Stranding patterns of harbour porpoises (*Phocoena phocoena*) in the German North and Baltic Seas: when does the birth period occur?

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ABSTRACT

Stranded harbour porpoises were analysed to investigate differences in stranding patterns along the North and Baltic Sea coasts of Schleswig-Holstein, Germany. A total of 1,015 stranded or bycaught harbour porpoises were recorded between 1990-2000. Most of the stranded animals were found during the summer months: in the North Sea, the peak occurred in the months of June and July, whereas in the Baltic most of the porpoises were found in July and August. Strandings of mature females (>3.9 years) and young animals (<1 year) were positively correlated during the summer months. No significant correlation between mature males and young porpoises nor between mature males and females was observed. By using a non-parametric procedure, a birth period for the North Sea population between 6 June and 16 July was calculated, with 27 June as the mean date of birth. In the Kiel Bight population, births were assumed to take place one month later than in the North Sea.

KEYWORDS: HARBOUR PORPOISE; STRANDINGS; REPRODUCTION; EUROPE; INCIDENTAL CATCHES; PARTURITION; AGE AT SEXUAL MATURITY

INTRODUCTION

The harbour porpoise (*Phocoena phocoena*) is the cetacean found stranded most on German coasts as well as those of England, The Netherlands and Denmark (Kinze, 1990b; Hammond *et al.*, 1995; Benke *et al.*, 1998; Addink and Smeenk, 1999). Sometimes called the common porpoise, it is a small cetacean species inhabiting coastal waters of the Northern Hemisphere (Nowak, 1991; Jefferson *et al.*, 1993).

In the 1995 review of North Atlantic harbour porpoises (Donovan and Bjørge, 1995) by the IWC Scientific Committee, in the absence of firm biological data the boundaries of the North and Baltic Seas were defined by geographical divisions. In the Baltic Sea, the Darss and the Limhamn underwater ridges were defined as the boundaries between the Baltic and the inner Danish and German waters. The North Sea coasts of Denmark, Germany and The Netherlands were divided into three ‘stock’ areas derived largely from the 1994 SCANS (Small Cetacean Abundance in the North Sea) surveys (Hammond *et al.*, 1995). In the German North Sea and Western Baltic waters, a further sub-division into local populations has been suggested by Tiedemann *et al.* (1996), who carried out DNA analysis of porpoises from the coasts of Schleswig-Holstein. They found that the Baltic Sea was inhabited by harbour porpoises several thousand years ago and that genetic exchange has been very limited between the two Seas. Thus, the animals of the North and Baltic Seas of Schleswig-Holstein can be considered as two different sub-populations.

The life history and reproductive cycle of harbour porpoises is relatively poorly understood. Generally, only rough estimates have been made to determine a birth (calving) period for harbour porpoises in the North (June-August) and Baltic (July/August) Seas (Fisher and Harrison, 1970; Kinze, 1990b; Lockyer, 1999; Lockyer and Kinze, 1999), although see Sørensen and Kinze (1994). In the present paper, German strandings data collected over 11 years have been analysed to investigate whether distinct stranding patterns exist and whether it is possible to calculate the birth periods of the local harbour porpoise populations in the North and Baltic Seas.

METHODS

In the North Sea, the sampling area included the mainland coast from the Danish border down to the Elbe River estuary, as well as all the islands in the Wadden Sea of Schleswig-Holstein. The area of the Baltic Sea referred to in this paper includes the mainland coast from the Danish border in the north down to Mecklenburg-Western Pomerania, as well as the island of Fehmarn (Fig. 1).

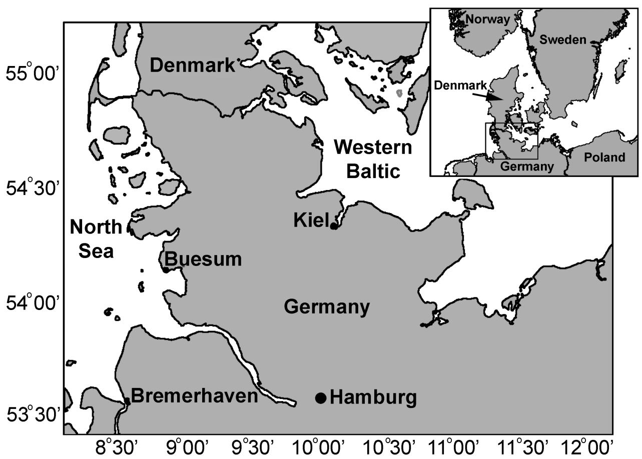

Fig. 1. Map of the study area: Federal State of Schleswig-Holstein, Germany.

Since 1990, the Federal State of Schleswig-Holstein and the Federal Ministries of Environment, Research and Technology, Germany, have financed a strandings network

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in order to perform research on stranded cetaceans along the coasts of the North and Baltic Seas. In addition to opportunistic reports, seal hunters, rangers and employees of environmental conservation authorities have patrolled the beaches and sandbanks regularly throughout the year since the last seal epidemic, to either take in the stranded animals or to give notice about a live stranding. Therefore, relatively constant observer effort can be assumed.

This paper considers data from 1990-2000, during which time 1,015 porpoises were recorded as either stranded or bycaught. In total, 106 bycatches were recorded, 20 caught in the North Sea and 86 in the Baltic. Some of the Baltic bycatches were reported directly by fishermen and some from post-mortem examination. For the North Sea, bycatches were only identified during dissection. Animals were classified by decomposition state and a total of 282 animals (147 >1 year and 135 <1 year) considered in states of either advanced decomposition or mummification, or of unknown state, were discarded from this study. An exception was made for animals >2 years where sex and the approximate age could be determined. Two females of unknown origin were also not included.

Before dissection, most animals were temporarily stored in a container at −20°C. Dissections were performed according to the procedures described in Siebert *et al.* (2001). From 1990-1993, age determination was performed by H. Kremer (Kremer, 1987). From 1994, age was determined by C. Lockyer by examining the zonation and Growth Layer Groups (GLGs) of the teeth as described in Lockyer (1995). Only a limited number of animals were aged for the period 1999-2000 and these years have thus been excluded from the study.

Four age categories of harbour porpoises were distinguished:

(1) Neonates: based on the lengths of the largest foetus (81.5cm) and smallest born animal (64.5cm). All porpoises between these values were considered neonates.
(2) Calves: animals which were calculated to be younger than 1 year and larger than 85cm.
(3) Juveniles: animals which were older than 1 year but not yet mature.
(4) Sexually mature: animals older than 3.9 years.

Bandomir *et al.* (1998) reported that in the German North Sea, female porpoises become sexually mature at a mean age of 4.58 years and males between 2 and 5 years. For Danish waters, Sørensen and Kinze (1994) reported average ages of sexual maturity for females to be 3.64 years and for males 2.93 years. It is not appropriate to review the nature of those studies here but for the purposes of the present paper, sexual maturity has been assumed to be four years.

The data were analysed to determine whether there was any significant difference between the numbers of strandings of male and female harbour porpoises and to investigate potential correlations between the numbers of stranded animals <1 year old and sexually mature females and males.

From the dates the animals were located (not necessarily the date of death) and lengths of stranded harbour porpoises <1 year from the North Sea, a non-parametric approach was used to estimate the birth period. Neonates from the North Sea population were classified into 1cm length categories, ranging from 65-85cm. The 'mean' date of birth around which to estimate the birth period was taken as the most frequent median date for each (cumulative) length class (e.g. see Table 1).

In order to estimate the birth period, a number of assumptions are made: (1) it follows a normal distribution; (2) neonates are found shortly after birth; (3) the sample of stranded/bycaught animals is representative of the whole population.

Given these assumptions, the complete sample (260 neonates and calves) was compared with the 'mean' date of birth (animals found on the 'mean' date were divided equally amongst those found before and after the 'mean' date) to estimate an approximate mean deviation. This value was used to estimate the standard deviation (SD) of the birth dates; 95.4% of the values of a normally distributed variable lie within ±2SD of the mean (e.g. Lorentz, 1996). Sample size considerations (only 33 calves) precluded use of this method for the Baltic Sea.

A Pearson-Correlation-Matrix (see Zar, 1999) was used to examine whether a correlation between the number of sexually mature females or males (≥4 years; Bandomir *et al.*, 1998) and young animals (<1 year) exists during the summer months (June, July, August). Due to lack of data from the Baltic Sea and from the years 1999 and 2000 for both areas, only the North Sea data for the period 1990-1998 were examined.

RESULTS

The annual number of harbour porpoises found along the North and Baltic Seas of Schleswig-Holstein was about 100 with considerable annual variation (mean=98.5; SD=24). The numbers show no trend with time over the study period (Fig. 2), for the North Sea (r_s=0.326, p=0.301) or for the Western Baltic (r_s=0.380, p=0.224; Spearman rank correlation). There was also no significant difference in the sexes of the stranded animals (t=-0.474, p=0.645 for the North Sea; t=-0.080, p=0.938 for the Baltic; t-test for paired samples).

Although porpoises are found stranded year-round, most animals are found during the summer months. In the North Sea, the highest numbers are found in June, July and August

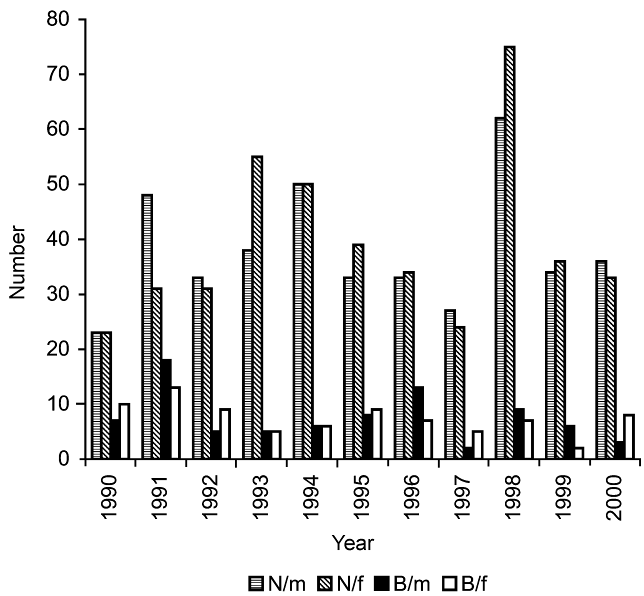

Fig. 2. Stranded and bycaught harbour porpoises along the coasts of the North (N) and Baltic (B) Seas of Schleswig-Holstein differentiated by sea and sex (1990-2000; m = male, f = female).

(Fig. 3), whereas in the Baltic the peak is about 1 month later, i.e. July, August and September (Fig. 4). In June and July, the strandings were dominated by young harbour porpoises (<1 year) in the North Sea (Fig. 3); in the Baltic most of the young animals were found in August (Fig. 4).

Table 1 shows the length classes for North Sea animals <1 year, the cumulative numbers and the median 'finding' date. As one might expect, as the length of animals increased, the median date generally became later. However, for the 70 neonates found in the length classes from 72-78cm, the median date was the same, 27 June (Fig. 5). The 'mean' date of birth for North Sea animals was thus assumed to be 27 June. The SD of the birth dates was about 40 days (or 5.7 weeks) around 27 June. Thus from our data, it is estimated that 95.4% of the births in the North Sea occur between 6 June and 16 July.

Using the data in Table 2 the Pearson-Correlation analysis (Table 3) revealed a significant correlation between the strandings of sexually mature females and animals <1 year (r=0.686) in the summer months (June, July, August in the North Sea). However, there was no correlation between males and young animals (r=0.145), or between adult males and females (r=0.238). Mature males stranded along the North Sea coast show a slight peak in August but are in general equally distributed over the year. Mature females however display a distinct peak in the summer months.

DISCUSSION

There are a number of possible explanations for the varying annual numbers of harbour porpoises found from 1990 to 2000 (Fig. 2) given the relatively constant effort. As is

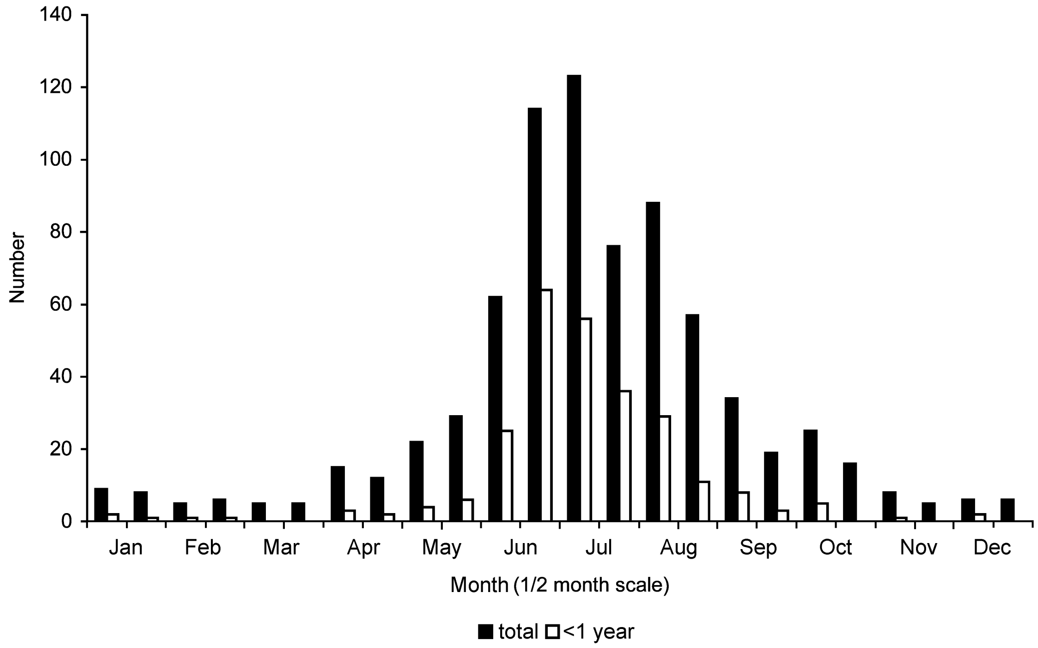

Fig. 3. Total number of stranded harbour porpoises and animals <1 year from the North Sea coast of Schleswig-Holstein (1990-2000).

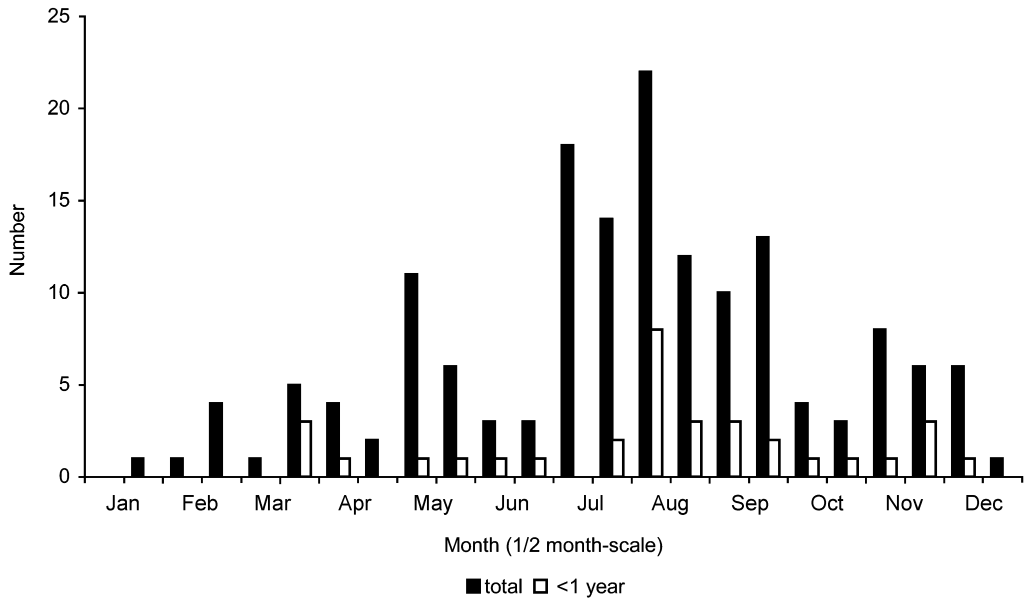

Fig. 4. Total number of stranded harbour porpoises and animals <1 year from the Baltic Sea coast of Schleswig-Holstein (1990-2000).

Table 1

Cumulative number of harbour porpoises (<1 year) of the different length classes and the respective median location date from the North Sea (1990-1998). The bold figures emphasise the most frequent median date and the respective length classes and number of animals found.

Length classes (cm)	Cumulative number	Median location date
65	10	26 June
66	15	25 June
67	22	26 June
68	30	26 June
69	36	27 June
70	41	25 June
71	49	25 June
72	**57**	**27 June**
73	**73**	**27 June**
74	**81**	**27 June**
75	**93**	**27 June**
76	**104**	**27 June**
77	**111**	**27 June**
78	**127**	**27 June**
79	138	28 June
80	146	28 June
81	151	30 June
82	154	30 June
83	161	01 July
84	168	01 July
85	177	02 July

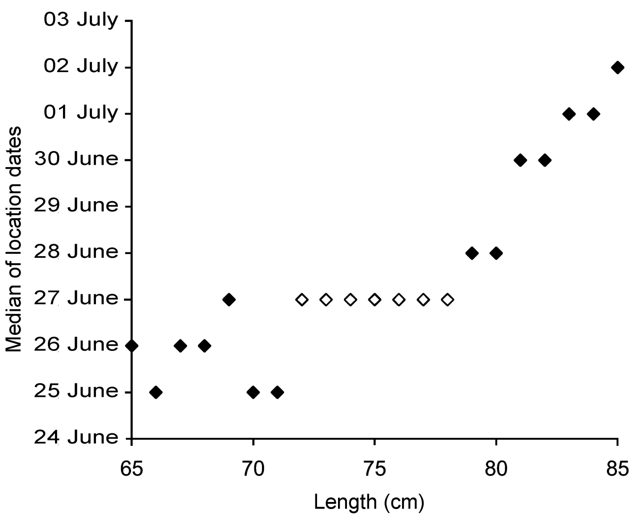

Fig. 5. Median of the location dates of young harbour porpoises (<1 year) for the different length classes of the Schleswig-Holstein North Sea coast (1990-1998). The lighter dots emphasise the most frequent median location date for each length class.

Table 2

Number of animals (<1 year), sexually mature females and males (>3.9 years) found in the summer months (June, July, August) from the North Sea (1990-1998).

Year	Number of animals of <1 year	Mature females	Mature males
1990	6	7	3
1991	11	7	13
1992	24	6	6
1993	50	12	4
1994	40	7	6
1995	28	10	5
1996	30	7	6
1997	14	3	2
1998	46	10	12

Table 3

Pearson-Correlation-Matrix of animals (<1 year), sexually mature females and males (>3.9 years) found in the summer months (June, July, August) from the North Sea (1990-1998).

	Female (>3.9 y)	<1 year	Male (>3.9 y)
Female	1.000		
<1 year	0.686	1.000	
Male	0.238	0.145	1.000

always the case with strandings data, it is not easy to ascertain whether the data are representative of the true population(s). One explanation of course is that they reflect actual changes in mortality by year while another is that they reflect varying weather and water conditions (see Polacheck *et al.*, 1995). The truth is probably some combination of these. In 1998, for example, a total of 158 strandings were reported (146 on the North Sea coasts and 12 in the Baltic). In the summer of that year, landward westerly winds prevailed on the North Sea coast of Schleswig-Holstein, which would have increased the likelihood of dead animals being washed ashore. In 1997 however, only 53 strandings were reported. The temperatures that summer were mostly warm, with easterly winds predominating. The high water temperature would have accelerated the decomposition of the animals and, in addition, the easterly wind would have kept the carcasses off the shore.

Most of the animals died in the summer months (Figs 3 and 4) i.e. during the birth period. A correlation between the strandings of sexually mature females (>3.9 years) and young harbour porpoises (<1 year) during the summer was found. There is no reported geographical segregation by sex for porpoises in the North Sea but there are few data to deny or confirm this. Recent aerial surveys have sighted mother-calf pairs as far out as the 'Doggerbank' halfway between Germany and England (M. Scheidat, pers. comm.). This, alongside the fact that there is no equivalent peak in mature males, infers that the period around parturition may pose an increased risk for the mother as well as the calf. However, of the 53 sexually mature females from the North Sea found during the summer and dissected, some 32% were either lactating, pregnant or both. This contrasts with pregnancy rates of over 0.85 found for other areas in the western North Atlantic (e.g. see Polacheck *et al.*, 1995; Read and Hohn, 1995) but is similar to those found off California (Hohn and Brownell, 1990). Other studies of (marine) mammals have shown that the mortality rate of adult females is highest during the birth period and (for both sexes) within the first year of life (e.g. Caughley, 1966; Siler, 1979).

By contrast to the North Sea, on the northeast coast of the USA, more harbour porpoises are found stranded during the winter months than during the summer (Polacheck *et al.*, 1995). The different findings between the east coast of the USA and Schleswig-Holstein may reflect different weather conditions, currents and/or, most likely population structure and migration.

At present, there is no clear picture of the population structure and movements of North Sea harbour porpoises. Further genetic analyses are required to clarify population structure, including obtaining sufficient samples from Danish, Dutch, British and German North Sea waters (R. Tiedemann, pers. comm.). There are suggestions of seasonal offshore/inshore movements of harbour porpoises in a number of areas (e.g. Evans, 1990; Kinze, 1990a; Verwey, 1975) as well as migrations, including differential migrations by sex (Teilmann *et al.*, 2004). A better understanding of these aspects of harbour porpoise ecology in the region is required to fully understand the strandings data and how representative they are of the total population(s).

The findings in this paper represent the first comprehensive attempt to examine the birth period for harbour porpoises apart from the study of Sørensen and Kinze (1994) who calculated a mean birth date for harbour porpoises in Danish waters as 30 June, a little later than our estimate of 27 June. However, their data may have included animals from more than one population as it included animals from the Baltic, the Belt, Kattegat/Skagerrak and the North Seas. The importance of only considering samples from a single population is illustrated by the fact that birth periods and birth rates of harbour porpoises may vary considerably by population and over time (e.g. see Read and Hohn, 1995; Hohn and Brownell, 1990). In our area, for example, Tiedemann *et al.* (1996) regard the harbour porpoises in the German North and Baltic Seas as different (sub-) populations, based on DNA analysis.

The results of this work emphasise the continuing need for collection of biological data and the value of data from strandings in order to analyse the status of harbour porpoise populations (including for example to examine further the suggestion that there may possibly have been a recent decline in fertility).

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