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Are solar activity and sperm whale *Physeter macrocephalus* strandings around the North Sea related?

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Abstract

In the final decades of the last century, an increasing number of strandings of male sperm whales (*Physeter macrocephalus*) around the North Sea led to an increase in public interest. Anthropogenic influences (such as contaminants or intensive sound disturbances) are supposed to be the main causes, but natural environmental effects may also explain the disorientation of the animals. We compared the documented sperm whale strandings in the period from 1712 to 2003 with solar activity, especially with sun spot number periodicity and found that 90% of 97 sperm whale stranding events around the North Sea took place when the smoothed sun spot period length was below the mean value of 11 years, while only 10% happened during periods of longer sun spot cycles. The relation becomes even more pronounced (94% to 6%, n = 70) if a smaller time window from November to March is used (which seems to be the main southward migration period of male sperm whales). Adequate chi-square tests of the data give a significance of 1% error probability that sperm whale strandings can depend on solar activity. As an alternative explanation, we suggest that variations of the earth's magnetic field, due to variable energy fluxes from the sun to the earth, may cause a temporary disorientation of migrating animals.

Keywords: Sperm whale strandings; North Sea; Solar cycles; Sun spots; Geomagnetic storms

1. Introduction

Sperm whale beachings are spectacular happenings of great human interest and so for centuries have been comparably well documented. The high number of reported strandings around the North Sea seems to indicate, especially for male sperm whales, that the frequency of such events increased towards the end of the last century. Anthropogenic encroachments such as contaminants or intensive sound disturbances which disturb the natural behaviour of cetaceans have been considered to be a cause (e.g. Simmonds, 1997; Goold et al., 2002), while other authors, for instance Smeenk (1997), have discussed the fact that the increasing number of sperm whales after the massive

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reduction of hunting in the last century may have resulted in a rising number of strandings. The most recent and detailed overview of possible causes of beaching is given by Goold et al. (2002).

In contrast to the still open question of why sperm whales strand, it is well known that they undertake long and well-directed journeys through the oceans. They seem to have a kind of 'global positioning system' that allows them to find the right and best way through their habitat. On their migration some animals, birds for example, get their bearings from the earth's magnetic field (Phillips, 1996; Kirschvink, 1997; Lohmann and Johnsen, 2000; Walker et al., 2002; Fischer et al., 2003) and it is conceivable that some whales, such as sperm whales, do the same. The magnetic field is available anytime and almost everywhere on the earth's surface, and the animals may take advantage of the global characteristics of the earth's magnetic field as well as of existing local anomalies related to the geological structure of the ocean floor (Klinowska, 1988; Walker et al., 1992).

It is known that solar radiation with its changing flux of ionised particles can temporarily interfere with the earth's magnetic field particularly in geomagnetic storms (Silbergleit, 1999; Burch, 2001). If sperm whales do use the earth's magnetic field for navigation purposes, it seems possible that such interference can lead to their disorientation (Phillips, 1996; Walker et al., 2002).

The energy flux of the sun is not constant and shows periodic variations (Hoyt and Schatten, 1997). One of the best-known cyclicities of the sun's energy flux is related to the number of sun spots. The cycle length of sun spot activity is around 11 years (Burroughs, 1992; Hoyt and Schatten, 1997; Berner and Hiete, 2000). This averaged period is based on observations over three centuries; the single periods vary from 8 to 17 years (Hoyt and Schatten, 1997). The energy radiated by the sun is approximately inversely proportional to the period length of sun spot activity. Short cycles imply intervals of high energy radiation and longer solar cycles have periods of lower energy flux. An illustration of this possible relation is given by Berner and Hiete (2000, e.g. their Fig. 2.8). A phase of low radiation from 1780 to 1910 correlates well with a period in which very few sperm whale strandings were documented (Smeenk, 1997). This observation leads to the question of whether sperm whale beachings around the North Sea can be correlated with sun spot activity and its effects on the earth's magnetic field. In this study we analyse to what extent strandings are related to solar activity and attempt to find alternative explanations for strandings.

2. Material and methods

The frequency of strandings of sperm whales (*Physeter macrocephalus*) around the North Sea was taken from Smeenk (1997, 1999, 2004 unpubl. data) and one report on a sperm whale beaching in 1848 on the island of Borkum (Germany) was added.

In general, we distinguish between "strandings" and "stranding events" around the North Sea. While the first term takes into account the number of beached individuals, the latter does not. Since sightings happen mostly during phases with many strandings, both values are highly correlated. So an additional consideration of the limited number of sperm whale sightings (e.g. Smeenk, 1997, 1999, 2004 unpubl. data) leads to no substantial improvement of the database.

Since the coasts of the North Sea have always been relatively densely populated, there is a good prospect that local people will have detected a high number of stranding events of these huge animals (Evans, 1997). The countries around the North Sea have a long tradition of records in written documentation of events of public interest, and we think that this very large dataset is good enough to be taken into account, although Smeenk (1997, 1999) rightly stresses that the past is decidedly underreported as compared to the present.

The cycles in sun spot activity are derived from the number of sun spots. These have been listed since 1712 (after the Maunder Minimum with nearly no sun spot activity) as shown in Fig. 1. At least over these three centuries the number of sun spots varies periodically with a mean cycle length of around 11 years. This solar cycle is called the 'Schwabe cycle' (Hoyt and Schatten, 1997) but for reasons of simplicity we shall call it the 'solar cycle'. The data used in this study are taken from the Internet page ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/maxmin, also described by NASA (2000) and for the last cycles from Thejll's Internet page