AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS
Aquatic Conserv: Mar. Freshw. Ecosyst. **24**(Suppl. 1): 4–10 (2014)
Published online 4 November 2013 in Wiley Online Library
(wileyonlinelibrary.com). DOI: 10.1002/aqc.2409

Sperm whales, Physeter macrocephalus, *in the Mediterranean Sea: a summary of status, threats, and conservation recommendations*

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ABSTRACT

1. Sperm whales in the Mediterranean are a genetically distinct population classified as Endangered on the basis of the IUCN Red List criteria.

2. Threats that result in sperm whale direct mortality, such as bycatch in illegal driftnets and collisions with ships, together with the noxious effects of noise, pollution, ingestion of solid debris, disturbance from irresponsible whale watching operations, and possibly prey depletion and climate change, affect the survival of the Mediterranean population and are the cause of an inferred continuing decline.

3. Recommendations to sustain the presence of sperm whales in the Mediterranean in the future include respecting existing fishery, pollution and whale watching regulations, and introducing precautionary noise and maritime traffic regulations in areas characterized by high sperm whale densities, some of which could be considered for MPA designation. Finally, the regular monitoring of sperm whale population ecology, behaviour and mortality at the regional scale, to detect trends and help to understand links between the observed phenomena and their possible cause(s), could help to address other potential threats, such as prey depletion and climate change.

Received 25 March 2012; Revised 12 April 2012; Accepted 5 September 2013

KEY WORDS: ocean; conservation; endangered species; mammals; fishing; shipping

SPERM WHALE STATUS IN THE MEDITERRANEAN SEA

Sperm whales (*Physeter macrocephalus*) in the Mediterranean Sea, a population genetically distinct from Atlantic conspecifics (Drouot *et al.*, 2004; Engelhaupt *et al.*, 2009) believed to contain fewer than 2500 mature individuals, are considered Endangered based on the IUCN Red List criteria EN C2a(ii) (Notarbartolo di Sciara *et al.*, 2012). It is suggested that a combination of pressure factors resulting in direct mortality, including bycatch in fishing gear and collisions with ships, has led over the last half-century to the decline of Mediterranean sperm whales, and that such decline will continue in the absence of effective conservation and management measures.

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THREATS

Organized whaling targeting sperm whales never occurred in the Mediterranean proper, with the exception of operations taking place in the Strait of Gibraltar, largely on the Atlantic side, during the early to mid-20th century (Sanpera and Aguilar, 1992). However, opportunistic deliberate killing of sperm whales, whether when the animals cruised near shore or when stranded alive (Bearzi *et al.*, 2011), was not infrequent until a few decades ago. Bolognari (1949, 1950, 1951, 1957) reported on the killing of sperm whales with a variety of means (including explosives) by fishermen in the area of the Strait of Messina, where herds consisting of as many as 30 individuals frequently occurred not far from shore. Such large groups have not been recorded in more recent times in that area or anywhere else in the Mediterranean.

Today direct killing is no longer reported in the Mediterranean; however, other effects of human activities at sea continue to threaten the survival of Mediterranean sperm whales in various ways. These include: (a) bycatch in fishing operations, (b) collisions with vessels, (c) ingestion of solid debris, (d) debilitation by chemical pollution, (e) disturbance deriving from anthropogenic noise, and (f) disturbance from irresponsible whale watching. In addition, (g) climate change, and (h) prey depletion deserve to be further investigated as possible threats. It is suspected that many of these factors, or combinations thereof, have led to a decline of sperm whales in the Mediterranean over the last half-century, and that in the absence of effective management to mitigate the ongoing threats the whales' decline will continue (Notarbartolo di Sciara *et al.*, 2012).

Bycatch

The greatest threat to sperm whales in the Mediterranean has been, until recently, entanglement in pelagic swordfish and tuna driftnets, which has caused considerable mortality since the 1980s, when this type of fishery started to be used on a large scale (Notarbartolo di Sciara, 1990; International Whaling Commission, 1994). The recorded number of sperm whales found dead or entangled between 1971 and 2004 in Spain, France and Italy (combined) was 229, clearly a minimum estimate, only 22 of which (10%) occurred between 1971 and 1986, when the Italian cetacean stranding monitoring programme started (Notarbartolo di Sciara *et al.*, 2004). Most of the strandings in Italy and Mediterranean Spain were caused by entanglement in driftnets, as evident from the reported presence of net fragments or characteristic marks on the whales' bodies (Podestà and Magnaghi, 1989; Lazaro and Martin, 1999). Cagnolaro and Notarbartolo di Sciara (1992) reported that for 83% of 347 cetaceans stranded in Italy from 1986 to 1990, which included 56 sperm whales, the cause of death, often obvious due to fragments of nets found on the carcasses or marks on the animals' skin, were related to net entanglement. The use of pelagic driftnets was banned in 2002 in the Mediterranean through a number of agreements and international and national regulatory bodies (i.e. European Commission, the International Commission for the Conservation of Atlantic Tuna, the General Fisheries Commission for the Mediterranean, and the CMS Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area), and has resulted in a decrease in entanglements of sperm whales in recent years. Unfortunately, however, entanglements have not ceased because fleets from many countries (e.g. Algeria, Italy, Morocco, Turkey) continue to fish illegally with pelagic driftnets. Thus there is still a threat to the survival of the species in the region as a result of sperm whale mortality in fishing gear (ACCOBAMS, 2003; Akyol *et al.*, 2005; Tudela *et al.*, 2005; Oceana, 2007; Pace *et al.*, 2008; Cornax and Pardo, 2009; Italian Cetacean Stranding Database, 2012).

Vessel collisions

Intense maritime traffic in sperm whale habitat is a potentially significant cause of mortality for sperm whales in the Mediterranean owing to collisions between the whales and large vessels such as cargo ships, tankers, hydrofoils and high-speed ferries (de Stephanis *et al.*, 2003, 2005; Italian Cetacean Stranding Database, 2012). More than 6% of 111 sperm whales stranded in Italy (1986–1999) and Greece (1982–2001) died after a collision with a

ship, and 6% of 61 photo-identified individuals (39 in Greece and 22 in Italy) bore wounds or scars attributed to a vessel strike (Pesante *et al.*, 2002; Abdulla and Linden, 2008).

Ingestion of debris

Solid debris, in large part plastic, are often found in the digestive tract of stranded sperm whales, sometimes with fatal consequences (Jacobsen *et al.*, 2010). Records of sperm whales stranded in the Mediterranean with plastic debris in their stomachs are not infrequent (Roberts, 2003), occasionally resulting in gastric occlusion and death (Viale *et al.*, 1992; de Stephanis *et al.*, 2013), although the presence of plastic in the stranded animals' gastrointestinal tract is not always necessarily lethal (Mazzariol *et al.*, 2011).

Chemical pollution

Like most marine long-lived apex predators, sperm whales are prone to accumulate in their bodies high levels of toxic xenobiotic compounds through biomagnification and bioaccumulation. However, intoxication by contaminants seems to be a lesser evil for sperm whales compared with other odontocetes (Bellante *et al.*, 2009), perhaps because their feeding habits mainly involve mesopelagic cephalopods and deepwater fish (Aguilar, 1983). In a circumglobal investigation, Wise *et al.* (2009) reported very high levels of chromium in sperm whales compared with other cetacean species, although the levels found in Mediterranean sperm whales were lower than the world average.

Noise

Underwater noise generated by industrial (oil and gas prospecting through seismic surveys) and naval sonar operations, as well as illegal dynamite fishing, all known to be highly disruptive of cetacean behaviour (Weir, 2008), has been a source of concern for causing disturbance to, and even potentially atypical mass strandings of sperm whales in the Mediterranean for at least two decades (Notarbartolo di Sciara and Gordon, 1997). Seismic surveys and military sonar operations are conducted in the Mediterranean with increasing frequency, including in areas containing sperm whale habitat, such as the Hellenic Trench where airguns have been used almost on a daily basis since 2007 (A. Frantzis, pers. comm.). Dynamite fishing is also a common, albeit illegal activity in large parts of the region, particularly in the eastern and southern Mediterranean, where breeding, feeding and socializing sperm whales present year-round are particularly vulnerable to this threat (Frantzis *et al.*, 2003).

Disturbance

In addition to unintended disturbance to cetaceans caused by human activities such as maritime traffic, fishing and pleasure boating in a small, crowded marine region such as the Mediterranean, deliberately approaching sperm whales in the course of commercial whale watching operations can also be a source of behavioural disruption (Gordon *et al.*, 1992). Disruption can be particularly serious when whale watching activities, inclusive of 'swim-with' operations, are conducted irresponsibly and in an unregulated fashion, as has been reported to occur in recent times off the French Riviera in the open sea waters of the Ligurian Sea, within the Pelagos Sanctuary for Mediterranean Marine Mammals, a Specially Protected Area of Mediterranean Importance established specifically to protect cetaceans (Notarbartolo di Sciara *et al.*, 2008). Here, in spite of the existing whale watching regulations, the distance from the coast where sperm whales are most frequently found facilitates breaches in compliance (A. Gannier, pers. comm.).

Climate change

Whitehead *et al.* (2008), on the basis of Intergovernmental Panel on Climate Change scenarios, predicted that mid-latitude, deep-water oceanic communities – which sperm whales are part of – may reorganize in response to ocean warming, with some of this reorganization involving shifts to higher latitudes. The Mediterranean Sea is considered one of the world's marine regions likely to be most affected by global warming in the future, and major changes in its sea surface temperatures and thermohaline circulation regimes, the latter possibly at least in part induced by climate change, are already being observed (Brand, 2008). Marine organisms in the Mediterranean are unable to move

north beyond 45°N, except by leaving the region through the Strait of Gibraltar, in response to deteriorating conditions, the result of either excessive warming of surface waters, or due to changes in primary productivity that result in a decrease in the region's carrying capacity.

Prey depletion

Although sperm whale prey depletion caused by human activities has not been demonstrated, a recent case of seven individuals stranded in southern Italy in 2009 with evident signs of starvation (Mazzariol *et al.*, 2011) is a cause of concern, because of its potential connection with industrial activities at sea. Seismic surveys have been reported to severely affect cephalopods and fishes (McCauley *et al.*, 2000; Guerra *et al.*, 2004), and the area where the sperm whales stranded has been intensely surveyed with airguns during the past few years. Considering the extent and intensity with which seismic surveys are currently conducted throughout large parts of the Mediterranean, the possibility of a cause/effect link between exploration activities and sperm whale feeding ecology needs further investigation.

CONSERVATION RECOMMENDATIONS

Addressing some of the pressure factors affecting sperm whales in the Mediterranean listed above can be relatively straightforward, because this would merely imply compliance with existing regulations, and appropriate conservation measures (which in most cases would benefit other components of marine biodiversity in addition to sperm whales) should be implemented immediately.

Bycatch in pelagic driftnets would cease to be a conservation problem for sperm whales if fishery regulations in Algeria, Italy, Morocco and Turkey were to be respected, and illegal fishing practices effectively prosecuted.

Marine pollution by toxic substances, oil and solid debris – including the emerging problem of microplastics (Andrady, 2011), can and must be combatted through the implementation of the appropriate Protocols to the 'Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean' (Barcelona Convention), such as the 'Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities', and the 'Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil', which entered into force, respectively, in May 2008 and March 2011.

Disturbance during irresponsible whale watching operations in sperm whale critical habitat can be addressed by passing and enforcing regulations based on the ACCOBAMS whale watching guidelines (ACCOBAMS, 2004), such as those recently adopted by Spain (Anon., 2008).

The problem of collisions between sperm whales and vessels is clearly more challenging, however, limiting maritime traffic to defined shipping lanes and limiting speed in areas characterized by high densities of sperm whales, and urging captains to navigate there with particular caution (following the suggestions by Laist *et al.*, 2001) would significantly reduce the risk of collisions (Vanderlaan and Taggart, 2009). A recent precedent was set by the Spanish Ministry of Defence, when a 'Notice to mariners to protect cetaceans from the risk of ship collisions in the Strait of Gibraltar' was published in January 2007 establishing a security area in a selected part of the Strait encompassing sperm whale critical habitat. In the notice, which is broadcast regularly by VHF radio from April to August and is included in the nautical charts, transitting ships are urged to limit their speed to ≤13 knots and to navigate with particular caution (Tejedor *et al.*, 2008).

To decrease the risk that sperm whale habitat is negatively affected by anthropogenic noise, significant results could be obtained by heeding the prescriptions from a specific resolution adopted by the parties to ACCOBAMS at their 4th Meeting. Resolution 4.17 urges the parties to:

(a) pay particular attention to the management of human activities in the habitats of sensitive cetaceans, taking into account cumulative and synergistic effects of such activities;

(b) inform the ACCOBAMS Secretariat on current and reasonably foreseeable noise-producing activities occurring under their jurisdiction within the ACCOBAMS area;
(c) ensure that underwater noise is fully taken into account in a precautionary manner when reviewing environmental impact assessments (EIAs) for activities that produce noise, including the provision of precautionary and effective mitigation and monitoring measures, as well as integrating noise considerations in the managing plans of marine protected areas; and
(d) emphasize the need for a provision for expert review of EIAs and associated mitigation and monitoring measures, as well as a provision for the action to be taken when unusual events occur, such as atypical mass strandings.

In addition, Resolution 4.17 contains guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area, providing explicit indication of measures to be adopted to avoid events such as the atypical mass stranding of sensitive cetacean species.

Many of the pressure factors mentioned above, and in particular fishing, maritime traffic, noise production and whale watching, should be considered with care particularly when occurring in sperm whale critical habitat, and if necessary the designation of specially protected areas should be considered in such locations as tools to mitigate specific threats, as also recommended in 2007 by the parties to ACCOBAMS during their 3rd meeting, with the adoption of Resolution 3.22. Currently, the only Mediterranean MPA specifically designated to protect cetaceans, which includes sperm whale critical habitat, is the Pelagos Sanctuary for Mediterranean Marine Mammals, that until now has failed to effectively contribute to cetacean conservation (Notarbartolo di Sciara, 2009). A significant improvement would involve obtaining from the International Maritime Organization the designation of the Pelagos Sanctuary as a Particularly Sensitive Sea Area, where specific measures can be applied to mitigate potential negative effects of shipping on the marine biota.

Other threats to Mediterranean sperm whales, such as prey depletion and climate change, are more difficult to address. The biological and ecological mechanisms that may be underlying prey depletion are still largely unknown, and made even more problematic by our current ignorance of the abundance and distribution of the mesopelagic cephalopod species these mammals mostly subsist on. Filling this gap would require the implementation of large-scale stock assessments in the deep seas, at the moment an enterprise technologically and economically beyond the reach of most Mediterranean marine mammal ecologists. However, research targeting the predators rather than the prey (e.g. by focusing on sperm whale foraging success through acoustic monitoring and the recording of defecation rates) may provide surrogate information useful to detect anomalies and eventually enable conservation action. Identifying climate change effects on Mediterranean sperm whale ecology may turn out to be even more intractable than detecting effects of prey depletion. Currently, monitoring programmes of sperm whale population ecology at the entire regional scale, to reveal and understand cause/effect links in the observed phenomena and their variability, seem like the best available option and should be strongly encouraged. Funding for the regular monitoring of sperm whale abundance, distribution and habitat choice throughout the Mediterranean, and the increase of coverage and effectiveness of a pan-regional stranding network which will include the systematic investigation of mortality causes, should be provided with continuity, because monitoring will continue to be a key, unavoidable requirement for ensuring the survival of the species in the region.

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