Agenda Item 5.1

Implementation of the Triennium Work Plan (2010-2012)
Review of New Information on Population Size, Distribution, Structure and Causes of Any Changes

Document 5-05 rev.1

Opportunistic Sightings of Harbour Porpoises (*Phocoena phocoena*) in the Baltic Sea at large – Kattegat, Belt Sea, Sound, Western Baltic and Baltic Proper

Action Requested

- Take note of the report

Submitted by

Germany

NOTE:
IN THE INTERESTS OF ECONOMY, DELEGATES ARE KINDLY REMINDED TO BRING THEIR OWN COPIES OF DOCUMENTS TO THE MEETING

Secretariat's Note

Germany requested the Secretariat to make the following web address available to participants, where the latest harbour porpoise sightings map can be accessed: http://www.bfn.de/habitatmare/de/spezielle-projekte-schweinswalsichtungen-2009.php.

The attached document was not changed. This revision affects the cover page only.

Opportunistic Sightings of Harbour Porpoises (*Phocoena phocoena*) in the Baltic Sea at large – Kattegat, Belt Sea, Sound, Western Baltic and Baltic Proper

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ABSTRACT: In order to supplement current knowledge on trends in harbour porpoise (*Phocoena phocoena*) occurrence, incidental sightings of harbour porpoises have been collected in the Baltic Sea. During the seasons 2003 - 2008 a total number of 5561 sightings were collected and saved for further analysis. Seasonal variation of harbour porpoise sightings, group size and group composition were examined. Sightings with juveniles (n = 539) were of special interest and were therefore analysed separately. Possible calving and nursing grounds (proposed by KOSCHINSKI, 2002) have been mapped together with all juvenile sightings in order to see if there are any notable clusters of juvenile sightings within these (or other) areas. To investigate seasonal and spatial trends in porpoise densities, sightings were divided into five different geographical and five different temporal subsets. Corresponding indices of relative density were computed using an adaptation of an effort correction method, described by COOKE (1984). Obtained results indicate that the seasonal distribution of porpoise sightings largely reflects the activity patterns of water sports enthusiasts. The group size was relatively small as in most sightings one single individual was observed. Very few reports refer to sightings of more than five individuals. Sightings with juveniles were found in nearly all proposed calving and nursing grounds, and three additional areas with a cluster of juvenile sightings could be identified. Harbour porpoise densities were found to severely decline from (north-) west to (south-) east in the western Baltic Sea. A seasonal variation in porpoise densities was detected at the end of summer with dropping densities in August and September. The study shows that incidental sightings of non-professional observers do have scientific value and provide data for various analyses concerning porpoise distribution, occurrence, and density.

KEY WORDS: Harbour porpoise · Incidental sightings · Relative density · Distribution

Introduction

Harbour porpoises (*Phocoena phocoena*) are small odontocete whales with a wide range in coastal waters in the northern hemisphere, including vast parts of European waters. While some stocks are relatively stable and healthy, the sub populations of the Baltic Sea and the Black Sea cause great concern among conservationists (ASCOBANS, 2002; REEVES *ET AL.*, 2003; IUCN, 2010).
In the Baltic Sea the harbour porpoise (subspecies *P. p. phocoena* or North Atlantic Harbour Porpoise) is the only permanently abundant and reproducing cetacean species (e.g. HAMMOND *ET AL.*, 2002; SIEBERT *ET AL.*, 2006; SCHEIDAT *ET AL.*, 2008; SIEBERT *ET AL.*, 2009).

There is widely accepted evidence from genetic, morphological, and contaminant load studies that there are at least two subpopulations in the Baltic Sea that most likely form isolated reproductive entities (TIEDEMANN *ET AL.*, 1996; BØRJESSON & BERGGREN, 1997; WANG & BERGGREN, 1997; BERGGREN *ET AL.*, 1999; HUGGENBERGER *ET AL.*, 2002, reviewed in EVANS *ET AL.*, 2009). One subpopulation is referred to as 'Baltic Proper', which includes animals that live east of the Darss and Limhamn underwater ridges (cf. Fig 1). The other subpopulation 'Inner Danish waters' is expected to live westwards of this putative demarcation line. Once numerous in vast parts of the Baltic Sea with confirmed sightings up to the northern Gulf of Bothnia, the harbour porpoise has shown a sharp decline since the middle of the 20th century (reviewed in KOSCHINSKI, 2002). Aerial and ship-based surveys revealed that porpoise densities decline drastically from west to east (HIBY & LOVELL, 1996; BMBF, 1997; HAMMOND *ET AL.*, 2002; HIBY & LOVELL CITED IN SCHEIDAT *ET AL.*, 2008). Very recent publications, which utilised different survey methods, indicate prevailing low densities in Baltic waters with a strong correlation between geographical longitude and porpoise presence (GILLESPIE *ET AL.*, 2005; COOKE *ET AL.*, 2006; SIEBERT *ET AL.*, 2006; VERFUß *ET AL.*, 2007; SCHEIDAT *ET AL.*, 2008; TEILMANN *ET AL.*, 2008).

Although other possible reasons which might have supported this decline are discussed, there appears to be agreement that accidental bycatch in fisheries has played a major role and is currently preventing successful recovery (ASCOBANS, 2002; BERGGREN *ET AL.*, 2002; KOSCHINSKI, 2002; SCHEIDAT *ET AL.*, 2008; HERR *ET AL.*, 2009). A conservative estimate for the years from 2005 to 2007 yields an annual mortality rate of 2.7% to 7.8% of the whole porpoise population in the German part of the Baltic Sea due to accidental bycatch in fishing nets (KOSCHINSKI & PFANDER, 2009, calculation is based on most recent stock estimates by SCHEIDAT *ET AL.*, 2008).

If no adequate measures are implemented to mitigate threats, especially accidental bycatch, it is likely that the Baltic harbour porpoise will face the same struggle as the Baiji (*Lipotes vexillifer*) did and the Vaquita (*Phocoena sinus*) currently does. To prevent further decline, ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas) developed a recovery plan for the Baltic harbour porpoise – The Jastarnia Plan (ASCOBANS, 2002, 2009).

In order to strengthen and support the goals of the Jastarnia Plan, the Society for the Conservation of Marine Mammals (GSM) picked up an idea from colleagues in Denmark ('Fokus på hvaler i Danmark', KINZE *ET AL.*, 2003) and launched the project 'Sailors on the Lookout for Harbour Porpoises' in Germany which has been running from 2002 onwards (DEIMER *ET AL.*, 2003). The project provides a platform to report sightings of harbour porpoises. On the one hand, the project raises awareness for the harbour porpoise and its situation in the Baltic Sea and on the other hand, the submitted sightings provide data for scientific analyses.

In the present study, we analysed data of incidental sightings from the Baltic Sea which were collected between 2003 and 2008. Different descriptive parameters such as the seasonal distribution of sightings and the group size were determined. All sightings with juveniles were of special interest and were therefore examined separately according to their spatial and seasonal distribution. Further, it was evaluated if there are any seasonal or spatial trends in calculated porpoise densities. Another objective of this study was to increase knowledge about the question how incidental sightings of non-professional observers can be analysed and interpreted from a scientific perspective (as shown in previous studies by EVANS, 1976, 1980; KINZE *ET AL.*, 2003; DEIMER *ET AL.*, 2004; COOKE *ET AL.*, 2006).

Material and Methods

In total, 5605 detailed reports of harbour porpoise sightings were obtained during six seasons (2003 - 2008) of the project 'Sailors on the Lookout for Harbour Porpoises'. All sightings were reported according to a questionnaire (cf. Fig. 1 in annex). The public appeal to report sightings focused on 400 groups of interest at the German coast, including harbours, marinas, sailing associations, camping grounds, and local authorities such as customs authorities, coast guard administration, and waterway police. The following data subset of each reported sighting was used for analysis: Date, time, description of area, GPS coordinates, minimum number of sighted porpoises, thereof juveniles (minimum number), name of vessel, and the name of observer. All sightings that were reported anonymously or without exact geographical position (either by GPS, landmarks or nautical navigation marks) were omitted. Descriptions of position were converted into geographical coordinates by a qualified geographer. As coordinates reported by sailors varied in their accuracy, some specifying only degrees and minutes, others reporting seconds as well, the critical value for inclusion of sightings was set to 1.5 geographical minutes (= 1.5 nm [nautical miles] comparable to 2.8 km). Thus, all sightings with degrees and minutes as position information were included and a tolerance of 0.5 nm was given for all positions.

For this study the term 'Baltic Sea at large' was defined as the waters south of a west-east line between Skagen, Denmark, and the Swedish coast (cf. Fig. 1). This delineation was chosen since further north the likelihood increases that sighted animals do not belong to the Baltic population. The Kattegat was included as recent telemetry studies strongly indicate that harbour porpoises from the Kattegat are most likely not to be coherent with animals of the North Sea but with animals of the waters further south and east into the Baltic Sea (TEILMANN *ET AL.*, 2008). After applying these inclusion criteria, a data set of 5561 sightings remained and served for further analysis.

The different descriptive and inferential parameters which were determined are explained below. As it is of special interest where and when juveniles occur, all sightings with juveniles were analysed separately whenever possible. For spatial analyses the program ArcGIS 9.3 (ESRI Corporation) was used. Statistical exercises were performed with SPSS (SPSS Inc.) and all necessary target figures were generated in MS Access (Microsoft Corporation).

Seasonal variation of porpoise sightings

Pooled data sets (2003 - 2008) were divided by month and their corresponding percentage of all sightings was displayed in order to detect any seasonal variation. All sightings with juveniles where divided and displayed accordingly.

Group size and composition

To explore the group size and composition of sightings, all data was grouped into different categories which were defined after a first review of all reports. The group composition was examined with reference to whether the group consisted solely of adult animals or whether juveniles were present. For sightings with juveniles it was examined how often the assumption of a ratio of at least 1:1 (adults : juveniles) was violated.

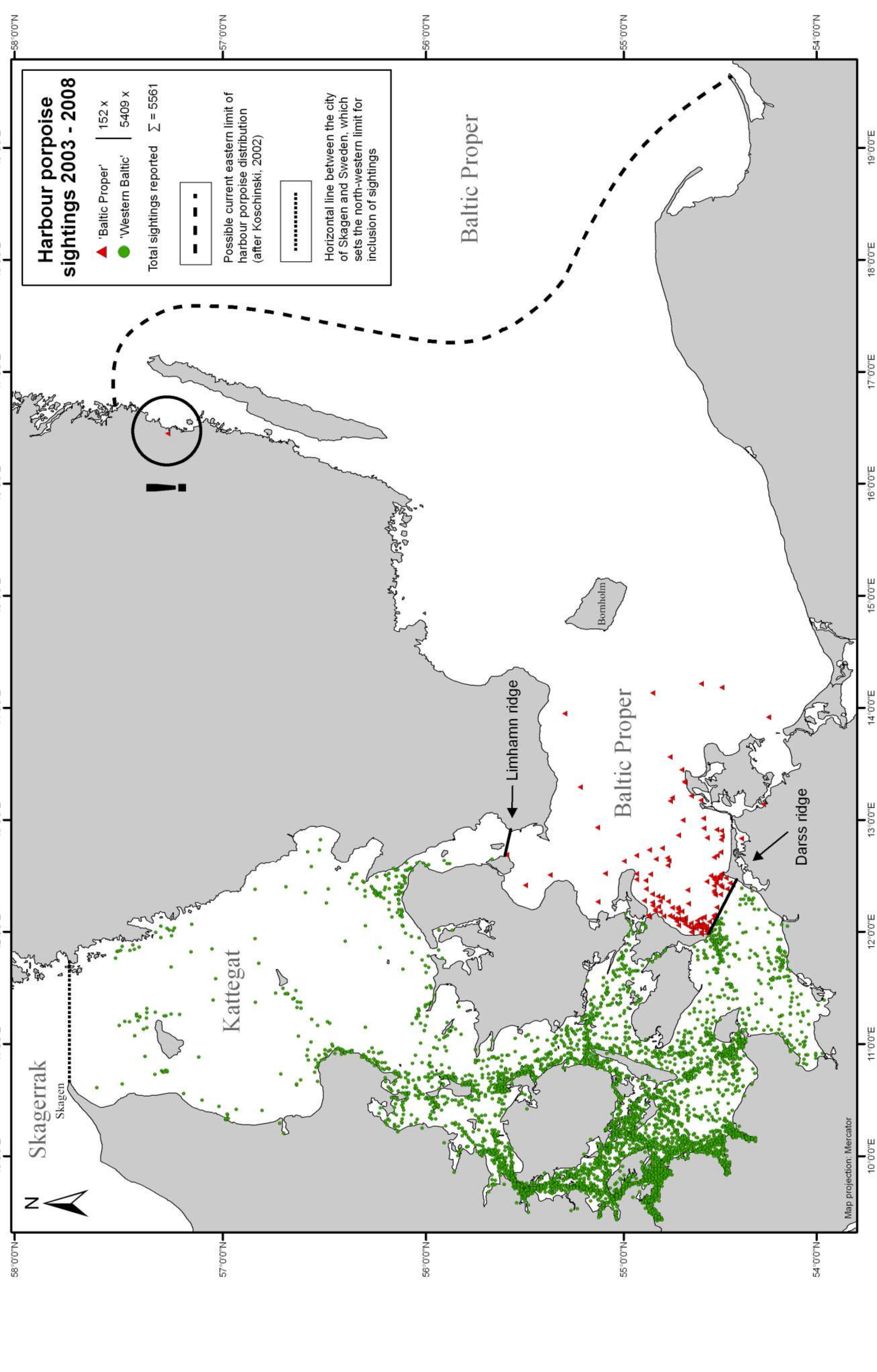

Fig. 1. All harbour porpoise sightings (2003 - 2008) which were included in analysis

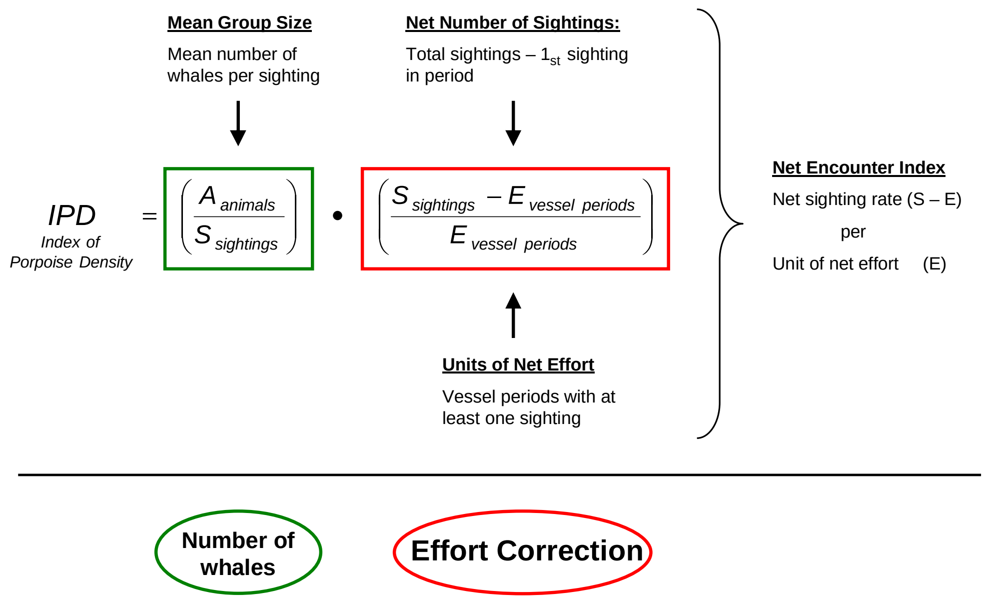

Fig. 2. Formula for effort correction of porpoise densities (after COOKE, 1984 and 2006)

Although this procedure does not consider the effect of possible 'nursing schools', it can be interpreted that reports with a lower ratio than 1:1 indicate less reliability, since for each juvenile there should be at least one corresponding adult (mother) animal (SCHULZE, 1996).

Index of porpoise density (IPD)

Incidental sightings of whales by definition do not involve effort measurements. However, in order to obtain an index of porpoise density, an effort measurement is required. To solve this problem, an adaptation of an effort correction method, described by COOKE (1984, 2006), was used. In the original paper the author demonstrates that a sightings per unit of effort index (SPUE) calculated on the basis of sightings per net sighting period (S/NSP) is proportional to an SPUE index which is calculated on the basis of sightings per gross sighting period (S/GSP). The net sighting period (NSP) is a unit of effort which is constructed for a dataset of incidental sightings. It is referred to as a certain amount of time. Taking into account the proportional relation of the two SPUE indices mentioned above, the constructed net effort measure enables to calculate a corrected SPUE index with data sets that lack records of gross periods without sightings (= true effort measures). The utilised mathematical formula is shown in Fig. 2. A detailed description of the effort correction method can be found in COOKE, 1984 and LOOS, 2009.

For density calculations five different geographical subsets labelled Great Belt (GB), Little Belt (LB), Flensburger Foerde (FF), Kiel Bight (KB), and Mecklenburg Bight (MB) were used to divide the data set (cf. Fig. 7). These areas were defined after reviewing where a homogeneous dispersion of sightings occurred. For the calculation of seasonal densities, the dataset was divided by month. Due to sparse coverage, sightings before 08:00 h and after 20:00 h were omitted as well as sightings that were earlier than May or later than September.

The Fredericia Channel in the Little Belt was excluded from analysis as the narrow waterways produce an unnatural bias towards a high concentration of sightings for which the effort correction method is not designed.

In order to obtain porpoise densities, an SPUE index or net encounter index (cf. Fig. 2) had to be determined. Therefore, the records of each vessel were grouped into 4-hour periods (1 = 08:00 h - 12:00 h / 2 = 12:00 h - 16:00 h / 3 = 16:00 h - 20:00 h) to construct a net effort measure. The result of this exercise is a data set that consists of vessel periods which contain at least one sighting. A vessel period represents the unit of net effort to which sightings can be assigned to, thereby filtering all dependent data of one boat (or person). The net encounter index functions as a basis on which the effort correction method can operate. It will be numerically small if a lot of vessel periods (effort) occurred in the data set and thereby scale down porpoise density and vice versa. Thus, the formula corrects overestimates in popular sailing areas and underestimates in rarely frequented waters. The calculated values yield the relative density as the number of harbour porpoises encountered per 4 h period per stratum or per month (density unit = animals / 4 h / stratum or month).

Seasonal and regional variation of porpoise densities

With the calculated indices of porpoise density (cf. annex, Tab. 1 and 2) a number of Spearman rank correlations were conducted. First, overall densities for the whole area (covered by all five strata) were correlated to the six levels of years (2003 - 2008) in order to monitor a possible overall trend in porpoise density. Further, it was checked whether there is a correlation between overall densities of each month (2003 - 2008, all strata) and the sequence of months (May to September).

A possible correlation between total densities (2003 - 2008) per stratum and the geographical sequence of strata from (north-) west to (south-) east was tested by giving each stratum a rank according to its geographical position. The ranking was as following: Great Belt = 1, Little Belt = 2, Kiel Bight = 3, and Mecklenburg Bight = 4. Because of an extraordinary high sampling rate compared to all other areas, the stratum 'Flensburger Foerde (FF)' was not included in this particular correlation analysis as it could have masked a possible overall trend between the four large areas.

Calving and nursing grounds

As there are several regions that have been identified as possible calving and nursing areas (reviewed in KOSCHINSKI, 2002), juvenile sightings were plotted separately using a map that shows all proposed calving grounds. It was intended to assess whether there are any obvious clusters within these calving grounds or elsewhere.

Results

A summary of all analysed sightings (2003 - 2008) is shown in Fig. 1. More detailed maps with all sightings of each year can be found in Fig. 2 to 7 in the annex. Most of the reports originated from waters west of the Darss and Limhamn ridges (n = 5409), whereas relatively few sightings were reported from the 'Baltic Proper' (n = 152). In six years, only one sighting was reported east of the island of Bornholm. This report of two adult animals off the Swedish east coast dates back to the year 2005 and is highlighted in the map by an exclamation mark (cf. Fig. 1).

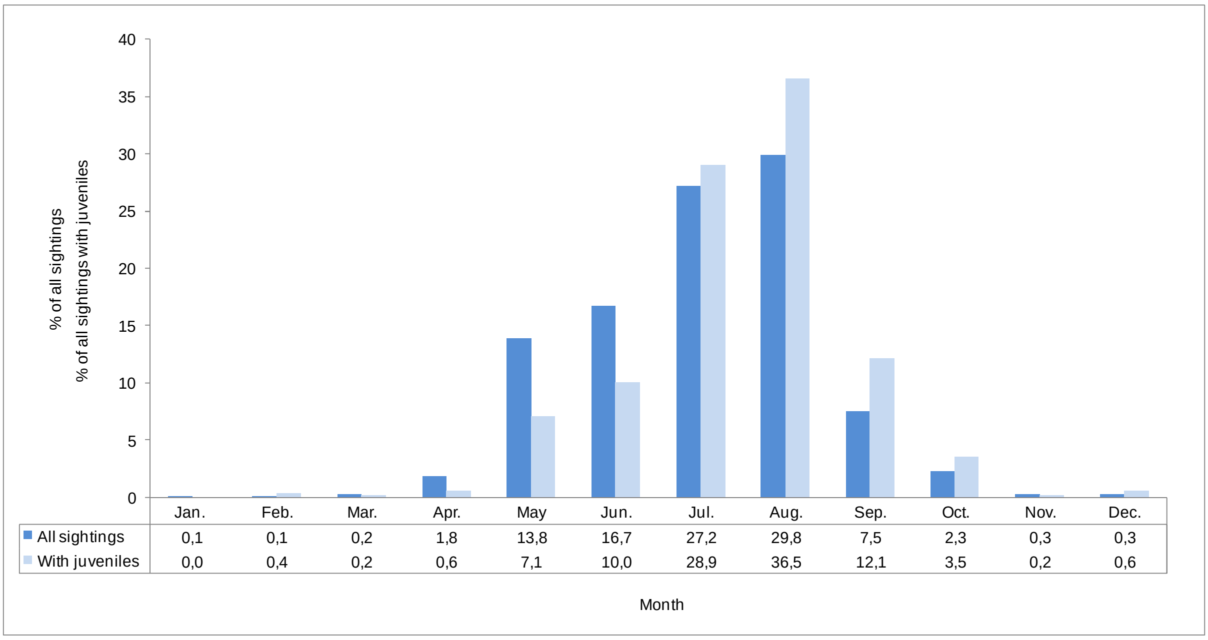

Fig. 3. Seasonal distribution of all sightings (n = 5561) and sightings with juveniles (n = 539)

Seasonal variation of porpoise sightings

The vast majority of sightings was reported in the summer months from June to August (73.7%, n = 4096). Fewest sightings were registered during the winter months December, January, and February (0.5%, n = 24). During the spring months March, April, and May the number of sightings increased gradually (15.8%, n = 882). Contrariwise numbers of reported sightings declined gradually in the autumn months September, October, and November (10.1%, n = 559). The 539 sightings with juveniles had a similar distribution with peaks in summer (75.4%, n = 407) and lower proportions in winter (1.0%, n = 5). A detailed overview of the seasonal distribution of all sightings and sightings with juveniles is presented in Fig. 3.

Group size and composition

The proportions of sightings per group class are illustrated in Fig. 4. They indicate that in 96.0% of all sightings a group size of one to five animals was reported. Only very few sightings of larger groups were recorded. The overall proportion of sightings with juveniles was 9.7% (n = 539). A clear trend towards one calf per sighting could be determined as this was the case in 84.6% of all sightings with juveniles. In 12.8% of all juvenile sightings a minimum ratio of 1:1 (adults : juveniles) was violated, meaning that more juveniles than adults were identified.

Index of porpoise density (IPD)

Overall indices of porpoise density (2003 - 2008) by area are associated with the different strata and illustrated in Fig. 7. A summary of sightings and IPD by area and by month is presented in Fig. 5 and 6. The IPD values that form the basis for Fig. 5 and 6 are highlighted with an arrow at the bottom of Tables 1 and 2 in the annex.

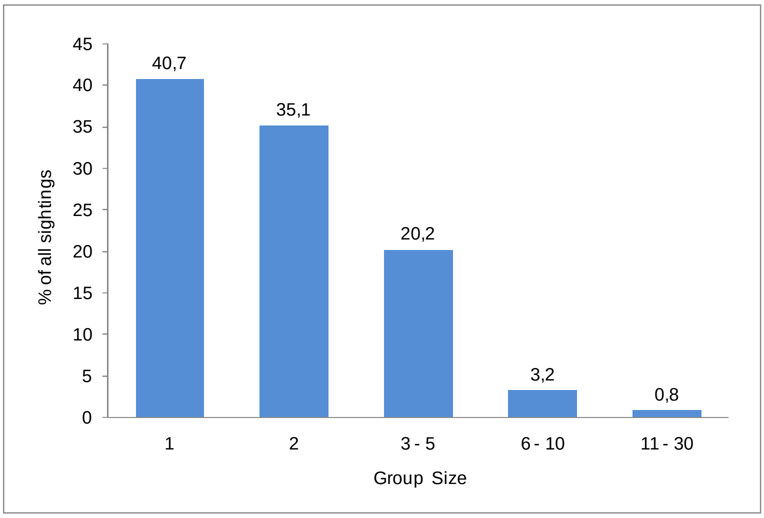

Fig. 4. Percentage of total sightings per group class

It is clearly apparent that areas with high numbers of sightings do not necessarily have a high IPD. For instance, from the raw numbers of sightings it could be interpreted that many harbour porpoises are living in Kiel Bight (cf. Fig. 5). The effort correction formula adjusts this impression by taking into account the high effort that exists in this area (cf. Table 1 in the annex), thus factoring in that this area is highly frequented by sailors and therefore yields the second highest number of sightings. IPD in Kiel Bight is therefore downsized by the effort correction formula. For densities by month the same correction effect can be inferred from the results (cf. Fig. 6).

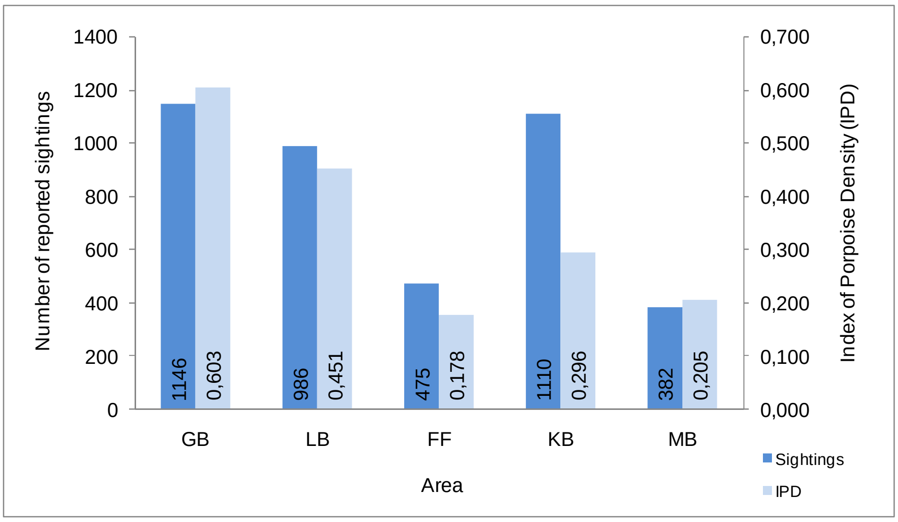

Fig. 5. Sightings and IPD by area

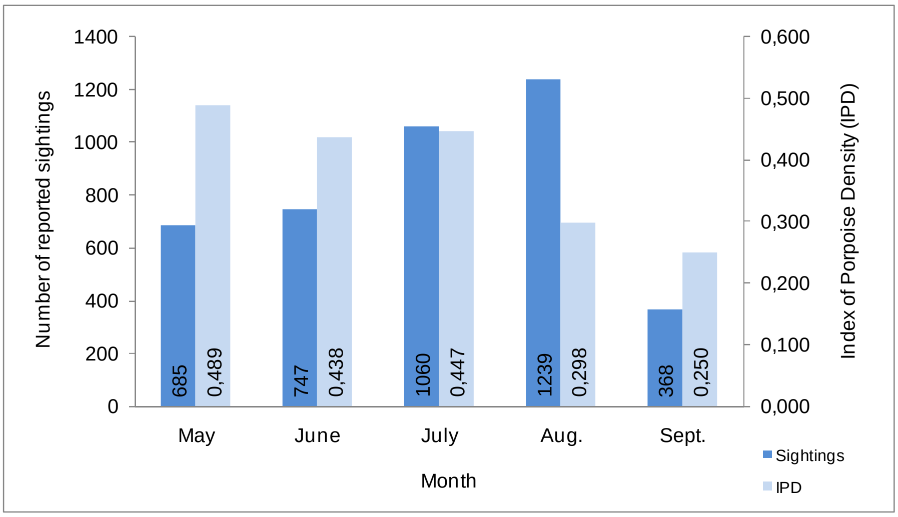

Fig. 6. Sightings and IPD by month

Seasonal and regional variation of porpoise densities

A negative trend that was close to significance could be detected between overall densities of the whole area (covered by all five strata) and different levels of years (r_S = - 0.771, N = 6 years in ascending order, highlighted in red in annex Table 1, $p = 0.072$).

Densities for each month (pooled dataset from 2003 - 2008) were higher during the months of May, June, and July and declined in August and September (cf. Fig. 6). A significant negative trend could be found for these densities and the sequence of months, indicating a decrease of porpoise density from May to September (r_S = -0.900, N = 5 months in ascending order, highlighted in blue in annex Table 2, $p = 0.037$).

The correlation analysis of total densities per stratum (pooled data set from 2003 - 2008) and the sequence of strata yielded a significant negative trend in porpoise density from (north-) west to (south-) east (r_S = -1.000, N = 4 areas ranked from (north-) west to (south-) east, highlighted in green in annex Table 1, $p < 0.01$).

Calving and nursing grounds

Relating all reported sightings with juveniles to possible calving and nursing grounds (after KOSCHINSKI, 2002) showed that there are confirmed observations of juveniles in each of the proposed areas except for the area around the island of Laesoe ('0' cf. Fig. 8). Very high numbers of sightings with juveniles could be found in the Fredericia Channel in Denmark ('121'). Another high proportion of sightings with juveniles within a relatively small area was found in the northern Great Belt ('17', plus surrounding sightings) and around the island of Drejoe ('21'). Three additional areas were noticeable because they showed a cluster of juvenile sightings within a relatively small area. These were the Flensburger Foerde ('88'), an area around Eckernfoerde Bight and Kieler Foerde ('85'), and the waters southwesterly off the island of Fehmarn ('15').

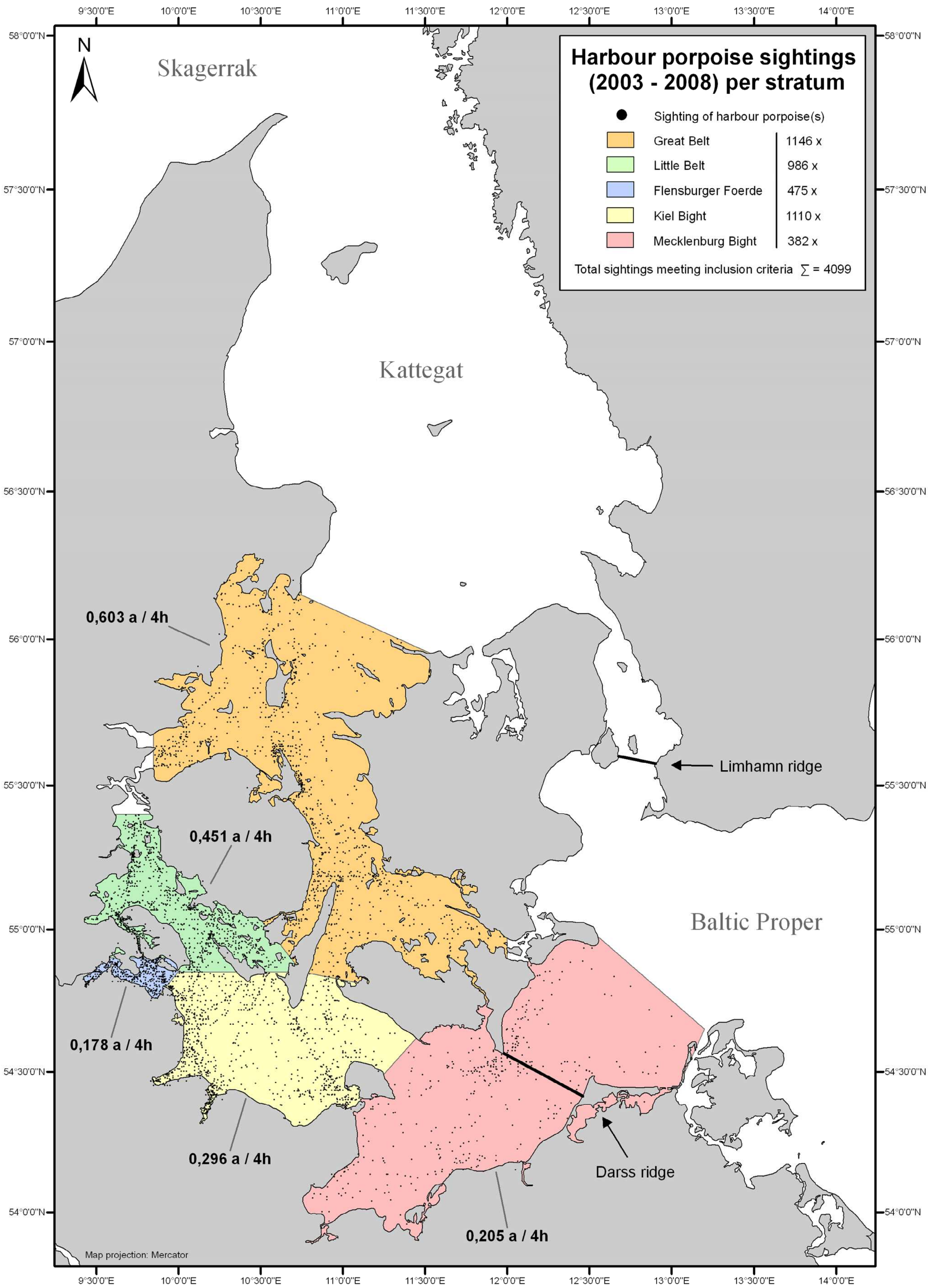

Fig. 7. Analysed strata with corresponding indices of porpoise density (IPD)

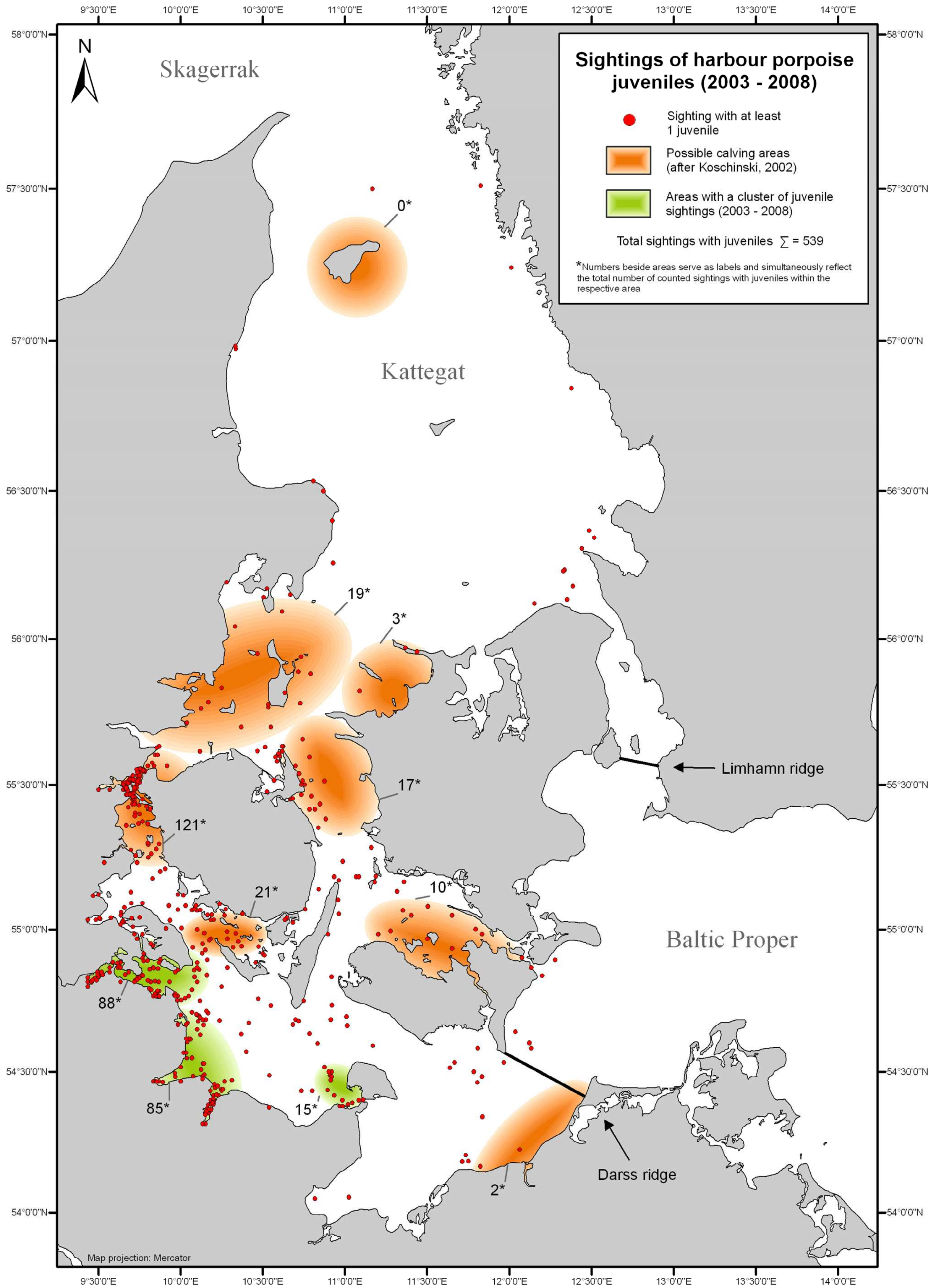

Fig. 8. Sightings with juveniles and proposed calving and nursing grounds

Discussion

The analysis of the sightings data showed that the vast majority of sightings occurred in western Baltic waters (west of the island of Ruegen) and only very few sightings originated from more easterly waters (cf. Fig. 1). This is most probably due to the fact that many harbours and marinas are located in western Baltic waters, the proximity to home ports is good, wind situations are advantageous, many tourist facilities are available, and the level of security is high.

The maps in Fig. 2 - 7 in the annex show that numbers of reported sightings increased from year to year. In the year 2008 more than twice as many sightings were reported as in 2003. This is not due to growing harbour porpoise populations, but to successful advertising efforts undertaken by the Society for the Conservation of Marine Mammals (GSM) as new project partners are sought every year.

Seasonal variation of porpoise sightings

The vast majority of sightings is reported in the summer months (cf. Fig. 3). This is most probably not due to a seasonal pattern of harbour porpoise occurrence, but to seasonal peaks in activity of water sports enthusiasts. These peaks in activity produce a high amount of effort especially during the yachting season which coincides with summer vacations in Germany. A similar distribution of sightings was found by a Danish incidental sightings program (KINZE *ET AL.*, 2003).

The same applies to the seasonal distribution of sightings with juveniles. Recent studies of stranded animals revealed that the birth period in the Baltic Sea occurs from July to August (HASSELMEIER *ET AL.*, 2004). Together with this information the seasonal distribution of sightings with juveniles may be related to the occurrence of juveniles as the exact same peaks are found (cf. Fig. 3). In July and August, over 65% of all sightings with juveniles were reported. This confirms that during the summer months highly sensitive processes take place – calving and nursing. The birth and nursing period in summer should be taken into account when assessing possible impacts of economic utilization of Baltic waters.

Group size and composition

Single animals and pairs predominated the records, thus indicating that group sizes of harbour porpoises tend to be quite small (cf. Fig. 4). Groups of three to five animals were sighted regularly but represented only about 20.0% of all sightings. Similar results were found in the Danish incidental sightings program, where one and two animals per sighting also comprised the vast majority of records (KINZE *ET AL.*, 2003). In 539 sightings (9.7% of all records), juveniles were observed. This proportion appears to be fairly low as it can be expected that since 2003 there have been many more juveniles in the examined proportion of the Baltic Sea. This bias might be due to the fact that it is quite difficult to spot porpoises in general and even more difficult to assess if one of the animals was a juvenile. Even experienced experts have trouble to detect (adult) porpoise schools in sea states exceeding two Beaufort (HAMMOND *ET AL.*, 2002).

It also has to be noted that there might be a sampling bias towards a smaller group size and a smaller number of identified juveniles as sailors are asked to report only the certain number of sighted whales and certain sightings of juveniles. But even if a slight bias is considered, the results correspond well to the biology of harbor porpoises which tend to live in small groups and have one calf per season (SCHULZE, 1996).

The relatively low proportion of violations of a ratio of 1:1 (adults : juveniles, 12.8%) indicates that if environmental conditions (sea state, visibility etc.) allow an identification of juveniles, sailors are fairly competent in distinguishing juvenile harbour porpoises from adult ones. This test does not consider the effects of possible 'nursing schools', where ratios of 1:2 (or lower) are normal. However, it can be regarded as an appropriate first measure of reliability, which indicates that it is legitimate to trust in reports of juveniles.

Index of porpoise density (IPD)

It has to be noted that the calculated densities are relative indices which are proportional but not equal to density indices with exact effort measurements or gross sighting periods (cf. COOKE, 1984). Therefore, it is possible to compare different areas among each other but not to infer absolute values for densities. Another important aspect is that the sample size must not be too low. Otherwise the effort correction method cannot distinguish if there was an absence of effort or an absence of porpoises.

Seasonal and regional variation of porpoise densities

The correlation analysis for the overall density (all five strata) and the different levels of years (2003 - 2008) showed a slight negative trend within a narrow interval of densities (0,451 - 0,349 animals / 4 h) that was close to significance. This allows the assumption that overall stocks of harbour porpoises (within the study area) might have shown a slight decline over the last six years. However, the results are not significant but only close to significance and therefore a decline can only be assumed but not be validated. Other authors found indications for declining stocks and high anthropogenic mortality in the Baltic Sea (reviewed in KOSCHINSKI, 2002; BERGGREN *ET AL.*, 2002; SIEBERT *ET AL.*, 2006; SCHEIDAT *ET AL.*, 2008; HERR *ET AL.*, 2009; KOSCHINSKI & PFANDER, 2009; SIEBERT *ET AL.*, 2009). Including this additional information and considering a precautionary approach, it appears important not to discredit results because of being only close to significance, but to be aware of a possible negative trend over the last six years.

A significant negative trend between porpoise density per month (2003 - 2008) and the ascending order of months could be detected. This seasonal decline is quite sharp as during May, June, and July densities are nearly constant (≈ 0,450 animals / 4h) and drop down in August and September (≈ 0,270 animals / 4h). Possible reasons for this decline could be migration patterns since harbour porpoises are known to swim vast distances (TEILMANN *ET AL.*, 2008) and there is widely accepted evidence that harbour porpoises have a complex migration behaviour (reviewed in KOSCHINSKI, 2002). With the data collected during this study no conclusions concerning spatial conditions (location, pathways, direction) of migration can be drawn. It can solely be stated that there seems to be a shift in porpoise densities from July to August which could be due to migration behaviour.

One of the most interesting outcomes of this study is the significant decline of porpoise densities from (north-) west to (south-) east. The (north-) westerly stratum 'Great Belt (GB)' showed the highest density. A gradual decline is apparent via stratum 'Little Belt (LB)', followed by 'Kiel Bight (KB)', and ending in 'Mecklenburg Bight (MB)', which showed a very low density. IPD in Mecklenburg Bight was three times lower than IPD in Great Belt, thus indicating that there is a sharp decline in density within a relatively small part of the Baltic Sea. These findings are consistent with other studies on the abundance of harbour porpoises in the Baltic Sea (HAMMOND *ET AL.*, 2002; SIEBERT *ET AL.*, 2006; VERFUß *ET AL.*, 2007; SCHEIDAT *ET AL.*, 2008).

The stratum 'Flensburger Foerde (FF)' showed the lowest density of all strata, suggesting that more detailed research in this area could be of interest. There are several local experts who consider the Flensburger Foerde to be a crucial habitat for harbour porpoises and therefore pledge to designate the whole region as a marine protected area (PFANDER PERS. COMM.; KOSCHINSKI PERS. COMM.). The findings of this study support these pledges as the lowest IPD was found in the Flensburger Foerde and simultaneously a considerable number of juvenile sightings was reported from this region (cf. Fig. 8), suggesting that this area is an important habitat with a low density. A recently published study from Denmark also stresses the importance of this region and ranked the Flensburger Foerde as a habitat of 'high importance, rank = 1' for harbour porpoises (TEILMANN *ET AL.*, 2008).

The detected decline from (north-) west to (south-) east gives reason for concern. As a matter of fact, harbour porpoises were once present in great numbers throughout the whole Baltic Sea and have not yet been able to repopulate their former range (KOSCHINSKI, 2002). Anthropogenic mortality remains high and is regarded to be the main factor preventing recovery, especially through accidental bycatch (ASCOBANS, 2002; BERGGREN *ET AL.*, 2002; SIEBERT *ET AL.*, 2006; SCHEIDAT *ET AL.*, 2008; HERR *ET AL.*, 2009; KOSCHINSKI & PFANDER, 2009; SIEBERT *ET AL.*, 2009). Therefore, harbour porpoises will most likely not recover successfully, but rather get closer to the brink of extinction, unless effective mitigation measures are implemented instantly.

Calving and nursing grounds

Harbour porpoises are highly mobile marine mammals, therefore, possible calving grounds can only be referred to as approximate areas without sharp borders. From obtained records it can solely be inferred where young animals were definitely present.

No ranking between the areas can be provided as actual densities of juveniles in areas with a high number of juvenile sightings might actually be lower than in areas with less juvenile sightings, due to varying effort. No adjustment to differing effort was possible as the effort correction method is not applicable to calculate relative densities within each proposed calving ground because the sample size is too low.

Most juvenile sightings originate from western Baltic waters. Besides an effort bias, it has to be considered that the eastern parts of the Baltic Sea have a much smaller amount of coastline in comparison to the western parts (e.g. the Belt Sea). As there is evidence that juveniles are born and nursed in shallow waters close to shore (KOSCHINSKI, 2002), the western parts of the Baltic Sea could be a popular area for mothers and their offspring and thus more juveniles are sighted within these coastal waters.

Incidental sightings – Advantages, shortcomings and improvements

All data on incidental sightings of whales has to be interpreted cautiously as the quality of this type of data depends on different external factors such as the willingness of observers to report their sightings, activity levels of participators (variation of effort), changing environmental conditions that affect the activity of participants, different levels of knowledge and experience of voluntary observers, and other effects that influence participants (number of harbours within a region, tourist attractions, and security). These shortcomings can lead to sparse coverage in certain areas, misidentification of group size or juveniles, and misidentification of whale species.

Different methods can be applied to overcome these restrictions. A very helpful tool is the effort correction method which allows to derive relative porpoise densities from sightings data that lack effort measures. The willingness to report sightings can be enhanced by dedicated campaigns to inform the public. This is particularly true for cetaceans as whales are credited with a high level of sympathy and most people can instantly relate to these animals.

Problems with misidentification of whale species are of minor importance in the Baltic Sea as harbour porpoises are the predominant cetaceans throughout the whole area and (once detected) show their very distinctive surfacing behaviour and triangular dorsal fin. The different levels of knowledge among observers can be adjusted by providing a comprehensive briefing prior to cruises. This can be realised by a detailed sightings sheet, additional information sheets, and online resources. Experience throughout the years showed that the vast majority of voluntary observers is willing to learn about new facts and information on porpoises. Most people are so enthusiastic and thrilled by the encounter of harbour porpoises that they demand more information on their own initiative.

In order to get more reports from areas with sparse coverage, it is intended to further the collaboration with very enthusiastic observers who are willing to collect more detailed information, especially complete data logs of the cruise track and measurements of sighting effort. For these participants special briefing and information material has been developed such as the 'Log Sheet for Cruise Tracks', which records the geographic coordinates every two hours and thereby provides data on effort (time) and identifies the surveyed area. Thus, it is possible to determine densities in areas with sparse coverage, especially in the eastern parts of the Baltic Sea.

Another possible method to increase the resolution of calculated densities (current densities are calculated for five relatively large areas) is to relate sightings to a grid with effort measurements. Different information on the availability and size of harbours, the amount of coastline (more interaction possibilities for sailors), and the presence of popular cruise tracks can be related to grid cells in a geographical information system (e.g. ArcGIS) and sightings data per grid cell can be weighted according to inferred effort within the respective grid cell.

In order to check whether the accuracy of current density indices can be enhanced, it is also possible to fit mathematical models to the data. As sightings data is made up of counts, log-linear models would have to be fitted assuming an (overdispersed) Poisson distribution. This exercise would show if any fine adjustment of density indices is reasonable.

As previous studies showed, it is very useful to extend incidental sightings programs to ferry companies and other commercial operators in the Baltic Sea (KINZE *ET AL.*, 2003). Data obtained by briefed staff can be related to effort information as ferries or cargo ships usually operate in the same areas with a constant amount of effort. Since commercial operators do not necessarily depend on seasonal conditions, they could provide data of months that are now underrepresented because virtually no water sports activities take place (especially in winter). Another possible group of interest are amateur pilots, who could report aerial sightings of harbour porpoises.

It is intended to combine the records of the Danish incidental sightings program (KINZE *ET AL.*, 2003, over 3000 sightings) with the data set of this study. With this joint data set the years of 2000 to 2009 will be covered, thus promising to provide a broader basis for calculations.

Final conclusion

Analysis works best if adequate methods are applied to overcome restrictions of incidental sightings. There is no doubt that dedicated surveys are superior concerning their scientific output. The scientific goal of incidental sightings programs is rather to supplement aerial surveys and acoustic monitoring. The advantage of incidental sightings programs over dedicated surveys is that the public can be included and participate actively. Since the public opinion has a substantial impact on decision makers (politicians), it is vital to constantly inform the public about the serious situation of the Baltic harbour porpoise. Therefore, the final conclusion of this study is that best conservation achievements can be expected if dedicated surveys (high level of accuracy) and incidental sightings programs (high publicity effect) are run simultaneously as decision makers want a high scientific output and need a strong public opinion.

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References

ASCOBANS - Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas, (2002) Recovery Plan for Baltic harbour porpoises (Jastarnia Plan). ASCOBANS, Bonn, www.service-board.de/ascobans_neu/files/recoveryplan.pdf

ASCOBANS - Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas, (2009) Recovery Plan for Baltic harbour porpoises (Jastarnia Plan) - Revision. ASCOBANS, Bonn, http://www.service-board.de/ascobans_neu/files/MOP6_7-01_RevisionJastarniaPlan.pdf

Berggren, P., Ishaq, R., Zebühr, Y., Näf, C., Bandh, C., Broman, D. (1999) Patterns and levels of organochlorines (DDTs, PCBs, non-ortho PCBs and PCDD/Fs) in male harbour porpoises (*Phocoena phocoena*) from the Baltic Sea, the Kattegatt-Skagerrak Seas and the west coast of Norway. *Mar. Pollut. Bull.* 38:1070-1084

Berggren, P., Wade, P.R., Carlström, J., Read, A.J. (2002) Potential limits to anthropogenic mortality for harbour porpoises in the Baltic region. *Biol. Conserv.* 103:313-322

BMBF, (1997) Untersuchungen an Kleinwalen als Grundlage eines Monitorings. - Schlussbericht des BMBF-Projektes 03F0139A. Bundesministerium für Bildung und Forschung, Berlin.

Børjesson, P., Berggren, P. (1997) Morphometric comparisons of skulls of harbour porpoises (*Phocoena phocoena*) from the Baltic, Kattegat and Skagerrak Seas. *Can. J. Zool.* 75:280–287

Cooke, J.G. (1984) The Relationship between the Net Catcher Day and the Gross Catcher Day as a unit of effort. *Rep. int. Whal. Comm.* 34:288-90

Cooke, J.G., Deimer, P., Schütte, H.J. (2006) Opportunistic Sightings of Harbour Porpoises (*Phocoena phocoena)* in the Baltic Sea; 3rd and 4th Seasons 2004-5. *AC13/Doc.23(P)*. ASCOBANS, Bonn

Deimer, P., Schütte, H.J., Wilhelms, S. (2003) Opportunistic Sightings of Harbour Porpoises (*Phocoena phocoena)* in the Baltic Sea. *AC10/Doc.8(P)*. ASCOBANS, Bonn

Deimer, P., Schütte, H.J., Wilhelms, S., Cooke, J.G. (2004) Opportunistic Sightings of Harbour Porpoises (*Phocoena phocoena)* in the Baltic Sea; Second Season 2003. *AC11/Doc.7(P)*. ASCOBANS, Bonn

Evans, P.G.H. (1976) An analysis of sightings of cetacea in British waters. *Mammal Review*, 6, 5–14.

Evans, P.G.H. (1980) Cetaceans in British waters. *Mammal Review*, 10, 1–52.

Evans, P.G.H., Andersen, L., Bjørge, A., Fontaine, M., Galatius, A., Kinze, C. C., Lockyer, C., De Luna, C., Pierce, G., Sveegaard, S., Teilmann, J., Tiedemann, R., Walton, M. (2009) Harbour Porpoise *Phocoena phocoena*. In: Report of the ASCOBANS / HELCOM small cetacean population structure workshop (Eds. Evans PGH, Teimann J). ASCOBANS Bonn, Germany

Gillespie, D. *et al.* (2005) Relative abundance of harbour porpoise (*Phocoena phocoena*) from acoustic and visual surveys of the Baltic and adjacent waters during 2001 and 2002. *J. Cetacean Res. Manage.* 7:51-57

Hammond, P.S., Benke, H., Berggren, P., Borchers, D.L. *et al.* (2002) Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology*. 39:361-376

Hasselmeier, I., Abt, K.F., Adelung, D., Siebert, U. (2004) Stranding patterns of harbour porpoises (Phocoena phocoena) in the German North and Baltic Seas: when does the birth period occur?. *J. Cetacean Res. Manage.* 6:259-263

Herr, H., Siebert, U., Benke, H. (2009) Stranding numbers and bycatch implications of harbour porpoises along the German Baltic Sea coast. *AC16/Doc.62(P).* ASCOBANS, Bonn

Hiby, L., Lovell, P. (1996) 1995 Baltic/North Sea aerial surveys - Final report. Conservation Research Ltd.

Huggenberger, S., Benke, H., Kinze, C.C. (2002) Geographical variation in harbour porpoise (*Phocoena phocoena*) skulls: support for a separate non-migratory population in the Baltic Proper. *Ophelia.* 56:1-12

IUCN – International Union for Conservation of Nature, (2010) IUCN Redlist (Version 2009.2). Accessed via www.iucnredlist.org, 8th of February, 2010

Kinze, C.C., Jensen, T., Skov, R. (2003) Fokus på hvaler i Danmark 2000-2002. *Biologiske Skrifter*, Nr.2, Fiskeri- og Søfartsmuseet, Esbjerg, Denmark.

Koschinski, S. (2002) Current knowledge on harbour porpoises (*Phocoena phocoena*) in the Baltic Sea. *Ophelia.* 55:167-198

Koschinski, S., Pfander, A.F. (2009) By-catch of harbour porpoises (*Phocoena phocoena*) in the Baltic coastal waters of Angeln and Schwansen (Schleswig-Holstein, Germany). *AC16/Doc.60(P)*, ASCOBANS, Bonn

Loos, P. (2009) Opportunistic sightings of harbour porpoises in the Baltic Sea at large – Kattegat, Belt Sea, Sound, Western Baltic and Baltic Proper. Bachelor thesis, University of Hamburg, Germany. Downloadable via www.gsm-ev.de in the English section under 'Publications'.

Reeves, R. R., Smith, B. D., Crespo, E. A., Notarbartolo di Sciara, G. (2003) Dolphins, Whales and Porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK

Siebert, U., Gilles, A., Lucke, K., Ludwig, M., Benke, H., Kock, K.H., Scheidat, M. (2006) A decade of harbour porpoise occurrence in German waters - Analyses of aerial surveys, incidental sightings and strandings. *Journal of Sea Research.* 56:65-80

Siebert, U., Lehnert, K., Seibel, H., Hasselmeier, I., Müller, S., Schmidt, K., Rademaker, M., Herr, H., Rosenberger, T., Wingberg, S. (2009) Totfundmonitoring von Kleinwalen und Kegelrobben in Schleswig-Holstein 2008. Bericht an das Ministerium für Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein. Forschungs- und Technologiezentrum Westküste

Scheidat, M., Gilles, A., Kock, K.H., Siebert, U. (2008) Harbour porpoise (*Phocoena phocoena)* abundance in the southwestern Baltic Sea. *Endang Species Res.* Preprint, 2008. doi: 10.3354/esr00161

Schulze, G. (1996): Die Schweinswale. 2. überarb. Auflage. Westarp Wissenschaften, Magdeburg

Teilmann, J., Sveegaard, S., Dietz, R., Petersen, I.K., Berggren, P., Desportes, G. (2008) High density areas for harbour porpoises in Danish waters. National Environmental Research Institute, University of Aarhus. - *NERI Technical Report* 657. www.dmu.dk/Pub/FR657.pdf

Tiedemann, R., Harder, J., Gmeiner, R.C., Haase, E. (1996) Mitochondrial DNA sequence patterns of harbour porpoises (*Phocoena phocoena*) from the North and the Baltic Sea. *Z. Säugetierkd.* 61:104-111

Verfuß, U.K., Honnef, C.G., Meding, A., Dähne, M., Mundry, R., Benke, H. (2007) Geographical and seasonal variation of harbour porpoise (*Phocoena phocoena*) presence in the German Baltic Sea revealed by passive acoustic monitoring. *J. Mar. Biol. Assoc. UK* 87:165-176

Wang, J.Y., Berggren, P. (1997) Mitochondrial DNA analyses of harbour porpoises (*Phocoena phocoena*) in the Baltic Sea, the Kattegat and Skagerrak Seas and off the west coast of Norway. *Mar. Biol.* 127:531-537

Annex

1. Fig. 1: Questionnaire for incidental sightings of harbour porpoises (in German)
2. Fig. 2 – 7: Detailed maps of incidental sightings from 2003 – 2008
3. Table 1: Summary of sightings and IPD by area and year
4. Table 2: Summary of sightings and IPD by month and year

MELDEBOGEN FÜR **SICHTUNGEN** VON SCHWEINSWALEN

Was wollen wir wissen?	***Wie sollte es gemeldet werden?***	***Sichtung 1***	***Sichtung 2***
Wann sahen Sie die Tiere?	**Datum / Uhrzeit** *		
Wo sahen Sie die Tiere?	**Seeposition** (GPS - Länge/Breite, Fahrwasser, Seezeichen) * **Landposition** (Insel, nächster Ort, Strandabschnitt)		
Wie viele Tiere waren es mindestens? - Waren sie dicht zusammen oder weit verteilt?	**Mindestzahl Sichtungen** (zusätzlich in Klammern: **davon Jungtiere**) Jungtiere sind etwa halb so groß wie Alttiere bzw. bis zu 1 Meter lang. Alttiere ca. 1,6 m * - Deutliche Schulen oder Mutter mit Jungtier, einzeln?		
Von wo erfolgte die Sichtung?	Boot / Schiff / Strand oder evtl. Flugzeug *		
Wie weit entfernt waren die Wale?	Geschätzte Entfernung in Metern zum Beobachter *		
Wie verhielten sich die Tiere? ▪ schwimmend, reisend ▪ futtersuchend ▪ ruhend ▪ anderes Verhalten	**S** = konstanter Kurs, regelmäßiges Tauchen **F** = unterschiedl. Kurs, kreisend, unregelm. Tauchen **R** = langsames Schwimmen, längere Zeit an Oberfläche; z.B. Springen, ans Boot kommend, beschreiben Sie		
Welchen Antrieb benutzte das Boot / Schiff während der Beobachtung?	**M** = Maschine **S** = Segel **A** = Ankerplatz bzw. keine Fahrt **T** = treibend		
Wie waren Windrichtung / -stärke?	z.B. SW = Südwest Windstärke in Beaufort		
Wie waren Seegang / **Wasserstand?**	**0** = Wasser spiegelglatt **1** = kleine Kräuselungen **2** = keine gebrochenen Wellen **3** = gebrochene Wellen (weiße Schaumkronen) HW / NW = Hoch- oder Niedrigwasser, bzw. auf-/ablaufend		
Sonstiges / Auffällige Merkmale	Boote in der Nähe / Deutliche Einkerbungen der Rückenfinne		

Ihre Kontaktdaten * (Name u. Adresse, bzw. Name des Schiffes; Telefon / Fax / Email):

Namensnennung in Internet-Sichtungskarte: * Ja [ ] Nein [ ]

(Der Schutz Ihrer persönlichen Daten hat für uns oberste Priorität. Kontaktdaten werden nur für interne Zwecke verwendet und bleiben geschützt.)

Bitte machen Sie so viele Angaben wie möglich. Wichtige Pflichtfelder sind mit dem * Symbol gekennzeichnet und sollten nach Möglichkeit ausgefüllt werden. Aber auch unvollständige Bögen sind verwertbar.

Hierhin können Sie alle Meldungen und *evtl. dazugehörende Fotos/Videos* von gesichteten Schweinswalen senden (Aufnahmen vorhanden? – Ja [ ] Nein [ ])

Gesellschaft zum Schutz der Meeressäugetiere e.V., Kieler Str.2, D-25451 Quickborn, Fax: 04106 – 620 907, Tel: – 620 601, Email: info@gsm-ev.de , www.gsm-ev.de

Fig. 1. Questionnaire for incidental sightings of harbour porpoises

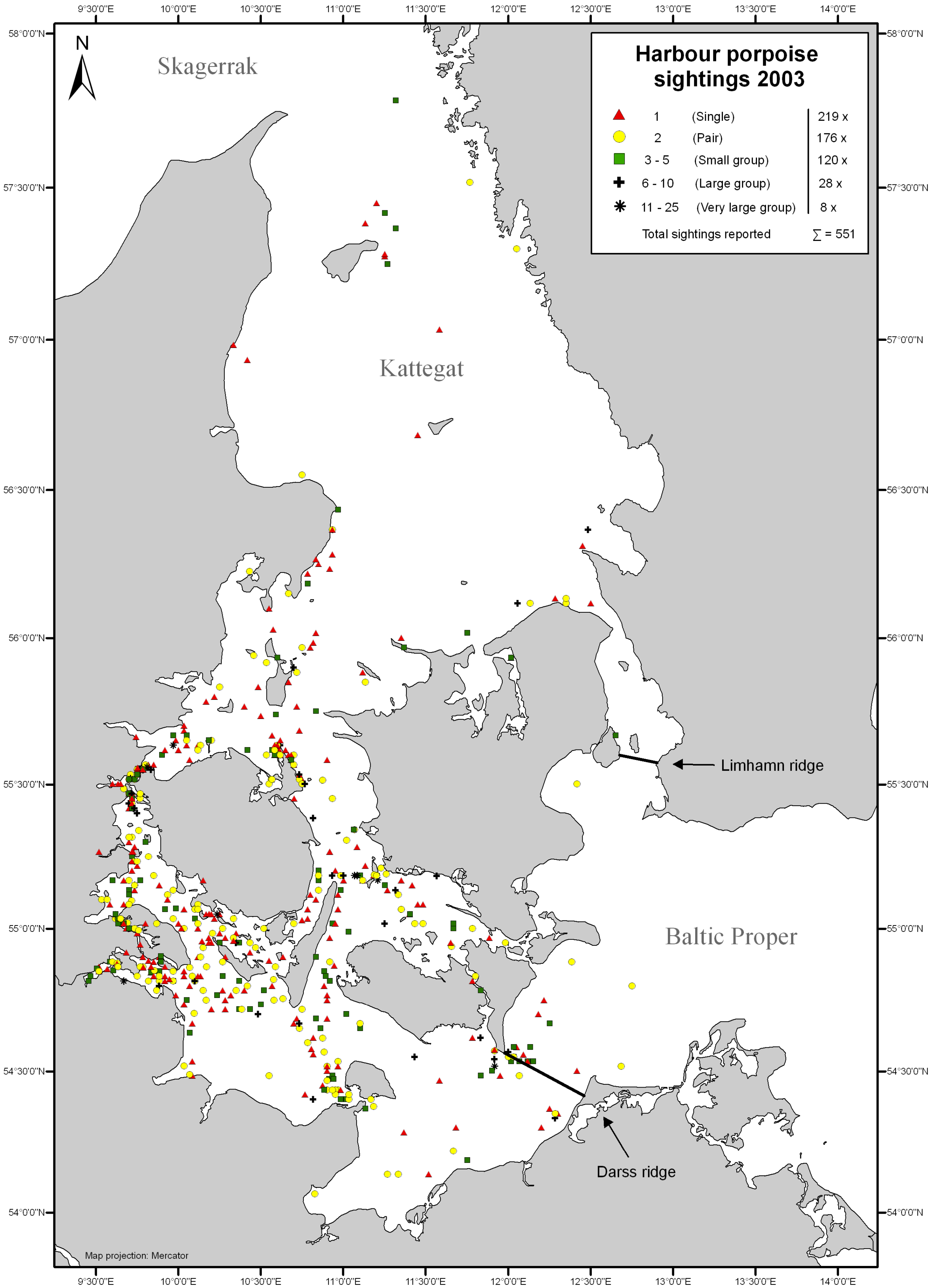

Fig. 2. Season 2003 – Incidental sightings of harbour porpoises

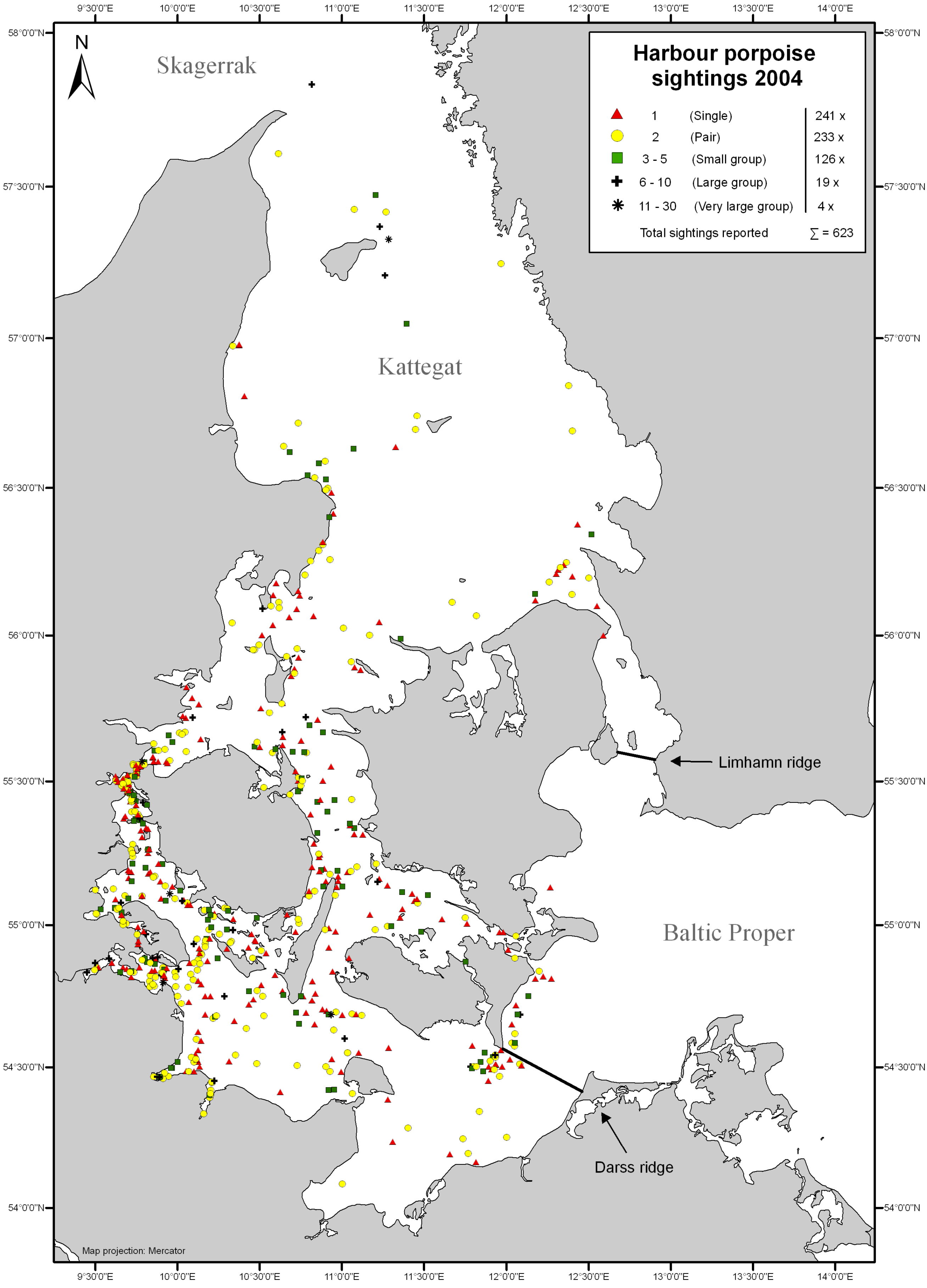

Fig. 3. Season 2004 – Incidental sightings of harbour porpoises

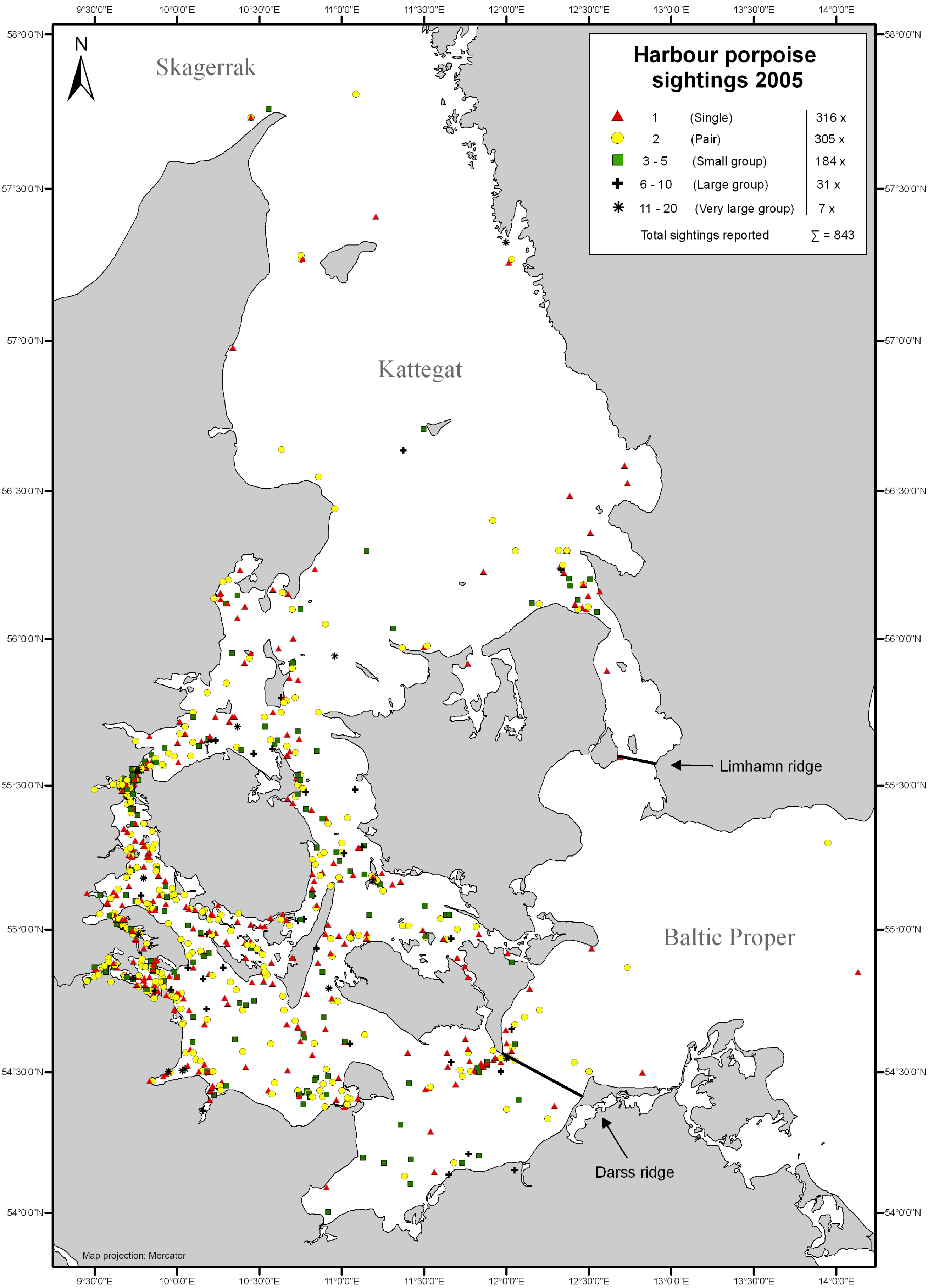

Fig. 4. Season 2005 – Incidental sightings of harbour porpoises

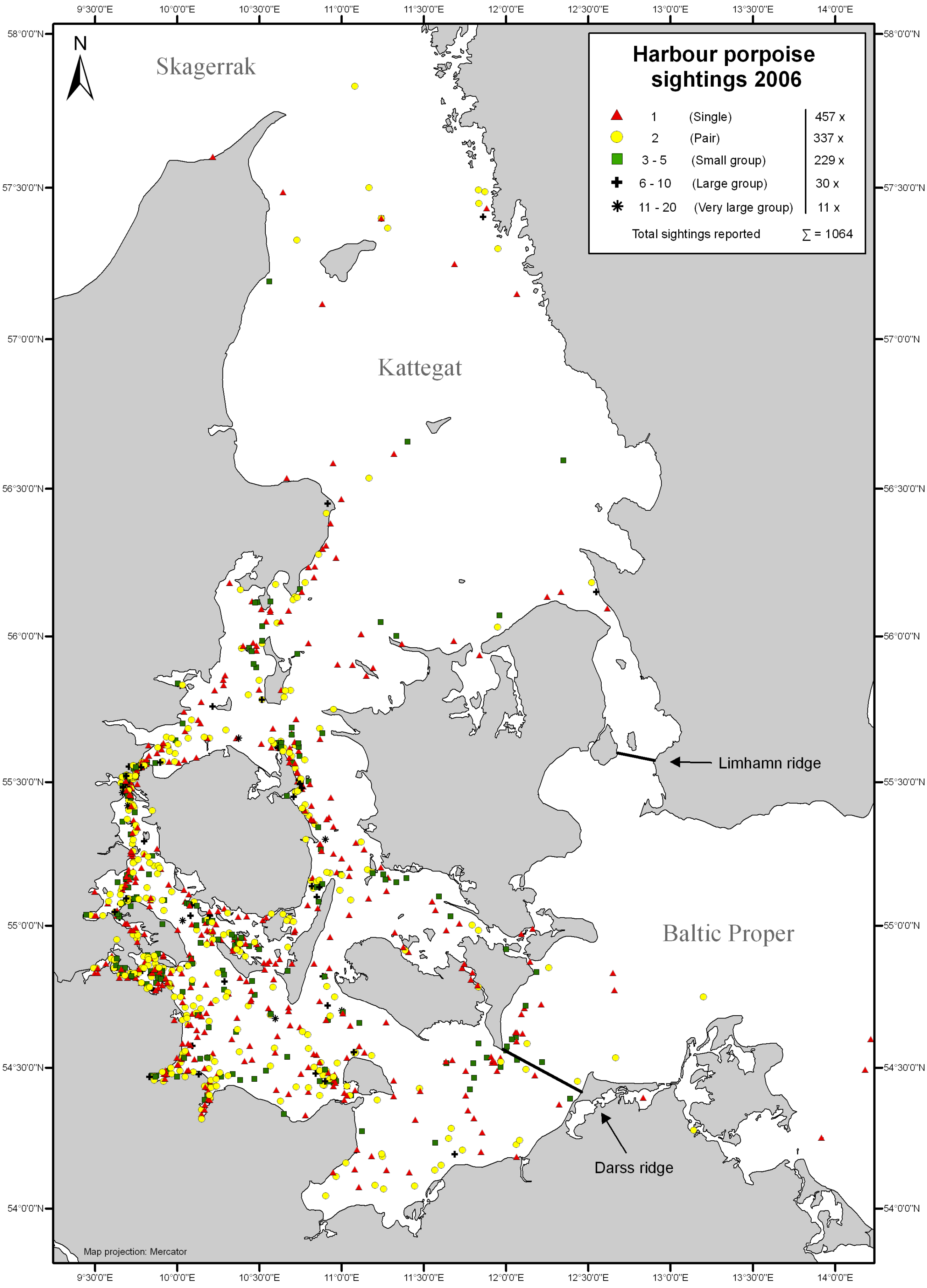

Fig. 5. Season 2006 – Incidental sightings of harbour porpoises

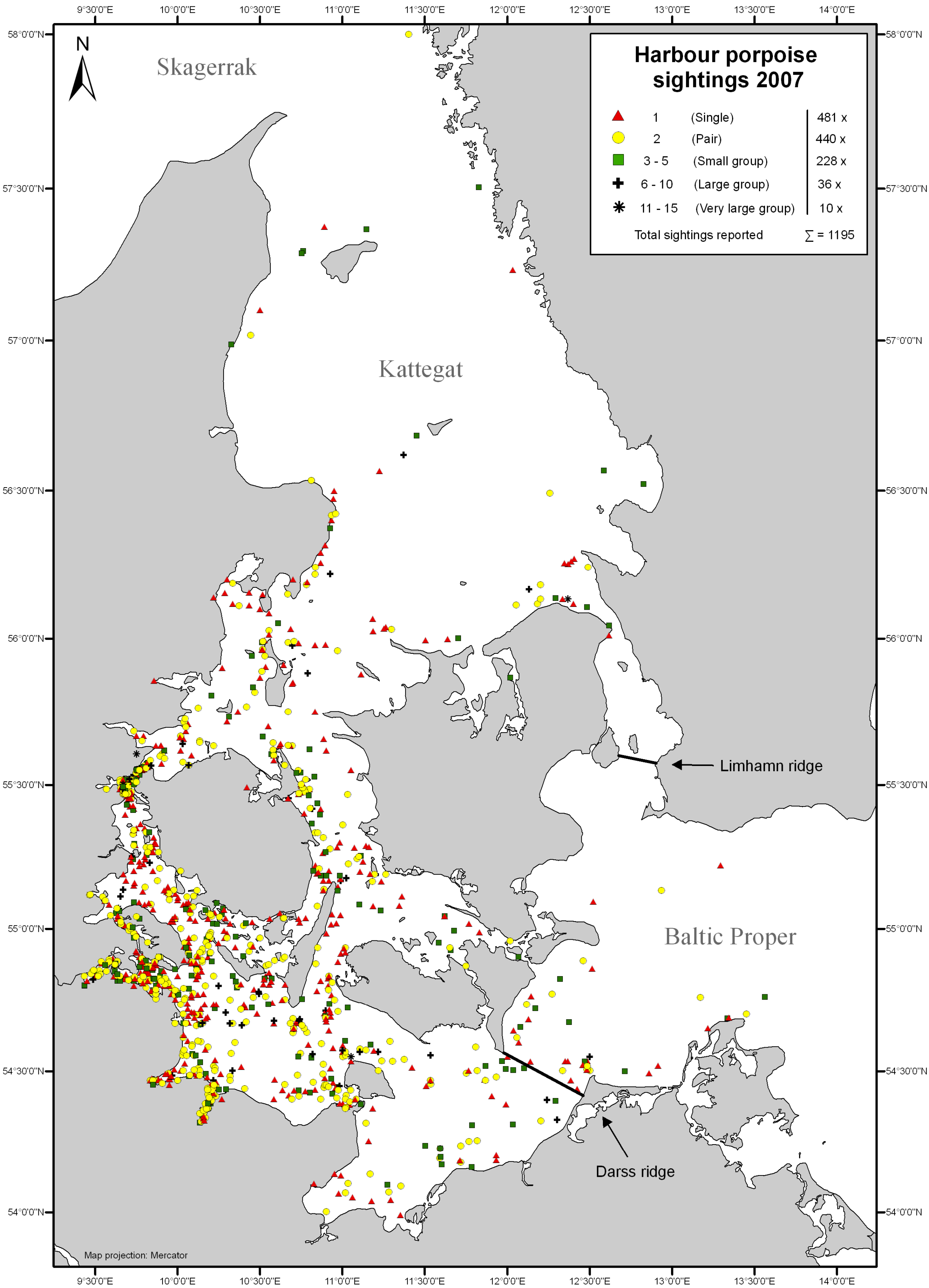

Fig. 6. Season 2007 – Incidental sightings of harbour porpoises

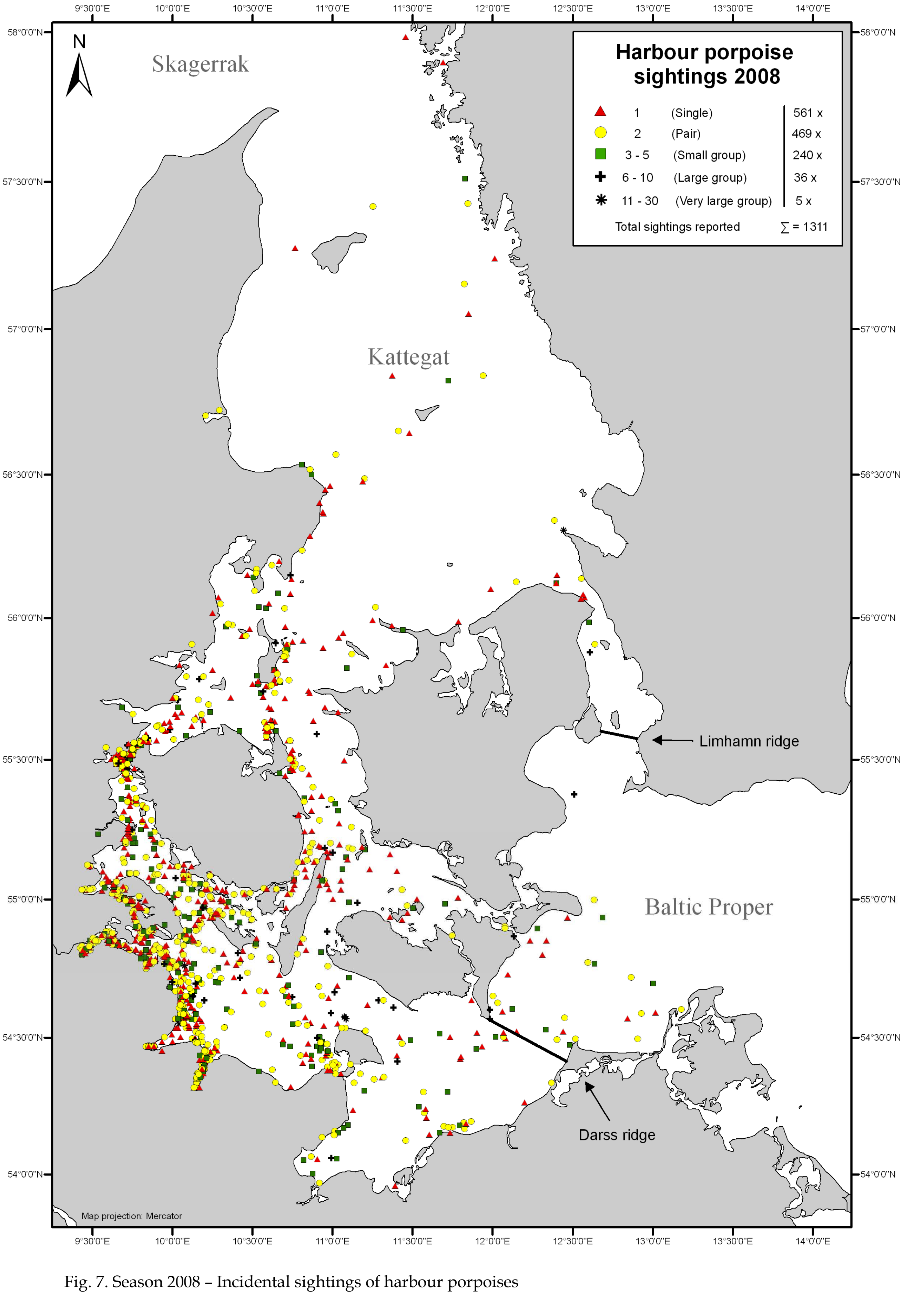

Fig. 7. Season 2008 – Incidental sightings of harbour porpoises

Table 1. Summary of sightings and IPD by area and year

Year	Area	Sightings	Net periods	Animals	IPD
2003	GB	149	106	352	0,958
2003	LB	99	91	196	0,174
2003	FF	43	42	95	0,053
2003	KB	87	74	176	0,355
2003	MB	47	46	112	0,052
2003	Total	425	359	931	0,403
2004	GB	149	116	282	0,538
2004	LB	113	86	234	0,650
2004	FF	37	36	93	0,070
2004	KB	99	88	237	0,299
2004	MB	42	37	89	0,286
2004	Total	440	363	935	0,451
2005	GB	186	143	445	0,719
2005	LB	161	131	330	0,469
2005	FF	75	69	153	0,177
2005	KB	124	114	279	0,197
2005	MB	67	62	171	0,206
2005	Total	613	519	1378	0,407
2006	GB	232	179	452	0,577
2006	LB	184	152	393	0,450
2006	FF	94	81	197	0,336
2006	KB	209	192	427	0,181
2006	MB	76	68	144	0,223
2006	Total	795	672	1613	0,371
2007	GB	200	159	367	0,473
2007	LB	188	147	341	0,506
2007	FF	106	95	205	0,224
2007	KB	276	231	569	0,402
2007	MB	73	66	145	0,211
2007	Total	843	698	1627	0,401
2008	GB	230	180	424	0,512
2008	LB	241	195	445	0,436
2008	FF	120	113	201	0,104
2008	KB	315	276	681	0,305
2008	MB	77	70	167	0,217
2008	Total	983	834	1918	0,349
∑ 03-08	GB	1146	883	2322	0,603
∑ 03-08	LB	986	802	1939	0,451
∑ 03-08	FF	475	436	944	0,178
∑ 03-08	KB	1110	975	2369	0,296
∑ 03-08	MB	382	349	828	0,205
∑ 03-08	Total	4099	3445	8402	0,389

IPD = Index of porpoise density

Table 2. Summary of sightings and IPD by month and year

Year	Month	Sightings	Net periods	Animals	IPD
2003	May	81	71	208	0,362
2003	June	112	92	219	0,425
2003	July	82	69	159	0,365
2003	August	116	96	250	0,449
2003	September	34	31	95	0,270
2003	Total	425	359	931	0,403
2004	May	44	30	101	1,071
2004	June	54	51	105	0,114
2004	July	172	131	359	0,653
2004	August	113	100	204	0,235
2004	September	57	51	166	0,343
2004	Total	440	363	935	0,451
2005	May	112	96	259	0,385
2005	June	73	61	154	0,415
2005	July	173	141	345	0,453
2005	August	202	173	473	0,393
2005	September	53	48	147	0,289
2005	Total	613	519	1378	0,407
2006	May	87	77	210	0,313
2006	June	149	126	274	0,336
2006	July	244	191	492	0,560
2006	August	245	218	468	0,237
2006	September	70	60	169	0,402
2006	Total	795	672	1613	0,371
2007	May	115	85	208	0,638
2007	June	235	178	467	0,636
2007	July	160	135	291	0,337
2007	August	279	247	555	0,258
2007	September	54	53	106	0,037
2007	Total	843	698	1627	0,401
2008	May	246	200	500	0,467
2008	June	124	102	237	0,412
2008	July	229	195	418	0,318
2008	August	284	247	572	0,302
2008	September	100	90	191	0,212
2008	Total	983	834	1918	0,349
∑ 03-08	May	685	559	1486	0,489
∑ 03-08	June	747	610	1456	0,438
∑ 03-08	July	1060	862	2064	0,447
∑ 03-08	August	1239	1081	2522	0,298
∑ 03-08	September	368	333	874	0,250
∑ 03-08	Total	4099	3445	8402	0,389

IPD = Index of porpoise density