



Vessel collisions and cetaceans:

What happens when they don't miss the boat



Bryde's whale, *Balaenoptera edeni*, draped over the bow of a ship © Fernando Felix

A WDCS Science Report

By Sarah Dolman, Vanessa Williams-Grey, Regina Asmutis-Silvia and Steve Isaac

Contents

Section 1:	Introduction
Section 2:	Case studies
Section 3:	Reasons for collisions
Section 4:	Problems of reporting, and types of injury
Section 5:	Assessing the global extent of the collision problem
Section 6:	Mitigation Measures
Section 7:	Considerations and Conclusions
Section 8:	References

Introduction

The scale of the problem

Evidence is emerging that collisions between vessels and whales, dolphins and porpoises (cetaceans) may be happening more frequently than previously suspected and, in the case of endangered, endemic or geographically-isolated cetacean populations in particular, may pose a significant conservation threat.

Studies in recent years indicate that, for populations in certain areas, up to one third of whales found dead display signs of having died due to a vessel strike (Laist *et al.*, 2001). The problem is even more serious for the critically-endangered North Atlantic right whale¹, which has a remnant population currently estimated at only 300-325 individuals. In more than half (10/18) of the post-mortem findings for right whales that died in the northwest Atlantic between 1970 and 2002 indicated that vessel collisions were a contributing cause of death (in the cases where presumed cause of death could be determined) (Moore *et al.* 2004). These data are likely to grossly underestimate the actual number of animals struck, as animals struck but not recovered, or not thoroughly examined, cannot be accounted for.

Although fatal collisions are the main focus of these pages, non-fatal collisions - which can also cause serious injury - are also of concern. These are likely to negatively affect the viability, both of the affected individual and also its social group. There have been many reported sightings of whales and dolphins with deformed dorsal fins or flukes and/or wounds suggestive of propeller strike, indicating the scale of this problem, but also suggesting that cetaceans can and do survive at least some strikes. However, some of these injuries may ultimately result in the death of the cetacean even if it is several years after the collision. In at least one known case, a pregnant, adult North Atlantic right whale is believed to have died as a result of an infection from ship strike wounds she obtained years earlier as a calf ('Right Whale News' May 2005).

The problem is global. While incident reporting and awareness has certainly increased, we believe that the problem has also intensified in the last half century, due to a significant rise both in the number of vessels on our seas and waterways, and also their size and speed. Given that some of the latest models of fast ferry are capable of reaching speeds in excess of 40 knots / 74 km per hr, the potential – indeed the likelihood – of further collisions is evident.

Additional concerns include the habitat shifts which may result from environmental changes. For example, right whales, in the Gulf of Maine, are drawn to food resources and *Centropages typicus* (Copepoda: Calenoida) density is believed to be dependent on water salinity and temperature (Fransz *et al.*, 1991). Shifts in food supply will likely result in shifts in right whale habitat use temporally and spatially. This is further supported by the May 6, 2004 testimony of William Curry (Ocean and Climate Change Institute Director at the Woods Hole Oceanographic Institution) to the US Senate Committee on Commerce, Science and Transportation. In his testimony, Dr. Curry stated that there have been “intriguing changes in the

¹ A distinction is made between North Atlantic and North Pacific right whale populations because they are considered to be separate species - *E. glacialis* in the North Atlantic and in the North Pacific *E. japonica*.

ocean that have (been) detected in only the last two years” and that “these rapid climate shifts are linked to changes in ocean circulation-in particular, to changes in the North Atlantic that make waters there less salty.” These shifts could result in whales moving into areas of high risk to anthropogenic threats, including ship strikes.



Section 2: Case studies

a) The Case of the Right Whale

Between 2004 and September 2006 at least 14 North Atlantic right whales have died and, an additional whale is believed to have died (Table I). In at least half of those cases, ship strikes were the suspected cause. Of these 15, 10 are known to be female and three of those were pregnant with near full term calves at the time of their death. Additionally, ship strikes could not be ruled out as a cause of death for the three additional carcasses, which were located, but not retrieved and two other animals reportedly survived vessel strikes during that same time period.

As a species, right whales were historically subject to commercial whaling, which drastically reduced their numbers. It was anticipated that after the hunting of right whales finished, populations would recover. Unfortunately, this has not been the case. Greene and Pershing (2004) have shown that right whales are also particularly vulnerable to population fluctuations of their primary planktonic food source, *Calanus finmarchicus*. This plankton species, in turn, is particularly vulnerable to changes in climate. If *Calanus* populations decline, right whale calving rates also decline as demonstrated in the 1990s. Changes in the earth's climate due to greenhouse gas emissions may lead to more *Calanus* population declines and threaten the right whale still further.

Recent right whale collisions have included a 46-foot female, who was struck and killed in late 2003 at the mouth of the Bay of Fundy near Nova Scotia. The whale's skull was broken in half by a collision with the hull of a large ship. Another incident involved one of the largest right whales in the Atlantic; a 53-foot female named Stumpy (because of her damaged tail), is thought to have been struck between New York and Virginia and was towed ashore in North Carolina in February 2004. Stumpy, thought to be older than 40, was especially prized by researchers as a prodigious procreator who gave birth to at least five calves and who was within a week or so of having her sixth when she was killed.

North Atlantic right whale #2143 died from infections resulted from opening of previous ship strike wounds caused due to expansion during her pregnancy, so, while she survived and “healed” from the original strike, the strike ultimately led to her demise.

WDCS believes that a combination of threats make the right whale particularly vulnerable. Reducing the risk of ship strikes is, therefore, essential to prevent the extinction of this endangered species.



Summary Table I:

	Sex	Date	Location	Alive or Dead	Cause of Death
1	Male (calf)	2/3/04	FL	Dead	Unknown
2	Female (adult; pregnant)	2/7/04	NC	Dead	Ship Strike suspected
3	Female (adult; pregnant)	11/24/04	NC	Dead	Ship Strike
4	Unknown	12/9/04	MA	Dead	Carcass not retrieved*
5	Female (adult)	1/9/05	MA	Dead	Carcass not retrieved*
6	Female (adult; pregnant)	1/12/05	GA	Dead	Infection from previous vessel strike
7	Female (adult)	3/3/05	VA	Dead	Entanglement
8	Female (adult)	3/10/05	GA	Injured Likely dead	Ship Strike
9	Female (9yrs old)	4/28/05	MA	Dead	Suspected ship strike
10	Unknown	7/13/05	MA	Alive-Strike	Vessel Strike
11	Unknown	2005	NY	Dead	Carcass was not retrieved.*
12	Male (calf)	01/10/06	FL	Dead	Ship strike
13	Calf	01/16/06	TX	Alive-Strike	Ship strike
14	Female (Calf)	1/22/06	FL	Dead	Entanglement.
15	Unknown	5/18/06	NY	Dead	Carcass was not retrieved.*
16	Female (yearling)	7/24/06	NB	Dead	Ship strike.
17	Female	9/03/06	NS	Dead	Ship Strike

Summary of 2004 and 2006 North Atlantic Right Whale Incidents²

*Carcass not retrieved but ship strike cannot be ruled out.

b) Strikes on rorquals

In January 2004, a Bryde's whale was impacted by the carrier "P&O Nedlloyd Pantanal" (200m in length) off the Gulf of Guayaquil, Ecuador (Félix & van Waerebeek, 2005). The strike probably occurred by night, but the crew only discovered the whale once they had entered the quarantine area of the port of Guayaquil in the early hours of the following morning. Curiously, the whale remained on the top of the bow dome, as seen in the above photo. A massive haemorrhage on its right side showed that the adult whale had been alive when it was struck by the ship. Laist *et al.* (2001) also document cases of fin whales being brought into port in this way during the 1980s and 1990s.

c) The 'bow-draping' problem

² Compiled using data obtained from by the National Marine Fisheries Service Office of Protected Resources' Marine Mammal Health and Stranding Response Program, Northeast Regional Office, and Southeast Regional Office with Assistance from the Provincetown Center for Coastal Studies and New England Aquarium. Information Current as of August 04, 2006.

In recent years there has been a spate of incidents involving large ships striking whales and bringing the animals into port draped over the bow of the ship. In many cases the ship's crew and passengers were unaware their vessel had even collided with a ship. These collisions have involved various cetacean species in different parts of the world and it is likely that many incidents remain unreported. Laist *et al.* (2001) note there have been some historic cases of bow-draping, between 1885 and 1950. However, the increase in number and the speed of vessels has likely led to an increase in such incidents since 1950. There have been a large number of cases of bow-draping incidents since 1950, but the following table illustrates a few selected examples.

	Species	Date	Location	Further information
1	<u>Bryde's whale</u> , <i>Balaenoptera edeni</i>	10/12/2004	Gulf of Guayaquil, Ecuador	Struck by 207m length <i>P&O Nedlloyd Pantanal</i> cargo vessel. Alive when struck but later died. <i>Source: Félix & van Waerebeek 2005</i>
2	<u>Humpback whale</u> , <i>Megaptera novaeangliae</i>	28/07/1999	Stephens Passage, SE Alaska, USA	Passenger reported an 11-12m long whale draped over the ships bulbous bow. Carcass slid off as ship slowed speed. <i>Source: Laist et al. 2001</i>
3	<u>Sei whale</u> , <i>Balaenoptera borealis</i>	19/03/1998	Between Las Palmas, Canary Islands and Dakar port, Senegal	Struck by the container ship OSNA Bruck. <i>Source: Félix & van Waerebeek 2005</i>
4	<u>Blue whale</u> , <i>Balaenoptera musculus</i>	3/03/1998	Narragansett Bay, Rhode Island, USA	Juvenile brought into harbour dead on bulbous bow tanker. Strike location information unknown. <i>Source: Laist et al. 2001.</i>
5	<u>Fin whale</u> , <i>Balaenoptera physalus</i>	09/09/1993	Toulon Harbour, France	Crew felt shock, strong vibrations and a decrease in vessel speed of the bulbous bow ferry. <i>Source: Collett in Jensen & Silber, 2004, Laist et al. 2001.</i>
6	<u>Minke whale</u> , <i>Balaenoptera acutorostrata</i>	31/03/1993	New York Harbour, Staten Island, NY, USA	A 7.5m minke was brought into port on a navy ship. <i>Source: NEFSC in Jensen & Silber, 2004, Laist et al. 2001</i>
7	<u>Bryde's whale</u>	15/05/1992	Bass Strait, Australia	12m long whale found draped around hull of bulbous bow container ship upon entering harbour. Necropsy indicated whale was alive when struck. <i>Source: Wapstra in Jensen & Silber, 2004, Laist et al. 2001</i>
8	<u>Fin whale</u> , <i>Balaenoptera physalus</i>	30/04/1991	Genova, Italy	Brought into port on bow of ferry. <i>Source: Laist et al. 2001</i>

The table shows that various cetacean species can be struck and 'lodged' in this way and that in all of these cases the strike proved fatal to the whale. The table also shows that various vessel types have been involved and the incidents have taken place in a variety of different locations. Vessels involved are often, but not exclusively ships with bulbous bows. The speed and gross tonnage of the ship appear to be fundamentally important with regard to lethal and serious collisions, as argued, for example, by Koschinski (2002) and Félix & van Waerebeek (2005). A more complete list of bow-drape strikes is provided by Jensen and Silber

(2004). It's possible that some whales are hit offshore and "fall" off the bulbous bow when the ship slows down near the coast, or in the harbor, and this may be the source of some of the floating whales that are found.

d) Whale-watching vessels and ship strikes

Several whale species have been killed or fatally wounded by whale-watching vessels in the recent past, including minke, humpbacks and fin whales, Jensen and Silber (2004). One example of such a fatality is a minke that was killed in 1998 when a whale-watch vessel was not actively watching whales but was in transit, on its way back to port. The whale surfaced about 14m in front of the vessel's bow and plunged down quickly. The vessel lurched and the whale resurfaced immediately behind the vessel with a deep bleeding gash believed to be fatal Laist *et al.* (2001). In this incident at least one propeller was damaged. Cetaceans can also be struck and sometimes severely injured or killed when the whale-watch vessel is actively whale-watching. Numerous incidences of collisions between whales and whale-watching vessels during 'watching time' are documented by Laist *et al.* (2001) and Jensen and Silber (2004).

Whale-watching vessels are documented as having caused injuries to whales on various occasions as a result of trying to approach too close to the whales. For example, in 1997, a whale-watching vessel attempted to approach a site where two other boats and four zodiacs were already watching a humpback whale. The pneumatic, rigid-hulled vessel subsequently struck the whale when the animal surfaced just in front of it. The whale then became less active and appeared injured (Laist *et al.* 2001).

Other researchers have noted other harmful effects that whale-watching vessels can have on cetaceans if they do not follow official guidelines on responsible whale-watching. For example, Erbe (2002) has documented the potentially harmful effects of the noise that these vessels produce on killer whales. The threats posed by marine noise pollution from vessels and other sources re described in the recently-updated report *Oceans of Noise* (available on the WDCS website, www.wdcs.org).

WDCS has made a series of recommendations on how whale-watching can be done in a responsible, educational and exciting way. (See 'A good whale watch' under the Whale Watch section at www.wdcs.org).

e) Fast ferries and ship strikes

A review of worldwide collisions between whales and fast ferries carried out by Weinrich (2004) noted that out of 24 collision reports, eleven collisions were with fast ferries (i.e. travelling at greater than thirty knots). Laist *et al.* (2001) also note that the average speed of vessels operating around whales has increased dramatically in the past 20 years. High speed ferries were introduced in the late 1980s. Since then, their numbers have increased dramatically and, in 2006, there were over 2000 in use (FFI, 2006). Weinrich (2004), reviewing earlier reports, notes that the speed of the vessel may significantly increase the risk of serious injury or fatality to the whales.

The records of fast ferry whale strikes seem to indicate that many of the whale species that are struck by other vessels are also struck by fast ferries. Of the eleven (out of twenty four) strikes recorded by Weinrich (2004), nine were of fin whales being struck in the Mediterranean. In November 2005, there was a joint ACCOBAMS / PELAGOS (www.accobams.org) workshop on fin whales and collisions.

Due to under-reporting of ferry strike incidents, it is not possible to accurately gauge the threat to cetacean populations in particular regions. However, there are strong concerns for the endangered humpback population in Hawaiian waters, as reported by Lammers *et al.* (2003), who recorded 22 collisions between vessels and cetaceans between 1975 and 2003. Japanese waters are another region of concern for collisions between whales and ferries, not least because strikes are likely under-reported.

Ferry strikes in Japanese waters

In April 2006, an unidentified whale was struck and almost certainly killed by a high-speed hydrofoil ferry near Kagoshima Bay, Japan. More than 40 of the ferry's passengers were taken to hospital and at least 12 were reported to be in a serious condition. Virtually all of the ferry's 103 passengers were injured in some way. This follows a similar strike near Nagasaki in March 2006 and a spate of similar incidents with fast

ferries in Japanese waters in recent years. One of these occurred in the sea ten miles off Busan on April 29th, 2005. Busan Maritime Police have reported six such accidents since 2004 across the Straits of Korea. The whale species that are struck in the wider region are generally either unknown or unreported. In fact, Weinrich (2004) notes that several areas worldwide, including the Sea of Japan, produce very few reports of ship strikes despite having highly-trafficked ferry routes and the 'largest ferryboat market in the world'. Without identifying the whale species involved in these collisions, it is difficult to assess the risks to cetacean populations in Japanese waters. Several large whales are known to inhabit these seas, including sperm whales, humpbacks and Bryde's whales. Even without population data, it is clear that strikes such as these represent a major welfare issue, both for the whales involved (as we do not know the nature of their injury or how long it takes for them to die) and the passengers of the ships that strike them.



Section Three: Reasons for collisions

There are conflicting studies regarding the response of certain large whale species to vessels (Baker and Herman, 1989, Peterson, 2001). Researchers have found that some larger whale species, such as the humpback, bowhead or grey whale, can detect and change course to avoid a vessel over relatively large distances, sometimes several kilometres from the approaching vessel. Conversely, whales may (consciously or unwittingly) allow vessels to approach very closely before they react, particularly when they are feeding or socialising - behaviours necessary for their survival.

Collisions, self-evidently, happen when either whales or vessels (or both) fail to detect the other in time to take avoidance action. Research suggests that there are several variables which, singly or in combination, may either make a collision more likely, or may influence whether a collision is likely to inflict fatal or severe injuries. These may be broadly divided into vessel-related factors, cetacean-related factors, and geographical factors.

1. Vessel factors

1.1 Vessel speed:

Historically, the first accounts of collisions fatal to whales began to appear in the late nineteenth century. While there may be an historical reporting bias, it is worth considering that, at this time, ships began to reach speeds of 13-15 knots (24-28 km/hr). For example, one of the earliest collision accounts, dated 1885, involved a pilot vessel travelling at around 13 knots. The number and speed of larger vessels (over 100 gross tons) registered with Lloyds Register of Shipping increased rapidly between about 1950-1980, as did the number of documented ship strikes, and likely, reporting effort. Currently, there are around 80,000 registered vessels over 100 tons travelling the world's oceans.

Operators are likely to have less opportunity to detect and try to avoid whales when travelling at higher speeds. Research on the probability of sighting an animal during vessel cruises conducted for the purpose of obtaining cetacean abundance estimates can be examined. These studies indicate that whales are more likely to be spotted if the vessel is moving at a relatively slower speed (Asmutis-Silvia, 1999).

Additionally, the probability of a collision causing fatal or serious injury to the struck whale obviously becomes more likely as speed increases. Limited information on whale/vessel collisions has shown increased severity of the strike based on speed. Whales that have been struck at speeds greater than 13 knots were more likely to sustain fatal injuries, while whales struck at speeds less than 13 knots were more likely to survive (Laist *et al.* 2001, Jensen and Silber 2003). Additionally, Butterworth *et al.* (1982) tested the impact of vessel speed and whale detection during a Southern Hemisphere minke whale cruise. Best (1982) summarized the Butterworth study stating "The chances of all the animals on a survey track line being seen (one of the critical assumptions of line transect theory) are therefore dependent on the speed of the surveying vehicle and the frequency with which the whales surface to breathe. Clearly, the faster the vehicle moves, and the more infrequently the whale surfaces, the greater the chances that not all of the animals on the track line will be detected."

1.2 Type and size of vessel:

Almost all vessel sizes and classes have been involved in collisions with cetaceans, including cargo ships, ferries (particularly the newer models of high-speed ferry), cruise liners, navy ships, recreational vessels, fishing boats, whale-watch vessels and research vessels. In recent years, there have also been reports of wet bikes (jet-skis) being involved in collisions. If not handled with care, these high-speed watercraft can present a real threat to cetaceans, since they are extremely fast, highly-maneuvrable and also noisy (above the water at least): these factors can combine to startle and panic cetaceans, and the frequent changes of direction made by wet bikes means that cetaceans are often unable to escape.

Non-motorised vessels can also pose a threat. In July, 2005, a sailing vessel reported striking a critically-endangered North Atlantic right whale while transiting the waters off Cape Cod during the night. It is often assumed that collisions involving sailing vessels are less likely to be fatal than those involving motorised

vessels. However, there are reports of significant injuries caused by collisions with racing yachts, which are capable of reaching speeds of around 30 knots (Laist *et al.* 2001).

Most fatal or serious whale injuries reported involved strikes from larger vessels. An examination of 23 fatal collisions involving great whales revealed that at least 20 (87%) of these incidents involved vessels more than 80m long (Laist *et al.* 2001). Most minor injuries, by contrast, involved collisions with vessels less than 45m long. When whales were, however, killed by smaller vessels, these were usually travelling at high speed. This is because the force of impact is a product of the size (mass) of the vessel and the speed at which it was travelling when the strike occurred. Dr. Michael Moore, and Regina Campbell-Malone of the Woods Hole Oceanographic Institution (WHOI) are currently working with scientists to model the force of collision that will result in a fatal impact to right whales.

There may be several reasons that smaller vessels appear to be less of a risk regarding collisions with cetaceans. First, there may be a reporting bias. In the U.S. and some other countries, military vessels have an obligation to report whale collisions. Carrying passenger vessels, such as commercial whale watch vessels, are also more likely to report due to the high number of witnesses on board. However, smaller vessels may not report because they are unaware of the reporting protocols, or fear fines may be imposed as a result of reporting. Secondly, smaller vessels (e.g. <20m), as long as they are not travelling at excessive speed, generally are:

1. More vulnerable to bad weather and night operation and are, therefore, more likely to operate in clear conditions, giving a better chance of sighting a whale in the vessel's path;
2. They are closer to the water and have better visibility all round their vessel - although, for the same reason, they are unable to see whales at a distance;
3. As compared to a large ship, they tend to be more manoeuvrable, may be more likely to be able to avoid striking a whale or dolphin in their path.

1.3 Visibility:

By contrast, the sheer size and bulk of the very large vessels (for example, those over 100m in length) and the fact that the bridge tends to be towards the back of the boat, means that visibility close to the bow of the vessel is more likely to be limited. The long reaction time needed to change course means that the boat may be unable to avoid striking a whale – it may, quite literally, be stuck on a 'collision course'. In 93% of collision accounts examined by Laist *et al.* (2001), whales were either not seen beforehand, or were seen too late to be avoided.

Also, the greater mass of these larger vessels would absorb much of the impact of a strike, so that a collision with even quite a sizeable whale might go unnoticed and unreported. Indeed, as discussed in the case studies section, for crew-members on the larger ships, the first indication that their vessel has struck a whale may be when the ship arrives in port with a whale draped upon its bow. We already know that the vast majority of reported fatal collisions are caused by larger vessels, but given this last point, it is quite likely that a number of collisions with larger vessels go unreported, as seems likely for smaller classes of vessels.

2. Cetacean-related factors

Generally speaking, cetaceans are difficult to locate. They spend the majority of their lives under the surface of the water giving us only a brief glimpse into their lives. This makes them a particularly difficult species to observe and, in this case, avoid.

As a rule of thumb, cetaceans may be more likely to be hit if they are:

- young or sick
- slow swimmers
- distracted by feeding or mating activities
- habituated to vessels (or otherwise fail to sense and react to vessel approach)
- congregated in an area for feeding or breeding (risk may be density dependent)

2.1 Species differences

Whilst there are formal reports of vessel strikes affecting around a quarter of the 80-plus cetacean species, the likelihood is that most, if not all, species of cetacean (particularly in those populations living close to areas of high vessel density or activity) will be involved in collisions with vessels at some time, and that incidents may be under-recorded (see Section B). The most comprehensive reviews, such as that conducted by Laist *et al.* 2001, have tended to focus on ship strikes involving great whales (the baleen whales, plus sperm whales), but there also accounts of collisions involving pilot whales, beaked whales, bottlenose dolphins, striped dolphins, orcas (killer whales), river dolphins and harbour porpoises, amongst other species. Unfortunately, there is no way to account for the number of animals that are lost at sea, especially those that are unlikely to float and, therefore, be detected, such as minke whales. Furthermore, unless a carcass has a necropsy performed on it the possibility of ship strike as a cause of death may not be ascertained. In other words, the body may have suffered internal injuries but there may be no visible external sign of a strike.

Great whale species most frequently involved in vessel collisions (based on reported data)³

1. Fin whale (*Balaenoptera physalus*)
2. Northern right whale (*Eubalaena glacialis*)/ Southern right whale (*Eubalaena australis*)
3. Humpback whale (*Megaptera novaeangliae*)
4. Minke whale (*Balaenoptera acutorostrata*)
5. Sperm whale (*Physeter macrocephalus*)
6. Sei whale (*Balaenoptera borealis*)
7. Grey whale (*Eschrichtius robustus*)
8. Blue whale (*Balaenoptera musculus*)

Fin whales: The above review revealed that 30% of collision incidents recorded on those databases involved fin whales (Koschinski, 2002). Laist *et al.* (2001) also list fin whales as most frequently-struck of the great whale species. It may be that fin whales are more likely to wrap around the bow and wash up in coastal areas when the ships slow down and the force of the forward momentum of the ship doesn't hold the carcass in place any longer, therefore being a detection issue. Regardless, ship strikes are likely to pose a serious threat to regional populations of some species - for example, there is a small, genetically-isolated sub-population of fin whales living in the Mediterranean Sea off Sardinia and Corsica. French and Italian strandings records (covering the periods 1972-98, and 1986-97 respectively) cite ship strikes as the known or possible cause of death in up to 22% of fin whale strandings.

Northern right whales: According to Moore *et al.* (2004), more than half of the post-mortem findings for right whales that died in the northwest Atlantic between 1970 and 2002 indicated that vessel collisions were a contributing cause of death (in the cases where presumed cause of death could be determined). These data are likely to grossly underestimate the actual number of animals struck, as animals struck and lost at sea cannot be accounted for.

In the past twenty years, forty-eight right whales have died; an average of 2.4 per year (Kraus *et al.* 2005). Given that the total population numbers only 300-325 individuals, this clearly represents a significant threat to a species driven almost to the brink of extinction by commercial whaling last century. Despite being officially protected since 1936, vessel strikes – and entanglement in nets – represent serious obstacles to the species' recovery.

Humpback whales: Around a third of humpback whales found dead along the US Atlantic coast between 1985-1992 had injuries caused by ships (Wiley *et al.* 1994). It is important to note that many of these animals did not show external signs of trauma and ship strike injuries were only detected through comprehensive necropsies. Since not all reported dead humpbacks are necropsied, these data represent a minimal estimate of the impacts from vessel strikes to this species.

³ A review of strandings databases for the US Atlantic Coast [1975-1996], Italy [1986-97], France [1972-98] and South Africa [1963-98], cited in Koschinski, 2002

2.2 Population differences

Cetaceans are divided into discrete (although often poorly characterised) biological populations. Some such populations are known to be genetically distinct. Damage to a single population thus needs to be seen in the context of the potential loss of a discrete biological entity as well as having implications for a wider species unit. Moreover, a local population of whales is an important component of its ecosystem and damage to this component may have implications for other species and habitats. Pesante *et al.* (2000) believe that the reproductive segregation of Mediterranean fin whales from the North Atlantic stocks, and the small population size of the Mediterranean fin whales (ca 3,500: Tethys, unpublished) mean that the level of dead/injured whales (due to collisions) is a source of concern.

2.3 Age/Gender:

Collision victims are often calves or juveniles, or mothers with newborn calves. For example, 75% (6 out of 8) northern right whales struck off the US Atlantic coast between 1975-1996 were calves or juveniles, similarly 80% (8 out of 10) of the humpback whales killed by ships in the same period were estimated to be three years of age or less (Stevick 1999). More recently, of the 15 known right whale mortalities in the North Atlantic between 2002 and September 2006, gender was known for 13 animals. Of those 13, 76% (10/13) were female and three of those were pregnant with near full-term calves. These individuals represent a loss of more than 5% of the breeding population.

In South Africa, stranding records (1963-98) for southern right whales reveal that 55% of animals killed by ship strikes were calves or juveniles (Best *et al.* 2001). Nursery and breeding areas, then, are frequently associated with increased risk of collisions. Younger animals may be more vulnerable to being hit by vessels for several reasons: they tend to swim more slowly; be less adept at diving (therefore spending relatively longer at the surface compared to adults), and also tend to congregate in shallow coastal waters. They are also often more curious than adults: wariness of vessels may come with age and experience. Also of note, nursery areas tend to be coastal and areas where animals congregate as opposed to offshore areas where reporting and locating carcasses is less likely to occur, hence this could at least in part be a detection issue.

2.4 Swim speed:

There are some accounts of whales displaying a 'last-second flight response' prior to being struck by a vessel and one might expect a threatened animal to try to avoid a collision by desperately speeding away. For example, the US Coastguard (1991) reported an incident where two large whales may have dived to avoid collision but were subsequently struck by the coastguard vessel.

Collisions occur with those species known for swimming relatively swiftly, particularly when large ships are involved. Depending on where the whale is in proximity to the ship, the hydrodynamic forces may pull the whale toward the hull, or repel the animal.

The issue was recently summed up as follows in a review of boat harassment: "It might be assumed that dolphins and other cetaceans can easily outpace vessels or dive deep underwater to safety. This notion is predicated on their first perceiving the presence of the vessel and then acting in good time in an appropriate manner to avoid it. ...In fact, dolphins cannot attain the speed of many vessels and have to come to the surface every few minutes to breathe..." (Simmonds, 2000)

2.5 Time at the surface:

The amount of time spent at or near the surface is an important factor when assessing the probability of an individual whale or dolphin being struck by a ship. Surface time may be dictated by prey density such. Studies by Baumgartner *et al.* (2003) indicate that the vertical migration of plankton results in dense patches of copepods at, or near, the surface at night. Right whales may be more susceptible to ship strikes at night as a result of spending more time at, or near, the surface as well as they are less likely to be detected by passing vessels in the dark. As already noted, mothers with newborn calves, older calves and juveniles are obliged to spend a greater proportion of their time at the surface and so are particularly vulnerable, as are sick or entangled whales. Some species, such as the sperm whale, spend a great deal of

time at the surface, resting and socialising, and hence, although renowned for their lengthy deep dives, sperm whales may be frequent victims of vessel strike.

2.6 Distraction by other activities:

It is not just the fact that whales are physically at the surface that puts them at risk, they may also be so preoccupied with feeding, socialising, courtship and mating, or some other activity, that they become oblivious to the presence of vessels. Researchers found that several great whale species, including humpback, blue and fin whales, were markedly less responsive to vessel approach when they were engaged in feeding (Richardson 1995). There are also many accounts of collisions with ‘sleeping’ sperm whales, right whales, humpbacks and bowhead whales (Slijper 1979).

2.7 Failure to hear approaching vessels/impaired hearing:

Since whales and dolphins live in an environment where sound – rather than sight/vision – is the dominant sense, it might be assumed that the sound of an approaching vessel would easily be perceived and would trigger an avoidance reaction. Yet, this is not automatically the case, for a variety of reasons. All vessels, large and small, including even sailing vessels, produce varying degrees of underwater sound. As a rule of thumb, sound levels increase with vessel size and speed, with larger vessels tending to create stronger and lower frequency sounds. The noise emanating from a large container vessel, for example, combines ‘narrowband’ sounds concentrated at specific frequencies, with ‘broadband’ sounds, which are spread over a range of frequencies (Richardson, 1995).

Some of the larger baleen whale species, such as fin and minke whales, produce a range of sounds (principally moans and grunts used for communication with other whales), at frequency levels primarily below 2 kHz with some frequency components as low as 10 Hz, in the case of fin whales. This is similar in frequency to the sounds generated by some of the larger vessels, and this, plus behavioural evidence indicating that baleen whales are capable of directional hearing, suggests that these whales should, in theory, be capable of hearing the approach of these vessels from a specific direction, and take appropriate avoidance action (Richardson, 1995).

However, this may not always be the case: for example, in areas where shipping traffic is particularly heavy, ongoing exposure to underwater noise from a range of sources - including industrial and military activities, as well as boat propellers and engines - can be sufficient to cause auditory trauma, impairing the whale’s ability to hear approaching vessels. Whales subjected to continuous loud noise or to sudden blasts of noise, can suffer ‘acoustic overexposure’ which can lead to temporary hearing loss for a period of hours, but in extreme cases, overexposure can lead to permanent damage to the ear or other organs and body tissues. Autopsies carried out on two sperm whales struck by boats in the Canarian Archipelago, revealed physical changes to the cochlea, the region of the ear responsible for detecting low frequency sounds. Researchers in the Canaries suspect that sperm whales in the vicinity are subjected to such continuous noise from vessels and other activities that they have lost hearing sensitivity in the low frequencies and, therefore, may not detect a vessel’s presence in time to avoid a collision (André 1997).

Further, whales both here and in other busy shipping areas, may experience such a high level of ambient ocean noise that the noise of an individual vessel approaching may be ‘masked’ until it is too late. This may be a particular problem in the case of non-motorised vessels, including sailing boats and kayaks, which may pose a threat precisely because they make so little sound. Whilst not entirely silent, their quiet approach may further be masked by the noise of motorised vessels in the vicinity.

Certain oceanographic conditions too, can cause cetaceans to become confused by the acoustic information picked up from an approaching vessel, or they may even fail to perceive that the vessel is in the vicinity until it is too late to avoid a collision. These include the ‘Lloyd Mirror effect’, which is an acoustic phenomenon which occurs only in calm sea conditions. It reduces or cancels low frequency sound at, or near, the surface of the water: this effect is particularly pronounced immediately prior to a collision, when the whale is very close to the sound source (the approaching vessel).

In addition, the hull of a particularly large vessel - and the minute air bubbles which surround it - can effectively absorb much of the noise made by the engine and propeller, so that its approach is less likely to

be detected by cetaceans immediately in front of the vessel. Again, this effect is particularly pronounced with lower frequency sounds. These and other effects can seriously impede cetaceans' ability to perceive – and respond appropriately to – an approaching vessel.

2.8 Habituation to vessel noise:

Cetaceans living in areas of high vessel traffic may also become habituated (or overly tolerant) to boat noise. Rather than failing to hear the vessel's approach because of physical damage to their hearing (as outlined above), the whales have simply been exposed to such a high degree of vessel noise and activity that they may simply 'switch off', rather as people do when they happen to live directly beneath a major flight path. Researchers have studied the reactions of several baleen whale species to whale-watching and research vessels and have compared these reactions over time. Humpback, minke, grey and fin whales all showed strong habituation effects. Specific populations of minke whales, for example, changed their reaction over time from one of strong interest in a vessel, to one of disinterest; some fin whales which had tended to react negatively to vessels changed to a disinterested reaction over the years, whilst some populations of humpback and grey whales changed their behaviour from one of outright avoidance of boats, to actually being interested enough to closely approach vessels (Watkins 1986; Richardson 1995).

Furthermore, experiments using acoustical alarms showed that North Atlantic right whales would surface immediately upon exposure to the alarm and then sink just below the surface, putting them at an increased risk of strike as they were not visible at the surface (Nowacek *et al.* 2004).

2.9 Lack of awareness of the danger posed by ships:

It is possible that some whales are struck simply because they have failed to recognise the threat posed by vessels. Whales and dolphins evolved many years before the advent of fast-moving and noisy vessels and, until the past century or so, would have known oceans filled only with natural sounds. Whale populations are learning the hard way that vessels can pose a deadly threat and must be treated with respect. The fact that a high percentage of collision victims are calves and juveniles may not only be due to the fact that they tend to be slower swimming than older animals, but it can also be due to playful naivety of the dangers associated with getting too close to vessels. Younger animals tend to be very curious in their approaches to investigate objects, including vessels - and close proximity to vessels naturally increases the risk of boat strike. Older animals tend to be more wary, possibly because they have witnessed other members of their group being struck, or have survived a minor collision themselves. It may also be because they are more preoccupied with feeding and mating than are juveniles.

3. Geographical factors

3.1 Hotspots:

Most collisions occur on the continental shelf, reflecting high usage by both vessels and cetaceans. Of 58 collision accounts examined by Laist *et al.* (2001), over 90% of incidents (53 accounts) occurred either on the continental shelf or shelf slope. In general, the cetacean populations which are most frequently-struck are those living on or near busy vessel routes (particularly shipping or ferry routes); or where there is an unusual concentration of vessels in a shallow, confined area. This is the case for the North Atlantic right whale off the east coast of the US and for sperm whales in the Canary Islands (Andre 1998). Calving and nursery areas are particularly vulnerable (see 2.3).



Section Four: Problems of reporting and types of injuries

Many, and probably the majority of, cetacean deaths as a result of vessel collisions will never come to light, for several reasons. Firstly, tidal patterns and other geographical factors make it likely that most fatally-struck carcasses are never retrieved. For instance, they probably never get seen because of limited offshore effort. A large number of them likely sink. Carcass recovery is particularly unlikely when collisions occur in the deep ocean, far from coastlines. Only a small percentage of animals that die will wash ashore to be discovered.

Secondly, of course, a witness has to report a definite or probable collision with a cetacean or sight a carcass. The problem is that, if a cetacean collides with a very large vessel of tanker size, or similar, the impact might not be felt as it would in a smaller vessel. Similarly, if collisions occur at night, then witnesses may not be present or may not be able to see clearly what has happened. There is also a concern in the US of liability - which results in some vessels not reporting.

Even those carcasses which do wash ashore and can be examined may not be retrieved in time to enable a full and proper necropsy to be carried out, or may not yield evidence that proves beyond doubt that cause of death (whether instantaneous following impact, or some time after, due to fatal injuries incurred) was due to boat strike. Larger rorquals can sometimes be struck and be brought into port on the bow of a ship (see case studies). In such cases it may not always be logistically or financially possible to retrieve the carcass for a full necropsy. Fatal and non-fatal injuries caused by vessel strike take two broad forms: a) propeller wounds, characterised by long, parallel gashes or cuts to the body, dorsal fin or tail stock (even severed tails); and b) blunt trauma injuries, indicated by fractured skulls, jaw and vertebrae, and massive bruises (Laist *et al.* 2001; Koschinski 2002) or gashes on the carcass.

Some carcasses may not have visible evidence of strikes, but nonetheless, an impact may have caused fatal internal injuries. Improved necropsy techniques now mean that many more whales that have died due to vessel strike can be identified as such, even if they do not display dramatic injuries such as propeller wounds or severed tails. Previously, whales and dolphins found dead without tell-tale wounds or marks indicating hunting or entanglement in nets might have had their deaths attributed to old age, disease or other factors.

However, some carcasses may have no obvious external damage and only the practice of flensing carcasses to the bone (not a routine practice for most large whale strandings) may reveal fractured vertebrae and skulls. Since this practice has only become routine during the past decade, when dealing with right whale carcasses off the eastern United States and Canada, it is probable that the true scale of right whale deaths due to ship strikes in those waters is only now becoming apparent. Wiley *et al.* (1994) have demonstrated that if the humpback whales they studied had not had a necropsy performed on them it would not have been discovered that the whales died from internal injuries caused by ship strikes. Laist *et al.* (2001) have also emphasised the importance of flensing the carcass to the bone, especially for cetacean populations that ‘may be affected by low levels of human-related mortality.’

Also, of course, it is important to ascertain that a struck cetacean was alive at the time of impact, rather than a vessel happening to strike a “floater” (or already dead cetacean) whose body floats due to putrefaction. Large haematomas⁴ - which indicate that the circulatory system was functioning at the time of death - provide evidence that a cetacean was alive when struck. More careful examination of carcasses has revealed extensive bruising in some animals; an animal has to be alive to bruise. Dead whales tend to float ventral side up and, therefore, the location of injuries can also help to determine whether wounds occurred before or after death.

Finally, under-recording contributes to the problem. Strikes may be under-reported for a variety of reasons, including a lack of awareness of the issue and a lack of knowledge of how and where to report actual, or apparent, collisions. Correctly identifying species struck can also be a problem, as witnesses may be certain that they have observed a strike but be uncertain of the species involved. Far out to sea, where carcass retrieval would be unlikely, any misidentification can skew collisions statistics and create further problems in keeping accurate track of the real scale of the problem.

⁴ A localised swelling, filled with blood

Section Five: Assessing the extent of the collision problem

Global cooperation and information gathering

Significance should be given to the percentage of collisions that don't come to light, as for each collision reported, many will go undiscovered. Others may be witnessed but may still not be reported. However, there are many things that can be done to improve the current situation and a major step forward will be the collection of as much information as possible.

Co-operation between all parties involved

In order to make progress, all stakeholders (users of the marine environment, scientists, conservation non-governmental organizations and relevant government departments) must communicate regularly. Collisions workshops have been held in Europe and the US to collate available information and to strategise possible solutions. Many workshops have also been held in the US to aid in the protection of the North Atlantic right whale. A workshop should also aim to educate and improve awareness of the issue, and to assist in the collection and dissemination of information.

The '*Co-operation Protocol on the conservation of the cetaceans of the Canarian Archipelago*' was signed in 2000. Actions planned under the Protocol include the financing of studies, the modification of the maritime route and navigation speed near the areas where the cetaceans are concentrated, and the development of education and social awareness campaigns and the training in the field of biology and ethology of the personnel steering the ships (Econews 2000).

Dedicated studies of cetacean distribution and populations

WDCS considers that the lack of cetacean distribution and population data available for much of the world to be a considerable obstacle in the assessment of impacts of collisions. Detailed studies of cetacean population distribution and abundance will help to identify general movements, and particularly, areas of biological significance to populations. Increased efforts to understand cetacean ecological and physiological needs will be an important first step to offering protection from individual and cumulative potential threats. Prey distribution and availability is also an important factor. For example, as mentioned previously, Baumgartner *et al.* (2003) show that copepod levels may be denser near the surface at night due to vertical migration, so, if right whales feed at night, they may be more susceptible to strikes at night than previously considered.

The location and the scale of the threat to different cetacean species will only be realised where basic information on the population is available. Only in areas where detailed population studies have been conducted, or where collisions incidents are regular, have we been able to start to quantify the significance of a problem to date (see Section Two: Case Studies). In those areas where a problem has been identified, funding of independent studies may be supported by industries that wish to be proactive in finding a solution - and even in those areas, it is important to remember that carcasses are likely lost at sea, or not thoroughly necropsied, and what is known should be considered a minimum estimate of the problem.

Where discrete populations are small, every fatality due to a collision is likely to be significant at a population level. It should be noted that if population assessment studies are carried out they are likely to be done on vessels. These vessels themselves should adhere to strict standards so as not to put the animals at risk from the research being conducted.

It should be noted that historical information on both cetacean populations and ship strikes need to be considered in the light of changes to marine ecosystems and prey availability that may be caused by climate change and other human-related activities.

As more information on cetacean abundance and distribution is gathered, it will become easier to implement more effective ship strike mitigation measures. Information on breeding and feeding areas could be provided to vessel owners and maritime organizations. Real-time alerts of cetacean sightings could further assist in allowing vessel captains to change the course or speed of their vessel to decrease

the risk of collision. Shipping lanes could also be altered to avoid areas that are frequently used by cetaceans.

The role of strandings data

Laist *et al.* (2001) state that, in some areas, ship strikes are now implicated in a substantial proportion of large whale strandings. Collation of such data is now underway in some parts of the world. A consistent and unified international effort would certainly help to advance our understanding of the causes of collisions. It would be helpful if such information were not restricted to fatalities, but such information alone, were it to be collected consistently, would offer a greater insight into the issue. Reporting of scars and wounds that are likely attributable to collisions with live animals would be valuable. Many studied cetacean populations have individuals that are recognisable to researchers because of old injuries that are attributable to interactions with vessels.

Co-ordination of collision records should be kept, and be accessible in a central database. This might be best operated in co-operation with strandings and sightings data in the relevant government department. For example, in the UK, each country has marine mammal strandings coordinators that collect dead-stranded animals for post-mortem studies that may establish the cause of death. In many cases, collisions information can only be ascertained from necropsied stranded animals, where collision impacts are likely to be evident due to either external wounds, such as propeller injuries, and/or internal blunt trauma injuries. Thorough necropsies that involve flensing the animal to the bone are necessary in order to check for all possible strike-related injuries.

Useful information in such data collation to assess frequency of collisions and potential significance to populations, where known, should include:

- i) Species involved
- ii) Geographical location
- iii) Seasonal timing
- iv) Age and health of the animal
- v) Type, size and gross tonnage and speed of vessel
- vi) Activity of vessel (if interacting with the animal)

The lack of such information has hampered efforts to evaluate the significance of ship strikes for whale populations and to develop appropriate mitigation measures (Laist *et al.* 2001).

The different reactions of different cetacean species to the approach of a fast vessel may greatly modify the collision risk. This highlights the need to collect pre-collision data and data where sightings are made close to the vessel. Noting a change in behaviour in response to the vessel's approach may provide valuable clues to feed into mitigation strategies.

Dedicated observers

In areas where repeated incidences of collisions with specific vessel and cetacean types occur, speed restrictions and trained observers may be useful on board vessels to alert crew when cetaceans are in the area, in order to help prevent collisions, although of course the preferred outcome would be not to operate where cetaceans are in the vicinity. Training the crew in the identification and biology of the animals is likely to be valuable but should not be considered an alternative to using independent, trained observers. The Coast Guard in the US requires a specially-trained marine mammal lookout on all its vessels transiting designated critical habitats or within 20 nautical miles of shore (NMFS, 1998). However, while trained observers are considered to be beneficial, they should not be considered as a sole mitigation method. Even the most highly trained observer is limited in their ability to detect whales depending on environmental conditions and vessel speed.

Legislation and voluntary guidelines

In a few countries, legislative requirements are in place for the protection of marine mammals. However, it is often difficult to assess the impacts of incidental collisions. Legislation is most likely to reflect those industries whose target is interactions with cetaceans (e.g. whale watching), rather than those whose interactions are incidental. Legislation might also be more likely to cater to the general impacts of shipping, for example the combined impacts of noise and chemical pollution (including oil

spills) and consideration of collisions is likely to be rare except in well-documented circumstances where evidence of repeated collisions exist.

Other countries may have voluntary or legislated guidelines for interactions between cetaceans and whale watch vessels. Often there are no procedures for other types of commercial vessels or recreational vessels, and for incidental interactions, which are just as likely to be the cause of a collision.

Regional agreements also exist to protect cetaceans in some areas. Each agreement is specific to the region, but there is potential to offer protection from collisions, and also from the cumulative impacts of collisions, noise pollution from vessels and other threats that they may face. ACCOBAMs has made some progress on this issue (recent recommendations may be found at (http://www.iwcoffice.org/documents/sci_com/SC58docs/sc58docs.htm)).

The need for further research into the impacts of shipping on cetaceans

Studies into the impacts of vessels on cetaceans have primarily been based on the whale watching vessels, seismic and military vessels that may have other impacts on the cetaceans. Comprehensive studies of the impacts of shipping movements on vulnerable populations are also needed and should be conducted as a matter of urgency. Southall *et al.* (2005) suggest that the number of large vessels in the world's oceans over the next two to three decades is expected to double. However, they also explain that shipping densities in specific areas and trends in routing and vessel design may be more significant in terms of impacts on marine mammals than the total number of vessels. Further, they point out that coastal routes for large commercial vessels are relatively well defined, while offshore routes are much less predictable and depend on a variety of environmental and economic factors and they expect that densities along existing coastal routes will increase along US coastlines and internationally. Such an increase in coastal route shipping density may have significant impacts for cetacean species that migrate along the US coast, such as the endangered north Atlantic right whale. Southall *et al.* (2005) also note the continuing international trend towards faster ships operating in higher sea states for lower operating costs.



Section Six: Mitigation measures

Assessing the effectiveness of mitigation measures

As shown in the case studies provided, mitigation generally requires a detailed case-by-case assessment to be effective. It has been suggested that some mitigation measures may not prevent collisions. Andre *et al.* (2000) suggest that active sonar devices are not effective or helpful. More research is needed in this field and this is discussed further below.

Measures aimed at reducing strikes

Many things influence the measures that are taken for the management and mitigation of collisions between cetaceans and vessels. As mentioned earlier, these factors include the species involved, the type, length, tonnage and speed of the vessel as well as other factors, such as its route. There is much still to be understood about cetacean ecology and behaviour.

Urgency will be a deciding factor in the methods and extent of mitigation undertaken. For example, a spatial model of collision risk has been developed (Tregenza *et al.* 2000) that identified a situation where mitigation procedures are urgently required. The model indicates that a population of short finned pilot whales off the Canary Islands is at risk of extinction from collisions, unless appropriate avoidance action is generated which is both consistent and effective.

Dotinga and Oude Elferink (2000) and Richardson (1995) noted that there are four main types of mitigation measures. Each of these is considered here in turn:

1. Vessel construction, design and equipment standards:

Where more 'environmental friendly' options are available, these should be considered, as should investigation into developing such technologies. A reasonable assumption would be that lower noise levels are always to be preferred. A nearby ship is likely to produce substantially higher sound levels locally than distant shipping noise (Cato 2000), yet the impact may be over a short time period. Should a cetacean population use an area in or near a shipping lane, there are also long-term implications of continuous noise and, possibly, masking for these individuals. Laist *et al.* (2001) highlight the 'startle response' shown by whales directly in front of passing ships caused by, for example, 'low amplitude, high intensity hull vibrations and bow-wave effects.' The authors argue that further research is needed into the frequency and intensity of sound produced by different types of ship at different depths, distances and directions, and what effect it has on cetaceans.

Vessels used for whale watching can produce high levels of underwater sound in close proximity to the animals. The factors most affecting the noise levels are the distance from the cetacean and vessel speed and, to a lesser extent, vessel type (McCauley *et al.* 1996). Thus, whilst benign observation and study of whales is to be encouraged, the expanding cetacean watching industry clearly benefits from regulation to ensure that it does not become harmful to cetaceans (Australian National Guidelines for Whale and Dolphin Watching 2005).

2. Restrictions:

Areas that are known to be biologically important for cetaceans might be expected to benefit from geographical and/or seasonal restrictions. Speed limits may be imposed in certain areas to protect cetaceans. This is usually a localised measure to protect resident populations or individuals and may be voluntary or compulsory.

Laist *et al.* (2000) reported that vessel speeds must be reduced to 13 km or less in areas where collision risks are high (e.g. in areas of high cetacean concentration). Reduction in speeds will not eliminate - but might certainly reduce - lethal collisions and severe injuries. Although 12% of reported collisions still occurred between 10-14 km, none were reported at speeds of less than 10 km. (However, it should be emphasised here that this report researched great whales only and considered limited reporting data - these figures are likely to be different for smaller cetacean species. Assessment of the true extent of fatal injuries that cetaceans suffer is unlikely.)

In areas where collision rates are high, it may be possible to avoid travelling at night or in bad weather, when sightings are likely to be much reduced.

3. Routing and positioning:

This involves management of a vessel's movements or other activities around an area where there is a high risk of impacting cetaceans, particularly where biologically important areas have been identified. Sufficient information on cetacean movements is required for such measures to be effective in many cases, so little is known about cetacean distribution that it isn't possible to time vessels around use of a particular area by cetaceans. Indeed, in coastal areas, where this might be appropriate, those animals suffering from collisions may be resident and present all year-round or they may be seasonal.

In areas of critical habitat, re-routing of vessels in order that they travel outside of the sensitive habitat is the preferred option; particularly where populations are of a vulnerable status. Similarly, aerial movements may be restricted due to the presence of cetaceans. For example, Australian National Guidelines for Whale and Dolphin Watching (2005) state that aircraft should not operate lower than 300m (1000 feet) within a 300m (1000 feet) radius of a cetacean, or approach a cetacean head on. US federal regulations state that all vessels and aircraft must stay a minimum of 500 yards from North Atlantic right whales.

The IMO is currently reviewing a proposal to shift the Traffic Separation Scheme (TSS) northward, in the Stellwagen Bank National Marine Sanctuary. This shift was proposed strictly as a means to reduce the risk of whale/vessel collisions within the Sanctuary.

4. Operational measures:

Methodologies will vary for different goals. Whale watching is increasingly regulated but should be accompanied, of course, by adequate monitoring and enforcement provision. In areas lacking specific legislation, voluntary codes of conduct or guidelines may be available. These guidelines often specify that vessels must travel at a 'no-wake' speed when in the vicinity of cetaceans, and must not approach the animals closer than a prescribed distance (for example, 100 metres), often depending on the number of vessels in the vicinity. Naturally, in order to minimize collision risk, such guidelines should apply to **all** vessels in the vicinity of whales, not just those engaged in whale watching.

Operational measures may also include designation and protection of what has been deemed 'critical habitat'. In the US, the primary goal of 'critical habitat designations' is to contribute to species protection by identifying key areas and describing features within those areas that are essential to the species, thus alerting public and private entities of the importance of the areas (NMFS website). Emphasis should be placed on habitat protection and this may include restriction from biologically-important areas to ensure that the biological and ecological activities of the animals can continue uninterrupted.

There are many methods available to assist in obtaining identification of as many individuals as possible and these can be used to better understand population dynamics and should be implemented with other observations with the goal of redefining future mitigation methods and guiding legislation.

5. Practical measures

5.1 Acoustic mitigation methods

Passive acoustic detection systems

Andre and Potter (2001) preliminary findings indicate that the solution to the problem of accidental collisions may lie in a better understanding of the hearing sensitivities of the local populations of whales, coupled with measures to decrease acoustic exposures of these whales rather than by increasing the acoustic loading by deployment of active acoustic deterrents.

Delory *et al.* (2002) used an Ambient Noise Imaging (ANI) Sonar (which does not emit sound) to detect a silent sperm whale near the sea surface from the backscatter of known natural acoustic sources.

As the result of an increased risk of collision posed by an LNG (Liquified Natural Gas) project proposal in Massachusetts Bay, the Stellwagen Bank National Marine Sanctuary (US) has recommended that USCG/MARAD (the US Dept. of Transportation Maritime Administration) "require the installation and operation, through the life of the deepwater port, of an array of near-real-time

acoustic detection buoys in the Boston TSS to reduce the incidence and probability of vessel-whale collisions.”

Passive acoustic detection is being used for North Atlantic right whales along the east coast of the US. More information can be obtained at http://www.nefsc.noaa.gov/press_release/2006/nr0601.htm

5.2 Other practical measures to reduce ship strikes

As already discussed, real-time cetacean sightings information could greatly assist in allowing a ship to reduce its speed or course. Dedicated observers could also be useful in spotting cetaceans from the bridge of many ships. The training of dedicated, perhaps independent, observers in cetacean observation and reporting might easily reduce the risk of strikes. However, as stated previously, trained observers should not be considered as a sole mitigation method. Even the most highly trained observer is limited in their ability to detect whales depending on environmental conditions and vessel speed.



Section 7: Considerations & Conclusions

A global evaluation of the significance of cetacean collisions should be undertaken as a top priority. This should aim to identify the areas and species of highest concern and provide a review of suitable mitigation methods.

Assessment of impacts

An evaluation of impacts should be made. Where population estimates are known and populations appear at risk, further mitigation measures should urgently be considered. Levels of mitigation are likely to vary from exclusion of vessels in important areas of habitat for endangered species to further research and reporting in areas of unknown or lesser significance.

Habitat protection

Protecting the wider ecosystem that cetaceans inhabit will certainly help to protect the cetacean species themselves. To do this effectively, it is important to take account of the behavioural and biological requirements of cetaceans, such as foraging and mating. A Marine Protected Area (MPA) may have to incorporate quite a large geographical area in order to be effective, not least because some cetaceans regularly migrate over large distances.

Cetaceans that are engaging in biologically-important activities have been shown to be less responsive to interference in some cases. It may be that collisions occur more frequently in such areas as feeding or breeding grounds. We can be sure that the probability of a collision will be exacerbated where vessel activities such as shipping, fast ferries, fishing and recreational boating activities impinge on important cetacean habitats and along migratory routes. Calves may be particularly vulnerable as they need to spend most of their time at the surface.

The primary concern is for immediate kill, but, as previously discussed, cetaceans can also be injured by vessels and the animal may subsequently die at a later date. Cetaceans can also be harassed or displaced from an area valuable to the individual or population. Thus, coordinated research into cetacean populations, distribution and shipping activity is essential and it will certainly contribute to better protection of vulnerable populations.

Long term and cumulative impacts

Collisions pose a serious additional threat to many cetacean populations already impacted by numerous other problems. Long-term research and monitoring is essential, particularly with respect to cetacean populations that suffer from a high level of collisions.

The impacts of collisions are immediate. However, the longer term implications of other interactions with vessels are as yet unclear and can only be assessed by long term monitoring with the clear objective of assessing the impacts of human activities on cetaceans.

Yet, immediate action is also warranted and effective management procedures should be put in place where evidence of impacts are available and particularly small or discrete populations are most at risk and where a significant impacts can be shown.

Regulation

Consideration of protection via domestic legislation and regional agreements would be valuable, and particularly in those regions where collisions are just one of a raft of threats facing cetaceans.

In the meantime, where collisions seem to be posing a serious threat to cetaceans - and where legislative measures are not in place for their protection - precautionary actions should be taken. These might include, as appropriate, use of passive sonar systems; whale detection alert broadcasts to mariners; speed guidelines (or, preferably, regulations), as well as outreach and education to recreational boaters.

WDCS concludes from this review that boat collisions present a substantial threat to cetaceans and, indeed, one that is only just becoming clear, with the exception of a few situations where the risk is already known to be one of extinction. We, therefore, call for urgent action to be taken to monitor and address this issue and to bring urgently into play the recommendations made above.

References

ACCOBAMS. 'Fins' Newsletter of ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area). Ship strike special feature. Vol 3 (1): 12-19, August 2006.

ACCOBAMS (cf http://www.iwcoffice.org/_documents/sci_com/SC58docs/sc58docs.htm)

Andre, M. & Potter, J.R. 2000. Fast-ferry acoustic and direct physical impact on cetaceans: evidence, trends and potential mitigation. Proceedings of the fifth European Conference on Underwater Acoustics. European Commission Community Research. ISBN92-828-9531-9.

Andre, M. 1998. The conservation status of cetaceans: A case study in the Canary Islands. Proceedings of the Morecambe Seminar, Theme II: Key Scientific Issues.

Andre, M.; Kamminga, C. & Ketten, D. 1997. Are Low Frequency Sounds a Marine Hearing Hazard: A Case Study in the Canary Islands. Underwater Bio-Sonar and Bioacoustics Symposium. Proceedings of the Institute of Acoustics. 19 (9):77-84

Australian National Guidelines for Whale and Dolphin Watching, 2005. 20pp.
(<http://www.deh.gov.au/coasts/publications/pubs/whale-watching-guidelines-2005.pdf>)

Asmutis-Silvia, Regina. 1999. An Increased Risk to Whales Due to High-Speed Whale Watching Vessels. International Whaling Commission SC/51/WW11.

Baumgartner, M.F; Cole, T.V.C; Campbell, R.G; Teegarden, G.J; Durbin, E.G. 2003. Associations between North Atlantic right whales and their prey, *Calanus finmarchicus*, over diel and tidal time scales. *Marine Ecology Progress Series*, **264**: 155-166.

Best, P. B., V. M. Peddenmors and N. Rice. 2001. Mortalities of right whales and related anthropogenic factors in South African waters, 1963-1998.' In: *Journal of Cetacean Research and Management* (Special Issue 2): 171-176.

Best, P.B. 1982. Whales as Target Animals for Sighting Surveys. Rep. Int. Whal. Commn. 32:551-553.

Butterworth, D.S., P.B. Best and M. Basson. 1982. Results of Analysis of Sighting Experiments Carried Out During the 1980/81 Southern Hemisphere Minke Whale Assessment Cruise. Rep. Int. Whal. Commn. 32:819-834.

Cato, D.H., and R.D. McCauley. 2002. Australian research in ambient sea noise. *Acoustics Australia* 30:13-20.

Curry, W., 2004 . Testimony to the Senate Committee on Commerce, Science and Transportation.
http://www.whoi.edu/institutes/occi/currenttopics/abruptclimate_curry_testim.html

Dotinga, H.M; Oude Elferink, A.G. 2000. Acoustic Pollution in the Oceans; The Search for Legal Standards. *Ocean Development and International Law*, **31**: 151-182

Econews, 2000. http://www2.ncsu.edu/grad/econ_grad_pgm/econews2000.html

Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact models. *Marine Mammal Science*, 18 (2): 394-418.

'Fast Ferry International' magazine, 2006. Available via <http://www.fastferryinfo.com/>

Félix, F; Waerebeek WV; 2005. Whale mortality from ship collisions underreported, case studies from Ecuador and West Africa. *Report to the Scientific Committee of the International Whaling Commission*. SC/57/BC1.

- Fransz, H., Colebrook, J., Gamble, J., & Kraus, M. (1991) The Zooplankton of the North Sea. *Netherlands Journal of Sea Research* 28(1-2) 1-52.
- Gerstein, E. R. (2002) Manatees, bioacoustics and boats, *American Scientist* vol 90, pages. 154-163.
- Greene, C.H., and A.J. Pershing. 2004. Climate and the conservation biology of North Atlantic right whales: the right whale at the wrong time? *Front. Ecol. Environ.* 2: 29-34.
- Jensen, A.S; Silber, G.K. 2004. Large whale ship strike database. Large whale ship strike database. U.S Department of Commerce, NOAA Technical Memorandum. NMFS-OPR-, 37pp.
- Knowlton, A; 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.
- Koschinski, S. 2002. Ship collisions with whales. A report prepared for the Eleventh Meeting of the CMS Scientific Council, Bonn, September 2002. 19pp.
- Kraus S. D., M. W. Brown, H. Caswell, C. W. Clark, M. Fujiwara, P. K. Hamilton, R. D. Kenney, A. R. Knowlton, S. Landry, C. A. Mayo, W. A. McLellan, M. J. Moore, D. P. Nowacek, A. D. Pabst, A. J. Read, and R. M. Rolland. **2005**. North Atlantic right whales in crisis. *Science* 309:561-562.
- Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podestà. 2001. Collisions between ships and whales. *Marine Mammal Science* 17:35-75.
- LaCasse, T. (New England Aquarium), 2005. <http://www.capecodtoday.com/news229.htm>
- Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet and M. Podesta 2001. Collisions between ships and great whales. *Marine Mammal Science* 17(1):35-75.
- Lammers, M.O; Pack, A.A; Davis, L. 2003. Historical evidence of whale/ vessel collisions in Hawaiian waters (1975-present). *OSI Technical Report 2003-01*.
- Lott, R., Williams-Grey, V. and Simmonds, M. 2006. Responsible whale watching: the way forward. *Report to the Scientific Committee of the International Whaling Commission*. SC/58/WW4
- McCauley, Robert D.; Cato, 2001, Douglas H. The underwater noise of vessels in the **Hervey Bay** (Queensland) whale watch fleet and its impact on humpback whales **The Journal of the Acoustical Society of America**, 109(5, Pt. 2); p. 2455
- Moore, M.J; Knowlton, A.R; Kraus, S.D; McLellan, W.A; Bonde, R.K. 2004. Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalaena glacialis*) mortalities (1970-2002). *J. Cetacean Res. Manage.* **6**(3):199-214.
- Nowacek, D.P., Johnson, M.P., and Tyack, P.L., 2004. Right whales ignore ships but respond to alarm stimuli. *Proceedings of the Royal Society B: Biological Sciences*, 271, 227-231.
- Parsons, E.C.M., Shrimpton, J. & Evans, P.G.H. (1999). *In Parsons et al.*, 2000.
- Pesante, G., Zanardelli, M., Panigada, S. 2000. Evidence of man-made injuries on Mediterranean fin whales. *European Research on Cetaceans*, 14:192-193
- Richardson, W. J., Greene C. R. Jr., Malme C. I., Thomson D. H. 1995. Marine mammals and noise. Academic Press, New York. 576pp.
- Slijper, E. J. 1979. Whales. Cornell University Press, Ithaca, NY, USA.
- 'Right Whale News' (the publication of the Southeast United States Right Whale Recovery Plan Implementation Team and the Northeast Implementation Team) Volume 12 Number 2 May 2005
- Simmonds, M.P. 2000. Chasing Dolphins. A WDCS Science Report. 26 pp.

Southall, B.L. 2005. Shipping noise and marine mammals: A forum for science, management and technology. Final report of the National Oceanic and Atmospheric Administration (NOAA) International Symposium, 18-19 May 2004, Arlington, Virginia, USA.

Stevick, P. T. 1999. 'Age-length relationships in humpback whales: A comparison of strandings in the western North Atlantic with commercial catches.' *Marine Mammal Science* 15:725-737.

Tregenza, N; Aguilar, N; Carrillo, M; Delgado, I; Díaz, F; Brito, A; Martin, V. 2000. Potential impact of fast ferries on whale populations. A simple model with examples from the Canary Islands. *European Research on Cetaceans*, **14**: 195-197.

U.S Coastguard, 1991. Incident report 3040. *In Laist et al.*, 2001.

Visser, I N & Fertl, D 2000. Stranding, resighting, and boat strike of a killer whale (*Orcinus orca*) off New Zealand. *Aquatic Mammals* 26(3): 232-240

Watkins, W. A. 1986. 'Whale reactions to human activities in Cape Cod waters.' *Marine Mammal Science*. 2(4):251-262.

Weinrich, M. 2004. A review of worldwide collisions between whales and fast ferries. J. Cetacean Res. Manage. *Report to the Scientific Committee of the International Whaling Commission*. SC/56/BC9.

Wiley, D. N., R. A. Asmutis, T. D. Pitchford and D. P. Gannon. 1994. 'Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. *Fishery Bulletin*, U.S. 93:196-205.



**Vessel collisions and cetaceans:
What happens when they don't miss the boat**

A WDCS Science Report

**By Sarah Dolman, Vanessa Williams-Grey,
Regina Asmutis-Silvia and Steve Isaac**

© Whale and Dolphin Conservation Society (September 2006)

**WDCS, the Whale and Dolphin Conservation Society, Brookfield House,
38 St Paul St, Chippenham, Wiltshire SN15 1LJ, IK
Tel: 44 (0)1249 449500
Email: info@wdcs.org
Website: www.wdcs.org**

**WDCS is the global voice for the protection of cetaceans (whales, dolphins and porpoises) and
their environment.**

Offices in: Argentina, Australia, Germany, New Zealand, the UK and the USA.

WDCS is a UK registered charity, No: 1014705