Report of the Workshop on Investigations of Large Mortality Events, Mass Strandings and International Stranding Response

Workshop on Investigations of Large Mortality Events, Mass Strandings and International Stranding Response[1]

Members: Rowles (co-Chair), Simeone (co-Chair), Bernaldo de Quiros, Brownell, Brownlow, Fauquier, Fernandez, Gulland, Jepson, Kemper, Kiernan, Litz, Mazzariol, Moore, Raverty, Roe, Seguel, Sharp, Simmonds, Stimmelmayr, Tajima, Thomas, Toole, Uhart, Ulloa, Wilkin, Yamada.

1. WELCOME AND INTRODUCTIONS

The Workshop was held at the Gulf of the Farallones National Marine Sanctuary Office in San Francisco, California from 11-12 December 2015.

Simeone and Rowles (co-Convenors) welcomed the group to San Francisco and participants were introduced. Participants and affiliations are given in Annex A.

2. APPOINTMENT OF CHAIR AND RAPPORTEURS

Simeone (USA) and Rowles (USA) were appointed co-Chairs of the Workshop and Fauquier and Wilkin were appointed as rapporteurs.

3. REVIEW AND ADOPT AGENDA

The agenda was adopted unchanged by the Workshop participants. The adopted Agenda is given as Annex B.

4. BACKGROUND

4.1 Scope of issues

Simeone presented an overview of the investigation process for mass mortality and mass stranding events. While significant work to standardise cetacean mass mortality and stranding response has been done in various regions, little consensus globally has been reached on definition of events, investigation processes of these events, and determination of the cause(s) behind these events. This Workshop was to focus on the investigative process and the promotion of international collaboration between countries that are involved in responding to and evaluating mass mortality or mass stranding events. Participants agreed that the term 'unusual cetacean event' would encompass mass stranding, mass mortality, and unusual mortality events in this report, unless otherwise specified.

4.2 Description in context of role of IWC

Simeone discussed the history of the IWC's work on cetacean strandings. With unusual cetacean events, such as those involving melon-headed whales in Madagascar in 2008, the IWC has become increasingly interested in stranding information to help understand anthropogenic impacts as threats to cetacean population health. Of particular interest for the Intersessional Working Group on Strandings was the definition of potential roles that the IWC might play in assisting countries with stranding response and investigation, for instance through expert input, coordination and oversight of events such as that in the Large Whale Entanglement Response Expert Group, or through monetary support for emergencies. Participants were invited to develop recommendations regarding the types of assistance that the IWC might provide.

[1]Presented to the Scientific Committee meeting as SC/66b/Rep09.

4.3 Review IWC Expert List and finalise by end of Workshop

Simeone presented the List of Stranding Networks which had first been distributed to all IWC Contracting Governments and members of the Scientific Committee in 2011. This list provides emergency contact information for all IWC Contracting Governments for live strandings and dead cetaceans found ashore/offshore. Ritter has been coordinating input to the list since 2011, and the Intersessional Working Group on Strandings was tasked with updating the list at SC/66a for use by the Scientific Committee and the Commission. Workshop participants were invited to review the list and to update their country's contact information. The list will then be sent to other IWC Member Governments for updating.

5. DEVELOPING BASELINES

5.1 Case studies

5.1.1 Southern right whales in Argentina

Uhart presented information on the Southern Right Whale Health Monitoring Program (SRWHMP) at Península Valdés, Argentina. The SRWHMP was established in 2003 and is run by a consortium of Non-Governmental Organisations (NGOs) and universities. The overall goal of the SRWHMP is to evaluate the health status of the southern right whale (*Eubalaena australis*; SRW) population that breeds at Península Valdés, by conducting post-mortem examinations of the animals that strand each year on the beaches of the peninsula and surrounding area. Over the years, the SRWHMP has gained experience in whale forensics, and, with over a decade of information and samples collected, has become the lead entity for monitoring the health status of the Península Valdés SRW population. In 2015, the SRWHMP completed its thirteenth consecutive season of fieldwork, having recorded and studied more than 700 dead whales, and creating an invaluable diagnostic and image database and tissue bank. A systematic, research-driven and long-term approach to documentation of strandings has been critical for establishing baseline information and constructing hypotheses on mortality causation. Frequent consultation with individual experts and International Governmental Organisations, such as the IWC, has enhanced the program's capacity to analyse evidence and define priorities. The main challenges for the SRWHMP have been securing sustained funding for field operations and diagnostics and building capacity (operational and personnel) to gradually increase and improve the quality and type of information collected during events over time. The Workshop thanked Uhart for her presentation, especially on evaluation of the challenges and successes nationally and internationally, and commended the SRWHMP for the tremendous amount of information that has been collected on mortalities of southern right whales.

The Workshop **recognised** the importance of monitoring cetacean populations through long-term biosurveillance programs to identify causes of mortality and to identify and aid in investigation of unusual mortality events, as well as the important role that the IWC has played in facilitating consultation and assistance in investigations.

5.1.2 Mysticetes in Alaska

Stimmelmayr presented information on the investigation of cetacean strandings in the US Arctic. Investigation and documentation of cetacean strandings play an important role in understanding the health status of free-ranging Arctic cetaceans and are excellent tools to evaluate trends in known threats or issues and to identify emerging marine threats. In the Arctic, many logistical and economic constraints must be taken into account when mounting a field response. Subsistence harvest of Arctic marine mammals is essential to the Inupiaq culture. Indigenous knowledge of common causes of death (COD) and injuries in large whale strandings is extensive and has been accumulated from observations gathered through living and subsisting on these resources since time immemorial. Indigenous knowledge of cetacean strandings, injuries and large whale butchering techniques in conjunction with the long-standing North Slope Borough bowhead whale (*Balaena mysticetus*) harvest monitoring program have, over time, provided the foundation for baleen whale specific post-mortem forensic tools and guidelines. This Arctic-focused, post-mortem evaluation approach resulted in the generation of stranding response strategies and protocols for the known threats facing large cetaceans in the Arctic, such as ship strike, line entanglement and killer whale predation. Since 2011, twelve beach cast baleen whales within the vicinity of Barrow, Alaska have been examined primarily to evaluate carcasses for evidence of blunt and sharp force trauma. Depending on carcass condition and logistics, partial or complete forensic necropsies have been performed. Current ongoing health assessments of subsistence-harvested bowhead whales have been expanded to include sampling and testing for novel threats. Investigations assessing the current health of harvested bowhead whales will aid in evaluating future baleen whale strandings in the Arctic. A retrospective review to summarise gray and bowhead whale strandings occurring Alaska-wide over time is currently underway. The Workshop thanked Stimmelmayr for providing this information, and **highlighted** the importance of long-term monitoring and collaboration in remote regions of the world.

5.1.3 Humpback whales in Brazil

Simone presented data on humpback whales (*Megaptera novaeangliae*) from Brazil on behalf of Marcondes. The humpback whale population in Bahia and Espirito Santo states has been estimated to be increasing at a rate of 10.79% per year based on aerial survey data obtained from 2002-15. Humpback whale strandings in these states have been monitored systematically since 2002. In 2010, an unusual mortality event occurred, with 96 whales stranding that year as compared to annual levels of roughly 30 whales. Although the exact cause of this mortality event is not known, there are some indications that it could have been related to the effect of the El Niño Southern Oscillation and decreased prey availability. From 2002-15, calves comprised 52% of strandings, and of the 614 total strandings, only 15% were live stranded (92). Strandings of humpback whales peak in August and September and mostly occur in the Bahia and Espirito Santo states. However, in 2015, the peak occurred in July, with a third of the strandings occurring in the southern region of Brazil, which is unusual. Marcondes has created a listserv for mysticete strandings in the Southern Hemisphere, which allows collaborators from different regions to be kept up to date on mysticete strandings. The Workshop **commended** Marcondes for this listserv resource, and **recommended** that a similar platform should be created for sharing information to request assistance or advice on unusual cetacean events worldwide.

5.1.4 Cetaceans in Japan

Tajima presented information on cetacean stranding events in Japan. For the past 30 years, stranding events have been recorded systematically in Japan. The total number of cetacean stranding events from 1960 to 2014 is 6,859, including 2,075 mysticete strandings and 4,784 odontocete strandings. Japan does not currently have a national marine mammal stranding network. The National Museum of Nature and Science, Tokyo, is primarily responsible for carrying out stranding surveys. Stranding information sources include local fisheries offices, aquariums, museums, universities, and local stranding networks. There were 230 drifting events (where carcasses do not reach shore); 2,497 entanglement events, and 92 mass stranding events. The finless porpoise is the species that most frequently strands in Japan. Pacific white-sided dolphins, harbour porpoises, and Dall's porpoises are also frequently encountered as incidental catches. A large number of minke whales strand, but most of these events are incidental bycatch. Humpback whales are also often found as incidental catch, especially during the winter. Of the 92 mass stranding events, more than 10 events have involved melon-headed whales (*Peponocephala*); beaked whales (*Ziphius*), sperm whales (*Physeter, Kogia*), dolphins (*Grampus, Stenella*) have each also been part of more than five mass stranding events. Most mass stranding events have not been properly investigated because of funding and logistical problems, but the museum responds as best they can when logistics and funding allow. For melon-headed whales, the species that most frequently mass strands in Japan, the majority of events have occurred around the meeting point of the Oyashio Current (warm current) and the Kuroshio Current (cold current). It appears that whales that prefer warm waters appear in Japan during the winter and strand, especially in the Chiba-Ibaraki area. All 53 whales that stranded in February 2011 and 33 of 156 that stranded in April 2015 were examined by the Museum. No pathologically significant findings, such as epizootic disease or biotoxins, were detected in any of the animals. From 1999 to 2014, 2,000 specimens were collected by the Museum. Of these, 750 cases were thoroughly investigated and pathology reports are available. The Workshop thanked Tajima for her presentation, and **highlighted** the importance of long-term record-keeping and pathologic investigation to more fully understand repeated mass stranding events such as the melon-headed whale events that have been observed in Japan.

5.1.5 Discussion

Each presenter was given the opportunity to share their opinions on what tools were integral to the success of their programs, as well as challenges that the programs faced when investigating mass mortality or stranding events. Successes included the importance of perseverance, long-term datasets incorporating long-term support for continued work, and bringing these events to the attention of the international community for collaboration and support. Challenges included logistical difficulties of performing an investigation with decomposed carcasses; difficulties in coordinating programs and collaborating with multiple entities, as well as difficulties in sustaining a multi-year investigation and in maintaining capacity (funding, logistics and training). Responses were tallied, and a Word cloud was created for words relating to successes (Fig. 1), as well as challenges (Fig. 2). The size of the words in the cloud corresponds to the relative popularity of the word among participants. The Workshop **agreed** on the importance of support from the international community, and **recommended** identifying or creating additional tools

Fig. 1. Word cloud demonstrating words associated with successes in unusual cetacean event response.

Fig. 2. Word cloud demonstrating words associated with challenges in unusual cetacean event response.

to support responders. The Workshop also **recommended** that investigators place emphasis on sharing their results, either at annual IWC Scientific Committee meetings or workshops, or other appropriate workshops or meetings (e.g. Wildlife Disease Association meetings), and peer reviewed publications or technical reports.

5.2 Pathologic investigation

5.2.1 Small cetaceans in UK

Jepson reported on necropsy as a key tool for investigating causes of morbidity and mortality in stranded cetaceans. The UK Cetacean Strandings Investigation Program (CSIP) has been funded since 1990 to conduct systematic necropsies of stranded cetaceans, pinnipeds, marine turtles and basking sharks. A standard necropsy protocol is used that is based on the protocol developed by the European Cetacean Society in 1991. This involves basic morphometric measurements like body length, body girth, body weight and standard measurements for blubber thickness. There is a standard necropsy protocol for the full necropsy and a standard report to record the main findings. Jepson noted that a basic kit or field kit for cetacean necropsy could be assembled relatively inexpensively with basic equipment (e.g. knives, scalpels, scissors) and basic sampling pots or bags for a range of tissue samples (e.g. microbiology, histopathology, toxicology). As any stranding network becomes more experienced, they can extend the basic necropsy protocols and report forms to collect more samples and data for other studies (e.g. algal toxins; gas and fat embolism; infection with or exposure to pathogens like morbilliviruses or *Brucella* sp. bacteria).

Brownlow presented data on four significant cetacean mass stranding events that have occurred in the UK in the past seven years. Unusual cetacean events elicit much interest from both the public and scientific community but the underlying reasons largely remain unknown. Live stranding events and, more specifically, mass live stranding events are extreme situations in which public safety, animal welfare and conservation science issues have to be managed with an extremely clear perception of priorities and often under a pressure of emergency. Thorough investigation of these events usually requires the consideration of a number of natural and anthropogenic factors. In 2008, a pod of common dolphins stranded in the rhea system around Falmouth, England and three significant mass strandings of long-finned pilot whales (*Globicephala melas*) occurred in Scotland in 2011, 2012 and 2015. Samples were collected according to standard protocols and investigations into potential trigger factors for the event were undertaken. The investigations included detailed pathological examination to quantify overall disease burden and specific diagnostics. This included microbiology, histopathology, morbillivirus (RT-PCR), and quantitative analyses for marine algal toxins (domoic acid and saxitoxin), organochlorine pesticides and 25 individual chlorobiphenyl congeners in blubber and metals concentrations in liver. External triggers, such as unusual climatic conditions and influences of underwater noise were also investigated. Requests were made to the UK Ministry of Defence and Department of Energy and Climate Change to establish the temporal-spatial distribution of civilian and military sources of underwater noise preceding the event. These investigations identified several main factors that would be plausible explanations for the stranding: navigational error in a complex, shallow tidal areas; acoustic impairment or a behavioural response to a series of military activities or underwater explosions conducted in the vicinity. Future investigations of mass stranding events (MSEs) would be greatly enhanced by maintaining worldwide collaborations between researchers in 'best practice' investigative techniques.

The Workshop thanked Jepson and Brownlow for their presentations and **agreed** that standardised investigative techniques are essential to understanding mass stranding events across countries. It was noted that without standardised approaches and consistent terminology it will be difficult to compare information across response areas and responders, especially across regions or ocean bodies. The Workshop **recommended** that a Best Practices document be created as a guide for investigation of unusual cetacean events.

5.2.2 Beaked whales in Europe

Fernandez and Bernaldo de Quiros presented information on beaked whale mass strandings in the Canary Islands. Following mass stranding events in 2002 and 2004, when beaked whale mass strandings were spatially and temporally associated with naval exercises and anti-submarine mid-frequency active sonar (MFAS), a moratorium was established on these activities in the Canary Islands. Prompt political action may have resulted in a remarkable conservation success for whales and dolphins. The Canary Islands used to be a hotspot for mass strandings, but there have been no mass strandings since the moratorium was imposed in 2004. Prompt response and the implementation of new techniques developed in recent years have been integral in establishing a more accurate diagnosis of death in these animals. Several points should be considered when investigating beaked whale mass strandings potentially related to military sonar. Beaked whale mass strandings may involve one or more species, and may involve animals stranding live, dead onshore or floating, or a combination. Cuvier's beaked whales are the most affected species in this region and appear to be the most sensitive species to MFAS. During these events, several animals tend to strand simultaneously, in a similar but not same location. Single beaked whale strandings have also been linked to sonar. Animals are typically in good body condition, with no evidence of other pathologic processes. Several specific gross and histopathologic findings are suggestive of barotrauma, including gas and fat emboli (Fernández *et al.*, 2005). Sampling for gas emboli should be performed as soon as possible, preferably within 12 hours of death.

The Workshop **agreed** with the recommendations posed by the presenters to improve diagnosis of these types of cases: improved international stranding networking and collaboration; faster communication with scientific experts to take quick action; systematic necropsy by a trained professional, whenever possible; improved necropsy and sampling training, including gas sampling, storage, and transportation; and improved communication and collaboration with military to exchange information on both sides. A review of historical events worldwide is warranted as well.

The Workshop **recommended** that a mechanism be developed by each country to obtain information about anthropogenic activities (e.g. seismic surveys, pile driving, sonar use, fishing) in the ocean as part of the investigation of unusual cetacean events.

5.2.3 Mysticetes in Chile

Ulloa presented findings from a mass mortality event of sei whales in the Gulf of Penas in southern Chile, first reported in May 2015. An investigative expedition was coordinated by Sernapesca and involved a multidisciplinary group of collaborators. A total of 39 cetaceans were observed, of which 29 corresponded to the most recent event, and the remaining 10 specimens corresponded only to bony structures, suggesting a probable past event. Samples of ater, sediment, stomach contents, faeces, and shellfish were collected for marine biotoxin testing. Skin samples obtained from 14 animals were subjected to genetic analysis and corresponded to the sei whale (*Balaenoptera borealis*). According to the diagnostics in the field and analysis of photographs, no direct action from human activity was observed. From the position of the whales on the shore (skull perched on its dorsal part), it is assumed that animals died while still in the water, then sea currents and winds pushed them ashore. All water samples were negative for harmful phytoplankton *Pseudonitzschia* and *Alexandrium*. Homogenised samples of mussels and clams were positive for saxitoxin and negative for domoic acid (DA). One whale had stomach contents with >20ug of DA per 100g of sample, and another whale had a low level of saxitoxin found in stomach contents. Both whales also had medium abundance on a relative scale of *Pseudonitzschia* in faeces. Dismissing a possible high intensity acoustic trauma after examining the periotic structure of the largest specimen found, the results obtained during the expedition, together with the high presence of *Pseudonitzschia* measures during February and March appears to support the hypothesis of biotoxin poisoning by harmful algal blooms. However, the advanced states of decay of the carcasses indicate that the results presented here are inconclusive. The presence of toxins in vectors in the area where the dead whales were found and the presence of toxins in two of the 39 whales found cannot be considered as conclusive evidence, but are rather agents for construction of hypotheses to be assessed

more rigorously in the near future. Although the mortality of whales in this region is not new, the mass mortality described in this report demonstrates an unprecedented event in Chile.

Seguel presented challenges encountered when conducting marine mammal stranding investigations in Chile. These investigations face challenges that are common to those in other locations but also situations that are particular to Chile's geography and political organisation. A major challenge to investigate stranding events is the extensive Chilean coast and the relative low human population density, especially in the north and south portions of the country. This translates into delayed or no reporting of most stranding events and in a delayed response to the few reported events due to the logistical difficulties of reaching isolated areas with a research team. With a few exceptions, information on the basic population biology of most cetaceans in Chile is very poor, probably due to the small number of researchers in the field and scarce funding for long-term monitoring programs. This translates into little or no baseline information for many cetacean species which makes it more difficult to understand impact at the population level and the causes of mass stranding events. Information generated in previous stranding investigations is not available from a central source, making it difficult for investigators to get access to historical data or tissue banks. Financial and human resources are scarce in the country, which make it difficult to establish investigations encompassing a broad group of experts and state of the art laboratory techniques. The development of local material and human capabilities is critical to properly investigate these events on the Pacific coast of South America.

The Workshop **expressed concern** regarding the high number of stranded baleen whales observed in Chile in 2015 and **supported** further investigations.

5.2.4 Cryptococcus in cetaceans

Raverty presented recent investigations into *Cryptococcus gattii*, a fungal pathogen which has historically been associated with dead and decomposing eucalyptus leaves in tropical and subtropical regions throughout the world. Since 1998, there has been an emerging of cryptococcosis due to *C. gattii* in human, veterinary companion and marine mammals along the west coast of North America. In humans, cases tended to be healthy and robust individuals, in contrast to *C. neoformans* which tends to afflict individuals who may be immunosuppressed or debilitated. In humans and companion animals infected with *C. gattii*, sinusitis, pneumonia and meningoencephalitis are prime presenting lesions. Among the first non-human cases was an adult male harbour porpoise stranded along the east coast of Vancouver Island, just south of Nanaimo, British Columbia. Since that initial detection, cases have been detected in humans and terrestrial animals in the lower mainland of British Columbia with eastward expansion into the Fraser Valley and subsequent detection in Washington State, south to California. The predominant genotype is VGIIA in the Pacific northwest of North America with more genetic diversity documented in Oregon and identification of hypervirulent VGIII. Possible mechanisms which may account for the emergence of this pathogen along the western seaboard of British Columbia and the United States may be increasing ambient temperatures related to climate change and subsequent emergence of dormant infective stages of this pathogen. Alternatively, aerosolisation of propocules in endemic regions of Australia with subsequent atmospheric transport and deposition along the coastal mountains may also have contributed to this emergence. Although sporadic cases of cryptococcosis due to *C. gattii* have been detected in regions throughout the midwest and eastern USA, there has been no confirmation of environmental contamination. *C. gattii* is the most common cause of infectious/inflammatory processes in the Pacific Northwest of North America. This case study demonstrates the importance of marine mammals as excellent environmental sentinels of ecosystem contamination by this pathogen.

The Workshop thanked Raverty for his presentation and **highlighted** the need for collaboration across disciplines when investigating complex mortality events.

5.2.5 Sperm whales in Mediterranean

Mazzariol reported on sperm whale (*Physeter macrocephalus*) stranding events in the Mediterranean. Mass strandings have been rarely reported in this region, except for those involving beaked whales, spatially and temporally associated to sonar exposure, and sperm whales in the Adriatic Sea. In this basin, sperm whales are considered vagrant and occur only in the southern part due to geographical features. Sperm whales strandings in this particular region have been reported since 1555, along a well-defined tract of the coastline between Rimini and Pescara. Mass stranding events have occurred seven times, with the last two in 2009 and 2014, which have been the only ones extensively investigated using a multidisciplinary approach and involving many national and international institutions. In 2009, a bachelor school of seven males entered the Adriatic and stranded alive on the shore. Seismic surveys were regarded as potential co-factors, even though no evidence of direct impact was detected. Infectious diseases (except for *T. gondii* in two individuals) and gas and fat embolic syndrome were ruled out by lab analysis. Mobilisation of organic pollutants and methyl-mercury secondary to starvation, was considered a key factor. A second event occurred in September of 2014, when a pod of seven females were found stranded on the shore of Italy. Four whales were extraordinarily refloated and were not observed to subsequently strand elsewhere along the entire Adriatic coastline. Necropsy of the others revealed that the oldest female, likely the leader, was pregnant and affected by a large stone in the right kidney with hydronephrosis. Dolphin morbillivirus (DMV) infection was detected by nested RT-PCR and immunohistochemistry on all three animals and in the foetus. Based on these observations, the main hypothesis is that DMV infection was a key factor for the animals to enter the Adriatic, but once there they could not find food. The last sperm whale mass stranding event involved more than 80 veterinarians and students which allowed complete gross necropsies and carcass disposal to occur in one day. Our experience underlines how cooperation, training and organisation are key steps in undertaking investigations of cetacean mass strandings and a good approach is to investigate these events in an open-minded, evidence-based and multidisciplinary manner.

The Workshop **agreed** that cooperation, training and organisation are key steps in responding to mass stranding events and that an open minded, evidence-based multidisciplinary approach to investigations is critical for understanding the causes or contributing factors for these events. The Workshop **recommended** the development of Best Practices guidelines for unusual cetacean stranding investigations.

5.2.6 Discussion

Each of the above presenters was given the opportunity to share their opinions on what tools were integral to the success of their programs, as well as challenges that the

programs faced when investigating mass stranding events. Successes included development of new techniques to elucidate the etiology of some events, collaborations that are fostered through long-term investigations, and incorporating graduate students to investigate certain aspects of the events. Challenges included achieving cooperation from multiple investigative groups, and lack of a centralised resource to access data for temporal and spatial comparisons.

The Workshop **recommended** the development of an Expert Panel on unusual cetacean events for regular communication and to provide input and guidance for investigations.

5.3 Recurring events

5.3.1 Mixed species – New Zealand

Roe presented information on strandings in New Zealand, which has one of the highest rates of stranding events in the world. Over 3,500 events have been recorded in the New Zealand Whale Stranding Database since 1840, affecting nearly 17,800 individual cetaceans. Mass stranding event 'hot-spots' occur at four locations, and the majority of these include pilot whales, sperm whales, pygmy sperm whales and common dolphins. Beaked whales also strand frequently, but usually as single animal events. Live stranding responses are coordinated by the Department of Conservation, with an active and highly effective refloating response network operated by a national charity, Project Jonah. All refloating efforts and investigations are conducted under consultation with land approval by local iwi (indigenous peoples). Currently, pathological investigations of mass stranding events are fairly limited, unless they are considered to be 'unusual events' (i.e. outside expected areas or affecting unusual species). In contrast, thorough investigations are carried out on all stranded Hector's and Maui dolphins, and on many beaked whales and single strandings. Gas and oil exploration companies are encouraged to fund investigations of stranding events that occur during seismic testing activities. Limitations of the existing investigation system include fragmented communication networks, lack of funding and incomplete recording of stranding events in the national database.

The Workshop **highlighted** the unique tiered approach to sampling and investigation in New Zealand and **recommended** that a lead for unusual stranding investigations and a coordinated structure for the response during an investigation be developed at national and regional levels.

5.3.2 Mass stranding events in USA

Moore provided an overview of the categorisation system used to better understand mass strandings of odontocetes, which occur regularly in the Cape Cod region of Massachusetts, USA. Records of these events pre-date anthropogenic causes, such as resource exploration, intensive shipping and military sonar, suggesting natural causes; however, the cause of each event is often elusive. Weather, tides, topography, social dynamics of the species, and a myriad of other factors can contribute to the occurrence of mass stranding events. Further complicating the understanding of these large scale events are complex stranding patterns. Groups of dolphins have stranded on successive days and single animals have stranded during or between mass stranding events. It is difficult to understand the possible relationships between these strandings when analysed spatially and temporally. In order to elucidate these possible relationships, life history information, environmental data, and a logical understanding of strandings based on response experience have been used to identify three key criteria: tide, location and species. Animals must strand on the same tidal cycle (one complete tidal cycle from when the first animals were found). If approximate time of stranding can be confidently inferred from the animal's location relative to the high tide line, that time should be used in making this determination. For location, animals must strand in the same body of water. When considering species as a factor, discrete groups of animals of a single species are considered separate events, but when multiple species mass strand together in time and space (in a mixed group), they can be considered part of the same event. These criteria are used to refine the traditional definition of mass strandings. Moore also presented criteria that were established to define related series of strandings. A series consists of a string of odontocete stranding events, whether they are mass strandings, single strandings, or a combination of the two. This allows the opportunity to acknowledge the potential relationship between stranding events and to better identify possible trends over longer periods of time that may allow for better determination of common causation.

The Workshop thanked Moore for her presentation and **acknowledged** the need to look across events and broader temporal and spatial scales when evaluating these events.

Litz presented a preliminary analysis of mass strandings of all cetacean species, other than bottlenose dolphins, in the Southeast United States (SEUS, Texas through North Carolina). The SEUS experiences roughly 1-2 cetacean (excluding bottlenose dolphins) mass strandings per year. Analysis was limited to mass strandings of at least three animals (to avoid analysing mother/calf pairs) in the stranding records. The most commonly mass stranded species in the SEUS are short-finned pilot whales and rough-toothed dolphins. Mass strandings in the Gulf of Mexico were rare west of the Florida Panhandle. Several 'hot spots' for mass strandings were identified including the Gulf side of the Florida Keys through Southwest Florida, the central Atlantic coast of Florida and North Carolina. Most but not all of the mass strandings include live animals. In many cases, we have been unable to determine a particular disease process or other particular cause of the event. It is speculated that these species travel to the Gulf side of the Florida Keys and then are unable to navigate their way out of the wide shallow shelf, which stretches more than 190 miles in some places. Typical mass strandings in the SEUS occur in a relatively small geographic area and last 1-2 days. Alternatively, some events are 'trickling events' which may span several weeks to a month in duration and a wide area of coastline making it difficult to define spatial and temporal events. Pilot whales more so than any other species, tend to have these trickling events. One example was in 1998 on the central Atlantic coast of Florida where 17 pilot whales stranded over 18 days and 80 miles. The timeline and locations of these stranding events were discussed, highlighting the problems of assigning temporal and spatial boundaries to these events. Photo-identification of the pilot whales helped to confirm subgroups but genetics analyses may help identify subgroups of related individuals within and between the stranding sites. The Workshop thanked Litz for her presentation.

Simeone reported on two additional stranding events in the US. In 2011 three long-beaked common dolphins (*Delphinus capensis*) were reported dead off of San Diego, California, after a Navy training exercise detonation. An underwater remote detonation was initiated but just before the detonation occurred approximately 100 common dolphins moved into the area. Three animals were found dead immediately, with

additional animals found several days later. Pathologic evidence of blast injury, along with the death of three animals occurring in close proximity to a detonation event, is strong evidence that the cause of death was barotrauma. This event highlighted the difficulties in accounting for injuries that were not directly observed, but are likely linked to the event. In addition Simeone summarised Cook Inlet beluga whale mass stranding events. This endangered population of beluga whales has experienced repeated live mass stranding events, with more than 640 whales having been stranded in upper Cook Inlet, Alaska, USA since the 1980s. The events often coincide with extreme tidal fluctuations, and few animals are found dead. Animals typically refloat on the next tide. This example of mass stranding events is largely associated with topography and tidal cycles, however other factors may also be contributors to these events. Access for live response and dead sampling is challenging especially given the tidal mud flats, but many animals survive and refloat on their own. These mass events are significant for this endangered population, where a large proportion of the population may be involved in a single event.

The Workshop **acknowledged** the role that topography and tidal cycles may play in mass stranding events in the US, as well as the importance of long-term data collection from repeated events. The Workshop **strongly encouraged** the standardised collection of environmental data as well as biological data in such events and provision of long-term funding to support the investigations of these events over time. The data from long-term support for these investigations should be made easily accessible to understand trends in strandings/health and to inform response and investigations in the event of an unusual cetacean event.

The Workshop **requested** the IWC Secretariat facilitate this endeavour.

5.3.3 Unusual mortality events – USA

Simeone presented information on the structure of Marine Mammal Unusual Mortality Event (UME) investigations in the USA. The US Working Group on Marine Mammal UMEs was established in 1991 in response to large numbers of marine mammal mortalities in the late 1980s. The Working Group's role is to determine when a UME is occurring, help direct the response and investigation, and determine when the event is over. UME investigations involve national and international collaboration of experts across a variety of fields. Sixty-two UMEs have been officially declared since the start of the program in 1991. Nearly half of UMEs have an unknown cause. Investigations are logistically difficult, labour-intensive, and expensive. Day-to-day operations of the stranding program provide baselines to facilitate detection of abnormalities or threats. Preparation, training, and detection of events have been difficult to maintain due to minimal funding. Overall, the goals of the UME investigative process are to minimise deaths, determine the cause or contributing factors, determine the effect on the population, and identify the role of chemical, physical, and biological parameters in the event.

The Workshop thanked Simeone for the presentation and again **agreed** on the importance of standardised investigation and **recommended** the development of Best Practices for mass stranding investigation to be developed through an Expert Panel.

5.3.4 Worldwide mass stranding events

Brownell discussed mass stranding events (MSEs) that have occurred historically. Typically when a mass stranding event occurs the following species come to mind: pilot whales, false killer whales and sperm whales. Over 100 sperm whale MSEs have been documented. The first was in 1572 in Denmark (Smeenk, 1997). Sixty percent of sperm whale MSEs have occurred in Tasmania, New Zealand and the North Sea. Roughly one-third of these 100+ MSEs have occurred over the past 20 years. Possible explanations include unusual geochemical/physical/meteorological events, contaminant exposure and acoustic disturbance. There are no clear explanations for why sperm whales mass strand but, with increasing numbers of events since the 1970s, investigations should continue and include environmental data including human activities. Beaked whale mass strandings were rare prior to 1960. After 1960, there have been multiple atypical mass strandings (Fernández *et al.*, 2005). Anthropogenic activities lead to mass strandings and pose conservation concerns for beaked whales, due to their sensitivity to anthropogenic noise, repeated naval or seismic operations in beaked whale habitat, and the low reproductive rate of these cetaceans. Many other species have only mass-stranded in the past 50 years. The role of anthropogenic sound needs to be better investigated for all events.

The Workshop thanked Brownell for sharing this information and **stressed** the importance of long-term datasets and centralised, accessible data.

5.3.5 Discussion

Each presenter shared their views on what tools were integral to the success of their programs, as well as challenges that the programs faced when investigating mass stranding events. Factors for success included well-funded, long-term stranding networks with well trained personnel (either permanent or volunteer), to address both single and mass stranding events, as well as the creation of stranding databases that provide easily accessible information to either collaborators or the public and allow for evaluation of trends and causes of mass stranding events. Challenges included relying on communication networks such as social media that may not provide immediate notification of strandings to the appropriate response network, loss of key/trained personnel, and the challenges associated with keeping a database complete and up to date.

In summary, the Workshop reviewed the main points of the earlier discussions. The Workshop **recognised** the importance of long-term data sets and **strongly encouraged** their standardised collection. The Workshop again **recognised** the importance of an Expert Panel in guiding investigations and emergency response.

6. DEVELOPING TOOLS FOR STRANDING EVENT TYPES

6.1 Develop templates for describing each of the event types

Workshop participants discussed the importance of creating standardised templates to describe the variety of events that occur globally. While further discussion is needed to refine and finalise the list of characteristics needed to describe event types, a preliminary list was created (shown in Table 1). As anthropogenic impacts have been shown to contribute to mass stranding events, a list of potential anthropogenic factors to consider during an investigation was also added (shown here in Table 2).

6.2 Develop a decision tree describing what samples to collect for suspected event types

Workshop participants discussed the types of sampling that are needed for a variety of suspected event types, and

Table 1

Key event characteristics that should be considered during investigation of a mass stranding event.

Geographic scope	Species
Temporal scope	Number of animals
Chronology of events	Age class
Oceanographic conditions	Sex
Weather conditions	Historical context
Tidal cycles	Diagnostic/pathologic results
Co-occurring human activities	Additional taxa affected

Table 2

Anthropogenic factors to consider during the investigation of a mass stranding event.

Potential human activities	Examples of human activities
Anthropogenic noise	Oil and gas Shipping Construction Aircraft Seismic
Military	Sonar Underwater detonations
Pollution events	Petroleum and other chemicals Biological pollutants
Prey depletion	Fishing activities Aquaculture
Recreational tourism	
Harvest/hunting	

Table 3

Sections of relevance that are recommended for inclusion into a best practices document for cetacean stranding events. *A section that will refer to other tools that are already in existence or development.

Organisational team structure	
Coordination/preparedness	
Authorisation	Includes cultural sensitivities
Baseline/datasets	
Collaborative approach	
Training/capacity building	
Expert list/mentorship	
Response*	Includes disposition of live animals
Euthanasia*	
Live animal sampling	Includes sample processing and storage
Dead animal sampling	Includes sample processing and storage
Post-release monitoring	
Human interaction	
Data archiving	
Carcass disposal*	
Communication/media management	
Public health concerns	
Human/investigator safety	

highlighted the importance of a systematic approach to investigation. Specific protocols and guidelines are valuable, but it is important to take into account the expertise of the responders. The Workshop **recommended** that an Expert Panel should undertake the development of a decision tree as part of their work.

7. DEFINITIONS

Workshop participants discussed a variety of definitions, including typical versus atypical mass strandings, unusual versus repeated mortality events, and the use of epidemiologic terms (i.e. epizootic, enzootic) to describe events. As had been previously noted, several variations of definitions and use of terms were noted across regions. The Workshop **recommended** that key event characteristics and potential influential factors should be the focuses of any investigation, rather than reliance on the standardised definitions to describe an event, given the current state of knowledge of causes and contributing factors. The refinement of these characteristics should be incorporated into the Terms of Reference for the Expert Panel.

8. BEST PRACTICES

Based on the discussion above, the Workshop **recommended** that an Expert Panel on unusual cetacean events be established to provide regular communication and collaboration, as well as input and guidance for investigations. The Expert Panel should meet or communicate on a regular schedule, to facilitate collaboration and sharing of ideas. Full Terms of Reference will be developed by Workshop participants at a later date. The Workshop **recommended** that responders adhere to best practices to guide the investigative process, and **recommended** that the Expert Panel create a Best Practices document to guide investigations of various mass stranding or mass mortality events, based on the discussions at this Workshop, as well as further discussion after the termination of the Workshop. Participants discussed the type of information that should be included in the Best Practices document, and developed the non-exhaustive list shown in Table 3.

Workshop participants also brainstormed the potential roles that IWC could play in supporting cetacean mass stranding or mass mortality event investigation. The Workshop noted that potential roles may include the following.

- Expert Panel (potentially as the Intersessional Working Group on Strandings).
- Developing training goals and coordinating training requests.
- Coordinating emergency response when requested at national or regional levels.
- Notifying IWC Member Governments of events.
- Creation of a special fund dedicated to the investigation of mass stranding or mass mortality cetacean events.
- Centralised expert information (potentially in the form of a website or listserv).
- Support of a centralised data repository.
- Creation of an Expert Institution List.
- Venue for sharing information from scientists that investigate unusual cetacean events.
- Consider future workshops focused on particular events.
- Revise the IWC Progress Reports database to include the addition of an 'events' parameter or have a reporting of a summary of events on the IWC website.
- Addition of 'event reporting' as an agenda item during Scientific Committee meetings.
- Communication via the IWC Secretariat with Contracting Governments with regards to stranding events and trainings.

9. NEXT STEPS

9.1 Highlights for each country/response group

The Workshop suggested that participants work intersessionally to collate the known stranding events for each region that participated in the Workshop, to develop a central document for reference of known events globally that can be published in a peer-reviewed journal, and kept up to date on the IWC website.

9.2 Reporting system (potential for monitoring MSEs over time)

The Workshop **noted** that the Expert Panel should discuss further potential reporting systems for monitoring mass stranding and mass mortality events over time.

9.3 Mechanism for mutual aid

9.3.1 Expert list – finalisation

The Stranding Network expert list is in the process of revision, and a revised version should be maintained by the Secretariat and as an aid to the Expert Panel.

9.3.2 Mentor program

Workshop participants expressed interest in being a part of a mentor program for stranding responders, which has the potential to increase capacity across regions. Further discussions by the Expert Panel will help to develop a mentor program.

10. ADOPTION OF REPORT

The report was adopted on 12 December 2015.

REFERENCES

Fernández, A., Edwards, J.F., Rodriguez, F., Espinosa de los Monteros, A., Herraez, P., Castro, P., Jaber, J.R., Martin, V. and Arbelo, M. 2005. 'Gas and fat embolic syndrome' involving a mass stranding of beaked whales (family Ziphiidae) exposed to anthropogenic sonar signals. *Veterinary Pathology* 42: 446-57.

Smeenk, C. 1997. Strandings of sperm whales in the North Sea: History and patterns. *Bulletin Institut Royal de Sciences Naturelles de Belgique Biologie* B67(Supplement): 15-28.

Annex A

List of Participants

Yara Bernaldo de Quiros
Universidad de las Palmas de Gran Canaria
Spain

Bob Brownell
NOAA Fisheries
USA

Andrew Brownlow
Scottish Marine Animal Stranding Scheme
UK

Deb Fauquier
NOAA Fisheries
USA

Antonio Fernandez
Universidad de las Palmas de Gran Canaria
Spain

Frances Gulland
Marine Mammal Commission/ The Marine Mammal Center
USA

Paul Jepson
Zoological Society of London
UK

Catherine Kemper
South Australian Museum
Australia

Paul Kiernan
Irish Whale and Dolphin Group
Ireland

Jenny Litz
NOAA Fisheries
USA

Sandro Mazzariol
University of Padua
Italy

Katie Moore
International Fund for Animal Welfare
USA

Stephen Raverty
University of British Columbia
Canada

Wendi Roe
Massey University
New Zealand

Teri Rowles
NOAA Fisheries
USA

Mauricio Seguel
University of Georgia
Chile

Brian Sharp
International Fund for Animal Welfare
USA

Claire Simeone
NOAA Fisheries/The Marine Mammal Center
USA

Mark Peter Simmonds
Humane Society International
UK

Raphaela Stimmelmayr
North Slope Department of Wildlife Management
USA

Yuko Tajima
National Museum of Nature and Science
Japan

Peter Thomas
Marine Mammal Commission
USA

Joanna Toole
World Animal Protection
UK

Marcy Uhart
University of California
Argentina

Mauricio Ulloa
SERNAPESCA
Chile

Sarah Wilkin
NOAA Fisheries
USA

Tadasu Yamada
National Museum of Nature and Science
Japan

Annex B

Agenda

OBJECTIVES/GOALS

- Bring together biologists, veterinarians, and stranding network investigators from various countries to facilitate international collaboration and coordination amongst national and regional programs on responses to and investigations of cetacean strandings, with a focus on unusual or large scale mortality events, mass strandings, and disease outbreaks.
- Identify common issues and share information on potential solutions relative to causes, responses, and mitigation of cetacean strandings.
- Promote international data sharing and mutual aid particularly for mass strandings and large mortality events.
- Discuss current terminology in use with regard to mass strandings, and Unusual Mortality Events, to better characterise and facilitate work amongst countries.

DAY 1

1. Welcome and introductions
2. Appointment of Chair and rapporteurs
3. Review and adopt Agenda
4. Background
   - 4.1 Scope of issues
   - 4.2 Description in context of role of IWC
   - 4.3 Review IWC expert list and finalise by end of Workshop
5. Presentations
   - 5.1 Developing baselines
     - 5.1.1 Southern right whales in Argentina (Uhart)
     - 5.1.2 Mysticetes in Alaska (Stimmelmayr)
     - 5.1.3 Humpback whales in Brazil (Marcondes)
     - 5.1.4 Cetaceans in Japan (Tajima/Yamada)
     - 5.1.5 Discussion

10:30-10:45: Coffee break

   - 5.2 Pathologic investigation
     - 5.2.1 Small cetaceans in UK (Jepson/Brownlow)
     - 5.2.2 Beaked whales in Europe (Fernandez/de Quiros)
     - 5.2.3 Mysticetes in Chile (Ulloa/Seguel)
     - 5.2.4 Cryptococcus in cetaceans (Raverty)
     - 5.2.5 Sperm whales in Mediterranean (Mazzariol)
     - 5.2.6 Discussion

12:00-13:30: Lunch

   - 5.3 Recurring events
     - 5.3.1 Mixed species - New Zealand (Roe)
     - 5.3.2 Mass stranding events in USA (Moore/Sharp/Litz)
     - 5.3.3 Unusual mortality events – USA (Simeone)
     - 5.3.4 Worldwide mass stranding events (Brownell)
     - 5.3.5 Discussion

14:15-14:30: Coffee break

6. Developing tools for stranding event types
   - 6.1 Develop templates for describing each of the event types
   - 6.2 Develop a decision tree describing what samples to collect for suspected event types
   - 6.3 Discussion

Conclusions from first day

Outline of plan for next day

DAY 2

Recap of Day 1 highlights/administrative tasks

7. Definitions
   - 7.1 Mass strandings
     - 7.1a. Typical *vs* atypical
   - 7.2 Mortality events
     - 7.2a. Unusual *vs* repeated
   - 7.3 Epizootic, enzootic, incidence, prevalence
   - 7.4 Discussion: way forward with definitions, big picture

10:00-10:15: Coffee break

8. Best practices
   - 8.1 Coordination, prioritisation of sampling for limited access/time
   - 8.2 Response (live and dead)
   - 8.3 Investigations of causes and contributing factors
   - 8.4 Guidelines for capacity building
   - 8.5 Guidelines for international cooperation responses
9. Next steps
   - 9.1 Highlights for each country/response group
   - 9.2 Reporting system (potential for monitoring MSEs over time)
   - 9.3 Mechanism for mutual aid
     - 9.3a Expert list – finalisation
     - 9.3b Mentor program
10. Report writing