Natural England Commissioned Report NECR289

Temporal and spatial analysis of Marinelife and Orca white-beaked dolphin data from Northumberland and adjacent sea areas

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Anecdotal sightings suggests that there are higher abundances of white-beaked dolphins off the coast of Northumberland, England, compared to elsewhere in the English North Sea. To determine whether this assumption was correct, and whether further protection for the species is warranted in this region, effort and sightings data were collated and analysed and compared against the rest of the North Sea.

This report provides an initial review of effort related sightings data for northeast England, produces abundance / density maps and investigates annual variability in white-beaked dolphin distribution and density. Future work should look at combining these data with other data available for the region (not available for this project), to improve the spatial and temporal resolution of these results.

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Further information
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Report to Natural England: V 3 July 2019

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1.0 Introduction

This report was commissioned by Natural England to get a better understanding of the distribution and abundance of white-beaked dolphins off Northumberland, and to place these results in the context of surrounding and wider waters of the North Sea and Eastern English Channel.

The project had the following objectives:

(1) Input, validate and merge Marinelife (and other available) sightings and effort-related data (ferries, research cruises, small boat surveys) for the north east of England, suitable for analysis in GIS. Further data was obtained from Orca who conduct ferry surveys using similar methods[1], to strengthen the pool of data available for analysis

(2) Generate relative abundance/density data and maps for white-beaked dolphin using the combined data. Investigate annual variability in distribution and compare relative density estimates

(4) Undertake a hotspot analysis, if data is sufficient, to highlight current key areas off the north east coast meriting specific conservation measures for white-beaked dolphin

(5) Summarise the results in a brief report including evaluation and recommendations

[1] https://www.orcaweb.org.uk/our-work/monitoring-protecting-our-oceans

2.0 Methods

2.1 Data input

Effort-related sightings data for white-beaked dolphin were obtained from four main data sources:

(1) Ferry and freight surveys on 21 routes made on over 800 days 2006-2016, conducted by Marinelife and Orca

(2) Marinelife surveys on fisheries research vessels, including the CEFAS *RV Endeavour* (17 days in four years 2011, 2013-15) and Ifremer's *Thalassa* (13 days in 2014)

(3) A Marinelife cruise ship survey over three days in the North Sea in 2008

(4) Marinelife/North East Cetacean Project (NECP) small boat surveys off the Northumberland coast (61 surveys 2009-2016)

The surveys used Distance sampling methods (Buckland et al. 1993), though a double platform was not deployed. There were no substantive differences between Orca and Marinelife ferry surveys. The survey methods undertaken by both groups are described in Brereton *et al*., 2018 and Orca, 2018.

2.2 Data validation

The data were subject to validation checks using Marinelife's bespoke in-house software (Brereton *et al*. 2018) and mapping in Google Earth to remove any spatial or other errors. Orca data errors were identified through mapping in GIS.

2.3 Merging data

Effort and white-beaked dolphin sightings data from Marinelife and Orca observations were combined into a single database, with each record representing information about a single survey leg, defined as the period between subsequent records of the ship's position. These ship positions either represented points at which position and environmental data were recorded or a white-beaked dolphin sighting was made. Hence, each record contained information on the position of the ship and environmental conditions at the start of a survey leg, position at the end of a survey leg, the survey route, whether the starting position represented a white-beaked dolphin sighting or an environmental record point, the time, day, month and year.

This database was then mapped in QGIS and the path of each survey re-created from the positional information. The data were divided into a grid of (1) 10x10 km cells and (2) 20 x 20 km cells where survey effort was collected, with the latter used to look at the effects of spatial scale on the results. The amount of survey effort (km travelled) and the number of white-beaked dolphins counted were used to generate an uncorrected measure of relative density (number counted per km travelled).

3.0 Results

3.1 Summary of survey effort off Northumberland and wider North Sea and Eastern English Channel waters

Across all sea areas sampled, within the North Sea and Eastern English Channel a total of ~185,000 km of survey effort was processed and validated from surveys made on 854 days over the period 2006-2016. Survey effort for Northumberland and surrounding north east English waters were grouped into 10 X 10 km grid cells across all years (Figure 1). The results show that across all years combined, spatial coverage of Northumberland waters within the 12 nautical mile was reasonably good, with no substantial gaps in coverage. However, this masks a lot of annual and seasonal variability in survey effort, as shown in Figures 4 and 5 respectively, with for example no effort at all in the North East of Farn Deeps. Survey effort encompassed four Marine Conservation Zones (MCZs) – Farnes East (southern half), Swallow Sand (western third), Runswick Bay (north end) and Compass Rose (parts of the southern half).

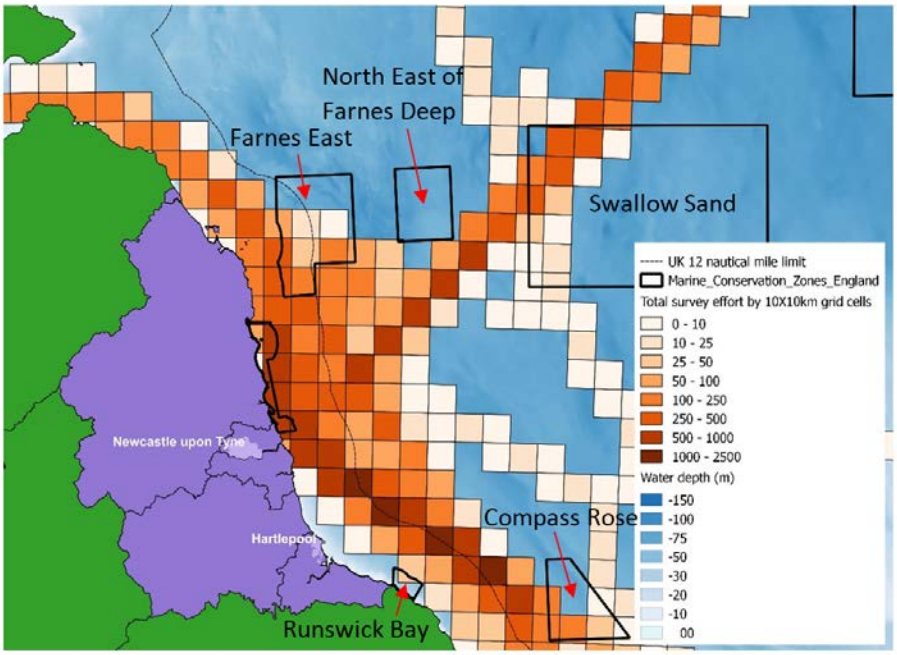

Figure 1: Survey effort at 10 X 10km grid cell resolution for Northumberland and surrounding north east England waters, for all years (2006-2016) combined.

3.2 Mapping relative abundance and density off Northumberland and surrounding waters

Relative density (no. animals counted/100 km of survey effort within grid cells) at 10 X 10 grid cell resolution and averaged across all years (due to insufficient reliable annual estimates), was highest in the Farne Deeps (deeper water area south of the Farnes East MCZ) (Figure 2).

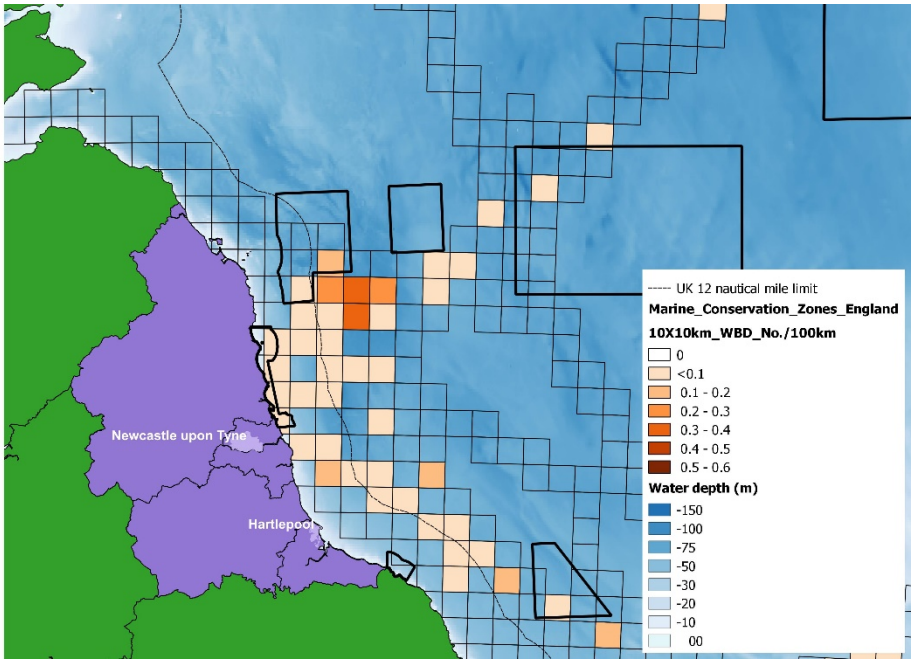

Figure 2: Relative abundance (no. counted/100 km survey effort) of white-beaked dolphin across all surveys (2006-2016), at 10X10 km grid cell resolution for Northumberland and surrounding north east England waters

To investigate the effects of spatial scale, relative density was also investigated at 20 X 20 km scale resolution (Figure 3). At this scale, relative density was again relatively high in the Farne Deeps, within and to the south (and east) of the Farnes East MCZ. Additionally, relative density was high in inshore waters (within the 12 nm limit) between Sunderland and north of Hartlepool.

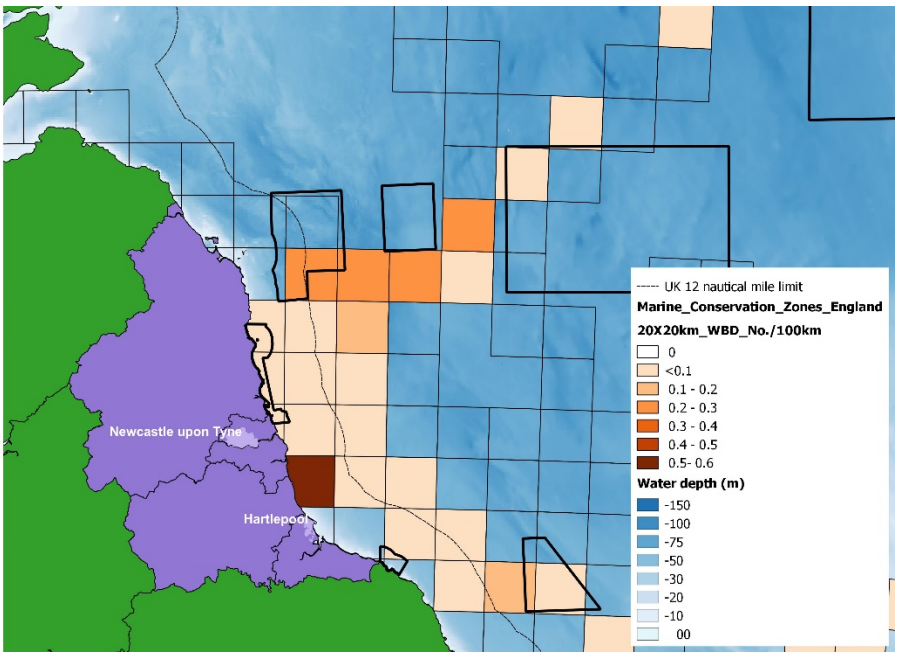

Figure 3: Relative density of white-beaked dolphin across all surveys (2006-2016), at 20X20 km grid cell resolution for Northumberland and surrounding north east England waters

3.3 Spatial and temporal variability in distribution and abundance off Northumberland and surrounding waters

3.3.1 Seasonal variability

The distribution of sightings and number counted for each of the four seasons is given in Figure 4. Data for seasons was pooled across all years, due to the paucity of consistent spatial coverage each year. The available data indicates that Northumberland and surrounding north east England waters support more white-beaked dolphins in the summer and autumn seasons, compared with spring and winter (Figure 4). Sightings within MCZs were only recorded during the summer months, though only Farnes East was sampled in the winter months.

3.3.2 Inter-annual comparisons of distribution and relative abundance

White-beaked dolphin sightings and the number counted on each survey in each year for the period 2006-2016, in relation to survey effort (tracklines), are illustrated in Figure 5. Inspection of the annual plots, indicates there is insufficient data to deduce definitive patterns in annual variability of occurrence of white-beaked dolphins in the region. The most consistent areas of white-beaked dolphin occurrence were in the Farne Deeps, with sightings in all years of summer effort (note: 2010 surveys in this area were made during the winter months) and from ferries running south east from Newcastle and covering offshore waters of County Durham and North Yorkshire. There were no sightings from inshore ferry routes north of the Farne Islands into Berwickshire and East Lothian.

3.4 Hotspot analysis

A hotspot analysis was undertaken to look for clusters of relatively high and low areas of white-beaked dolphin relative abundance, defined by the Getis-Ord Gi function in ArcGIS 9.3.1. (Getis and Ord, 1992). In this function, the dependent input variable was the number of animals counted per km in each sampled 10km^2 grid cell. The output from the Hot Spot Analysis tool is a Z score and p-value for each feature. The statistical testing assumes data is normally distributed, which in this case is not so given the large number of zeros.

We have been given conflicting advice on the applicability of using the Hotspot Analysis. One opinion is that the results can be used as indicative, with clusters of squares with relatively high Z scores (above 1.96) indicative of likely hotspots for white-beaked dolphin However, a second opinion is that because a fundamental assumption has been violated (not normally distributed data), then test can't be used. In view of this, the result of the hotspot analysis are not presented here, but have been supplied and made available in previous draft reports as reference material available from natural England.

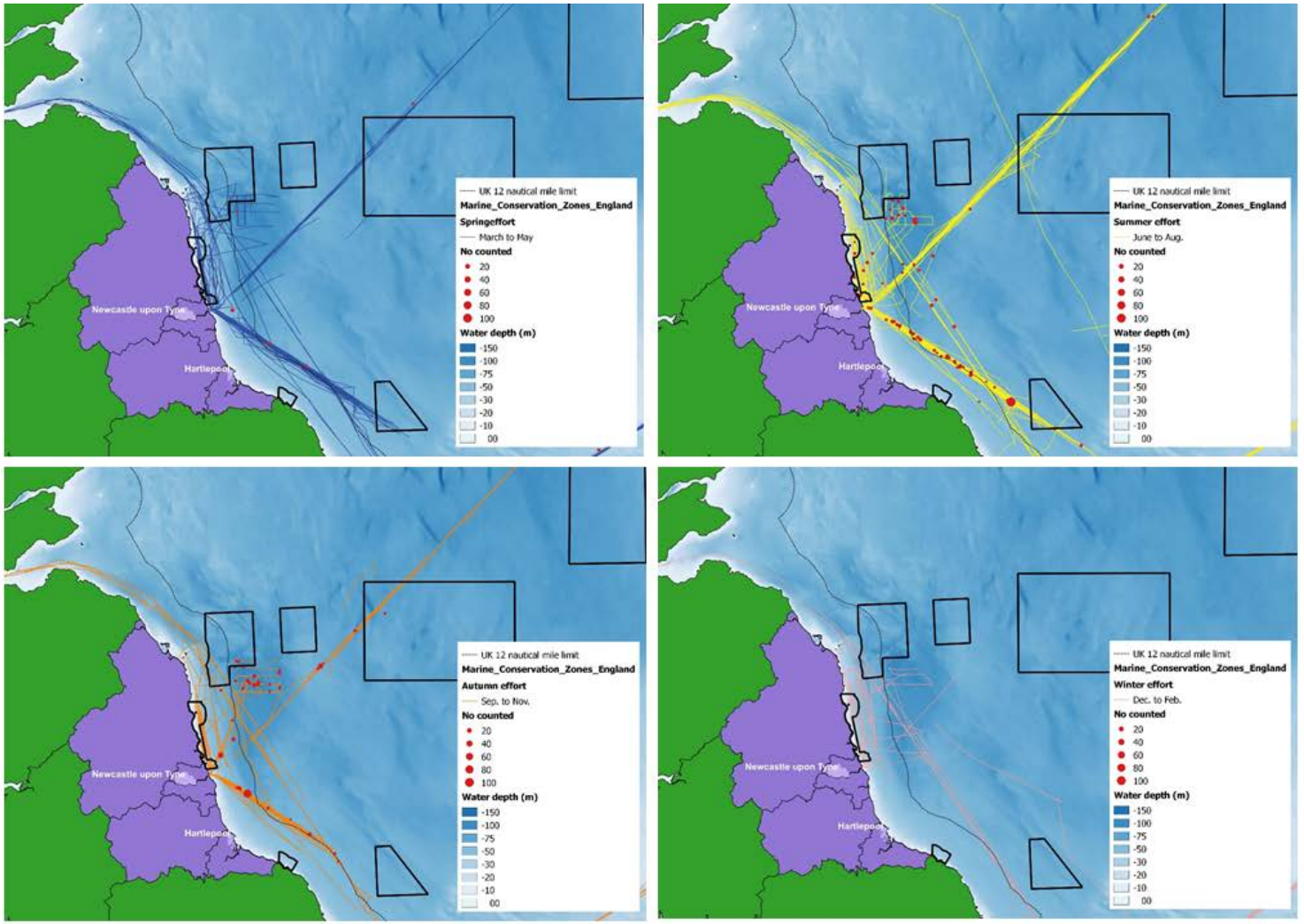

Figure 4: Seasonal patterns in the number of white-beaked dolphins counted for the pooled years 2006-2016, in relation to survey effort (coloured lines) by season. Survey effort: Spring 2050 km; Summer 8794 km; Autumn 15053km; Winter 4924. Total 30821 km.

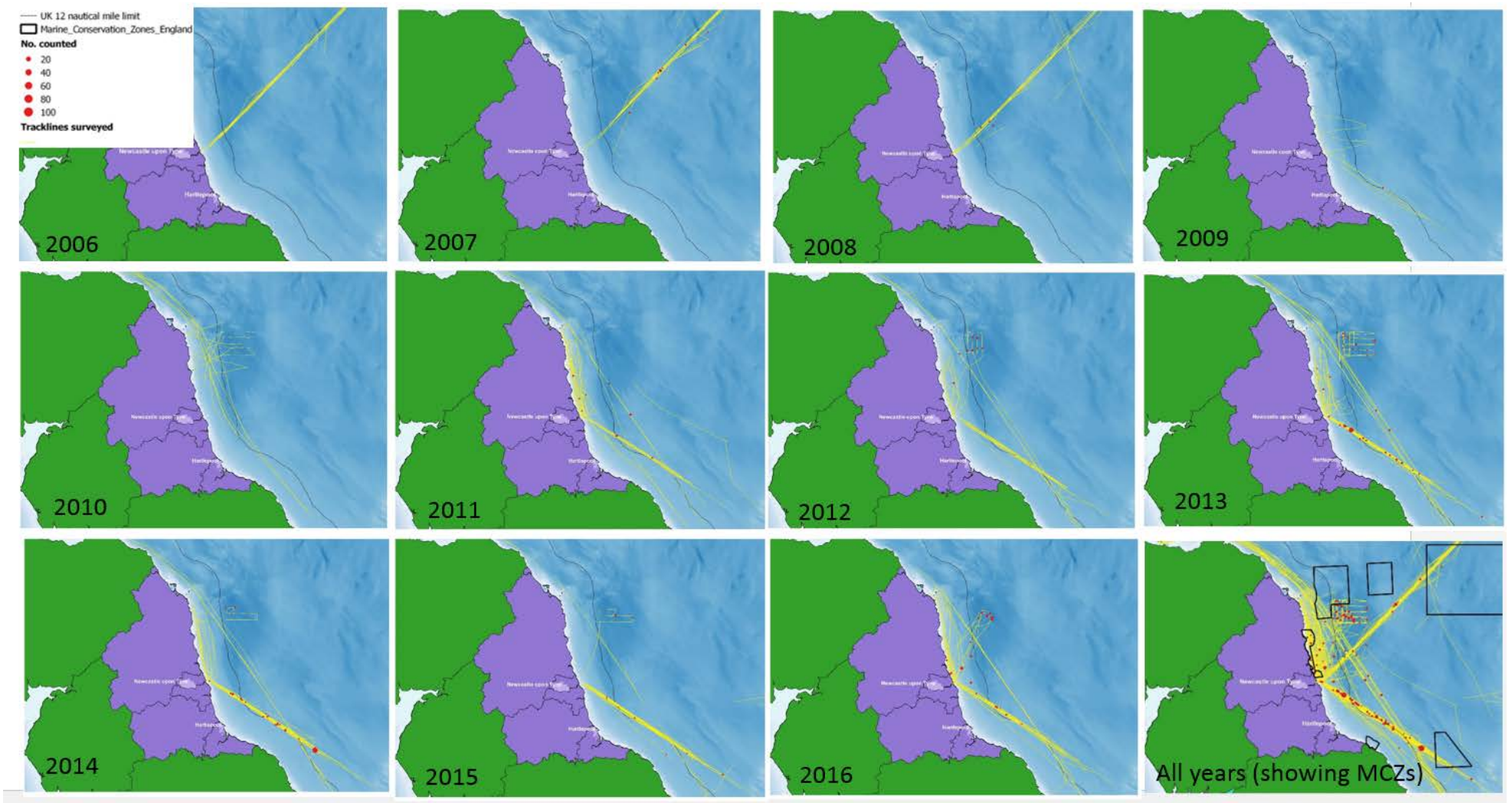

Figure 5: Annual white-beaked dolphin sightings and number counted 2006-2016, in relation to survey effort (coloured yellow lines). For water depths see Figure 4.

3.5 Mapping and comparison of relative abundance between north east England and wider North Sea / Eastern English Channel areas

The spatial distribution of survey effort at 10km square resolution across the wider North Sea area, demarcated by UK regional seas and European countries is illustrated in Figure 6. The maps show that across all years, spatial coverage is most representative for the southern North Sea and eastern English Channel, and least for the northern North Sea whilst there are substantial gaps in coverage. The relatively low level of coverage for the northern North Sea has been exacerbated in recent years by the cessation of the Newcastle to Bergen ferry route. Most survey effort (two thirds of the total) has been made during the spring and summer months (April to August). The lowest level of survey effort (~5000 km across all years) was made from November to February. The pattern of relatively high summer, and relatively low winter, survey effort was broadly consistent annually.

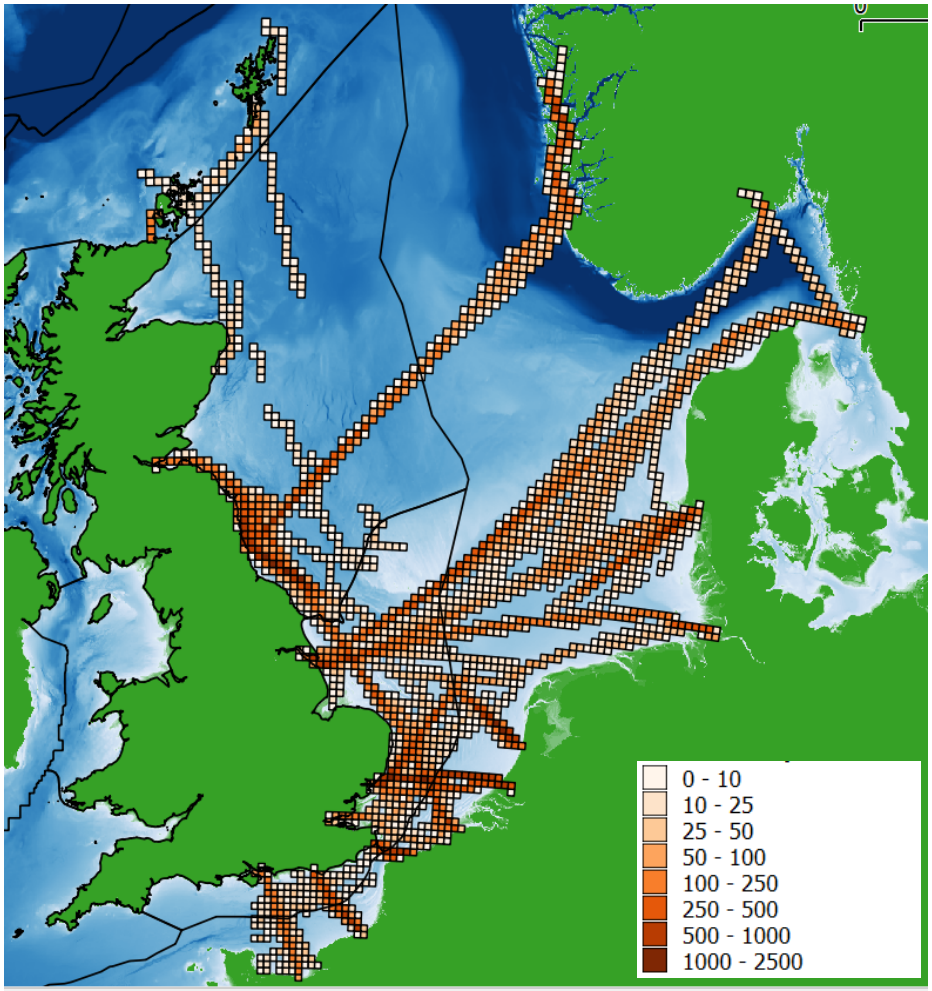

Figure 6: Survey effort (no. km surveyed) at a 10km square scale averaged across all years (2006-2016). The number of km travelled in each cell is classed into one of eight categories (see the legend). For water depths see Figure 4.

Survey effort has increased over time, with the combined totals approximately 6-11,000 km per annum in the first six years of surveys, to more than double (20-32,000 km) over the last five years. Not all 2016 data was processed in time for this report, so the total presented for this year is unduly low.

White-beaked dolphins were present in 4% of (81 of 2041) 10x10km squares sampled. Spatial patterns in relative abundance across all years at 10km square scales, demarcated by UK regional seas is illustrated in Figure 7. The northern North Sea (including Northumberland small boat data) was the UK region with highest relative abundance in all years, followed by the southern North Sea (Table 1). This higher level could not all be explained by greater targeted survey effort from small boats off Northumberland, as for example, higher relative abundance was recorded in this sea area in 2013 and 2014 from ferries and in other years, relative abundance was high when there were no small boat surveys (e.g. 2007).

Table 1: Monthly relative abundance (no./km travelled) from all years of surveys for UK regional seas and off the Northumberland coast from small boat surveys. Red shaded values are peak measures.

UK sea area	January	February	March	April	May	June	July	August	September	October	November	December
Northern North Sea	0	0	0.134	0.101	0.439	2.772	1.890	1.842	7.593	0	0	0
Southern North Sea	0.242	0	0.539	0	0.351	0.154	0.191	0.057	0	0	0.324	0.056
Eastern English Channel	0	0	0	2.192	0	0	0	0	0	0	0	0
Scottish Continental Shelf				0		0	0					
Off Northumberland (small boats)		0	0.1355	0.3	0	0	2.791	14.65	15.580032	0	0	0

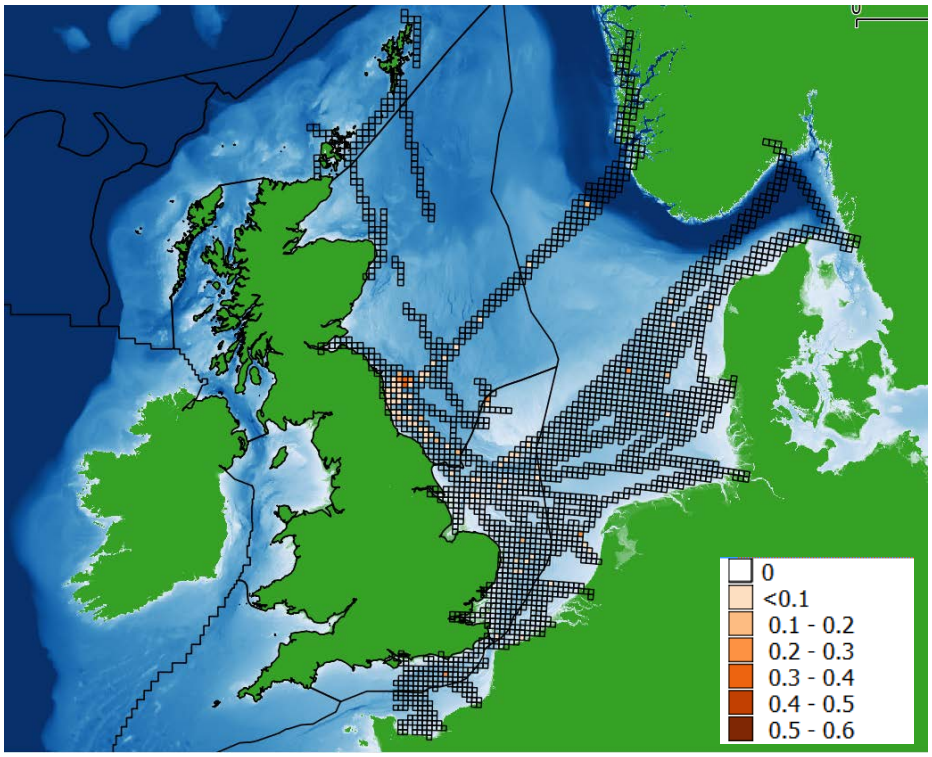

Figure 7: Relative abundance (no./km travelled) of white-beaked dolphin across all surveys (2006-2016), at 10X10 km grid cell resolution. For water depths see Figure 4.

4.0 Discussion

4.1 Evaluation and recommendations

Since 2006, Marinelife and Orca have undertaken a large amount of survey effort in the eastern English Channel and northern North Sea. There is a time series of effort across months and years totalling ~185,000 km of trackline, with ~ 30,000 km off Northumberland and surrounding waters (Figure 4). Most of this effort has been coordinated and conducted, either with the support of commercial freight and ferries, or through various small boat operators on other business. There has been a lot of flux in the shipping industry and a number of routes have started or stopped over the period, outside of the control of Marinelife and Orca. Hence, the large total in survey effort masks a lot of inter-annual variability both spatially and temporally, making comparisons between regions, seasons and years challenging and the results presented in this report should be treated with caution and understanding of these limitations.

Relative density estimates, did not correct for differences in platform type (and speed), or sea state However, for the latter 90% of the survey effort was made in suitable conditions (sea state 4 or less), so the results were unlikely to be biased in major way due to differing seas conditions.

There was reasonable body of evidence to indicate that the waters off Northumberland (an area totalling ca 30,000 km^2) support relatively high densities of white-beaked dolphins during the summer months compared to other regions, though due to the patchy nature of the data, this could not be accurately quantified. The higher sightings rates off Northumberland (and adjacent waters) could not all be explained by targeted surveys for white-beaked dolphin during the summer months through the NECP project, as the area is also sampled by ferry surveys.

4.2 Future work

Given the findings in this study suggesting the importance of Northumberland waters, it would be beneficial to carry out a more systematic survey for white-beaked dolphins in the region; removing as far as possible variability due to platform type and better controlling for spatial and temporal variability. Two comparative and representative areas could be sampled, deemed through this study to support relatively high and relatively low densities of white-beaked dolphins, through monthly surveys over a two-year period.

It would also be valuable to do some sampling within the existing MCZs off the Northumberland coast to determine their importance for white-beaked dolphin. There has been no survey effort in the North East of Farnes Deep and relatively little in the Farnes East. Further afield, Compass Rose, Runswick Bay and Swallow Sand MCZs area also relatively poorly sampled by Marinelife and Orca surveys. There may also be other sources of data that could be added in to the analyses (e.g from universities).

There is a need for a more concerted effort to improve monitoring coverage more widely, by investigating survey opportunities in set areas and times where coverage is currently limited or absent, thereby targeting these effort gaps in order to minimise, if not remove, spatial and temporal variability in effort. This can be difficult owing to the dynamic nature of the ferry and shipping

industry. However, it is important that groups such as Marinelife and Orca are strategic in their network development and make a concerted effort to minimise variability and maintain good coverage. Such challenges include the cessation of the Newcastle to Bergen ferry route through the northern North Sea. Late 2016 also saw the cessation of multiple ferry surveys departing from Immingham, data from which have contributed greatly to this study, impacting both Marinelife and ORCA. It is therefore key to review and maintain current levels of coverage, while also targeting areas where effort is lacking. Improved survey coverage throughout winter months is also important to minimise bias when investigating seasonal variation.

5.0 Acknowledgements

We would like to thank the Ferry and boat operators and crew for supporting our programmes of surveys and hosting Marinelife and ORCA surveyors on board these vessels. Also thanks to the committed pool of trained surveyors for their time and dedication to the surveys and collecting high quality data. Also thanks to Natural England for providing vital funding for this project.

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