Collisions and near miss events between sailing vessels and cetaceans

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ABSTRACT

Vessel-whale collisions are of growing concern worldwide, but information about collisions involving sailing vessels is especially scarce. This study represents the first quantification of this kind on a global basis, using a variety of sources, including an online survey, internet research, etc.. A total of 111 collisions and 57 near misses were identified, spanning from 1966 until 2010. 75% of cases was reported for the period from 2002-2010, indicating an increasing trend. Collisions and near misses occurred on all oceans, often during ocean races and regattas, and were most frequent in the North Atlantic. 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 54 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 seven 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, an open dialogue with regatta organizers, changes in the design of regattas and ocean races and public outreach initiatives.

INTRODUCTION

Collisions between vessels and cetaceans are of growing concern on a global scale. Information about collisions involving sailing vessels is especially scarce, and there seems to be more anecdotal knowledge of collisions between sailing boats and cetaceans. While sailing vessels usually are of smaller size, modern racing yachts including multihull vessels frequently reach speeds of more than 20 knots, thereby likely increasing both collision risk and probability of injuries for humans and cetaceans. However, no systematic investigation has been conducted so far. The study presented here focused on instances where sailing vessels had a collision or near miss with cetaceans, by using a variety of sources. It aimed at shedding 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 and the. It was also investigated if numbers of collisions are increasing and what the risks posed to animals, vessels and sailing crew are.

METHODS

A variety of sources were used to collect collision cases. Firstly, the internet was searched for vessel-whale collision cases. 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 to date. This search resulted in regular references to websites which subsequently were inspected for collision reports involving sailing vessels (here termed "internet reports"). Additionally, 16 international internet websites related to world sailing activities and 5 sailing magazines were contacted. Furthermore, through a co-operation with one of the major sailing websites worldwide (*noonsite.com*), an online survey was established. A questionnaire was elaborated including questions about the most important features of a collision or near miss event. The survey asked 19 questions about the actual incidents, including time, day and location of collisions or near miss events, factors like vessel size, hull type and speed, species type ("large whale", "small whale" or "dolphin") and species identification. It was also asked if whales were seen before a collision, if any avoiding manoeuvres were taken, if any injuries were observed on the animals after the collision, if crew members were injured or the vessel damaged. The questionnaire can downloaded at *m-e-e-r.de/442.1.html*.

The survey was put online June 2006 and simultaneously announced on *noonsite.com* and *m-e-e-r.org* and via a press release. Additionally, 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

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

was defined as a close encounter of a vessel with a cetaceans (animal within 30 metres or less) bearing a collisions risk but not leading to an impact.

Survey entries and internet reports were collected until March 31, 2010. Survey entries that did not yield useful information were discarded. Where necessary, the following steps were taken to make data quantifiable: For vessel speed, to receive a conservative value, the lower value of a given range was set as the travel speed of the vessel. 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". 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 45 reports on collisions and two reports of a near miss event. The online survey yielded a total of 66 reports on collisions and 55 reports of near miss events. Thus, a total of 111 collisions and 57 near misses were identified.

The temporal distribution of incidents spanned from 1966 until 2010 for collisions and from 1979 until 2008 for near miss events. The annual number of reports ranged from 0 to 21 collisions and from 0 to 11 near miss events. 72 collisions (75%) occurred in the period from 2002 until 2010 (see Fig. 1).

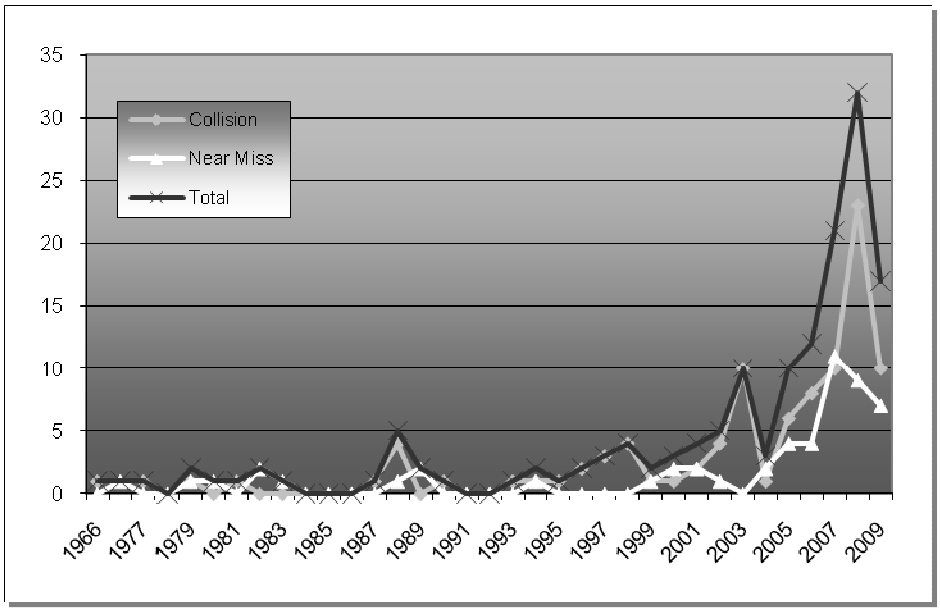

***Fig. 1*: Number of reported collisions (N=98) and near miss events (N=53) between sailing vessels and cetaceans per year worldwide (1966-2009)**

Due to the generic difference of collisions 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.

Near miss events

Out of the total of 57, 55 incidents (96.5%) were reported by sailors directly involved and two were found on the internet. The majority of near miss events occurred in the Atlantic Ocean (N=32; 56.2%), 29 in the North Atlantic including the Caribbean Sea and three in the South Atlantic. 18 incidents were reported for

the Pacific Ocean (12 in the North and 6 in the South Pacific). The Mediterranean sea accounted for two cases, the Indian Ocean for three, and two were reported from other areas (see Table 1).

75.4% vessels were monohulls (N=43), and two catamarans. The majority of vessels were made of GRP fibreglass (N=39), 12 of aluminium and few vessels being made of wood (N=2), or steel (N=1). The size of the vessels ranged from less than 10 m (N=6) to more than 20 m (N=1). Most vessels were 10-15 m (N=36, 62.2%) and three were 15-20 m long (see Table 2).

Table 1: Locations of collisions and near miss events between sailing vessels and cetaceans (1966-2010)

Location	Collision (N=106)	Near miss (N=57)	Total (N=165)	Total (%)
North Atlantic Ocean	43	26	69	41.8 %
Caribean Ocean	5	3	8	4.8 %
South Atlantic Ocean	12	3	15	9.1 %
North Pacific Ocean	14	12	26	15.8 %
South Pacific Ocean	21	6	27	16.4 %
Northern Indian Ocean	1	2	3	1.8 %
Southern Indian Ocean	4	1	5	3.0 %
Mediterranean Sea	3	2	5	3.0 %
Baltic Sea	1	0	1	0.6 %
Other	4	2	6	3.6 %

45 near misses (78.9%) occurred during day time, 9 (15.8%) at partial light (dawn/dusk) and two at night time (darkness). 30 times, the animal were seen before and 33 times after the near miss (see Table 2), and before *and* after the in 22 cases.

During the incident, most vessels were under sail (N=38, 66.7%), while 9 (15.8%) were either motoring or motorsailing. Reported speed of the vessels varied from 2 to 9 knots (N=42). Most vessels travelled at 5-10 kn (N=30), and 12 less than 5 kn (see Figure 2).

16 sailors reported that they took manoeuvres to avoid the collision (which otherwise would have been very likely), and four reported that they saw the animals only when it was too late to take any action. In 36 cases the animal was reported to be missed by only a few metres (<15 m, most often much less). Four incident involved apparent inquisitive behaviour, e.g. approaches by the animals, that led to a near miss.

35 times (61.4%) the animal was categorised as a "large whale" and 11 times (19.3%) as a "small whale" (see Table 3a). In 22 instances the cetacean species was identified. These included sperm whales (N=9), right whales (N=3), grey, humpback whales (N=3) and fin as well as grey whales (each N=2). One case each was reported for blue whales pilot whales and orcas (see Table 3b). However, in 35 cases no species identification was provided. No injuries to the crew or vessel were reported.

Collisions

Of a total of 111, 54 incidents (48.6%) were reported by sailors directly involved and 52 (46.8%) were found on the internet. The majority of collisions occurred in the Atlantic Ocean (N=60, 54.1%), 48 in the North Atlantic including the Caribbean Sea and 12 in the South Atlantic. 35 (31.5%) incidents were reported for the Pacific Ocean (14 in the North and 21 in the South Pacific). The Mediterranean Sea accounted for three cases, the Indian Ocean for five (one in the Northern Indian Ocean and four in the Southern Indian Ocean, see Table 1). Two collisions with whales were caught on film[2].

82.1% of vessels were monohulls (N=64) , 10.3% were catamarans (N=8), and 5.1% were trimarans (N=4). The size of the vessels ranged from less than 10 m (N=7) to more than 20 m (N=6). Most vessels were 10-15 m (N=43) and six were 15-20 m long (see Table 2). The majority (N=45, 76.3%) of vessels were made of GRP fibreglass, with smaller numbers made of wood (N=7), steel (N=5) or aluminium (N=2).

53 collisions (47.7%) occurred during day time, 9 (8.1%) at partial light (dawn/dusk) and 19 (17.1%) at night time (darkness). In 54 cases (48.6%), the animals were not seen before the collision, this was only the

[2] The video sequences can be watched on the internet at: http://www.sailvalis.com/Pac%20Cup%2008/Images/Whale.mpg and http://www.youtube.com/watch?v=D21iF3N_cbY , respectively.

case during 22 incidents (see Table 2). However, in 63 cases (56.8%) the animals were seen after the collision.

Most vessels were under sail (N=86, 90.5%) while 9 (9.5%) were either motoring or motorsailing. 38 (34.2%) collisions were reported occurring during sailing regattas, most of these being ocean races.

Vessel speed at the time of the collisions varied from 0 to 25 knots (N=65). Most vessels travelled at 5-10 kn (N=39, 60.9%), 14 between 10-15 knots (21.9%) and four faster than 15 knots (see Figure 2). Yet, for 46 incidents (41.4% of the total), 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 (N=15) with a mean of 12.7 (SD=5.73), including nine cases where speed was 10 kn or more (see Figure 2).

***Table 2**: Collisions and near miss events between sailing vessels and cetaceans worldwide (1966-2010): vessel size, vessel type, light conditions and detection of whales*

		Collision	Near miss	Total	Total %
Vessel size	< 10 m	7	6	13	12.0 %
	> 10 m	43	36	79	73.1 %
	> 15 m	6	3	9	8.3 %
	> 20 m	6	1	7	6.5 %
	N	*62*	*46*	*108*	
Vessel type	Monohull	64	43	107	88.4 %
	Catamaran	8	2	10	8.3 %
	Trimaran	4	0	4	3.3 %
	N	*76*	*45*	*121*	
Light	Day time	53	45	98	71.5 %
	Dawn/Dusk	9	9	18	13.1 %
	Night time	19	2	21	15.3 %
	N	*81*	*56*	*137*	
Whale seen	Yes	22	30	52	43.0 %
before	No	54	15	69	57.0 %
	N	*76*	*45*	*121*	

51 times (45.9%) the animals were categorised as a "large whale" and 12 times (10.8%) as a "small whale", and four (3.6%) were dolphins (see Table 3a). For 44 accounts (39.6%), no categorisation was made or the answer was "not known". In 32 cases, the cetacean species was identified, these included: humpback whales (N=15), sperm whales (N=9), grey whales (N=3), and one each of the following species: right whale, fin whale, pilot whale, orca and common dolphin (see Table 3b). Yet again, in the majority of descriptions (N=77, 70.6%) 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.

The behaviour of the animals prior to the collision was described for 20 instances. Six times, the animals appeared to be sleeping/logging on the surface, one whale was seen travelling, and two showed inquisitive behaviour, by riding the bow wave (both cases 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 two instance a 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. The two cases where large whales lept onto vessels involved a humpback and a right whale. One of these cases was caught on film as well as photographs. Finally, one whale was reported to be floating dead on the surface when it was hit.

Sometimes a collision was described as being relatively soft, felt as a bump or light shudder, but during 18 collisions the vessel came to an abrupt halt. Consequently, there were several reports of crew members being hurt (N=9) 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=7), while "no injury" was reported for collisions happening at speeds from 3-25 knots (N=58, Mean 7.84, SD=4.09).

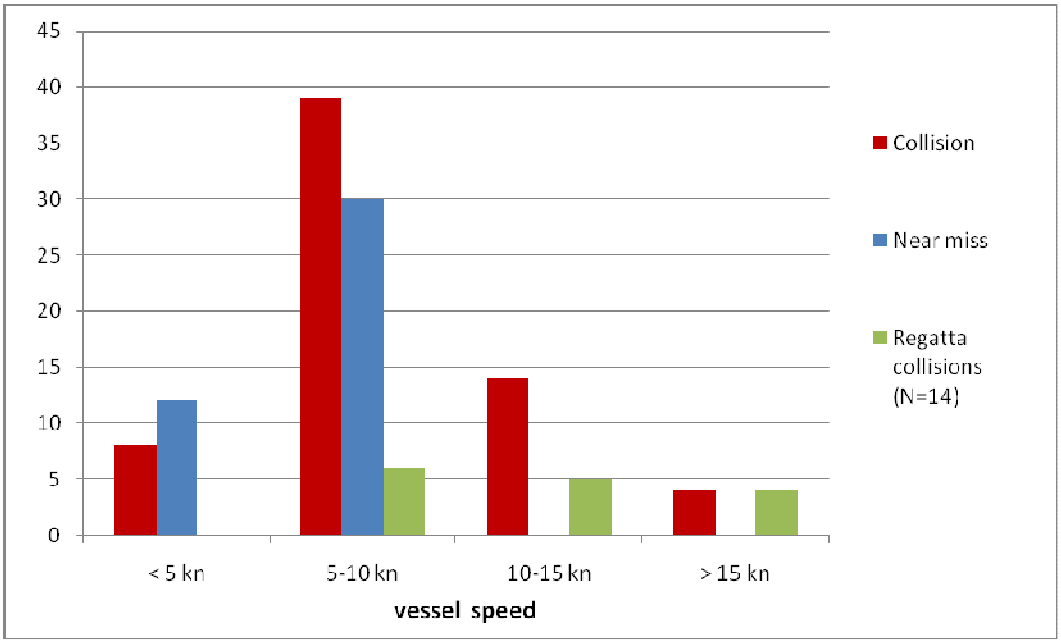

Fig. 2 *: Collisions (N=65) and near miss events (N=42) between sailing vessels and cetaceans in relation to vessel speed (1966-2010, numbers of green bars are also included in red bars).*

There were 20 reports indicative of some kind of visible reaction of the whale after the strike. Nine whales were said to "dive away", and six to "swim away", both apparent evasive behaviours. Seven 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. 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". Three times it was explicitly stated that there was no apparent reaction by the whale.

Table 3*: Collisions and near miss events between sailing vessels and cetaceans worldwide (1966-2010). a) ID category and b) species identification.*

a) ID Category	Collision (N=67)	Near miss (N=46)	Total (N=113)	Total (%)
Large whale	51	35	86	76.1
Small whale	12	11	23	20.4
Dolphin	4	0	4	3.5

b) Species	Collision (N=32)	Near miss (N=22)	Total (N=54)	Total (%)
Humpback whale	15	3	18	34.6
Sperm whale	9	9	18	34.6
Grey whale	3	3	6	11.5
Right whale	1	3	4	7.7
Fin whale	1	2	3	5.8
Blue whale	0	1	1	1.9
Pilot whale	1	1	2	3.8
Orca	1	0	1	1.9
Common dolphin	1	0	1	1.9

Injuries inflicted on the animals varied from "no visible injury" to "possibly dead". In 20 cases (18.3%) blood was seen in the water after the collision, and four 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". Six animals were seen to have minor visible

injuries, described e.g. as “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 24 occasions (22.0%), there was “no visible injury”, while 19 times (17.4%) 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 9.0, SD=5.7, N=15) involving 14 vessels ranging from 10 to more than 20 m length, including 11 cases with monohulls and two cases with catamarans.

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, etc.) to severe rudder, keel or daggerboard damages and major hull cracks or leaks. Five times, the collision caused a vessel to sink. In another incident, crew *and* vessel were rescued, but the vessel turned out to be not functional anymore. During the 2010 case when a right whale lept onto a vessel the vessel suffered total loss, too. 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 63 collision events where damage was reported, 29 (46.0%) were classified as minor damages, and 27 (42.9%) as major damages, where sailing could only be continued with some restriction. As described above, seven strikes (11.1%) resulted in vessel loss.

DISCUSSION

This study constitutes the first attempt to quantitatively assess collisions involving sailing vessels on a global scale. Collision accounts involving sailing vessels are a rarity in the scientific literature, while this study showed that the phenomenon is quite widespread. 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.

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 1974 (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, several aspects potentially leading to an under estimation of the previous collision rate have to be taken into account. Cases that date back years or decades may not be reported because the details are not clearly remembered. Early cases also would not appear on the internet. 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.

Generally, 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, but it is by far too early to make any assumption about “true” numbers.

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 most sailing yachts are crossing the North Atlantic (Jeremy Wyatt, *pers. comm.*).

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

In the ship strike database of the IWC, the majority of identified whales 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. Sailing vessels apparently tend to collide less often with fin whales than with sperm and humpback whales, but an explanation could also 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.

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). Personal observations of the author in the Canary Islands (Ritter, *unpublished data*) draw a similar picture.

Reasons for collisions

Not much is known about the sound generated by sailing vessels, and 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. However, 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). Nonetheless, some collisions occurred while the vessel was motoring or motorsailing. 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.

The 7 cases of 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).

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 28% of collisions happened at faster speeds despite very few boats sailing at these speeds shows that speed probably has an effect. 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 half of the collisions (49.5% out of N=76), 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. 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. Melville, 1851; 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), and one may speculate if the right whale which leapt onto a sailing vessel in 2010 somehow knew what it did.

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. 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 reports of vessel losses and vessels sinking after a collision are alarming. They underline the potentially great 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 could 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 (2001) 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 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

To mitigate the risk of vessel-whale collisions, several measures have been discussed, e.g. speed reduction, dedicated observers, or the shift of shipping lanes. Technical measures up to now mostly have failed to prove their efficacy (ACCOBAMS, 2005) or are extremely expensive to install. Only a fraction of available options will be applicable to 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, 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.

Speed limitations by their nature are not likely to be applied during regattas or 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). Protected areas or regions where cetaceans are known to be abundant should be avoided whenever possible. 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 [3].

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.

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 on behalf of the "sailing scene", as expressed through a number of emails by sailors and sailing website administrations and through the establishment of the online questionnaire initiated by a major sailing website. Thus it seems realistic to raise further interest and to develop e.g. dedicated websites or website sections highlighting the issue. Existing websites thereby should explicitly mention sailing vessels as a potential cause of concern.

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. Hence, the existence of the IWC Ship Strike Data Base and other regional data bases should be broadcasted widely. By any means, a precautionary approach appears warranted and necessary.

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

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