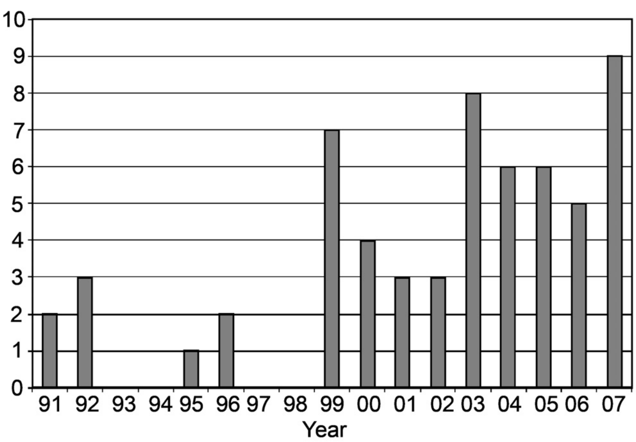

Fig. 2. Temporal distribution of vessel whale collisions in the Canary Islands 1991–2007 (n = 59).

As previously reported (Laist *et al.*, 2001; Van Waerebeek *et al.*, 2007), a variety of different cetacean species, including both large and small cetaceans, were affected by vessel collisions. Nonetheless, the numbers presented here are based exclusively on strandings and animals found floating dead at sea. To date, no single case has been corroborated by ferry operators, despite several witness reports from, for example, tourists and fishermen (Aguilar *et al.*, 2000; Ritter, unpubl. data; see also Table 1). As pointed out by Weinrich (2004), intentionally not reporting collisions may entail the attempt to avoid the implication of industrial involvement in vessel-whale collisions. Thus, the true numbers of ship strikes remain largely unknown. Official numbers provided by the Canarian Government vary from three to seven ship strikes per year from 2000–08, with a total of 42 cases in the same period (Gobierno de Canarias, 2009). These numbers are based on data provided by different Canarian research groups, including the data presented in this paper. It presumably is an underestimation, not least because collisions may go unnoticed, animals hit may sink to the seafloor or simply drift away (ACCOBAMS, 2005; Laist *et al.*, 2001). Therefore, to date it has not been possible to calculate any collision risk or conduct sound modelling for Canarian waters, despite the relatively predictable numbers concerning ferry traffic (see below).

A high percentage of juveniles and calves being hit by vessels has been observed before (Laist *et al.*, 2001; Lammers *et al.*, 2007; Panigada *et al.*, 2006). This could be explained by a greater naivety of younger animals towards ships, or less experience. Most ship strikes (41%) involved sperm whales. This number is unprecedented, as elsewhere other cetacean species are more commonly affected. In Jensen and Silber's (2004) large whale ship strike database, 5% of strandings were sperm whales. 4.8% of ship strikes in the Mediterranean Sea were reported to involve sperm whales (ACCOBAMS, 2005). Also, in the Strait of Gibraltar, where sperm whales are partially resident (Cañadas *et al.*, 2005), 'only' two collisions have been reported from 2001 until 2005 (de Stephanis and Urquiola, 2006). To our knowledge, there is no other area where sperm whales are at an especially high risk of being hit by vessels. Thus, sperm whales in the Canaries apparently are more vulnerable than elsewhere.

André *et al.* (1997) found little or no behavioural reactions of sperm whales in the Canaries after the playback of artificial sound, which was explained by a loss of sensitivity to low frequencies or habituation processes. This could explain at least partly the elevated percentage of strikes. More generally, it may be difficult for whales to detect ship noise due to a variety of different biological and physical factors (ACCOBAMS, 2005), although this will affect all species similarly. Whales also may be unaware of ships because they are distracted or asleep. This may be especially true for the sperm whales which only recently were found to show apparent bi-hemispheric sleep and may not react to approaching vessels at all (Miller *et al.*, 2008). Apparently, ship strikes have increased since the introduction of fast and high speed ferries in the Canaries. Hence, the high density of ferry traffic in the Canaries may also play a central role. Several million people (tourists and locals) travel from one island to the other every year (Rodrigez *et al.*, 2005), therefore ferry traffic is an important transport medium within the archipelago. There are several types of ferries operating between the islands to date, including one 'normal' traditional monohull and a number of different fast ferries (travelling at approx. 25 knots) as well as numerous high speed crafts (HSC, reaching maximum velocities of 40 knots, see Ritter, 2010), including the largest ferry trimaran in the world. The large catamarans are so called wave-piercing vessels and strongly dominate the inter-island traffic in the Canaries today. As pointed out by Ritter (2010), there is a concentration of HSC ferry traffic in the southwest of Tenerife (>11,000 transects per year) and between Tenerife and Gran Canaria (6,760 transects per year). The latter area is known for its high abundance of sperm whales (André, 1998). This might explain why so many sperm whales are hit by ships, and why the majority of cetaceans become stranded/washed ashore on Tenerife (see Fig. 1).

The temporal distribution of strandings indicates that the number of collisions has been at a consistently high level since 1999 (see Fig. 3). In the same year, a regular high speed craft service was introduced in the Canaries (Rodrigez *et al.*, 2005) and within the first weeks of the operation, a number of ship strikes were documented (Aguilar *et al.*, 2000). A hydrofoil operating between Tenerife and Gran Canaria in 1999 collided with a whale, which caused numerous injured passengers and one fatality (de Stephanis and Urquiola, 2006). It is not always clear if a collision took place ante or post mortem. In many animals, the symptoms (e.g. hematoma) unambiguously pointed to an ante-mortem strike, and other animals were subsequently necropsied at the University of Las Palmas in detail. The great majority of these were identified as being hit while still alive (Gobierno de Canarias, 2009).

Commercial, fast and HSC ferries today are almost the only means to travel between the islands at sea. This is illustrated in Fig. 3, which represents an overview over the inter-island ferry transects, and the types of ferries operating on each transect. Ritter (2010) calculated that there were around 29,000 transects between the islands and almost 1.5 million kilometres were covered in 2007, the vast majority by fast and high speed ferries. As can be seen from Fig. 3, there is a considerable overlap with important cetacean habitats, as well as with Special Areas of Conservation under the EU Habitat Directive (see Fig. 1). Based on several cetacean studies conducted in the Canary Islands, Ritter (2010) also identified (small scale) high risk areas for vessel whale collisions, located between the islands of Tenerife and Gran Canaria as well as between La Gomera and Tenerife.

It was found that the major proportion of animals (58%) came ashore on Tenerife. Strikingly, 14 of 21 sperm whales (66%) were found on the coast of this island, and one should question the reason for this accumulation. In one of the most detailed studies on sperm whales in the archipelago, André (1998) identified the region between Tenerife and Gran

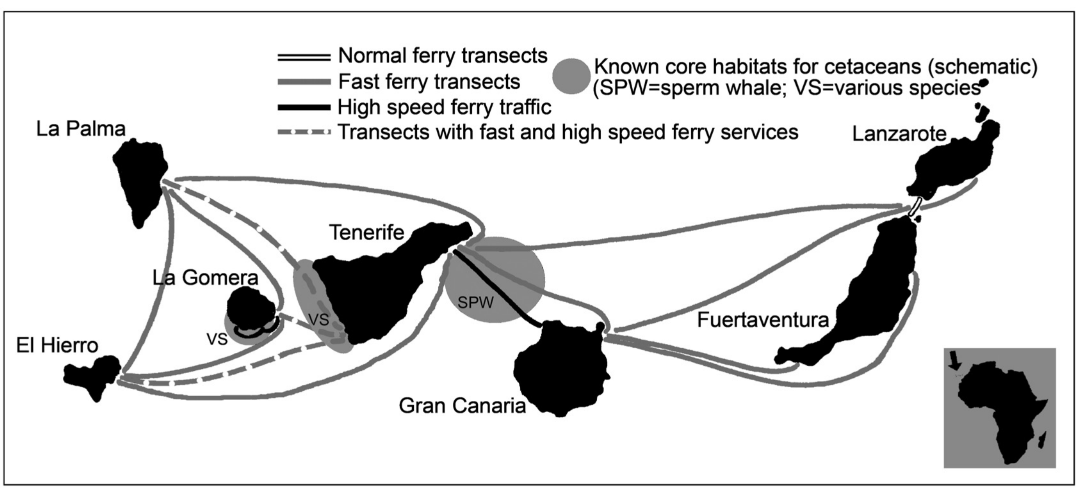

Fig. 3. Ferry transects in the Canary Islands in 2007. Adapted from Ritter (2007).

Canaria as a prime habitat for this species, where the animals were seen most regularly. This area clearly overlaps with HSC ferry transects (see Fig. 3), and for this reason was also identified as a high risk area by Ritter (2010, see above). Ritter (2010) also pointed out that if a sperm whale was hit in this area, one would expect the carcass to appear somewhere west or southwest to this region due to the prevailing south-westerly direction of the Canaries current. Most likely such a carcass therefore would strand on Tenerife.

Furthermore, some types of trauma (large whales cut in half, large longitudinal slashes, see Fig. 4) leave almost no other conclusion than that the animal was killed by a large vessel. Sometimes animals are caught on top of the bulb of monohull vessels, which was the case with one whale during this study. In any case, bulbous bows will not be capable of separating large proportions from a whale's body, as is expected from the sharp-edged wave-piercing hulls of catamarans customarily used in the Canary Islands, as witnessed several times by ferry passengers and fishermen (Aguilar *et al.*, 2000; see also Table 1). HSC were reported to have caused 43% of ship strikes in the Mediterranean Sea (Panigada, 2006). Weinrich (2004), in reviewing collision cases with ferries on a global scale, found that 46% involved ferries travelling at speeds >30 knots. Hence, it is suspected that wave piercing HSC play a major role in the magnitude of collision numbers in the Canary Islands.

Although to date a huge knowledge gap exists, especially concerning true numbers of vessel-whale collisions, it can be stated that a minimum of 1–3 sperm whales are hit per year (see Table 1). It is not possible to determine (although it is suspected) that this affects the population, as to date there exist no population estimates for most cetacean species in the archipelago. Unfortunately it is still unknown whether the sperm whales form a 'resident' population or are part of a wider unit (see Whitehead, 2003).

In light of the numbers presented here, the Canary Islands can be acknowledged as a hot spot for vessel-whale collisions. This situation certainly is a matter of concern and poses a risk to humans and cetaceans alike. There is an urgent need for mitigative action to avoid ship strikes, to achieve more transparency in reporting and to obtain more reliability for recorded numbers of collisions, in the interest of cetacean conservation.

CONCLUSIONS

Several measures have been discussed to mitigate the risk of vessel-whale collisions, such as a reduction in speed, placing dedicated observers onboard, the shift of shipping lanes, remote sensing of cetaceans via night vision, laser, sonar or infrared techniques and passive acoustic monitoring systems, among others (ACCOBAMS, 2005; IWC, 2008).

While technical measures up to now mostly have failed to prove their efficacy (ACCOBAMS, 2005) or are extremely expensive to install, a number of measures are relatively easy to realise in the short term. First, and most obviously, reducing speed will have an instant effect. High speed limits the time frame to take evasive navigational action once a whale is seen. For example, detecting a whale in the ship's path 600m away at a speed of 40 knots leaves a vessel's captain a reaction time of 30 seconds before a whale potentially is hit. Vanderlaan and Taggart (2007), reviewing

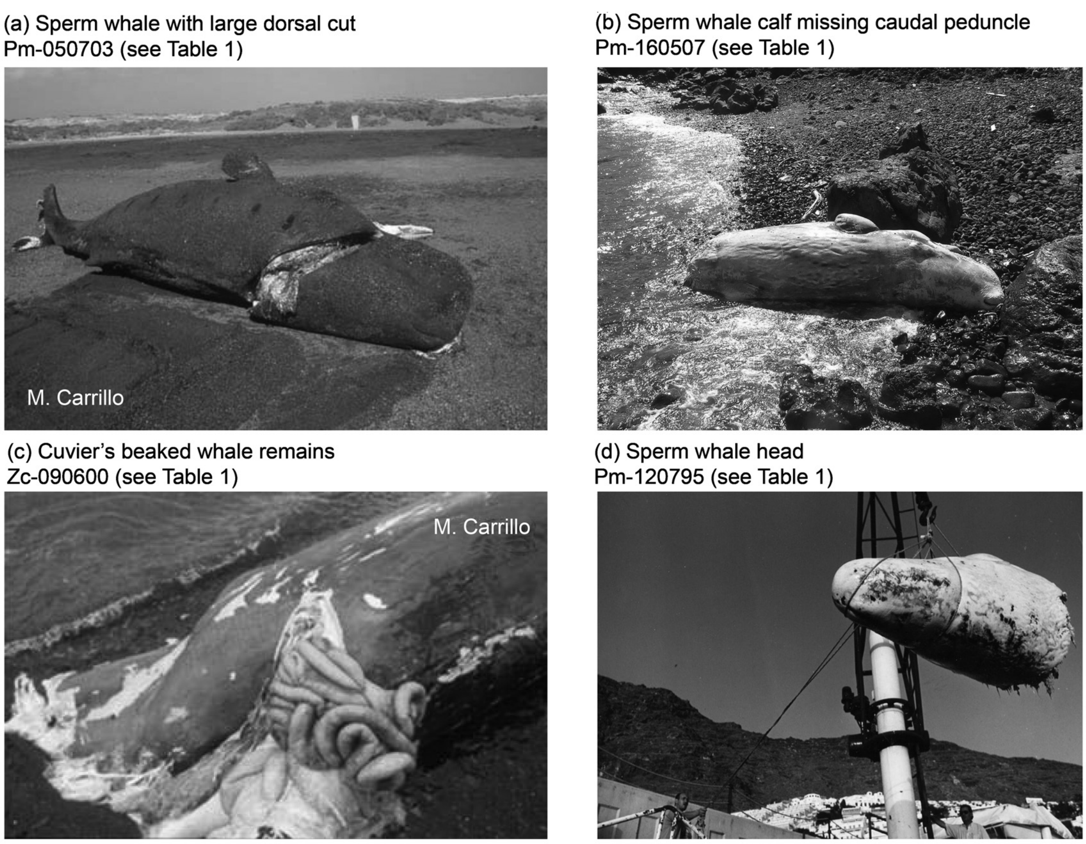

Fig. 4. Examples of injuries found in cetaceans hit by ships in the Canary Islands. All images copyright Manuel Carrillo.

collisions listed in Laist *et al.* (2001), found that at 15 knots 80% of collisions were fatal to the whales. At speeds of 11.8 and 8.6 knots the percentage of fatal collisions dropped to 50% and 20%, respectively. A speed limitation was introduced in Hawaii for the new 'super ferry' which operated 2007–09. Also, on the US East Coast vessels of 65ft and above are asked to slow down as they enter certain right whale habitats. Speed reduction has also been used to lower the risk of collision with marine mammals other than cetaceans (Calleson and Frohlich, 2007), although problems with compliance will often remain.

Dedicated observers onboard vessels have proven to be an effective means to detect whales (ACCOBAMS, 2005; Weinrich, 2004), which under high speed conditions is a crucial aspect. In Hawaii, the newly introduced HSC ferry has two full time look-outs (IWC, 2008).

Therefore, under the current state of knowledge, and re-iterating some of the recommendations by Ritter (2010), the following measures should to be taken immediately as high priority action in the Canary Islands:

(1) The placement of dedicated onboard observers (look-outs) on fast and high speed ferries operating in known core habitats (i.e. between Tenerife and Gran Canaria/La Gomera, respectively), as well as experimental onboard application of technical mitigation measures to test the feasibility and effectiveness of such measures for fast and HSC ferries.

(2) The introduction of a speed reduction on an experimental basis in zones identified as local high risk-areas (see Ritter, 2010) so as to assess a comparative collision risk.

(3) The introduction of a mandatory reporting scheme for collisions, thereby making use of the database being developed by the IWC Vessel Strike Data Standardisation Group (Van Waerebeek and Leaper, 2007).

To address knowledge gaps, a Canarian-wide quantification of both cetacean densities and shipping traffic should be conducted to enable modelling of collision risks. It should be stressed that the current situation is very favourable for research being conducted on board ferries, not least because ferry operators may be accepting observers, as indicated by De Stephanis and Urquiola (2006). In this way, the Canaries can be turned into a centre for investigating ways to avoid ship strikes. The ultimate goal must be to protect the integrity of the Canarian cetacean populations on the grounds of precaution and sustainability and to develop an effective policy to manage shipping traffic so as to secure both human and animal safety.

ACKOWLEDGEMENTS

We would like to thank all members of the Red Canaria de Cetaceos Varados (Canarian Cetacean Stranding Network) for their work, with special thanks to Marisa Tejedor. The Canarian Cetacean Sighting Network is supported by the Government of the Canary Islands (Dirección General del Medio Natural). The preparation of this paper was supported by M.E.E.R. e.V. (Berlin), Deutsche Umwelthilfe (Radolfzell) and Gesellschaft zur Rettung der Delphine (Munich). Thanks to Koen van Waerebeek, Mason Weinrich, Mark Simmonds, Claire Bass and Volker Smit for their reviews of earlier drafts as well as for their helpful comments. Many thanks also to two anonymous reviewers.

REFERENCES

ACCOBAMS. 2005. Report of the Joint ACCOBAMS/Pelagos Workshop on Large Whale Ship Strikes in the Mediterranean Sea, Monaco, 14–15 November 2005. 35pp. [Available from: *http://www.accobams.org*]

Aguilar, N., Carrillo, M., Delgado, I., Díaz, F. and Brito, A. 2000. Fast ferries impact on cetacean in Canary Islands: collisions and displacement. *Eur. Res. Cet.* 14: 164.

Andre, M. 1998. Cachalotes en Canarias. PhD thesis, La Universidad de Las Palmas de Gran Canaria.

Andre, M., Terada, M., Lopez Jurado, L.F. and Watanabe, Y. 1997. Sperm whale (*Physeter macrocephalus*) behavioural response after the playback of artificial sounds. *Rep. int. Whal. Commn* 48: 499–504.

Calleson, C.S. and Frohlich, R.K. 2007. Slower boat speeds reduce risk to Manatees. *Endangered Species Research* 3: 295–304.

Cañadas, A., Sagarminaga, R., De Stephanis, R., Urquiola, E. and Hammond, P.S. 2005. Habitat preference modelling as a conservation tool: proposals for marine protected areas for cetaceans in southern Spanish waters. *Aquat. Conserv.* 15: 495–521.

de Stephanis, R. and Urquiola, E. 2006. Collisions between ships and cetaceans in Spain. Paper SC/58/BC5 presented to the IWC Scientific Committee, May 2006, St. Kitts and Nevis, West Indies (unpublished). 6pp. [Paper available from the Office of this Journal]

Douglas, A.B., Calambokidis, J., Raverty, S., Jeffries, S.J., Lambourn, D.M. and Norman, S.A. 2008. Incidence of ship strikes of large whales in Washington State. *J. Mar. Biol. Assoc. UK*. [Published online by Cambridge University Press, 17 March 2008, doi: 10.1017/S0025315408000295]

European Cetacean Society. 1991. *Guidelines for the Postmortem Examination and Tissue Sampling of Cetaceans*. Leiden, The Netherlands.

Gobierno de Canarias. 2009. Activities on cetaceans carried out by the Canary Islands Government in 2008 and review of historic data records of cetaceans and ship strikes in the Canary Islands. Paper IWC/61/CC16 presented to the IWC Conservation Committee, Madeira, June 2009. [Paper available from the Office of this Journal]

IMO. 2007. Work Programme of the Committee and Subsidiary Bodies – Measures for minmising the risks of collisions with cetaceans. Marine Environment Protection Committee: MEPC 57/18/2.

IMO. 2009. Report of the Marine Environment Protection Committee: MEPC 59/24.

IWC. 2008. Third Progress Report to the Conservation Committee of the Ship Strike Working Group. Paper IWC/60/CC3 presented to the IWC Conservation Committee, Santiago, Chile, June 2008. [Paper available from the Office of this Journal]

Jensen, A.S. and Silber, G.K. 2004. Large Whale Ship Strike Database. US Department of Commerce, NOAA Technical Memorandum, NMFS-F/OPR-25, January 2004. 37pp.

Knowlton, A.R. and Kraus, S.D. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *J. Cetacean Res. Manage. (special issue)* 2: 193–208.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. 2001. Collisions between ships and whales. *Mar. Mammal Sci.* 17(1): 35–75.

Lammers, M.O., Pack, A.A. and Davis, L. 2007. Trends in whale/vessel collisions in Hawaiian waters. 12pp. Paper SC/59/BC14 presented to the IWC Scientific Committee, May 2007, Anchorage, USA (unpublished). 12pp. [Paper available from the Office of this Journal]

Miller, P.J.O., Aoki, K., Rendell, L.E. and Armano, M. 2008. Stereotypical resting behaviour of the sperm whale. *Current Biology* 18(1).

Panigada, S. 2006. Ship Strikes in the Mediterranean Sea and the ACCOBAMS activities. Special-Ship Strikes. Vol. 3(1), August 2006. pp.12.

Panigada, S., Pesante, G., Zanardelli, M., Capoulade, F., Gannier, A. and Weinrich, M. 2006. Mediterranean fin whales at risk from fatal ship strikes. *Mar. Poll. Bull.* 52: 1287–98.

Pesante, G., Collet, A., Dhermain, F., Frantzis, A., Panigada, S., Podesta, M. and Zanardelli, M. 2002. Review of collisions in the Mediterranean Sea. *In*: Pesante, G., Panigada, S. and Zanardelli, M. (eds). *Proceedings of the Workshop: Collisions between Cetaceans and Vessels: Can we find solutions?* 15th Annual Meeting of the European Cetacean Society in Rome, 2001. ECS Newsletter No. 40: 5–12 (Special Issue).

Ritter, F. 2003. *Interactions of Cetaceans with Whale Watching Boats – Implications for the Management of Whale Watching Tourism*. MEER eV, Berlin. 91pp. [Available from the author].

Ritter, F. 2010. Quantification of ferry traffic in the Canary Islands (Spain) and its implications for collisions with cetaceans. *J. Cetacean Res. Manage. 11(2).* [This volume]

Ritter, F. 2009. Collisions of sailing vessels with cetaceans worldwide: first insights into a seemingly growing problem. Paper SC/61/BC1 presented to the IWC Scientific Committee, June 2009, Madeira, Portugal (unpublished). 13pp. [Paper available from the Office of this Journal].

Rodrigez, M.C., Garcia, E. and Poleo, A. 2005. High speed crafts in the Canary Islands. *Journal of Maritime Research* II(2): 81–91.

Van Waerebeek, K., Baker, A.N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, P.G., Secchi, E., Sutaria, D., van Helden, A. and Wang, Y. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere; an initial assessment. *LAJAM* 6(1): 43–69.

Van Waerebeek, K. and Leaper, R. 2007. Report from the IWC Vessel Strike Data Standardisation Group. 6pp. Paper SC/59/BC12 presented to the IWC Scientific Committee, May 2007, Anchorage, USA (unpublished). 6pp. [Paper available from the Office of this Journal]

Vanderlaan, A. and Taggart, C.T. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Mar. Mammal Sci.* 23(1): 144–56.

Weinrich, M. 2004. A review of worldwide collisions between whales and fast ferries. Paper SC/56/BC9 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy (unpublished). 8pp. [Paper available from the Office of this Journal]

Whitehead, H. 2003. *Sperm Whales: Social Evolution in the Ocean*. University of Chicago Press, Chicago. 464pp.

Date received: September 2009
Date accepted: February 2010