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# THE FIRST MASS STRANDING THAT WAS ASSOCIATED WITH THE USE OF ACTIVE SONAR (KYPARISSIAKOS GULF, GREECE, 1996)

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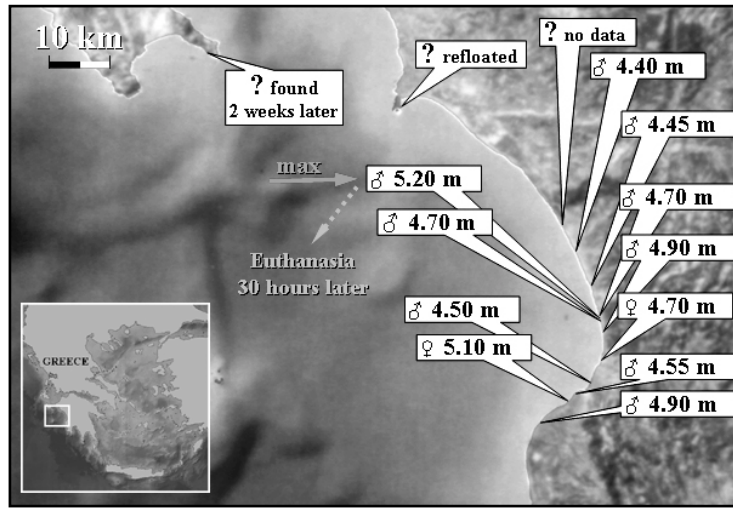
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**INTRODUCTION** The Greek Seas occupy the northern part of the eastern Mediterranean and are characterised by a very long, highly irregular coastline and a rich geomorphology (Stergiou *et al.*, 1997). The depressions and the deep trenches that surround Greece (Fig. 1) create appropriate habitats for deep diving cetaceans close to the coasts.

The Cuvier's beaked whale *Ziphius cavirostris* is the only ziphiid regularly present in the Mediterranean Sea (Notarbartolo di Sciara, 2002). Both strandings and sightings recorded during the last decade have showed clearly that the Greek Seas are an important area for this species (Frantzis *et al.*, in press). The yearly average of Cuvier's beaked whale strandings in Greece is 5.6 individuals (C.L.95%=2.78) for the decade 1990-1999 (the mass stranding of May 1996 excluded). Although underestimated (because no official stranding network was established in Greece before 1992), this number is significantly higher than the respective average for each of the three northern countries of the west and central Mediterranean (Spain 1.9, France 0.2, Italy 2.6), and higher (although not significantly) than their sum. Most of the strandings that occurred in Greece were recorded along the Hellenic Trench, which runs all around the west and south Greece, and marks the limits of the European continental shelf with steep underwater relief. Surveys conducted along the Hellenic Trench confirmed that Cuvier's beaked whales are abundant (Frantzis *et al.*, in press).

The mass stranding of Cuvier's beaked whales presented in this work was the first to be associated with the use of active sonar. It took place in Kyparissiakos Gulf (Frantzis, 1998), which is also found along the Hellenic Trench. It is a long sandy beach in the west coast of the Peloponnese (Fig. 1). Mass strandings involving beaked whales had repeatedly coincided with the proximity of military manoeuvres in the recent past in the Canary Islands (Vonk and Martin, 1989; Simmonds and Lopez-Jurado, 1991); however no data regarding the nature of the military activity and the possible use of active sonar that was taking place are available.

**THE MASS STRANDING** During the first hours of the morning of 12 May 1996, Cuvier's beaked whales started to strand alive in many different locations of Kyparissiakos Gulf. The strandings went on until the afternoon of 13 May. A few more specimens (4-5) were reported as stranded and rescued, entangled and rescued, or swimming very close to the coasts during the next three days. However, only one of those reports could be confirmed. Twelve whales have been recorded in total the 12<sup>th</sup> and 13<sup>th</sup> May. Those whales were spread along 38.2 kilometres of coast and were separated by a mean distance of 3.5 km (SD = 2.8,  $n = 11$ ) (Fig. 1).



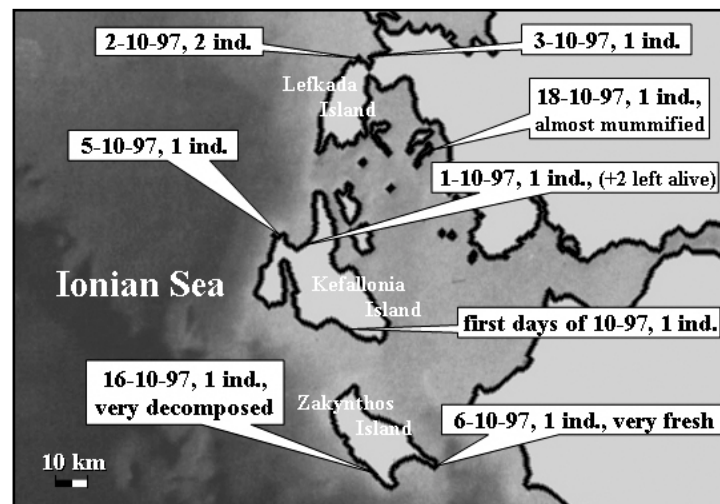
**Fig. 1.** Position, sex and total length of the 14 Cuvier's beaked whales that were recorded during, or shortly after the mass stranding of 12 and 13 May 1996 in Kyparisiakos Gulf, Greece.

Another whale stranded on 16 May and was driven back to the open sea. Two weeks later, one more animal was found decomposing on a remote beach of the neighbouring Zakynthos Island, 57 km away from the closest stranding on the mainland. We had the opportunity to observe, measure, and sample 11 whales. Nine of them were immature males with no erupted teeth and two were females (Fig. 1). The recorded spread of the stranded animals in location and time was atypical, as whales usually mass-strand at the same place and at the same time. The term "atypical mass stranding" has been proposed for the recorded strandings as opposed to typical mass strandings known mainly from pilot whales and false killer whales (Geraci and Lounsbury, 1993).

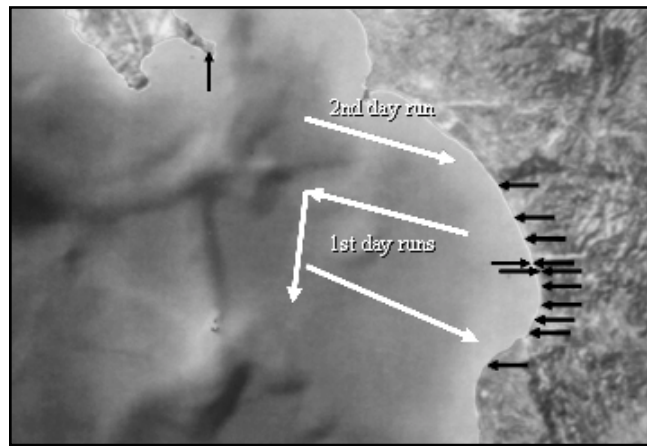
Necropsies of eight stranded animals were carried out, but no apparent abnormalities or wounds were found. These necropsies were limited to basic external examination and sampling of stomach contents, blood and skin. No ears were collected; no entire organs or histological samples were conserved because of many problems related to permits, lack of facilities and means, and lack of relevant knowledge and trained specialists. A recent re-examination of old photos of the mass stranding showed that the eyes of (at least) four individuals were bleeding. These animals had been photographed soon after their death. Stomach contents had variable quantities of squid remains (like beaks and ocular lenses) from three different squid species. Many of them contained cephalopod flesh, indicating that recent feeding had taken place.

The following year (October 1997), several strange strandings of Cuvier's beaked whales were recorded in the Ionian Sea, once more spread along several kilometres of coast. The northern stranding position was slightly north of Lefkada Island (some 80 nautical miles north of Kyparisiakos Gulf) and the southern was in south Zakynthos Island (Fig. 2). At least nine Cuvier's beaked whales stranded within a period of about ten days. Two more whales were reported to accompany one of the stranded animals. However, no photographic documents exist to confirm these reports. At least one of the stranded animals was alive when stranded on the 1<sup>st</sup> October. According to the state of decomposition of the whales that were found dead, the strandings should have started by the last days of September 1997. Once more there was military activity in the area. Unfortunately, no precise data regarding this activity have become available until today. This is the reason why this second atypical mass stranding of Cuvier's beaked whales in the Greek Ionian Sea remained largely unreported.

**THE CAUSE** All available information regarding the conditions associated with the mass stranding of May 1996 was gathered, and many potential causes were listed and examined. The most important of them were: major pollution events, important tectonic activity, unusual geochemical/physical/meteorological events, magnetic anomalies in the area, epizootics, and conventional military exercises. However, none of the potential causes listed above coincided in time with the mass stranding or could explain its characteristics (see also NATO-Saclantcen, 1998, which came to the same conclusion). Several months after the mass stranding I found a warning to mariners issued by the Greek Hydrographic Service, which provided significant information relevant to its cause. This warning (586 of 1996) was stating that ‘sound-detecting system trials’ were being performed by the NATO research vessel *Alliance* from 24:00 on 11 May to 24:00 on 15 May - a period that encompassed the mass stranding. The officially declared area where the sea trials had been carried out enclosed all the co-ordinates of the stranding points. The tests performed were for Low Frequency Active Sonar (LFAS), a system that introduces very high level of low and medium frequency sound into the marine environment to detect quiet diesel and nuclear submarines. Detailed information regarding the time schedule, the runs (Fig. 3) and the specific sound characteristics of the transmissions became unclassified and available through NATO-Saclantcent by the fall of 1998 (NATO-Saclantcen, 1998). The *Alliance* was using high power active sonar, transmitting simultaneously to both low (450-700 Hz) and medium (2.8-3.3 kHz) frequencies, at a maximum output of 228 dB re 1  $\mu$ Pa @ 1 m, which enables long detection ranges.



**Fig. 2.** Date of discovery, number of individuals, and carcass state for the Cuvier's beaked whales that stranded in the east Ionian Sea by the end of September - beginning of October 1997.



**Fig. 3.** Runs of the first and second day of the LFAS tests (12 and 13 May 1996) according to NATO-Saclantcen (1998). The black arrows indicate the stranding positions of the whales during the same days, plus the position of the whale found in Zakynthos Island

**DISCUSSION** Research on LFAS began by NATO in 1981 (NATO-Saclantcen, 1993) and a statement on its environmental impact was formally initiated in July 1996 by the US navy. The adverse effects of low and mid-frequency sound on whales were poorly studied (Richardson and Würsig, 1997) by the time the mass stranding occurred in Kyparissiakos Gulf. However, many specialists had warned that at high levels, as occurs with LFAS, they could be dramatic (see relevant discussions on LFAS in MARMAM list in 1996). Like all Ziphiids, the Cuvier's beaked whale is a deep-diving, pelagic cetacean that rarely mass-strands (Heyning, 1989). Only seven strandings of more than four individuals had been recorded from 1963 to 1996 worldwide - the individuals on these occasions numbering 5, 6, 6, 10, 12, 15 and 19 (Frantzis, 1998). On most of these clearly extremely rare occasions mass strandings showed atypical characteristics unlike those that occur with other whales. This suggests that the cause should have a large synchronous spatial extent and a sudden onset. Such characteristics are shown by sound in the ocean. Cetaceans, and particularly the deep-diving whales, were known to be especially affected by low and mid-frequency anthropogenic sound, even at quite low received levels (Watkins *et al.*, 1985; Finley *et al.*, 1990; Finley and Greene, 1993; Bowles *et al.*, 1994; Richardson and Würsig, 1997), and it is worth-noting that the first atypical mass stranding of ziphiids was recorded in 1963 (Tortonese, 1963), i.e. at the time that the use of a new generation of powerful mid-frequency tactical sonars became widely deployed (Balcomb and Claridge, 2001). In addition, the proximity of military manoeuvres had already been suspected of causing three previous atypical mass strandings of Cuvier's beaked whales, spread over wide areas of the Canary Islands (Vonk and Martin, 1989; Simmonds and Lopez-Jurado, 1991).

Although the available data in 1996 could not directly prove that the use of active sonars caused the mass stranding in Kyparissiakos Gulf, all evidence clearly pointed to the LFAS tests. The main arguments and the supporting evidence are listed below:

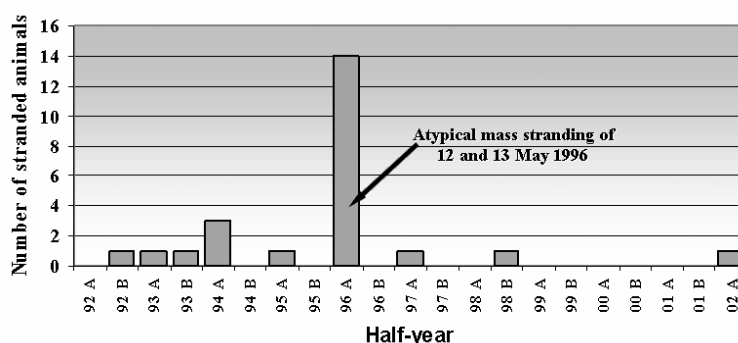
- At least 12 of the 14 animals stranded alive in a completely atypical way.
- The robust condition of the stranded animals plus the stomach content analyses were not consistent with pathogenic causes (which anyway are not known to provoke atypical mass strandings).
- No unusual environmental events occurred before or during the stranding (e.g. tectonic activity, magnetic anomalies, geophysical or geochemical events, meteorological events etc.).



- The stranding characteristics suggested a cause with large synchronous spatial extent and sudden onset (i.e. those shown by sound in the ocean).
- Loud, low and mid-frequency sound was already known to have an impact upon deep-diving cetaceans.
- And most importantly, the probability for the two events (i.e. the LFAS tests and the mass stranding) to coincide in time and location, while being independent, was extremely low. In other words if we consider the 16.5-year period before the mass stranding (1981 was chosen arbitrarily because this was the year that NATO started to experiment on LFAS, and we are sure that no mass stranding, nor other tests of LFAS had occurred in the area since that year), the probability of a mass stranding occurring for other reasons during the period of the LFAS tests (i.e. from the 12<sup>th</sup> to the 15<sup>th</sup> of May 1996 instead of any other day) is less than 0.07%

Today, after the repeated mass strandings that followed the Greek case with identical characteristics and always in close association with naval exercises and use of military active sonar in the Bahamas (Balcomb and Claridge, 2001), Madeira, and Canary Islands (see this volume), there is little doubt in the scientific community regarding the cause of the mass stranding in Kyparissiakos Gulf. If the precautionary principle had been applied shortly after the analysis of the data related to the Greek case, and active sonar tests had been stopped, the most recent mass strandings would have been avoided.

The Cuvier's beaked whale stranding history of Kyparissiakos Gulf (Fig. 4) shows that although no mass strandings had been recorded before 12 May 1996 the strandings of this species were not rare. The average stranding rate was 0.88 individual/half year (SD = 0.99,  $n = 8$ ). After the mass stranding of May 1996, the stranding rate was reduced to less than one third of what it was before the mass stranding (0.25 individual/half year, SD = 0.45,  $n = 12$ ). This is an alarming result, which is in accordance with what has been observed in the Bahamas after the multi-species mass stranding of March 2000: previously photoidentified and re-sighted beaked whales were not sighted again after the mass stranding (Balcomb and Claridge, 2001). These results indicate that the damage could be significantly higher than the death of the stranded whales. Many others may have left the area or may have died in the deep offshore waters.



**Fig. 4.** The stranding history of Kyparissiakos Gulf regarding Cuvier's beaked whales from 1992 to 2002

The present workshop, as well as the exponentially increasing number of studies regarding beaked whales indicate that there is a high interest of the scientific community regarding the serious problem of the use of high power active sonars in the oceans, and a lot of effort is dedicated in finding solutions. The recognition of the problem, which is now unanimous, is an important first step. The various interesting theories regarding the mechanisms through which sound sends the

animals ashore are also very useful in an effort to mitigate the problems. However this significant progress is not able to stop further loss of cetaceans and cetacean habitats, if not accompanied by the proper decisions. The scientific community does not need to witness further mass strandings linked to naval exercises in order to advance its knowledge. There are enough data to show that the most reasonable decision is to stop all dangerous, powerful sonar activities in the ocean. Cetologists prefer to have the opportunity to observe and study the beaked whales and all other cetacean species alive and free ranging in their habitats rather than lying dead on a beach.

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