

A NEW BREEDING GROUND? THE SPATIO-TEMPORAL DISTRIBUTION AND BATHYMETRIC PREFERENCES OF SPERM WHALES (*PHYSETER MACROCEPHALUS*) IN THE BAY OF BISCAY

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INTRODUCTION

Little is known about the abundance and distribution of sperm whales in north-east Atlantic waters. The species is thought to occur in small numbers throughout the deep offshore waters of this area, including the Bay of Biscay (Evans 1997). The social organisation of sperm whales is thought to be highly complex with a matrilineal structure. Several group types have been described, and are largely based on studies from sub-tropical (Best 1979; Best *et al.* 1984) and tropical waters (Christal & Whitehead 2001). Group types include those of females and calves, females and calves with mature males, 'bachelor' groups of immature males, juveniles of either sex and single mature males. The traditional model is that of sexual segregation by latitude/temperature with groups of females occupying warmer sub-tropical or tropical waters and males moving into cooler waters before returning to breed seasonally when sexually mature. Sperm whale social interactions have not been studied in the North Atlantic in any detail. Females and calves do not typically occur above 40-45°N, with females known to occur north to the subpolar convergence, 45-50°N (Rice 1989). Calves have occasionally been recorded above 45°N in the North Atlantic (Fraser 1974; Berrow *et al.* 1993; NASS 1989) but appear to be rare.

METHODS

Effort and sightings data was collected from single line transect shipboard surveys, onboard a passenger ferry, the P&O *Pride of Bilbao*. Surveys were undertaken year-round between August 1995 and December 2006. The vessel sails from Portsmouth (England) to Bilbao (Spain) through the western English Channel and Bay of Biscay (see Figure 1.) Two kinds of survey were employed to collect data; dedicated and non-dedicated. The former involved 3-4 observers on monthly surveys and the latter involved (usually) a single observer collecting opportunistic data. Both methods used the same standardised vessel based effort and sightings proforma and only data collected in sea states of three or less were used in analysis. In addition, three physiographic variables were used to explain the bathymetric preferences of sperm whales in the study area; depth, slope (degrees) and aspect. Water depth was extracted from a digital bathymetric set compiled from the GEBCO digital atlas (GDA) Centenary Edition (2003). Data was

imported into *ArcView* 3.3 (AV3, ESRI Systems 1992) and *ArcGIS* 8.0 (AG8, ESRI Systems 1999) software for processing and interpolated into a grid of 1 km x1 km for analysis. Slope and aspect were calculated for each raster cell using the Slope and Aspect commands in Spatial Analyst (AV3).

For the data analysis, a Generalised Additive Model (GAM) with a quasi-binomial distribution was used to describe the relationship between sightings and variables. The variables were depth, slope, latitude (as proxy for SST), standard deviation of slope and aspect (as a factor). The Akaike Information Criterion (AIC) was used to select the best fit model. Two statistical tests were used; Kruskal-Wallis, to test habitat preferences and group sizes against years and seasons, and Mann-Whitney to test habitat preferences, group size and seasonality for groups with calves against those without. Seasons were split into, winter (December – February), spring (March – May), summer (June – August) and autumn (September – November).

RESULTS

Effort and sightings

During the period August 1995 and December 2006 over 170,000 km was surveyed at a mean speed of 30km/h. There was significant variation in daylight hours which led to uneven sampling of habitats. During March - October, the entire length of the route was sampled at least once on most surveys, with some overlap during May - July. During November - February, approximately 75% of the route was sampled (Figure 1). Non-dedicated surveys typically concentrated effort in the areas with the highest cetacean relative abundance, which introduced a bias in the sampling strategy. A total of 203 sightings of ca. 400 sperm whales were recorded. Group size varied between 1-18 animals (median = 1). Animals were recorded in all months except December and January but primarily between April and October, with peak in July-September (n=122, Table 1). Six sightings of calves, totalling seven animals,

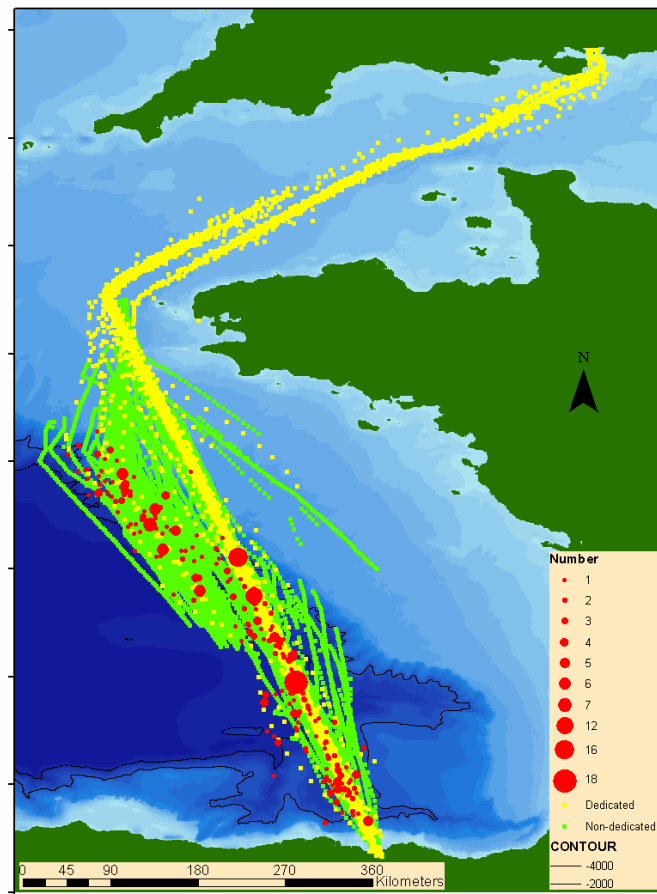


Figure1: Map of study area showing map of effort points from both dedicated and non-dedicated survey and group size recorded from sperm whale sightings.

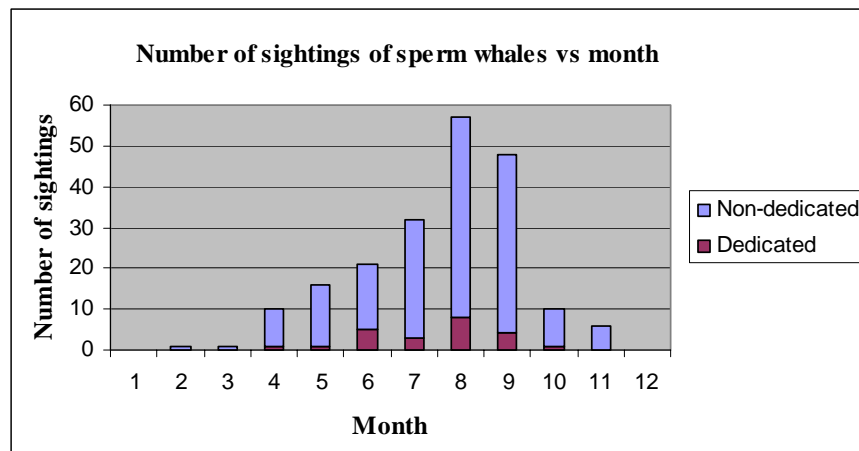
Six sightings of calves, totalling seven animals,

were recorded (Figure 2). Calves were recorded between April-August and, notably, only in recent years (2003-2006).



Figure 2: sperm whale with calf at 44.728°N, -3.714°E (Bay of Biscay), 13th April 2005.

Table 1: sperm whale sightings against month



Habitat preferences

Two different models were used to examine sperm whale habitat preferences. The first quantified the most significant predictor variables for sperm whale occurrence (presence/absence) and the second for sperm whale relative abundance (group size). For the former, the best fit model, i.e. the one with the lowest AIC value included depth, aspect and latitude. Of these depth ($p < 0.001$) and aspect were significant. The likelihood of occurrence increases until water depths of around 2,500m and then remains high. Occurrence was significantly higher ($p = 0.02$) for NW facing slopes than slopes that face in other directions. However, the deviance explained by the predictor variables was only 8% implying that other variables are also important for explaining sperm whale distribution. For the latter model, the best fit model included only latitude and depth. Of these only depth was significant ($p = 0.004$). Relative abundance is greatest at water depths around 2,500m. However, the deviance explained was only ~5%, so again other variables are probably important in explaining sperm whale distribution.

When the two models were compared (Figure 3) it is clear that while relative abundance drops off in waters deeper than about 2,500m, occurrence (presence absence) does not, suggesting that group size gets smaller as water depth gets deeper in waters greater than 2,500m. This result may indicate that larger groups of sperm whales occupy different depths of water than smaller groups.

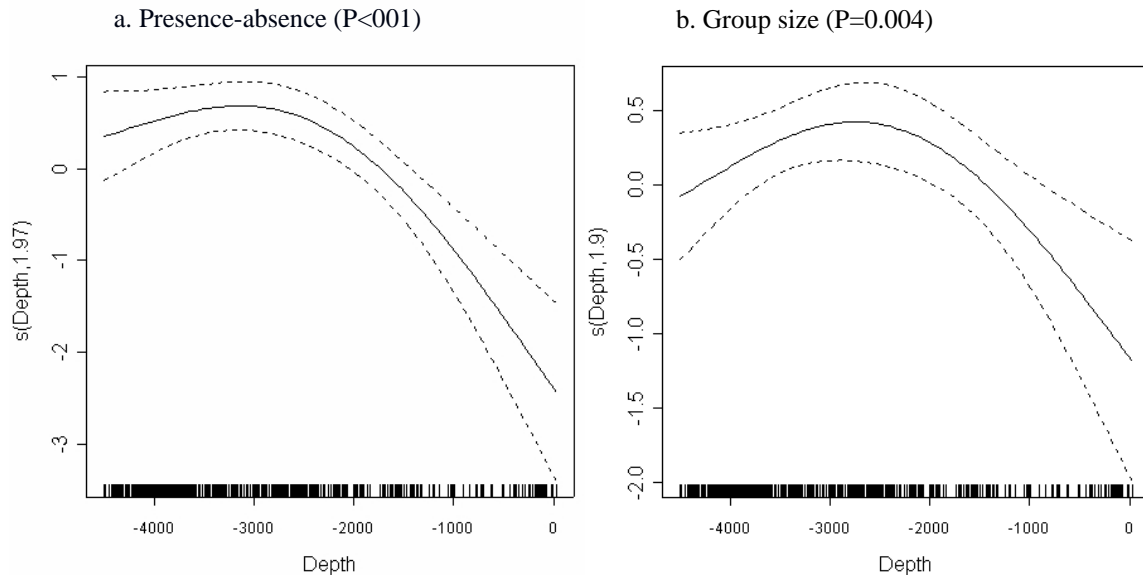


Figure 3: Comparison of depth preferences from GAM models using presence-absence data and relative abundance data.

The results of Kruskal-Wallis tests showed no significant differences between habitat preferences and group sizes across years but there was a significant difference in depth preferences between seasons, with whales preferring shallower waters in the autumn (spring = 3590m, summer = 3577m, autumn = 2774m, $H = 12.09$, $DF = 3$, $P = 0.007$). Also The group size of adults in association with calves (median = 3) was significantly higher than those without (median = 1, $W = 960$, $p = 0.01$). In addition, groups with calves were found earlier in the season (median = spring, $P = 0.004$) than groups without calves (median = summer).

DISCUSSION

The deep water areas of the Bay of Biscay seem to provide an important habitat for sperm whales. In the study area, sperm whales prefer very deep waters with most sightings recorded in water depths greater than 2000m ($n=155$, $mean=3087m$). The distribution of sperm whales is centered upon the lower northern Celtic-Biscay shelf-break, the edge of the Biscay abyssal plain and the Santander canyon, near Bilbao.

The existence of breeding population of sperm whales in the Bay of Biscay was previously unknown but there is now strong evidence that the area may be a breeding ground/nursery area. It is also likely that the areas support a complex temperate

population which may include a range of different group types, including groups of females and calves, 'bachelor' groups and mature males. Although length data is not available to support this hypothesis the latter two group types are known to occur at these latitudes. It is also possible and supported to some degree by the results presented here, that habitat partitioning occurs between nursery groups (with calves) and groups of males with larger groups apparently occupying shallower waters. Habitat partitioning between females and males has been shown to occur in other temperate waters (Gregr *et al.* 2000). It is currently not clear if a breeding population has been present for some time in the Bay of Biscay or whether this is a recent trend. Although sea surface temperature (SST) has not been considered in this analysis, future work should consider whether rising SST may contribute to the occurrence of female/calf groups at the northern limits of their distributional range.

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