Collisions of sailing vessels with cetaceans worldwide: First insights into a seemingly growing problem

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ABSTRACT

Vessel-whale collisions are of growing concern worldwide. Up to now, no systematic investigation has been conducted in relation to collisions involving sailing vessels. This study represents the first quantification of this kind on a global basis. An online survey was set up including questions about the most important features of a collision or near miss event. Additionally, the internet was searched for reports involving sailing vessel-cetacean collisions. A total of 81 collisions and 42 near misses were identified, spanning from 1966 until 2008. Collisions and near misses occurred on all oceans, often during ocean races and regattas, and were most frequent in the North Atlantic. A larger proportion of cases was reported in the past few years, indicating an increasing trend. Vessel type and speed as well as circumstances of the incident varied widely, but most often monohulls were involved, predominantly sailing at speeds between 5 and 10 knots. Most reports referred to "large whales" as opposed to "small whales" or "dolphins". The species could be identified in 44 cases. Most recognized animals were humpback or sperm whales. Injuries to the whales varied strongly from "not visible" to "dead after collision", but mostly could not be determined. Sailing crew members were hurt in several cases, including collisions occurring at low speeds, and collisions often damaged vessels, including major impairment and three cases of vessel loss. The findings presented here suggest that elevated vessel speed contributes to a higher risk of collisions. Conversely, the outcome of a collision (e.g. injury to whale or crew, damage to vessel) is not a direct function of vessel speed. Several measures are discussed which potentially can contribute to mitigating the problem, including placing watchposts, changes in the design of regattas and ocean races and education initiatives.

KEYWORDS : CETACEANS, COLLISIONS, NEAR MISS, SAILING VESSELS, ONLINE SURVEY

INTRODUCTION

Collisions between vessels and cetaceans are of growing concern on a global scale. Historical records of collisions date back to the early 17th century, and the worldwide number of collisions appears to have increased steadily during the recent decades (Laist *et al.*, 2001; IWC, 2008). Today, collisions may significantly affect the status of cetacean populations in certain areas of the world, namely where both cetaceans and shipping traffic are concentrated (Pesante *et al.*, 2002; ACCOBAMS, 2005; Panigada, 2006; Carrillo & Ritter, 2008). While the issue meanwhile has entered discussions at international levels, with the IWC playing a major role in raising knowledge and awareness, it is still not known how many whales and/or dolphins are hit each year, although it is widely accepted that collision numbers are mostly underestimated and generally increasing.

Most cases where whales were known to be severely hurt or killed occurred at vessel speeds of 14 knots or more and were caused by large ships of 80 m or more in length (Laist *et al.*, 2001). While sailing vessels usually are of smaller size, modern racing yachts including multihulls vessels frequently reach speeds of more than 20 knots, thereby likely increasing both collision risk and probability of injuries for humans and cetaceans.

The types of vessels involved in collisions with whales include tankers, cargo or cruise ships, but also whale watching vessels, navy ships, hydrofoils, high speed ferries and sailing vessels (Laist *et al.*, 2001; Jensen & Silber, 2004; Van Waerebeek *et al.*, 2007; Carrillo & Ritter, 2008). Information about collisions involving sailing vessels is especially scarce. There is anecdotal knowledge of collisions between sailing boats and cetaceans, however, no systematic investigation has been conducted so far. To counteract this knowledge gap, the study presented here focused on instances where sailing vessels had a collision or near miss with a cetacean, the reports on which were obtained from a variety of sources.

The aim of this study was to shed light on the issue in general and to qualitatively and quantitatively investigate

- the circumstances under which collisions occur
- which types of sailing vessels are usually involved in collisions
- the prevalence of collisions between sailing vessels and cetaceans
- if numbers of collisions with sailing vessels are increasing and
- the risks posed to animals, vessels and sailing crew.

METHODS

A variety of sources were used to collect collision cases. Initially, the internet was searched directly. Additionally, the *Google Alert*[1] function was used, which automatically delivers search results, i.e. links to websites, where defined search words were detected. Search words were "collision whale" and "Kollision Wal". The *Google Alert* was active from June 2006 until end of December 2008. This search resulted in regular references to websites (here termed "internet reports") which subsequently were inspected for collision reports involving sailing vessels. Additionally, numerous international internet websites related to world sailing activities (N=16) and sailing magazines were contacted (N=5) for information on the issue. The latter initiative resulted in a co-operation with one of the major sailing websites worldwide (*noonsite.com*), who offered to establish an online survey.

For this survey, a questionnaire was elaborated including questions about the most important features of a collision or near miss event. These features were selected in accordance with the existing IWC ship strike data base (IWC, 2008). The questions included time, day and location of collisions or near miss events and factors like vessel size, hull type and speed. Enquiries were also made about species type ("large whale", "small whale" or "dolphin") and species identification. To learn how often collisions occur, it was asked if whales were seen before a collision, if any avoiding manoeuvres were taken, or if any injuries were observed on the animals after the collision. Other questions dealt with possible injuries to vessel crew, vessel damage, etc. The survey asked 19 questions about the actual incidents and additional information about the identity of the reporter. A copy of the survey is given in Appendix 1. The questionnaire hence combined a large amount of information gained with a high degree of user-friendliness, i.e. making it practicable to go through the survey within a relatively short period of time.

The survey was put online early in June 2006 and simultaneously announced on *noonsite.com* and *m-e-e-r.org*. A press release further distributed the news about the survey. Finally, the MARMAM discussion group and the email discussion group of the European Cetacean Society (ECS) were used to a) announce the online survey and b) to find out if members of the marine mammal researcher community were aware of any collision or near miss events. A near miss was defined as a close encounter of a vessel with a cetaceans (animal within only a few metres or less) bearing a collisions risk but not leading to an impact.

Survey entries and internet reports were collected until December 31, 2008. Survey entries that did not yield useful information were discarded. Where necessary, the following steps were taken to make data quantifiable: For vessel speed, where a range was provided rather than a distinct number, the lower value of the range was set as the travel speed of the vessel. This was done to receive a more conservative value. Concerning species identification, the species status was categorized into (1) definite, when there appeared to be no doubt about the species, sometimes with records of distinctive morphological features or behaviours of the animals observed, (2) probable, when there was little doubt about the species identity, sometimes with records of distinctive morphological features or behaviours observed and (3) possible, when there was considerable doubt about the identity of the species. For analysis by species, only categories (1) and (2) were considered. The question regarding vessels being "under sail" or "motoring" sometimes was answered as "motorsailing". These cases were classified as "motoring", as the crucial aspect here is the vessel engine running (as the potential predominant acoustic cue to the animals). Evidence of vessel damage was further classified into i) minor, when sailing could be continued without restrictions, ii) major, when sailing was only possible in a limited manner and iii) vessel loss, when the vessel finally had to be given up or turned out to be irreparable.

RESULTS

The internet search resulted in 29 reports on collisions and one report of a near miss event. The online survey yielded a total of 52 reports on collisions and 41 reports of near miss events. Thus, a total of 81 collisions and 42 near misses were identified. The majority of internet reports delivered answers to only a fraction of the questions asked because they usually were relatively broad in scope. Likewise, many contributors to the online survey did not answer all questions.

The temporal distribution of incidents spanned from 1966 until 2008 for collisions and from 1979 until 2008 for near miss events. The annual number of reports ranged from 0 to 18 collisions and from 0 to 9 near miss events. 66 (70%) occurred in the period from 2003 until 2008 (see Fig. 1)

Due to the generic difference of collision and near miss events, especially in light of the dissimilarity of their outcomes, results will be presented separately here. Percentage numbers mostly refer to the numbers of cases for which information was available. Accordingly, missing percentages represent the fraction of survey entries without answers or where the answer was "Not known", and absent information in internet reports, respectively.

[1] *Google Alert* is a search engine based internet crawler obtaining keyword related search results from news, web, blogs, and groups

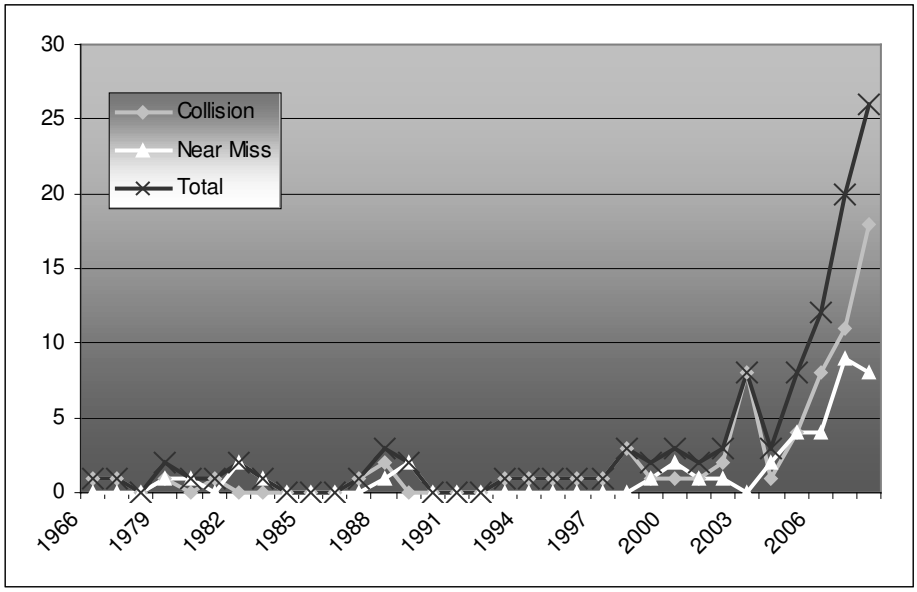

***Fig. 1*: Number of reported collisions (N=70) and near miss events (N=40) between sailing vessels and cetaceans per year worldwide (1966-2008)**

Near miss events

Out of the total of 41, 38 incidents (92.7%) were reported by sailors directly involved and one was found on the internet. The majority of near miss events occurred in the Atlantic Ocean (N=26; 63.5%), 24 in the North Atlantic including the Caribbean Sea and two in the South Atlantic. Ten incidents were reported for the Pacific Ocean (eight in the North and two in the South Pacific). The Mediterranean sea accounted for two cases, the Northern Indian Ocean for one, and six from other areas (see Table 1).

31 vessels (75.6%) were monohulls, and the majority (N=27) of vessels were made of GRP fibreglass, with only a few vessels being made of wood (N=2), aluminium (N=2) or steel (N=1). The size of the vessels ranged from less than 10 m (N=3) to more than 20 m (N=1). Most vessels were 10-15 m (N=24, 58.5%) and four (9.8%) were 15-20 m long (see Table 2).

Location	Collision (N=79)	Near miss (N=41)	Total (N=120)	Total (%)
North Atlantic Ocean	31	22	53	44,2 %
South Atlantic Ocean	5	2	7	5,8 %
Caribean Ocean	4	2	6	5,0 %
North Pacific Ocean	12	8	20	16,7 %
South Pacific Ocean	17	2	19	15,8 %
Northern Indian Ocean	1	1	2	1,7 %
Southern Indian Ocean	3	0	3	2,5 %
Mediterranean Sea	2	2	4	3,3 %
Other	4	2	6	5,0 %

***Table 1*: Locations of collisions and near miss events between sailing vessels and cetaceans (1966-2008)**

30 near misses (73.2%) occurred during day time, 9 (22%) at partial light (dawn/dusk) and one at night time (darkness). The animals were seen before *and* after the near miss in only 11 cases (26.8%), and either before or after in 8 cases each (19.5%, see Table 2).

During the incident, most vessels were under sail (N=24, 58.5%), while 8 (19.5%) were either motoring or motorsailing. The speed of the vessels varied from 2 to 8.5 knots. Most vessels travelled at 5-10 kn (N=24, 58.5%), and 8 (19.5%) less than 5 kn (see Figure 2).

12 sailors reported that they took manoeuvres to avoid the collision (which otherwise would have been very likely), and two reported that they saw the animals only when it was too late to take any action. In 15 cases the animal was reported to be missed by only a few metres (<10 m, most often much less). Four times it was apparently inquisitive behaviour, e.g. approaches by the animals, that led to a near miss.

		Collision	Near miss	Total	Total %
Vessel size	< 10 m	3	3	6	7,7 %
	> 10 m	34	24	58	74,4 %
	> 15 m	5	4	9	11,5 %
	> 20 m	3	1	4	5,1 %
	N	*46*	*32*	*78*	
Vessel type	Monohull	48	31	79	89,8 %
	Catamaran	6	0	6	6,8 %
	Trimaran	3	0	3	3,4 %
	N	*57*	*31*	*88*	
Light	Day time	42	30	72	68,6 %
	Dawn/Dusk	7	9	16	15,2 %
	Night time	16	1	17	16,2 %
	N	*65*	*40*	*105*	
Whale seen	Yes	17	19	36	39,1 %
before	No	46	10	56	60,9 %
	N	*63*	*29*	*92*	

***Table 2**: Collisions and near miss events between sailing vessels and cetaceans worldwide (1966-2008): vessel size, vessel type, light conditions and detection of whales*

24 times (58.5%) the animal was categorised as a "large whale" and seven times (17.1%) as a "small whale" (see Table 3a). In 10 cases (24.4%), no categorisation was made. In 15 instances the cetacean species was identified. These included sperm whales (N=6), right whales (N=2), grey whales (N=2), blue whales (N=1), fin whales (N=1), minke whales (N=1) and pilot whales (N=1; see Table 3b). In 21 cases (63.4%), no species identification was provided. No injuries to the crew or vessel were reported.

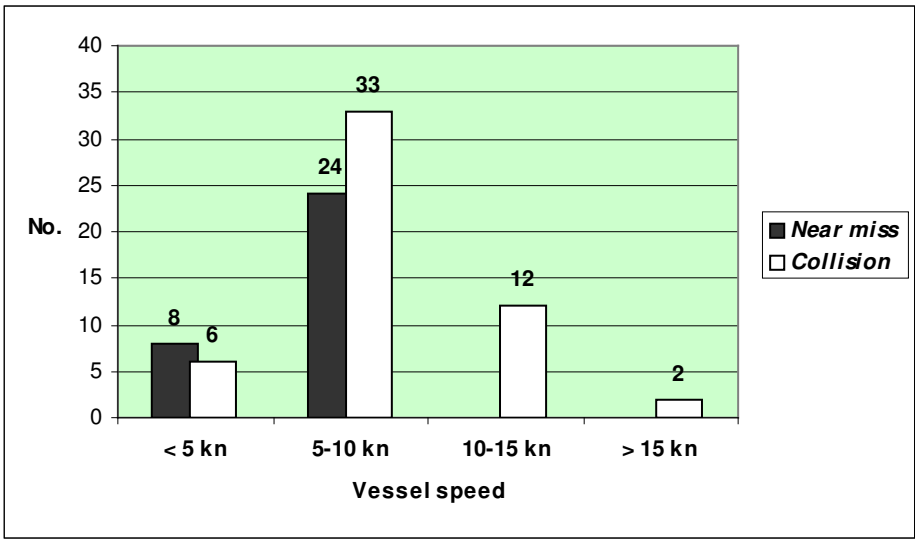

***Fig. 2**: Collisions (N=53) and near miss events (N=36) between sailing vessels and cetaceans in relation to vessel speed (1966-2008).*

Collisions

Of a total of 81, 45 incidents (55.6%) were reported by sailors directly involved and 31 (38.3%) were found on the internet. The majority of collisions occurred in the Atlantic Ocean (N=40, 49.4%), 31 in the North Atlantic including the Caribbean Sea and five in the South Atlantic. 29 (35.8%) incidents were reported for the Pacific Ocean (12 in the North and 17 in the South Pacific). The Mediterranean Sea accounted for two cases, the Indian Ocean for four (one in the Northern Indian Ocean and three in the Southern Indian Ocean, see Table 1). One collision with a humpback whale was caught on film[2].

48 vessels (59.3%) were monohulls, 6 (7.4%) were catamarans, and 3 (3.7%) were trimarans. The size of the vessels ranged from less than 10 m (N=3) to more than 20 m (N=3). Most vessels were 10-15 m (N=34, 42%) and five (9.8%)

[2] The video sequence can be watched on the internet at: http://www.sailvalis.com/Pac%20Cup%2008/Images/Whale.mpg

were 15-20 m long (see Table 2). The majority (N=35, 43.3%) of vessels were made of GRP fibreglass, with smaller numbers made of wood (N=5), aluminium (N=2) or steel (N=2).

42 collisions (53.1%) occurred during day time, 7 (8.6%) at partial light (dawn/dusk) and 16 (19.8%) at night time (darkness). In 46 cases (56.8%), the animals were not seen before the collision (see Table 2). In 49 cases (60.5%) the animals were seen after the collisions (12.3%).

Vessels mostly were under sail (N=64, 79.0%) while 6 (7.4%) were either motoring or motorsailing. 23 (28.4%) collisions were reported occurring during sailing regattas, most of these being ocean races.

Vessel speed at the time of the collisions varied from 2 to 25 knots. Most vessels travelled at 5-10 kn (N=33, 40.7%, see Figure 2). Yet, in one third of the incidents (N=27), vessel speed remained unknown or was not provided. Four sailors reported that they took manoeuvres to try to avoid the collision. Collisions during regattas involved vessel speeds ranging from 7 to 25 knots with a mean of 11.5 (SD=4.99; N=12), including 50% of cases where speed was 10 kn or more.

37 times (45.7%) the animals were categorised as a "large whale" and 11 times (13.6%) as a "small whale", and four (4.9%) were dolphins (see Table 3a). For 28 accounts (34.5%), no categorisation was made or the answer was "not known". In 28 cases, the cetacean species was identified, these included: humpback whales (N=15), sperm whales (N=6), grey whales (N=3), blue whales (N=1), pilot whales (N=1), common dolphins (N=1) and orcas (N=1, this case was attributed to the "small whale" category due to the large body size of orcas) (see Table 3b). Yet again, in the majority of descriptions (N=53, 65.4%) no species identification was provided. For five situations, it was reported that juveniles or calves (="small animals") were seen, and in one of these cases it was reported that the young animal was hit.

a) ID Category	Collision (N=53)	Near miss (N=31)	Total (N=84)	Total (%)
Large whale	37	24	61	72,6
Small whale	11	7	18	21,4
Dolphin	4	0	4	4,8

b) Species	Collision (N=29)	Near miss (N=15)	Total (N=44)	Total (%)
Humpback whale	15	1	16	36,4
Sperm whale	6	6	12	27,3
Grey whale	3	2	5	11,4
Right whale	0	2	2	4,5
Pilot whale	1	1	2	4,5
Blue whale	1	1	2	4,5
Fin whale	0	1	1	2,3
Minke whale	0	1	1	2,3
Common dolphin	1	0	1	2,3
Orca	1	0	1	2,3

Table 3: Collisions and near miss events between sailing vessels and cetaceans worldwide (1966-2008). a) ID category and b) species identification.

The behaviour of the animals prior to the collision was described for 20 instances. Five times, the animals appeared to be sleeping/logging on the surface, one whale was seen travelling, and four showed inquisitive behaviour, e.g. by approaching the vessel and/or riding its bow wave (two bowriding cases both involved dolphins). Seven times, whales appeared to emerge from below and thus apparently hit the vessel while trying to surface. Three cases involved animals being described as "attacking" the vessel and in one instance a (humpback) whale leapt onto a vessel. Where sailors described attacks (these involved one group of sperm whales, and one pod each of pilot whales and orcas), the animals' behaviour appeared to be intentional, with the animals actively ramming the vessel in all three cases. Finally, one whale was described as intentionally approaching the vessel and "rubbing up and down the port side", thereby causing considerable damage.

Cetaceans reportedly were hit by different parts of the vessels, typically by the bow and parts of the keel, with some assertions made about damage caused to the daggerboard. Sometimes the collision was described as being relatively soft, felt as a bump or light shudder, but during 16 collisions the vessel came to an abrupt halt. Consequently, there were several reports of crew members being hurt (N=7, 8.6%) including one instance of a crew member going over board (and 7 out of 17 crew members being injured in that same incident). Crew members were hurt during collisions

at vessel speeds ranging from 4-10 kn (N=6), while "no injury" was reported for collisions happening at speeds from 3-25 knots (N=46, Mean 7.64, SD=4.08).

There were 20 reports indicative of some kind of visible reaction of the whale after the strike. Eight whales were said to "dive away", and six to "swim away", both apparent evasive behaviours. Three whales struck the water surface with either their flukes or flippers and two were observed defecating. One injured whale "spied" at the vessel just after the strike. Three times it was explicitly stated that there was no apparent reaction by the whale. One dolphin hit by a vessel's rudder was described rolling on its side in the wake as if "stunned or the breath knocked out of it".

Injuries inflicted on the animals varied from "no visible injury" to "possibly dead". In 14 cases (17.3%) blood was seen in the water after the collision, and three whales carried visible severe injuries. One animal supposedly was dead just after a strike with a monohull vessel travelling at 15 knots, a second one was suspected to have "surely died shortly after the collision". Three animals were seen to have minor visible injuries, described as e.g. "minor scratches to the whale's skin", and in 10 cases an apparent injury could not be determined as being minor or severe (five of theses cases involved blood seen in the water). On 19 occasions (23.5%), there was "no visible injury", while 17 times (21.0%) the answer was "Not known".

No relation was identified between the gravity of the injury and the size nor the speed of the vessel. There were severe injuries and/or blood seen in water at speeds ranging from 4 to 25 knots (Mean 10.22, SD=7.02, N=9) and involving vessel sizes ranging from less than 10 m to more than 20 m length (N=8).

Vessel damage also varied widely from superficial effects (e.g. paint or antifouling ripped off the hull, scratches or small cracks, broken or bent steel poles, dents) to severe rudder, keel or daggerboard damages and major hull cracks or leaks. Two times, the collision caused the vessel to sink. In another incident, crew *and* vessel were rescued, but the vessel turned out to be not functional anymore. Additionally, several whales performed abrupt body movements at the time of the strike, thus forcefully hitting the vessel and causing damage.

Put into numbers, of those 48 collision events where damage was reported, 24 (50.0%) were classified as minor damages, and 21 (41.7%) as major damages, where sailing could only be continued with some restriction. As described above, three strikes (6.3%) resulted in vessel loss.

DISCUSSION

This study constitutes the first attempt to quantitatively assess collisions involving sailing vessels on a global scale. The internet was found to be an effective means to collect collision reports. However, the number of collision events reported on the world wide web, particularly near misses, is – and probably will remain – restricted. Logically, only the more spectacular cases will enter news coverage and internet reports in general. Moreover, the information given in internet reports usually is not extensive and generally does only cover the most basic aspects of an incident.

Conversely, a large number of collision and near miss reports were collected via the dedicated online survey, which thus was the more efficient way to collect data for this study, especially because survey entries by their nature yielded more detailed information. A considerable interest in the issue on behalf of the "sailing scene" was noticed, as expressed through a number of emails by sailors and sailing website administrations and, of course, through the establishment of the online questionnaire initiated by a major sailing website. Nevertheless, in numerous cases not all questions of the survey were answered, and thus information repeatedly was limited, too. Moreover, many sailors around the world may have no access to the internet and therefore are not aware of the online survey. Although the online questionnaire could be answered anonymously, there might generally be a certain reluctance to report a collision at all, as it plausibly is an unpleasant experience. Sailors may also be unsure if there will be (legal or other) consequences when they report an incident (IWC, 2003; Lammers *et al.*, 2007). The survey is still online and it is hoped that sailors will increasingly make use of it.

The temporal distribution of collisions and near miss events showed that this is not a new phenomenon. The earliest cases reported occurred in 1966 (collision) and 1979 (near miss), respectively. Yet, most of the incidents were reported to have happened during the past few years (see Figure 1). Although this points to a marked increase in collisions with sailing vessels in recent years, we have to take into account several aspects potentially leading to an under estimation of the previous collision rate. First of all, cases that date back years or decades may not be reported because the details are not clearly remembered. The internet was used as the primary source of data, thus reports in newspaper archives and other written media referring to more historical accounts were missed. E.g., collision accounts involving sailing vessels are a rarity in the scientific literature (see Appendix 2), while this study showed that the phenomenon is quite widespread.

Ocean sailing has become a diversion or profession for an increasing number of people around the world. Hence there are many more vessels sailing on the oceans, which inevitably increases the likelihood of collisions with marine mammals. Consequently, the increase in collision and near miss events during recent years found in this study can be interpreted as a representative reflection of growing number of sailing vessel-cetacean collisions.

Although it is assumed that collisions with sailing vessels are far less frequent than with motorized vessels (see Lammers *et al.*, 2007), they may not be as rare as previously thought. Yet, this study has to be considered but a first

glimpse at how widespread sailing vessel-whale collisions are and how often they occur. It is by far too early to make any assumption about "true" numbers, this is a feature of collision research in general. It is also likely that no near misses were reported by vessels travelling at high speeds (10 kn or more) because they would typically have been in rougher seas and so less likely to see a whale and been aware of having almost hit it.

This study has demonstrated that collisions between sailing vessels and cetaceans may occur on all oceans, but are most common to the Atlantic. This in line with the geographical distribution of current entries in the IWC ship strike data base (Russell Leaper, pers. comm.), and also represents the fact that there is generally more sailing traffic observed in the Atlantic, and that the largest proportion of sailing yachts are crossing the North Atlantic (Jeremy Wyatt, pers. comm.). It is worth noting that sailing yachts tend to sail in "trade wind zones" at particular times of year – i.e. when wind speed and direction are favourable, and future investigations may highlight such geographical areas.

The large proportion of monohull sailors, generally made from fibreglass, reflects the fact that this is by far the most abundant vessel type worldwide, and most large scale ocean races and regattas are conducted with monohull vessels.

Species affected

The minority of cases reported in this study relates to animals classified "small whales" or "dolphins". This corresponds to the general knowledge about ship strikes (see Van Waerebeek & Leaper, 2008). The assumed comparable low risk of dolphins colliding with vessels still may be an underestimation, as evidenced by Van Waerebeek (2007), who found 31% of worldwide collision reports related to small cetaceans. Personal observations of the author in the Canary Islands (Ritter, unpublished data) draw a similar picture.

Laist *et al.* (2001) and Van Waerebeek *et al.* (2007) name a variety of cetacean species affected by vessel collisions, including large whales and small cetaceans like dolphins, beaked whales a.o.. As pointed out by Carrillo & Ritter (2008), certain large whale species are especially vulnerable, namely those ones staying at the surface for longer periods of time, for example right whales (*Eubalaena spp.*, see also Knowlton & Kraus, 2001) and sperm whales (*Physeter macrocephalus*, see also Ritter, 2007). The ship strike database of the IWC, as for 2008, contained a total of 572 cases where the species was positively identified (Van Waerebeek & Leaper, 2008). The majority were fin, humpback and right whales (Russell Leaper, pers. comm.). In the Mediterranean Sea, fin whales are at highest risk to be hit by vessels (Panigada, 2006). Fin and humpback whales were also the most common species in the US Large Whale Ship Strike Database (Jensen & Silber, 2004). While the high proportion of humpback whales (and large whales in general) corresponds to the findings presented here, there are otherwise considerable differences in the frequency of different species being struck. We do not know the reasons why sailing vessels apparently tend to collide less often with fin whales than with sperm and humpback whales. One explanation could be the degree of familiarity of sailors with these species due to relative obvious morphological and/or behavioural features compared to e.g. fin whales. Likewise, the relatively high proportion of near miss events involving sperm whales can be attributed to their rather distinctive behaviour of frequently logging on the surface. As pointed out by Leaper (pers. comm.), sperm and humpback whales were also more approachable by open boat whalers. Thus there may be behavioural reasons for the species' differences, something well worth to be investigated in the future.

Reasons for collisions

Animals were hit by different parts of the vessels, most logically by the bow and the keel. Some claims were made about the daggerboard being damaged, too. In ultra-light, high speed boats sailing faster than hull speed, there is minimal hull in the water and the main contact is likely to be the keel or daggerboard. This part of the vessel strongly protrudes from the hull downwards, sometimes several metres. Not much is known about the sound generated by daggerboards, however, it was stated by one sailor, that daggerboards can be "quite noisy and they buzzed so maybe the whales could hear it"3. While this is speculative, there appears to be a real chance that cetaceans may hear an approaching sailing vessel, at least under "ideal" conditions. Sailing vessels produce faint sounds by the flow of the water along the hull (Richardson et al., 1995 cited in Koschinksi, 2002), and daggerboards may contribute their own frequencies. As was stated in Koschinski (2002), many sailors put on diesel generators when whales are seen to make the vessel more audible. Hence, there is some awareness that cetaceans can be surprised by "silent" vessels. But it has to be stressed that running a propeller would be much louder, as the source level of the boat's engine or generator will be dominated by propeller noise.

Nonetheless, some collisions occurred while the vessel was motoring or motorsailing. It may be difficult for whales to detect the faint sound of sailing vessels ship noise, due to a variety of biological and physical factors (ACCOBAMS, 2005) or masking through ambient sounds generated by wind, rain and shipping noise (WDCS, 2006). The relatively high number of whales colliding with a vessel from below, assumingly while trying to surface, again points to the whales not being aware of the vessel, both visually and acoustically. Whales also may be unaware of ships because they are distracted or asleep (WDCS, 2006). This may be especially true for sperm whales which only recently were found to show apparent bi-hemispheric sleep and sometimes do not react to approaching vessels at all (Miller *et al.*, 2008).

Vessel speed

In motorized vessels, speed is generally thought to be a major factor concerning the number of collisions (see Laist *et al*., 2001; Vanderlaan & Taggart, 2007). This appears to be similar in sailing vessels: Although the majority of collisions occurred at speeds of 5-10 knots (see Fig. 2), the vast majority of sailing vessels cannot go faster than 8-9 knots which is the displacement hull speed for boats up to about 20 m overall length. The fact that 26% of collisions happened at faster speeds despite very few boats sailing at these speeds shows that speed probably has an effect. In this relation, it is worth mentioning that collisions during regattas on average happened at faster speeds than during other contexts.

The number of regattas and ocean races has steadily grown during the past decades, and there have been dramatic increases in speed of the vessels in long distance sailing races. Many of these events seem to have at least one account of a collision. Given the scarcity of multihulls it appears that this vessel type has a higher rate of collision reports. This could be due to their generally higher speed, their involvement in high profile races with good media coverage or because they are more vulnerable to damage due to lightweight construction – or a combination of these aspects (Russell Leaper, pers.comm.).

Although in the majority of collisions (56,8%, N=46), the animals were not seen prior to the impact, a number of sailors who had seen the whale reported that they took steps to circumvent a collision. In 12 cases, this actually helped to avoid a strike, while in four it didn`t. This underlines that collisions might be prevented if a whale is seen early enough to take action. Obviously, this is dependant on someone being on the helm, which in solo sailors will not always be feasible. A high degree of effectiveness to avoid collisions has been attributed to dedicated look-outs on larger vessels (Weinrich & Pekarcik, 2007), therefore in larger sailing crews it might be beneficial to establish a permanent watch-post, at least while sailing in areas where cetacean abundance is known or expected.

Behaviour of the animals

Some whales hit were seen logging on the surface which can be interpreted as resting or slow travelling behaviours. While floating behaviours logically are particularly risky, the relative high number of whales being described as surfacing from a dive (i.e. colliding with the bottom/keel of the vessel) is surprising. Regularly, animals apparently tried to surface without noticing an approaching vessel. An unfavourable combination of the ship's speed and the low sound level it produces may account for such instances. What is more, some whales may also actually have been attracted to the vessel before colliding (four near miss events were preceded by apparent "inquisitive" behaviours on behalf of the animals, two times bowriding behaviours resulted in a collision).

Sometimes a collision was initiated by the cetaceans through apparent aggressive behaviour. Cetaceans attacking vessels have been described, albeit rarely (but famously), in world literature (e.g. Philbrick, 2000). Van Waerebeek *et al. (*2007) also mentioned that some cetaceans may violently hit or push vessels. An interesting case involving orcas was described by Notarbartolo die Sciara (1977). Although these are puzzling and as yet unexplained events, they are beyond the scope of this study, which focused on accidental and unintentional strikes as a contribution to human-induced mortality in cetaceans.

Injuries to sailing crew or cetaceans; vessel damage

Collisions with whales can pose a threat to human safety which is highlighted by the fact that considerable damage to ships has been reported (Laist *et al.*, 2001; IWC, 2008; Jensen & Silber, 2004), as well as instances where sailors and ferry passengers have been hurt (De Stephanis & Urquiola, 2006; Jensen & Silber, 2004). This study confirmed that crew members may be hurt during collisions even at rather low speeds (the minimum found was 3 knots). On the other hand, high speed may not automatically lead to injured crew. In fact, during none of the collisions happening at speeds of 15 knots or more a sailor was hurt, which clearly contrasts to findings by Jensen & Silber (2004) and Vanderlaan & Taggart (2007), although their investigations mainly involved motor vessels. This implies that factors like the momentary whereabouts of crew members and the way a collision occurs ("softly" or with an abrupt halt) will have a stronger influence than vessel speed. In particular, sailing vessels are only likely to be travelling fast in sufficient wind. Thus unlike powered vessels which travel fastest on flat water, the motion of the vessel is likely to force the crew into positions where they are braced against the motion of the boat.

The same may apply for vessel damage. While Jensen & Silber (2004) found that all collisions where the speed was known and resulting in vessel damage took place at speeds of 10 knots or more, this study produced different results. How can a collision at low speed lead to substantial damage then? Some whales were observed hitting the surface with their flukes or other body parts when the collision occurred. Startle reactions like bending the body or slamming the tail fluke are easily understandable as natural responses to a strike, and in at least some instances this had a greater influence on the degree of vessel damage than vessel size or speed. The size of the animal, its swimming speed as a function of its behaviour, the angle at which it is hit, its immediate (startle) reaction, etc. all can play a major role for the outcome of a collision.

Last but not least the two reports of vessels sinking after a collision are alarming. A third case resulting in vessel loss underlines the potential threat to the life of a sailor when hitting a whale. A similar scenario was described in IWC (2006, p. 13). Again, speed was not a major factor for the vessel loss: one of the instances occurred when a 10-15 m monohull hit a sperm whale at a speed of 7 knots. The crew were uninjured in all three instances and finally were rescued, but one may speculate if there may have been similar cases without happy end.

Similar aspects as described for injured crew may be true for the injuries inflicted to the animals. These varied strongly from "no visible injury" to "possibly dead". One of the cases where the animal likely was killed involved a monohull vessel travelling at 15 knots (in the other case vessel speed is unknown). While this case corresponds to the general admission that most collisions causing severe injuries or death occur at greater speeds than 14 knots (Laist *et al.*, 2001), there were several cases where blood was seen in the water involving small vessels (<10 m) hitting whales at slow speeds (4-5 kn). This is contrary to what has been by Laist *et al.*'s assumption that collisions with sailing vessels only cause minor injuries.

Overall, we have to assume that the number of whales that appeared uninjured after the collisions is overestimated while the severity of an injury usually will be underestimated (see also IWC, 2003; WDCS, 2006; Lammers *et al.*, 2007). The fact that many sailors had no chance to have a closer look at the animal after the collision - if at all - because the animal will be out of sight within seconds, makes it unlikely to detect injuries or to classify them correctly (see e.g. IWC, 2005).

CONCLUSIONS

Several measures have been discussed to mitigate the risk of vessel-whale collisions, e.g. speed reduction, dedicated observers, the shift of shipping lanes as well as technical means like remote sensing of cetaceans via night vision, laser, sonar or infrared techniques, as well as passive acoustic monitoring (Pesante *et al.*, 2002; ACCOBAMS, 2005; IWC, 2008). Technical measures up to now mostly have failed to prove their efficacy (ACCOBAMS, 2005) or are extremely expensive to install. Only a fraction of these options will be applicable on sailing vessels. However, there are a number of potential solutions that might contribute to a higher awareness of the issue and the prevention of collisions, respectively.

First of all, and most obviously, keeping a sharp lookout is essential. Some collisions could be prevented after a whale was seen and according avoiding action was taken. Dedicated observers on board have proven to be an effective means to detect whales in the path of a ship (Weinrich & Pekarcik, 2007; ACCOBAMS, 2005), and combined with a general knowledge about where and when to expect cetaceans, this measure could be helpful also for participants of ocean races and regattas. However, permanent lookouts will only be practical with larger crews. Reducing speed as a voluntary measure should be considered anywhere sailors enter important cetacean habitats. Protected areas or regions where cetaceans are known to be abundant should be avoided whenever possible.

Speed limitations by their nature will not be feasible for regattas and ocean races, but other measures can usefully be considered. Gill (1997) has proposed to shift regatta routes away from the continental shelf, as these are known to commonly be inhabited by cetaceans. If this idea is thought further, other types of habitats and marine protected areas could be included as "no go's" for regattas (compare Tejedor *et al.*, 2007). Another idea by Gill (1997) is to conduct acoustical or aerial surveys just prior to a sailing event. This will help to find out if there are cetaceans present or to be expected and if yes, to shift routes around them – as has been done during the Volvo Ocean Race in April 2009 [4].

Finally, the idea to start the engine/propeller while under sail and when in areas of known high cetacean abundance appears reasonable, although we do not know if this will be effective. Experimental investigations will be necessary to confirm or reject the underlying assumption. Future research also should relate species distribution to certain vessel types and contexts (e.g. sailing regattas, etc.).

The basis for many of the options mentioned above is education. Sailors have to know about a) the risk of colliding with cetaceans, b) where they are likely to encounter cetaceans and c) what can be done to avoid a collision. Without basic knowledge, little change will be achieved. This study has shown that there is considerable interest in the issue on behalf of the sailors. Thus it seems realistic to raise further interest and to develop e.g. dedicated websites or website sections highlighting the issue.

On the other hand, if a collision has happened, sailors and regatta administrations must be encouraged to report it, and they also have to know where to direct such information to. The permanent establishment of an online survey like the one developed for this study could thereby play an important role. Also, the existence of the IWC Ship Strike Data Base should be broadcasted widely. By any means, a precautionary approach appears warranted and necessary. This study is hoped to be one of the first steps towards an open discussion with the final goal to make sailing safer, both for animal and humans.

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[4] see http://www.nytimes.com/2009/04/25/sports/othersports/25sailing.html?_r=1&ref=sports

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APPENDIX 1:

ONLINE SURVEY QUESTIONNAIRE ON COLLISIONS BETWEEN SAILING VESSELS AND CETACEANS, POSTED ON NOONSITE.COM

1. Please describe your involvement

□ I saw the incident
□ I am reporting for someone who saw the incident
□ Other: _____

Comment: _____

2. What date did the collision occur?

_____

3. Was the incident…?

□ A near miss (no collision)
□ A collision

4. Did the incident take place in

□ Day time
□ Night time (darkness)
□ Dawn/dusk (partial light)
□ Not known

5. Where did the collision occur?

□ North Atlantic
□ South Atlantic
□ Caribbean
□ North Sea / Baltic
□ Mediterranean
□ North Indian Ocean / Red Sea / Gulf
□ South Indian Ocean
□ South China Sea
□ North Pacific
□ South Pacific
□ Other: _____

6. Was the whale seen BEFORE the collision?

□ Yes
□ No
□ Not known

7. Was the whale seen AFTER the collision?

□ Yes
□ No
□ Not known

8. Any injuries to the animal? Please tick any that apply

□ Blood seen in water
□ Visible minor external injury
□ Visible severe external injury
□ Indeterminate injury
□ Dead after collision
□ No visible injuries
□ Not known

9. What was the animal? Please add a comment if the species is known, or include any features such as size, colour, fin/flipper size, behaviour

□ Large whale – over 10m/32ft long
□ Small whale less than 10m/32ft long
□ Dolphin
□ Not known

Comment: _____

10. Please briefly describe the collision.

_____

11. Were any crew aboard the vessel injured? Please give details in comment.

□ Yes
□ No
□ Not known

Comment: _____

12. Was the vessel damaged? Please give details in comment.

□ Yes
□ No
□ Not known

Comment: _____

13. At the time of the incident: was the vessel…

□ sailing
□ motoring
□ Not known

Comment: _____

14. At the time of the incident, what was the speed in knots of the vessel?

_____

15. What type of vessel was involved

□ monohull
□ catamaran
□ trimaran
□ Not known

16. What was the hull construction?

□ GRP – fibreglass or composite
□ steel
□ aluminium
□ wood
□ fero-cement
□ Not known

17. What was the approximate size of the vessel?

□ less than 10m/32ft
□ larger than 10m/32ft and smaller than 15m/50ft
□ larger than 15m/50ft and smaller than 20m/65ft
□ larger than 20m/65ft
□ Not known

18. Please include any other relevant information about the incident

_____

14. If MEER have additional questions, may they contact you? If yes, please give details. Your details will not be given to third parties and will only be used in connection with this survey.

First Name: _____
Last Name: _____
Email Address: _____

APPENDIX 2:

COLLISIONS BETWEEN SAILING VESSELS AND CETACEANS:
CASES IDENTIFIED IN THE SCIENTIFIC LITERATURE (N=8)

Date	Location	Vessel type	Species	Source
Jan 1897	Mediterranean Sea, France	Yacht	n.n.	Panigada *et al.*, 2006
Jun 1972	Pacific Ocean	Schooner	Orca	Notarbartolo die Sciara, 1977
Apr 1973	Mediterranean Sea, Italy	Yacht	16 m whale	Panigada *et al.*, 2006
Febr 1981	N. Pacific Ocean, Hawaii	Trimaran	"whale"	Lammers *et al.*, 2007
Febr 1995	N. Pacific Ocean, Hawaii	65ft sailing v.	"whale"	Lammers *et al.*, 2007
Oct 1996	Pacific Ocean, Ecuador	n.n.	Possibly sperm whale	Félix & Van Waerebeek, 2005
Dec 1997	Caribbean	Yacht	„whale"	Koschinski, 2002
Jul 2005	N. Atlantic Ocean	n.n.	NA right whale	WDCS, 2006