Cetacean Strandings, Diseases and Mortalities in European Waters

***Sandro Mazzariol**, University of Padova, Italy*

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“Cetaceans are being affected by many factors in our increasingly busy seas and it has never been more important than now to monitor their health. Working together to build functional stranding networks would help us to monitor both cetacean and ocean health.”
Sandro Mazzariol

Introduction to stranding numbers and trends

Any marine mammals found dead or still alive stranded on the beach, floating near the shoreline, or being transported by sea currents are defined as stranded. Strandings are categorized as single events, involving an individual cetacean or a mother-calf pair. Mass strandings are those cases when two or more individuals are beached on the same stretch of coast over a narrow timespan. Mass strandings are considered atypical when they involve different species over a lengthy stretch of coastline and over a long timeframe.

These events are monitored and reported by stranding networks established in many countries worldwide, including many European countries. Unfortunately, different national organization, legal frameworks and funding mean that data collection is not carried out systematically. It is, therefore, difficult to extrapolate and compare stranding trends worldwide or on a continental level. However, individual, well-organized countries can report any anomalies in their stranding numbers. In Europe two major Agreements (i.e. ASCOBANS[1] and ACCOBAMS[2]) have both recommended the establishment of fully-functional stranding networks as well as the use of regional databases through which individual nations can voluntarily enter their stranding reports. Despite technical and economic limitations, some information can be extrapolated.

ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas)

The 16th ASCOBANS Advisory Committee in 2009 recommended a review of trend analyses of stranding and other data available regarding small cetaceans in the Agreement area. In 2010, an overview of trends in status, distribution and impacts on small cetaceans was presented (Evans, 2011). Systematic stranding reporting varies greatly in its coverage between countries: the UK, Netherlands, Belgium, Germany and France have the longest running and most comprehensive schemes with the Baltic States being less interested due to the very few cetaceans occurring in the region. The same pattern can be found for systematic postmortem examinations aimed at investigating the possible cause of death through a common protocol applied since 1990.

Sample sizes are greatest for harbour porpoises (*Phocoena phocoena*) and short-beaked common dolphins (*Delphinus delphis*), and so the knowledge of major causes of mortality is best for these two species. The most common causes of death for stranded harbour porpoises are bycatch, infectious disease and attacks by bottlenose dolphins (*Tursiops truncatus*) (in areas where the two species are sympatric). Trends in bycatch showed declines in the British Isles but possible increases in Belgium and the Netherlands. These trends were considered a possible combination of reduced fishing effort in the case of the UK, and geographical shifts in porpoises possibly interacting with increased fishing effort in the case of the southernmost North Sea. For common dolphins, the most common cause of death has been bycatch, followed by live stranding, although proportions of bycatch amongst postmortem examinations have generally declined. In the ASCOBANS report it is underlined that it is much easier to establish bycatch as cause of death than many other activities, such as prey depletion, pollution, noise disturbance and ship strikes.

ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area)

In the Mediterranean regions, Black Sea and adjacent waters there is no similar ongoing initiative due to the lower presence of well-established stranding schemes and political and economical difficulties. ACCOBAMS has established a common stranding database, named MEDACES (Mediterranean Database of Cetacean Strandings), which gives details on stranding numbers and trends[3]. Unfortunately, even though almost 20,000 stranded cetaceans are reported, this database is not able to cover the entire basin since data are not provided consistently from all countries. For instance, between 2001-2008 Italy only reported 1,348 strandings in MEDACES out of the 5,500 animals reported in the Italian Stranding Database[4]. Merging these two major databases established in the Mediterranean Sea, more than 24,000

[1] https://www.ascobans.org
[2] https://accobams.org
[3] http://medaces.uv.es
[4] http://mammiferimarini.unipv.it/index_en.php

cetacean strandings were reported between 1998 and 2018 (Figure 1) with a prevalence of striped dolphins (*Stenella coeruleoalba*) (29%), bottlenose dolphins (15%), common dolphins (15%) and harbour porpoises (9%) and a large percentage of stranded specimens remaining unidentified (21%) (Figure 2).

Causes of strandings are difficult to assess in this area due to poor body condition of the stranded cetaceans (74.7% were not well preserved according to MEDACES) and due to diagnostic difficulties in spite of a well-structured network involving veterinary laboratories established in Spain, Italy and, to a lesser extent, in France and Croatia.

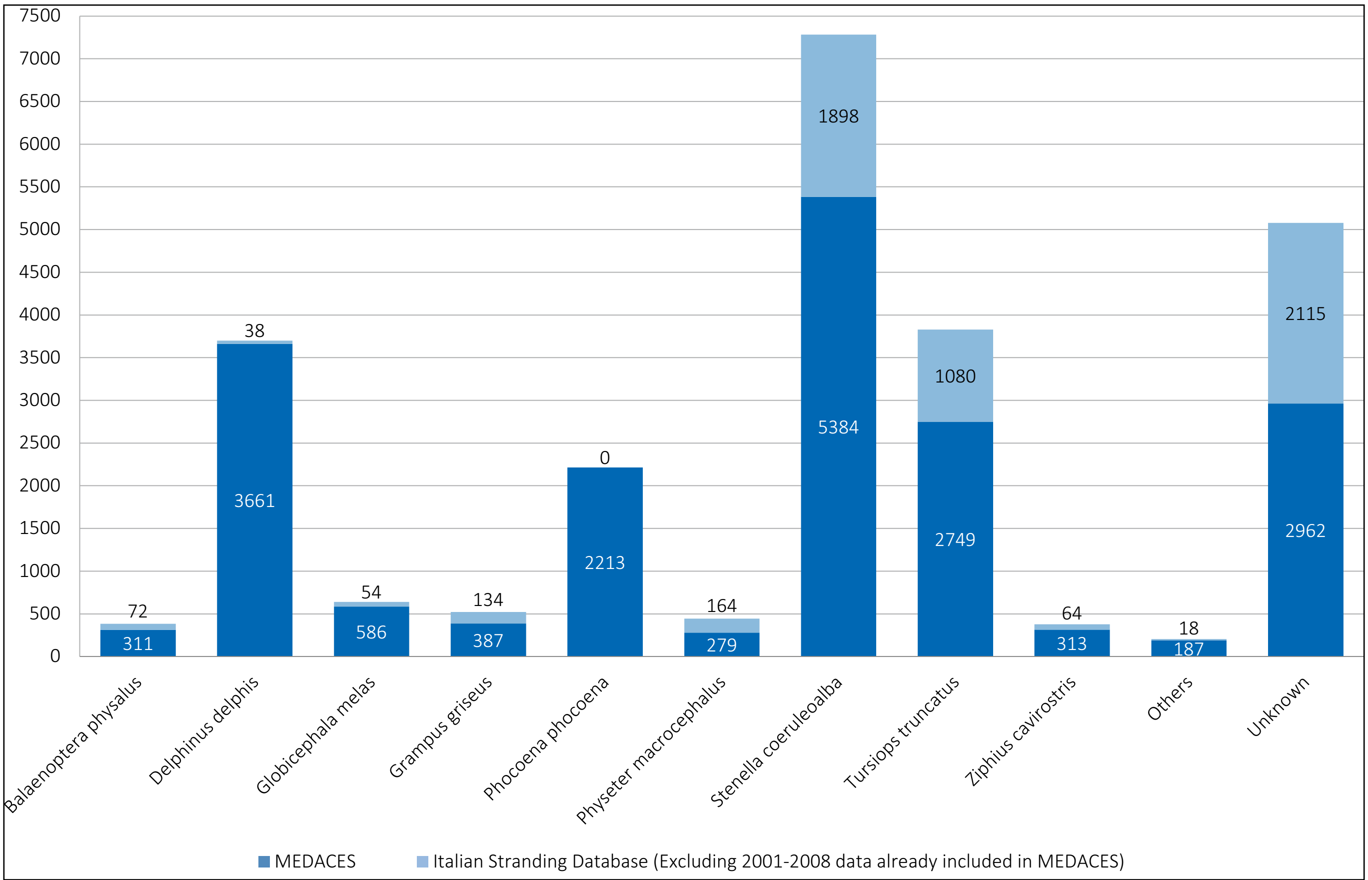

Figure 1: Total number of cetacean strandings in the Mediterranean Sea merging data from MEDACES and Italian Strandings Databases (1998 – 2018).

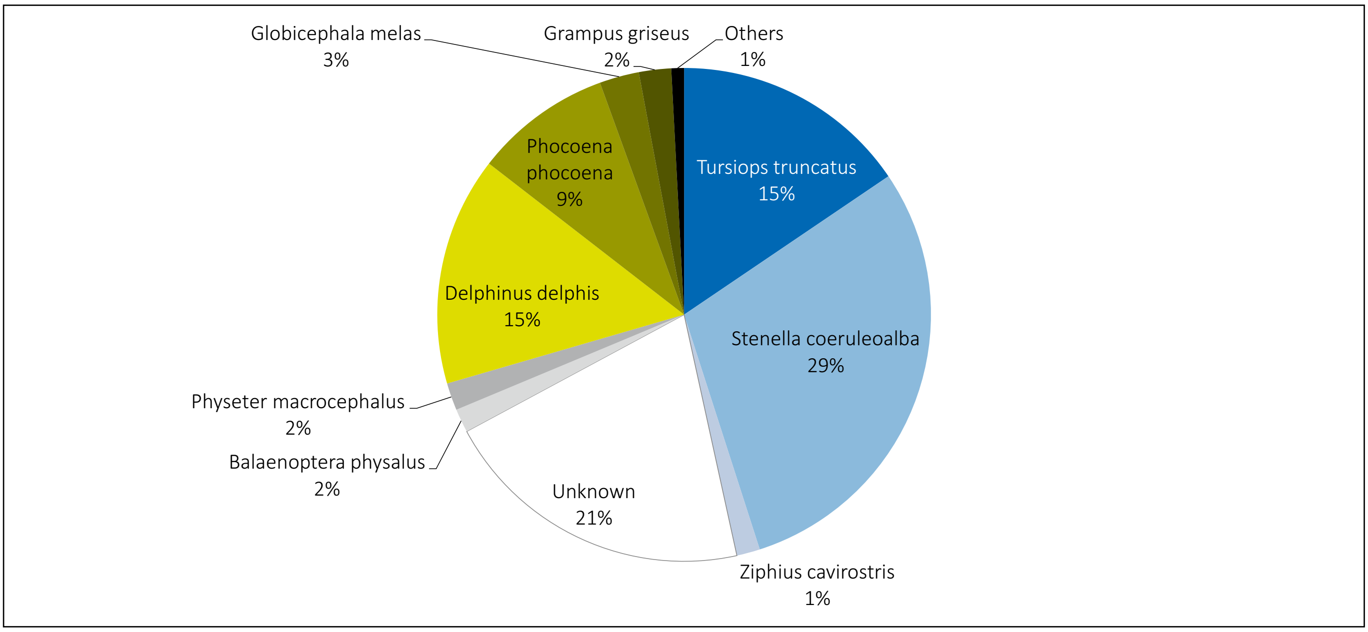

Figure 2: Percentage of each cetacean species stranded in the Mediterranean Sea (1998 – 2018).

Mortalities related to spontaneous diseases

Cetacean strandings are an important source of information for cetacean population health status, allowing not only the causes of mortality to be determined, but also the threats that affect these populations, including anthropogenic and natural risks (Peltier *et al*., 2014). Global contamination has become a great concern, especially for cetaceans, because they are one of the populations receiving high concentrations of persistent organic pollutants (POPs) arising out of an alarming anthropogenic pressure (Tanabe, 2002). Although the majority of these toxic chemicals are currently banned, significant levels still persist in the environment, accumulate in lipid-rich tissue and build up along trophic levels, thereby affecting cetacean populations all over the world. After the 1990-1992 morbillivirus epizootic occurred in striped dolphins in the Mediterranean Sea (Domingo *et al*., 1992), many publications stressed the role of contaminant levels in facilitating infectious diseases (Ross, 2002). Although direct effects of POPs are difficult to assess, many studies have related pollutant load with adverse health effects, such as immune suppression, endocrine disruption, reproductive impairment and carcinogenic effects (Martineau *et al*., 1994; De Swart *et al*., 1995; Lahvis *et al*., 1995; Schwacke *et al*., 2002; Wells *et al*., 2005; Schwacke *et al*., 2012; Yap *et al*., 2012). However, the influence of pollution in the development of diseases is not clearly evident during postmortem investigations. Emerging and re-emerging viral, bacterial, protozoal, and fungal diseases are being increasingly described in cetaceans. The most significant cetacean pathogens are reviewed here, namely *Morbillivirus, Herpesvirus, Brucella ceti* and *Toxoplasma gondii* infections, along with several additional pathogens which have gained progressive importance in recent years in European waters.

Morbillivirus

Cetacean morbillivirus (CeMV) is recognized as a biological disease agent of great concern for free-ranging cetaceans and is responsible for several outbreaks in marine mammals worldwide in the last 25-30 years (Van Bressem *et al*., 2014). Focusing on cetacean species, the most dramatic episodes affected bottlenose dolphins along the Atlantic coast of the United States in 1987-88 and in 2013-2015 (Lipscomb *et al*., 1994; Schulman *et al*., 1997; NOAA, 2019) and striped dolphins in the Mediterranean Sea between 1990 and 1992 (Domingo *et al*., 1990, 1992) and in 2007-2008 (Raga *et al*., 2008). Interestingly, before this latter event, at the end of 2006, a morbilliviral epidemic was also reported in long-finned pilot whales (*Globicephala melas*) around the Strait of Gibraltar (Fernández *et al*., 2008). In the following months, it was reported in striped dolphins and pilot whales along the Spanish Mediterranean coast as well as a pilot whale and a bottlenose dolphin found stranded on the French Mediterranean coast (Keck *et al*., 2010) and in striped dolphins in Italy (Di Guardo *et al*., 2013). In the following years other smaller episodes were reported mainly in Italian waters (Casalone *et al*., 2014; Pautasso *et al*., 2019) affecting not only small odontocetes but also larger ones (Mazzariol *et al*., 2017; Centelleghe *et al*., 2017) and mysticetes (Mazzariol *et al*., 2016).

Mortalities related to CeMV were also reported in the Black Sea involving common dolphins and harbour porpoises (Mazzariol, personal communication). In specific conditions this strain also infected other species such as pinnipeds, as in the case of a monk seal (*Monachus monachus*) mortality episode in 2000 (Van de Bildt *et al*., 2000) and in a single captive harbour seal (*Phoca vitulina*) (Mazzariol *et al*., 2013), and river otters (*Lutra lutra*) (Padalino *et al*., 2019). These peculiar epidemiological trends (small outbreaks, cross-species infections) suggest an endemic circulation among cetaceans of the Mediterranean Sea with two different lineages (Rubio-Guerri *et al*., 2018; Pautasso *et al*., 2019) infecting cetaceans living in this basin and in adjacent waters of the Atlantic Sea (Bento *et al*., 2016; Sierra *et al*., 2016). Sporadically, CeMV has been reported in the North Sea in multiple species such as white-beaked dolphins (*Lagenorhynchus albirostris*) (van Elk *et al*., 2014) and fin whales (*Balaenoptera physalus*) (Jo *et al*., 2017), after the morbilliviral epidemics affecting harbour porpoises in the late 1980s (Visser *et al*., 1993; Van Bressem *et al*., 2014). CeMV causes a systemic infection, characterized by broncho-interstitial pneumonia, lymphoid depletion with germinal centre necrosis and non-suppurative encephalitis (Domingo *et al*., 1992; Duignan *et al*., 1992; Raga *et al*., 2008; Soto *et al*., 2011). In case of recovery, as with other morbilliviral species, the immune function of the affected animal is impaired and the capability to face other diseases is consequently reduced, so these animals could also die from subsequent complications (Van Bressem *et al*. 2014).

Herpesvirus

Herpesvirus causes disease of varying severity in many species, including cetaceans. However, little is known about the distribution and the pathogenic effects of these viral agents on dolphins and whales living in the Mediterranean Sea and nearby Atlantic waters (Arbelo *et al*., 2012; Lecis *et al*., 2014; Melero *et al*., 2015).

Infections induced by herpesviruses (Esperón *et al*., 2008), have been reported in bottlenose dolphins (Blanchard *et al*., 2001), as have proliferative dermatitis lesions (Manire *et al*., 2006). Similar infections have also been described in beaked whales, namely in Cuvier's beaked whale (*Ziphius cavirostris*) (Arbelo *et al*., 2010) and in a Blainville's beaked whale (*Mesoplodon densirostris*) (Arbelo *et al*., 2012). Reports of primary herpesviral infection in free-ranging cetaceans include cases of non-suppurative encephalitis in bottlenose dolphins (Esperón *et al*., 2008) as well as in harbour porpoises living in the North Sea and Northern Atlantic waters (Kennedy *et al*., 1992; van Elk *et al*., 2016). The relationship between herpesviruses and immunocompromised hosts has been described, including the presence of systemic herpesviral lesions in a striped dolphin, probably secondary to immunosuppression caused by morbillivirus co-infection (Soto *et al*., 2012) and in common dolphins (Bento *et al*., 2019).

Brucella and other bacteria

Cetaceans living close to coastal areas, such as bottlenose dolphin populations, can be exposed to pathogens normally associated with humans or domestic animals, especially in urbanized areas. Bacteria such as *Salmonella* spp., *Escherichia coli* and *Listeria monocytogenes* have been found in some stranded animals (Davison *et al*., 2010; Grattarola *et al*., 2016). Methicillin-resistant *Staphylococcus aureus* (MRSA), a bacterial species responsible for several nosocomial infections both in human beings and in farm animals, has been isolated in free-ranging cetaceans close to the shores of Florida in the USA but also in dolphins under human care (Mazzariol *et al*., 2018b). These findings, even if they are generally detected in single animals, support the idea of a telluric biological pollution with these bacteria being carried by sewage waters or flooding from land facilities to the marine environment, with these latter events increasing due to extreme events related to climate change.

In the Mediterranean Sea, these strandings seem to be clustered closest to the shorelines of the Ligurian and Adriatic Seas where rivers or floods are able to carry bacterial pathogens from terrestrial sources. Among these bacteria, *Brucella* spp. and *Erysipelothrix rusiopathiae* are considered among the most worrying. *Brucella* spp. have been isolated from free-living cetaceans in Northern European and Mediterranean waters. While these infections are probably not fatal, they can lead to several chronic disease conditions which make animals more susceptible to other pathogens, or prevent them from feeding in an effective manner. *Brucella* spp. infections have been described in different marine mammals worldwide (Nymo *et al*., 2011). Since the first reference in these species in 1994 (Ewalt *et al*., 1994; Ross *et al*., 1994), they have been related to placentitis, abortion (Miller *et al*., 1999), and non-suppurative meningo-encephalitis (González *et al*., 2002; Davison *et al*., 2009). Based on their biological and molecular characteristics, the isolates obtained from cetaceans were distinguished into *B. delphini* and *B. phocoenae* (Bourg *et al*., 2007). Several cases of Brucella infection in bottlenose dolphins have been previously described with a wide range of induced lesions, such as pulmonary abscesses (Cassle *et al*., 2013), vertebral osteomyelitis (Goertz *et al*., 2011), and abortion and placentitis (Miller *et al*., 1999).

Initially Brucella infections were reported mainly in Northern European waters, however, in recent years, an increasing number of cases have been reported in striped dolphins and bottlenose dolphins living in the Mediterranean Sea (Alba *et al*., 2013; Garofolo *et al*., 2014; Isidoro-Ayza *et al*., 2014; Cvetnić *et al*., 2016). *Erysipelothrix rhusiopathiae* is ubiquitous and can persist for long periods in the environment, including in the marine environment (Wang *et al*., 2010). *E. rhusiopathiae* is the causative agent of erysipelas, a disease of many mammalian and avian species, mainly swine and turkeys (Kinsel *et al*., 1997). In humans, it is considered an occupational zoonosis caused by contact with contaminated animals (especially handling fish), their products and their waste (Wang *et al*., 2010). The dermatologic and acute septicemic forms of this disease have been reported in several cetacean species, including free-ranging bottlenose dolphins (Melero *et al*., 2011).

Toxoplasma gondii

Toxoplasma gondii, an apicomplexan protozoan parasite, infects a range of hosts worldwide, including several marine mammal species, in which it may cause abortion, lethal systemic disease (Dubey *et al*., 2003), and non-suppurative encephalitis (Resendes *et al*., 2002; Dubey *et al*., 2009; Di Guardo *et al*., 2010, 2011). Free-ranging bottlenose dolphins rank among *T. gondii*–susceptible hosts inhabiting the Mediterranean Sea and many other marine ecosystems worldwide. *T. gondii* is believed to be a pathogen of concern for this and other cetacean species, with a documented potential to affect their already threatened health and conservation status, as clearly highlighted by the prominent subacute-to-chronic, non-suppurative meningoencephalitis lesions reported in several striped dolphins found stranded between 2007 and 2008 along the coast of the Ligurian Sea in Italy (Di Guardo *et al*., 2010). The presence of parasitic bodies and zoites was documented in earlier studies as associated with encephalic abnormalities with the simultaneous finding of a mild inflammatory reaction, lung and lymph node levels, in the latter site a moderate to serious necrotizing lymphadenitis was also apparent. This protozoan has also been documented in large pelagic species such as the sperm whale (*Physeter macrocephalus*) and the fin whale (Mazzariol *et al*., 2011, 2012), generally as the consequence of either virus- or pollutant-induced/related immunosuppression, or cachexia/starvation. The number and the nature of infections caused by *T. gondii* underlines how this agent has spread in coastline waters likely affected by anthropogenic pressure and by coastline changes, along with the prolonged resistance of protozoan oocysts even in sea water.

Unusual Mortality Events (UMEs) in Europe

When unexpected events involve a significant die-off within a cetacean population which requires an immediate response, it is defined as an Unusual Mortality Event (UME). Large cetacean mortalities are often believed to be caused by human activities either by the media or the general public. However, according to the US National Oceanic and Atmospheric Administration (NOAA), between 1991 and 2019, only 6% of UMEs involving marine mammals were related to human activities while 14% were associated with infectious diseases, 19% with biotoxins and 13% were caused by ecological factors, while 48% had unknown causes.[5] In Europe, the lack of a centralized and systematic stranding reporting system prevents a similar data collection and response to UMEs. Despite these difficulties, it is possible to report some large mortalities involving specific causes. As mentioned previously, morbilliviral outbreaks have been responsible for many mortality outbreaks in the Mediterranean Sea since the 1990s. Recently, CeMV has also been deemed a possible co-factor in a mass stranding of sperm whales in Italy (Mazzariol *et al*., 2017) (Figure 3).

Figure 3: A mass stranding of sperm whales occurred in the Adriatic in 2014. *Cetacean morbillivirus was deemed as a co-factor in this "follow-me" stranding. © Sandro Mazzariol.*

[5] https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-unusual-mortality-events

Tragic events involving pods of this species usually occur in well-defined geographical areas such as the Adriatic and the North Seas with social, bathymetric and/or marine factors being proposed as possible causes. In most cases, human activity has been excluded as a reason for the stranding even if marine debris has been found during postmortem investigations and ocean noise sources have been considered among the possible factors (Mazzariol *et al*., 2011, 2018a; IJsseldijk *et al*., 2018).

Large mass strandings involving hundreds of common dolphins on the French coast in recent years are likely related to bycatch activities, in particular to trawling in the North Atlantic. Peltier and colleagues (2014) estimated a total of 4,000 dead animals at sea by using a drift prediction model applied to 800 stranded animals in 2015.

A similar predictive model based on drifting of carcasses helped to support postmortem investigations carried out by several countries during an UME that occurred in 2018 in the North Atlantic involving beaked whales. More than 70 beaked whales were reported dead stranded on the UK and Irish Atlantic coasts during August and September 2018, with similar stranding reports also in Iceland and Norway. Infectious or toxic diseases were unclear from pathological data, but unlikely based on epidemiological analysis with strandings incidence not consistent with infectious or toxic aetiology. Based on ocean and wind models, as well as simulations with carcass conditions and buoyancy, Brownlow (2018) hypothesized a sudden ocean noise source as the likely cause of stranding. Impulsive ocean noise sources have been spatially and temporally linked to other UMEs, mainly involving Cuvier's beaked whales in the Mediterranean and adjacent Atlantic waters. A recent report summarized all these events with more than 61 atypical stranding events involving this species in the Northern Hemisphere, spatially and temporally associated with military exercises using naval mid-frequency active sonar. The most recent events occurred in the Canary Islands (2002/2004), Almeria, Spain (2006/2011) and Greece (2011/2014) (Bernaldo de Quiros *et al*., 2019). The ban of military exercises using anti-submarine sonars in waters around the Canary Islands coincides with the absence of further beaked whale atypical mass strandings (Fernandez *et al*., 2013).

Conclusion

Strandings offer a valuable source of information regarding infectious and toxic diseases and it is essential that stranding networks are adequately funded and organized and that strandings databases are kept up to date with all available information. A number of pathogens affect cetaceans in European waters and are of particular concern when they combine with other threats affecting animal immune systems such as chemical pollution (see Chapter 9).

Recommended actions

Policy

- A functional and fully-funded stranding network is needed in each country and this should be twinned with centralized European coordination in order to obtained standardized and harmonized data which can be used for conservation purposes.
- Common procedures and national protocols should be implemented; reference laboratories should be identified with fully trained veterinarians performing necropsies.

Management measures

- Stranding networks should be linked to a centralized authority.
- Each stranded animal in appropriate condition should be collected and delivered to an appropriate veterinary laboratory.

Science

- Postmortem examinations should be carried out by trained personnel using common procedures aimed at understanding the cause(s) of death and investigating every case according to a forensic approach.

- Examination should not only aim at finding evidence of human interactions, but should be undertaken with an open mind and without expectations.
- Data should be exchanged through common databases through which information can be easily found for management and/or policy.

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