Marine mammal surveys in the wider Dogger Bank area summer 2013

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Summary

In summer 2013 aerial surveys using distance sampling methods where conducted in UK, Dutch, German and Danish waters to investigate the occurrence of marine mammals in the Dogger Bank area.
The Dogger Bank is a candidate Special Area of Conservation (cSAC) under the EC Habitats Directive (Natura 2000) and part of the OSPAR network of Marine Protected Areas in the North East Atlantic Ocean.

The survey was conducted in August and September 2013, covering waters of The Netherlands, the United Kingdom, Denmark and Germany. Aim was to investigate the importance of this marine feature as summer habitat for marine mammals. In total 619 harbour porpoises were sighted, of these 21 calves, which resulted in an estimate of 45,177 (CI 25,105-84,556) harbour porpoises. Highest porpoise density was found in the north-western, southern and south-western parts of the survey area, whereas over the sandbank itself and to the southeast relatively low densities were estimated. Additionally to the porpoises, 18 minke whale (*Balaenoptera acutorostrata*) and 12 white-beaked dolphin (*Lagenorhynchus albirostris*), 35 seals (grey seal *Halichoerus grypus* and common seal *Phoca vitulina)* and two basking sharks were recorded. Numbers of these species were too low to calculate densities and abundance estimates.

In comparison to a survey of the same study area in summer 2011, the abundance estimate in 2013 was lower: 45,177 (CI 25,105-84,556) vs 116,446 (CI 64,423-224,881). The observed distribution showed roughly the same pattern around the Dogger Bank for both years. Compared to 2011, in the areas west of the Dogger Bank porpoise densities in 2013 were higher in the north and lower in the central part.
The abundance estimate from 2013 represents a substantial proportion of the abundance estimate for the harbour porpoise population in the North Sea and adjacent shelf waters (n = 375,000 in 2005).

This survey was commissioned by the UK Department for Environment, Food and Rural Affairs and the Dutch Ministry of Economic Affairs (EZ).

1. Introduction

The Dogger Bank is the largest sandbank in the North Sea. The area consists of three Special Areas of Conservation (SAC) which are (to be) designated for the so-called qualifying feature of the habitat "sandbanks which are slightly covered by sea water all the time". Harbour porpoise *Phocoena phocoena*, grey seal *Halichoerus grypus* and common seal *Phoca vitulina* occur in the Dogger Bank region and are included in the SACs as non-qualifying features.

All cetaceans are offered strict protection in their entire range under Annex IV of the European Commission's Habitats Directive. The grey seal and harbour seal are listed in Annex V "animal and plant species of Community interest whose taking in the wild and exploitation may be the subject of management measures". In addition, grey and harbour seal, harbour porpoise and bottlenose dolphin *Tursiops truncatus* are also listed in Annex II of the Habitat Directive, "animal and plant species of community interest whose conservation requires the designation of Special Areas of Conservation that will form part of a coherent European network of protected areas named the Natura 2000 network".

The German, Dutch and British part of the Dogger Bank (respectively 1,624, 4,715 km^2 and 12,331 km^2) are identified as Sites of Community Importance (SCI) and included in the EU list of SCI's, which is a prerequisite to designation as a SAC. These three proposed Dogger Bank SACs adjoin each other. Therefore, accurate baseline data on distribution and abundance of small cetaceans is urgently needed. To fill this knowledge gap Gilles et al. (2011) conducted an aerial survey of the entire Dogger Bank between 28 July and 1 September 2011 to collect data on the distribution and abundance of marine mammals. Their results showed that harbour porpoises were abundant in this area, with high densities along the edge of the UK's portion of the Dogger Bank. It should be noted, however, that the abundance of porpoises on the actual Dogger Bank within the UK's proposed SAC was not high compared to neighbouring waters. Additional data on the distribution and abundance of cetaceans, particularly harbour porpoise, is now needed to investigate seasonal changes as well as changes in occurrence between years. To provide data on the latter an aerial survey of the entire Dogger Bank was conducted in summer 2013, following the same survey design and survey method as in 2011. In this report we present the results of the aerial surveys of the Dogger Bank in summer 2013.

2. Assignment

This report presents the results of the aerial survey of the wider Dogger Bank area using line transect distance sampling as described in the original assignment from the UK's Department for Environment, Food and Rural Affairs (DEFRA) and in the additional so-called Helpdeskvraag 3486 "Bruinvissurvey Doggerbank" from the Dutch Ministry of Economic Affairs (EZ).

3. Materials and Methods

Study area, survey design and data acquisition

The study area included the entire Dogger Bank and adjacent waters in British, Danish, German and Dutch waters, totalling 66,768 km^2. The Dogger Bank (ca 18,000 km^2) is the largest sandbank in the North Sea. The central part of the area is shallow with water depths that are rarely deeper than 20 m (13 m at its shallowest part). The bank slopes down further in waters deeper than 50-70 m. The Dogger Bank has a high primary production (Brockmann et al. 1990), that provides good conditions for higher trophic levels resulting in rich food sources for top predators as marine mammals. Sand eels (*Ammodytes* spp.) are an especially abundant prey species. Their distribution is concentrated along the edges in water depths of 20-30 m (van der Kooy et al. 2008).

The survey design was created by Anita Gilles (ITAW) using DISTANCE 5.0 (Thomas et al. 2010) and comprised eight strata (DA-DH) within the study area. In order to provide equal coverage within each stratum a design with parallel track lines spaced 10 km apart (except stratum DD, where transects were spaced 12 km apart due to the long transit) was made (Figure 1). The 74 transect lines covering 6,460 km of survey effort (Table 1) run perpendicular to water depth gradients in an east-west direction over most of the area, as (distance) sampling theory dictates that transect direction should not parallel physical or biological features (Buckland et al. 2001). Flights were operated from the airfields of Newcastle (UK), Westerland Sylt (GER) and Texel (NL).

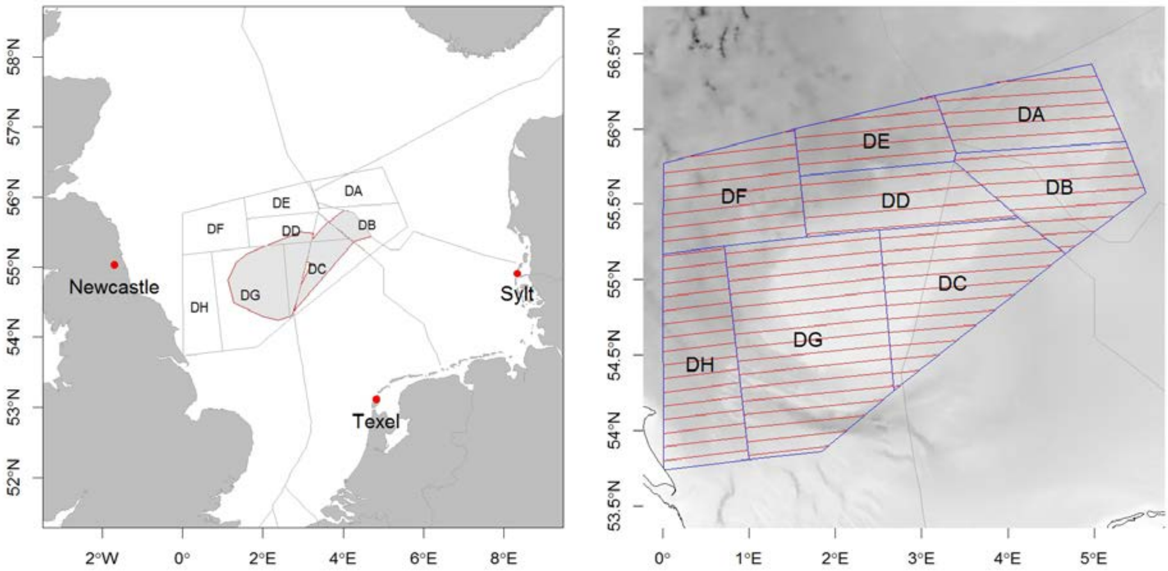


Figure 1. Study area and survey design of the international Dogger Bank survey in summer 2013 (strata DA to DH). The (proposed or designated) SACs are presented as grey polygons with red boundaries in the left panel. Parallel transects are spaced 10 km apart, with the exception of stratum DD (12 km). Shading gives an indication of water depth: deeper water is indicated by darker shading. National boundaries are indicated by grey lines.

The aircraft used was a high-winged two-engine Partenavia 68, equipped with bubble windows (Figure 2), flying at an altitude of 183 m (600 feet) with a speed of ca. 185 km/hr (ca. 100 knots). Every four seconds the aircraft's position and time (to the nearest second) was recorded automatically onto a laptop computer connected to a GPS. Surveys were conducted by a team of three people. Details on environmental conditions were entered by one person (the navigator or data recorder) at the beginning of each transect and whenever conditions changed. Observations were made by two dedicated observers located at the bubble windows on the left and right sides of the aircraft. For each observation the observers acquired sighting data including species (all cetaceans and seals), declination angle measured with an inclinometer from the aircraft abeam to the group, group size, presence of calves, behaviour (Table 2), swimming direction, cue, and reaction to the survey plane. These data were entered in real time by the navigator. The perpendicular distance from the transect to the sighting were later calculated from aircraft altitude and declination angle. Environmental data included sea state (Beaufort scale), turbidity (4 classes, assessed by visibility of objects below the sea surface), cloud cover (in octaves), glare and subjective sighting conditions (Table 3). These sighting conditions represent each observer's subjective view of the likelihood that the observer would see a harbour porpoise within the primary search area should one be present, and could differ between the left and right observer position in the airplane.

Table 1. Surveyed area, planned transect length and number of designed transects per stratum.

Stratum	**Area (km^2)**	**Transect length (km)**	**No. of transects**
DA	6,202	557	5
DB	6,766	680	8
DC	9,582	947	12
DD	6,134	550	4
DE	4,671	427	5
DF	7,464	702	8
DG	17,104	1,712	16
DH	8,845	885	16
Total	66,768	6,460	74

Table 2. Behavioural codes and description for marine mammals.

Behaviour	**Description**
Swimming	directional swimming
Slow swimming	slow directional swimming
Fast swimming	fast directional swimming or porpoising
Milling	milling, non-directional swimming
Resting	resting/logging: not moving at the surface
Feeding	Feeding
Head-up	spy hop of seals vertically in the water column
Other	other behaviour, noted down in comments

Figure 2. The survey aircraft used, a Partenavia 68, at Newcastle airport.

Table 3. Description of subjective sighting conditions.

Sighting condition	Description
Good (G)	Observer's assessment that the likelihood of seeing a porpoise, should one occur within the search strip, is good. Normally, good subjective conditions will require a sea state of two or less and a turbidity of less than two.
Moderate (M)	Observer's assessment that the likelihood of seeing a porpoise, should one occur within the search area, is moderate.
Poor (P)	Observer's assessment that it is unlikely to see a porpoise, should one occur within the search strip.
Exceptional (X)	Observer off effort due to adverse circumstances

Surveys were conducted in weather conditions safe for visual flying operations (no fog, low clouds or rain, visibility >3 km, no military activity) and suitable for porpoise surveys (Beaufort sea state equal or less than 3). Surveys were conducted by experienced observers Geert Aarts, Rob van Bemmelen, Steve Geelhoed and Hans Verdaat.

Data analysis

Before analysing the collected data it was checked for consistency of codes, scanned for outliers and subsequently stored in the Dutch aerial survey database. Data on sightings and effort, stratified by the described sighting conditions, are used to estimate densities and abundances, and to produce distribution maps. For the latter sightings are presented as sightings un-corrected for effort and as sightings corrected for survey effort and conditions per grid cell (20x20 km). Only data from transect lines flown in good or moderate conditions were considered in the analyses.

Line-transect distance sampling

The survey plane followed pre-designed track lines in the eight designated survey strata (Figure 1). Line-transect distance sampling allows for obtaining absolute densities, i.c. the number of animals/km^2 with the associated 95% confidence interval (CI) and coefficient of variation (CV; Buckland et al. 2001). To do this the so called effective strip width (ESW), the strip along the track line in which the number of animals counted equals those that are missed outside the strip, has to be estimated. To obtain the first component the perpendicular distance of a sighting (a single animal or the centre of a group of animals) to the track line is measured. To calculate the distance of the sighting to the track line from air, the plane flies at a constant height (600 feet = 183m) and the vertical or 'declination' angle to the sighting is measured when it comes (or is estimated to come) abeam. ESW is estimated by fitting a detection function to all these observed distances.

One of the key assumptions of line-transect distance sampling is that all animals on the track line are detected, which would mean that all animals at a distance of 0 m from the track line are seen i.e. detection is 1 (or 100%). For most animals, but in particular for cetaceans, this assumption is not true and a correction factor, called g (0) (detection probability on the transect line), needs to be obtained to correct for the proportion of animals missed on the track line. In the present study g(0) values of 0.37 for good conditions and 0.14 for moderate conditions were applied for harbour porpoises, based on previous estimation using the same methods and study area (Gilles et al. 2009; Scheidat et al. 2008).

Harbour porpoise abundance in each stratum v (DA-DH) was estimated using a Horvitz-Thompson-like estimator (Horvitz & Thompson 1952) as:

$$\hat{N}_v = \frac{A_v}{L_v}\left(\frac{n_{\mathrm{gs}v}}{\hat{\mu}_{\mathrm{g}}} + \frac{n_{\mathrm{ms}v}}{\hat{\mu}_{\mathrm{m}}}\right)\bar{s}_v \qquad (1)$$

where Av is the area of the stratum, L_v is the length of transect line covered on-effort in good or moderate conditions, n_{gsv} is the number of sightings that occurred in good conditions in the stratum, n_{msv} is the number of sightings that occurred in moderate conditions in the stratum, $\hat{\mu}_{\mathrm{g}}$ is the estimated total effective strip width in good conditions, $\hat{\mu}_{\mathrm{m}}$ is the estimated total effective strip width in moderate conditions and $\bar{s}_v$ is the mean observed school size in the stratum.

Group abundance by stratum was estimated by $\hat{N}_{v(\mathrm{group})} = \hat{N}_v / \bar{s}_v$. Total animal and group abundances were estimated by

$$\hat{N} = \sum_v \hat{N}_v \quad \text{and} \quad \hat{N}_{(\mathrm{group})} = \sum_v \hat{N}_{v(\mathrm{group})} \qquad (2)$$

respectively. Densities were estimated by dividing the abundance estimates by the area of the associated stratum. Mean group size across strata was estimated by $\hat{E}[s] = \hat{N} / \hat{N}_{(\mathrm{group})}$.

Coefficients of variation (CV) and 95% confidence intervals (CI) were estimated by a non-parametric bootstrap (999 replicates) within strata, using transects as the sampling units. The variance due to estimation of ESW was incorporated using a parametric bootstrap procedure which assumes the ESW estimates to be normally distributed random variables. More details on this method can be found in Scheidat *et al.* (2008).

Distribution maps

Distribution maps were created using R software (R Core Team 2013). Densities were represented spatially in the 1/9 ICES grid. This grid has latitudinal rows at intervals of 10', and longitudinal columns at intervals of 20'. ICES 1/9 rectangles intersecting with the study area measure approximately 20x20 km, resulting in areas ca. 400 km^2.

Densities per 1/9 ICES grid cell were calculated by dividing the total number of animals observed during good and moderate conditions by the total surveyed area. The surveyed area is the distance travelled multiplied by the total effective strip width (ESW). The effective strip half-width (ESW corrected for g(0) values of 0.37 and 0.14 for good and moderate sighting conditions respectively) was defined as 76.5 m for good sighting conditions and 27 m for moderate sighting conditions on each side of the track line (Gilles *et al.*, 2009; Scheidat *et al.*, 2008). Densities in grid cells extending outside the borders of the surveyed area could be less reliable due to lower effort. Grid cells with an effort less than 1 km^2 were omitted from the density calculations.

4. Results

Weather conditions and survey effort

After relocation from Texel (NL) to Newcastle (UK) on 19 August 2013 aerial surveys were conducted in strata DD-DG on 7 days from 20 to 28 August (Table 4). After the survey in stratum DG the team re-allocated to Westerland on Sylt (Ger) on 28 August but the weather deteriorated rapidly. Therefore continuation of the survey was postponed to 3 September. In strata DA-DC aerial surveys were conducted from Texel and Sylt on 3 days from 3 to 5 September (Table 4). A total of 4,767 (left) and 4,908 (right) km survey effort under good or moderate conditions was carried out during the 10 survey days.

All in all 26% of the survey effort (n = 9674 km) was conducted in good or excellent conditions. Conditions were poor in the survey strata DE and DG on 22 August and in stratum DB on 5 September, which meant that these survey strata could not be completed. It was not feasible to find a window with suitable survey conditions in the remainder of September.

Table 4. Survey dates and surveyed strata.

Survey date	Surveyed stratum
20 August	Stratum DH (north) and DG (north)
21 August	Stratum DH (south)
22 August	Stratum DE and DG (north)
23 August	Stratum DD and DG
26 August	Stratum DD and DF (north)
27 August	Stratum DF (south) and DG (south)
28 August	Stratum DG (centre)
3 September	Stratum DC (north)
4 September	Stratum DC (south), DA (south) and DB (north)
5 September	Stratum DB

Table 5. Total survey effort (surveyed distance km) per sighting condition (g – good, m – moderate, p – poor, x – not possible to observe) in each stratum.

Stratum	good	moderate	poor	x
DA	0	365	122	0
DB	0	259	233	0
DC	102	1232	366	173
DD	465	427	201	0
DE	0	820	7	0
DF	416	876	99	0
DG	1385	1678	295	40
DH	157	1492.	147	0
Total	2524	7149	1470	213

General results

In total 475 sightings of 684 individuals of three cetacean species and two mostly unidentified seal species were collected on-effort. Apart from harbour porpoises (Figure 3) the following species were observed: 18 minke whales *Balaenoptera acutorostrata* (Figure 5), 12 white-beaked dolphins *Lagenorhynchus albirostris* (Figure 6) and 35 unidentified seals, that could be either harbour seal P*hoca vitulina* or grey seal *Halichoerus grypus* (Figure 7). In addition, 2 basking sharks *Cethorinus maximus* (Figure 8) were observed.

Table 6. On-effort number of sightings and individuals of marine mammals in the Dogger Bank area in summer 2013.

	Harbour porpoise		Minke whale		White-beaked dolphin		seal	
	sighting	ind	sighting	ind	sighting	ind	sighting	ind
DA	6	8	-	-	-	-	-	-
DB	6	8	-	-	-	-	-	-
DC	21	24	-	-	-	-	-	-
DD	28	33	-	-	-	-	-	-
DE	1	1	-	-	-	-	1	1
DF	62	128	10	12	2	7	10	17
DG	246	352	6	6	2	3	9	10
DH	57	65	-	-	1	2	7	7
total	427	619	16	18	5	12	27	35

Harbour Porpoise

In total, 427 sightings of 619 individual harbour porpoises were made, including 21 calves (Table 6). The distribution of these sightings is shown in Figure 3. Porpoises showed a heterogeneous distribution with most sightings south and southwest of the Dogger Bank and to a lesser extent in the north-western part of the study area. Low numbers were recorded in the northernmost stratum DE and in the non-UK waters at (DC) or east (DA and DB) of the Dogger Bank.

The mean pod size was 1.45 individuals (n = 619). During all surveys, sightings concerning single individuals predominated (72%, n = 619), pod sizes of two animals were less numerous (18.5%, n = 619), with a maximum pod size of eight animals recorded twice (22 August in stratum DG and 26 August in stratum DF).

Porpoise density in the entire study area was estimated to be 0.68 n/km^2 which translates to an absolute number of 45,177 animals (CV = 0.31) (Table 7). Highest porpoise densities were estimated in strata DF (1.28 n/km^2, CV = 0.34) and DG (1.23 n/km^2, CV = 0.34) in the north-western part of the survey area and south of the sandbank itself respectively. The lowest density (0.02 n/km^2, CV = 0.91) was estimated in stratum DE north of the sandbank. Overall densities in the other strata were in the same order of magnitude and intermediate between these values.

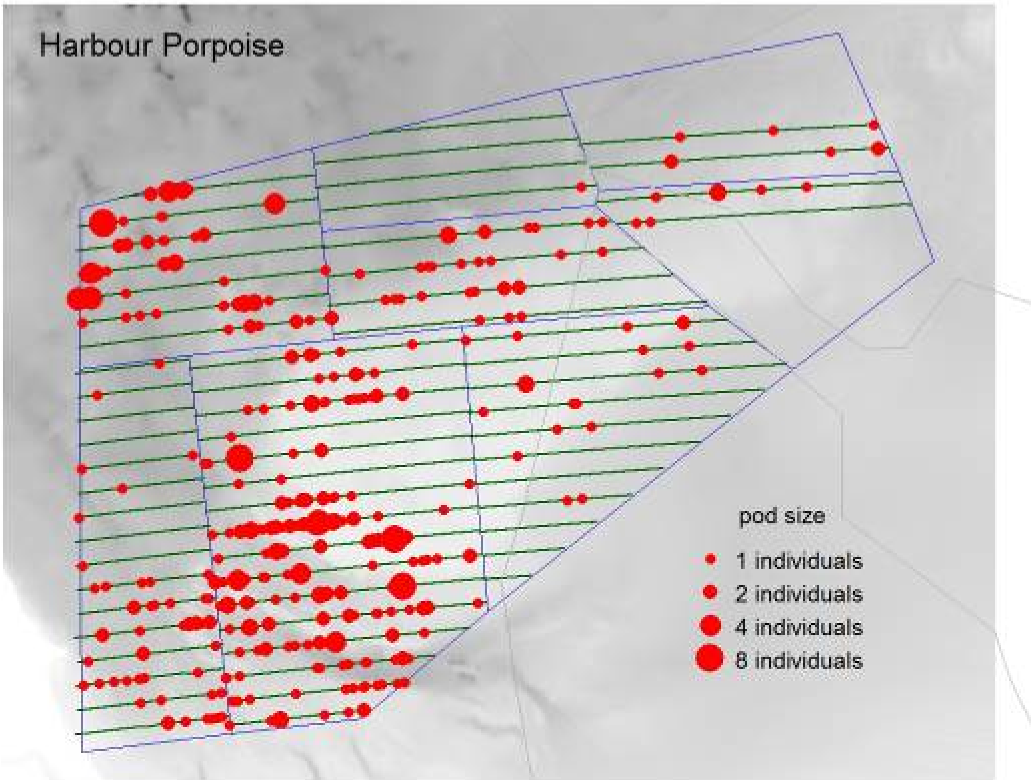


Figure 3. Harbour porpoise on effort sightings in the Dogger Bank area in summer 2013. Shading gives an indication of water depth: deeper water is indicated by darker shading. National boundaries are indicated by grey lines.

Table 7. Harbour porpoise abundance in the Dogger Bank area in summer 2013. CI=Confidence interval, CV=Coefficient of variation.

Stratum	**Density [n/km²] (95% CI)**	**Abundance (95% CI)**	**CV**
DA	0.31 (0.16 - 0.69)	1,889 (964 – 4,302)	0.40
DB	0.43 (0.11 - 1.02)	2,898 (714 – 6,887)	0.56
DC	0.25 (0.10 - 0.56)	2370 (996 – 5,405)	0.43
DD	0.35 (0.16 - 0.74)	2,165 (961 – 4,535)	0.38
DE	0.02 (0 - 0.08)	106 (0 – 361)	0.91
DF	1.28 (0.65 - 2.50)	9,560 (882 - 18,698)	0.34
DG	1.23 (0.62 - 2.40)	20,960 (10,588 - 40,958)	0.34
DH	0.59 (0.26 - 1.32)	5229 (2,277 - 11,683)	0.44
Total	0.68 (0.38- 1.27)	45,177 (25,105 – 84,556)	0.31

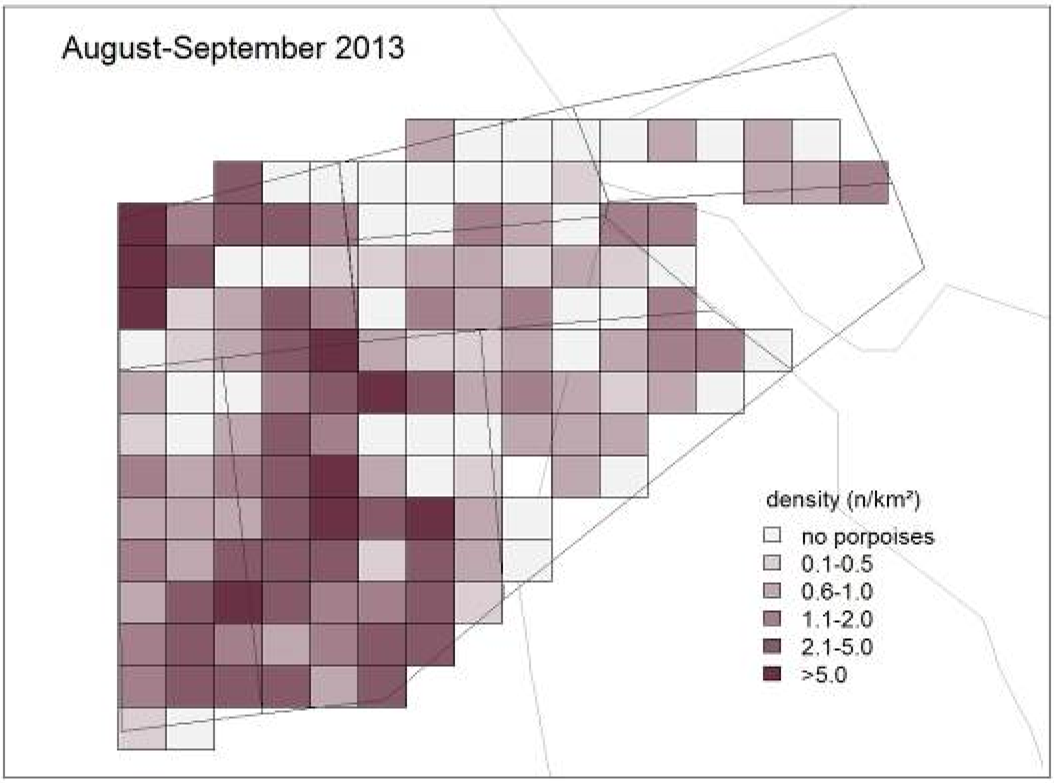


Figure 4. Harbour porpoise density (n/km²) per 1/9 ICES grid cell in the Dogger Bank area in summer 2013.

Other species

Minke whale was the second most observed cetacean species, with 30 records of which 16 were on-effort and the remainder during transit (Table 6; Figure 5). Sightings were made in a band from the south western edge of the Dogger Bank to the north western part of the study area. Several minke whales were concentrated in a small area in DF with so-called fish balls (concentrations of fish) and associated (grey) seals, common guillemots *Uria aalge* and black-legged kittiwakes *Rissa tridactyla*, indicating that these minke whales were feeding.

A handful of sightings of white-beaked dolphins were made. On-effort 5 groups totalling 12 individuals were seen (Table 6). Off-effort 3 groups totalling 15 individuals were recorded. Sightings were concentrated in the north-western part of the survey area, mainly in stratum DF (Figure 6).

Apart from cetaceans, 27 sightings (35 individuals) of seals were made on-effort (Table 6). Since identification of seals to species level is almost impossible from a plane at the survey height all sightings are presented as unidentified seals, either harbour seal *Phoca vitulina* or grey seal *Halichoerus grypus* (Figure 7). Sightings were restricted to the western strata with the highest numbers in stratum DF, associated with the fore mentioned concentration of (feeding) minke whales.

Basking sharks were recorded on two occasions. A feeding individual (ca 5 m length) was seen on-effort on the northern slope of the Dogger Bank in stratum DE on 26 August 2013. A smaller individual (2-2.5 m) was recorded off effort in stratum DH on 22 August 2013 (Figure 8).

At this point the number of sightings from all other species than the harbour porpoise is too low to estimate densities.

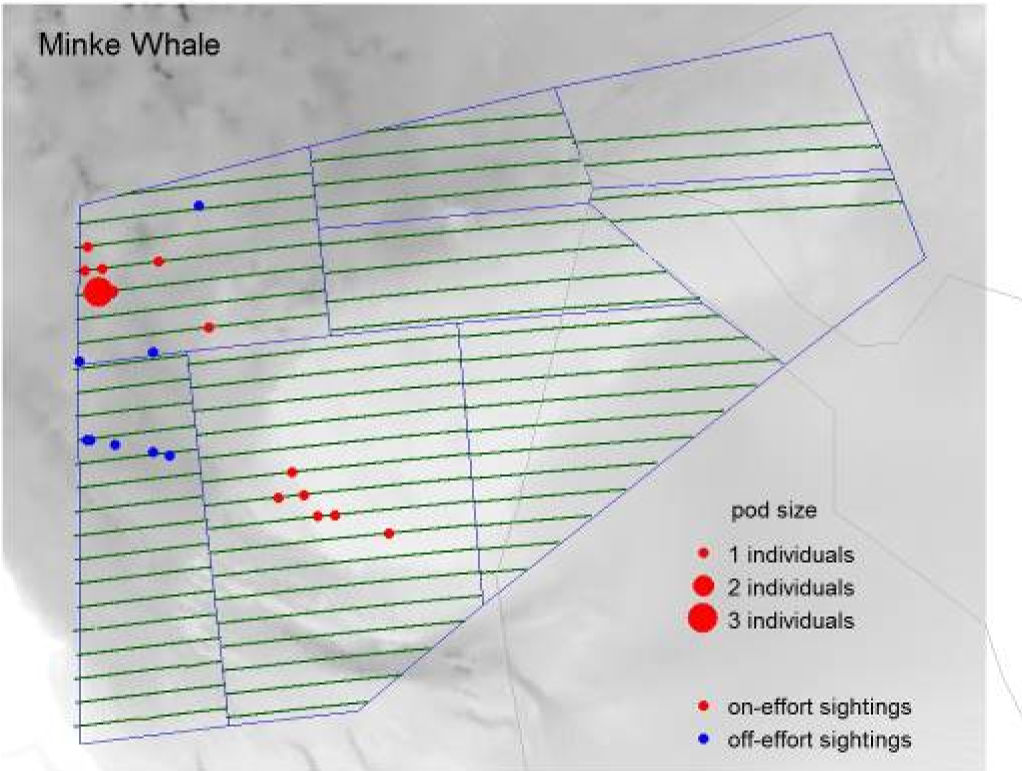


Figure 5. Minke whale sightings in the Dogger Bank area in summer 2013. See Figure 3 for explanation.

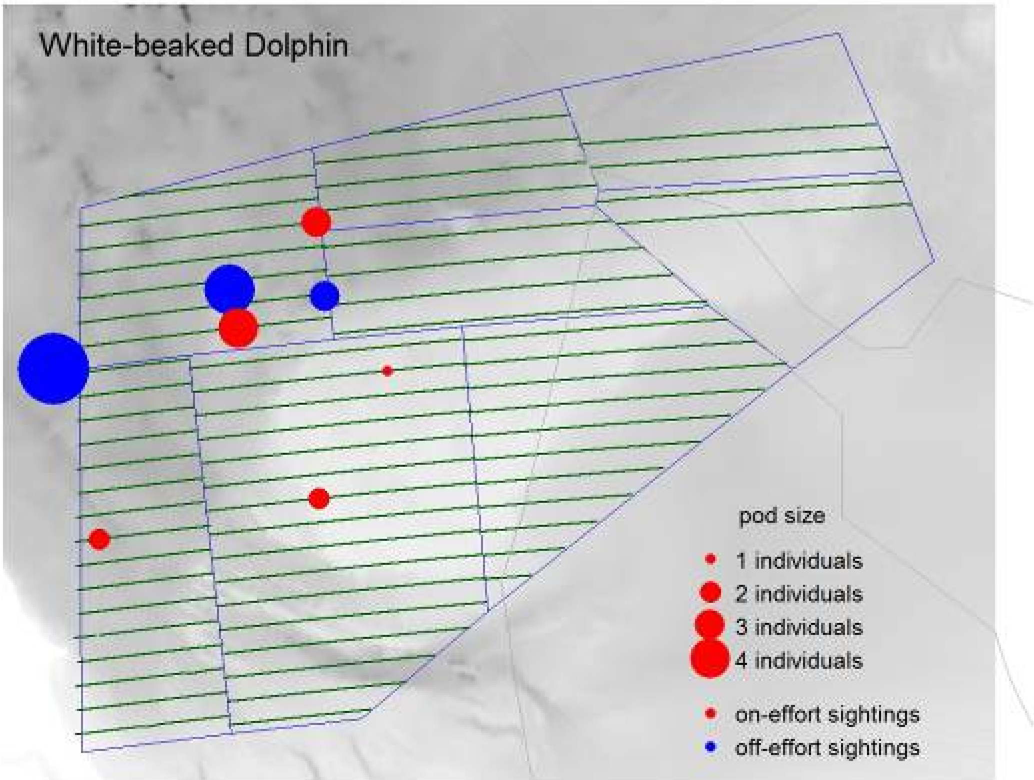


Figure 6. White-beaked dolphin sightings in the Dogger Bank area in summer 2013. See Figure 3 for explanation.

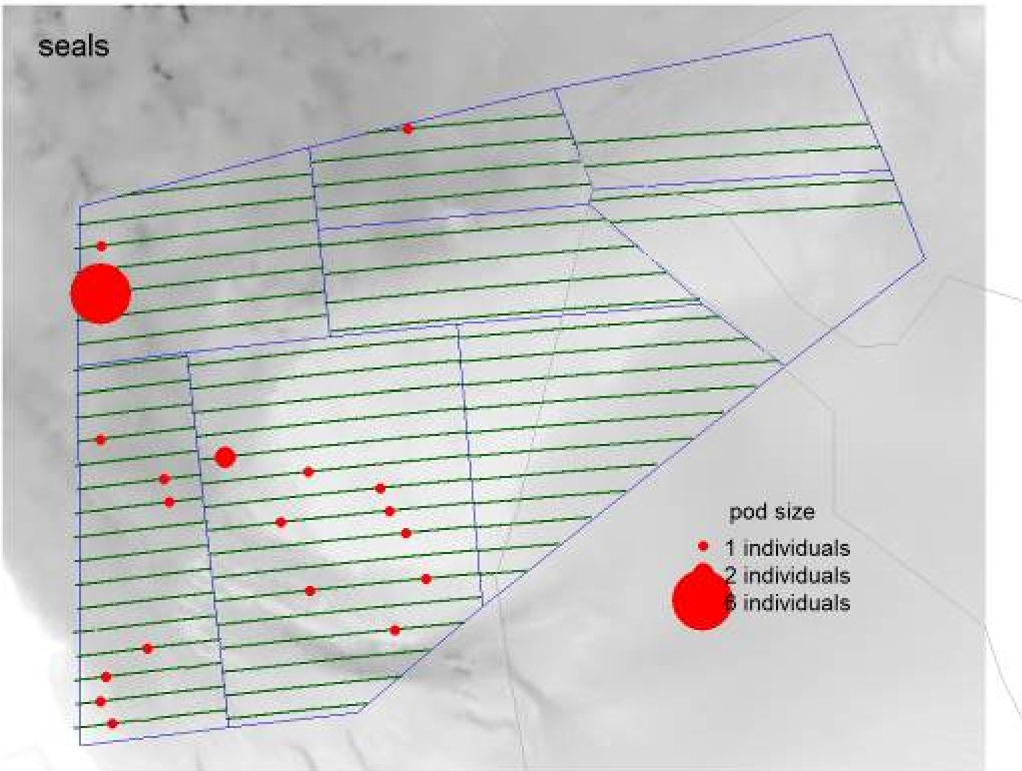


Figure 7. Seal sightings in the Dogger Bank area in summer 2013. Since identification to species level is almost impossible from an airplane all sightings are shown as unidentified seal. See Figure 3 for explanation.

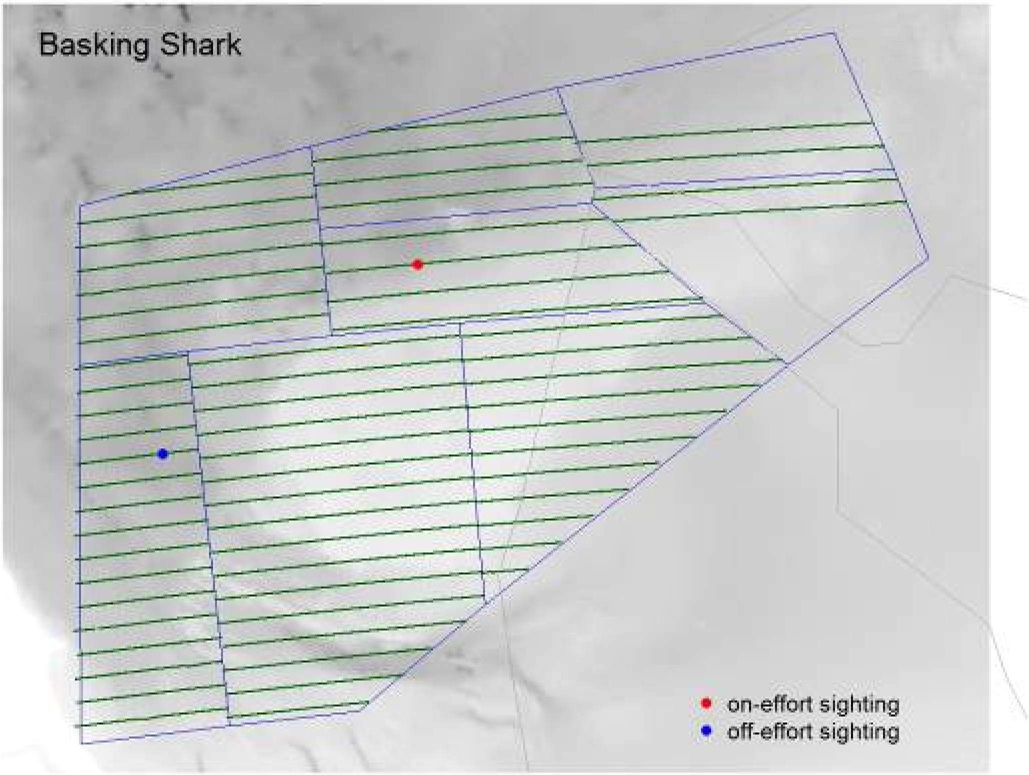


Figure 8. Basking shark sightings in the Dogger Bank area in summer 2013. See Figure 3 for explanation.

5. Comparison with 2011 survey

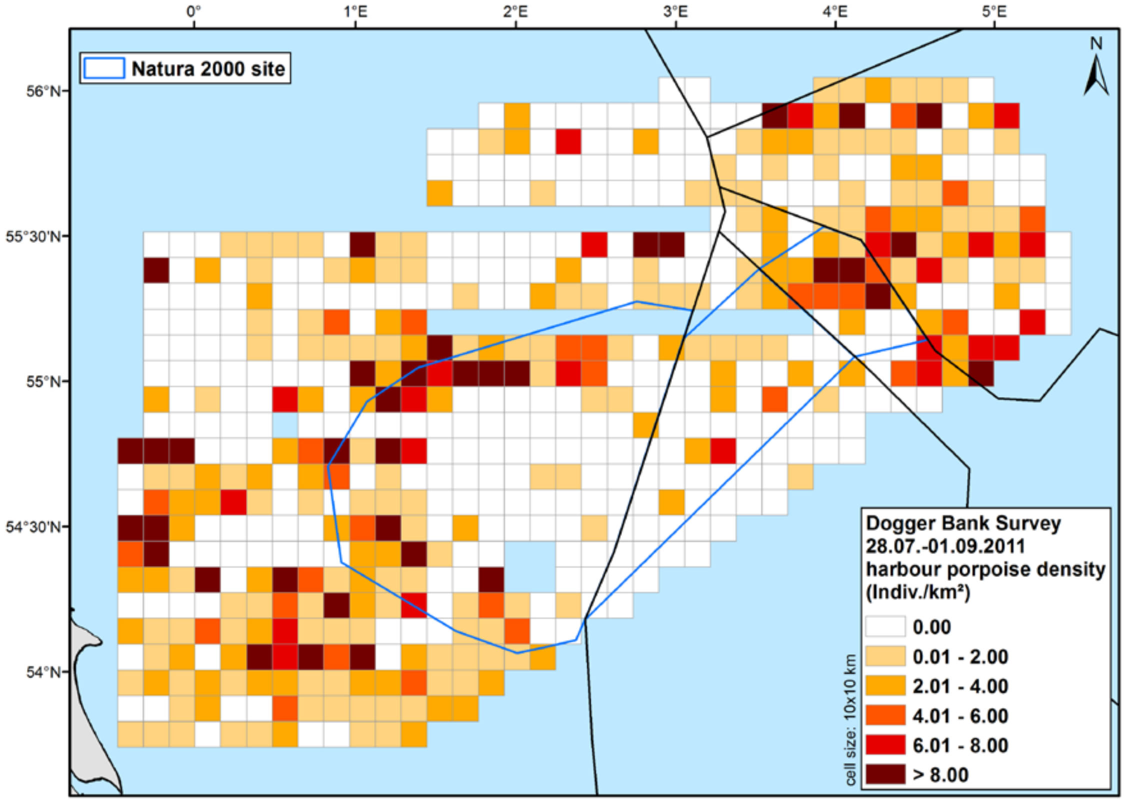
In summer 2011 the entire Dogger Bank was surveyed by airplane by ITAW (Institute for Terrestrial and Aquatic Wildlife Research; Gilles et al., 2011). IMARES contributed by surveying the Dutch part of the Dogger Bank (Scheidat et al., 2013). During 10 days between 28 July and 1 September 2011 all strata except four transects in stratum DF were surveyed. These transects in stratum DF could not be surveyed due to adverse weather conditions.

In 2011 a total of 1,104 harbour porpoises were sighted. The porpoise density in the entire study area was estimated to be 1.82 n/km^2 which translates to ca 116,446 (95% CI 64,423-224,881) individuals. In 2013 the average density of harbour porpoises was estimated at 0.68 n/km^2 corresponding to ca 45,177 (CI 25,105-84,556) individuals. Both density and abundance estimate were lower than the 95% confidence limits of the corresponding 2011 numbers. Densities and numbers were lower in all strata in 2013, except stratum DF that was incompletely surveyed in 2011 (Table 8). The biggest absolute differences were found in the western strata DG and DH, where ca 45,000 less animals were estimated in 2013 than in 2011. In the eastern strata the biggest difference was found in stratum DB, where ca 11,000 less animals were estimated in 2013 than in 2011.

Table 8. Harbour porpoise abundance in the Dogger Bank area in summer 2011 and summer 2013. CI=Confidence interval. CV=Coefficient of variation.

Stratum	**Density [n/km²] (95% CI)**		**Abundance (95% CI)**			
	2011	**2013**	**2011**	**CV**	**2013**	**CV**
DA[1]	1.22 (0.48 - 2.72)	0.31 (0.16 - 0.69)	7,563 (2,950 - 16,899)	0.44	1,889 (964 – 4,302)	0.40
DB[1]	2.12 (0.95 - 4.53)	0.43 (0.11 - 1.02)	14,322 (6,457 - 30,654)	0.40	2,898 (714 – 6,887)	0.56
DC	0.85 (0.27-1.82)	0.25 (0.10 - 0.56)	8,136 (2,598 – 17,449)	0,43	2370 (996 – 5,405)	0.43
DD	1.20 (0.59-2.42)	0.35 (0.16 - 0.74)	7,370 (3,642-14,865)	0.36	2,165 (961 – 4,535)	0.38
DE	0.58 (0.06-1.55)	0.02 (0 - 0.08)	2,722 (271 - 7,246)	0.62	106 (0 – 361)	0.91
DF[2]	1.19 (0.59-2.40)	1.28 (0.65 - 2.50)	5,412 (2,674 - 10,892)	0.36	9,560 (882 - 18,698)	0.34
DG	3.14 (1.59-6.36)	1.23 (0.62 - 2.40)	53,652 (27,184-108,822)	0.36	20,960 (10,588 - 40,958)	0.34
DH	1.95 (0.89-4.29)	0.59 (0.26 - 1.32)	17,270 (7,906 - 37,958)	0.40	5229 (2,277 - 11,683)	0.44
Total	1.82 (1.01-3.51)	0.68 (0.38- 1.27)	116,446 (64,423-223,881)	0.31	45,177 (25,105 – 84,556)	0.31

[1] Strata AA and AB were incompletely surveyed in 2013. [2] Area DF was incompletely surveyed in 2011.



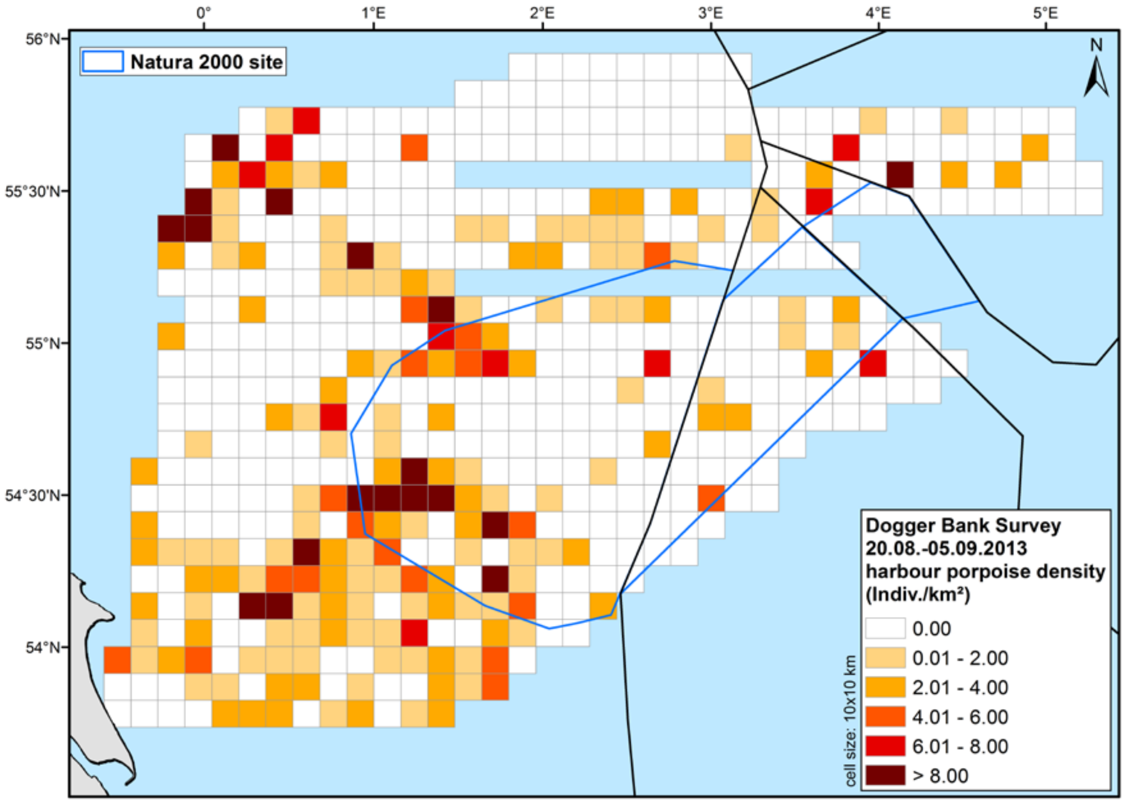


Figure 9. *Spatial distribution of harbour porpoise density (n/km^2) in Dogger Bank area in summer 2011 (top) and 2013 (bottom). Grid cell size: 10x10 km.*

To compare the spatial distribution of harbour porpoises between 2011 and 2013 densities were calculated for 10x10 km grid cells (Figure 9). Porpoise distribution in 2013 showed roughly the same pattern as in 2011 with low densities on the central Dogger Bank and in the northern parts of the study area, whereas higher densities were found on the slopes of the sandbank, mainly in the western and south-western strata. Contrary to 2011 low densities were found east of the Dogger Bank, whereas these areas yielded high densities in 2011. It should be noted, however, that the effort in 2013 was lower in this area. In the western part of the study area densities in 2013 were lower than 2011 in the central part, whereas densities in the north western part were higher in 2013.

The same marine mammal species were recorded in 2011 and 2013. Minke whales and seals were seen more in 2013, whereas more white-beaked dolphins were recorded in 2011 (Table 9). The distribution of minke whale and white-beaked dolphin showed the same pattern in both years.

Table 9. On-effort number of sightings and individuals of marine mammals in the Dogger Bank area in summer 2011 and summer 2013.

	Minke whale		White-beaked dolphin		Seal	
	sighting	**Ind**	**Sighting**	**ind**	**sighting**	**ind**
2011	7	8	11	35	15	15
2013	16	18	5	12	27	35

The comparison between the 2011 and 2013 surveys shows a decrease in estimated harbour porpoise density. The two surveys differed in a number of aspects (survey team, sighting conditions, and timing of the survey) which might have had an impact on the recorded sightings. The IMARES-team surveyed area DC in both years,. All observers of the different teams follow the same protocol and have extensive experience, indicating that the change in teams would not affect the results. The survey conditions were different in both years with 79% good conditions in 2011, and 74% in moderate conditions in 2013. However, abundance estimates are corrected for conditions by using specific g(0)s and esw for each sighting condition and therefore differences in survey conditions are reflected in the density calculations. Incomplete surveys of the eastern strata DA and DB can explain part of the lower total number in 2013, as this area showed a fairly high density of harbour porpoises in 2011.
Another possible impact could have been the different timing of the survey (almost 3 weeks later start in 2013), which could have resulted in lower numbers in all strata. One assumption is that porpoises in the Dutch (and the whole southern) North Sea move up north in summer and early autumn and therefore show a gradually decrease in numbers in the southern areas (Evans et al., 2003; Gilles et al., 2009; Haelters et al., 2011; Jung et al., 2009; Scheidat et al., 2012; Teilmann et al., 2008).
All in all, the drop in numbers seems too big to be explained by the aforementioned differences alone. It can be hypothesized that the difference reflects a numerical change or a shift in distribution in a bigger area. Aerial surveys in the Dutch Continental Shelf and in the German North Sea show a decline after 2011.In the Dutch Continental Shelf numbers dropped from 85,572 (CI = 49,324-165,443) in March 2011 to 66,685 (CI = 37,284-130,549) in March 2012 and 63,408 (CI = 32,478–128,588) in March 2013 (Geelhoed et al., 2011, 2013a, 2013b & 2013c). Since 2011, however, no summer surveys in Dutch waters have been conducted. Results of aerial surveys in the German North Sea are similar, where 2011 has been a year with very high porpoise densities (e.g. 1.78 n/km^2, CV = 0.36) in the southern German Bight including a part of Dutch waters; Siebert et al. 2012). In spring, summer and autumn 2012 surveys of the total German EEZ in the North Sea were conducted. Density was estimated to be highest in spring (1.93 n/km^2, CV = 0.30), intermediate in summer (0.75 n/km^2, CV=0.32) and lowest in autumn (0.42 n/km^2, CV = 0.34). The density in summer 2012 was significantly lower than during spring 2012 and also during summer surveys of former years (Gilles et al., 2012). Density estimates for 2013 are not yet finalized, however the sighting rate is lower than 2012 (A. Gilles, pers. comm).

All in all the abundance estimate showed lower numbers in 2013 than in 2011, whereas the distribution showed roughly the same pattern around the Dogger Bank in both years. Compared to 2011, in the areas west of the Dogger Bank porpoise densities in 2013 were higher in the north and lower in the central part.

6. Conclusions

The Dogger Bank was surveyed in in August-September 2013, resulting in an abundance estimate of ca 45,000 harbour porpoises. This represents a substantial proportion of the abundance estimate for the North Sea and adjacent shelf waters population (n = 375,000 in 2005; Hammond et al., 2013).
The main aggregations of porpoises were found outside the shallow parts of the Dogger Bank. Animals were mainly encountered on the slopes and in UK waters west of the Dogger Bank. This distribution pattern was found also in 2011, but high densities were found in the areas east of the Dogger Bank as well. In the western part of the study area porpoise densities in 2013 were higher in the north and lower in the central part.
The estimated densities were lower in 2013 than 2011 (116,000), possibly due to slight difference in survey timing and/or changes in the porpoise distribution and population in the (southern) North Sea. The Dogger Bank area constitutes an important habitat for harbour porpoises in the North Sea and further investigation of seasonal patterns in this area would be advisable.

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7. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

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The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

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Signature:

Date: 4 February 2014

Approved: Jakob Asjes
Head of Department

Signature:

Date: 4 February 2014