

# Does acoustic testing strand whales?

Mass strandings of live whales have been explained by proposing many 'natural' or human-related causes<sup>1</sup>. I found that a recent stranding of Cuvier's beaked whale coincided closely in time and location with military tests of an acoustic system for submarine detection being carried out by the North Atlantic Treaty Organization (NATO).

Cuvier's beaked whale (*Ziphius cavirostris*) seems to be abundant in the East Ionian Sea (Mediterranean Sea), as indicated by strandings and sightings recorded there from 1992 to 1997. This species is a deep-diving, pelagic cetacean that rarely mass-strands<sup>2</sup>. Only seven strandings of more than four individuals have been recorded since 1963 worldwide, the individuals on these occasions numbering 5, 6, 6, 10, 12, 15 and 19 (refs 3–7). In the Kyparissiakos Gulf specifically, the average number of individual whales stranded every half-year is 0.7 (s.d. = 0.9,  $n = 11$ ), with the exception of a mass stranding that occurred on 12–13 May 1996 (Fig. 1).

From the morning of 12 May until the afternoon of 13 May, we recorded 12 Cuvier's beaked whales stranded alive along the coasts of the Kyparissiakos Gulf. The whales were spread along 38.2 kilometres of coast and were separated by a mean distance of 3.5 km (s.d. = 2.8,  $n = 11$ ). This spread in time and location was atypical, as whales usually mass-strand at the same place and at the same time. 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.

Necropsies of eight stranded animals were carried out, but no apparent abnormalities or wounds were found. Many of the stomach contents that were collected contained cephalopod flesh, indicating that recent feeding had taken place.

After looking for possible causes of the mass stranding, we discovered that 'sound-detecting system trials' had been performed

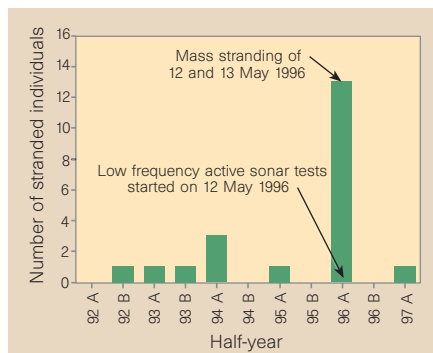


Figure 1 Cuvier's beaked whale strandings in the Kyparissiakos Gulf, 1992–97.

by the NATO research vessel *Alliance* from 24:00 11 May to 24:00 15 May (Warning to mariners 586 of 1996, Hellenic Navy Hydrographic Service) — a period that encompassed the mass stranding. Also, the officially declared area where the sea trials had been carried out enclosed all the coordinates of the stranding points.

The tests that RV *Alliance* performed were for Low Frequency Active Sonar (LFAS), a system for the detection of quiet diesel and nuclear submarines. This system generates extremely loud low-frequency sound (maximum output of  $\geq 230$  decibels as 1 micropascal broadband waveforms centred at frequencies that range from 250 to 3,000 hertz), which enables long detection ranges<sup>8,9</sup>.

Research on LFAS began in 1981 and a statement on its environmental impact was formally initiated in July 1996 by the US navy. The adverse effects of low-frequency sound on whales are poorly studied<sup>10</sup>, but many specialists warn that at high levels, as occurs with LFAS, they could be dramatic.

The proximity of military manoeuvres has been suspected of causing three previous atypical mass strandings of Cuvier's beaked whales, spread over wide areas of the Canary Islands<sup>6,11</sup>. On most of the extremely rare occasions that mass strandings are seen in

this species, they show characteristics unlike those that occur with other whales. This suggests that the cause has a large synchronous spatial extent and a sudden onset. Such characteristics are shown by sound in the ocean. Also, deep-diving whales seem to be especially affected by low-frequency sounds, even at quite low received levels<sup>12,13</sup>.

We know that LFAS was used in the Kyparissiakos Gulf. We also know that no other LFAS tests or mass strandings have occurred in the Greek Ionian Sea since 1981. Taking the past 16.5-year period into account, the probability of a mass stranding occurring for other reasons during the period of the LFAS tests is less than 0.07%.

Although pure coincidence cannot be excluded, it seems improbable that the two events were independent. Little is known about whales' reactions to LFAS; to obtain definitive answers, more information needs to be gathered. But unfortunately, most of the data about the use of LFAS are subject to military secrecy.

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## Electron pairs shed light on frustrated percolation

Cahn, in his News and Views article<sup>1</sup>, wondered why an arsenic–boron pair is best suited to 'stuff' a double vacancy in the crystal lattice in preference to a pair of boron atoms or arsenic atoms. The answer can be found if to describe bonding Linnett's model<sup>2</sup> for the covalent chemical bond is used. This is a generalization of the electron-pair idea which incorporates the Pauli and

Ruedenberg principles and accounts well for molecular structures without resonance or configuration interaction.

Homogeneous dimers of either boron (B) or arsenic (As) in a brass matrix should not be more stable than monomers or homogeneous polymers, and their concentration should be low. Such polymers exist only in the less electronegative metals, so are not expected in zinc, copper or brass.

On the other hand, once boron arsenide (BAs) is formed in a metal, it is unlikely to grow by trapping free B and As atoms alternately — a concept that can be derived from

its Linnett configuration. This way of describing compounds shows that the BAs molecule has three bonds, a pair of non-bonding electrons on the As and an empty site on the B atom. Therefore the molecule still has room to accept charge from the metal matrix. A more complete electron occupation then impedes further growth of the dimer. B and As oligomers exist in metal matrices but the BAs network does not — it exists only in the free cubic BAs solid. The BAs molecule should be stable in a metal matrix and it fits into the zinc double vacancy (divacancy) which has the right size.