From:	Brown, Emma (NE)
To:	Hornsea Project Three
Cc:	Burton, Louise (NE)
Subject:	Natural England Deadline Three Submission for Hornsea Project Three
Date:	14 December 2018 19:16:02
Attachments:	EN 10080 NE Hornsea Project three Deadline 3 Submission - ISH 4.pdf EN 10080 NE Hornsea Project three Deadline 3 Submission - ISH 1 (002).pdf EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 2 PART 1 - Ornithology.pdf HP00066 101 HOW03 HiDef Method statement 20160401.pdf EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 2 PART 2 - Benthic.pdf EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 2 PART 2 - Benthic Annex 2.2B Response on REP2-004.pdf EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 3 .pdf

Hello,

Please find attached Natural England's Deadline Three Submission.

This includes the following documents:

- EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 1
- EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 2 PART A – Ornithology
- HP00066_101_HOW03_HiDef_Method_statement_20160401 (Submitted as appendix 5 of ISH 2 Part 1)
- EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 2 PART 2 – Benthic
- EN 10080 NE Hornsea Project Three Deadline 3 Submission – ISH 2 PART 2 – Benthic Annex 2.2A – Review of Applicant's response to IP response to ExA Questions – Benthic Ecology
- EN 10080 NE Hornsea Project Three Deadline 3 Submission – ISH 2 PART 2 – Benthic Annex 2.2B – Response on REP2-004
- EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 3
- EN 10080 NE Hornsea Project Three Deadline 3 Submission - ISH 4

Kind regards,

Emma

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http://www.gov.uk/naturalengland

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METHOD STATEMENT

Hornsea Project Three (HOW03) – method statement for ornithological, marine mammal and marine megafauna survey

April 2016

Authorisations

Responsibility	Name	Signature	Date
Prepared By	A. Webb	[redacted]	31 March 2016
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Document History

Issue	Date	Status / Changes
First draft	29 March 2016	First draft for DONG Energy consideration
Issued	1 April 2016	Issued document for submission to Ornithology and Marine Mammal Expert Working Group

Contents

1 Introduction

1.1 Hornsea Project Three (HOW03)

DONG Energy Power UK Limited ("DONG Energy") purchased the rights to develop the remainder of the Hornsea Round 3 zone ("the Hornsea Zone") from the SMartwind consortium ("SMW") in August 2015. The Hornsea Zone is located adjacent to the River Humber, 200 kilometres ("km") south of Newcastle and 75km north of The Wash. The East Riding of Yorkshire coast lies 31km to the west of the Hornsea Zone's boundary and the Hornsea Zone's eastern boundary is 1km from the median line between UK and Netherlands waters.

A phased development approach has been applied to the development of the Hornsea Zone, as shown in Table 1.

Table 1 Hornsea Zone development timetable

Name	Size	Development stage	Date consented / expected	Comment
Project One	1.2 GW	Consented	December 2014	Dong Energy and SMW entered a joint venture in December 2011. DONG Energy assumed full ownership in February 2015.
Project Two	1.8 GW	Determination	June 2016	DONG Energy assumed ownership in August 2015.
Project Three	2.4 GW	Pre-planning	Winter 2018 / Spring 2019	DONG Energy assumed ownership in August 2015.

DONG Energy is now proposing to construct and operate the third project in the Hornsea Zone ("HOW03"), which will consist of the following:

- An offshore wind farm with an installed capacity of up to 2.4 GW situated within the Hornsea Zone; and
- Associated onshore / offshore electrical and ancillary works to connect the offshore wind farm to the electricity transmission network in England. The grid connection is still to be confirmed.

The survey design and programme proposed within this document follows that outlined under HiDef Aerial Surveying Limited's ("HiDef") proposal to undertake marine ornithology, megafauna and anthropogenic activity surveys. This survey approach was designed to provide information on ornithological, marine megafauna and anthropogenic activity surveys which shall provide information to inform the HOW03 Environmental Impact Assessment ("EIA") and Habitats Regulations Assessment ("HRA").

HOW03 is in the earliest stages of consultation with the Marine Management Organisation ("MMO") and other statutory consultees, and this document has been produced to support DONG Energy in these discussions. DONG Energy intends to approach the consultees with an Evidence Plan, which is intended for use in seeking high-level, in principle agreement, for the selected methodology. As part of the HRA Evidence Plan process, HOW03 shall present this aerial survey methodology for discussion and agreement in principle with the relevant participants.

1.2 HiDef Aerial Surveying Limited

HiDef is the International market leader in high resolution digital aerial surveys. There is a good reason why HiDef's transect-based survey method is the market leader in the United Kingdom's ("UK"), Germany and the United States of America ("USA"): it has been proven to give accurate and precise abundance estimates for seabirds and marine mammals wherever it is used.

HiDef is ideally placed to deliver this work for HOW03 as we have developed a good working relationship while undertaking surveys for DONG Energy at both the Burbo Bank Extension Offshore Wind Farm ("Burbo Bank Extension") and the Isle of Man Offshore Wind Farm ("Isle of Man") projects. We are able to count Natural England, Scottish Natural Heritage, Marine Scotland Science and the Joint Nature Conservation Committee ("JNCC") as customers, all having contracted or being under current contract with HiDef. This demonstrates the considerable confidence that the development community and SNCBs across the UK have in HiDef to collect data which permits the delivery of scientifically robust results.

Key to this robustness is our Environment and Statistics team, led by Andy Webb. Andy has a wide breadth of experience of offshore ornithological survey design obtained through twenty-eight (28) years with the JNCC. In addition to Andy, the team comprises over twenty-five (25) of the most experienced field ornithologists and seabird specialists in the sector, including three (3) current members of the British Birds Rarities Committee ("BBRC"). It is this team, coupled with our leading and evolving approach to technological development that is key to the science-led data outputs HiDef provide.

1.3 Key considerations for a robust baseline

HiDef's industry-leading second generation ("GEN II") camera technology is supported by bespoke software and proprietary algorithms. Surveys using our GEN II system provide an average identification rate in excess of ninety-five percent, including difficult to differentiate species such as puffin *Fratercula arctica*, razorbill *Alca torda*, guillemot *Uria aalge*, diver species (Gaviidae) and even tern species (Sternidae) at similar 95% levels, which it is able to maintain throughout the year. High quality identification of the three auk species is essential for this project, and thanks to HiDef's high quality imagery, the availability of multiple frames from which to make the identification, the unique camera angle used and the use of many of the UK's foremost seabird identification experts in the process who have researched and perfected new methods for separation of this species group, identification rates in excess of 95% are possible (Table 2).

HiDef's GEN II camera technology combined with our expert identification team is able to achieve identification rates to species for cetaceans, turtles and sharks (referred to in this document as "marine megafauna") of over 99%. For pinnipeds, the proportion identified to species is more precautionary at approximately 50%, which is similar to or better than other targeted survey platforms. A high level of species identification creates a more robust baseline and allows more accurate predictions, with few assumptions, to be made regarding the effects of the construction and operation of an offshore wind farm.

Table 2 Percent of key species groups successfully identified to species level by HiDef's digital video aerial survey method in different seasons of the year

Species group	Survey period	Percent identified to species
Small gull species	Oct 2014 to February 2015	96.26%
	March to June 2015	98.81%
	July to September 2015	99.61%
Large gull species	Oct 2014 to February 2015	98.38%
	March to June 2015	96.16%
	July to September 2015	95.40%
Auk species	Oct 2014 to February 2015	90.64%
	March to June 2015	94.23%
	July to September 2015	93.90%

HiDef's digital video aerial survey technique is particularly adept at recording cetaceans and other surface-dwelling predators, such as turtles and sharks. In particular, the detection rates for these animals are high compared to dedicated visual aerial surveys, and much higher than digital still providers, who struggle to distinguish submerged animals.

The higher detection rates of digital video aerial surveys over other methods, especially digital stills, are essential for better estimation of abundance and, where supporting data are available, for more accurate calculation of the effect of availability bias. HiDef's surveys of waters around the Isles of Scilly, in the Irish Sea and North Sea have proved to be particularly effective for detecting blue shark *Prionace glauca*, leatherback turtle *Dermochelys coriacea* and ocean sunfish *Mola mola* when present, with multiple observations of these species. Consequently, HiDef's video aerial survey technique is the preferred digital method for dedicated cetacean surveys, as highlighted by Marine Scotland's 2014 East Scotland surveys and Aberdeen University's Moray Firth surveys.

The HiDef survey technique

The GEN II camera rig contains four (4) extreme high-resolution digital video cameras (each camera is the equivalent of 16x HD quality) and is operated at a survey altitude of 550m (1800ft) above sea level ("ASL") and at a speed of 220km per hour ("kph") (equivalent to 120 knots ("kn")). At this altitude, the HiDef cameras and lenses each surveys a strip of approximately 125m, with a ground sample distance ("GSD") resolution of 2cm. Combined, these cameras are able to survey a total strip width of 500m (although the strip width adopted for HOW03 will be 250m).

A gap of approximately 20m is maintained between the cameras; this has the benefit of ensuring no overlap between cameras and slightly enlarging the swathe over which over which the survey takes place, which increases the chance of detecting densely aggregating species such as dolphins (Delphinidae), shearwaters (Procellariidae) and seabird multi-species feeding assemblages (typically comprising species such as gannets

Morus bassanus, kittiwakes *Rissa tridactyla*, and auks (Alcidae)). We believe that in order to detect and identify birds such as guillemots, razorbills and puffins which are sitting on the sea with a high level of accuracy and confidence, 2cm image resolution is the minimum that should be used for these surveys.

HiDef has found that this configuration of camera rig represents the ideal combination of survey altitude, image resolution and total transect width; flying higher or lower results in proportionate changes in the image resolution and the transect width. Flying higher than the proposed altitude of 550m (1800ft) would benefit the survey by increasing the transect width and the samples size. However, this would come at the expense of image resolution. HiDef has found that lower image resolution results in a significant deterioration from its industry-leading species identification rates, which is a problem that also affects our competitors when using 3cm GSD cameras.

We fly all our surveys at 550m ASL using the latest generation of modern, quiet survey aircraft. This is particularly important, as sensitive species are likely to exhibit responsive movement to aircraft flying at altitudes up to 500m ASL (Thaxter *et al*., 2015), which risks biasing abundance estimates. This flushing behaviour appears to be in response to visual and sound stimulus, with a key manner of determining flushing behaviour being where a high percentage of birds are observed to be taking off. The risk therefore exists that some of the key species, such as Manx shearwaters *Puffinus puffinus* and auks, might be affected particularly when not actively feeding. Even small amounts of responsive movement away from the aircraft would be sufficient to affect abundance estimates in a digital aerial survey, or might even result in some species not being recorded at all.

An important benefit of using HiDef's unique digital video aerial survey technique when compared with other types of aerial survey is that it uses bespoke technology, designed specifically for detecting seabirds and marine mammals on the sea. Because the camera rig is purpose-built, it does not experience many of the disadvantages associated with off-the-shelf digital stills solutions, which are designed primarily for landscape aerial photography rather than for meeting the specific challenges of detecting and identifying birds and marine mammals and for providing associated other information essential for monitoring at offshore wind farms. Figure I provides an illustration of the GEN II sampling method.

HiDef's digital video service is the only technique able to operate above Beaufort Scale 4 wind speeds, a limitation set by the British Trust for Ornithology ("BTO") almost eight years ago. The use of digital video allows operators to play and rewind video highlighting the contrast between sea and target objects more obviously than digital stills platforms and is one of the major advantages of the video technique. HiDef's limitation on operating conditions is Beaufort Scale 6. Our operating parameters are shown in Table 3.

Figure 1 Illustration of the survey swathe for HiDef's bespoke GEN II camera rig

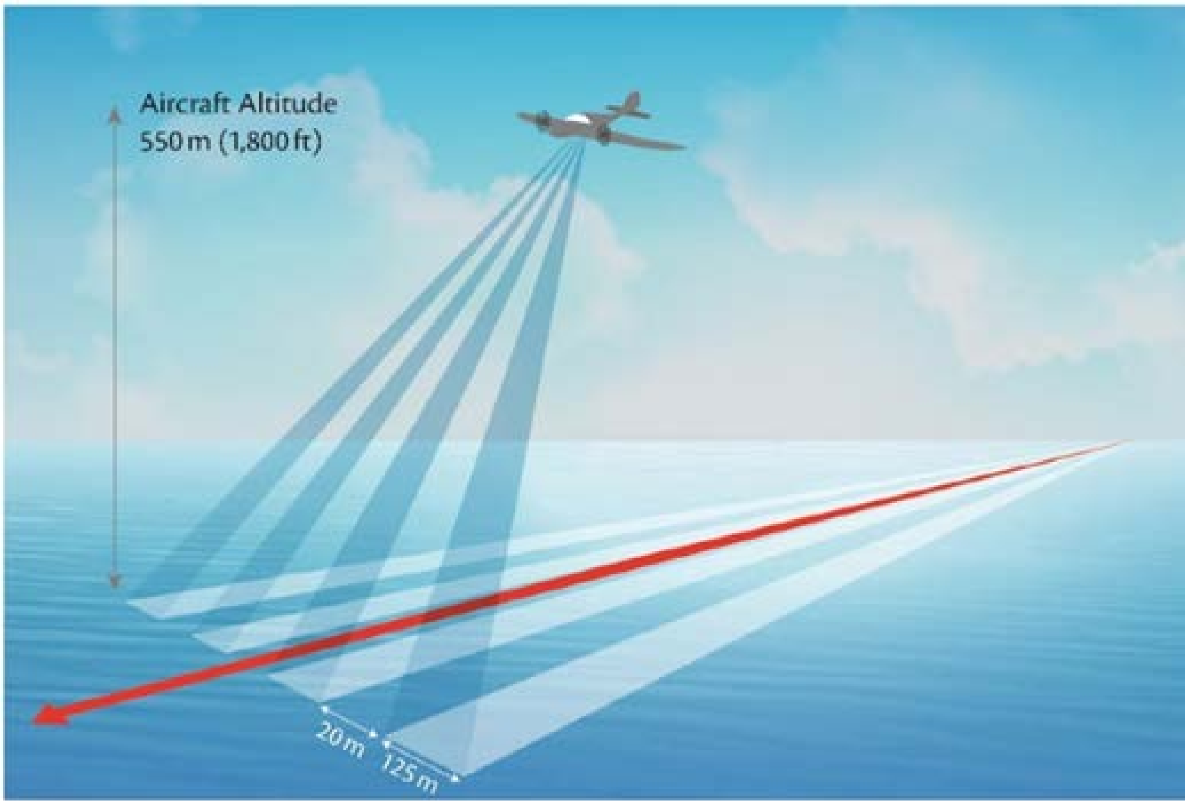


Table 3 Minimum acceptable weather conditions for survey

Parameter	Minimum acceptable weather condition for survey
Cloud	Cloud base above survey altitude
Precipitation	Nil
Wind	Less than 30mph at sea level
Sea State	Less than 6 (as per World Meteorological Organization sea state codes)
Time	Not before 1.5 hours after sunrise Not after 1.5 hours before sunset If E – W transects, no nearer than 1 hour to the Sun's zenith

2 Approach to survey, data analysis and reporting

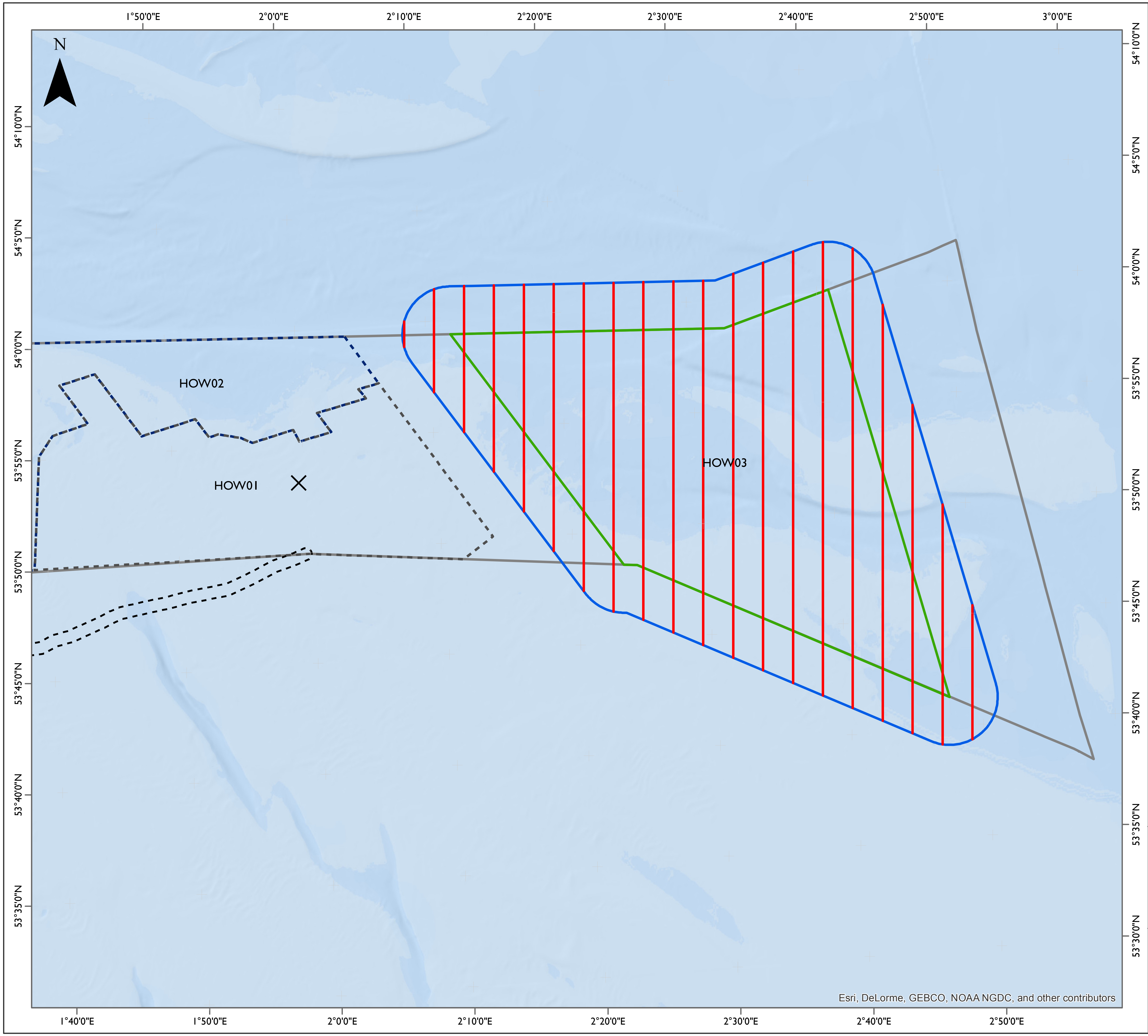
2.1 Survey design

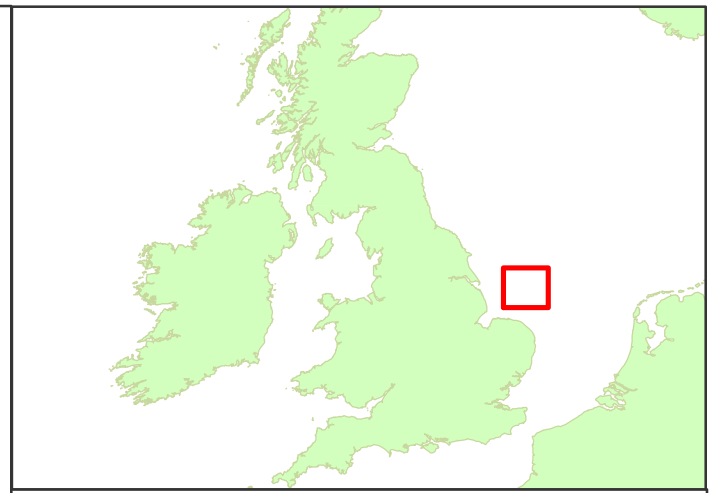
The HOW03 study area can be characterised as being relatively shallow and sitting on the southern edge of a trough known as the Outer Silver Pit. This trough is approximately twice the water depth of the HOW03 site, where it creates a significant north to south depth gradient, although depth difference becomes less to the north of the HOW03 site. The substrate is a mixture of sand, shingle and gravel with patches of mud in the deeper parts of the proposed study area. Overall, the substrate type is unlikely to influence the distribution of seabirds and other marine megafauna within the survey area. Tides in the region are relatively weak, and the water column remains almost completely mixed throughout the year, meaning that tidal effects over banks will likely only have weak impacts on the availability of prey for seabirds and marine mammals.

The key locational 'habitat' is the proximity to the large seabird colony at the Flamborough Head and Bempton Cliffs SPA, which lies 150km to the west of HOW03. For all species apart from two (fulmar *Fulmarus glacialis* and gannet, Thaxter *et al.* 2012), HOW03 lies beyond the typical foraging range for most birds and is therefore unlikely to cause a gradient in bird numbers that should influence the sampling strategy for this site. However, it seems likely that breeding kittiwake may also be reach the project site from Flamborough Head and Bempton Cliffs SPA too (unpublished tracking data).

The basis of HiDef's approach is to provide a design-based non-stratified survey, consisting of a series of parallel transects which are aligned north to south in the HOW03 area and a 4km buffer around it. Although this survey uses design-based principles, it is also beneficial for analysis using model-based principles as well. The benefit of such an orientation of transects is that each transect will sample a gradient in the key habitat that might affect bird and marine mammal distribution, namely water depth. Many surveys of seabird distribution designed to measure displacement effects of wind farms on seabirds have focussed on a 4km buffer around the wind turbines, based upon results for some of the first monitoring projects in UK waters.

The proposed survey area lies adjacent to the Southern North Sea draft Special Area of Conservation ("dSAC"), which if classified, contains harbour porpoise *Phocoena phocoena* as its only feature of interest. The location of the dSAC is such that it will not provide a directional gradient to harbour porpoise distribution that differs from the potential habitat features described above (i.e. depth is likely to have the most important impact on this species' distribution within the study area). Because of the large distance of HOW03 from the nearest seabird colonies, it is unlikely that there will be a significant east / west gradient in seabird abundance. Therefore, the most important static feeding 'habitat' within the proposed study area is water depth, and in order to improve the precision of abundance estimates for the key species likely to occur in the study area, it will be important to sample across the key depth contours, because this reduces the amount of variability in animal abundance between the individual transect. Figure 2 shows the proposed survey design.





LEGEND

- Proposed transects at 2500m spacing
- HOW03 survey area
- HOW03 4km buffer
- HOW01 project area
- HOW02 project area
- Hornsea Zone met mast
- Hornsea Zone cable route
- Hornsea Zone Development Agreement (ZDA) area
- UK outline

0 7 14
Kilometres

CLIENT
DONG Energy

PROJECT
HP00066 - Hornsea Project Three

DRAWING TITLE
Figure 2 - Survey Design
for Project 3 with 4km buffer

DRAWING NUMBER
HP00066-001-002

VERSION	DATE	Drawn	Checked	Approved
1	24/03/2016	CI	AW	KH

SCALE	PLOT SIZE
1:300,000	A3
DATUM	PROJECTION
WGS84	UTM31N

HiDef
AERIAL SURVEYING LIMITED

The amount of survey required for a project is determined by the target precision (expressed as confidence intervals ("CI")) and the coefficient of variance ("CV") of abundance estimates, because this is a measure of uncertainty in the data, and determines the amount of change that it is possible to detect in any monitoring programme.

In a design-based survey, such as this, the precision of abundance estimates is affected by a number of factors. The most important is the amount of variation in abundance between samples, which can be reduced, as described above, by orienting transects so that there is as much similarity in the habitats between transects as possible; this adjustment to samples is not possible in a plot sampling survey design where the samples form a grid over the entire study area. Other factors which influence the precision of abundance estimates are the number of observations of a given species and the amount of survey effort. The number of observations of a species relates directly to the amount of survey effort and therefore is important and the key determinant of survey precision.

Typically for a site characterisation survey, coverage of the site of about 10% by area is considered appropriate to deliver sufficient precision for abundance estimates. In HiDef's experience from other projects (e.g. Dogger Bank, Celtic Array, Kincardine, Dounreay and First Flight Wind) the proposed coverage of 10% will be sufficient for achieving a CV of 16% or better for abundance estimates of the key species, and this level of coverage is the recommended minimum by the regulator BSH in Germany (StUK 4, 2013). In order to achieve 10% coverage and ensure that there are sufficient transects (or samples) for a design-based analysis, HiDef proposes processing data from only two of the four cameras. The analysis and reporting of the data collected under this approach will achieve just over 10% coverage (with an additional 10% total area available for analysis should HOW03 subsequently require it). Table 4 shows the survey parameters; this survey design can be completed in about 2½ hours so can be completed comfortably within one day by a single aircraft, thus avoiding the problems of unfinished surveys prevalent in boat-based surveys.

A 4km buffer is proposed for this survey, which is consistent with characterisation surveys at a large number of other sites around the UK (although larger buffers are recommended for post-consent monitoring of effects, based on existing survey programmes, such as those undertaken and the Lincs and Burbo Bank Extension projects).

Table 4 Metrics for HiDef's proposed survey options for HOW03

Buffer (km)	No. of transects	Transect spacing (km)	Transect length (km)	Transect width (m)	Area sampled (km^2)	Study area size (km^2)	Total coverage (%)
4	20	2.5	491.80	250	122.95	1229.97	10.00

2.2 Availability bias

"Availability bias" is a term coined by Marsh and Sinclair (1989) to describe the bias that results from neglecting the fact that not all members of a population are available to be detected when surveying the population. Using methods that overcome availability bias is crucial for unbiased estimation of true density or abundance from surveys.

Availability bias is more acute for aerial surveys than boat-based surveys because the time window in which marine mammals and diving seabirds are available for detection is short. In the case of digital aerial surveys (video and stills), this time window is effectively instantaneous. For seabirds, the calculation of availability is relatively straightforward in digital surveys because there are only two states of behaviour to consider: at or above surface or submerged. For marine mammals three states need to be considered: at the surface, below surface but detectable and below surface not detectable.

Of the potential target species for any survey, abundance estimates of cetaceans and the three auk species (guillemot, razorbill and puffin) have the potential (among others) to be affected by availability bias. As such, without adjustment, any abundance estimates should be regarded as 'relative abundance', whereas abundance estimates that are adjusted for availability can be regarded as 'absolute' or 'true abundance'. When monitoring potential displacement effects of an offshore wind farm, as long as availability bias is constant, then it is acceptable to use relative abundance measures. But if there is a displacement effect, then in order to calculate the impact of this effect, it is essential to relate the relative abundance measures to the absolute abundance if the impacts are not to be underestimated.

Three approaches for accounting for availability bias can be used at present. We propose to use the most appropriate of these during analysis of the Hornsea 3 Project:

1. Using diving behaviour data from telemetry studies to calculate the proportion of time at sea that is spent at sea for the key species. If available, any spatial or temporal variation in diving rates would be included in any calculations to provide spatial adjustment to abundance estimates. The use of these data carries a number of assumptions: that data collected during June (the main telemetry period for seabird studies) can be applied to aerial data collected at other times of the year; and that the diving patterns for tagged birds is the same as for unmarked (e.g. non-breeding) birds. The last assumption is almost certainly violated because of different colony attendance patterns of breeding and non-breeding birds, but may also be violated because of sampling bias when selecting which animals to tag and because the process of attaching tags might alter diving patterns;
2. Using a comparison study between aerial digital video and double-platform calibrated visual aerial data for harbour porpoise. Williamson *et al.* (in press) compared abundance estimates from digital video aerial surveys with dedicated visual aerial surveys and, as well as finding good agreement in the distribution patterns between the methods, estimated that the availability of harbour porpoise during the digital video surveys in the Moray Firth was a factor of 0.56. While this is a crude calculation, the figure is of a similar order to that calculated from Webb (2014) of 0.44, based upon surfacing rates of harbour porpoise in Teilmann *et al.* (2013) for the North Sea. If there is a sufficiently large sample size in the data, it might be possible to investigate if there is a difference in the proportion of submerged animals in different sea states and use this to modify the correction for availability bias under different conditions; and

3. Using the ratio of attended and unattended chicks at sea. This method can only be applied to guillemots and razorbills in late June and July, in which a single parent will guard their chick at sea except when diving for food, while the chick will not dive until it starts to learn to feed for itself during August (when it also becomes difficult to distinguish adult from chick guillemots by size in digital imagery). This method is clearly limited in its applicability by species and time of year. There may also be differences in diving behaviour between adult guillemots and razorbills attending their chicks and those not attending chicks. Additional diligence is required at the review and identification stages of HiDef's image analysis process to ensure that the results are not biased.

HiDef has also used data from tagging studies to account for availability bias in a number of projects so far:

- Kincardine Offshore Wind Farm (guillemots, razorbills, puffins and harbour porpoise);
- Rhiannon Offshore Wind Farm (guillemots and razorbills);
- Marine Scotland East Coast surveys (guillemots, razorbills and puffins);
- Dounreay Trí Demonstrator (guillemots, razorbills and puffins);
- Isles of Scilly (shags *Phalacrocorax aristotelis*); and
- Oil and Gas UK (seaduck, divers, shags, cormorants, all auks).

The assumption that availability bias is constant in time and space has not been tested and could potentially vary markedly. For example, seabirds might show different diving patterns within a wind farm compared to outwith the boundary. Diving patterns will differ markedly in feeding hotspots compared to areas and times of day when little feeding takes place at sea. The approach to measuring such variation is possible using a 'double platform' method similar to the principals deployed by Hiby and Lovell (1998) and Hiby (1999), but would require a targeted solution which cannot yet be offered commercially. Of the methods proposed for correcting relative abundance measures, those based upon data from tagging studies are least likely to provide local measures of availability bias.

2.3 Flight heights

One of the key factors in understanding the interaction of birds around offshore wind farms is assessing the collision risk posed due to individuals flying at given heights in the vicinity of a project. HiDef has developed a unique computational approach to enable this data to be calculated directly from video. The basis of the technique is the well-established practice of using a mathematical principle called parallax effect to compute the height of an object from aerial imagery.

Although there are established 'off the shelf' software packages to perform this type of analysis, they are designed to work for stationary objects only and therefore inaccurate when applied to flying birds. To overcome this, HiDef has developed and patented a unique extension of the parallax method. This method simultaneously calculates the bird's altitude, direction and speed so that the effects of bird motion on the height estimate can be accounted for. An essential feature of this method is that the application of video imagery provides the ability to measure relative movement between multiple pairs of frames and calculate a mean flight height, which is required for robust estimates. Flight heights of birds are calculated to the nearest ± 1m and provided with the 95% bootstrapped CI. The technique used by HiDef has been tested and validated using sample data sets with objects for which the altitude can be determined using alternate methods (Mellor, 2011).

HiDef's parallax method appears not to be biased, although HiDef is still in the process of analysing data collected during a recent correlation survey. HiDef uses a bespoke algorithm that a) takes account of the effect of bird movement on the parallax calculation and b) identifies spurious calculations resulting from low or high wind speed or flight direction (as above). This method can have some challenges, such as when there is a mirror-calm sea (rare in UK waters) or during very high wind speeds at sea level. This does lead to a number of flight height calculations being rejected, although the remaining data are still considered by Thaxter *et al*. (2015) as being more accurate and precise than that collected by boat-based survey.

The advantage of HiDef's method is that it is fully transparent because all of the errors associated with each measurement are known. On average, these errors are about 10 – 15m either side of the measurement (and well within the bandings used by boat-based surveyors). The advantage of using calculated flight speeds and flying directions is that using generic or average flight speeds from other studies may bear little relationship to actual flying speeds, for example, when a bird is flying within or near to a wind turbine. Similarly, a bird's orientation may not be the best way to describe its flying direction, for example if it compensating for the effects of a cross-wind. The primary weakness of HiDef's method, is that measurement is challenging if the bird is flying parallel to the aircraft's track or when the sea surface is glassy calm (Beaufort Force 0, although this last issue is seldom encountered in the UK offshore environment!) which results in lower (but unbiased) sample sizes than the total number of flying birds encountered during the surveys.

Of particular relevance to DONG is the fact that Thaxter *et al*. (2015) considered that boat-based surveys were not regarded as being reliable enough to provide robust flight height data in comparison to other methods, including digital video aerial surveys. Indeed, Thaxter *et al*. (2015) suggested that although boat-based survey had historically been widely used to give flight height distributions, they could only be used during the day in good weather conditions and have an unknown degree of imprecision, because they are assigned usually to 5m height bands with no estimate of the precision of each height estimate.

2.4 Data review and identifcation

Data review

Once data have been delivered to the HiDef offices, the raw video data are converted into statistical data for further analysis on digital data review stations. These stations can also be used for converting the archival and analysis format into more generic video formats for sharing of video when required. The survey images are viewed by trained, experienced HiDef reviewers using high resolution viewing screens and an image management software package that allows the reviewer to adjust and control the appearance of the images to allow identification of the object to a high level of confidence.

In addition to ornithological activity, any shipping, fishing, human activity or marine mammals observed will also be logged during data review, while other information, such as water turbidity or algal bloom occurrence can also be recorded. Reviewers are not required to identify objects but simply mark the images as requiring further analysis, with this spatial information providing an accurate record of an individual's (or object's) location. A sample of a minimum of 20% of material is subjected to a "blind" re-review; if the agreement is less than 90% then a further review of the material, and re-training, is initiated as required.

Object identification

Images that have been marked as requiring further analysis are passed to highly experienced marine ornithologists and surveyors, the majority of whom have worked with HiDef for a number of years and have received training in the analysis of high definition video imagery of birds, marine mammals and other vertebrates. Images can be managed using software to enhance their appearance and assist the ornithologist in identifying the object. For this project the ornithologists will identify down to species level where possible, and also record any other information which is available (behaviour, flight or swimming direction, sex, age).

For any marine mammals or megafauna identified, their behaviour is also recorded, whether they occur at the surface or subsurface, and their direction of movement between the first and last frame in which they occur. Should it be needed, additional support in identification is provided by industry leading specialist seabird and marine mammal survey experts. Other parameters recorded include:

- Location;
- Species group (e.g. tern species, large auk species);
- Confidence in species group identification (possible, probable and definite);
- Species (and if not possible, No ID);
- Confidence in species group identification (possible, probable and definite);
- BTO Code;
- Behaviour (e.g. flying NW, sitting, loafing (on land) and if possible feeding behaviour);
- Submerged (used only for marine mammals and other non-avian animals);
- Flying height and 95% CI;
- Age class;
- Sex; and
- Additional information, including feeding behaviour where visible and association with man-made objects/vessels.

The presence of other anthropogenic features (such as fixed structures, fishing vessels, dredgers, construction vessels, ferries, yachts or recreational vessels, etc.) which might influence the behaviour of birds and marine mammals will also be recorded and assessed in the analysis.

A randomly selected sample of at least 20% of material is identified independently by a separate group of expert ornithologists and this requires that there is no more than 10% disagreement (no less than 90% agreement) with the first identification of birds and mammals. The output of these results are then compared and any discrepancies reviewed by a further set of expert ornithologists. In the case of any significant discrepancies (i.e. more than 10% disagreement for the whole audit), then the images are re-reviewed by a third ornithologist who acts as an adjudicator in the process to make a decision on the correct observations.

2.5 Data analysis

The exact approach to presenting distribution and density of key bird and marine mammal species will be discussed and agreed with the Ornithology and Marine Mammal Expert Working Group(s) as part of

Stage 2 (develop and agree evidence gathering approaches) and Stage 3 (defining the baseline environment) of Evidence Plan Process.

2.6 Analysis reporting

The approach to presenting distribution and density of key bird and marine mammal species will be discussed and agreed with the Ornithology and Marine Mammal Expert Working Group(s) as part of Stage(s) 2 and 3 of the Evidence Plan Process.

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