Marine mammal surveys in Dutch North Sea waters in 2017

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Contents

Summary

In July 2017 aerial surveys to estimate the abundance of Harbour Porpoise *Phocoena phocoena* were conducted on the Dutch Continental Shelf. These surveys followed predetermined track lines in four areas: A - Dogger Bank, B - Offshore, C - Frisian Front & D - Delta. Between 7 and 18 July the entire Dutch Continental Shelf (DCS) was surveyed.

Marine mammals were assessed using line track distance sampling methods. Density and abundance estimates were calculated. In total, 230 sightings of 299 individual Harbour Porpoises were collected. Porpoise densities varied between 0.14-1.28 animals/km² in the areas A-D. The overall density on the entire Dutch Continental Shelf was 0.79 animals/km².

The total number of Harbour Porpoises on the Dutch Continental Shelf (areas A-D) was estimated at 46,580 animals (CI = 23,986 – 92,842) in July 2017. This number is in the same order of magnitude as the abundance estimate of 41,299 animals (CI 21,194-79,256) in 2015, and lies in between the abundance estimates in July 2010 (25,998, CI = 13,988 – 53,623) and July 2014 (76,773, CI = 43,414-154,265). The confidence intervals of the abundance estimates overlap indicating no statistically significant differences between the years.

These abundance estimates mean that 7-21% of the North Sea population, estimated at 345,000-361,000 individuals, was present on the Dutch Continental Shelf during the summer surveys.

In total 18 sightings of other marine mammal species were recorded. These comprised 16 sightings of single seals, which remained unidentified. The majority of the seals was observed in coastal waters of the Wadden Isles. Two Minke Whales were seen in area B – Offshore, with another two off effort in the same area.

This research is part of the project ‘KRM monitoring bruinvis’.

1 Introduction

In the Dutch Harbour Porpoise conservation plan (Camphuysen & Siemensma, 2011) abundance estimates of the Dutch population of Harbour Porpoise *Phocoena phocoena* have been identified as one of the research needs with the highest priority. These assessments are needed to evaluate potential impacts of anthropogenic activities on the national population level and to monitor the development of this protected species in general. Abundance estimates for the entire Dutch Continental Shelf were lacking until 2010. In July 2010-March 2011, under the umbrella of the Shortlist Masterplan Wind programme, dedicated aerial surveys of the entire Dutch Continental Shelf were conducted for the first time, in three different seasons (Geelhoed et al., 2011 & 2013a). These surveys resulted in abundance estimates and distribution maps of Harbour Porpoises, thus providing a baseline for subsequent surveys in order to study annual and seasonal variations in the numbers and distribution of porpoises in Dutch waters.

As a follow-up, surveys of the Dutch Continental Shelf were conducted in spring 2012 (Geelhoed et al., 2013b), spring 2013 (Geelhoed et al., 2014a), summer 2014 (Geelhoed et al., 2014b), summer 2015 (Geelhoed et al., 2015), and summer 2017. In this report we present the results of the aerial surveys conducted in July 2017. It was the fourth time ever a complete dedicated survey of Dutch waters took place in July. These surveys are conducted under the umbrella of the KRM-project monitoring bruinvis, a continuation of the BO-project BO-11-011.04-004 funded by the Ministry of Economic Affairs of The Netherlands. Apart from aerial surveys this KRM-project contains diet studies, and studies on contaminant loads in stranded harbour porpoises. The results of these studies are published separately.

2 Assignment

This report presents the aerial survey results using line transect distance sampling as described in the original assignment of KRM monitoring bruinvis, a continuation of the Beleidsondersteunend Onderzoek program of the Ministry of Economic Affairs. This assignment consisted of aerial surveys of marine mammals on the entire Dutch Continental Shelf in 2017.

3 Materials and Methods

3.1 Study area, survey design and data acquisition

The study area included the entire Dutch section of the continental shelf (59,417 km²). The study area was divided into four sub-areas: A - Dogger Bank (9,615 km²), B - Offshore (16,892 km²), C - Frisian Front (12,023 km²) and D - Delta (20,797km²) (**Fout! Verwijzingsbron niet gevonden.**). The design of the track line set-up was chosen to be parallel in areas C and D and zigzag in area A and B to ensure a representative coverage of the sub-areas and minimize off effort time. In addition, the direction of transects followed depth gradients in order to get a better sample by minimising variance in encounter rates between transect lines (Buckland et al., 2001). The survey design has been the same since the first aerial surveys were conducted in 2008 (Scheidat et al., 2012).

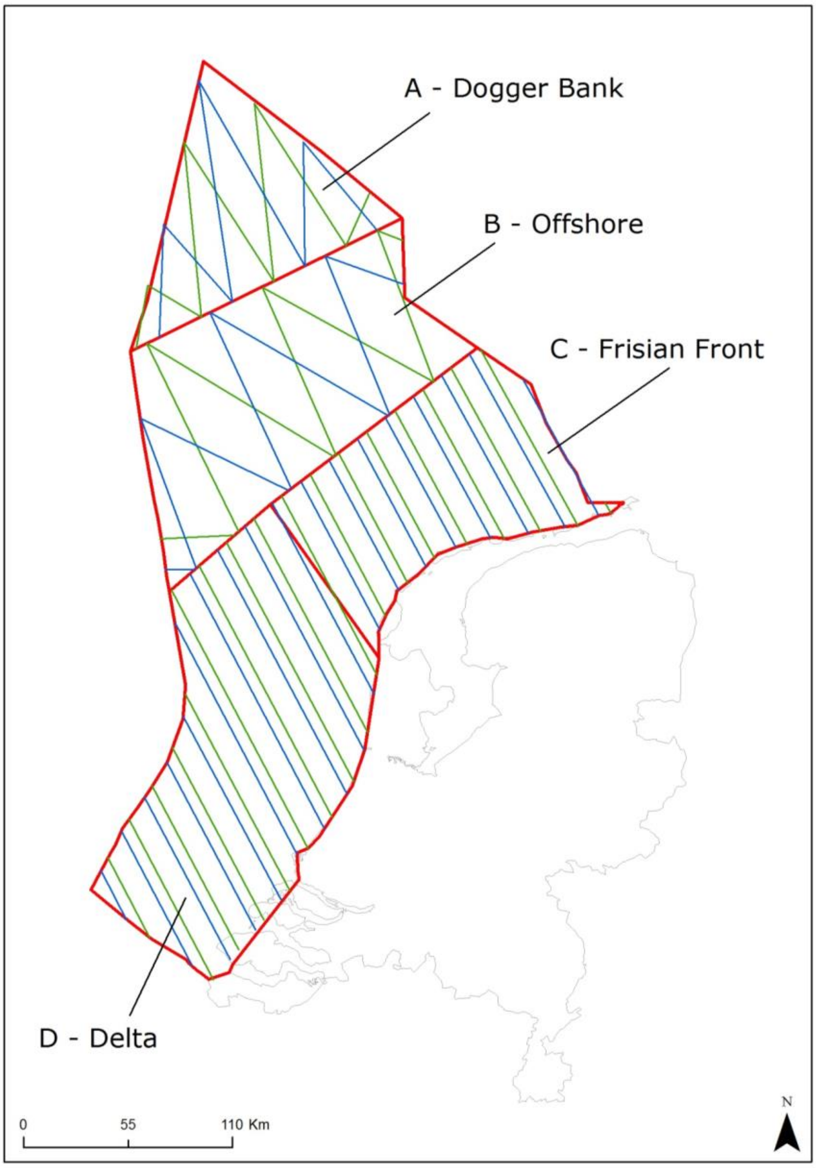

Figure 1. Map of the Dutch Continental Shelf with the planned track lines in study areas A - Dogger Bank, B - Offshore, C - Frisian Front and D - Delta. Colours indicate sets of track lines.

Surveys were conducted with a Partenavia 68 Observer, a high-winged twin-engine airplane equipped with bubble windows, flying at an altitude of ca. 183 m (600 ft) with a speed of ca. 186 km/hr (ca. 100 knots). Every four seconds the aircraft's position and time (to the nearest second) were recorded automatically onto a laptop computer connected to a GPS. Surveys were conducted by a team of three people. Sighting information and details on environmental conditions were entered by one person (the navigator) 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 1), swimming direction, cue, and reaction to the survey plane. The perpendicular distances 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 2). 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 (< 300 m from the track line) should one be present, and could differ between left and right.

Table 1. Behavioural codes and description for marine mammals.

Code	Behaviour
Swim	directional swimming
Slswim	slow directional swimming
Fasw	fast directional swimming or porpoising
Mill	milling, non-directional swimming
Rest	resting/logging: not moving at the surface
Feed	Feeding
Headup	spyhop of seals vertically in the water column
Other	other behaviour, noted down in comments

Table 2. Description of 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 searching area, is moderate.
Poor (P)	Observer's assessment that it is unlikely to see a porpoise, should one occur within the search strip.
Not possible to observe (X)	Observer off effort due to adverse circumstances

Surveys were conducted in weather conditions safe for flying operations (no fog or rain, visibility > 3km) and suitable for porpoise surveys (Beaufort sea state equal or less than 3). Surveys were conducted by Steve Geelhoed, Nicole Janinhoff, Linn Lehnert and Hans Verdaat as observer and navigator. Peter Reijnhout was the pilot.

3.2 Data quality check and data storage

All collected data was checked, e.g. for consistency of codes, corrected and subsequently stored in the Dutch database.

3.3 Data analysis

The survey data were collected using distance sampling techniques (Buckland et al., 2001). The collected sightings are used to calculate densities and abundance estimates, and to produce distribution maps. Only data from transect lines flown in good or moderate conditions were considered in the analyses.

Densities and abundance estimates were calculated according to distance sampling methods, that yield absolute densities, i.e., the number of animals/km² with the associated 95% confidence interval (CI) and coefficient of variation (CV; Buckland et al., 2001). To do this the so called effective strip half-width (ESW) is calculated. The ESW is calculated for each side of the track line. To obtain the first component to calculate the ESW the perpendicular distance of a sighting to the track line is measured. To calculate the distance of the sighting to the track line from air, the plane's altitude (600 feet = 183m) and the vertical or 'declination' angle to the animal are used. The latter is measured when it comes (or is estimated to come) abeam. By modelling a detection curve to all these distances the effective strip half-width is obtained; this is defined as the distance at which the expected number of detected objects would be the same as for the actual survey (Buckland et al., 2001).

One of the assumptions of line-transect distance sampling is that all animals on the track line are detected, which would mean that the chance to see all animals at a distance of 0 m from the track line is 1 (100%). For most animals, but in particular for cetaceans, this assumption is not true and a correction factor, called g(0), needs to be obtained to correct for the proportion of animals missed on the track line. In practice there are two reasons why animals are not recorded: 1. the animals are not "available" to be seen, (e.g. because they are sub-merged) or 2. they are missed by the observers ("observer bias"). To obtain a reliable estimate of absolute abundance (the number of animals in a given area e.g., the DCS) it is therefore needed to estimate the proportion of animals actually seen on the track line: the true value of g(0), and use the reciprocal of this value to correct the ESW. In the analysis g(0) values of 0.37 for good conditions and 0.14 for moderate conditions are used (taken from Scheidat et al., 2008).
Animal abundance in each stratum v (i.e., area) was estimated using a Horvitz-Thompson-like estimator as:

$$\hat{N}_v = \frac{A_v}{L_v}\left(\frac{n_{gsv}}{\hat{\mu}_g} + \frac{n_{msv}}{\hat{\mu}_m}\right)\bar{s}_v$$

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, $\hat{\mu}_g$ is the estimated total effective strip width in good conditions, $\hat{\mu}_m$ 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 . $\hat{N}_{v(\text{group})} = \hat{N}_v / \bar{s}_v$ Total animal and group abundances were estimated by:

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

respectively. Densities were estimated by dividing the abundance estimates by the area of the associated stratum. Mean group size across strata was estimated by $\hat{E}[s] = \hat{N} / \hat{N}_{(\text{group})}$.
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 were created using R 3.0.1 software. 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 DCS measure approximately 20x20km, resulting in areas ranging from 388 to 409 km^2, depending on latitude.

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) 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 (e.g., the Wadden Sea) could be less reliable due to lower effort and habitat discontinuities within the grid cell. Grid cells with an effort less than 1 km^2 were omitted from the density calculations.

4 Results

4.1 Weather conditions and survey effort

The entire Dutch Continental Shelf was surveyed on six days in the period 7-18 July (Figure 2, Table ***3***), resulting in a total distance of 2362 km on effort. Of this distance 1901 km (80.5%) was surveyed with good or moderate conditions on at least one side of the plane (Table 4). Some of the track lines with poor or worse conditions were surveyed again under better sighting conditions. Particularly every second southbound track line in Area B – Offshore that witnessed poor conditions due to strong glare on 9 July, was surveyed under better conditions on July 18th.

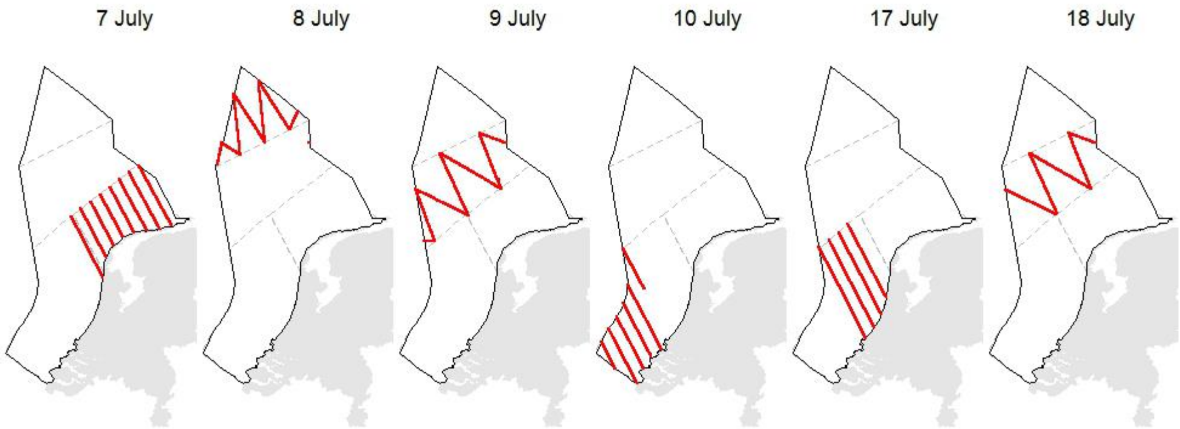

Figure 2. Survey effort per day July 2017.

Table 3. Survey dates and surveyed areas in July 2017.

Survey date	**Surveyed area**
7 July	Area C - Frisian Front & Area D – Delta
8 July	Area A - Dogger Bank
9 July	Area B – Offshore
10 July	Area D - Delta
17 July	Area D – Delta
18 July	Area B – Offshore

Table 4. Total survey days, effort (surveyed distance), sighting conditions (g – good, m – moderate, p – poor, x – not possible to observe) and Harbour Porpoise sightings on both sides during the aerial surveys. Navigator sightings are excluded.

Effort (km)	**Sighting conditions (%)**			**Harbour Porpoise sightings (n)**		
	G	**m**	**p/x**	**Sightings**	**Individuals**	**'Calves'**
2362	18.9	61.6	19.5	230	299	21

4.2 Harbour Porpoise sightings – pod size and behaviour

In total, 230 sightings with 299 individual Harbour Porpoises, including 21 calves, were collected (Table 4). These sightings are shown in Figure 3. Most sightings concerned single individuals, with an average pod size of 1.3 individuals. The majority of the sightings concerned directionally swimming animals (74%, n = 299); 20% was milling or resting at the surface. Six animals, in three groups were qualified as feeding, associated with a fish ball, and feeding seabirds.

4.3 Harbour Porpoise - distribution

Using the effectively covered strip width during the survey, a grid map was created showing the distribution pattern density of porpoises (animals/km²) per 1/9 ICES grid cell (Figure 4). Harbour Porpoises were widely distributed and showed a homogenous distribution in a band from area D – Delta north to area B- offshore. The highest densities were found NW of the Wadden Isles. Harbour Porpoises were virtually absent in large areas in the eastern part of area C – Frisian Front north of the Wadden Isles. Porpoises were scarce in area A – Dogger Bank.

4.4 Harbour Porpoise - densities and abundance estimates

Densities of Harbour Porpoises were estimated for each survey stratum (areas A-D) as well as for the whole DCS. Figure 4 gives an overview of density (animals/km²) as well as abundance (number of animals) per survey area. The overall density was 0.79 animals/km². The lowest density (0.14 animals/km²) was found in area A – Dogger Bank. The highest density was found in area B – Offshore with 1.28 animals/km² (Table 5).

The total number of Harbour Porpoises on the Dutch Continental Shelf (areas A-D) was estimated at 46,902 animals (CI = 24,389 – 93,532, Table 5) in July 2017. The majority of the animals (83.6%) was estimated in areas B – Offshore and D - Delta, both areas covering together 63.6% of the total surface of the DCS.

Table 5. Abundance estimates of Harbour Porpoises for July 2017 per area.

	Density (animals/km²)	**C95% CI**	**Abundance (n animals)**	**95% CI**	**CV**
Area A – Dogger Bank	0.14	0.01 - 0.29	1325	167 – 2833	0.46
Area B – Offshore	1.28	0.55 - 2.92	21,584	9229 – 49,331	0.44
Area C – Frisian Front	0.53	0.08 - 1.53	6360	991– 18,402	0.64
Area D - Delta	0.85	0.41 - 1.66	17,631	8595 – 34,552	0.37
Total DCS	0.79	0.41 – 1.86	46,902	24,389 – 93,532	0.35

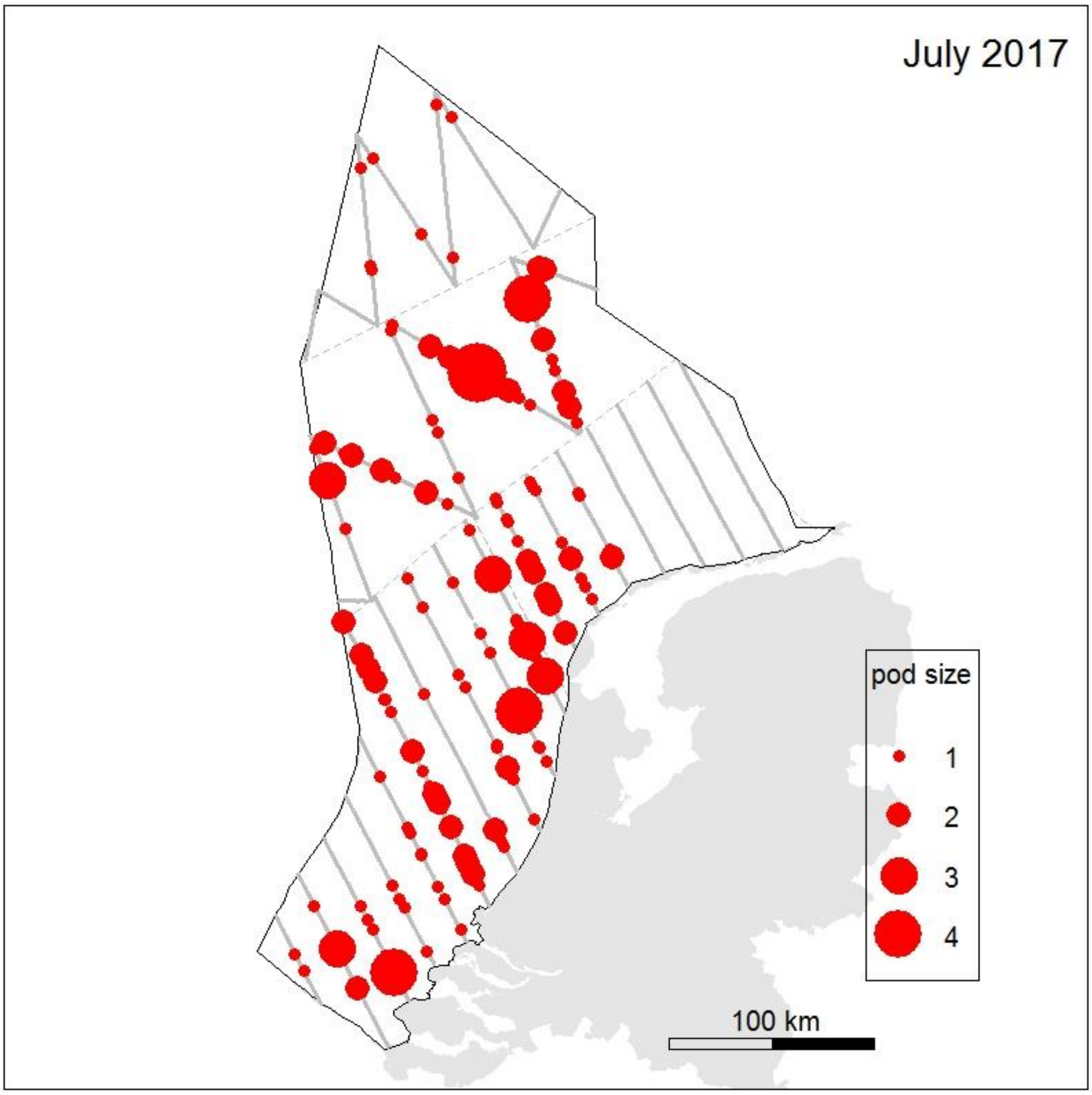

Figure 3. Harbour Porpoise sightings during the DCS survey in July 2017.

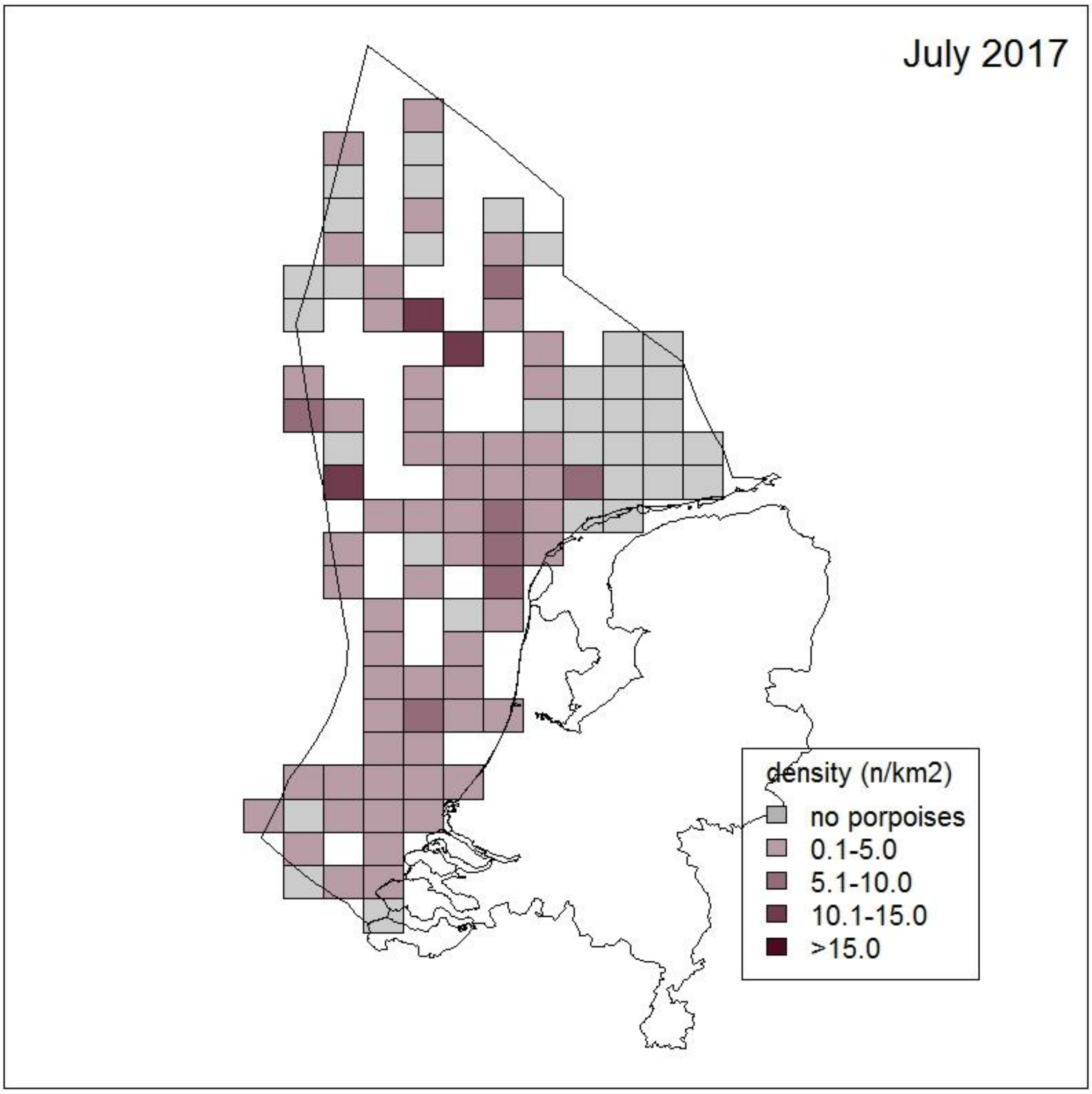

Figure 4. Density distribution of Harbour Porpoises (animals/km²) per 1/9 ICES grid cell, July 2017. Grid cells with low effort (< 1 km2) are omitted.

4.5 Other marine mammals - sightings

During the surveys 20 sightings of other marine mammal species were made on effort (Table 6). One other cetacean species than Harbour Porpoise was sighted: Minke Whale *Balaenoptera acutorostrata*. Two Minke Whales were seen in the north-eastern part of area B - Offshore (Figure 5). Off effort two more sightings of single animals were made in this area, where some fish balls and feeding seabirds were present. Seals (Grey Seal *Halichoerus grypus* and Harbour Seal *Phoca vitulina)* were mainly seen in the vicinity of the coast, with a concentration north of the Wadden Isles near their haul out sites (Figure 6). Numbers of seals and Minke Whale were too low to calculate densities and abundance estimates.

Table 6. Total survey days, effort (surveyed distance), and on effort sightings of other marine mammals during the aerial surveys.

Effort	**Minke Whale**		**Seals**	
(km)	**Sightings**	**N**	**Sightings**	**N**
2362	2	2	16	16

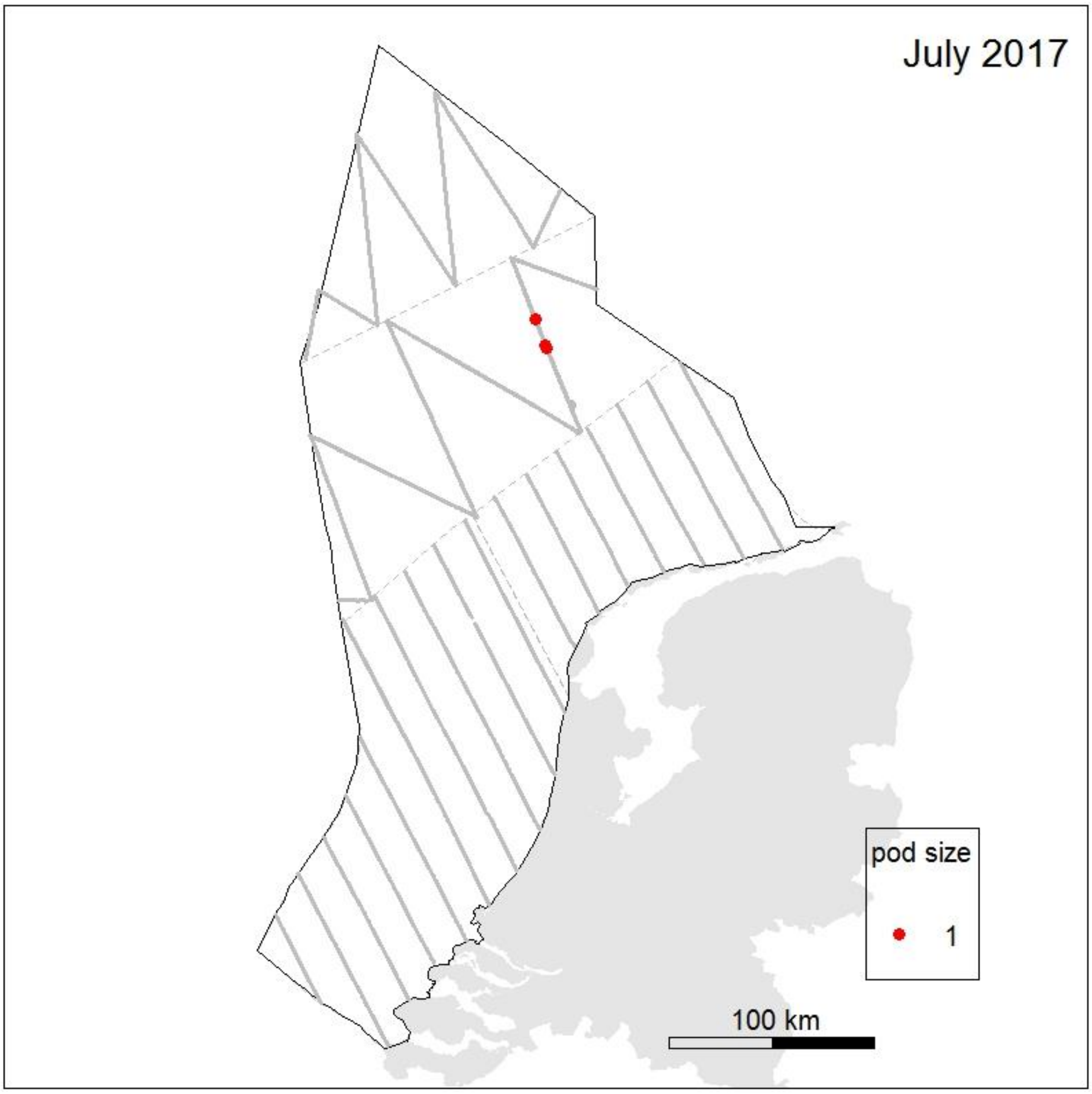

Figure 5. Minke whale sightings during the DCS survey in July 2017.

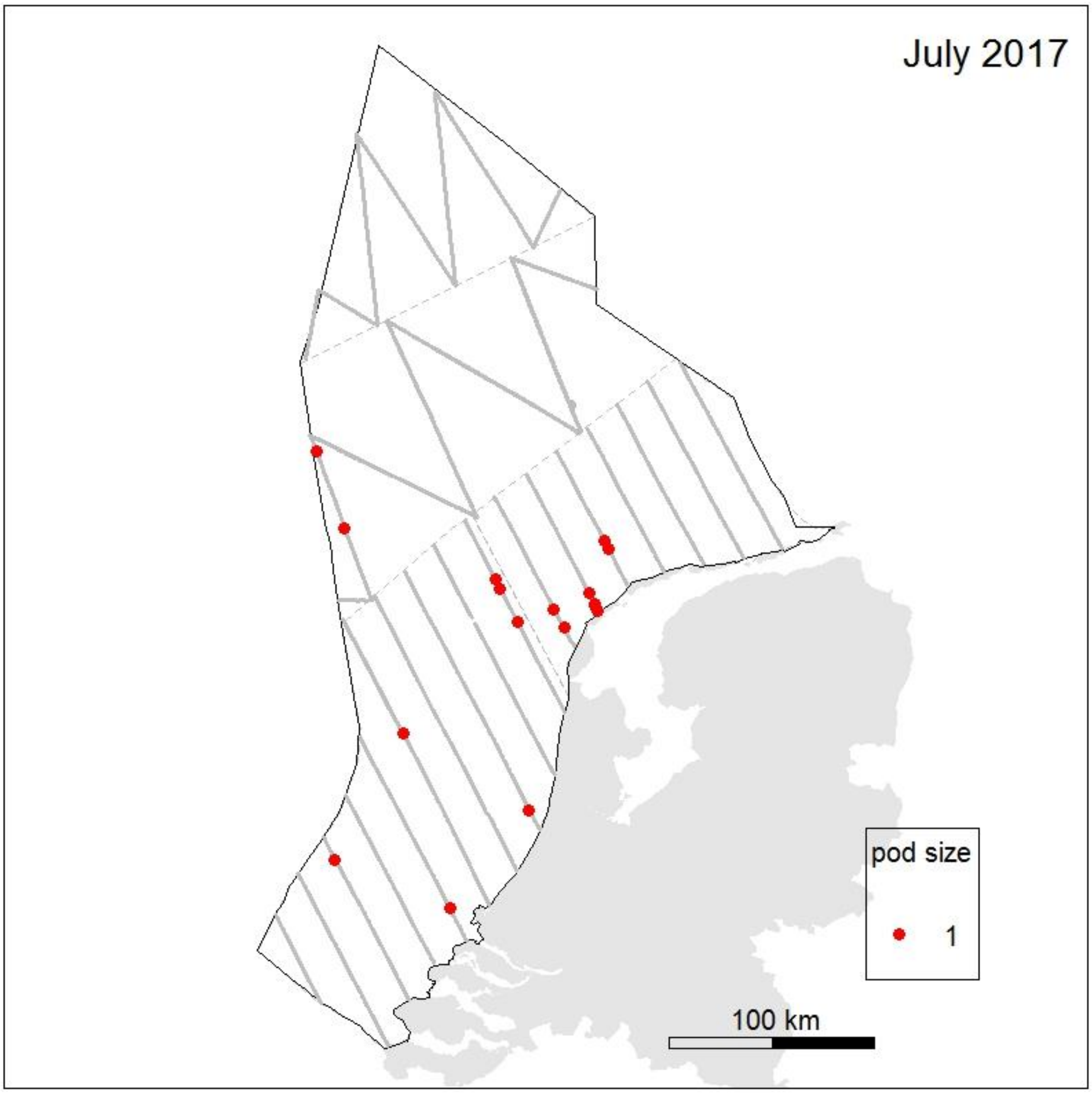

Figure 6. Seal sightings during the DCS survey in July 2017.

5 Discussion

5.1 Comparison with other surveys

Wageningen Marine Research and its predecessor IMARES have been conducting aerial surveys in Dutch North Sea waters since May 2008. In July three DCS wide surveys have been conducted previously, in 2010, 2014 and 2015. Densities and abundance estimates of Harbour Porpoises in July are presented in Table 7. The summer densities for the different years vary between 0.14 and 3.08 animals/km^2, highlighting that the density between the sub-areas is highly variable.

The abundance estimate in 2017 of 46,902 individuals (CI = 24,389 – 93,532) is in the same order as magnitude as the abundance estimate in 2015 (n = 41,299; CI 21,194-79,256), and intermediate between 2010 (n = 25,998; CI = 13,988 – 53,623) in 2010 and 2014 (n = 76,773; CI = 43,414-154,265). The confidence intervals of the abundance estimates overlap indicating no statistically significant differences between the years.

The porpoises in Dutch waters belong to the population that uses the wider North Sea (Evans et al 2009). This whole area was surveyed during summer of 2005 and 2016 (SCANSII and SCANS-III), resulting in an abundance estimate of 355.000 or 345.000 individuals respectively (Hammond et al., 2013, 2017). Using a model-based approach, with the SCANS data and national surveys, Gilles et al. (2016) estimated the population size to number 361,000 individuals in 2005-2013. This means that 7-21% of the North Sea population is present on the Dutch Continental Shelf in summer.

Table 7. Density and abundance estimates of Harbour Porpoises obtained in July 2010, 2014, 2015 and 2017 (Geelhoed et al. 2011, 2013a, 2014b).

2017	**Density (animals/km^2)**	**C95% CI**	**Abundance (n animals)**	**95% CI**	**CV**
Area A – Dogger Bank	0.14	0.01 - 0.29	1325	167 – 2833	0.46
Area B – Offshore	1.28	0.55 - 2.92	21,584	9229 – 49,331	0.44
Area C – Frisian Front	0.53	0.08 - 1.53	6360	991– 18,402	0.64
Area D - Delta	0.85	0.41 - 1.66	17,631	8595 – 34,552	0.37
Total DCS	0.79	0.41 – 1.86	46,902	24,389 – 93,532	0.35
2015					
Area A – Dogger Bank	1.12	0.43-2.25	10,748	4113 – 21,676	0.39
Area B – Offshore	0.80	0.17-1.20	13,573	7 002 – 26,606	0.35
Area C – Frisian Front	0.44	0.20-0.98	5304	2354 -11,798	0.43
Area D - Delta	0.56	0.41-1.58	11,674	3542 -24,958	0.45
Total DCS	0.70	0.36-1.34	41,299	21,194- 79,256	0.33
2014					
Area A – Dogger Bank	3.08	1.50 -6.45	29,689	14,375 – 61,995	0.37
Area B – Offshore	0.37	0 – 1.21	6297	0 – 20,509	0.96
Area C – Frisian Front	1.83	0.97 – 4.11	22,010	11,623 – 49,439	0.39
Area D - Delta	0.90	9.46 – 1.84	18,778	9548 – 38,167	0.36
Total DCS	1.29	0.73 – 2.60	76,773	43,414 – 154,265	0.34
2010					
Area A – Dogger Bank	0.40	0.18 - 0.85	3806	1738 – 8165	0.40
Area B – Offshore	0.48	0.21 - 1.06	8055	3589 – 17,872	0.42
Area C – Frisian Front	0.34	0.05 - 0.89	4039	553 – 10,701	0.62
Area D - Delta	0.48	0.21 - 1.06	10,098	4341 – 22,024	0.40
Total DCS	0.44	0.24 - 0.90	25,998	13,988 – 53,623	0.34

6 Conclusions and recommendations

An aerial survey of the Dutch Continental Shelf in July 2017 resulted in an abundance estimate of 46,902 animals (CI = 24,389 – 93,532). This number is in the same order of magnitude as the abundance estimate of 41,299 animals (CI 21,194-79,256) in 2015, and lies in between the abundance estimates in July 2010 (25,998, CI = 13,988 – 53,623) and July 2014 (76,773, CI = 43,414-154,265). The confidence intervals of the abundance estimates overlap. The confidence intervals of the abundance estimates overlap indicating no statistically significant differences between the years.

These abundance estimates indicate that 7-21% of the North Sea population, estimated at 345,000-361,000 individuals, was present on the Dutch Continental Shelf during these summer surveys.

The results of these aerial surveys will feed into the OSPAR MSFD indicator on abundance and distribution of marine mammals.

7 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V.

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Justification

Report C030/18
Project Number: 4312100062

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

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Wageningen Marine Research is the Netherlands research institute established to provide the scientific support that is essential for developing policies and innovation in respect of the marine environment, fishery activities, aquaculture and the maritime sector.

Wageningen University & Research:
is specialised in the domain of healthy food and living environment.

The Wageningen Marine Research vision
'To explore the potential of marine nature to improve the quality of life'

The Wageningen Marine Research mission

- To conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas.
- Wageningen Marine Research is an independent, leading scientific research institute

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