

## Harbour porpoise (*Phocoena phocoena*) abundance in German waters (July 2004 and May 2005)

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### Abstract

Harbour porpoise abundance in German waters is of interest for different management aims, such as estimating the impact of anthropogenic activities on the local population. Here, we present first results from density estimates of harbour porpoise in the German waters of the North Sea and the Baltic. The estimates are based on line transect aerial surveys conducted in July 2004 and May 2005. Two survey strata (North Sea and Baltic), subdivided into different survey blocks, were defined. Abundance and corresponding confidence intervals were calculated for each stratum and each block, separately for each survey. In July 2004 overall abundance in the North Sea strata was estimated to be 34,309 animals (95% C.I. 17,463 – 69,866) and in the Baltic Sea strata 2,031 animals (95% C.I. 921 – 4,243). In May 2005 abundance was estimated to be 64,506 (95% C.I. 36,776 – 127,036) in the North Sea strata and 4,793 (95% C.I. 2,440 – 9,752) in the Baltic Sea strata. The highest densities during both surveys were found in North Sea block CN with 3.23 animals per km<sup>2</sup> (C.V. 0.39) in July 2004 and 3.16 animals per km<sup>2</sup> (C.V. 0.30) in May 2005.

Key words: abundance, distribution, North and Baltic Sea, harbour porpoise, aerial survey

### Introduction

The harbour porpoise (*Phocoena phocoena*) is the only cetacean species found on a regular basis in both the German Exclusive Economic Zone (EEZ) in the North Sea and in the Baltic ([Reijnders 1992](#); [Benke & Siebert 1994](#); [Schulze 1996](#); [Benke et al. 1998](#); [Hammond et al. 2002](#)). It is the smallest cetacean inhabiting temperate to cold waters throughout the northern hemisphere. It occurs mostly in coastal or shelf waters and is therefore threatened by a variety of anthropogenic impacts including by-catch in fisheries ([Vinther 1999](#), [ASCOBANS, 2000](#), [Vinther & Larsen 2004](#)) and habitat degradation due to e.g. chemical pollution ([Jepson et al. 1999](#), [Siebert et al. 1999](#)).

Until recently, only limited data existed on the distribution and density of harbour porpoises in the German North and Baltic Seas. Most of what was known was based on results of the large scale SCANS (Small Cetacean Abundance in the North Sea and Adjacent Waters) survey undertaken in July 1994 ([Hammond et al. 2002](#)). The SCANS survey did not include all areas of the German EEZ, such as the region east of the island of Rügen close to the Polish border in the Baltic and some parts off the East Frisian Islands between the Elbe estuary and the Dutch border in the North Sea. The results of previous surveys though, allowed the calculation of abundance estimates for the SCANS blocks. However, those do

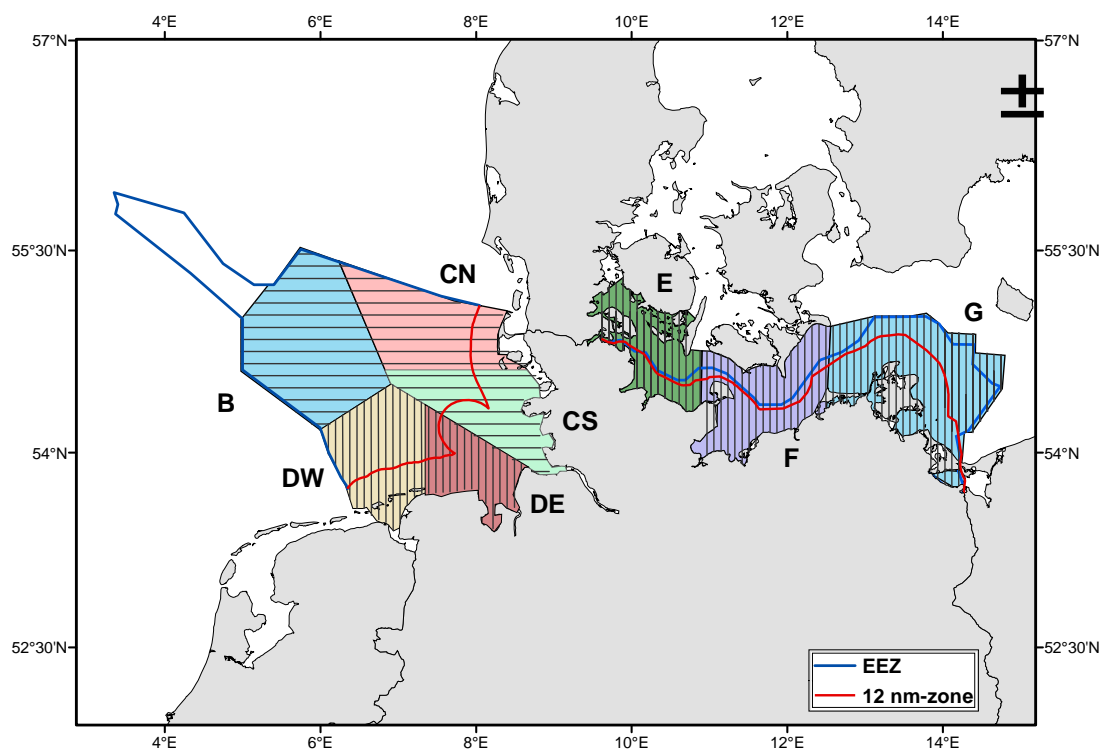
not correspond with EEZs which are often utilised in approaches to an integrated coastal zone management.

Aerial surveys conducted since 2002 in the German North Sea and the Baltic increased our knowledge on the summer distribution of porpoises in this area considerably ([Scheidat \*et al.\* 2005](#)). However, robust abundance estimates for porpoises in German waters were still missing. In this paper we present the first results on density and abundance estimates for harbour porpoises in German waters for two surveys conducted for the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV).

## **Materials and methods**

### *Study area*

The study area in the North Sea was comprised of the German EEZ and the 12 nm zone close to the coast. The area was divided into five blocks (B, CN, CS, DE, DW) (Fig. 1). The study area in the Baltic included the 12 nm zone, the German EEZ and was extended into Danish waters. The Baltic Sea stratum was divided into three blocks (E, F, G) (Fig. 1). Blocks were separated according to their differences in bathymetry and the maximum range of the survey plane. The western borders of areas CN, CS, DE and DW were located along the 35 m depth contour. One survey block was usually surveyed within one day (5 to 9 flying hours).



**Figure 1:** Study areas in the North and Baltic Sea. Transect lines for aerial surveys are indicated by the solid black lines. Transect lines are equispaced: 10 km in the North Sea (except areas DE and DW with 6 km space) and 6 km in all Baltic Sea study areas.

### *Survey Design and Data Acquisition*

The surveys were following standard line-transect methodology for aerial surveys ([Hiby & Hammond 1989](#); [Buckland \*et al.\* 2001](#)). The first survey was conducted from July 16<sup>th</sup> to July 28<sup>th</sup> 2004, the second survey from 28<sup>th</sup> April to 27<sup>th</sup> May 2005. Surveys were flown along predetermined parallel track lines, which were superimposed randomly on the study area. The direction of tracks was either north-south or east-west in order to follow depth gradients to minimise variance in encounter rate ([Buckland \*et al.\* 2001](#)). The chosen distance between tracklines was 6 km in coastal areas of expected lower density (DE, DW, E-G) and 10 km in offshore areas and in the expected higher density areas CN and CS (Fig. 1). To ensure an adequate sighting probability, surveys were only conducted in wind of Beaufort 3 or less.

The aircraft used was a high-wing two-engine Partenavia 68, equipped with bubble windows, flying at an altitude of 182 m (600 ft) and with a speed of 167 to 186 km/hr (90 to 100 kts). Data collection was based on the “VOR” software designed by Lex Hiby and Phil Lovell and described in [Hammond \*et al.\* \(1995\)](#). Every two seconds the aircraft’s position and the time (to the nearest second) was recorded automatically onto a laptop computer connected to a GPS. Additionally, sighting positions of marine mammals and the following environmental conditions were stored: Sea state (according to the Beaufort scale), glare, cloud cover (in parts of eight), turbidity (judged visually: 0 - clear water with several meters of visibility to 2 - very turbid, no visibility under the surface) and subjectively judged sighting conditions (“good”, “moderate” or “poor”). The sighting conditions were entered at the beginning of each transect and whenever any of the environmental conditions changed.

Sighting data was acquired by two observers at the time, located at the bubble windows on the left and right of the aircraft. Sighting information was entered into the computer by the navigator, located in the co-pilot’s seat. Sighting data included species, group size, presence of calves, behaviour, swimming direction, cue, possible reaction to the survey plane, location of porpoise during the time of the sighting (at surface or under water) and inclinometer angle measured from the aircraft abeam to the porpoise group.

In order to reduce fatigue, observers were not surveying for marine mammals in the course of transit between the parallel track lines. Positions between observers and navigator were rotated after breaks or during flight when deemed necessary. Observers also recorded floating debris, boats and fishing nets when there were no marine mammal sightings. For these additional sightings only presence or absence were recorded. Sightings made by the navigator or pilot were recorded as “off-effort” and not used in density estimate calculations.

Sightings made during transit to and from transect lines were noted but not included in our analysis.

### *Data analysis*

Density of harbour porpoise was calculated using line transect estimates based on perpendicular distances of sightings to the trackline. Tracks flown in sighting condition "poor" were excluded. To determine the probability of detecting harbour porpoises on the trackline ( $g(0)$ ), the "racetrack" design, which involves some doubling-back to search previously searched trackline segments again, was applied. Details of this method and the analysis is described in [Hiby \(1998\)](#) and [Hiby & Lovell \(1998\)](#). Under good conditions  $g(0)$  was estimated to be 0.37 and under moderate conditions  $g(0)$  was estimated to be 0.14 (C.V. 0.30 for both). Detection curves were calculated for all data collected in each survey year (this includes aerial survey data from 2002 to 2005) by pooling all sightings in a given year. Since the probability density function ( $f(0)$ ) did not differ between years and since the estimated detection curves were similar, one detection curve was computed from the pooled data and a single estimate for  $f(0)$  obtained.

The analysis started by fitting a detection function to the data, which assumed that  $g(0)$  was 1. Best model chosen, using the Akaike's Information Criterion (AIC; Akaike 1973), was the hazard rate model with sea state, turbidity, "subjective" (a subjective measure of sighting conditions with levels "good" and "moderate") and observer as covariates. Considering the  $g(0)$  values this functional form was used to estimate effective half strip width (esw) to be 0.077 km under good conditions and 0.027 km under moderate conditions.

Investigation of possible school size-bias suggested that no such bias was present. Mean school size was estimated using the mean of the observed school sizes separately within each stratum.

Coefficients of variation (C.V.s) and 95% confidence intervals (C.I.s) were estimated by bootstrapping (999 replicates) within strata, using transects as sampling units. The variance due to estimation of esw was incorporated using a procedure which assumes the esw estimates in good and moderate conditions to be normally distributed random variables. To do this, for each bootstrap pseudo-sample of transect lines, a bivariate lognormal random variable was generated from a distribution with mean and variance-covariance matrix, equal to those estimated for the esw (including the  $g(0)$ ). This was used as the esw for the pseudo-sample. 95% C.I.s were calculated using the percentile method.

## Results

### Survey results

The total search effort for both surveys in good and moderate conditions during the July 2004 survey was 2,412 km in the North Sea and 1,886 km in the Baltic. During the May 2005 survey effort was 3,215 km in the North Sea and 3,126 km in the Baltic (Table 1). The mean group sizes for each survey varied between 1 and 1.57 (Table 1).

Table 1: Group size per area and number of porpoises (porp.) sighted in the survey areas of the North Sea (NS) and Baltic Sea (BS) under good (g) and moderate (m) conditions.

July 2004							
area	block	survey dates	Effort km	Mean group size	Porp. (g)	Porp. (m)	Total number porp.
NS	B	28/07		1.16	49	7	56
	CN	22/07		1.57	114	27	141
	CS	22/07		1.25	3	5	8
	DE	21/07		0	0	0	0
	DW	23/07		1	1	0	1
Sum/overall mean			<b>2,412</b>	<b>1.43</b>	<b>167</b>	<b>39</b>	<b>206</b>
BS	E	18/07		1.25	2	2	4
	F	16/07 18/07		1.33	11	1	12
	G	16/07 17/07		1	1	0	1
Sum/overall mean			<b>1,886</b>	<b>1.29</b>	<b>14</b>	<b>3</b>	<b>17</b>

May 2005							
area	block	survey dates	Effort km (g) and (m)	Mean group size	Porp. (g)	Porp. (m)	Total number porp.
NS	B	3/05 27/05		1.21	30	22	52
	CN	28/04		1.12	118	45	163
	CS	27/05		1.09	47	29	76
	DE	3/05 23/05		1.20	1	4	5
	DW	27/05		1.13	67	31	98
Sum/overall mean			<b>3,215</b>	<b>1.13</b>	<b>263</b>	<b>131</b>	<b>394</b>
BS	E	22/05		1.27	41	7	48
	F	13/05		1.35	21	2	23
	G	11/05 12/05		0	0	0	0
Sum/overall mean			<b>3,126</b>	<b>1.30</b>	<b>62</b>	<b>9</b>	<b>71</b>

*Abundance estimates*

Abundance was estimated separately for each of the North Sea and Baltic blocks and for each survey year. The survey results for the survey blocks are listed in table 2.

In July 2004, the overall abundance in the North Sea strata (survey blocks B to D) was 34,309 (95% C.I. 17,463 – 69,866; C.V. 0.36) and in the Baltic strata (survey blocks E to G) was 2,031 (95% C.I. 912 – 4,243; C.V. 0.39). In May 2005, the overall abundance in the North Sea was 64,506 (95% C.I. 36,776 – 127,036; C.V. 0.31) and in the Baltic Sea 4,793 (95% C.I. 2,440 – 9,752; C.V. 0.36%).

Table 2. Density estimates per survey block (95% confidence intervals (C.I.) and coefficient of variation (C.V.), both based on bootstrap estimates).

<b>JULY 2004</b>				
<b>block</b>	<b>density</b>	<b>CI low</b>	<b>CI high</b>	<b>CV</b>
<b>North Sea</b>				
<b>B</b>	<b>0.59</b>	0.27	1.30	0.40
<b>CN</b>	<b>3.23</b>	1.45	6.59	0.39
<b>CS</b>	<b>0.53</b>	0.00	1.31	0.70
<b>DE</b>	<b>0.00</b>	0.00	0.00	0.00
<b>DW</b>	<b>0.02</b>	0.00	0.06	0.99
<b>Baltic Sea</b>				
<b>E</b>	<b>0.13</b>	0.02	0.38	0.61
<b>F</b>	<b>0.18</b>	0.08	0.39	0.42
<b>G</b>	<b>0.01</b>	0.00	0.03	1.07

<b>MAY 2005</b>				
<b>block</b>	<b>density</b>	<b>CI low</b>	<b>CI high</b>	<b>CV</b>
<b>North Sea</b>				
<b>B</b>	<b>0.92</b>	0.43	2.03	0.40
<b>CN</b>	<b>3.16</b>	1.80	6.06	0.30
<b>CS</b>	<b>2.27</b>	1.09	4.82	0.38
<b>DE</b>	<b>0.22</b>	0.02	0.60	0.71
<b>DW</b>	<b>1.14</b>	0.30	3.07	0.57
<b>Baltic Sea</b>				
<b>E</b>	<b>0.65</b>	0.32	1.39	0.39
<b>F</b>	<b>0.24</b>	0.08	0.54	0.46
<b>G</b>	<b>0.00</b>	0.00	0.00	0.00

Densities in areas CS, DE and DW in the North Sea was higher during the May 2005 survey compared to the July 2004 survey. The estimated densities for area B, CN and DE were similar between the two surveys (see Fig. 2). In the Baltic Sea the density in area E was higher in May 2005 than in June 2004 (Fig. 3).

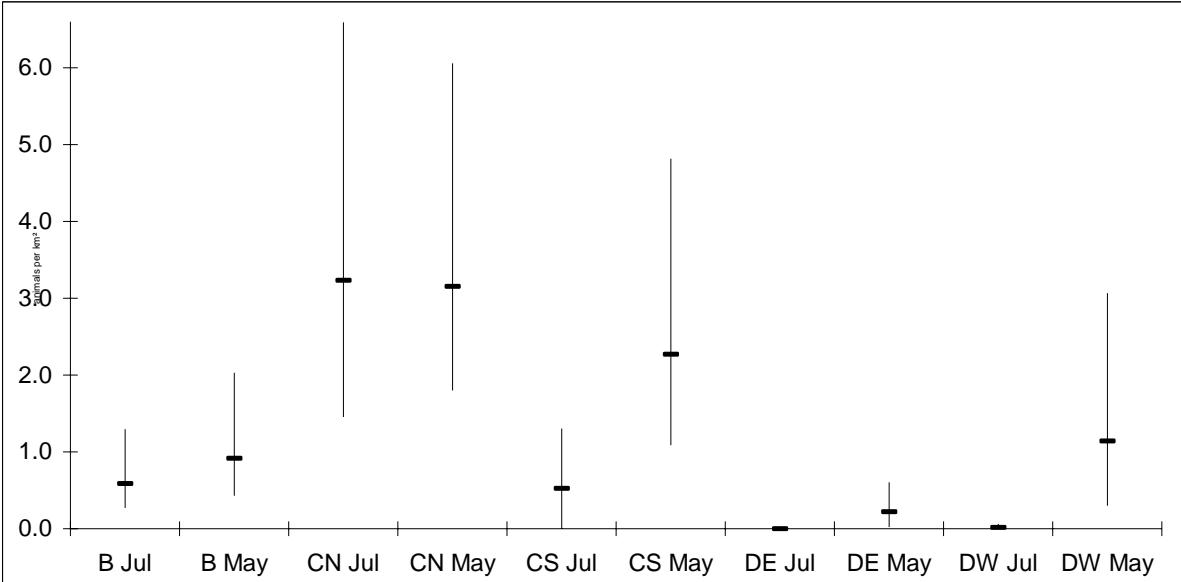


Figure 2. Comparison of harbour porpoise density between all survey blocks in the North Sea strata (B, CN, CS, DE, DW) for July 2004 (Jul) and May 2005 (May). Error bars indicate 95% C.I.

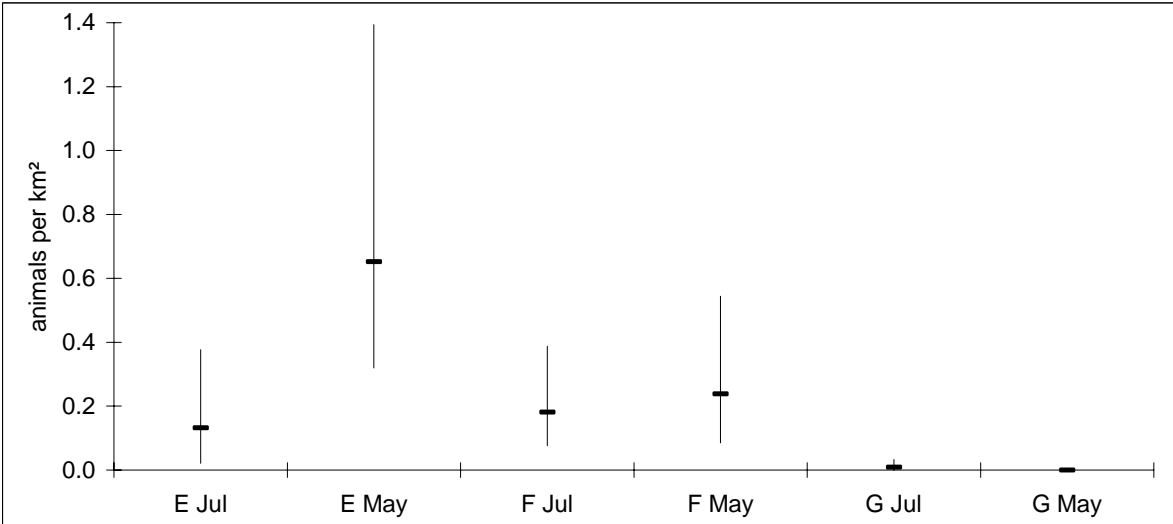


Figure 3. Comparison of harbour porpoise density between all survey blocks in the Baltic strata (E, F, G) for July 2004 (Jul) and May 2005 (May). Error bars indicate 95% C.I.

## **Discussion**

### *Methodological considerations*

Aerial surveys are useful in areas that have only limited time frames of favourable weather conditions to conduct surveys. The North Sea is a typical example for such an area, since weather conditions often change quickly. Offshore areas, such as e.g. survey block B, with large distance from shore make surveys logistically very difficult. Military activity further limits the possibility of conducting surveys. This was particularly the case in survey blocks E and to some extent in CN. In block E surveys were only possible on weekends or national holidays, when no military activity took place.

Weather conditions were more favourable during May 2005 than July 2004. This is mirrored in the higher overall effort, resulting in higher number of porpoises sighted, and a reduced C.V. in May 2005.

Survey precision was reduced in those areas where porpoise densities were low, such as in areas DE, DW and G. [Mundry et al. \(in prep.\)](#) have simulated the expected precision of density estimates while looking at different survey parameters. The results of the simulations suggested that low density areas (less than 0.01 animals per km<sup>2</sup>) were always associated with large confidence intervals and coefficients of variation. C.V.s of the estimates of generally more than 0.30 are partly due to the inclusion of the C.V. of the esw and g(0) calculation. As flights continue and more racetrack flights are conducted with the same aerial survey team this C.V. is expected to decrease and thus also reduce the over all C.V. and the width of the confidence intervals.

### *Abundance estimates*

Highest densities of harbour porpoise in the North Sea, both in July 2004 and May 2005, were observed in study area CN, the northernmost part of the German EEZ, close to the Danish border. Density in area CN was more than 3 animals per km<sup>2</sup>. The increase in abundance in the North Sea from July 2004 to May 2005 is consistent with previously observed changes in porpoise distribution in German waters ([Scheidat et al. 2004](#)). Interestingly, this increase in abundance did not occur in the high density area CN, but in the southern part of the German EEZ (study areas CS and DW). The area DW close to the Dutch border showed an almost tenfold increase in the abundance of porpoises. Recent increases in strandings in Lower Saxony (Germany) in winter and spring and an increase in sightings of harbour porpoises between February and May ([Camphuysen 2004](#)) along the neighbouring Dutch coast, point at an increase of harbour porpoise in that area in winter and

spring and may partly explain the large difference in density between the survey months July and May.

Density estimates of porpoises during the July SCANS survey in 1994 in those areas which covered German waters (survey blocks Y, H and G) were 0.812, 0.095 and 0.34 animals per km<sup>2</sup> ([Hammond et al. 2002](#)). These estimates are comparable to results from most of the German survey blocks, with the exception of block CN. A density of more than 3 animals per km<sup>2</sup> was neither observed during SCANS (Hammond et al., 2002) nor during SCANS II (Macleod, 2006). This would suggest that the high density occurs on a scale too small to be detected by large scale surveys, such as SCANS or at a different time (May vs. July).

Surveys of the Baltic during the last 10 years demonstrated that porpoise abundance decreased from west to the east, becoming extremely low in the central Baltic to the east of the Darss sill (Berggren et al. 2002). The SCANS area X from July 1994 in the Baltic showed densities of 0.01 porpoises per km<sup>2</sup>. This was lower than the densities of 0.13 estimated for the corresponding survey block E in July 2004. In addition, we observed an increase in density in survey block E in May 2005.

New results from ongoing studies, investigating spatial use of harbour porpoises by means of stationary acoustic methods (PODs), are showing a strong seasonality of harbour porpoises in this area (U. Verfuß, pers. comment), indicating migration patterns. The observed increase of porpoises in the month of May could be caused by such a temporal change in abundance. However, further analyses of aerial surveys throughout the year are needed to see whether any seasonal changes in density are detectable.

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