RETROSPECTIVE INVESTIGATION OF TWO DOLPHIN MASS MORTALITY EVENTS IN SOUTHERN IRAN

Final Report

G. T. Braulik[1] and A. Fernandez[2]

[1] Sea Mammal Research Unit, University of St. Andrews, St. Andrews, Fife, KY16 8LB, UK
[2] Unit of Veterinary Histology and Pathology, Institute for Animal Health and Food Security, Veterinary School, University of Las Palmas de Gran Canaria, Spain

Executive Summary

During the autumn of 2007, two dolphin mass mortality events involving at least 152 small cetaceans were reported from southern Iran. Both events occurred near Jask (Iranian Gulf of Oman coast), separated by a month in time and more than 170 km in distance. The Iran Department of Environment and the Regional Organisation for Protection of the Marine Environment (ROPME) based in Kuwait requested that the IUCN-Cetacean Specialist Group provide assistance in investigating the causes of these events. The investigation team consisted of two CSG members – cetacean biologist G.T. Braulik and veterinary pathologist A. Fernandez. The team visited Iran from 21-25 November 2007.

During the visit, Braulik and Fernandez met with, and obtained information from, national and regional offices of the following agencies and individuals: Department of Environment, Iranian Fisheries Research Organisation, Fisheries Department (Shilat), research and diagnostic laboratories, veterinary institutes, captain of a purse-seine fishing vessel in Bandar Abbas port, and local fishermen at the stranding locations. The team also visited the beaches where the two events occurred. They collated and scrutinised information, photographs, biological samples and video recordings from each event. All available information has been compiled into this report. The results of some toxicological, virological and histological analyses are not yet available, therefore, the conclusions contained in this report may be subject to change.

The two mass mortality events involved different species and exhibited many different characteristics. There is no evidence to suggest they were linked and therefore they are considered separately.

The first mass mortality event on 20 September 2007, involved 79 animals, probably all spinner dolphins (*Stenella longirostris*). Dead animals, all exhibiting a similar degree of decomposition, stranded at approximately the same time along the same stretch of coast. These circumstances indicate that the mortality was caused by a single acute event. Several carcasses had evidence of traumatic injuries, the stranding event was spatially

and temporally coincident with active fisheries and other potentially bycaught and discarded species were found on the beach. This pattern is generally consistent with the hypothesis that the dolphin mortality was caused by fishing operations, although data are insufficient to unequivocally confirm that hypothesis.

The second event involved the live mass stranding of at least 73 striped dolphins (*Stenella coeruleoalba*) on 24 October 2007. Why this locally rare, typically pelagic species entered the shallow waters outside the mouth of the Kangan estuary is not known. The data available are insufficient to form firm conclusions, however, the simplest explanation appears to be that the dolphin group was entrapped by the complex coastal configuration and after they were on the beach the animals subsequently died due to "Stranding Stress Syndrome".

These two mortality events were considered "unusual" in Iran and they attracted much public and official interest as well as international attention. If this interest can be sustained, it will provide a good opportunity to enhance Iran's capacity for research and conservation of marine mammals at the national level.

1. Cetacean mass strandings: causes and hypotheses

A cetacean mass stranding is generally defined as two or more cetaceans of the same species coming ashore at the same time and the same place. Species that mass strand in large numbers (more than about 15) are normally pelagic animals that live in gregarious, cohesive social groups; coastal cetacean species are much less likely to mass strand. Species that are known to mass strand are sperm whales, pilot whales, false killer whales, Atlantic white-sided dolphins, white beaked dolphins and rough-toothed dolphins; other pelagic species do so rarely. The animals in these mass strandings are almost always alive when they arrive on the coast. Cetacean mass strandings have been recorded for centuries but there has been an increase in the frequency of documented cases in recent years (Gulland and Hall, 2007) which may be due to an increase in anthropogenic activities causing strandings combined with improved documentation (i.e. detection and reporting) of events. High-profile mass strandings have been attributed to a variety of causes. Examples include a mass stranding of beaked whales due to military sonar in the Canary Islands in 2002 (Fernandez et al., 2005; Jepson et al., 2003), a morbillivirus epizootic in Mediterranean striped dolphins between 1990 and 1992 (Aguilar and Raga, 1993) and brevitoxin poisoning during a harmful algal bloom which killed multiple species including Bottlenose dolphins (*Tursiops truncatus)* and manatees (*Trichechus manatus)* off the west coast of Florida in 2005 (Gulland and Hall, 2007). In Mauritania 125 spotted dolphins (*Stenella frontalis*) were found dead along an 85-km stretch of coastline in November and December 1995. The mortality was attributed to interactions with local fishing operations (Nieri, 1999). The largest cause of cetacean mortality worldwide is believed to be interactions with fisheries, and bycatch in fishing gear is driving some species to local or global extinction (Reeves et al., 2003).

The following is a summary of potential causes of cetacean mass stranding and mass mortality events (Geraci and Lounsbury, 2005):

1. **Complex topographic and oceanographic conditions** – In some instances a group of cetaceans is trapped and then grounded by the outgoing tide. These incidents

occur most often in areas with complex topography such as long meandering channels, sand banks, broad tidal mudflats, estuaries, strong or unusual currents or extreme tidal flow or volume. The intricate configuration of the coastline may serve as a trap for cetaceans that stray into the area. There are several locations in the world (e.g. Sable Island – Nova Scotia, Lingley Cove – Maine, Wellfleet Bay – Cape Cod, Cook Inlet – Alaska) where the complex coastal topography leads to a relatively high incidence of mass strandings. These areas are termed 'whale traps'. Mass strandings in 'whale traps' sometimes coincide with spring tides or the new or full moon.

2. **Contaminants** – Cetaceans may be killed by acute chemical spills. Generally cetaceans are expected to be less vulnerable to oil spills than other less mobile marine organisms, however they may suffer from ingesting prey contaminated with oil or oil by-products. As top predators in the marine environment, cetaceans are chronically exposed to a variety of pollutants and while these may reduce fitness, cause immunosuppression or impair reproductive success, there is no evidence that chronic exposure to pollution or high pollutant loads have been responsible for any cetacean mass deaths or die-offs.

3. **Weather conditions** – Occasionally, strandings occur after large storm events such as cyclones or hurricanes. The stranding of a Sperm Whale on the Iranian coast a few days after the Gono cyclone in June 2007 may have been connected in some way to the extreme weather.

4. **Natural toxins** – Biotoxins produced by harmful algal blooms are accumulated in fish and invertebrates and can be ingested by cetaceans in their prey. Saxitoxin, domoic acid, brevitoxin and ciguatoxin have all been linked to marine mammal mass mortality. Presence of an algal bloom and coincident mortality or sickness of other marine organisms indicates that this may be the cause. Presence of toxins in the stomach and/or other tissues provides additional evidence. Generally, cetacean mass mortality caused by biotoxins involves more than one species and the mortality may occur over a period of weeks.

5. **Disease** – Several disease epizootics have affected cetaceans but morbillivirus is the disease that has caused the greatest number of deaths. Generally, individual animals of the same species strand in different locations over a period of weeks or months as the disease spreads. Some animals strand alive, clearly exhibiting signs of disease, such as disorientation and poor body condition. Morbillivirus is diagnosed using virology and immunohistochemistry (Domingo et al., 1992).

6. **Social cohesion** – Most cetacean species that mass strand occur in large groups and have a highly evolved social structure. If a subset of a group is apt to strand, for any of the reasons described here, social cohesion may cause the remainder of the group to follow. Thus, mass strandings may include healthy individuals as well as sick or injured animals.

7. **Sound** – Underwater sound from various anthropogenic sources (e.g., seismic surveys and mid-frequency naval sonar) is believed to cause mass and mixed-species strandings of deep-diving cetaceans. Scientific data has linked mid-frequency sonar (MFS) to mortality of beaked whales (Cox et al., 2006; Fernandez et al., 2005; Jepson et al., 2003). Evidence that MFS causes mortality of dolphins (family Delphinidae) is weaker. Investigators have concluded that it was 'plausible, if not likely' that offshore naval exercises contributed to a near mass stranding of approximately 150 melon-headed whales (*Peponocephala electra*) in Hawaii in July 2004 (Southall et al., 2006).

8. **Fisheries –** The largest human-related cause of cetacean mortality worldwide is incidental capture in fishing gear. As air-breathing mammals, cetaceans often drown after becoming entangled in fishing nets. Animals bycaught in fishing gear show characteristic internal and external injuries, including bruising, muscular tearing, broken beaks, torn and severed fins and flukes, and cuts and abrasions on the skin (Kuiken et al., 1994). Most carcasses probably sink at sea and are never observed or documented; currents and wind direction determine the distribution and timing of dolphin strandings. The incidence of mortality, species affected and types of fisheries

and gear involved vary from place to place, but globally the greatest number of cetacean deaths have been linked to gillnet fisheries, pelagic trawls and tuna purse-seine fisheries (Northridge, 2002). In the Eastern Tropical Pacific (ETP) several species of dolphin (pantropical spotted, *Stenella attenuata*; spinner, *Stenella longirostris*; and common dolphin, *Delphinus delphis*) swim together with yellow-fin tuna (*Thunnus albacares*). The take of small cetaceans in tuna purse-seine nets are the result of deliberate incidental capture and a single set can result in the death of hundreds of dolphins. Over approximately 4 decades the tuna fishery in the ETP is estimated to have killed more than 6 million dolphins (Gerrodette, 2002). Large-scale public pressure led to management interventions that after 1990 significantly reduced the mortality rate (Gosliner, 1999).

Gillnets are used throughout the world and have caused population declines in some cetacean species such as the critically endangered vaquita (*Phocoena sinus*), which inhabits the Gulf of California, Mexico. Many coastal cetacean species suffer high gillnet entanglement, however, porpoises, such as the harbour porpoise (*Phocoena phocoena*) and finless porpoise (*Neophocaena phocaenoides*) appear to be particularly susceptible. Dolphins are also caught in large numbers in pelagic trawl fisheries in several areas including the United States, Europe and New Zealand (Northridge, 2002).

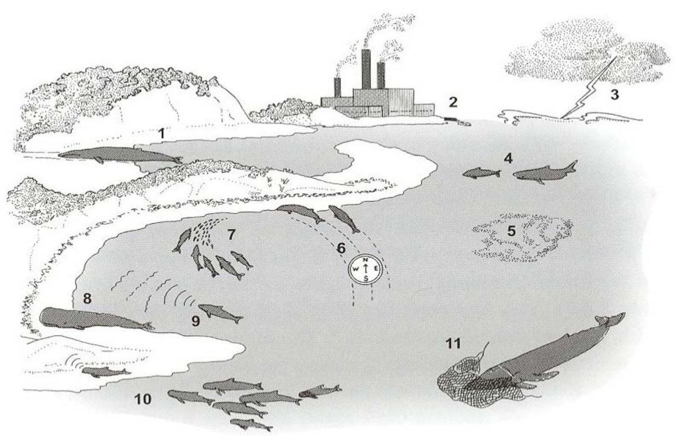

Fig. 7.1. Possible causes of cetacean strandings. **1.** Complex topographic and oceanographic conditions. **2.** Contaminants. **3.** Weather conditions. **4.** Predators. **5.** Natural toxins. **6.** Geomagnetic disturbances and errors in navigation while following geomagnetic contours. **7.** Following prey inshore. **8.** Disease. **9.** Disturbance of echolocation in shallow water. **10.** Social cohesion. **11.** Human-related injuries.

Figure 1 – Potential causes of cetacean mass strandings (Geraci and Lounsbury, 2005).

2. History of the two mass mortality events in Iran

During the autumn of 2007, two dolphin mass mortality events involving at least 152 small cetaceans (dolphins) were reported from southern Iran. Both events occurred near Jask (Iranian Gulf of Oman coast), but the events were a month and more than 170 km apart (Fig 2). The Iran Department of Environment and the Regional Organisation for Protection of the Marine Environment (ROPME) based in Kuwait requested that the IUCN-Cetacean Specialist Group provide assistance in investigating the causes of these mass strandings. The investigation team consisted of two CSG members – cetacean biologist G.T. Braulik and veterinary pathologist A. Fernandez (see Annex 1 for a synopsis of each author's qualifications and experience). The team visited Iran from 21-25 November 2007.

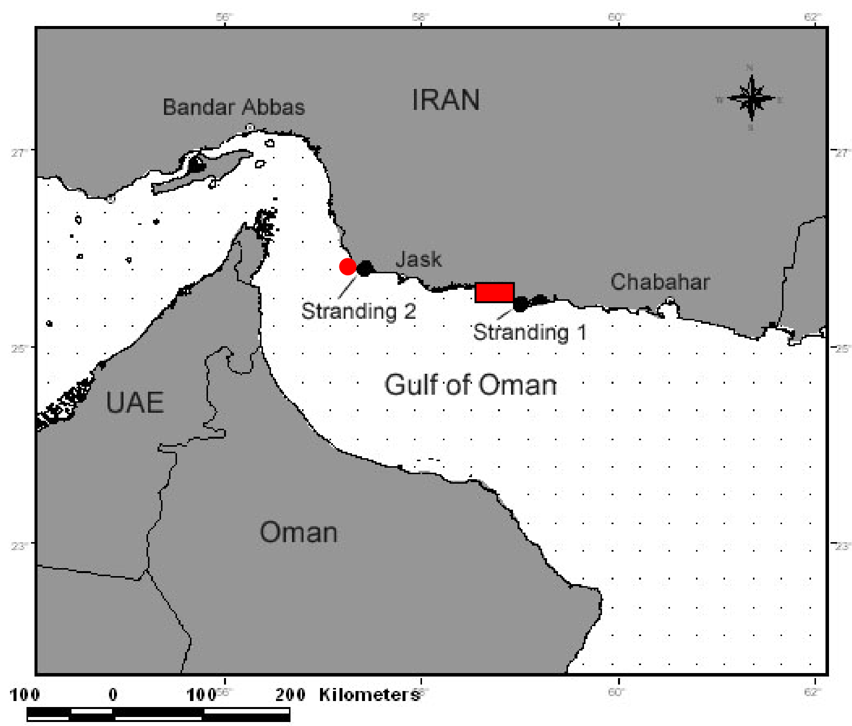

Figure 2 – Location of the two mass mortality events in Iran in 2007

All of the referenced causes and hypotheses for cetacean mass mortality events detailed above were considered during this retrospective investigation. During the visit extensive meetings were held with, and information obtained from, the following national and regional Iranian agencies: Department of Environment, offices of the Iranian Fisheries Research Organisation, the Fisheries Department (Shilat), research and diagnostic laboratories, veterinary institutes and departments, one industrial purse-seine fishing vessel in Bandar Abbas port and local fishermen at the stranding locations. A site visit was also made to the two beaches where the mass mortality events occurred.

Information on the following aspects of each mortality event was compiled and considered in this evaluation:

1. Species identification and knowledge of species distribution and behaviour;
2. Stranding location, coastal topography and oceanography;
3. Tidal cycle and moon phase during periods when strandings took place;
4. Distribution of carcasses on beach;
5. Account of stranding event from eye-witnesses and examination of video;
6. State of decomposition of carcasses;
7. External examination of animals (e.g. body condition, body decomposition, external marks, external lesions; from photos, video and other evidence);
8. Internal examination of animals (from pictures and video) and sample analysis (for infectious agents and toxic pollutants) where available;
9. Reports or evidence of harmful algal blooms;
10. Reports of evidence of chemical or oil spills;
11. Weather conditions;
12. Knowledge or evidence of human activities in the vicinity, including military exercises, seismic surveys or fishing activity.

We were given access to information, photographs, samples and video from each stranding. More information and samples were collected from the second event than from the first because (1) the first event highlighted the need for the authorities to respond adequately and (2) personnel gained experience during the first stranding and were therefore better prepared to respond. Although carcasses examined from the first stranding were decomposed, samples were of sufficient quality for some analyses to be conducted. The carcasses from the second stranding were very fresh and could yield high-quality information. However, the results of toxicology, histology and virology analyses conducted on samples collected by the Iranian authorities were still pending during our visit and results were not available for consideration in this report.

3. First dolphin mass mortality event

3.1. History of the first stranding event

On 20 September 2007, 79 dolphin carcasses washed ashore over a period of at least 24 hours. The carcasses were spread along 13 km of coastline between N25.41163 E59.06824 and N25.77260 E57.38684, i.e. approximately 125 km east of Jask port (Fig. 2 & 3). All animals were already dead and decomposed when they washed onto the beach.

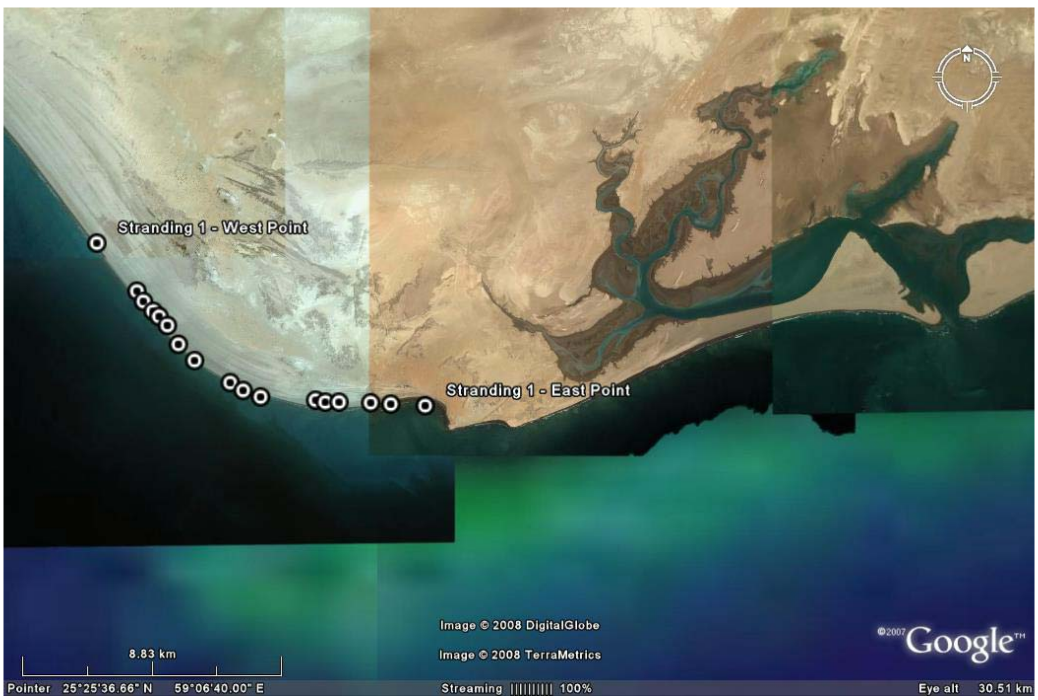

Figure 3 – Location of the mass mortality event of spinner dolphins on the Iranian Coast in September 2007.

3.2. Species identification and review of knowledge on species

External morphology and coloration of the carcasses, the flat palatine of the rostrum and high tooth count (UR50, LR51 and UR52, UL53, LL51, LR51) indicate that all of the stranded animals in this event were spinner dolphins (*Stenella longirostris*) (Fig 4). Approximately 80% of the individuals were adult, with an average length of 160 cm (range from 90 to 184 cm).

Figure 4 – Skull used to identify the species of dolphin (spinner) stranded during first mass stranding event in September 2007.

Spinner dolphins are widely distributed in tropical and subtropical oceans between 30^0N and 30^0S. They are gregarious and occur in groups of a few tens up to several thousand individuals. They are highly acrobatic and gained their name from their habit of jumping clear of the water and spinning in the air. They generally occur in pelagic waters, occasionally entering shallower areas to rest, but they are not a deep-diving species. Spinner dolphins feed on a variety of small mesopelagic fish, squid and shrimp (Reeves et al., 2002). Van Waerebeek et al. (1999) concluded that spinner dolphins in the Gulf of Oman should be treated as a discrete population, morphologically distinct from other spinner subspecies.

Spinner dolphins are abundant in Oman waters (on the southern side of the Gulf of Oman) where groups of more than 1500 have been reported (Fig 2). They often occur in mixed groups with Common dolphins (*Delphinus* spp.) and occasionally with Pantropical spotted dolphins (*Stenella attenuata)* and they frequently associate with tuna (Baldwin et al., 2001; Baldwin et al., 1998; Collins et al., 2002). Spinner dolphin groups also have been sighted and have stranded in Iranian waters of the northern Gulf of Oman and Hormoz Straits (Fig 2) (Braulik et al., 2007). They are probably common off the Iranian coast of the Gulf of Oman and the morphologically distinct form documented off Oman (Van Waerebeek et al., 1999) may also occur off the Iranian coast.

3.3. Data and analysis of first mass mortality event

During the first stranding event, dolphins stranded along a gently shelving, wide, sandy beach oriented in a SE-NW direction. The predominant ocean currents in the area run from east to west. Local villagers claimed to have seen the dolphin carcasses coming to the beach over approximately a 24-hour period starting on 20 September 2007. Photographs of the stranded animals were taken from 2 to 7 days after they washed ashore. Examination of photographs showed that all individuals exhibited moderate to advanced decomposition and therefore it was not possible to identify external marks or lesions on the skin with certainty. However, two different individuals with maxillary and mandible fractures could be clearly seen in pictures. Other carcasses (based on photographs) had no other visible morphological peculiarities. When we visited the site, three carcasses were exhumed and one skull, still encased in flesh, was found to have a severe fracture to the top of the cranium.

There were no obvious marks on the bodies but some dolphins had circular, perforating holes in the flesh that were determined to have been made by ghost crabs (*Ocypode* sp.). Ghost crabs were observed feeding on carcasses in video recordings and were also observed in high numbers during the field visit to the stranding location.

Due to the advanced state of decomposition, nothing of use could be discerned from photographs of internal organs. The results of histological, toxicological and virological analyses from this stranding were not available for the present retrospective investigation.

The Iranian Gulf of Oman coast is periodically subject to harmful algal blooms (HABs) especially in the post-monsoon period when upwelling occurs (Anon., 1994; Anon., 2003; Heil et al., 2001; ROPME, 2003). Several government and university departments are conducting research on phytoplankton linked to HABs and they are equipped to monitor for, and respond to, these events. There was no report of a HAB event near the time of the mass mortality event by any agency in Iran, the U.S. National Oceanographic and Atmospheric Administration (NOAA), or from neighbouring countries. Water samples from the location of the stranding were collected and analysed for the presence of toxic phytoplankton by the Department of Environment and no evidence of a HAB was found.

The human population density along the Gulf of Oman coast of Iran is very low and as a consequence coastal waters are relatively unpolluted (ROPME, 2003). Investigators did not receive any affirmative information regarding a chemical or oil spill, seismic surveys, military exercises or unusual weather at the time of the first mass mortality event, however, this type of information is often hard to obtain.

On visiting the stranding site (13 km of beach) almost two months after the stranding occurred, two additional decomposed (code 5) cetacean carcasses were discovered: one finless porpoise (*Neophocaena phocaenoides*) 152 cm in length, and one long-beaked common dolphin (*Delphinus capensis*) approximately 147 cm long. The cause of death could not be determined due to the advanced state of decomposition. The remains of seven sea turtles, a puffer fish and a moray eel were also documented, all in different states of decomposition. These species have no economic value and are frequently bycaught in fishing gear and discarded. Many fishing vessels and fishermen were located on the beach as well as large amounts of debris from the fishing industry including net fragments, buoys, rope, buckets and other marine rubbish.

In 2002, fisheries contributed only 0.23% of the national product of Iran which is an affluent, resource-rich country. However, in the Gulf of Oman, Arabian Sea and Indian Ocean the fisheries sector is expanding rapidly, especially artisanal deep-sea fishing for large pelagics such as tuna, (FAO, 2005). Iran has six industrial tuna purse-seine vessels and numerous pelagic trawlers that are reported to fish in the Gulf of Oman from June to October when tuna and other pelagic species migrate into the Gulf and productivity is high following monsoon wind-driven upwelling. The Iranian coastline between Chabahar and Jask is reported to be especially productive and intensively fished by a variety of vessels and gear types. Iran captures more than 12% of the tuna harvested from the NW Indian Ocean and catches more than doubled from 1997 to 2003 (FAO, 2005). The Iran Fisheries Department state that several tuna purse-seine vessels and some trawlers were active in the Jask area at the time of the strandings and this is supported by the logbook of one purse-seine vessel which was examined. Other fishing gear that is used in the Gulf of Oman and the Jask area includes drift gillnets, wire traps, longlines, trawlers and beach seine nets (FAO, 2005).

3.4. First Mass Mortality Event – Interpretation and Conclusions

Dead spinner dolphins, all exhibiting a similar degree of decomposition, stranded at approximately the same time along 13 km of coastline. These circumstances indicate that this was a group of dolphins that died at sea at approximately the same time. This mass mortality event therefore was caused by an acute single event. Causes that are more chronic in nature or that would typically cause cetacean mortality over an extended period of time or across a wider geographic area (such as chronic diseases) can therefore be excluded.

Important observations include evidence of traumatic injuries (broken rostrums and one skull) of investigated animals. There was no evidence that a toxic agent, oil or chemical spill was involved in the mortality and these typically would have induced death and stranding of other marine species. The available evidence was not sufficient to evaluate whether acoustical disturbance might have played a role in the stranding. Deep-diving cetaceans appear to be more vulnerable to acoustic disturbances and as spinner dolphins are a shallow-water species an acoustic-related cause to the stranding seems unlikely. However, as noted above, sonar has been linked to the near mass stranding of melon-headed whales in Hawaii (Southall et al., 2006), and much remains to be learned about such potential effects for both deep- and shallow-diving species..

The remains of other marine organisms found on the beach near the stranded dolphins could point to a HAB as a possible cause of death. However, there was no evidence of a

HAB in the area, and although we cannot exclude this hypothesis, we do not consider it the most likely cause of the stranding event.

The presence of an active fishery immediately coincident spatially and temporally with the mass stranding, the acute nature of the event, presence of several specimens with physical injuries, and the presence of other potentially bycaught and discarded species on the beach, all are consistent with the hypothesis that this mass mortality was caused by interaction with fishing operations. However, this evidence is circumstantial and cannot be treated as conclusive.

It is important to note that the Iranian tuna purse-seiner observed during our visit did not have speed boats which typically would be needed if herding and fishing on dolphins was routinely practiced.

4. Second dolphin mass stranding

4.1. History of the second stranding event

At 09:00 on 24 October 2007, 73 striped dolphins (*Stenella coeruleoalba*) were discovered stranded in the mouth of Kangan Bay, near Kuh Mobarak village, 45 km west of Jask and 170 km from the first mass stranding. On discovery, approximately 10% of the dolphins were still alive. Villagers tried to return several animals to the sea but without success, and all animals were dead by the end of the day. According to the Department of Environment, the majority of the group were adults – average length 204 cm, maximum 260 cm and minimum 145 cm. Examination of photos and video showed that 40-50% of individuals exhibited haemorrhages from the eyes, mouth and skin around the head, all had red skin on the belly and most had large blisters on the skin. In several of the photos examined, the dolphins exhibited rigor mortis which normally starts about 6 hours after death and lasts until 30 to 36 hours post mortem. The stranded animals were spread in small clusters over approximately 700 m of very gently shelving beach and mud flats immediately west of an estuary (Fig 5). The coastal topography in this area was extremely complex; the location where the dolphins stranded was just west of an estuary and was bordered on three sides by sand banks; the tide in this area falls approximately 1 km. A single striped dolphin stranded in the same area two days later and is assumed to have been a member of the same group (see Fig 5, western most dolphin location).

Figure 5 – Location of striped dolphins that live stranded in Iran on 24th October 2007

4.2.Species identification and review of knowledge on species

Analysis of photos and video showed all stranded individuals to be clearly identifiable as striped dolphins, based on diagnostic external morphology and colouration (Fig 6).

Figure 6 – Striped dolphin mass stranding in October 2007 in Iran

Striped dolphins are widespread and reasonably abundant in tropical and warm temperate oceans of the world and are common in deeper waters of the continental slope. They generally travel in tight groups that average about 100 individuals but may contain as many as 500. Groups are very cohesive and have strong social bonds enabling hunters in Japan to drive large schools into shallow water where they can be easily captured. Striped dolphins are the most common cetaceans in the Mediterranean Sea, where there was a large morbillivirus outbreak and mass mortality in this species between 1990-1992. Their diet consists of a large variety of shoaling fish and cephalopods. Although they occur in pelagic waters, striped dolphins are not considered deep-divers (Reeves et al., 2002).

Striped dolphins are rare in Oman waters of the Gulf of Oman where they are known from only two separately stranded individuals (Baldwin et al., 2001; Baldwin et al., 1999; OWDRG, 2007). Prior to the mass stranding in October 2007, the only Iranian record of this species was a skull stored in the Jask office of the Department of Environment (Braulik et al., 2007). This specimen was discovered in autumn 2004 near Jask during a time when the Department of Environment had received reports of a mass stranding event in the area. These reports were never substantiated. Striped dolphins are assumed to be present but rare in the Gulf of Oman.

4.3.Data and analysis of second Stranding

Examination of video and photographs of cetaceans from the day of the stranding showed that the dolphins appeared to be in good body condition with no marks, scars or abrasions on the skin. On the beach, bodies showed rigor mortis and also livor mortis, best visible in non-pigmented areas of the body. Livor mortis or postmortem lividity (Latin: *livor*—bluish color, *mortis*—of death) is one of the changes that occurs soon after death, and is a settling of blood due to gravity into the lower (dependent) portion of the body, causing a purplish red discoloration of the skin.

Examination of photographs of necropsies conducted on the beach did not show lesions in the organs, only a marked congestion of the liver that, although a non-specific haemodynamic change, is routinely observed in animals that strand alive. Histologically, samples of one dolphin lung (checked microscopically) showed chronic parasitic lesions and one granulomatous lesion presenting numerous parasitic eggs. These are routinely found in striped dolphin lungs and are not a direct cause of death. It has been reported that massive infestation of trematodes (*Nasitrema* sp.) may injure the nervous system, causing disorientation (Morimitsu et al., 1987) and therefore it would have been important to check the brain, sinuses, ears and acoustic nerves of the stranded dolphins for parasites. As a systematic professional necropsy was not conducted, this possibility cannot be investigated further. However, while massive infestation by *Nasitrema* may occur in a small number of individuals, it would not occur in such a large number of dolphins.

Liver and kidney samples that were checked histologically did not present any significant morphological changes or recognizable lesions. All samples were partially autolitic, but of sufficient quality for detecting histological lesions.

Results of toxicological and virological analyses of internal organs collected from these stranded animals have not been released by the relevant Iranian authorities and were therefore not available for this evaluation.

According to the Iran Department of Environment (DoE), Iranian Fisheries Research Organisation (IFRO) and other monitoring agencies there was no HAB in the area of the stranding. Several stomachs from the stranded animals were analysed by IFRO for the presence of toxic phytoplankton but results were negative. There was no recorded mortality of other marine organisms in the vicinity of the stranding as is typically found when HABs occur.

There were no unusual weather events around the time of the stranding, no military exercises or seismic surveys were reported in the vicinity, and there were no reports of oil or other chemical spills nearby. However, details on these types of events are often difficult to obtain.

No potentially bycaught organisms were discovered dead on the beach in the location of the stranding, no fishing debris was found on the beach and no fishing vessels were visible. The stranding location is not intensively fished as it is outside (west of) the area of upwelling where productivity and fishing activity is concentrated. According to the Fisheries Department, all but one vessel in the Iranian tuna-purse seine fleet had left the area at the time of the stranding.

From visiting the area and examining maps (Fig 5), it is clear that this mass stranding occurred adjacent to an estuary in a complex coastal area surrounded by sand banks and gently shelving mud flats. The tide falls rapidly here, tidal range is 2-4 m and water recedes over a distance of about 1 km between high and low tide. The exact location of the stranding was almost entirely enclosed by shallow sand banks to the north, east and south. The stranding occurred two days prior to the full moon, which was on 26 October, and it was not spring or neap tide. On 24 October 2007 at Ras al Kuh, approximately 15 km west of the stranding location, low tide occurred at 01:15am (local time) and was

0.7m, high tide occurred at 07:06am and was 2.4m (http://easytide.ukho.gov.uk/EasyTide/EasyTide/index.aspx).

4.4.Second mass Stranding – Interpretation and conclusions

The close proximity of the carcasses, presence of rigor mortis in many animals, evidence of livor mortis in all individuals and sun-burnt blisters on the dorsal and lateral skin indicates that the striped dolphin group stranded alive, together, at the same time, and subsequently died due to "Stranding Stress Syndrome"(Dierauf and Gulland, 2001).

All investigated animals were in good body condition with no external or internal traumatic pathology visible (on photos and video). We believe fisheries interaction can be ruled out as a possible cause due to the pattern of the stranding (e.g. animals alive, same location, etc.) and the pathological findings in the stranded dolphins (good body condition without external marks or traumatic injuries indicative of fishing interactions, signs of "Stranding Stress Syndrome," etc.). Current information indicates that no large-scale fishing operations were underway at that time in that area and fishing operations are anyway unlikely to cause live cetacean strandings.

Information needed to categorically rule out involvement of toxins or an acute viral infection has still not been released by the relevant authorities in Iran. However, there was no evidence of any oil or chemical spill, HAB, underwater sound or unusual weather coincident spatially or temporally with the stranding. The epidemiology and pathology of the stranded animals did not exhibit any characteristics consistent with involvement of any of the above and, based on the available information, these possible causes appear to be unlikely.

The factor or factors that caused the group to enter this shallow estuarine area remain unknown. Such factors might include following prey, accompanying a diseased dolphin to shore, or panic due to human activities. It is possible that this was simply a 'natural' mass stranding, in which dolphins were entrapped by the complex coastal configuration. This has been reported previously in several parts of the world with very similar coastal features (Geraci et al., 1999). In the present case, the location of the mass stranding was an area of complex sandbanks and tidal mudflats associated with an estuary. The group of striped dolphins may have entered this area during high tide and became trapped by the complex coastal topography and stranded by the rapidly falling tide.

Striped dolphins are not normally found in shallow water or close to the coast and their occurrence in this area, is therefore considered unusual.

5. Overall conclusions

The two mass mortality events occurred a month in time and more than 170 km apart, involved different dolphin species and exhibited many different characteristics. There is no evidence to suggest they were linked and therefore they are considered separately in this report.

The first mass stranding involved 79 spinner dolphins. Based on the fairly limited evidence the leading hypothesis to explain the stranding is fishery interaction. Dead, decomposed dolphins washed ashore during a short period of time at different points along the same stretch of coast; several dolphins bore evidence of traumatic injuries; and the stranding event was spatially and temporally coincident with an active fishery. This evidence should be viewed as circumstantial rather than conclusive.

The second event involved 73 striped dolphins that stranded alive. The evidence indicates that a number of factors were unlikely to be the cause (fisheries, HABs, contamination by oil or chemical spills) and suggests that this stranding resulted from the animals becoming entrapped by the complex coastal configuration and then dying due to "Stranding Stress Syndrome". The factors (natural or human-related) that might have caused them to enter the estuary, which is not their typical habitat, are not known.

6. Recommendations

It is important to scientifically evaluate the cause of cetacean mass strandings or unusual mortalities and also to use these experiences to improve the capacity to respond to future events and to reduce the likelihood of their future occurrence. The following recommendations are made with this view in mind:

1. Establishment of an Iran cetacean stranding response network

Establishment of a network of individuals and organisations to respond when marine mammals strand along the Iranian coast is a relatively low-cost but highly effective way to collect information on marine mammal species occurrence and threats. DoE is the ideal organisation to coordinate this effort. This will require training of DoE personnel, the design and distribution of basic data collection protocols, and the posting of contact telephone numbers of responders via sign boards (posters) or other media. A central location is needed to store information and to coordinate the processing of samples. A regular survey of beaches, especially those adjacent to areas of fishing activity, is important for detection of strandings and to establish a baseline to better understand future mortality events.

2. Specialised training in stranding response

Iranian personnel and technical capabilities were identified during the visit and this existing capacity will be valuable for diagnosing causes of death of cetaceans stranded on the coasts of Iran in the future. Following establishment of a stranding network as indicated above, it is vital to develop protocols and train veterinarians in necropsy techniques and sample collection. Prior identification of (a) laboratories able and willing to analyse samples, (b) parameters to be analysed, (c) techniques for analysis and (d) reporting requirements for the laboratories will ensure that useful data are generated in a timely manner. This will ensure that sufficient and appropriate information is collected to identify problems, and make it possible to differentiate natural from human causes of mortality. Also, it will allow the national stranding network to join other regional and international networks.

3. Evaluation of cetacean mortality in fisheries

The concern about issues surrounding dolphin health and conservation is high on the part of both the Environment Department and the Fisheries Department, and there is a strong will to find solutions regarding general and specific problems affecting marine mammals. As is true elsewhere in the world, data indicate that bycatch of dolphins and porpoises in fishing gear may be the largest single threat to marine mammals in Iranian waters (Braulik et al., 2007). It is likely that as a stranding network develops and the efficiency of detection and reporting improves, more incidents of cetacean mortality and bycatch will be discovered. It is therefore important for the Department of Environment, Fisheries Department and other relevant authorities to jointly take responsibility for and address these issues. A study of ports, fish landing sites and fish markets, and a program of interviews with fishermen, are needed to identify fishing gear and fisheries with significant marine mammal bycatch and to determine which species are most vulnerable. The placement of independent, trained observers onboard a sample of fishing vessels is the most effective method to obtain reliable information on bycatch rates.

4. Baseline distribution and abundance surveys

Marine mammal surveys at specific locations where marine mammals are believed to be resident or where marine mammals are particularly under threat are needed to guide conservation efforts. Promising areas for survey work are the Oman Sea coast where cetaceans may experience negative interactions with fisheries; coastal waters of Khuzestan where marine mammals are likely to be threatened by pollution following multiple wars in Iraq; Qeshm Island which appears to be an important area for finless porpoises and humpback dolphins; and the coasts of Sistan and Baluchistan where humpback whales likely occur. Researchers will require training in cetacean survey techniques.

7. Acknowledgements

We would like to gratefully acknowledge our hosts in Iran: Dr Nabavee, Mr Omid Sedighi and Mr Shahrom Fadakar from the Department of Environment in Iran who facilitated every aspect of our visit. Support for the investigation was provided by the Regional Organisation for Protection of the Marine Environment (ROPME) in Kuwait, Iran Department of Environment, US Marine Mammal Commission and the University of Las Palmas de Gran Canaria, Spain. We would also like to acknowledge the valuable input to this investigation of Randy Reeves, Robert Brownell Jr, Tim Ragen and Koen Van Waerebeek. Many Iranian wildlife enthusiasts, biologists and journalists responded to the mass strandings and there was a large public response to the photos and information they collected. We thank them and hope that their efforts are rewarded by an increased awareness and focus on marine mammal conservation in Iran.

8. Scientific Literature

Aguilar, A. and Raga, J.A., 1993. The striped dolphin epizootic in the Mediterranean Sea. Ambio, 22: 524-528.

Anon., 1994. Red tide in the Sea of Oman. Iranian Fisheries Research and Training Organisation Newsletter, 6 (Autumn 1994): 2.

Anon., 2003. Red tide bloom in Sistan and Baluchistan Province coastal waters (Oman Sea). Iranian Fisheries Research Organisation Newsletter, 37 (Autumn 2003): 2.

Baldwin, R., Minton, G. and Collins, T., 2001. Cetaceans of the Sultanate of Oman, Report of the Second Arab International Conference on Environmental Biotechnology, Emirates Heritage Club, Abu Dhabi.

Baldwin, R., Van Waerebeek, K. and Gallagher, M., 1998. A review of small cetaceans from waters off the Arabian Peninsula. International Whaling Commission Scientific Committee Document SC/50/SM6. Cambridge, UK.

Baldwin, R.M., Gallagher, M. and Van Waerebeek, K., 1999. A review of cetaceans from waters off the Arabian Peninsula. In: M. Fisher, S.A. Ghazanfur and J.A. Soalton (Editors), The natural history of Oman: a Fetschrift for Michael Gallagher. Backhuys publishers, Leiden, pp. 161-189.

Braulik, G.T. et al., 2007. Marine mammal records from Iranian waters of the Persian Gulf and Gulf of Oman, pp. unpublished report. 36pp.

Collins, T. et al., 2002. A preliminary assessment of the frequency, distribution and causes of mortality of beach cast cetaceans in the Sultanate of Oman, January 1999 to February 2002. International Whaling Commission, Scientific Committee Document SC/54/O4. Cambridge, UK 13pp.

Cox, T.M. et al., 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3): 177-187.

Dierauf, L. and Gulland, J.D. (Editors), 2001. Handbook of Marine Mammal Medicine, 2nd edition. CRC Press, Boca Raton, FL, 83-95 pp.

Domingo, M. et al., 1992. Pathologic and immunocytochemical studies of morbillivirus infection in striped dolphins (*Stenella coeruleoalba*). Veterinary Pathology, 29(1-10).

FAO, 2005. FAO Fishery Country Profile - Islamic Republic of Iran. FAO, Rome.

Fernandez, A. et al., 2005. "Gas and Fat Embolic Syndrome" involving a mass stranding of beaked whales (Family *Ziphiidae*) exposed to anthropogenic sonar signals. Veterinary Pathology, 42: 446-457.

Geraci, J.R., Harwood, J. and Lounsbury, V.J., 1999. Marine mammal die-offs: causes, investigations and issues. In: J.R. Twiss Jr. and R.R. Reeves (Editors), Conservation and Management of Marine Mammals. Smithsonian Institution Press, Washington D.C., pp. 367-395.

Geraci, J.R. and Lounsbury, V.J., 2005. Marine Mammals Ashore: A Field Guide for Strandings. Second Edition. National Aquarium in Baltimore, Baltimore, MD.

Gerrodette, T., 2002. The Tuna-Dolphin Issue. In: W.F. Perrin, B. Wursig and J.G.M. Thewissen (Editors), Encyclopedia of Marine Mammals. Academic Press, San Diego, pp. 1269-1273.

Gosliner, M.L., 1999. The Tuna-dolphin controversy. In: J.R. Twiss Jr. and R.R. Reeves (Editors), Conservation and Management of Marine Mammals. Smithsonian Institution Press, Washington D.C., pp. 120-155.

Gulland, F.M.D. and Hall, A.J., 2007. Is marine mammal health deteriorating? Trends in the global reporting of marine mammal disease. EcoHealth, 4: 135-150.

Heil, C.A. et al., 2001. First record of a fish-killing *Gymnodinium* sp. bloom in Kuwait Bay, Arabian Sea: chronology and potential causes. Marine Ecology Progress Series, 214: 15-23.

Jepson, P.D. et al., 2003. Gas-bubble lesions in stranded cetaceans. Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? Nature, 575-576.

Kuiken, T. et al., 1994. Mass mortality of common dolphins (Delphinus delphis) in south west England due to incidental capture in fishing gear. Veterinary Record, 134(4): 81-89.

Morimitsu, T. et al., 1987. Mass stranding of odontoceti caused parasitogenic eight craneal neuropathy. Journal of Wildlife Diseases, 23(4): 586-590.

Nieri, M., 1999. Mass mortality of Atlantic Spotted dolphins (*Stenella frontalis*) caused by a fishing interaction in Mauritania. Marine Mammal Science, 15(3): 847-854.

Northridge, S., 2002. Fishing Industry, Effects of. In: W.F. Perrin, B. Wursig and J.G.M. Thewissen (Editors), Encyclopedia of Marine Mammals. Academic Press, San Diego, pp. 442-446.

OWDRG, 2007. Oman Cetacean Database. Oman Whale and Dolphin Research Group, PO Box 2531, CPO 111, Muscat, Oman.

Reeves, R.R., Smith, B.D., Crespo, E.A. and Notarbartolo di Sciara, G. (Editors), 2003. Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK., 139 pp.

Reeves, R.R., Stewart, B.S., Clapham, P.J. and Powell, J.A., 2002. National Audubon Society Guide to Marine Mammals of the World. Illustrated by Pieter Folkens. Alfred A. Knopf., New York, 527 pp.

ROPME, 2003. State of the Marine Environment Report. ROPME/GC-11/003, Regional Organisation for the Protection of the Marine Environment, Kuwait.

Southall, B.L. et al., 2006 Hawaiian melon-headed whale (*Peponocephala electra*) mass stranding event of July 3-4, 2004. . NOAA Technical Memorandum NMFS-OPR-31: 73.

Van Waerebeek, K., Gallagher, M.D., Baldwin, R.M., Papastavrou, V. and Mustafa Al-Lawati, S., 1999. Morphology and distribution of the spinner dolphin *Stenella longirostris*, rough-toothed dolphin, *Steno bredanensis*, and melon-headed whale, *Peponocephala electra*, from waters off the Sultanate of Oman. Journal of Cetacean Research and Management, 1: 167-177.

Annex 1 – Synopsis of experience and qualifications of report authors

Gillian T. Braulik

Gill Braulik is a biologist who has spent more than ten years conducting research and conservation of river and marine cetaceans in Asia. Her main research interest is endangered or little-known species in the developing world. She is currently affiliated with the Sea Mammal Research Unit, University of St. Andrews, UK and is working with the Ministry of Environment, Pakistan on the biology and conservation of the endangered Indus River dolphin and its habitat. In 2005 she visited Iran to conduct a review of marine mammals and since that time she has provided training and coordinated an informal Iranian marine mammal stranding network. She is also involved in marine mammal research and conservation in the wider Indian Ocean region and with river dolphin conservation in Pakistan, India and Bangladesh. She was a member of the Scientific Advisory Group on conservation of the Yangtze River dolphin in China and is a longstanding member of the IUCN-Cetacean Specialist Group.

Antonio Fernandez

Professor Fernández is currently director of the Research Institute for Animal Health at University of Las Palmas de Gran Canaria (Canary Islands – Spain). This Institute has five veterinary departments (Microbiology, Parasitology, Pathology, Epidemiology and Preventive Medicine). As a full professor and European Diplomat of Veterinary Pathology (including whale and dolphin pathology), his areas of expertise include Animal Histology and Pathology. Currently, he is a member of the IUCN–Cetacean Specialist Group and Convenor of the International Whaling Commission's specialist group on "unusual cetacean mortalities". His research interests include infectious diseases and anthropogenic effects (ship collision, sound, fishing, etc.) on whales and dolphins.