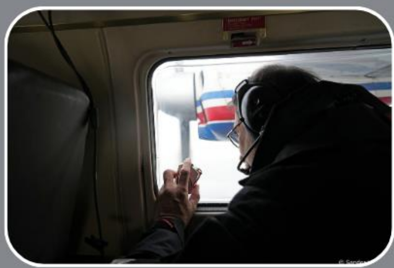
Winter SCANS-IV 2024

winterSCANS: ESTIMATES OF CETACEAN ABUNDANCE IN THE SOUTHERN NORTH SEA IN WINTER 2024



winterSCANS:

Estimates of cetacean abundance in the southern North Sea in winter 2024

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Contents

INTRODUCTION

In the early 1990s, the high bycatch numbers of harbour porpoise in gillnet fisheries in the North and Celtic Seas prompted the first large-scale line transect (distance) sampling survey for cetaceans (Small Cetaceans Abundance in the North Sea and adjacent waters, known as SCANS) in summer 1994 (Hammond et al. 2002). SCANS generated abundance estimates for harbour porpoise that allowed bycatch to be assessed in a population context. Abundance was also estimated for white-beaked dolphin and minke whale in the North Sea.

SCANS 1994 was envisaged to be the first in a long-term series of large-scale surveys with an approximately decadal frequency, which are now recognised as being more appropriate at 6-year intervals primarily to support key assessment and reporting evidence needs. Accordingly, a second survey covering all European Atlantic shelf waters was conducted in summer 2005 (Hammond et al. 2013), supplemented by a survey in offshore waters in 2007 (CODA 2009). A third survey, SCANS-III, followed in 2016 (Hammond et al. 2021) covering the same area as SCANS-II and CODA combined but excluding waters to the south and west of Ireland, which were surveyed by the ObSERVE project in 2015 and 2016 (Rogan et al. 2018). Recently, in summer 2022, SCANS-IV was completed in a 1.7 million km^2 study area stretching from the Strait of Gibraltar to southern Norway, providing robust abundance estimates and trends of regularly occurring cetacean species (Gilles et al. 2023), but excluding waters to the south and west of Ireland, which were surveyed by Phase II of the Irish ObSERVE programme in 2021 and 2022 (Giralt Paradell et al. 2024).

SCANS surveys are conducted in summer, with the objective of ensuring optimal surveying conditions; there is limited understanding of species distribution and abundance in other seasons (but see Gilles et al. 2016). Further data collection in seasons other than summer would not only enhance our understanding of seasonal changes in distribution but could also inform the need to adapt management (e.g., management of threats and spatial/temporal protection measures). The Southern North Sea Special Area of Conservation (SAC) for harbour porpoise has been designated in UK waters with an understanding of differing winter and summer distributions which are referenced through seasonal boundaries within the wider SAC. Given the skew of data availability to summer months, it is essential to better understand the seasonality of this region for this species. More information about winter distribution and connectivity with sister SACs in Dutch and German waters is very valuable.

Therefore, as an extension to SCANS-IV, and to assess the feasibility of conducting surveys during winter, aerial surveys were conducted in the southern North Sea from January to March 2024, designated as **winterSCANS**. Concurrently, another survey initiative following the SCANS protocol, the French MAMO survey, was undertaken in the Channel and the data were analysed together.

This is the first time a large-scale systematic survey has been conducted in winter under the SCANS project. The survey provided valuable information on seasonal variation in cetacean distribution and abundance in this area.

METHODS

Study area and survey design

The objective of winterSCANS was to survey the SCANS-IV blocks in the southern North Sea, including at least the northeastern part of the Channel. The planned SCANS-IV survey blocks in winterSCANS were NS-B, NS-C, NS-H and NS-I at minimum, and potentially NS-D (Figure 1). Parts of block NS-A were to be covered by a sister project, the French MAMO[1] survey, supported by the French Biodiversity Agency (OFB) through the Marine Nature Park Estuaires picards et mer d'Opale. The MAMO survey was conducted at the same time as surveys of the blocks in winterSCANS, also following the SCANS-IV protocol (Blanchard et al. 2024) (Figure 1, block N1).

The size and boundaries of the survey blocks were consistent with those designed for (summer) SCANS-IV, which were determined partly by logistics but also to encompass designated/proposed protected areas or other areas of high probability of species occurrence in some cases. In the French MAMO project, the survey covered only part of block NS-A, including the narrowest part where the Channel joins the North Sea.

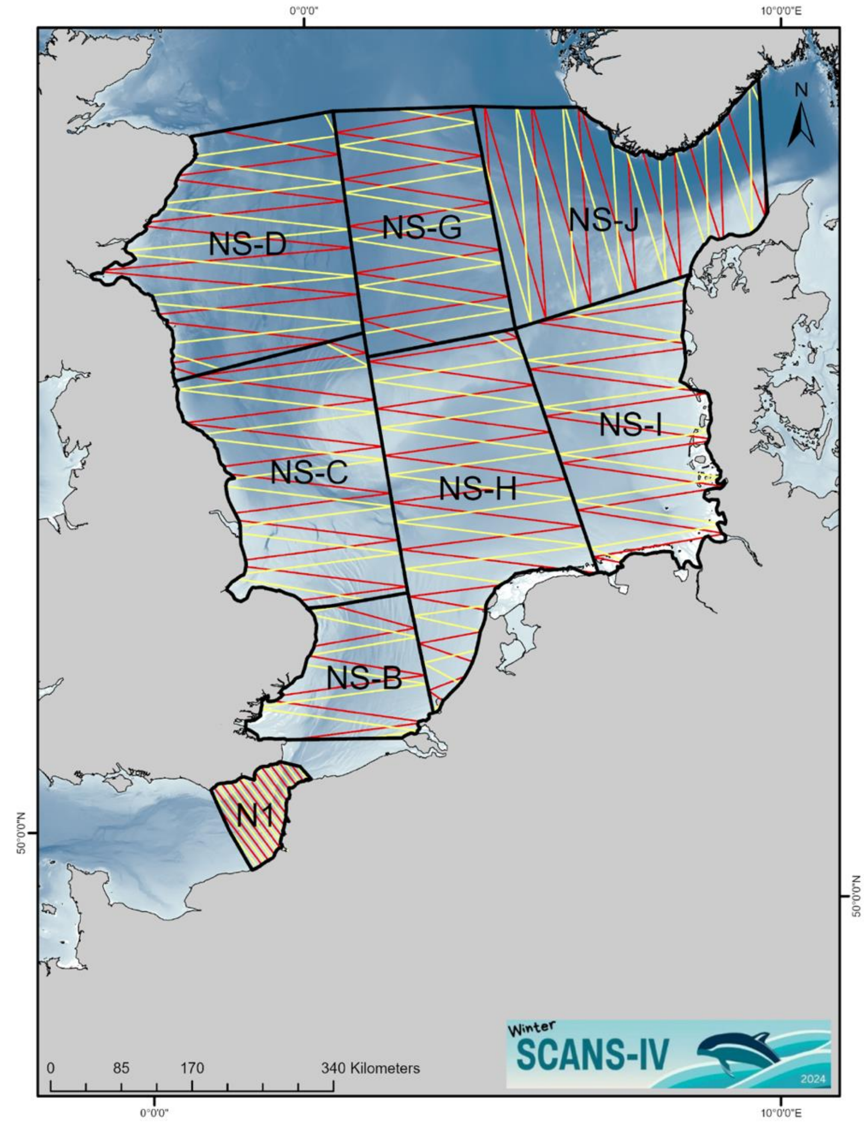

Figure 1. The planned study area and survey design of winterSCANS and MAMO (N1). Transects are depicted in yellow (replicate 1) and red (replicate 2).

[1] Etude de la **M**égafaune marine par observation **A**érienne en **M**anche **O**rientale, en particulier dans le Parc naturel marin des estuaires picards et de la mer d'Opale

Overall coverage probability for the survey was determined by available resources (total flying hours). Searching effort was distributed approximately equally among all blocks.

Surveys within blocks were designed to provide equal coverage probability, using the equal spaced zig-zag design option for the blocks in the North Sea, using the survey design R package dsss (Marshall 2023) in R 4.0.5 x64 (R Core Team 2021). This ensures that each point within a block has the same probability of being surveyed, allowing unbiased abundance estimation by extrapolating estimated sample density to the entire block. Transects were designed as parallel lines in block N1 (MAMO project).

Within each aerial survey block, two new sets (replicates, different from SCANS-IV) of transect lines were generated with the minimal aim that at least one set would be covered in each block and the expectation that one would be covered in most blocks, depending on the weather, limited day light hours in winter and further logistic constraints (e.g., active military areas).

Data collection

Data collection followed the SCANS protocol for aerial surveys (Hammond et al. 2021; Gilles et al. 2023). Each of the aircraft accommodated three scientific crew members in addition to the pilot. Target altitude was 600 feet (183 m) and target speed was 90-100 knots (167-185 km.h^{-1}). Two observers sat at bubble windows on the left and right sides of the aircraft, and the third team member acted as navigator and data recorder for environmental and sightings data, entering data into a laptop computer running dedicated data collection software. Sighting conditions were classified subjectively as good, moderate or poor based primarily on sea conditions, water turbidity and glare. When detected groups came abeam, data were recorded on time, declination angle to the detected animal or group (from which perpendicular distance was calculated), cue, presence of calves, behaviour, species composition and group size. Further details of the field protocol are given in Gilles et al. (2009; 2023).

Data were recorded with the dedicated software for aerial survey SAMMOA 2.1.3 (SAMMOA 2022). SAMMOA builds on the VOR data collection software used in previous SCANS but offers many enhancements such as being compatible with the newest Windows version, implementing simultaneous audio recordings and data validation. SAMMOA was successfully implemented during SCANS-IV (Gilles et al. 2023).

Estimation of abundance

Abundance was estimated using the same methods as for SCANS-III and SCANS-IV. The following description is taken from the reports on design-based estimates of abundance from these surveys (Hammond et al. 2021; Gilles et al. 2023).

Aerial survey

Only survey effort collected under good and moderate sighting conditions were used in analysis.

For each species, abundance of animals in block *v* was estimated as:

$$\hat{N}_v = \frac{A_v}{L_v}\left(\frac{n_{gsv}}{\hat{\mu}_g} + \frac{n_{msv}}{\hat{\mu}_m}\right)\bar{s}_v \qquad \text{(Equation 1)}$$

where A_v is the area of the block, L_v is the length of transect line covered on-effort in good or moderate conditions, n_{gsv} is the number of sightings of groups that occurred in good conditions in the block, n_{msv} is the number of sightings of groups that occurred in moderate sighting conditions in the block and s_v is the mean observed group size in the block. Exploratory plots indicated no dependence of group size on perpendicular distance, nor was group size found to be a significant explanatory variable for detection probability.

Group abundance by block was estimated by $\hat{N}_{v(group)} = \hat{N}_v/\bar{s}_v$. Total animal and group abundances were estimated by $\hat{N} = \sum_v \hat{N}_v$ and $\hat{N}_{(group)} = \sum_v \hat{N}_{v(group)}$, respectively. Densities were estimated by dividing the abundance estimates by the area of the associated block. Mean group size across blocks was estimated by $\hat{E}[s] = \hat{N}/\hat{N}_{(group)}$.

Coefficients of variation (CVs) and 95% confidence intervals (CIs) were estimated by bootstrapping. A parametric bootstrap was used to generate estimates of ESW, and these were combined with encounter rates obtained from a nonparametric transect-based bootstrap procedure within blocks. The parametric bootstrap procedure assumes that the ESW estimates in good and moderate conditions were lognormally distributed random variables. Therefore, for each bootstrap pseudo-sample of transect lines, a bivariate lognormal random variable was generated from a distribution with mean and variance-covariance matrix equal to those estimated during the circle-back ("racetrack") analysis (see Hiby & Gilles 2016). 95% CIs were calculated using the percentile method.

In the SCANS aerial surveys, the racetrack or circle-back method, first implemented in SCANS-II (Hammond et al. 2013), corrects for both availability and perception bias and therefore estimates the fraction missed on the transect line (Hiby et al. 1998; Hiby 1999). The racetrack method was again successfully implemented in SCANS-III and SCANS-IV in the summers of 2016 and 2022 (see Hammond et al. 2021; Gilles et al. 2023).

Due to the shorter survey windows in winter, it was not feasible to implement the racetrack data collection procedure in the winterSCANS survey. Instead, it was planned to use available estimates from the recently conducted summer SCANS-IV surveys to correct for perception and availability bias. This is justified because in winterSCANS, the same type of aircraft and the same observer teams were used as during SCANS-IV. It is also important to note that all observers involved in the survey were very experienced and had undergone rigorous training in data collection techniques, in accordance with the SCANS-IV protocol, including being trained to define subjective sighting conditions in a comparable manner.

RESULTS

Realized survey effort and sightings

Two aircraft surveyed five SCANS-IV blocks in the southern North Sea, on eight days between 9th January and 3rd March 2024. In addition, the French team surveyed the MAMO block N1 in the northeastern Channel on two days (16th and 19th January).

The area covered by the blocks in winterSCANS was 45% of the total area of the North Sea blocks covered by SCANS-IV. Due to the challenges associated with conducting aerial surveys in winter (ice conditions, fog, freezing rain, short days, etc.), blocks NS-D and NS-I were only partially surveyed, with coverage rates of 49% and 79%, respectively. In contrast, no surveys could be conducted in blocks NS-G and NS-J. The amount of effective search effort on transect in each of the survey blocks is shown in Table 1.

In winterSCANS, only one (or part of one) of the zig-zag sets of lines was covered, whilst in MAMO both parallel replicates were covered. Figure 2 shows the total realised survey effort achieved under good and moderate conditions.

Table 2 shows the total number of sightings and individuals of the three detected species during winterSCANS and MAMO, and Figure 4 shows the distribution of these sightings.

Table 1. Area and search effort for each aerial survey block, excluding data from 'poor' sighting conditions that were not used in analysis.

Block	Region	Surface area (km^2)	Search effort (km)
N1	Eastern Channel	8,045	1,557.1
NS-B	North Sea	25,785	860.0
NS-C		60,203	1,665.0
NS-D		64,455	1,051.3
NS-G		49,672	0
NS-H		69,317	2,304.6
NS-I		56,098	1,568.5
NS-J		63,546	0
Total		**397,121**	**9,006.5**

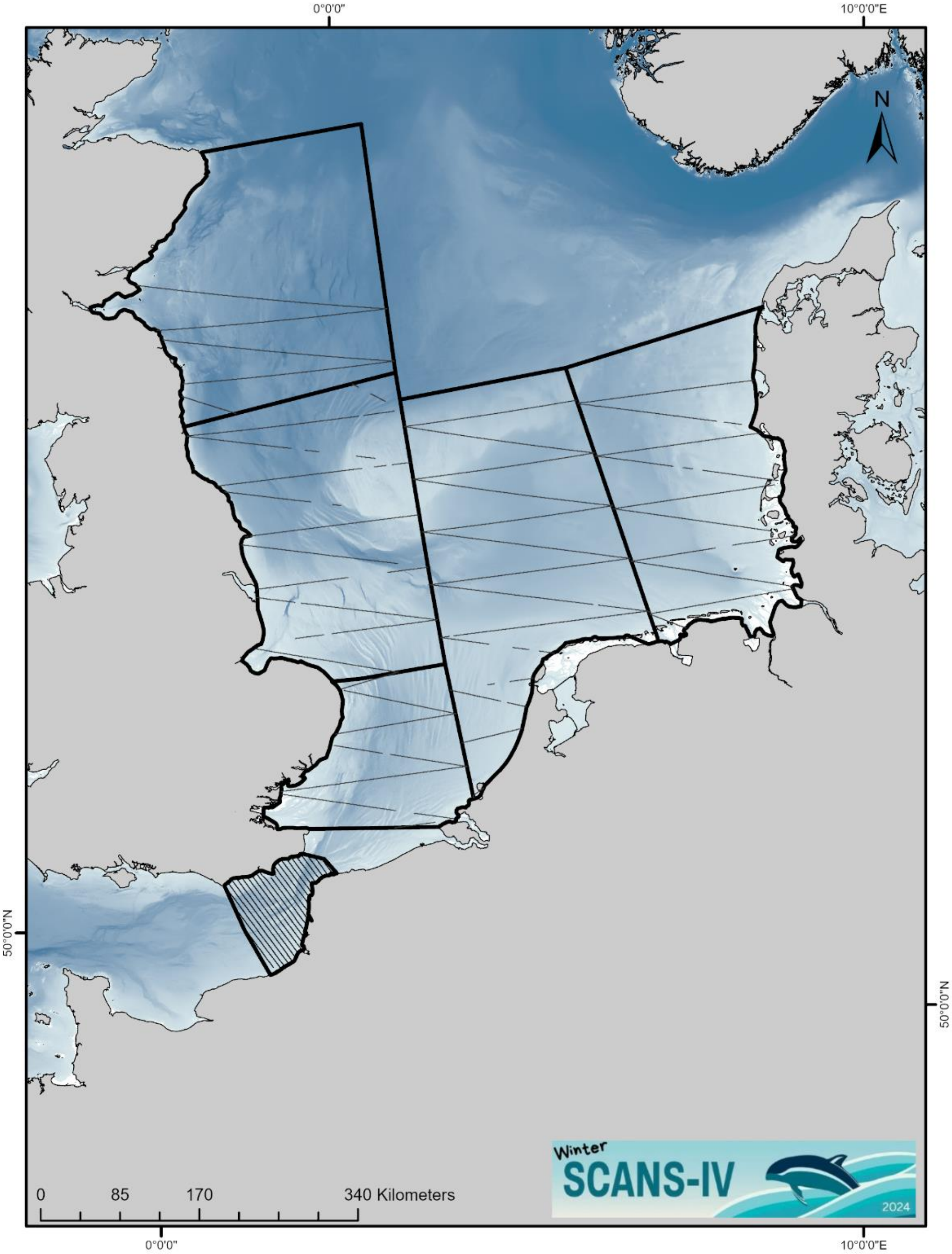

Figure 2. Total search effort achieved under good and moderate conditions in survey blocks covered in 2024 winterSCANS and French MAMO. Only blocks with realised effort are shown.

Table 2. Total number of sightings and individuals of the three detected species from winterSCANS and MAMO surveys recorded from aerial surveys under good or moderate sighting conditions.

Species	**Sightings on search effort**		**Number of individuals on effort**	
	winterSCANS	**MAMO**	**winterSCANS**	**MAMO**
Harbour porpoise	450	55	562	126
White-beaked dolphin	14	0	44	0
Minke whale*	3	0	3	0

*Minke whales had a too low sighting rate to estimate abundance.

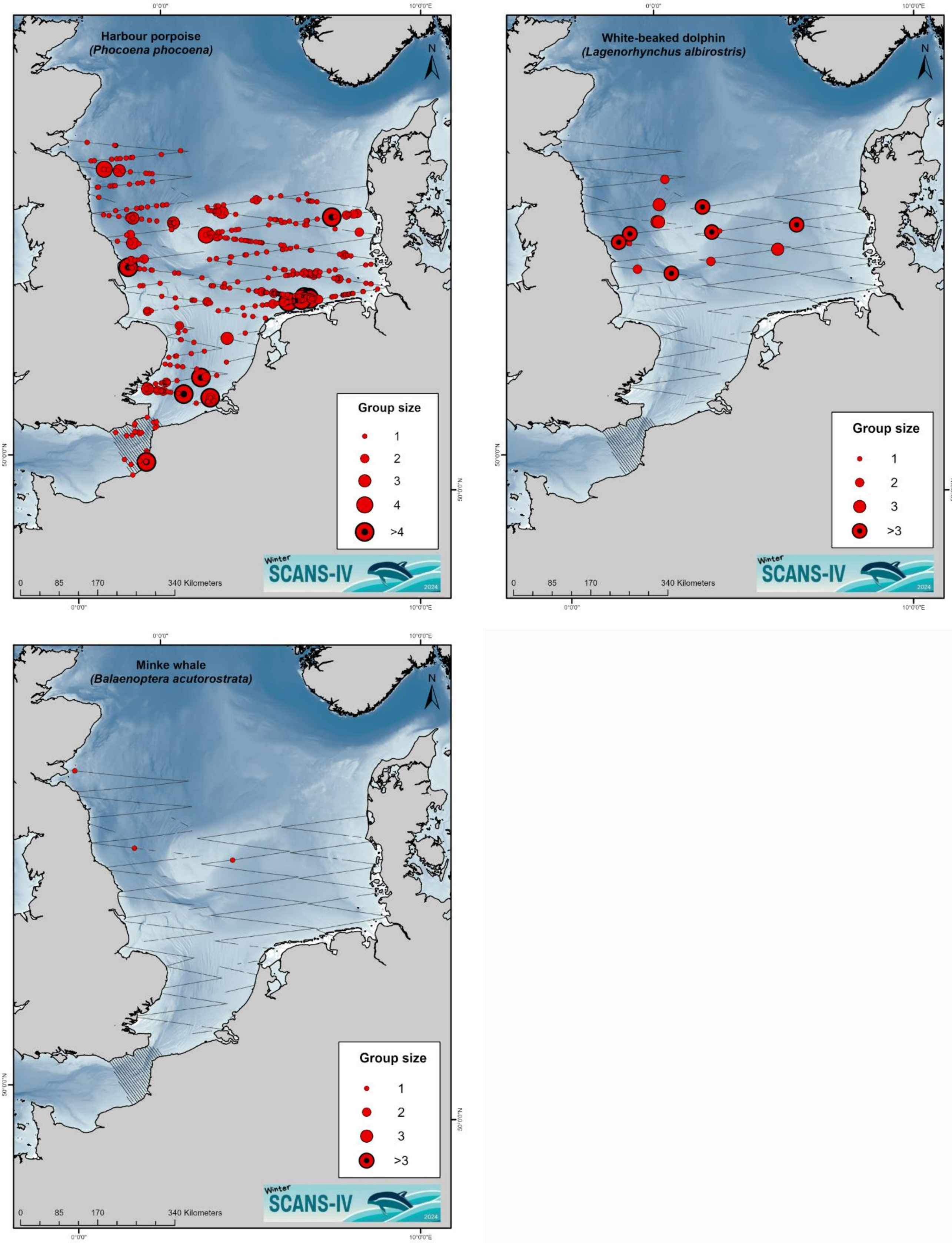

Figure 3. Distribution of sightings of the detected species. Underlying effort is that used in the analysis: i.e., under good and moderate sighting conditions. Harbour porpoise (top left); white-beaked dolphin (top right); minke whale (bottom left).

Estimates of abundance

As outlined above, in winterSCANS, we could not apply the racetrack method to collect double-platform data. Therefore, we used the estimated ESW incorporating g(0) from SCANS-IV, stratified for good and moderate subjective sighting conditions (see above). All our experienced observers also participated in SCANS-IV and were trained to apply the definition of these subjective sighting conditions in a comparable manner. Also, the same data collection protocol and the same aircraft type was used in both surveys.

The correction incorporated, for harbour porpoise, g(0) values of 0.415 and 0.298 for good and moderate conditions respectively, and, for white-beaked dolphin, g(0) values of 0.805 and 0.414 for good and moderate conditions respectively, as estimated from the SCANS-IV racetrack aerial surveys (Gilles et al. 2023) to provide an unbiased corrected absolute abundance estimate.

Estimates of abundance for each block for harbour porpoise and white-beaked dolphin are shown in Tables 3-5. The sighting rate of minke whales was too low to determine abundance estimates.

Table 3. Harbour porpoise density (groups or animals/km^2) and abundance estimates from the winterSCANS aerial survey. CV is the coefficient of variation of abundance and density of animals. CL low and CL high are the estimated lower and upper 95% confidence limits of abundance.

Block	Density (groups)	Mean group size	CV (mean group size)	Density (animals)	CV	Abundance	CL low	CL high
NS-B	0.5005	1.65	0.168	0.8253	0.393	21,281	6,755	39,364
NS-C	0.3024	1.25	0.069	0.3780	0.250	22,758	13,515	36,333
NS-D	0.2270	1.13	0.083	0.2569	0.265	16,558	9,239	27,021
NS-H	0.5847	1.19	0.40	0.6934	0.278	48,065	25,640	77,989
NS-I	0.3615	1.18	0.058	0.4261	0.290	23,901	12,591	39,161
All	**0.3863**	**1.24**	**0.037**	**0.4806**	**0.195**	**132,564**	**89,642**	**192,169**

Table 4. Harbour porpoise density (groups or animals/km^2) and abundance estimates from the French MAMO aerial survey in block N1. CV is the coefficient of variation of abundance and density of animals. CL low and CL high are the estimated lower and upper 95% confidence limits of abundance.

Block	Density (groups)	Mean group size	CV (mean group size)	Density (animals)	CV	Abundance	CL low	CL high
N1	0.2312	2.29	0.219	0.5296	0.420	4,261	1,889	9,133

Table 5. White-beaked dolphin density (groups or animals/km^2) and abundance estimates from the aerial survey. CV is the coefficient of variation of abundance and density of animals. CL low and CL high are the estimated lower and upper 95% confidence limits of abundance. Blocks with no white-beaked dolphin sightings are excluded.

Block	Density (groups)	Mean group size	CV (mean group size)	Density (animals)	CV	Abundance	CL low	CL high
NS-C	0.0172	3.43	0.253	0.0589	0.483	3,546	841	7,897
NS-D	0.0024	2.00	-	0.0049	0.930	314	0	1,012
NS-H	0.0074	2.80	0.208	0.0208	0.563	1,439	190	3,395
NS-I	0.0016	4.00	-	0.0065	1.001	367	0	1,235
All	**0.0065**	**3.15**	**0.152**	**0.0205**	**0.364**	**5,666**	**2,274**	**10,685**

Distribution of estimated density over the survey area

For harbour porpoise and white-beaked dolphin, distribution over the survey area at a coarse scale can be seen from maps of estimated density by survey block (Figure 4). Subsequent analyses will employ spatial modelling of the data collected in winterSCANS to investigate fine-scale distribution and habitat use.

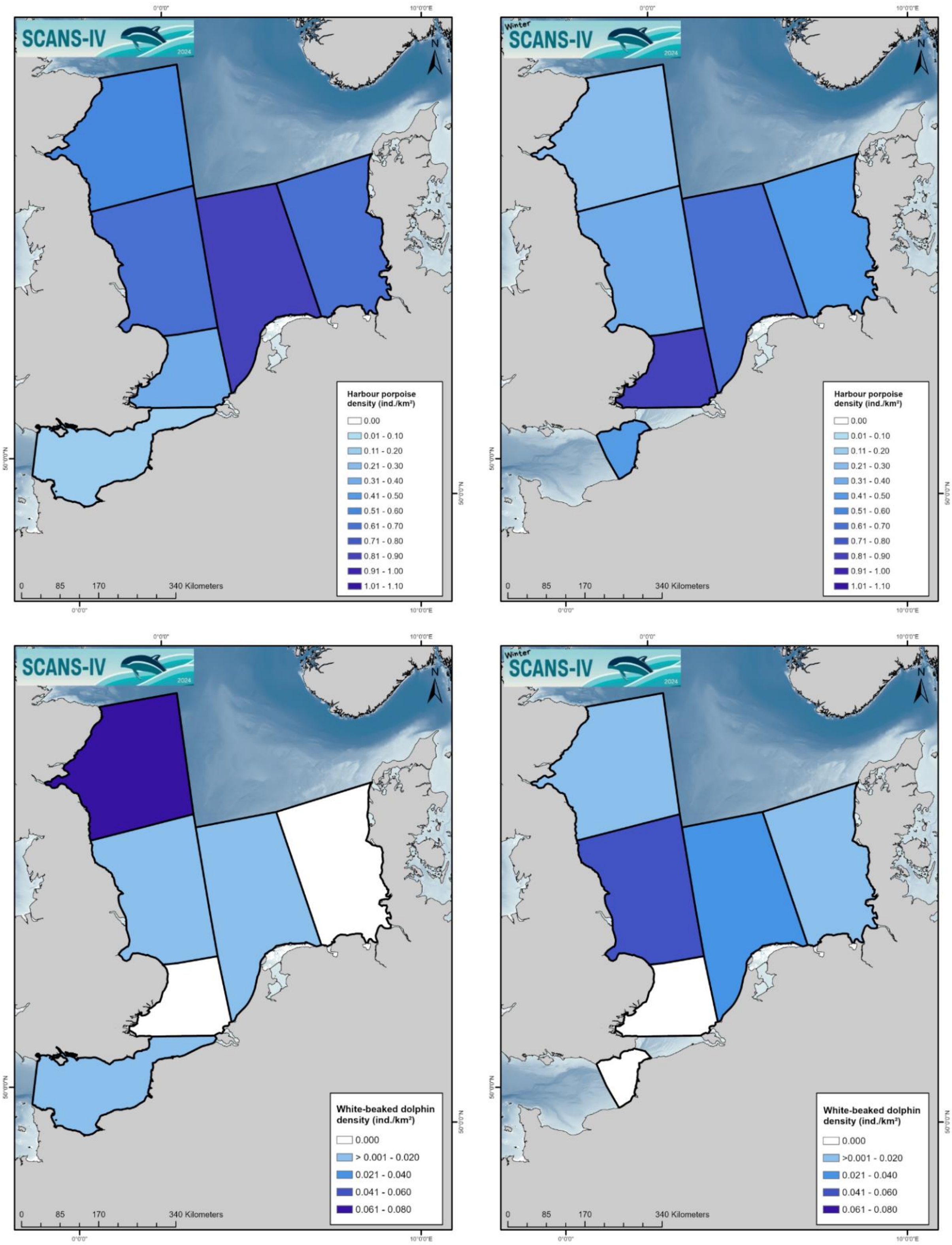

Figure 4. Estimated density in each survey block for harbour porpoise (top) and white-beaked dolphin (bottom), comparing density from summer SCANS-IV (left panels; from Gilles et al. 2023) with density in winterSCANS (right panels).

DISCUSSION

This report summarises the results from the first winterSCANS survey, in conjunction with the adjacent French survey (MAMO), which covered the southern North Sea and the northeastern part of the English Channel, respectively. These surveys offered a unique opportunity to provide information on the distribution and abundance of cetaceans during the winter months in the southern North Sea, a region with some evidence of seasonality in cetacean distribution. This is the first occasion inter-seasonal comparisons of cetacean distribution have been made between the winter and summer SCANS surveys.

The cetacean species observed in winterSCANS were harbour porpoise, white-beaked dolphin and minke whale. The abundance in the surveyed area was overall lower for winter compared to the summer surveys. However, when comparing block by block that was not always the case. In winter, harbour porpoise estimated abundance was highest in the southeastern block (NS-B), while for white-beaked dolphin the highest abundance was found in the neighbouring block to the north (NS-C). The estimated abundances in both these blocks were higher than in summer 2022, during SCANS-IV.

Only three minke whales were sighted during winterSCANS, so no further comparisons can be made. Acoustic surveys off the east coast of Scotland have shown that minke whales are present from early summer to November (Risch et al. 2019). This pattern is supported by visual observations, which allows the conclusion that the animals leave the area, and possibly the North Sea, in winter and return in late spring. Strandings in winter in the North Sea are also rare, and it is unclear where minke whales are present at this time of year. There is some evidence that they undertake extensive seasonal migrations between feeding and reproduction areas, travelling to feeding areas at higher latitudes in summer and to reproduction and calving areas at lower latitudes in winter (Danielsdottir et al. 1992, Skaug et al. 2004, Perrin & Brownell Jr 2009, Risch et al. 2014).

The region surveyed by winterSCANS represents only a portion of the known distribution range for the three observed species but offers critical insight into identifying seasonality in their distributions. While their full winter distribution remains uncertain, evidence to date suggests it is expected to differ from their summer range due to for example, variations in prey availability or, for minke whales, to breed in lower latitudes.

New information on distribution and abundance

Harbour porpoise

Harbour porpoises were observed in all blocks surveyed during the 2024 winter survey, including the southern North Sea (winterSCANS) and the eastern Channel (French MAMO). There have not been similar synoptic efforts covering the southern North Sea in winter previously, which means direct seasonal comparisons are not possible. If compared with summer distribution from the SCANS long-term series (Hammond et al. 2002, Hammond et al. 2013, Hammond et al. 2021, Gilles et al. 2023), harbour porpoises were reported in all the blocks also covered in winterSCANS and the French MAMO area. The exception was in the summer of 1994 (SCANS), when no porpoises were sighted in the Channel or the south-eastern North Sea (Hammond et al. 2002). Gilles et al. (2023) summarised the range expansion of porpoises in the Channel throughout the summer SCANS surveys, highlighting the ongoing change in porpoise distribution. In summer, the estimates for the whole North Sea have been very similar in 2022 (339,000, CV = 0.17), 2016 (345,000, CV = 0.18) and 2005 (355,000, CV = 0.22), and slightly lower in 1994 (289,000, CV = 0.14). These estimates have not shown evidence of change (Gilles et al. 2023).

In winterSCANS, harbour porpoise abundance was estimated to be 132,564 (CV = 0.195), and another 4,261 porpoises (CV = 0.420) were estimated from MAMO (combined estimate: 136,825, CV = 0.189). However, making comparisons of the estimates between winter and summer, at least on a large scale, must be done with caution given that the area covered by the blocks in winterSCANS and MAMO (N1) represents only 46% of the whole area of the North Sea from SCANS-IV. Yet, a comparison only between the blocks covered during winterSCANS and SCANS-IV shows a higher abundance in the southern block (NS-B) in winter than in summer, while all the other blocks had a lower abundance (Figure 1, Figure 4).

In terms of winter distribution, further comparisons can only be made on a smaller scale; for example, in the Channel with the French SAMM I-II surveys and with dedicated aerial surveys conducted in Belgian waters. In winter of 2011-2012, the SAMM surveys ("S*uivi Aérien de la Mégafaune Marine*" [aerial survey for marine megafauna]) covered the Channel and most of the harbour porpoise sightings occurred in the eastern part, in French, Belgian, Dutch and English waters (Laran et al. 2017). During the winter of 2021 (SAMM-II), porpoises were sighted in the eastern and western parts of the Channel, with the highest densities still in the eastern Channel-North Sea area (Blanchard et al. 2021). Laran et al. (2022) compared porpoise density in winter and summer from SAMM I-II and SCANS-III and showed that the highest density was in winter of 2021. Including the estimates from the French MAMO surveys in this comparison shows that, out of the seven surveys conducted in all four seasons, the highest density was recorded in the most recent survey conducted in the winter of 2024 (*In prep,* Blanchard et al. 2025). However, it needs to be considered that the survey area in the SAMM surveys was much larger, covering the full extent of the Channel.

Bouveroux et al. (2020), analysing data from a platform-of-opportunity (ferry) between Dunkirk (France) and Dover (England), reported significant seasonal variation in relative abundance with peaks in the northeastern English Channel in winter.

Belgian waters have been covered only in the winter of 2010 and 2011. The average group size in the winter of 2011 was the highest of the different seasons surveyed between 2009 and 2022. When comparing the sighting rate between summer (5 years) and winter (2 years), only one summer (2017) had a sighting rate that was slightly higher than in the winter of 2011 (Haelters et al. 2023). Here, we find the same pattern of higher porpoise densities in winter; when comparing SCANS-IV (summer 2022, Gilles et al. 2023) and winterSCANS, the highest density was found in the southernmost block close to the Channel (in NS-B, Figure 4) and it was higher than in SCANS-IV. It is also noteworthy that winterSCANS block NS-B and MAMO block N1 exhibited the highest recorded group sizes in winter 2024.

The recent designation of parts of our study area as an "Important Marine Mammal Area" (IMMA) by the IUCN Task Force (IUCN-MMPATF 2024) is of particular interest. The *Southern North Sea and Eastern Channel Seasonal Aggregation IMMA* describes an important harbour porpoise aggregation in spring. Its diverse habitat, including sandbanks, reefs and a front system, supports an abundance of porpoise prey species. Our data collated between January and March may be pertinent to this "spring aggregation" and indicates that this aggregation may already be commencing earlier in the season. Further data and research are required in this area to facilitate a more complete understanding of this phenomenon.

White-beaked dolphin

During winterSCANS, white-beaked dolphins were observed in all North Sea blocks surveyed except in the block closest to the Channel (NS-B) and in the northeastern Channel (French MAMO, N1) (Figure 4). The summer distribution has not changed much over the different SCANS surveys in 1994, 2005, 2016 and 2022, with white-beaked dolphins consistently observed mostly in the north and central part of the North Sea (Hammond et al. 2002, Hammond et al. 2013, Hammond et al. 2021, Gilles et al. 2023). In relation to the observations in the southern part of the study area, SCANS-IV was the only survey to record a sighting in the Channel, although this was only a single sighting (Gilles et al. 2023), while SCANS in 1994 was the survey with more sightings in the southwestern North Sea (Hammond et al. 2002). In the southeastern part of the North Sea, in block NS-I, no sightings of white-beaked dolphins have been reported during the summer SCANS surveys.

The estimated abundance of white-beaked dolphins in winterSCANS was 5,666 (CV = 0.36). As mentioned above a comparison of the estimates derived from the winter and summer SCANS surveys, at least on a large scale, should be approached with a degree of caution, since not all blocks in the North Sea were covered. WinterSCANS did not encompass the northern blocks and the northern part of block NS-D, where the maximum densities were observed during the summer months. Consequently, it is not possible to make wider inferences about the abundance in the North Sea during winter. However, when a comparison is made between the blocks that were covered both during winterSCANS and SCANS-IV in the southern North Sea, the abundances estimated in three blocks (NS-C, NS-H and NS-I; Figure 1, Figure 4) were higher in winter than in summer, indicating a more southerly distribution in winter.

In summer, the estimate for the whole North Sea was 46,300 (CV = 0.42) in 2022, 20,453 (CV = 0.36) in 2016, 29,010 (CV = 0.35) in 2005, and 22,619 white-beaked dolphins (CV = 0.23) in 1994 (Hammond et al. 2021, Gilles et al. 2023). The trend analysis of the summer estimates has shown no evidence of significant change in the North Sea (Gilles et al. 2023). Recently, Gose et al. (2024) presented new evidence for the genomic population structure of white-beaked dolphin across the North Atlantic and adjacent waters. Their findings revealed that two regional populations, the North Sea as well as western Scotland and Ireland, are highly differentiated from all other clades, but both have an area of overlap off eastern Scotland. WinterSCANS results and the new population genomics knowledge are of particular importance for the species management in the North Sea.

CONCLUDING REMARKS - lessons learned from a SCANS survey in winter

Seasonal data on cetaceans remain insufficient, yet evidence suggests seasonality in the distributions of key species, such as the harbour porpoise. This lack of understanding limits our ability to make informed and effective management decisions. The collection of seasonal data enhances the value of the summer SCANS surveys by contributing to a more comprehensive year-round picture of cetacean distribution. The collection of such data also supports the management of Marine Protected Areas (MPAs), improves species status assessments and reporting, and facilitates the identification of seasonal trends, including the impacts of climate change, such as range shifts.

WinterSCANS demonstrated the feasibility of conducting cetacean surveys in extensive regions of the North Sea during the winter months. However, due to less optimal weather conditions overall and shorter daylight periods than in summer, a winter survey is logistically more challenging and, thus, potentially more expensive. Nevertheless, the ongoing industrialisation of the North Sea to meet society's need for energy and national security, involving the introduction of associated infrastructure to the marine environment, underscores the importance for acquiring seasonal data to facilitate effective management. The collected information on distribution and abundance in winter enhances our understanding of seasonal variation in cetacean distribution but could also inform the need to adapt management (e.g., management of threats and implementation of spatial/temporal protection measures). This is particularly relevant in the context of the impacts of climate change and the associated trends, for example with respect to geographical range shifts driven by changes in sea surface temperature and in both primary production and prey species. Expanding the surveyed area to the Greater North Sea, and other areas to cover entire species-specific assessment units (e.g. at population level), would enhance our understanding of species spatio-temporal occurrence.

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