Agenda Item 4.2: **Abundance survey planning (SCANS II), update**

Summer distribution of Harbour Porpoise (*Phocoena phocoena*) in the German North and Baltic Sea

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Working paper presented at the 2003 ASCOBANS meeting

Summer distribution of harbour porpoise (*Phocoena phocoena*) in the German North and Baltic Sea

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ABSTRACT
Current plans to utilize German offshore waters as sites for windmill parks as well as ongoing investigation of potential areas to implement Natura 2000 have led to an increased research effort on local marine mammal populations. The aim of our study was to determine the spatial distribution of harbour porpoise in the German part of the North Sea and Baltic Sea. Aerial surveys were conducted from May to August 2002 using standard line-transect methodology. A total of 21 days were spent flying a total of 8072 km tracks on effort. A total of 785 harbour porpoises (488 sightings) were seen. 4908 km of the tracks were conducted in conditions of good visibility and 597 animals (427 sightings) were detected under those conditions. The study area was divided into a grid of 3' latitude x 6' longitude squares. Porpoise relative abundance and distribution was estimated as number of animals per km on effort in each square. The results showed that in the North Sea the highest relative abundance of porpoises was observed in the north-eastern part of the surveyed area, close to the Danish border and in the area of Amrum Outerbank. In the Baltic, the highest relative abundance of porpoises was seen in the Pomeranian Bight between the island of Rügen and the Polish border. Pod size in the Baltic was larger than in the North Sea. These aerial surveys will continue in 2003 in order to collect more information on temporal and spatial distribution of harbour porpoise and its intra and inter – annual variability in German waters. This data will serve as a baseline for management decisions.

INTRODUCTION

The harbour porpoise is protected by a variety of national and international agreements. This includes the Appendix II of the Convention on Migratory Species (CMS), the Habitat Directive of the European Commission as well as the red list of Endangered Species of Germany which is currently under revision.

The endangered status of harbour porpoises and management issues of marine mammals on a broader scale have found much more attention recently with respect to the German part of the North Sea and the Baltic. This is further fuelled by the necessity to propose areas in offshore waters of Germany which need to be incorporated into the European Natura 2000. Additionally potential sites for windmill parks are surveyed in front of the German coasts and plans for the establishment of the first park ('Butendiek') have been accepted by the government recently. The ongoing search for additional sites and future construction campaigns may interfere with marine mammals and risk further habitat degradation.

In order to try and better accommodate interests of porpoises with respect to their habitat it became apparent that very little data existed on their distribution in German waters. Current information on distribution of porpoises in the German North and Baltic Sea is mostly based on results of the SCANS survey of 1994 (Hammond et al. 2002). Unfortunately the coverage during SCANS left out some areas of the German EEZ (exclusive economic zone), such as the region east of the island of Rügen close to the Polish border in the Baltic, and some parts of the Eastern Frisian Islands between the estuary of the river Elbe and the Dutch border. However, stranding data submitted to the IWC on an annual basis since 1990 suggest that harbour porpoise occur in these areas regularly albeit in small numbers. Heide-Jørgensen et al. (1993) and Sonntag et al. (1999) surveyed some areas in the German North and Baltic Sea, but they were too small to draw conclusions about the general distribution of porpoises.

In this paper, we would like to present the first results of aerial surveys conducted from May to August 2002. This study will continue until the end of 2003 and is hoped to serve as a baseline information on distribution patterns of harbour porpoises in German waters.

MATERIALS AND METHODS

Study Area

The study area included the exclusive economic zone of Germany in the North Sea and the Baltic Sea, as well as the 12nm zone in front of the coastline (Figure 1). In the Baltic Sea the study area was extended into Danish waters for methodological reasons and the boundaries of the transects were the Danish isles (Figure 1). The study area in the North Sea was divided into four different regions (A to D). The Baltic was separated into three blocks (E to G) (Table 1). Regions were separated according to their differences in bathymetry, range of the plane and number of observers available. One region (block) was usually surveyed within one day (about 3 hours). Consideration was also given to putative stock boundaries, such as the Darss Ridge, separating the central Baltic stock from the Kattegat – Belt Sea – Western Baltic stock.

Table 1: Survey regions within the German North Sea and the Baltic Sea study areas

Region	**Size**
A 'Entenschnabel'	3 903 km²
B Offshore	11 650 km²
C North Friesia	13 668 km²
D East Friesia	11 824 km²
Summary North Sea regions	*41 045* km²
E Kiel Bight	4 696 km²
F Mecklenburg Bight	7 248 km²
G Rügen	10 990 km²
Summary Baltic Sea regions	*22 934* km²
Total area surveyed	63 979 km²

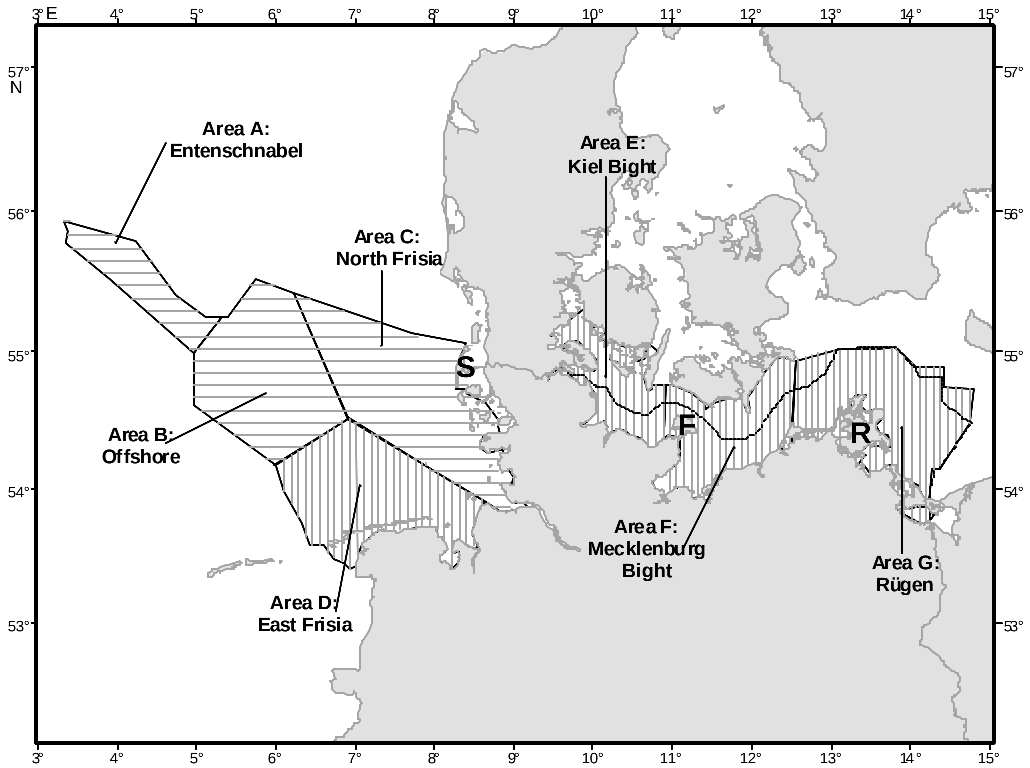

Figure 1: Study areas and planned transect lines of the aerial surveys in the Baltic and the North Sea. The dashed line in the Baltic indicates the German EEZ (Exclusive Economic Zone). The main islands are marked as: **S –** Sylt, **F -** Fehmarn and **R** - Rügen.

Survey Design and Data Acquisition

The surveys followed standard line-transect methodology for aerial surveys (Hiby & Hammond 1989; Buckland et al. 1993). From May to August 2002, a total of 8190 km of tracklines were conducted on effort following a parallel track design for a high-wing twin engine aircraft (Partenavia) flying at an altitude of 182 m (600 ft) and a speed of 167 to 186 km/hr (90 to 100 kts). The direction of tracks was either north-south or east-west, to follow gradients of depth (Figure 2). Some regions (A, C, D, F and G) within the two areas of investigation (North Sea, Baltic) were given particular attention. These regions are likely to host windmill parks in the future or are potential or designated Natura 2000 areas.

Data collection was based on the VOR software ((Hammond et al. 1995). Every four seconds the aircraft position was recorded automatically onto a laptop computer connected to a GPS. Additionally, the position was stored whenever a sighting was made. Sea state (according to the Beaufort scale), glare, observer positions, sighting probability (judged subjectively by the observers as probability to sight a porpoise), turbidity (judged visually: 0 - clear water with several meters of visibility to 3 - very turbid water with no visibility under the surface) and percent cloud cover (parts of eight) were entered at the beginning of each transect and whenever environmental conditions changed. Sighting data were acquired by two observers located at each bubble window of the aircraft. Data were entered into the computer by the recorder located in the co-pilot's position. Sighting data included species, group size, presence of young animals, behaviour, swimming direction, clue, reaction and clinometer angle measured from the aircraft to the porpoise group when it passed abeam of the aircraft.

Data Analysis

Data collected from sightings were summarised for every 4 seconds which coincides with a distance flown of about 200m. For each of these 4 second intervals the number of animals and the relative density (animals per km survey flight) were calculated.

Only data obtained in good conditions of visibility were used for the analysis. This category never included sightings obtained in sea state of more than 2 or turbidity of more than 2. Observations collected in the region of the "Entenschnabel" (furthest out in the North Sea, see figure 1) have not been included. Conditions encountered in this region were only moderate during all flights. The impact of other environmental parameters, such as glare, on sighting probability (see above) are currently being analysed and are not part of this paper.

Geographic cells, measuring 3 minutes latitude by 6 minutes longitude, were defined throughout the study area in order to obtain information on distribution and relative abundance of harbour porpoise. This was computed as sighting rates (animals/km) for each cell. The data was analysed using GIS software (ArcView). Empty cells were those cells where no effort (in good visibility) was conducted. All maps are shown in Transverse Mercator projection.

RESULTS

Survey effort

Environmental conditions varied between survey days and sometimes during a single flight. Table 2 shows the survey effort covered under different environmental conditions, sea state and turbidity.

Table 2: Environmental conditions during aerial surveys from May to August 2002

subjective	% effort	Sea state	% effort	turbidity	% effort
Good	23.9	0	9.4	0	19.0
Moderate	36.6	1	38.0	1	67.3
Poor	39.5	2	34.3	2	13.5
		3	17.4	3	0.2
		4	0.9		

Two regions (1 in the North Sea, 1 in the Baltic) received substantially less coverage in terms of survey effort than planned (Table 3). Region A ('Entenschnabel') was only covered once during moderate conditions. Region E (Kiel Bight) could not be covered to the extent intended due to military activities in that area during the week. This limited surveys to weekends.

Sighting rates in good conditions were always higher than in the total data set pooled over all sighting conditions. An example from region F demonstrated how dependable sighting rates were on weather conditions: an substantially increased effort (1030km versus 572km) under less favourable sighting conditions only led to an increase in sightings by one (14 sightings versus 13) (Table 3).

Table 3: Survey effort, sighting rates (animals and sightings per km) and group sizes in the North Sea and the Baltic study area (May to August 2002). Data are provided for total survey effort and for survey effort in good visibility only.

	North Sea survey regions					Baltic survey regions				
	A	**B**	**C**	**D**	Summary	**E**	**F**	**G**	Summary	Summary total survey
Total effort km	144	647	2991	1804	5586	382	1030	1075	2486	8073
Total number of sightings	2	29	371	33	435	5	11	37	53	488
Total sightings per km	0.014	0.045	0.124	0.018	0.078	0.013	0.011	0.034	0.021	0.061
Total number of animals	5	37	542	86	670	9	14	92	115	785
Total number of animals per km	0.035	0.057	0.181	0.048	0.12	0.024	0.014	0.086	0.046	0.097
Total mean group size	2.50	1.28	1.46	2.61	1.54	1.80	1.27	2.49	2.17	1.61
Effort km in good conditions	-	372	1801	1132	3305	382	572	649	1603	4908
Number of sightings in good conditions	-	28	323	25	376	5	10	36	51	427
Sightings per km in good conditions	-	0.075	0.179	0.022	0.114	0.013	0.017	0.055	0.032	0.087
Number of animals in good conditions	-	34	410	43	487	9	13	88	110	597
Number of animals per km in good conditions	-	0.091	0.228	0.038	0.147	0.024	0.023	0.136	0.069	0.122
Mean group size in good conditions	-	1.21	1.27	1.72	1.30	1.80	1.30	2.44	2.16	1.40
Number of calf sightings per km in good conditions	-	0.003	0.007	0.004	0.005	0	0	0.002	0.001	0.004

Pod size was consistently bigger when sighting data obtained under different conditions were pooled than pod sizes obtained from sighting data made in good visibility (Table 3). Maximum pod size in the North Sea was 5 and in the Baltic 10 porpoises. Mean pod size was 1.30 in the North Sea and 2.16 in the Baltic (Table 3). In the North Sea, almost 78% of the sightings were of individual porpoises compared to only 57% in the Baltic (Figure 2).

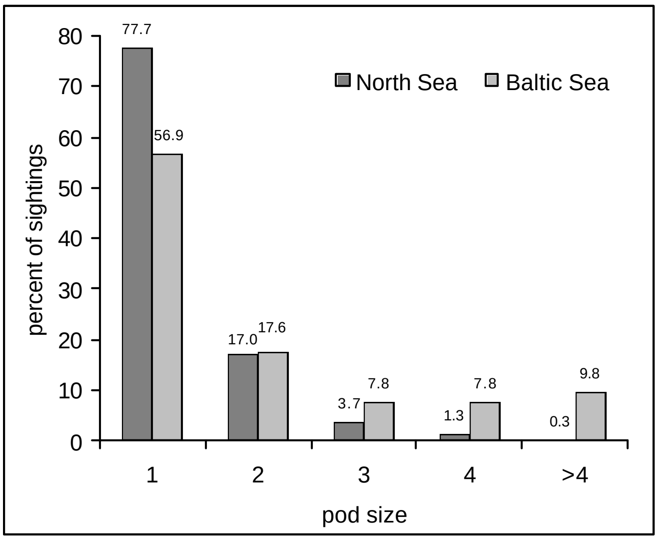

Figure 2: Distribution of pod sizes of harbour porpoise sightings in the North Sea and Baltic (only in sightings in good visibility were considered)

Figure 3 shows the track lines flown on effort during the aerial survey in the German North Sea as well as the number of sighted porpoises and their pod sizes. An increased number of tracks was flown in area C and D.

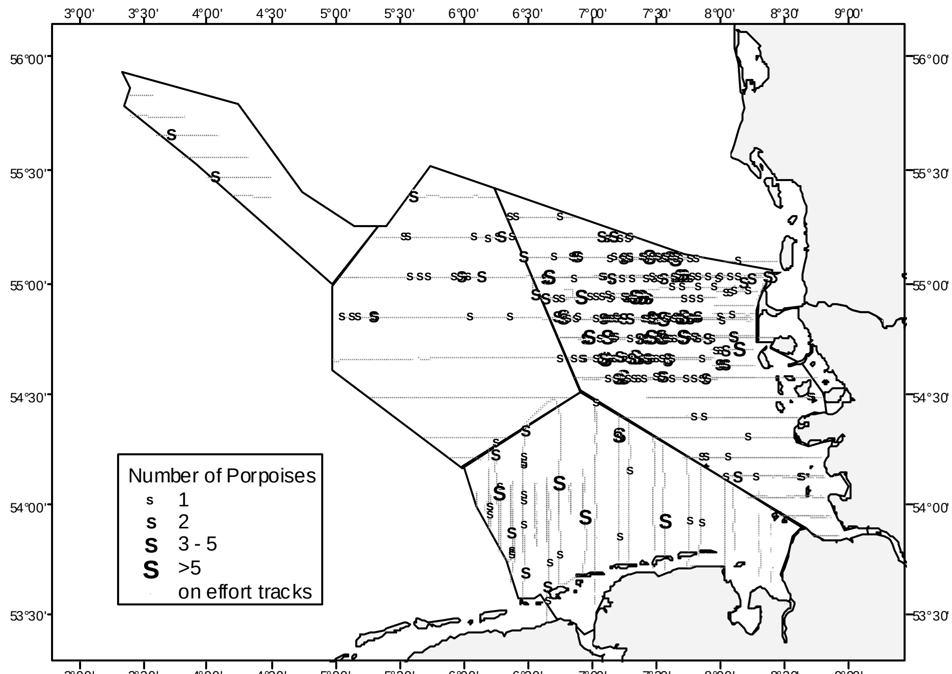

Figure 3: Total number of tracks flown on effort from May to August in the German North Sea and porpoise sightings.

Figure 4 shows the tracks flown in the Baltic and the sightings of harbour porpoise. In the Baltic a larger number of tracks was flown around the island of Fehmarn (area F) and the Kadet fairway (Area F) as well as in the Pomeranian Bight (Area G). Larger pod sizes of up to 10 animals were only seen in the eastern part of the Baltic. This area includes the Oderbank a shallow in the centre of the Pomeranian Bight (Figure 4).

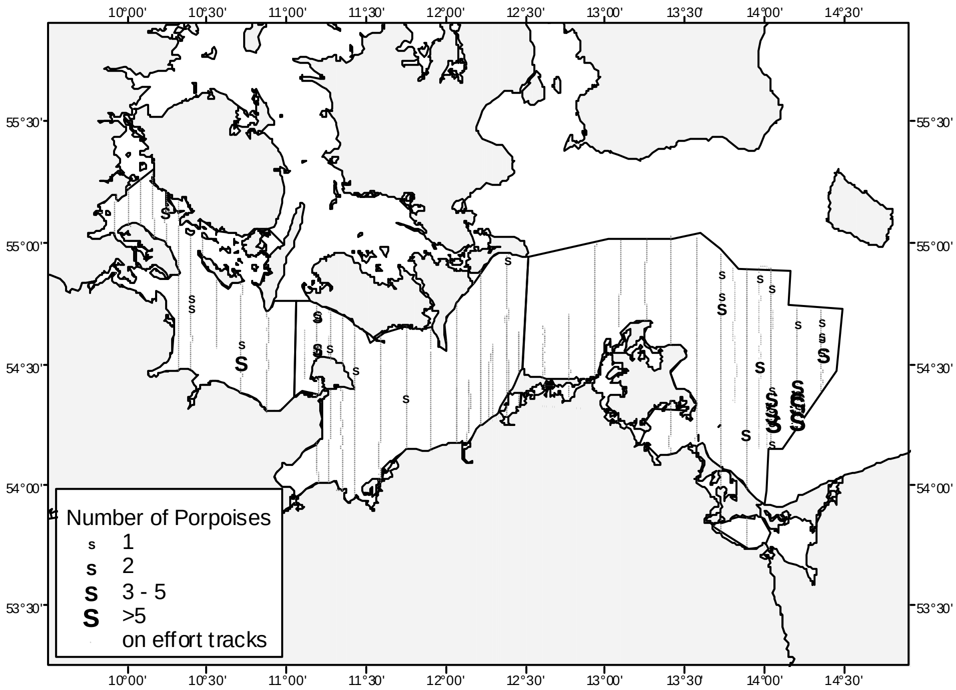

Figure 4: Total number of tracks in the Baltic flown from May to August 2002 and number of porpoise sightings.

Figures 5 and 6 show the study area separated into 3'latitude x 6'longitude grids. For each cell the number of porpoises per km survey effort collected in good visibility was calculated. A cross indicates those cells for which no sightings were made. No cross or dot shows that no survey effort in good conditions was made in that part of the area.

In the North Sea, the highest relative abundance (animals per km) was seen in the centre of Area C. In the Baltic, most porpoises were encountered in Area G, east of the island of Rügen.

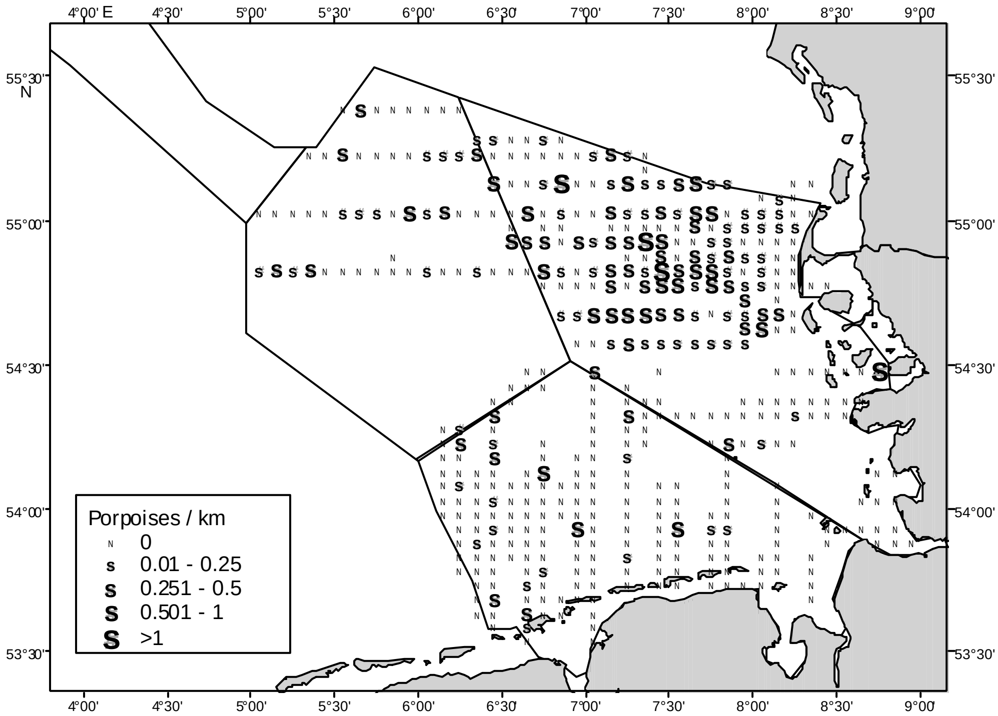

Figure 5: Distribution of harbour porpoise in the German part of the North Sea (May to August 2002). Each circle or cross represents a cell of 3' latitude by 6' longitude. For each cell the number of porpoises per km survey is shown. Only data obtained in good survey conditions was used.

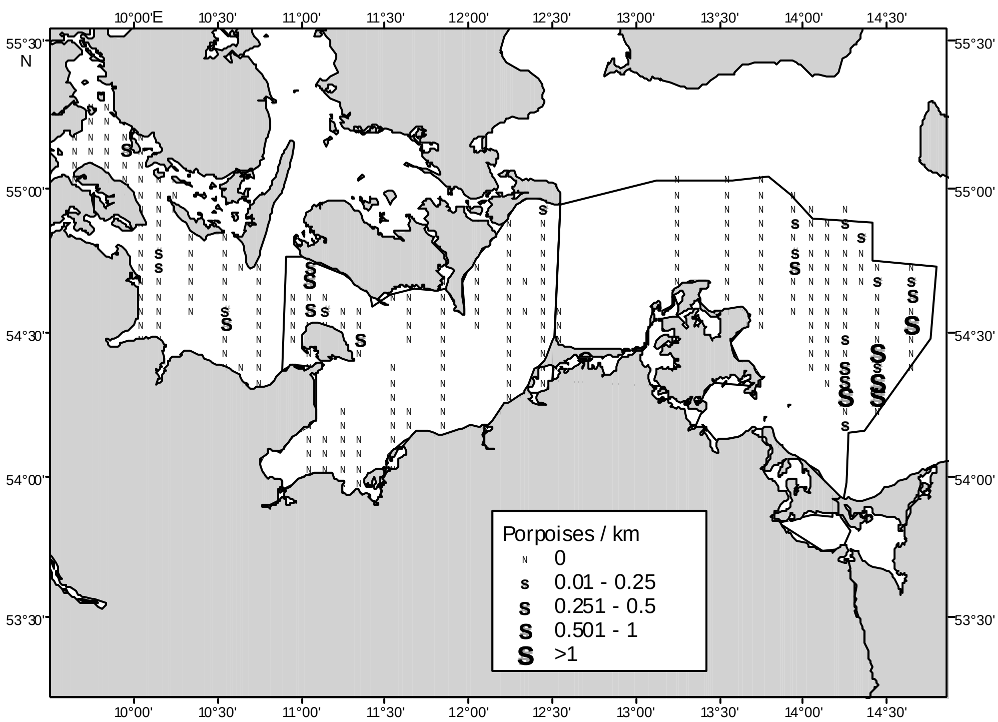

Figure 6: Distribution of harbour porpoise in the German part of the Baltic including the Danish coastal waters (May to August 2002). Each circle or cross represents a cell of 3' latitude by 6' longitude. For each cell the number of porpoises per km survey is shown. Only data in good survey conditions was used.

To calculate the mean and the standard error for the relative abundance, the number of animals per km was calculated for each 4 second sample unit (Fig.7). North Sea Area C had the highest value with 0.18 animals per km (S.E. 0.027). The highest values in the Baltic were found in the Pomeranian Bight with 0.15 animals per km (S.E. 0.069).

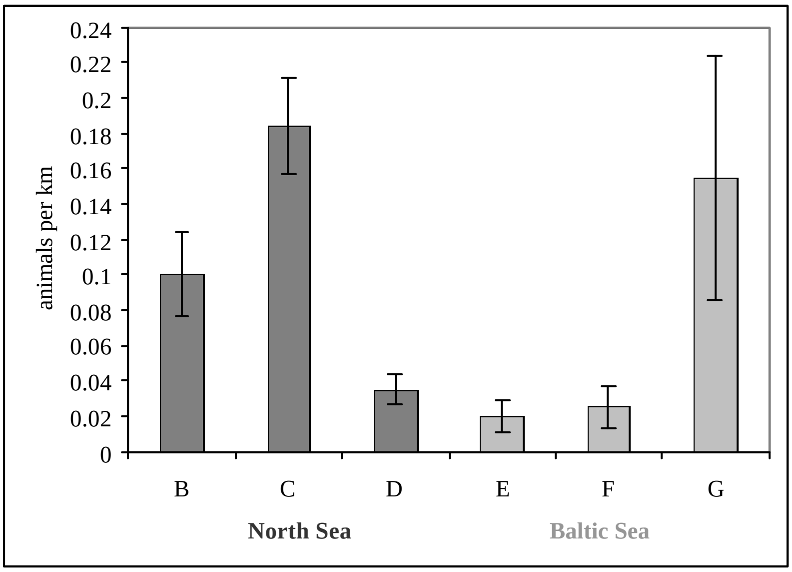

Figure 7: Mean values of porpoises per km survey for each region (calculated from all 4 second samples in each region). The error bars indicate the standard error for the sample within each region.

DISCUSSION

Two main results were obtained from this study. On the one hand our data underlined the importance of using a stringent sighting protocol and of including only good sighting conditions when comparing data obtained during aerial surveys. On the other hand our results provided some new insight into the summer distribution of harbour porpoises in German waters.

Survey methodology

Our study underlined the importance of conducting surveys for harbour porpoise only when sighting conditions are optimal. A description of the sighting conditions is crucial if the data were compared to other studies conducted on the same or other temporal and/or spatial scales. Our data re-iterated that the sighting rate, both for animals per km and sightings per km, decreased noticeably when all flights on efforts, i.e. also those under deteriorating weather conditions, were included in the analysis. Mean pod size also increases when all flights were taken into consideration. This indicates that the probability of seeing single animals or small groups decreases with deteriorating weather conditions. Due to the difficulty in sighting porpoises when the water is very turbid, certain areas (such as the river estuaries of Elbe and Weser) will probably always have worse sighting conditions than others.

North Sea

Highest aggregations of harbour porpoise were observed in the northern part of the German EEZ and close to the Danish border (area C). This area also include the German whale sanctuary off the isle of Sylt. In the remainder of the study area harbour porpoises were more evenly distributed and no particular aggregations were found. The sighting rates of 0.18 sightings per km in Area C were substantially higher than those obtained during two preceding surveys in 1992 (0.06 sightings per km, Heide-Jørgensen et al., 1993) and 1994 (0.05 and 0.04 sightings per km resp., Hammond et al., 2002) using the same aircraft and methodology. The higher sighting rate during our survey might be related to the observed aggregation of animals in May. This is the beginning of the mating and breeding season when harbour porpoises might be more gregarious than in other times of the year. It is also possible that these aggregations were caused by food availability. Swarm fish, such as herring or sprat, might have been present in the area. Other potential prey species were sandeels (*Ammodytes marinus*), which often burrow in the seafloor from October to early April. During April and May they emerge from the seafloor to feed in the water column (Evans 1990). At this time they aggregate in the water column and are available to predators. Analyses of stomach content of porpoises (1992/1993) showed that 37% of the fish found in the stomachs (by weight) were sandeel. Dab (*Limanda limanda*) and common sole (*Solea vulgaris*) made up 38% and whiting (*Merlangius merlangus*) and cod (*Gadus morhua*) 15.1% of prey (Benke et al. 1998). If aggregations of harbour porpoise occur due to prey concentrating in certain areas, they then would most likely occur in spring. Most previous aerial and shipborne surveys in this area have taken place in July or August. This might indicate why these higher densities had not been observed.

Mean group sizes of 1.27 porpoises in Area C and 1.72 in Area D were comparable to those found during the SCANS survey with a mean pod size of 1.45 in area Y and 1.62 in area L (Hammond et al. 2002). Heide-Jørgensen et al. (1993) surveyed only a small part of Area C directly off the island of Sylt in 1992 and found a lower mean group size of 1.03 porpoises. These differences could also be due to changes in behaviour of harbour porpoise throughout the year. Their main prey in the North Sea was flatfish in most years investigated, which are benthic species and tend not to aggregate in large concentrations. Therefore, it seems unlikely that porpoises would gather in larger groups when feeding.

Baltic Sea

In the Baltic Sea harbour porpoises were only seen in Kiel Bight and around the island of Fehmarn (Figure 1) and east of Rügen. Sighting rates in the Baltic were three times lower than in the North Sea. The sighting rates are lowest in the two western areas of the Baltic, the Kiel and Mecklenburg Bight (E and F), with 0.013 and 0.017 sightings per km survey effort. During the SCANS survey in area X, 0.008 sightings per km were made (Hammond et al., 2002) and during the flights from Heide-Jørgensen (1993) 0.004 sightings per km were made. For the Kiel and Mecklenburg Bight the mean group size was 1.3 and 1.8 animals. Comparable values of 1.5 were found during the SCANS survey (Hammond et al., 2002).

Heide-Jørgensen et al. (1993) came up with a lower mean group size of 1.13 porpoises in 1992.

An unexpected observation was made during flights between the island of Rügen and the Polish border (Area G, Figure 1) in May and July 2002. The highest sighting rates for the Baltic Sea, highest maximum pod size (10 porpoises) and the highest number of porpoises per sampling unit (4 seconds survey) for both Baltic and North Sea were found in this area. Again, the proximity to the mating and calving season and the calving season itself may have concentrated most porpoises in a comparatively small area. Flights in August, September and December in the same area did not find a single porpoise. This demonstrated that overall density of porpoises was lower between the island of Rügen and the Polish border than indicated through the surveys in May and July. Further surveys in 2003 will show if the concentrations found in May and July were a local phenomenon which was limited in space and time to the mating and calving season or if the number of porpoises in that area has actually increased since the mid-1995.

Large aggregations of up to several hundred harbour porpoises have been observed in other areas of the world, probably related to good feeding grounds (Rae 1965). If prey is only available for a short period of time, as are for example spawning shoals of herring or sprat, these aggregations might be difficult to encounter using standard line-transect methodology. In contrast to the German North Sea, the Baltic has herring available all year round. Stomach analyses of harbour porpoises from the German coast of the Baltic showed that 22.8% of the fish found (by weight) was herring, 52.7% goby (*Pomatoschistus* spec.) and 14.8% cod (Benke et al. 1998). These results should be viewed with caution because results were integrated over whole years and areas and may mask seasonal and geographical variation in the diet. The continuous presence of herring within the reach of harbour porpoise might cause porpoises to form larger group sizes than in the North Sea where prey was more evenly distributed.

The population east of the Darss – Limhamn Ridge is considered a different population from the rest of the Baltic/Belt Sea (Börjesson and Berggren 1997, Huggenberger et al. 2002, Tiedemann et al. 1996). Joint activities of ASCOBANS and the IWC have underlined the precarious situation in which the stock seems to be. With the exception of our observations during flights in May and August sighting rates are extremely low. Two cruises of the IFAW sailing boat 'Song of the Whale' between Darss ridge and the Bay of Gdansk in Poland in July/August 2001 and 2002 have revealed only single sightings or acoustic detection in the area (Gillespie et al., 2002). It seems unlikely that the stock is much larger than the 599 animals (CV = 0.57) estimated for 1995. Recent observations in Puck Bay (inner Bay of Gdansk) found very few animals (Berggren, pers. comm.). By-catches of harbour porpoises in Puck Bay are on average 2.2 a year (a total of 22 animals from 1990 to 1999) (Kuklik and Skóra 2000, in press). Further research is needed to find out if the animals that were sighted east of Rügen belong to the western or eastern population. This can only be done when strandings are sampled and the samples analysed in terms of morphology and genetics. The flights are continuing in the winter and spring and the collection and analyses of this data will hopefully give us with more insight into the distributional patterns of porpoises.

In areas that might only be used for a very limited period in space and time, the use of a continuous method of monitoring, such as stationary acoustic devices (e.g. PODs – porpoise detectors) would be useful. The PODs will store data 24 hours per day and can detect animals when they move into an area, provided the animals move close enough to the POD. In this respect, PODs could be especially useful in areas with very low densities of porpoises and animals are moving a lot. Survey effort in low density areas would have to be extremely high to obtain any reasonable results.

The aerial surveys in German waters in the course of summer of 2002 yielded information on distribution of porpoises that was new and in some respects unexpected. The main results were large aggregations and high densities of porpoises found in area C in the North Sea and in area G in the Baltic Sea. The continuation of the flights into autumn and winter 2002 led to a better coverage in both North and Baltic Sea as well as collect information on possible changes in distribution throughout the year. Large-scale information on abundance, distribution and stock identities are necessary to put the observations from this study into a broader context. A second survey similar to the SCANS 1994 survey is urgently needed in order to assess the current status of the harbour porpoise. Plans for such a survey are currently underway for the years 2004 and 2005.

Acknowledgements

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