A long-term cetacean sighting data set from whale watching operations as a reflection of the environmental dynamics in a multi-species cetacean habitat[1]

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ABSTRACT

Through a co-operation between the NGO MEER and local whale watching operators on the island of La Gomera (Canary Islands, Spain) a long-term sighting data scheme was initiated in 1995 which lasts until today. During 15 years (from September 1995 until October 2010) a total of more than 6,000 sightings of up to 23 cetacean species have been documented at low cost in a pioneering way, establishing previously unknown detailed knowledge about the local cetacean fauna. As of today, this collection represents one of the few data sets where cetacean abundance and distribution has been monitored throughout the year for almost one and a half decades. Here, we describe inter-annual changeability and long-term trends of abundance in several species inhabiting the same general area. Long-term trends in abundance were found, with some species showing significantly declining sighting numbers. Because cetaceans are known to react with great flexibility to changes in their habitat, these findings reflect the dynamic nature of the environment itself, but they also could be related to climate change effects. Cetaceans can thus function as indicators for environmental changes. The relation between cetacean abundance and the ecological conditions of the sea around them is laid out.

KEYWORDS : LONG TERM DATA, CETACEANS, ABUNDANCE, INTER-ANNUAL VARIABILITY, ENVIRONMENTAL DYNAMICS, CLIMATE CHANGE, LA GOMERA

INTRODUCTION

Off La Gomera (Canary Islands, Spain), 23 cetacean species have been documented. Through a co-operation between the NGO MEER and local whale watching operators on the island, a long-term sighting data scheme was initiated in 1995 which lasts until today. The majority of whale watching vessels operating from Valle Gran Rey in the South West of the island have been involved in cetacean sighting data collection in coastal and pelagic habitats. As of today, this collection represents one of the few data sets where cetacean abundance and distribution has been monitored throughout the year for almost one and a half decades.

Here, we describe inter-annual changeability and long-term trends of abundance in several species inhabiting the same general area: bottlenose dolphins (*Tursiops truncatus*), short-finned pilot whales (*Globicephala macrorhynchus*), Atlantic spotted dolphins (*Stenella frontalis*), rough-toothed dolphins (*Steno bredanensis*), short-beaked common dolphin (*Delphinus delphis*), as well as beaked whales (dense beaked whales *Mesoplodon densirostris* and Cuvier's beaked whales *Ziphius cavirostris*) and baleen whales (comprising mainly Bryde's and sei whales, but also other *balaenopterids*). All five delphinid species are resident off La Gomera, or form part of larger populations inhabiting the Canary Islands archipelago.

METHODS

La Gomera (17°15'W-17°21'W and 28°1'N-28°14'N) lies about 400 kilometres off the West African mainland in the Northeast Atlantic Ocean. The island is surrounded by deep waters of more than 2,000 metres relatively close to the coast.

Data on cetacean abundance was collected year-round from whale watching vessels operating in the South and South West of the island from September 1995 until October 2010 (with few breaks in-between). Whale watching trips usually took place once or twice a day according to sea state and tourist demand. Data collection also included date, time, and geographical position.

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In order to compare the frequencies of sightings of different species over time we counted sightings year wise. To account for different sighting effort over time, we estimated the number of sightings for a maximum sighting effort of 12h/d. Years where average sighting effort differed markedly from average were discarded not to produce misrepresentative results. Statistic software PASW 18 was used to calculate a Jonckheere-Terpstra-Test to analyse trends in frequencies of sightings over the 12 years of observation for each species. For the tests a level of significance of 5% was determined.

RESULTS

A total of 5,712 sightings were made: 1,756 with bottlenose dolphins, 1,377 with short-finned pilot whales, 1,258 with Atlantic spotted dolphins, 596 with rough-toothed dolphins and 259 with common dolphins. 116 sightings were made with beaked whales and 361 times baleen whales were seen.

Except for the beaked whales, the total number of sightings differed substantially from year to year for each of the species (see Figure 1). For two species a statistically significant long-term trend was detected: common and rough-toothed dolphins showed a decrease in sighting numbers over the investigation period (see Table 1 & Figure 2a,b). Bottlenose dolphins showed a conspicuous break in abundance after 2002 and a slow increase hereafter (see Figure 2c). Contrastingly, the number of sightings of pilot whales increased markedly, especially in the period from 2002 until today (see Figure 2d). Although not statistically significant, numbers for bottlenose dolphins and pilot whales resulted in very low p-values (see Table 1). Atlantic spotted dolphin sighting numbers varied strongly but did not show an overall trend (see Figure 2e). Baleen whale sighting numbers were especially high during distinct years while for others they remained generally low (see Figure 2f). Figure 1 summarised sighting numbers for all species.

DISCUSSION

Cetacean distribution is related to the characteristics of a species' habitat. In many populations, a relationship between cetacean abundance and physical (e.g. depth, distance to coast and sea bottom slope, see Baird *et al.*, 2003; Cañadas *et al.*, 2002; Ingram & Rogan, 2002; Smit *et al.*, 2010), environmental/ oceanographic (e.g. sea surface temperature, Balance *et al.*, 2006; de Stephanis *et al.*, 2008; Strüh, 2008) or biological characteristics (e.g. primary productivity/chlorophyll contents and prey abundance, see Bluhm, 2007; Jaquet *et al.*, 1995; Laidre *et al.*, 2010; Moore, 2002) has been found.

Different species use the same habitat differently, e.g. by separating abundance on a fine spatial scale, the pursuit of different prey organisms and/or hunting at different times of day (Bearzi, 2005; Smit *et al.*, 2010). While the physical character of the habitat off La Gomera does not change, environmental and oceanographic variables – which act as determining factors e.g. for prey abundance – may be highly unpredictable over periods of months or years. As a consequence, inter-annual changes in environmental conditions will influence habitat partitioning and thus also contribute to changing numbers of cetacean sightings. Yet again, the driving force for the variation will be the underlying environmental dynamics (see Doksætera *et al.*, 2008; Stevick *et al.*, 2008), which have been well documented for the Canary Islands (Aristegui *et al.*, 1997; Neuer *et al.*, 1997; van Camp *et al.*, 1991). We conclude that the variation in cetacean abundance off La Gomera reflects such changes in suitability of the environment for each of the species.

To summarize, the results presented here suggest that cetaceans adapt their movements (i.e. their abundance) according to environmental and ecological conditions given in any one year. However, these changes will only be possible within the range of a species' general habitat requirements and in accordance to its flexibility to react to environmental variability. Habitat partitioning in a multi-species habitat thus may be a sensitive equilibrium, where over the long term some populations will be “winners” while others become “losers”. The detected long-term trends point to significant changes over the past years, which might be indicative of such winners and losers. We suspect that these changes are related to climate change effects such as rising sea surface temperatures and their consequences for overall habitat quality and suitability. Hence, cetaceans can function as indicators for environmental variability, and the potential long-term changes in environmental variables and their relation to cetacean abundance will be subject to future investigations.

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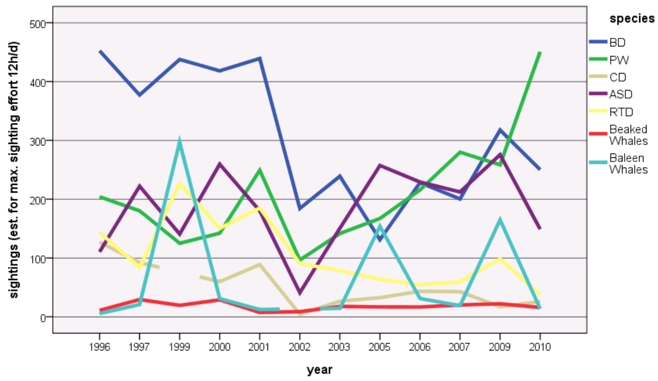
Table 1: Long-term trends in abundance of different cetaceans off La Gomera: p-values.

Jonckheere-Terpstra-Test

Bottlenose dolphin (BD)	N	12
	Sign. / p-value	,075
Pilot whale (PW)	N	12
	Sign. / p-value	,055
Common dolphin (CD)	N	11
	Sign. / p-value	,024
Atl. spotted dolphin (ASD)	N	12
	Sign. / p-value	,337
Rough-toothed dolphin (RTD)	N	12
	Sign. / p-value	,014
Beaked whales	N	12
	Sign. / p-value	,891
Baleen whales	N	11
	Sign. / p-value	,586

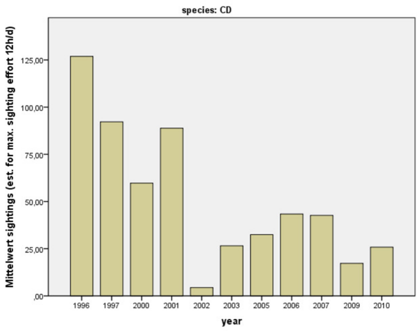
Figure 1*: Number of cetacean sightings off La Gomera (1996-2010)



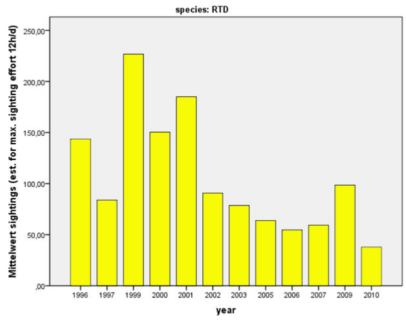
Abbreviations of species names according to Table 1.

Figure 2*: Number of cetacean sightings off La Gomera per species/species group (1996-2010)

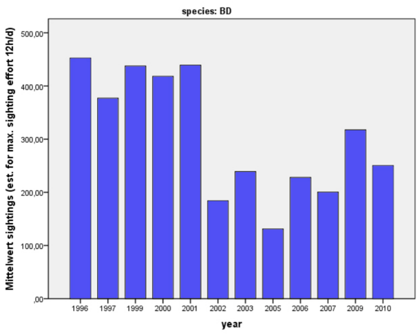
2a Common dolphin (*Delphinus delphis*)



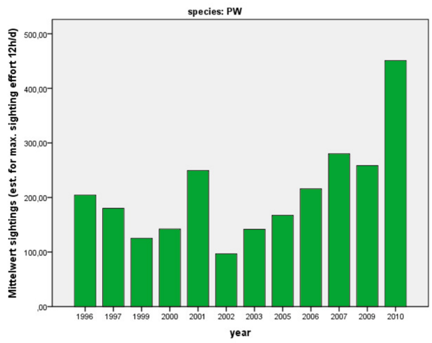
2b Rough-toothed dolphin (*Steno bredanensis*)



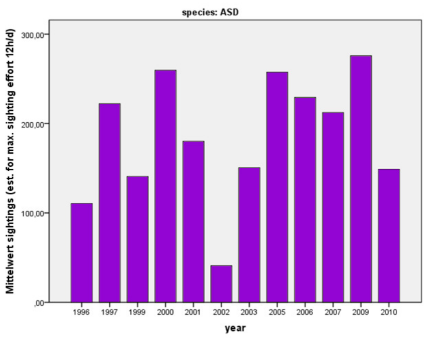
2c Bottlenose dolphin (*Tursiops truncatus*)



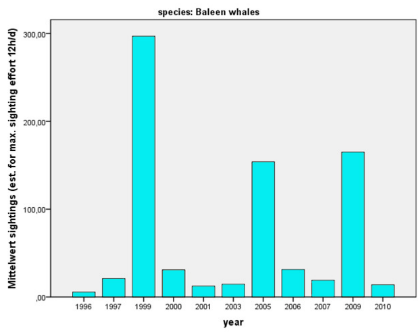
2d Short-finned pilot whale (*Gl. macrorhynchus*)



2e Atlantic spotted dolphin (*Stenella frontalis*)



2f Baleen whales (*Balaenoptera sp.*)



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