The harbour porpoise *Phocoena phocoena* in the Belgian part of the North Sea: trends in abundance and distribution

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ABSTRACT. The harbour porpoise *Phocoena phocoena* is currently common in the Belgian part of the North Sea (BPNS), after decades of virtual absence. This article describes the results of aerial surveys to assess its distribution and density in Belgian waters, in concert with the first results of tests with passive acoustic monitoring devices (Porpoise Detectors - PoDs), and a basic analysis of strandings. The strandings data over four decades clearly demonstrate an increase of harbour porpoises in the BPNS, with only few stranded animals between 1970 and 1997 (0 to 6 per year), increasing numbers between 1998 and 2004 (8 to 40 per year), and even higher numbers between 2005 and 2009 (62 to 94 per year). The combined results of aerial surveys, strandings monitoring and tests with passive acoustic monitoring reveal a seasonal pattern, with harbour porpoises being abundant from February to April, and more scarce from May to January. Average densities in 2008 and 2009, as estimated by aerial monitoring covering most of the BPNS (with the exclusion of the nearshore 5 km strip), ranged from 0.05 animals per km², or in total less than 200 animals in an area equivalent to the BPNS in August 2009, to 1.01 animals per km², or in total almost 3,700 animals in an area equivalent to the BPNS during April 2008. In the first quarter of the year porpoises occur throughout the BPNS, including territorial waters (12 mile zone), whereas they are restricted to more offshore and northerly waters later in the year. Erratic invasions in the BPNS however blur general seasonal spatio-temporal patterns, which complicates our understanding of spatial distribution and migration.

KEY WORDS: Harbour porpoise, *Phocoena phocoena*, Belgian part of the North Sea, abundance, seasonal distribution

INTRODUCTION

The harbour porpoise *Phocoena phocoena* (Linnaeus, 1758) is by far the most common marine mammal in Belgian waters (CAMPHUYSEN & PEET, 2006; HAELTERS, 2009). Like most marine mammals, it is wide-ranging and highly mobile. A wide-scale southward shift in the summer distribution of harbour porpoises within the North Sea has been observed between 1994 and 2005 (SCANS II, 2008). Up to this day, the movements of harbour porpoises in the North Sea throughout the year have remained unclear, as have the driving forces behind them and behind the shift in distribution (SCANS II, 2008;

HAELTERS & CAMPHUYSEN, 2009). Yet, a good knowledge of the occurrence and distribution of harbour porpoises, and reliable predictive models are a prerequisite for the assessment of the conservation status of the species, as required for instance in the framework of the European Habitats Directive (92/43/EEC) and the assessment of the impact of human activities such as fisheries and the construction of offshore windfarms. This paper examines patterns in population size, spatial distribution and temporal variability of the harbour porpoise in Belgian waters, using quantitative observations and semi-quantitative detection methods.

MATERIALS AND METHODS

The current baseline situation (population size, spatial and temporal distribution) of the harbour porpoise in the Belgian part of the North Sea (BPNS) was studied through a combination of methods: (1) aerial line transect sampling to assess population size and spatial distribution; (2) passive acoustic monitoring (PAM) to investigate local short- to medium-term variability (weeks to months) in (relative) abundance, and (3) strandings data analysis to assess medium- to long-term trends in general occurrence.

Such a combined approach is needed given the difficulties in elucidating the population dynamics and behaviour of harbour porpoises, even if they are the most common marine mammal in one of the best studied marine areas in the world.

Aerial line transect sampling

The strategy used in aerial surveys is line transect sampling (BUCKLAND et al., 2001), in which a number of predefined tracks are flown and observations are recorded together with their perpendicular distance to the observation platform. The aircraft used was a high-winged two-engine Norman Britten Islander, owned by the Royal Belgian Institute of Natural Sciences (RBINS). This aircraft was equipped with one bubble window up to spring 2009, and from then onwards with two bubble windows, accommodating two observers. The survey altitude was 600 feet (183 m), and the groundspeed was kept at 100 knots (185 km/h). Flights were only performed during good to moderate observation conditions (sea states of 0 - 3). The surveys covered parallel track lines, 5 km apart and perpendicular to the coastline, to follow a presumed onshore–offshore gradient of porpoise density. For practical and flight-technical reasons (frequent other air traffic along the coast, vicinity of the Ostend and Koksijde airport and presence of a military shooting range), and given a sometimes high turbidity of coastal waters, survey tracks only started 5 km from the shore.

We measured the perpendicular angle from the trackline to the animals observed with a hand-held SUUNTO PM-5/360PC clinometer. From this angle, the shortest distance at which the aircraft passed the animal(s) was calculated. The flight track and the position of the observations were recorded by GPS. The programme DISTANCE (Version 6.0, Release 2) (THOMAS et al., 2009) was used to determine the most suitable detection model for the data collected, and to estimate average density and number of animals in the survey area. A similar methodology was used in SCANS II (2008) and during aerial surveys in neighbouring countries (eg. SIEBERT et al., 2006; SCHEIDAT et al., 2008; SCHEIDAT & VERDAAT, 2009).

During 2008 and 2009 five surveys were performed: 8-9 April 2008, 5 May 2008, 18-19 February 2009, 14-20 May 2009 and 4-5 August 2009. The surveys covered most of the BPNS (with a total surface of approximately 3,600 km²), only excluding a 5 km wide strip along the coast. The survey of 5 May 2008 covered a smaller area. The distances covered on track ranged from 448 km to 661 km (10 to 13 tracks), while the 5 May 2008 survey only covered 265 km (6 tracks). The individual tracks varied in length between 37 km and 63 km.

Given the relatively low number of detections, it was necessary to pool data across surveys, to make some assumptions, and to apply some parameters taken from literature:
(1) The probability of detecting animals is independent from group size.
(2) The detection probability remains constant over the area surveyed, season, time of day, density of animals, and between observers.
(3) All data can safely be pooled in order to establish a detection model. A hazard rate cosine adjusted distribution was selected as the detection function, on the basis of the Akaike Information Criterion (AIC) (BUCKLAND et al., 2001).
(4) As not all animals are observed on the track (perception bias), and some are not visible because they are too deep to be observed

(availability bias), a correction factor for the probability of seeing an animal or a group of animals at distance 0 needs to be applied. The correction factor, g(0), was given the value 0.45, as estimated by Hiby (2008) for similar surveys during good observation conditions; it was not possible to calculate this correction factor for the surveys undertaken, and no confidence values were applied to g(0), which needs to be taken account of when interpreting the CI presented for density and numbers.

(5) Given that a survey cannot be performed in a single flight, two single flights performed within a week and covering complementary tracks were treated as one survey, assuming that abundance and distribution remained similar during that week.

Passive Acoustic Monitoring

For PAM we used C-PoDs (porpoise detectors), which consist of a hydrophone, a processor, batteries and a digital timing and logging system, and have an autonomy of up to four months (www.chelonia.co.uk). A C-PoD does not record sound itself, but generates raw files with sound event characteristics, i.e. time, duration, dominant frequency and sound pressure level. In 2009 PoDs were anchored under water at two locations, on moorings of opportunity. The raw files generated were analyzed with the software CPOD.exe (Version 2.009), which applied a filter to only retain sounds identified as being porpoise clicks (within a certain probability). The data obtained provided an indication of the (relative) abundance of harbour porpoises in the vicinity of the device, up to a distance of approximately 300 m.

The PoDs provided continuous information over a short- to medium-term period, independent of weather conditions, for two locations. For the mooring of both PoDs, a tripod (VAN DEN EYNDE et al., 2010) was used: the PoD was attached to the central column of the tripod, at 1.5 m above the seafloor. A first PoD was moored from 19 October 2009 to 9 December 2009 at the Gootebank (51°26.9'N, 002°52.6'E;

21.4 km offshore; depth of 22 m below Mean Low Low Water Spring - MLLWS). The second PoD was moored, with short interruptions for servicing, from 6 November 2009 to 22 July 2010 at a location closely inshore (51°21.4'N, 003°07.0'E; 4.5 km offshore; depth of 6.5 m below MLLWS).

For the data analysis, only data of high and moderate train quality (high and moderate detection probability) were used, and the species filter was set to harbour porpoises (long narrow-band clicks in the 110-160 kHz range). All detections were visually inspected to remove any false positives, although it cannot be excluded that a small number remains, especially in noisy locations. The data obtained during the day of the mooring and the day of the retrieval of the PoD were excluded, given that the mooring platform (RV BELGICA) often remained in the vicinity for many hours after the placement of the mooring, or prior to the retrieval of the mooring, and thus possibly kept porpoises at a distance.

As a measure for harbour porpoise presence we used the number of detection positive 10 minutes per day (dp10m/d), or the number of 10 minute blocks per day in which porpoises were detected by the C-PoD. This measure was chosen over the number of detection positive minutes per day (dpm/d) as the number of detections was very low in many cases, and as this measure minimises the effects of variation between C-PoDs (C-PoD manual, www.chelonia.co.uk).

Strandings data

A last source of information included in this paper is strandings data. A trend in strandings can reflect a trend in the number of harbour porpoises at sea and can reveal seasonal patterns. Being legally protected, stranded and accidentally caught marine mammals must be reported to the authorities, represented by the Royal Belgian Institute of Natural Sciences (RBINS). To all possible extent, the carcasses are collected and made available for scientific research purposes. As a consequence of the legal requirements,

in combination with the easy public access to the Belgian shoreline and the fact that coastal authorities and members of the public are well informed, the marine mammal strandings database managed by the RBINS can be considered as fairly complete from 1990 onwards.

For this paper, general trends in monthly and yearly (i.e. medium- to long-term variability) strandings are presented. The data include a very small number of animals found dead at sea, and animals accidentally caught, and brought to port by fishermen. They also include accidentally caught animals that were discarded and subsequently washed ashore.

RESULTS

Aerial surveys

The detection model was based on 223 observations of a total of 264 porpoises. The resulting estimate of the Effective half strip width (ESW) was 144 m (95% CI: 129 m - 162 m). Between three and 43 harbour porpoises were detected per survey, which renders a population size estimate for an area equivalent to the BPNS, and covering it for the largest part, ranging from 186 to 3,697 individuals (Table 1). The average group size varied between 1.00 and 1.35 individuals. The May 2008, May 2009 and August 2009 surveys (i.e. late spring and summer) indicated the lowest density of harbour porpoises (max. 0.29 ind./km²), whereas the aerial surveys of April 2008 and February 2009 (i.e. late winter and early spring) yielded a much higher density (min. 0.63 ind./km²).

In April 2008 and February 2009, harbour porpoises were present both in territorial waters (12 nautical miles) and in waters further offshore, whereas observations during the May 2008, May 2009 and August 2009 surveys were virtually restricted to the northern half of the BPNS, further offshore (Figs 1-2).

TABLE 1

Results of the aerial surveys for marine mammals - overview of the observations of harbour porpoises: number of groups (number of animals) and estimates of the average group size (individuals, 95% Confidence Interval (CI)), density (ind./km², 95% CI) and abundance (number of animals, 95% CI) within a surface area equivalent to the Belgian part of the North Sea, i.e. 3,600 km². No estimate of the number of animals was made for the survey of 5 May 2008, given the incomplete coverage of the study area.

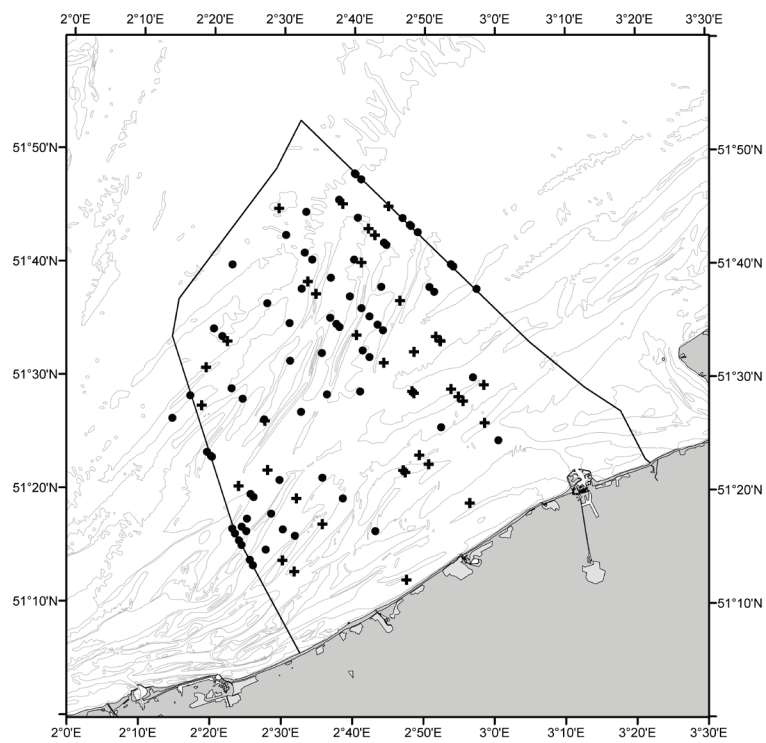| Survey	Observations	Group size	Density	Abundance
8-9 April 2008	40 (43)	1.08 (1.00-1.16)	1.03 (0.65-1.63)	3,697 (2,330-5,867)
5 May 2008	5 (5)	1 (-)	0.29 (0.05-1.80)	-
18-19 February 2009	20 (27)	1.35 (1.04-1.75)	0.63 (0.40-1.00)	2,265 (1,429-3,592)
14-20 May 2009	12 (13)	1.08 (1.00-1.29)	0.15 (0.07-0.33)	556 (261-1,184)
4-5 August 2009	3 (3)	1 (-)	0.05 (0.02-0.15)	186 (62-554)

Fig. 1. – Detections of harbour porpoises during the survey of 8-9 April 2008 (circles) and 18-19 February 2009 (crosses). Observations made off track, as well as those made by the observer sitting at the side of the aircraft without bubble window, are included in the figure, but were not used in the analysis.
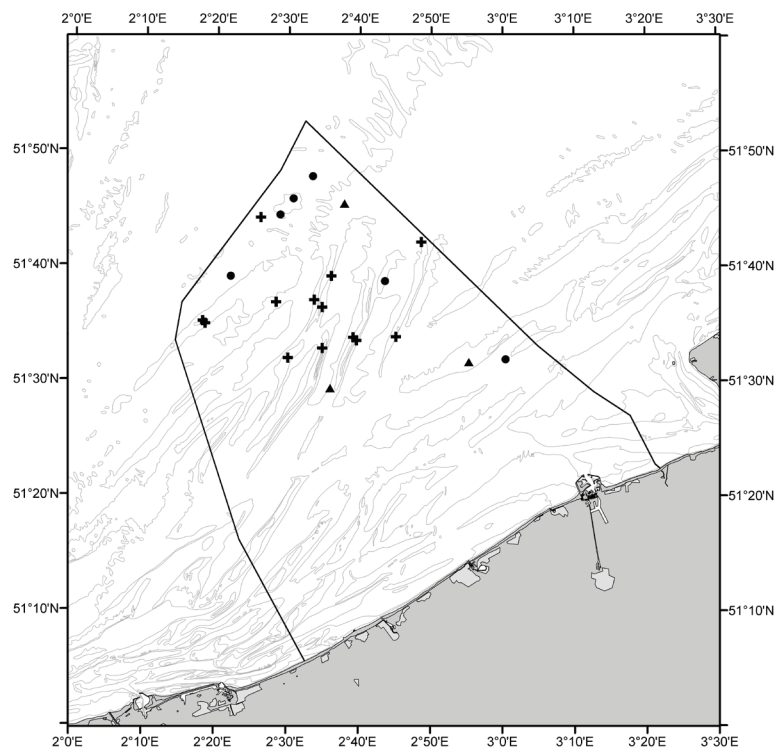

Fig. 2. – Detections of harbour porpoises during the survey of 5 May 2008 (circles), 14-20 May 2009 (crosses) and 4-5 August 2009 (triangles). Observations made off track, as well as those made by the observer sitting at the side of the aircraft without bubble window, are included in the figure, but were not used in the analysis.

Passive acoustic monitoring

Although the PoD moorings should be considered as a trial, given the low number used and the short period of time of one of the moorings, the analysis of the dp10m/d indicated a higher frequency of occurrence of harbour porpoises in the location further offshore than in the inshore location in November to the beginning of December 2009 (Wilcoxon signed rank test: p < 0.001) (Fig. 3). Furthermore, an increase in the number of dp10m/d was observed from October to December in the offshore location (on average 13 dp10m/d between mid-October to mid-November 2009, and 26 dp10m/d between mid-November and early December 2009). In the nearshore location, the number of detections was generally low (on average 4 dp10m/d between early November 2009 and the end of July 2010). Periods with slightly higher detection rates at MOW1 were the last fortnight of December 2009, short periods between the end of January and the beginning of February, and the end of March to mid-April 2010. The number of detections from May 2010 to the end of the mooring in July 2010 was very low, indicating very low numbers of harbour porpoises.

Strandings data

The total number of recorded stranded harbour porpoises between 1970 and 2009 was 597. The yearly number clearly increased from the late 1990s onwards: from only few animals between 1970 and 1997, to a peak in numbers in the period 2005-2007, with respectively 89, 94 and 86 animals (Fig. 4). In 2008 and 2009, the increase was interrupted, with respectively 62 and 66 ind./y.

Figure 4 also indicates a seasonality in strandings. The monthly number of stranded and bycaught animals peaked from March to May (monthly average: 14% of all animals) and in August (13% of all animals stranded). Only few animals were collected in June (8%) and July (6%) and between September and February (monthly average: 5% of all animals).
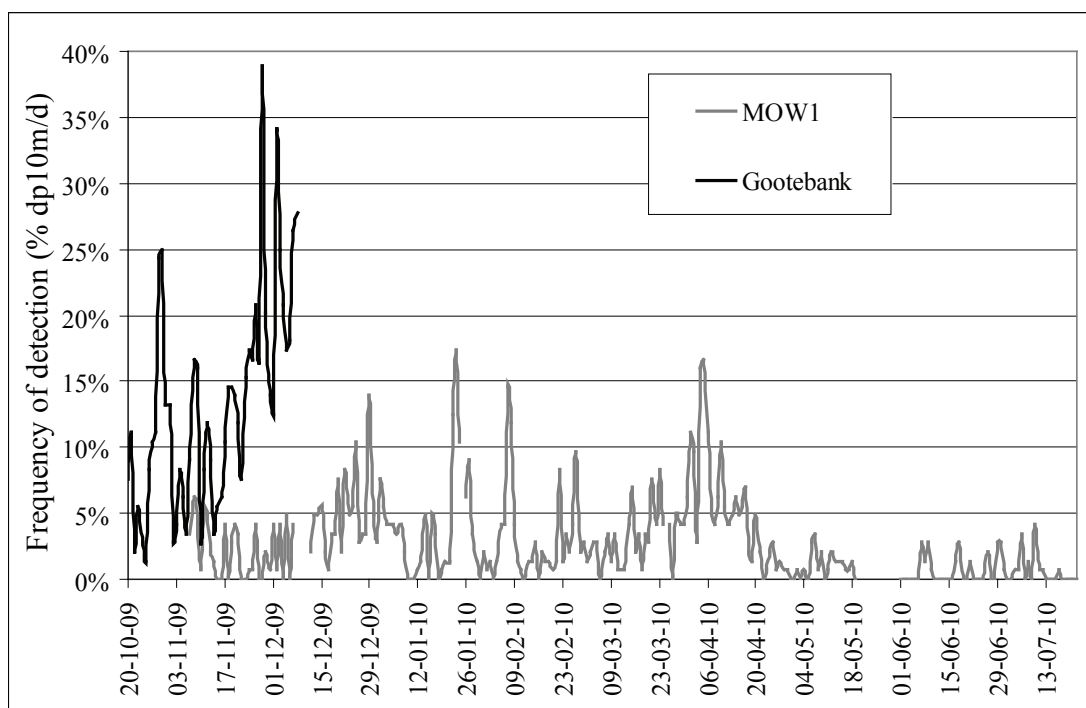

Fig. 3. – Results of the PoD moorings: frequency of detection (dp10m/d), expressed in % of the 144 blocks of 10 minutes per day, at the offshore Gootebank site (20 October to 8 December 2009: black line) and at the nearshore MOW1 site (7 November to 22 July 2010, with short interruptions for servicing the PoD: grey line).

	1970 to 1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Jan	0	1	1							1		2		1	4	1	3	2	1	1	6	24
Feb	3	1									3		4	1		1	6	2	9	3	3	36
Mar	3								1	1	3	1	3	1	4	8	4	20	9	11	6	75
Apr	3		1		2		1			1	3	1	4		7	8	21	18	13	9	5	97
May	4							1		2	1		5	2	4	6	18	17	14	8	5	87
Jun	0		1	2				1		1	1	1	2	2	1	2	7	9	4	7	5	46
Jul	0	1					1	2	1	1	1	2		1	4	7	3	1	4	5	3	37
Aug	3		1			1				1		1	1	2	8	5	13	13	13	4	10	76
Sep	1							2					1	4	2		6	5	12	3	13	49
Oct	3			1					1								4	1	4	8	8	31
Nov	2		1		1						4		1		2	1	2	3	3	3	1	24
Dec	2	1		1		1					2			1	2	1		3			1	15
Total	24	4	4	4	3	2	3	6	3	8	18	8	21	14	38	40	89	94	86	62	66	597

Fig. 4. – Number of harbour porpoises stranded on Belgian beaches per month from 1970 to 2009 (including bycaught animals), and totals per month and per year.

DISCUSSION

Monitoring strategy

Aerial surveys were chosen over ship-based surveys because predefined track lines can be covered easily, without having to take account of shipping lanes, anchorage areas and shallows. Also, a large area could be covered in a short period of time. For short- to medium-term (i.e. weeks to months) monitoring of cetaceans, PAM was chosen, a method which at present can only yield relative estimates of density. Although general trends can be discerned in the few PAM data that are available up to now, large day to day variations occurred in the harbour porpoise encounter rate. This illustrates that the distribution and density data obtained through aerial surveys should be considered with caution: accurate though only snapshot data.

The importance of Belgian waters for harbour porpoises

The harbour porpoise density estimates obtained from five aerial surveys in an area equivalent to, and covering almost the entire BPNS, range from 186 to 3,697 animals/km². These are the first absolute estimates of the number of harbour porpoises present in Belgian waters. This means that at least during part of the year, this species commonly occurred in the BPNS, whereas during other periods it was much scarcer. The estimates indicate that seasonally a number equivalent to 1.5% of the North Sea (summer) population of harbour porpoises, estimated at a quarter of a million individuals (SCANS II, 2008), can be found in the BPNS. Given its significant presence and its protection status, at the Belgian level (Royal Decree of 21 December 2001; Decision of the Flemish Government of 15 May 2009) as well as at the European level (Habitats Directive 92/43/EEC), it is clear that the harbour porpoise legitimately takes an important position in the assessment of the effects of human activities, such as fisheries and offshore construction.

The harbour porpoise showed a tenfold increase in the yearly number of stranded animals from 1970 to the first decade of the 21st century, an increase that started during the last years of the 20th century. This suggests a recent increase in harbour porpoise numbers in Belgian and surrounding waters. One should however take into account that strandings data as a relative estimate of density at sea is biased by meteorological conditions, incidental catches and a high mortality rate of juveniles. Between 2003 and 2006, for example, the proportion of

bycaught animals among the stranded animals for which a cause of death could be identified, rose from 19% to 63% (Jauniaux et al., 2008, Haelters & Camphuysen, 2009). Despite this, a similar increase in strandings has been observed in Dutch waters (Witte et al., 1998; Camphuysen & Peet, 2006), and it should be interpreted as an increase of harbour porpoises in the Southern North Sea. The reappearance of this species seems to be due to a shift in the distribution of the population, rather than an increase in the population size (Camphuysen, 2004; SCANS II, 2008), and may have been caused by local reductions in prey availability, especially in the northern part of the North Sea. These reductions are probably the consequence of changes in environmental conditions (Greene & Pershing, 2000; Beaugrand et al., 2002; MacLeod et al., 2007; Simmonds & Elliott, 2009).

Spatial and temporal patterns

The spatial and temporal distribution of the harbour porpoises in Belgian waters indicates that harbour porpoises are relatively abundant in the BPNS from February to April, including in territorial waters. From May to August their numbers are lower, and they tend to stay in more offshore and more northerly waters. The few PoD measurements also indicated (1) a higher density offshore than inshore between October and December, (2) an increasing density from October to December, (3) a regular occurrence closely inshore between November and April, and (4) a low density inshore from May to July.

The strandings data showed a peak from March to May, which could be linked to higher nearshore densities in that period. The peak of strandings in May can partly be explained by the washing ashore of many decomposed animals, many of which probably died earlier in April (Haelters et al., 2006). To a large extent, the peak of strandings in August also concerned decomposed carcasses, mostly juveniles, probably drifted in from more offshore waters (Haelters & Camphuysen, 2009), although account should

be taken of a more rapid decomposition during the months with higher water temperatures.

The seasonal cycle in density and distribution, as described above, seems to be blurred by more erratic events, complicating our understanding of harbour porpoise's movements. Two examples of such erratic events were detected during the present study. Firstly, a dip in the number of strandings (a decrease of approximately 30%) was observed in 2008 and 2009. This dip could be due to a more offshore distribution of harbour porpoises during the first months of 2008 and 2009 in comparison to the previous years (Haelters, 2009; Haelters & Camphuysen, 2009). It should hence not necessarily be interpreted as a decrease in population size. Secondly, the relatively high proportion of stranded animals between August and October 2009 suggests a short intrusion into Belgian waters.

CONCLUSIONS

The assessment of strandings data, in combination with the results of the first aerial and PAM efforts in the BPNS have allowed us to draw some initial conclusions about the current spatio-temporal pattern of harbour porpoises in the BPNS. To draw firmer conclusions, more efforts are needed, especially in the field of PAM and aerial monitoring.

Harbour porpoises do not show a random spatio-temporal distribution in the BPNS: in general they are currently found abundantly throughout the whole BPNS from February to April, in numbers amounting up to 1.5% of the North Sea population (the North Sea population as estimated during summer surveys), whereas lower numbers tend to occur in more offshore waters during the rest of the year. The pattern observed might be described as migration, random movement, dispersal or avoidance of areas with temporarily poor feeding conditions. This pattern does not seem to be stable, possibly as a consequence of the small surface of Belgian

waters compared to the distribution range of the harbour porpoise, the fact that it is a highly mobile species, and that Belgian waters are at the edge of their distribution range in the North Sea. Therefore studies covering a larger spatial (e.g. the whole North Sea) and temporal scale are necessary, in combination with studies on harbour porpoise population dynamics and on the distribution and abundance of their dominant prey species.

ACKNOWLEDGEMENTS

REFERENCES

BEAUGRAND G, REID PC, IBAÑEZ F, LINDLEY JA & EDWARDS M (2002). Reorganization of North Atlantic Marine Copepod Biodiversity and Climate. Science, 296(31): 1692-1694.

BUCKLAND ST, ANDERSON DR, BURNHAM KP, LAAKE JL, BORCHERS DL & THOMAS L (2001). Introduction to Distance Sampling: estimating abundance of biological populations. Oxford University Press.

CAMPHUYSEN CJ (2004). The return of the harbour porpoise (Phocoena phocoena) in Dutch coastal waters. Lutra, 47(2): 113-122.

CAMPHUYSEN CJ & PEET G (2006). Whales and dolphins of the North Sea. Fontaine Uitgevers, Kortenhoef.

GREENE CH & PERSHING AJ (2000). The response of Calanus finmarchicus populations to climate variability in the Northwest Atlantic: basin-scale forcing associated with the North Atlantic Oscillation. ICES Journal of Marine Science, 57: 1536-1544.

HAELTERS J (2009). Monitoring of marine mammals in the framework of the construction and exploitation of offshore wind farms in Belgian marine waters. In: DEGRAER S & BRABANT R (Eds.). Offshore wind farms in the Belgian part of the North Sea: State of the art after two years of environmental monitoring. Royal Belgian Institute of Natural Sciences, Department MUMM, 237-266.

HAELTERS J & CAMPHUYSEN K (2009). The harbour porpoise in the Southern North Sea: abundance, threats and research- & management proposals. Royal Belgian Institute of Natural Sciences (RBINS/MUMM) and the Royal Netherlands Institute for Sea Research (NIOZ); report commissioned by the International Fund for Animal Welfare (IFAW).

HAELTERS J, JAUNIAUX T, KERCKHOF F, OZER J & SCORY S (2006). Using models to investigate a harbour porpoise bycatch problem in the Southern North Sea–eastern Channel in spring 2005. ICES CM 2006/L:03.

HIBY L (2008). Effective strip half-width estimates from aerial survey data. In: SCANS II, 2008. Small Cetaceans in the European Atlantic and North Sea (SCANS II). Final Report to the European Commission, Appendix D3.1.

JAUNIAUX T, BERGUERIE H, CAMPHUYSEN K, DAOUST P-Y, DROUGUET O, GHISBAIN T, GARCIA-HARTMANN M, GRONDIN A, HAELTERS J, JACQUES T, KISZKA J, LEOPOLD M, PEZERIL S, SCHNITZLER J & COIGNOUL F (2008). Causes of death of harbor porpoises (Phocoena phocoena) stranded on the continental coastline of the southern North Sea (Belgium, France, and Dutch

coasts) between 1990 and 2007. ICES Annual Science Conference, Halifax, Canada, ICES CM 2008/D:09.

MacLeod C, Santos M, Reid RJ, Scott B & Pierce GJ (2007). Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biology Letters, 3: 185–188.

SCANS II (2008). Small Cetaceans in the European Atlantic and North Sea (SCANS II). Final Report to the European Commission under project LIFE04NAT/GB/000245. Available from SMRU, Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife, KY16 8LB, UK.

Scheidat M, Gilles A, Kock KH & Siebert U (2008). Harbour porpoise *Phocoena phocoena* abundance in the southwestern Baltic Sea. Endangered Species Research, 5: 215–223.

Scheidat M & Verdaat H (2009). Distribution and density of harbour porpoises in Dutch North Sea waters. IMARES Report N° C125/09, Wageningen.

Siebert U, Gilles A, Lucke K, Ludwig M, Benke H, Kock KH & 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(1): 65-80.

Simmonds MP & Elliot W (2009). Climate change and cetaceans: concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom, 89(1): 203-210.

Thomas L, Laake JL, Rexstad E, Strindberg S, Marques FFC, Buckland ST, Borchers DL, Anderson DR, Burnham KP, Burt ML, Hedley SL, Pollard JH, Bishop JRB & Marques TA (2009). Distance 6.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/

Van den Eynde D, Brabant R, Fettweis M, Francken F, Van Lancker V, Sas M & Melotte J (2010). Monitoring of hydrodynamic and morphological changes at the C-Power and Belwind offshore windmill sites – A synthesis. In: Degraer S, Brabant R & Rumes B (Eds.). Offshore wind farms in the Belgian part of the North Sea: Early environmental impact assessment and spatio-temporal variability. Royal Belgian Institute of Natural Sciences, Department MUMM, 19-36.

Witte RH, Baptist HJM & Bot PVM (1998). Increase of the harbour porpoise *Phocoena phocoena* in the Dutch sector of the North Sea. Lutra, 40: 33-40.