Marine mammal surveys in Dutch North Sea waters in 2015

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Cover: Minke Whale on the Dutch Continental Shelf, 16 July 2015 (Sander Lagerveld)

Contents

Summary

In July 2015 aerial surveys to estimate the abundance of Harbour Porpoises *Phocoena phocoena* on the Dutch Continental Shelf were conducted. These surveys followed predetermined track lines using distance sampling methods in four areas: A - Dogger Bank, B - Offshore, C - Frisian Front & D - Delta. Between 13 and 20 July the entire Dutch Continental Shelf (DCS) was surveyed.

In total, 144 sightings of 172 individual Harbour Porpoises were collected. Porpoise densities varied between 0.36-1.34 animals/km² in the areas A-D. The overall density on the entire Dutch Continental Shelf was 0.70 animals/km².

The total numbers of Harbour Porpoises on the Dutch Continental Shelf (areas A-D) in July were estimated at 41 299 (Confidence Interval (CI) = 21 194 - 79 256). This estimate is intermediate between the estimate for July 2010 (25 998, CI = 13 988 – 53 623) and July 2014 (76 773, CI = 43 414-154 265), however, the confidence intervals of the estimates overlap.
Land-based observations during systematic seawatches and records of beached animals showed lower numbers in Dutch coastal waters in 2015 (including July) compared to previous years. This caused concern about a potential reduction in abundance of porpoises in Dutch waters. However, the results of the abundance estimates per area show that most porpoises (58.9%) were estimated for the northernmost areas A –Dogger Bank and B – Offshore. This suggests that harbour porpoises had a more offshore distribution in 2015.

In total 7 sightings of other marine mammal species were made. These comprised 6 sightings of in total 20 seals, which remained unidentified except one group of 15 Grey Seal *Halichoerus grypus* on 15 July. One individual Minke Whale was seen in area D - Delta north northwest of Texel on 16 July.

This research is part of the Beleidsondersteunend Onderzoek (BO-11-011.02-004) program of the Ministry of Economic Affairs (EZ).

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 population assessments are needed to evaluate potential impacts of anthropogenic activities on the population level and to monitor the population 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 other 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), and summer 2015. In this report we present the results of the aerial surveys conducted in July 2015. It was the third time ever a complete dedicated survey of Dutch waters took place in July. These surveys are part of the BO project (BO-11-011.04-004) funded by the Ministry of Economic Affairs (EZ) of The Netherlands. Apart from aerial surveys this project contains diet studies, and studies on contaminants. The results of these studies will be published separately.

2. Assignment

This report presents the aerial survey results using line transect distance sampling as described in the original assignment of the Beleidsondersteunend Onderzoek (BO-11-011.02-004) program of the Ministry of Economic Affairs (EZ). This assignment consisted of aerial surveys of the entire Dutch Continental Shelf in 2015.

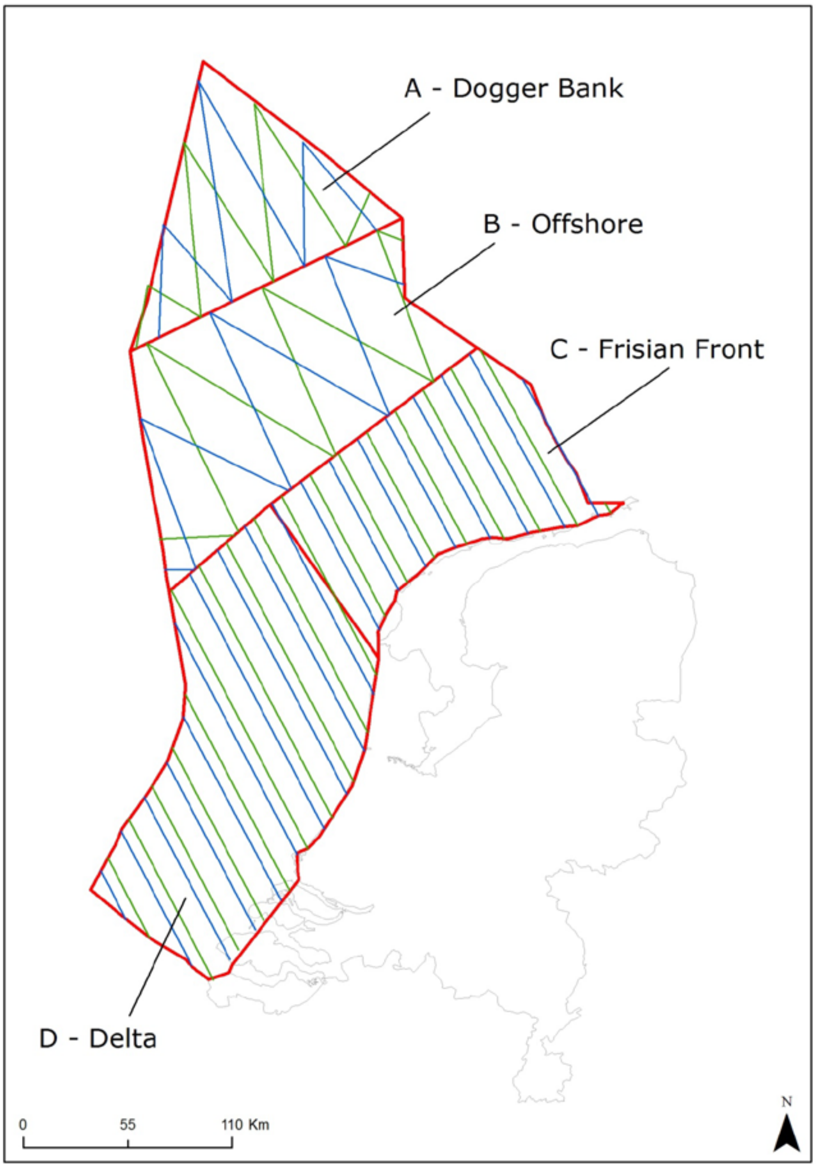

Figure 1. Map of the Dutch Continental Shelf with the planned track lines in study areas A - Dogger Bank, B - Offshore, C - Frisian Front and D - Delta. Colours indicate sets of track lines.

3. Materials and Methods

Study area, survey design and data acquisition

The study area included the entire Dutch section of the continental shelf. The study area was divided into four sub-areas: A - Dogger Bank (9615 km²), B - Offshore (16 892km²), C - Frisian Front (12 023km²) and D - Delta (20 797km²) (Figure 1). 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. The direction of transects followed depth gradients in order to get a better sample by minimising variance in encounter rate between transect lines (Buckland et al., 2001). The survey design has been the same since 2008 (Scheidat et al., 2012).

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 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) was 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 a beam 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.

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 and Hans Verdaat as observers. Martin Baptist and Sander Lagerveld were navigator. Peter Reijnhout was the pilot.

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.

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 obtaining absolute densities, i.e., the number of animals/km² with the associated 95% confidence interval (C.I.) and coefficient of variation (C.V.; Buckland et al., 2001). To do this the so called effective strip half-width (ESW), the strip along the track line in which all animals are counted, 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 are detected on the track line, 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:

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

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 (C.V.) and 95% confidence intervals (C.I.) 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 (R). 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

Weather conditions and survey effort

The entire Dutch Continental Shelf was surveyed on five days in the period 13-20 July (Figure 2, Table 3), resulting in a total distance of 2333 km on effort. Of this distance 2238 km (95.9%) was surveyed with good or moderate conditions on at least one side of the plane (Table 4). Technical problems on 16 July resulted in loss of data on one transect in area D – Delta. The surveys took place during the initial phase of construction activities for the GEMINI offshore wind farm north of Schiermonnikoog in area C-Frisian Front.

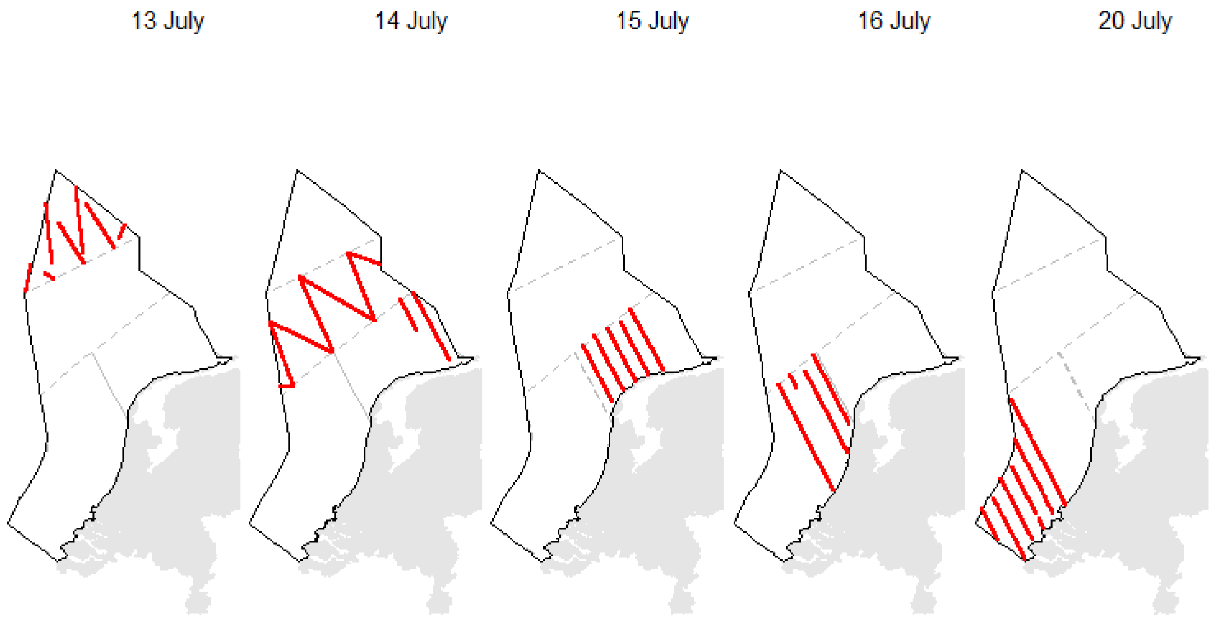

Figure 2. Survey effort per day July 2015.

Table 3. Survey dates and surveyed areas.

Survey date	Surveyed area
13 July	Area A - Dogger Bank
14 July	Area B – Offshore and Area C - Frisian Front
15 July	Area C - Frisian Front
16 July	Area D - Delta
20 July	Area D – Delta

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'
2333	0.7	95.2	3.9	144	172	13

Harbour Porpoise sightings – pod size and behaviour

In total, 144 sightings 172 individual Harbour Porpoises, including 13 calves, were collected (Table 4). These sightings are shown in Figure 3. Most sightings concerned single individuals, with an average pod size of 1.2 individuals. The majority of the sightings concerned directionally swimming animals; 10% was milling or resting at the surface.

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 patchy distribution. Larger areas of high densities were seen further offshore in area A – Dogger Bank and area B – Offshore. Harbour porpoises were virtually absent in large areas north of the Wadden Isles in area C – Frisian Front and in the western part of area D – Delta.

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 0.70 animals/km². The highest density was found in area A – Dogger Bank with 1.12 animals/km². Second highest density (0.80 animals/km²) was found in area B – Offshore (Table 5).

The total number of Harbour Porpoises on the Dutch Continental Shelf (areas A-D) was estimated at 41 299 animals (CI = 21 194 - 79 256, Table 5) in July 2015. More than half (58.9%) of the animals were estimated in areas A – Dogger Bank and B – Offshore, together covering 44.7% of the total surface of the DCS.

Table 5. Abundance estimates of Harbour Porpoises for July 2015 per area.

	Density (animals/km^2)	**95% CI**	**Abundance (n animals)**	**95% CI**	**CV**
Area A – Dogger Bank	1.12	0.43-2.25	10 748	4 113 – 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	5 304	2 354 - 11 798	0.43
Area D - Delta	0.56	0.41-1.58	11 674	3 542 - 24 958	0.45
Total DCS	0.70	0.36-1.34	41 299	21 194 - 79 256	0.33

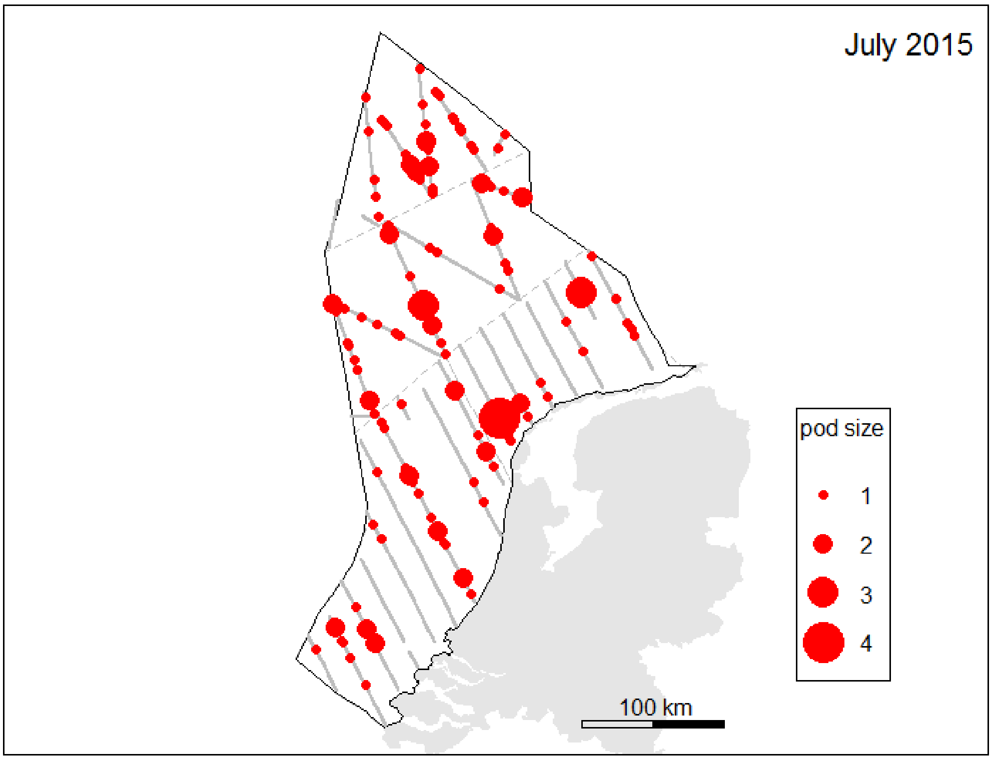

Figure 3. Effort and Harbour Porpoise sightings during the DCS survey in July 2015.

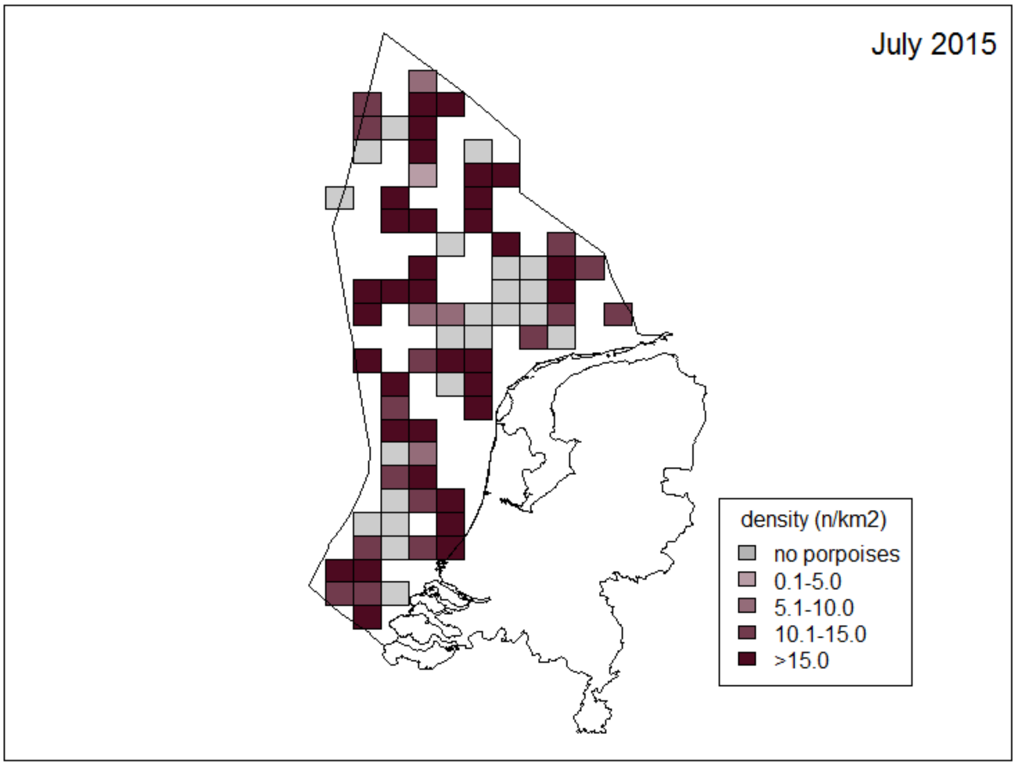

Figure 4. Density distribution of Harbour Porpoises (animals/km²) per 1/9 ICES grid cell, July 2015. Grid cells with low effort (< 1 km²) are omitted.

Other marine mammals - sightings

During the surveys 7 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*. The Minke Whale was seen in the northern part of area D - Delta, where several fish balls were seen (Figure 5) on 16 July. Several Harbour Porpoises were seen in the same area, whilst none were seen on the southern part of the trackline. Due to technical problems the latter data were not stored. Most groups of seals (n = 6, Grey Seal *Halichoerus grypus* and Harbour Seal *Phoca vitulina)* remained un-identified. One group of 15 Grey Seals was identified on 15 July, just north of the Wadden Isles. Seals were seen mainly in coastal waters near their haul out sites, north of the Wadden Isles and of the Dutch Delta (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**
2333	1	1	6	20

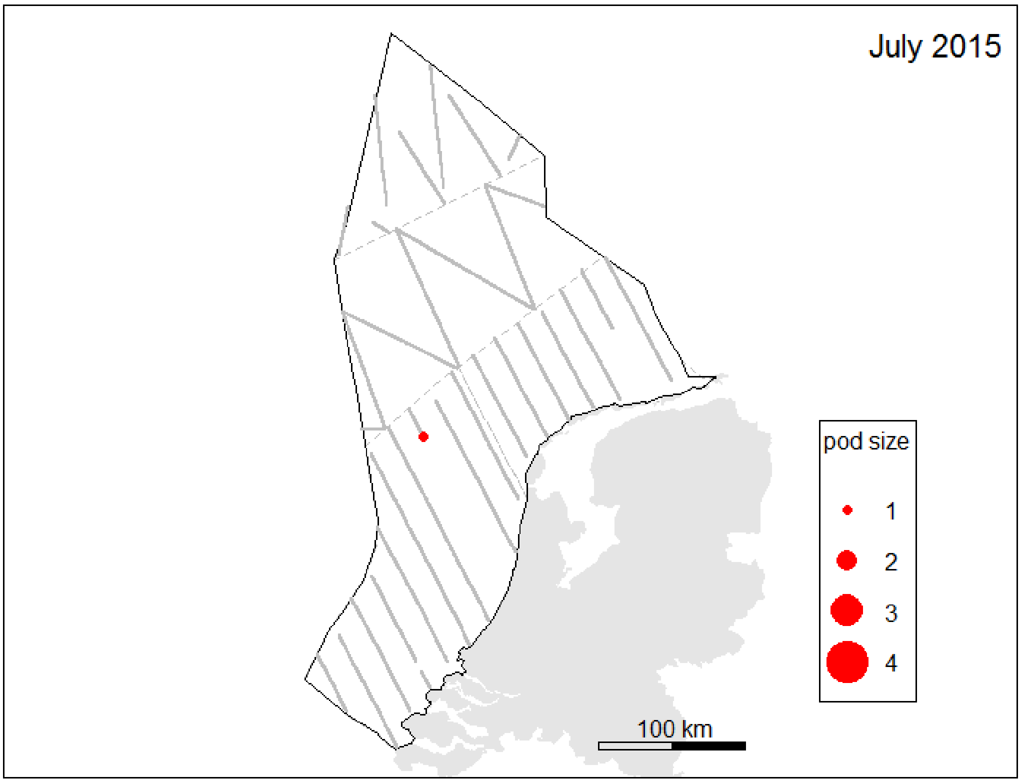

Figure 5. Effort and Minke whale sightings during the DCS survey in July 2015.

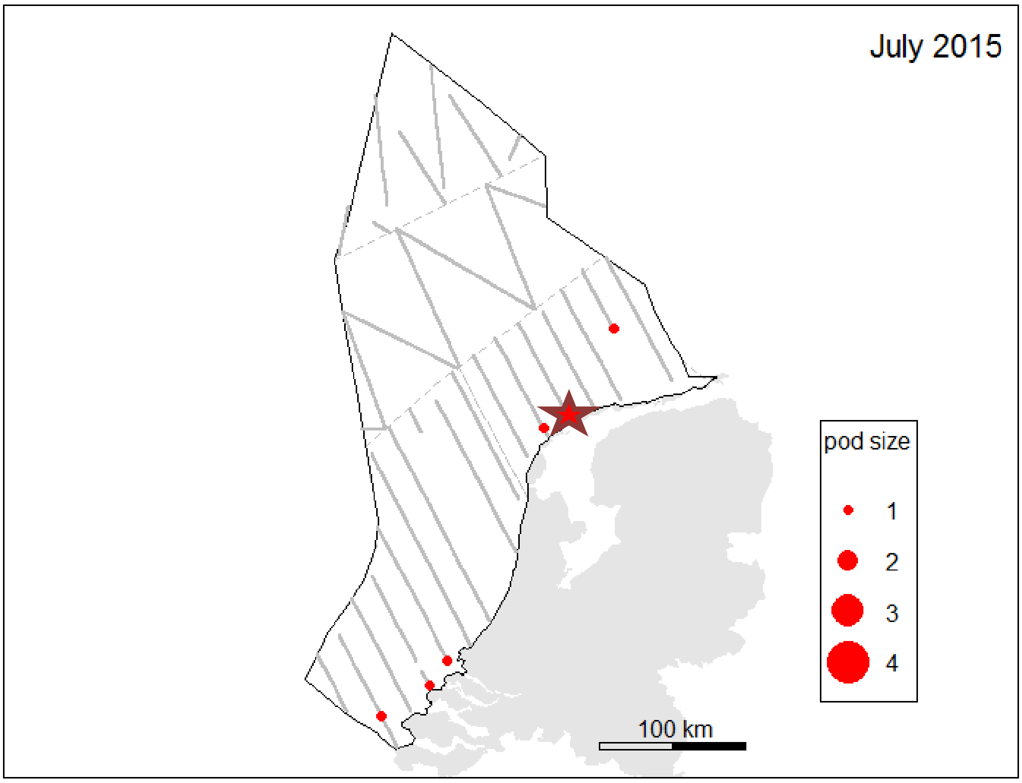

Figure 6. Effort and seal sightings during the DCS survey in July 2015. Asterisk = fifteen Grey Seals.

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

2015	Density (animals/km^2)	C95% CI	Abundance (n animals)	95% CI	CV
Area A – Dogger Bank	1.12	0.43-2.25	10 748	4 113 – 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	5 304	2 354 -11 798	0.43
Area D - Delta	0.56	0.41-1.58	11 674	3 542 -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	6 297	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	9 548 – 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	3 806	1 738 – 8 165	0.40
Area B – Offshore	0.48	0.21 - 1.06	8 055	3 589 – 17 872	0.42
Area C – Frisian Front	0.34	0.05 - 0.89	4 039	553 – 10 701	0.62
Area D - Delta	0.48	0.21 - 1.06	10 098	4 341 – 22 024	0.40
Total DCS	0.44	0.24 - 0.90	25 998	13 988 – 53 623	0.34

Comparison with previous surveys

IMARES has been conducting aerial surveys in Dutch North Sea waters since May 2008. In July two DCS wide surveys have been conducted previously, in 2010 and 2014. Densities and abundance estimates of Harbour Porpoises in July are presented in Table 7. The abundance estimates of Harbour Porpoises were 76 773 (CI = 43 414-154 265) in 2014, and 25 998 (CI = 13 988 – 53 623) in 2010 (Table 7). The estimate in 2015 is intermediate. The confidence intervals of the subsequent estimates overlap indicating no significant differences between the years. A rough comparison of the density and abundance estimate per sub-area shows no consistent trends over the years either.

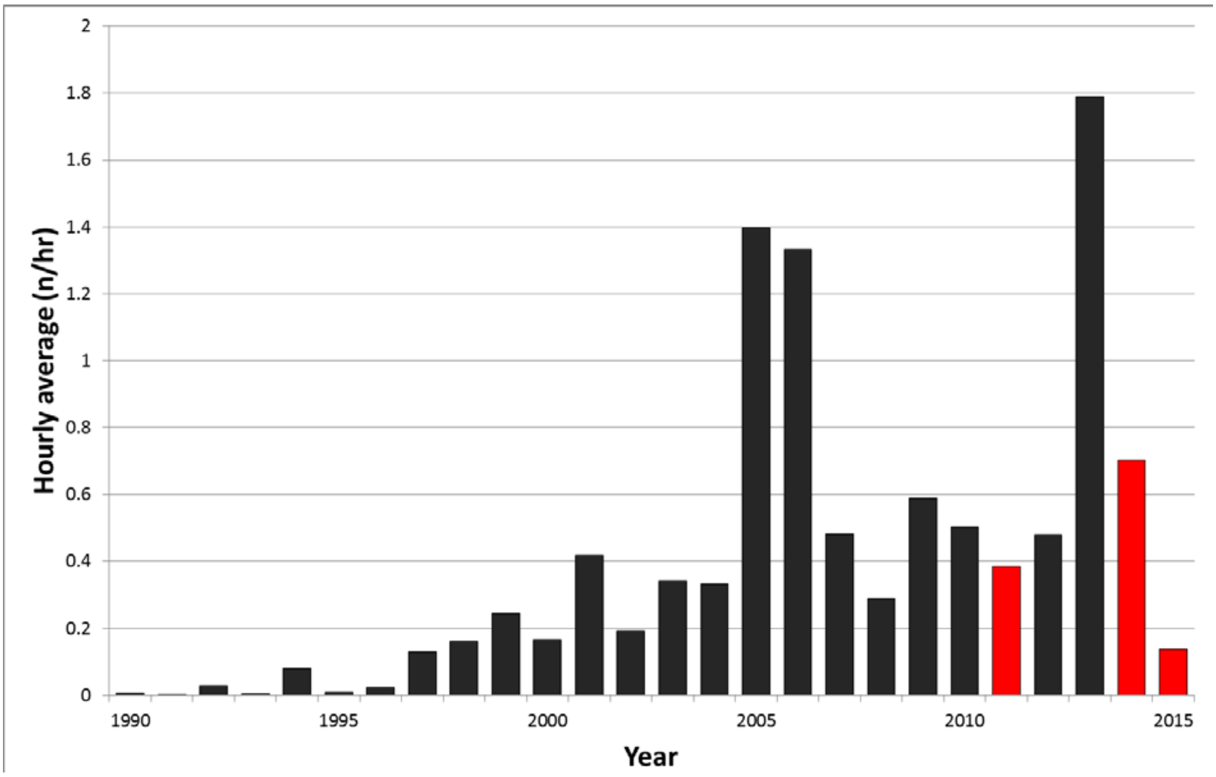

Figure 7. Numbers of Harbour Porpoise per hour per year observed in Dutch coastal waters (N = 8997) since 1990 from systematic seawatching results at regularly manned posts (Westkapelle, Maasmond, Scheveningen, Katwijk, Noordwijk, Bloemendaal aan Zee, Egmond aan Zee and Camperduin).Porpoises were scarce before 1990. Data till 8 December 2015. Red bars aerial surveys of the DCS in summer.

Numbers of observed Harbour Porpoises in Dutch and Belgian coastal waters were low in 2015 (Haelters & Geelhoed, 2015), as witnessed by low numbers of stranded animals (www.walvisstrandingen.nl) and low numbers during coastal sea watches in the Netherlands (Figure 7). Compared to the seasonal pattern in previous years, the hourly averages were low for each month in 2015 (Figure 8). The seasonal pattern of Harbour Porpoises in 2015 deviates from the temporal occurrence of Harbour Porpoises along the Dutch coast in previous years. In 2015 peak numbers were observed for a shorter period than before 2015, when peak numbers were recorded in December-March. After this period the hourly averages dropped, and increased slightly from July onwards. In 2015 the hourly average in July was even lower than June, and twenty times lower than the 1990-2014-average. The number of beached Harbour Porpoises in the Netherlands was lower for each month in 2015 than the previous period 2005-2014. The number of reported porpoises in July 2015 was slightly lower than average (Figure 9). The number in July 2014 was slightly above average. In conclusion, numbers of Harbour Porpoises in Dutch coastal waters were low in 2015, including July.

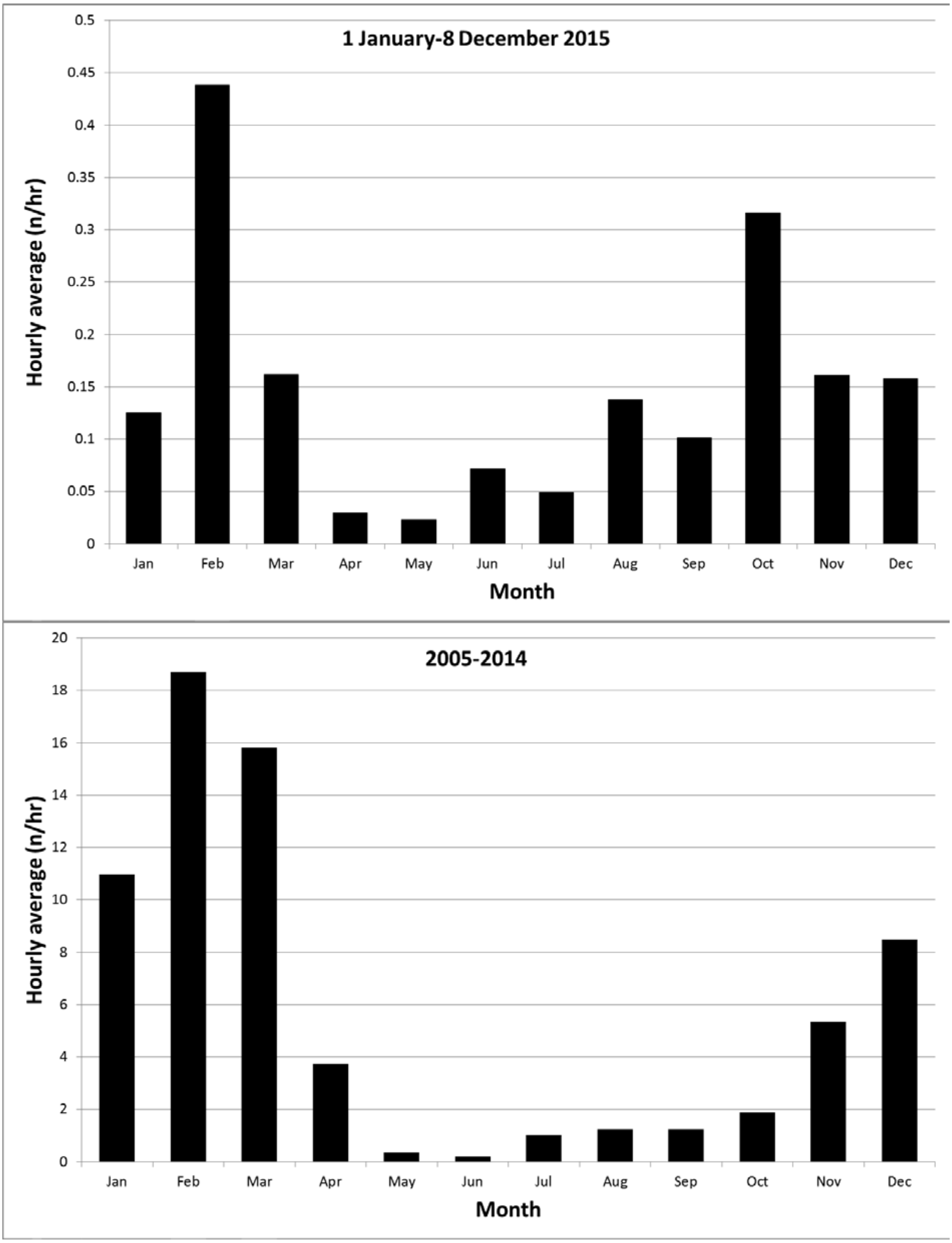

Figure 8. Seasonal pattern of Harbour Porpoise per hour per month observed in Dutch coastal waters from systematic seawatching results at regularly manned posts (Westkapelle, Maasmond, Scheveningen, Katwijk, Noordwijk, Bloemendaal aan Zee, Egmond aan Zee and Camperduin). Top; 1 January-8 December 2015 (N = 242), bottom 1990-2014 (N=8997). Note the different scales of the Y-axis.

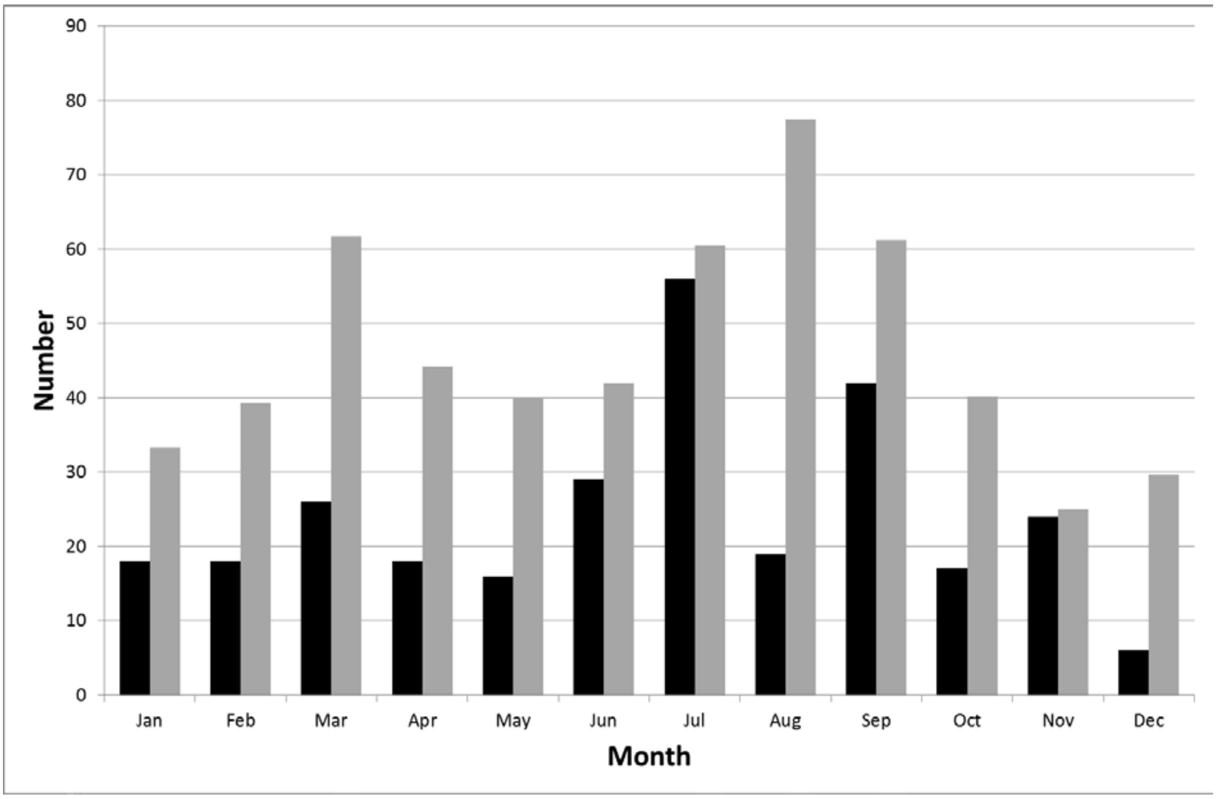

Figure 9. Seasonal pattern of beached Harbour Porpoise in the Netherlands. Black bars 1 January-8 December 2015 (N=287), grey bars 2005-2014 (N = 5541). Source: www.walvisstrandingen.nl.

The observed numbers in the coastal zone in 2015, as low as the late nineties (e.g. Figure 7), are not reflected in the abundance estimate for the DCS. The aerial surveys show a more offshore distribution of porpoises than in 2014 (Figure 3). In other words similar numbers as the previous summer surveys of Harbour Porpoises were present in Dutch waters in the summer of 2015, but their distribution was more offshore, with few sightings in the coastal zone and larger areas with high densities in the northern part of the DCS (areas A – Dogger Bank and B – Offshore).

The land-based data and the aerial surveys show a contrasting and complementary picture of the occurrence of Harbour Porpoises in Dutch waters. A more detailed analysis of these data, combined with data from future surveys, data on habitat parameters and prey species, could answer the questions in the Dutch Harbour porpoise conservation plan (Camphuysen & Siemensma, 2011) how much variation occurs in numbers and distribution of Harbour Porpoises in Dutch waters. North Sea wide data, e.g. SCANS III in 2016, are clearly needed to provide the fore mentioned information on population level. SCANS III can for instance document if the more offshore distribution in summer is an incident on a local scale, or part of a larger pattern.

5. Conclusions

An aerial survey of the Dutch Continental Shelf in July 2015 resulted in an abundance estimate of 41 29 (CI = 21 194 - 79 256) animals. This number 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 three abundance estimates overlap. Statistically, the estimates do not differ from each other.

The observed low numbers of Harbour Porpoises in coastal waters in 2015 did not reflect the actual numbers on the DCS. Tens of thousands Harbour Porpoises were present on the DCS, but their distribution was more offshore than in previous surveys.

Acknowledgements

This survey was funded by the Dutch Ministry of Economic Affairs (EZ). Jeroen Vis (EZ) provided feedback on the project and commented on a draft report. Meike Scheidat critically reviewed earlier versions of the report. Martin Baptist is acknowledged for his stint as navigator. Guido Keijl (Naturalis) provided the data on stranded porpoises. Last but not least, we would like to thank Peter Reijnhout from ZeelandAir for his safe flying and pleasant company during the survey. Ed and Mike de Bruijn from Texel International Airport always made us feel at home when we visited.

6. Quality Assurance

IMARES 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. 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. The scope can be found at the website of the Council for Accreditation (www.rva.nl).

On the basis of this accreditation, the quality characteristic Q is awarded to results of components which are incorporated in the scope, provided they comply with all quality requirements, as described in the applied Internal Standard Working procedure (ISW) of the relevant accredited test method.

The quality of the test methods is ensured in various ways. The accuracy of the analysis is regularly assessed by participation in inter-laboratory performance studies including those organized by QUASIMEME. If no inter-laboratory study is available, a second-level control is performed. In addition, a first-level control is performed for each series of measurements.
In addition to the line controls the following general quality controls are carried out:

- Blank research.
- Recovery.
- Internal standard
- Injection standard.
- Sensitivity.

The above controls are described in IMARES ISW 2.10.2.105.

If the quality cannot be guaranteed, appropriate measures are taken.

7. References

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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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