Marine mammal surveys in Dutch waters in 2013

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Summary

In March/April 2013 aerial surveys to estimate the abundance of Harbour porpoises *Phocoena phocoena* on the Dutch Continental Shelf were conducted. These surveys were conducted along predetermined track lines using distance sampling methods in four areas: A “Dogger Bank”, B “Offshore”, C “Frisian Front” & D “Delta”. Between 18 March and 22 April the entire Dutch Continental Shelf (DCS) was surveyed.

In total, 197 sightings of 223 individual Harbour Porpoises were collected. Porpoise densities varied between 0.47-1.44 animals/km² in the areas A-D. The overall density on the entire Dutch Continental Shelf was 1.07 animals/km². Harbour Porpoises were widely distributed in March with higher densities in area D “Delta”. In the northern part of the DSC the distribution seemed more patchy, with lower densities in the northern part of area B “Offshore” and in area A “Dogger Bank”.

The total numbers of Harbour Porpoises on the Dutch Continental Shelf (areas A-D) in March were estimated at ca. 63 000 animals (C.I.: 32 000-129 000). Even though this number is lower than the population estimate in March 2011 (86 000, C.I.: 49 000-165 000) it is similar to the abundance estimate in March 2012 (66 000, C.I.: 37 000-130 000). However, the confidence intervals of the three estimates greatly overlap and therefore these numbers can be considered of comparable size.

In total 12 sightings of other marine mammal species were made. These comprised 11 sightings of in total 11 single seals, which remained unidentified except 1 Grey Seal *Halichoerus grypus* on 6 April. One White-beaked Dolphin was recorded the same day.

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. 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 (first start for 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 2012 (Geelhoed et al., 2013b) and 2013. In this report we present the results of the aerial surveys that took place in March/April 2013. These surveys were part of the BO project (4308201106) 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. The Dutch part of the Dogger Bank was surveyed in summer 2013 as part of a survey of UK, Dutch, German and Danish waters to investigate the occurrence of marine mammals in the Dogger Bank area. Results of this survey is published in a separate report (Geelhoed et al., 2014).

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 March/April 2013.

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).

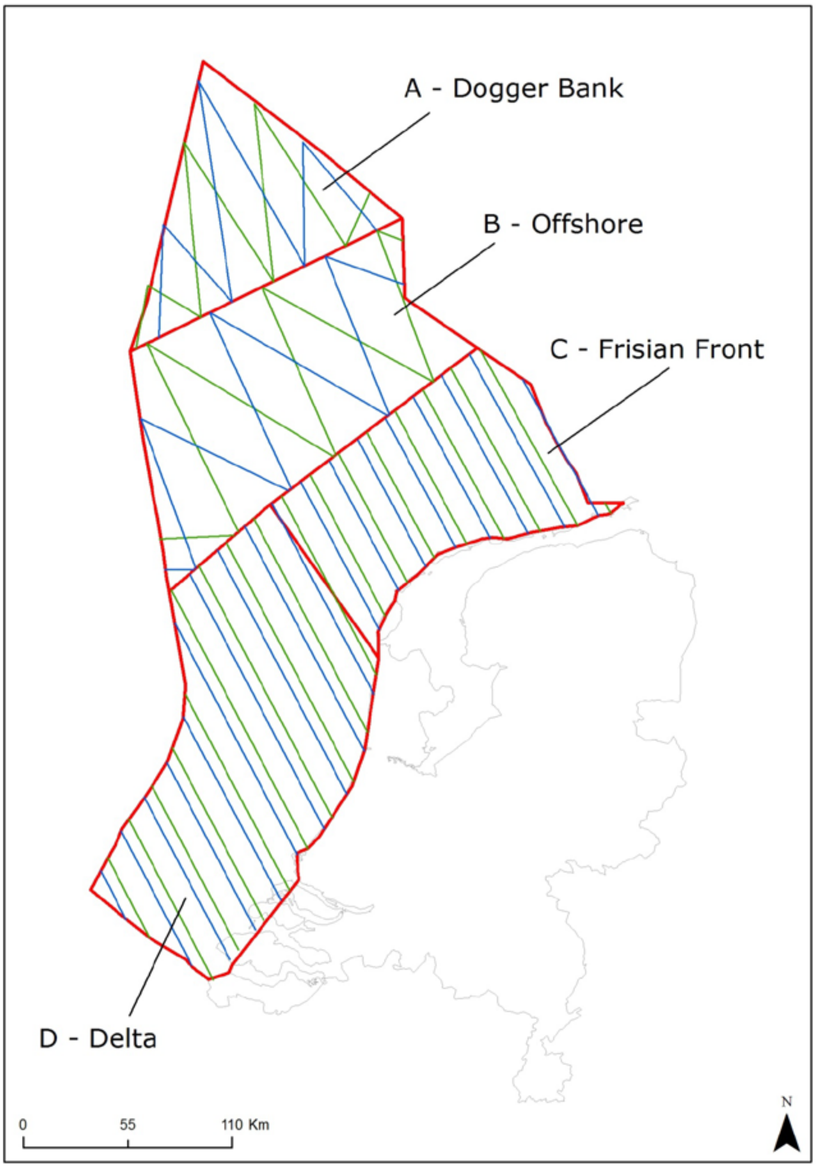

Figure 1. Map of the Dutch Continental Shelf with the planned track lines in study areas A ("Dogger Bank"), B ("Offshore"), C ("Frisian Front") & D ("Delta"). Colours indicate sets of track lines.

Surveys were conducted with a Partenavia 68 Observer, a high-winged twin-engine airplane equipped with bubble windows (Figure 2), flying at an altitude of ca. 183 m (600 feet) 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.

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

Figure 2. The used survey aircraft: a Partenavia 68 Observer.

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.
Exceptional (X)	Observer off effort due to adverse circumstances

Surveys were conducted in weather conditions safe for flying operations (no fog or rain, no chance of freezing rain, visibility > 3km) and suitable for porpoise surveys (Beaufort sea state equal or less than 3). Whenever possible, surveys were co-ordinated with aerial surveys conducted by the department Management Unit of the North Sea Mathematical Models (MUMM) in Belgian waters. Results of each survey are presented separately.

Surveys were conducted by Geert Aarts, Rob van Bemmelen, Steve Geelhoed, Linn Lehnert, Klaus Lucke, Nicole Janinhoff, Meike Scheidat and Hans Verdaat.

Data quality check and data storage

All collected data was checked, e.g. for consistency of codes, 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 (but used for the abundance estimates).

4. Results

Weather conditions and survey effort

Between 18 March and 22 April the entire Dutch Continental Shelf was surveyed (Figure 3, Table 3), resulting in a total distance of 3445.7km on effort. Of this distance 97.6% (3363.5 km) was surveyed with good or moderate conditions on at least one side of the plane (Table 4).

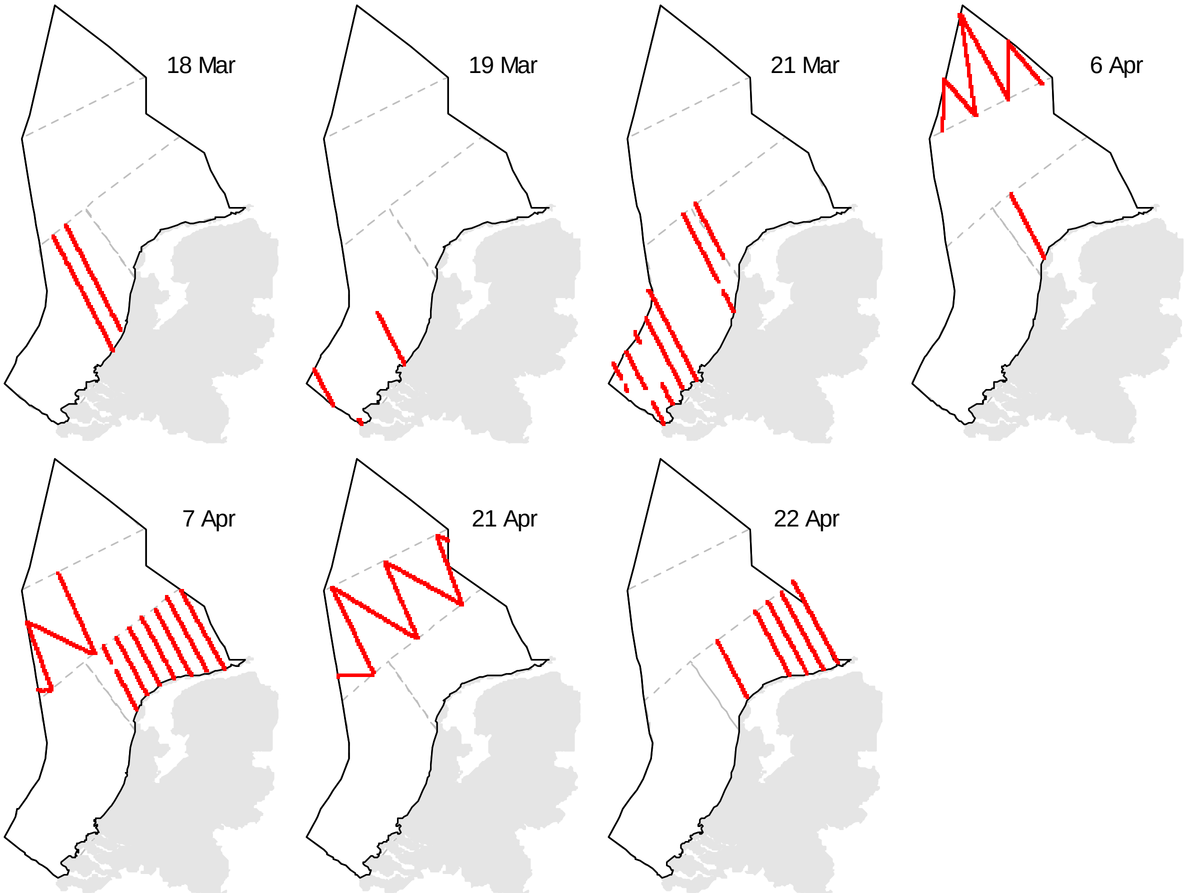

Figure 3. Survey effort per day March-April 2013.

Table 3. Survey dates and surveyed areas.

Survey date	Surveyed area
18March	Area D "Delta"
19 March	Area D "Delta"
21 March	Area D "Delta"
6 April	Area A "Dogger Bank"
7 April	Area B "Offshore" and Area C "Frisian Front"
21 April	Area B "Offshore" and C "Frisian Front"
22 April	Area C "Frisian Front"

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.

Dates	Effort (km)	Sighting conditions (%)			Harbour Porpoise sightings (n)		
		G	m	p/x	Sightings	Individuals	'Calves'
18, 19 & 21 Mar	950.0	20.9	69.7	9.4	76	87	-
6, 7, 21 & 22 Apr	2495.7	10.2	70.1	19.7	121	136	-
Total	3445.7	13.2	69.9	16.9	197	223	**-**

Harbour Porpoise sightings – pod size

In total, 197 sightings of 223 individual Harbour Porpoises were collected (Table 4). These sightings are shown in Figure 4. No calves were seen. Most sightings concerned single individuals, with an average pod size of 1.1 individuals. The majority of the sightings concerned directionally swimming animals; 8% 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 in March-April 2013 (Figure 5). Harbour Porpoises were widely distributed. Highest densities were found in area D "Delta" and the north-western part of area B "offshore", whereas lowest densities were found in area A "Dogger Bank".

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 5 gives an overview of density (animals/km²) as well as abundance (number of animals) per survey area. The overall density in March/April was 1.07 animals/km². The highest average density was found in area B "Offshore" and area D "Delta", 1.44 and 1.32 animals/km² respectively.
The total number of Harbour Porpoises on the Dutch Continental Shelf (areas A-D) in March/April was estimated at ca. 63 000 animals (C.I.: 32 000- 129 000, Table 5).

Table 5. Abundance estimates of Harbour Porpoises for March/April 2013 per area.

	Density (animals/km^2)	C95% CI	Abundance (n animals)	95% CI	CV
A	0.47	0.184 - 1.197	4492	1768 – 11 505	0.49
B	1.44	0.465 – 3.482	24 268	7856 – 58 820	0.51
C	0.59	0.305 – 1.240	7046	3663 - 14 907	0.36
D	1.32	0.662 – 2.827	27 602	13 815 – 58 987	0.36
Total	1.07	0.547 – 2.165	63 408	32 478 – 128 588	0.35

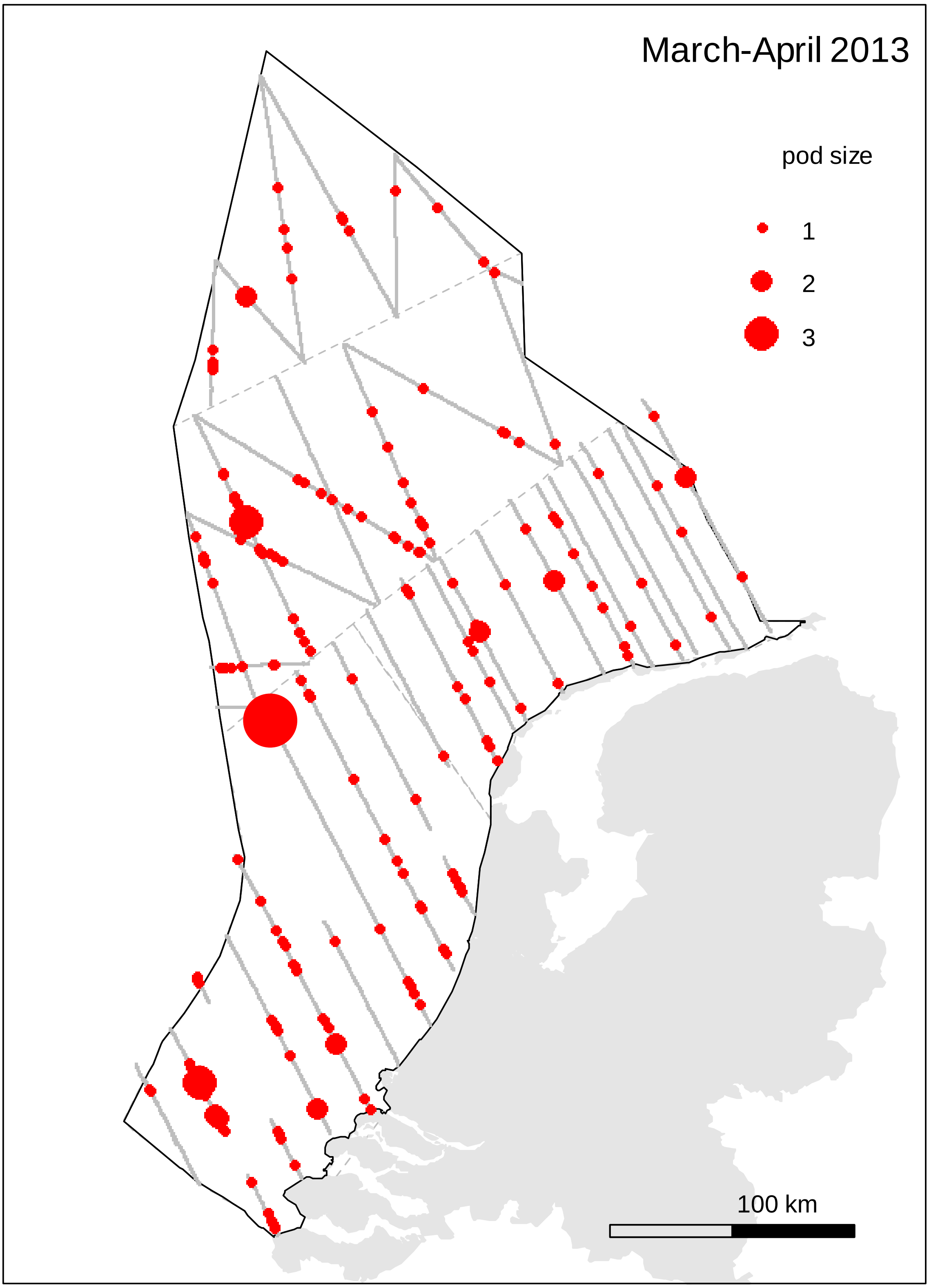

Figure 4. Effort and Harbour Porpoise sightings during the DCS survey in March-April 2013.

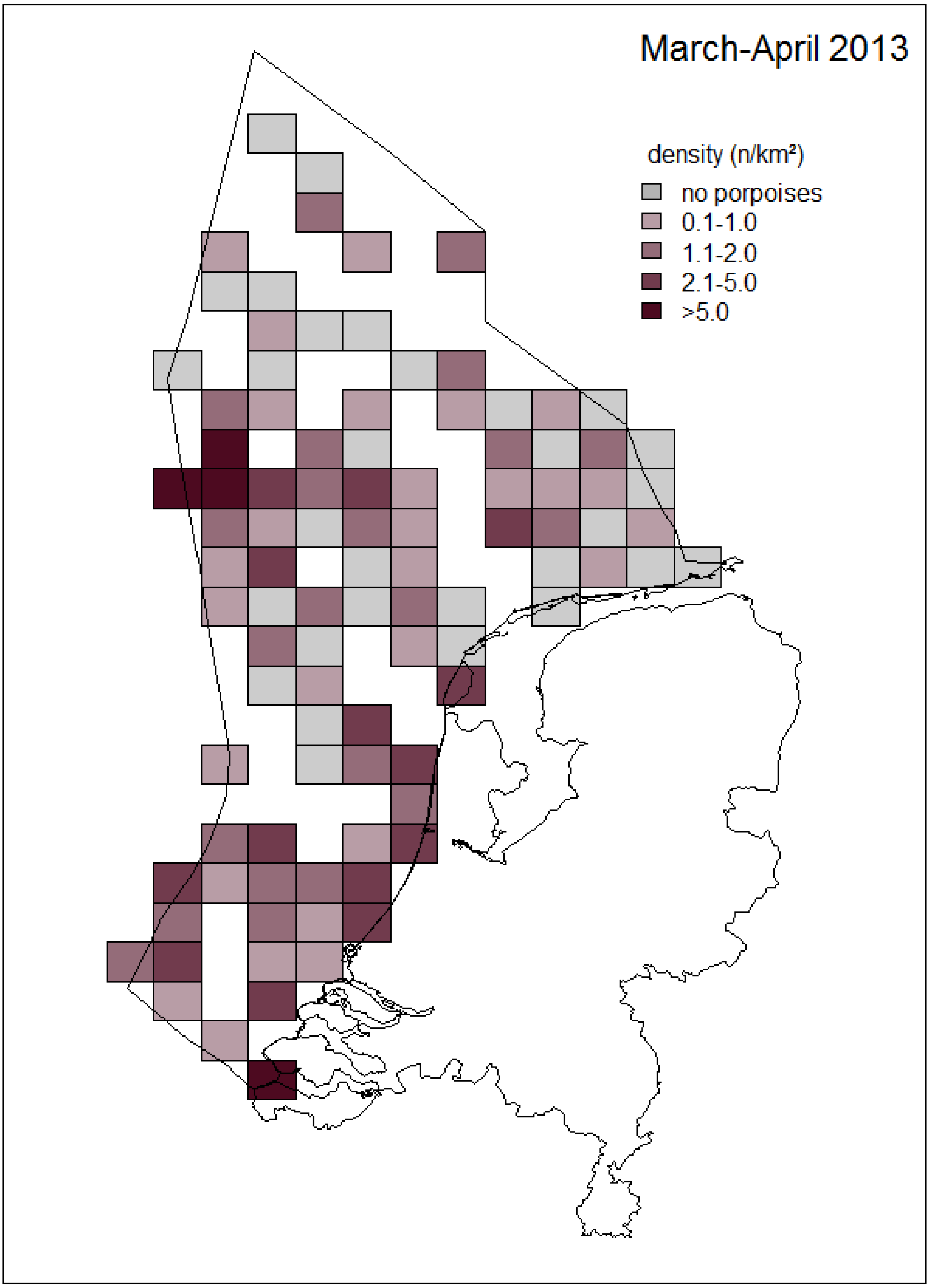

Figure 5. Spring density distribution of Harbour Porpoises (animals/km²) per 1/9 ICES grid cell, March-April 2013. Grid cells with low effort (< 1 km²) are omitted.

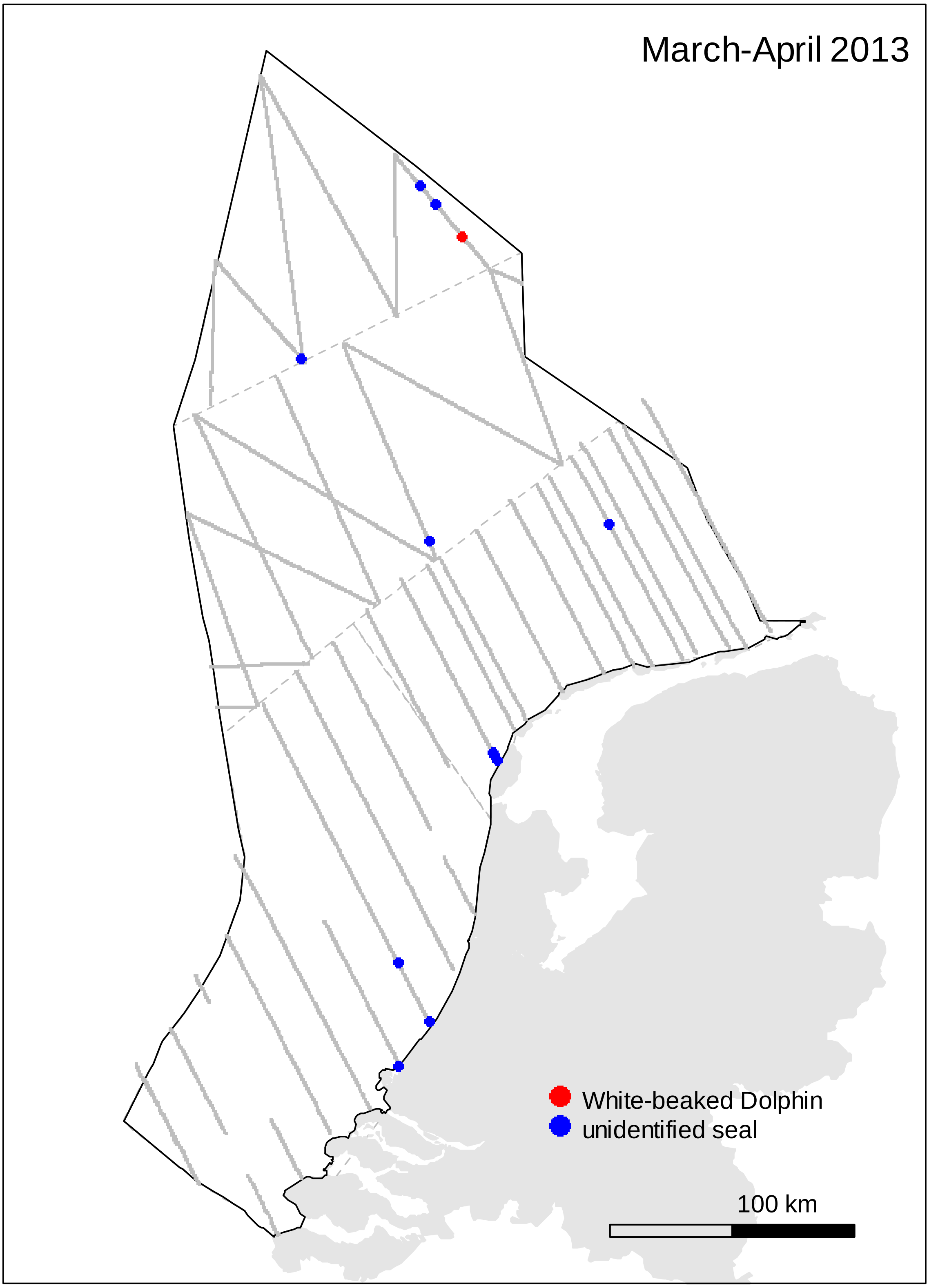

Figure 6. Effort and sightings of marine mammal sightings other than Harbour Porpoises during the DCS survey in March-April 2013.

Other marine mammals - sightings

During the surveys 11 sightings of other marine mammal species were made in March (Table 6). The only other cetacean species that was sighted during the surveys was the White-beaked Dolphin *Lagenorhynchus albirostris*. One sighting of one animal was made by the navigator 6 April 2013 in the northern and western part of the DCS (Figure 6).

Apart from White-beaked Dolphin, 11 single seals were seen, which mostly were unidentified except Grey Seal *Halichoerus grypus* on 6 April 2013. The distribution of the sightings is shown in Figure 6.

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

		White-beakedDolphin		Seals	
Dates	**Effort (km)**	**Sightings**	**N**	**Sightings**	**N**
18, 19 & 21March	950.0	-	-	3	3
6, 7, 21 & 22 April	2495.7	1	1	8	8
Total	3445.7	1	1	11	11

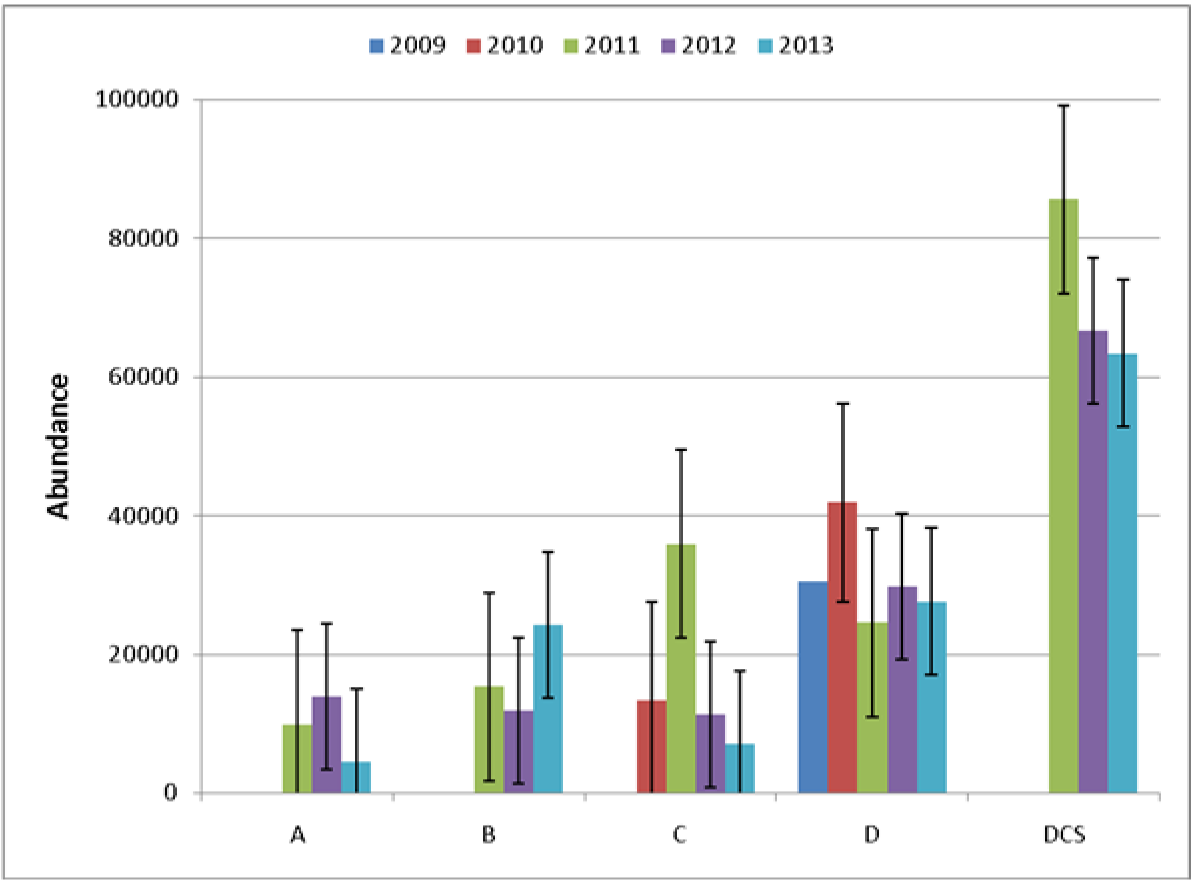

Figure 7. Comparison of abundance estimates of harbour porpoises in the DCS per sub-area, 2009-2013.

Comparison with previous surveys

IMARES has been conducting aerial surveys in Dutch North Sea waters since May 2008. From May 2008 to April 2013 27 867 km were covered on effort during 62 survey days in three different seasons: March, July and October/November. Complete DCS wide surveys could be made in all three seasons between July 2010-March 2011. Since 2011 the complete DCS has been surveyed in March/April for three subsequent years. Densities and abundance estimates of Harbour Porpoises are presented in Figure 7 and Table 7.

Table 7. Comparison between density and abundance estimates of Harbour Porpoises obtained in the same areas and months (2008 to 2013) using results from Geelhoed et al. (2011, 2013a, b) and Scheidat et al. (2012).

		Density (animals/km²)	Abundance (N animals plus C.I.)	C.V.
DCS (A-D)	Mar-Apr 2013	1.07	63 408	0.35
		(0.55–2.17)	(32 478–128 588)	
	March 2012	1.12	66 685	0.33
		(0.63-2.20)	(37284-130549)	
	March 2011	1.44	85 572	0.32
		(0.83-2.78)	(49 324-165 443)	
Area A	Mar-Apr 2013	0.47	4492	0.49
		(0.18-1.20)	(1768–11 505)	
	March 2012	1.44	13 860	0.36
		(0.69-2.72)	(6601-26 156)	
	March 2011	1.03	9890	0.39
		(0.52-2.14)	(5018-20 618)	
Area B	Mar-Apr 2013	1.44	24 268	0.51
		(0.47–3.48)	(7856–58 820)	
	March 2012	0.70	11 877	0.42
		(0.25-1.51)	(4285-25 557)	
	March 2011	0.91	15 331	0.31
		(0.52-1.79)	(8795-30 249)	
Area C	Mar-Apr 2013	0.59	7046	0.36
		(0.31-1.24)	(3663–14 907)	
	March 2012	0.94	11 252	0.48
		(0.33-2.09)	(4023–25 079)	
	March 2011	2.98	35 850	0.33
		(1.65-5.81)	(19 772–69 808)	
	March 2010	1.11	13 309	0.44
		(0.48–2.49)	(5819–29 918)	
Area D	Mar-Apr 2013	1.32	27 602	0.36
		(0.66–2.83)	(13 815-58 987)	
	March 2012	1.42	29 696	0.35
		(0.77-2.91)	(15 992–60 810)	
	March 2011	1.17	24 501	0.34
		(0.66-2.39)	(13 726–49 833)	
	March 2010	2.01	41 878	0.39
		(0.82–4.04)	(17 145–84 302)	
	Feb -Mar 2009	1.47	30 534	0.33
		(0.78-2.70)	(16 265–56 161)	

The abundance estimates of Harbour Porpoises in March/April were 85 572 (CI 49 324-165 443), 66 685 (CI 37 284-130 549) and 63 408 (CI 32 478-128 588) for 2011 till 2013 (Table 7). Though the numbers in 2011 seemed higher 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. Area D “Delta” shows high densities and abundance estimates in all years, whereas the other areas show more inter-annual fluctuations. 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.

5. Conclusions

The entire Dutch Continental Shelf was surveyed in March-April 2013, resulting in an abundance estimate of 63 000 (C.I.: 32 000-129 000) Harbour Porpoises. Though this number is lower than the abundance estimates in March 2011 (85 000C.I.: 49 000-165 000), it is similar to the abundance estimate in March 2012 (66 000 C.I.: 37 000-130 000). However, the confidence intervals of the three abundance estimates greatly overlap and therefore these numbers can be considered of comparable size.
A rough comparison of the density and abundance estimate per sub-area shows no consistent trends over the years.

6. 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 27 March 2013 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.

Approved: Mardik Leopold
Researcher

Signature:

Date: 18 February 2014

Approved: Jakob Asjes
Department Head

Signature:

Date: 18 February 2014