FOREWIND

DOGGER BANK
TEESSIDE A & B

March 2014

Environmental Statement Chapter 14 Appendix B DMP Analysis Report

Application Reference: 6.14.2

TEESSIDE ANALYSIS REPORT

PREPARED FOR FOREWIND
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CONTENTS

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1 OVERVIEW

This document presents the results of statistical analyses of survey data for the Dogger Bank development zone (Figure 1) for Forewind. We first reiterate the analysis activities and outputs indicated within the scope of work. The fulfillment of these requirements is also noted.

We then present a description of the methods, followed by results of the analyses. The analysis outputs mainly consist of estimates of the abundance surfaces (variously by month, year or entire survey period), monthly or annual abundance estimates and inference about both the surface and point estimates. As such, the bulk of deliverables are the report's graphics and their underpinning datasets, which are supplementary to this report.

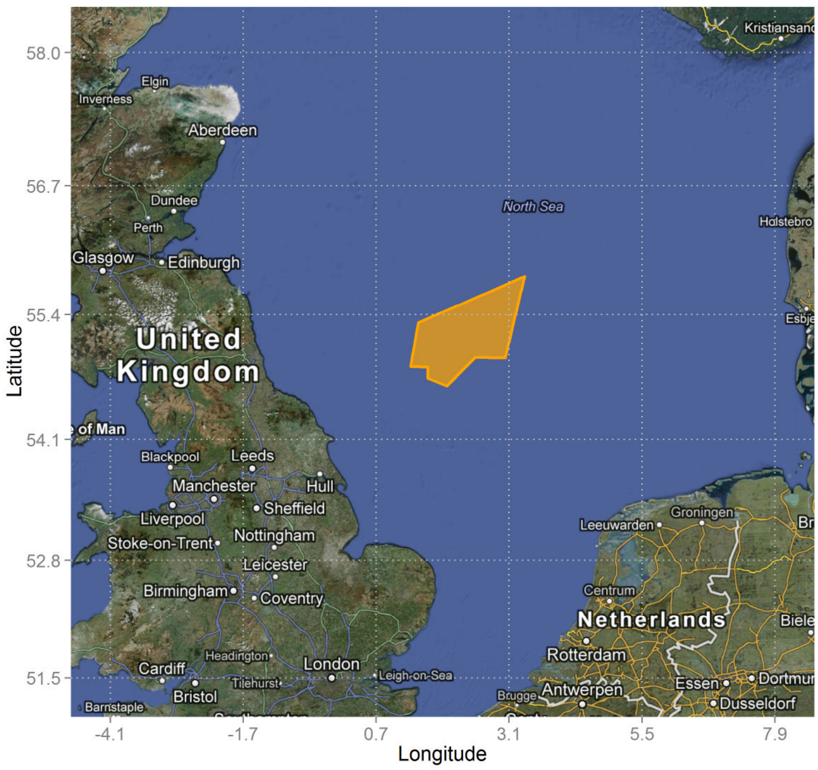

Figure 1: Localization of the Dogger Bank development area, represented by the orange polygon.

1.1 PROPOSED ACTIVITIES

The scope of work requested from DMP Statistical Solutions UK Limited (DMP hereafter) was a package of outputs that reflect the spatial distribution of several species/groups through time. The outputs were to be mainly graphical, comprising of density surfaces & associated inference.

1.1.1 Data preparation and calculation of survey effort

Similarly a preliminary data management phase, for the Hi-Def aerial survey data, comprising of:

i. Combining of all data sources into file(s) amenable to statistical analysis.

ii. Checking and correcting for erroneous values, condensing of detail unnecessary for the plotting and modelling.

iii. Determining survey effort from characteristics of the camera deployment[†].

iv. Setting and summarising to an appropriate spatio-temporal resolution[‡].

v. Expansion of data to include survey points where animals were not observed.

vi. Quality assurance: iterations of data checking/plots, querying client and subsequent modification.

†Based on the transect paths/times, survey craft speed and video equipment characteristics (e.g. effective swath coverage), survey effort was calculated for each grid cell.

‡A grid-cell based system was created to produce species-specific maps.

1.1.2 Statistical modelling

This was followed by modelling of the data to produce species distribution maps for a selected set of species and timeframes. The details of the modelling process are given in §2. Uncertainties were quantified for all of these outputs and relative and absolute abundances calculated for all species/species groups.

1.2 OUTPUTS

The outputs are reiterated below. Their level of completion is also presented.

1.2.1 Data

All datasets produced by the preliminary data management phase. These form the basis of subsequent plotting and modelling. The format in the first instance will be platform independent flat-files, e.g. Comma Separated Value (CSV). The data provided will be that which underpins:

- Plots of density and survey effort.
- Models for estimated (relative and absolute) densities and their uncertainties.

Completed - all the datasets underpinning this report are available –issued as GIS shapefiles and associated metadata.

1.2.2 Plots

The following plotting outputs will be generated:

- Survey paths & effort.
- Plots of species densities/counts over various temporal resolutions.
- Model-derived density maps, for identified species and time-points comprising of the (relative and absolute) estimate and upper/lower confidence surfaces.
- Relative and absolute estimates for each month, by species with associated uncertainties.

The data underpinning all plots will also be provided.

Completed - all the datasets underpinning this report are available –issued as GIS shapefiles and associated metadata.

1.2.3 Reporting

Detailed reporting will be provided, which outlines: the modelling methods, statistical outputs along with interpretations and discussions.

Completed - this report constitutes detailed reporting – in particular regarding analysis methods refer §2.

1.3 SCOPE OF SPECIES AND SPECIES-GROUPS

The scope of species and species-groups were agreed with Forewind prior to analysis. The requirements were:

1. Annual relative abundance surfaces where possible for identified groups.

2. Relative and absolute abundance surfaces, over all surveys, for:
    a. Harbour porpoise.
    b. 'Potential harbour porpoise' grouping.
    c. Harbour porpoise & 'Potential harbour porpoise' grouping combined.
    d. White-beaked dolphin.
    e. Minke.
    f. Grey seal.

Potential harbour porpoise were observations that were classified as any of the following Hi-Def species group categories, where no species level ID was able to be made:

SPECIES GROUP CATEGORY
cetacean species
cetacean species / seal species / shark species
N/A or No ID
small cetacean species
Small Cetacean / Seal Species

These are represented in this report by:

- Annual relative and absolute abundance surfaces for harbour porpoise (§3.1), the potential harbour porpoise species group (§3.2), harbour porpoise & potential harbour porpoise combined species group (§3.3) and grey seals (§3.6).

- Relative and absolute abundance estimates & surfaces, over the entire survey period, for all species and species groups: harbour porpoise (§3.1), the potential harbour porpoise species group (§3.2), harbour porpoise & potential harbour porpoise combined species group (§3.3), white-beaked dolphin (§3.4), minke whales (§3.5) and grey seals (§3.6).

2 MODELLING METHODOLOGY

We present here a technical description of the statistical models used to generate the species density maps and abundance estimates. This pre-supposes knowledge of Generalized Linear Models (GLMs) and smoothing methods.

2.1 MODEL STRUCTURE

To accommodate local surface features in species distribution and potentially patchy numbers of animals across the survey area, a range of candidate models were considered for the species-specific density surfaces. The scope of the models considered was chosen to adequately capture surfaces with both local surface features (e.g. patchy surfaces with locally acting hotspots) and global surface features (e.g. flat surfaces or far-reaching trends).

The count data were assumed to be (potentially over-dispersed) Poisson counts with spatio-temporal autocorrelation. Flexible surfaces were implemented for each species and, data permitting, the average surface densities for each species were allowed to change across years (via models with year as a factor variable). In all cases, a log link and over-dispersed Poisson errors were assumed and spatio-temporal auto-correlation was permitted.

2.1.1 Smoothing Details

Model flexibility for the spatial surfaces in this setting is determined by both the number of 'knots' used (i.e. anchor points) for the model and the effective range (*r*) of the basis associated with each knot (the spatial extent to which each knot influences the fitted surface). Since the optimal choices for both of these features are always unknown, these details were considered as a part of the model selection process governed by objective fit criteria.

Spatially adaptive models for a range of knot numbers were considered. For a given knot number, the initial knot locations on the spatial surface were chosen to maximise the coverage across the spatial area (via a space filling algorithm[1]) and these locations were permitted to move according to the Spatially Adaptive Local Smoothing Algorithm (SALSA[2]). This targeting of model flexibility was coupled with the Complex Region Spatial Smoother (CReSS[3]) which was employed for the spatial smoothing. CReSS is recently developed and is finding widespread use to model both seabird and marine mammal distributions on small and large spatial scales (e.g. the Joint Cetecean Protocol[4]).

2.1.2 Model Selection

Discriminating between models with different amounts of flexibility was undertaken using 10-fold cross-validation (CV). This process balances fit to the data with model complexity and is based on evaluating model predictions to data unseen by the model (validation data). The data are split into 10 mutually exclusive sets and while 9 of the 10 sets are used to train the model, the remaining set is used to evaluate these trained model predictions to the validation set (values unseen by the data). This is repeated until all 10 sets have acted as validation sets. The sum of the squared differences between the observed data in the validation sets and the predictions based on the training data are then found in each case, and the average of these 10 values used to give a CV score.

1 1990. Johnson, M.E., Moore, L.M., and Ylvisaker, D. Minimax and maximin distance designs. Journal of Statistical Planning and Inference 26, 131-148.

2 2011. Walker, C., MacKenzie, M. L., Donovan, C. R.,& O'Sullivan, M. SALSA – A Spatially Adaptive Local Smoothing Algorithm. Journal of Statistical Computation and Simulation. 81, 2.

[3] 2013. Scott-Hayward, L.A.S. , Mackenzie, M. L. , Donovan, C. R., Walker, C. G. and Ashe, E. Complex Region Spatial Smoother. Journal of Computational and Graphical Statistics, In Press, Available online: DOI: 10.1080/10618600.2012.762920.

[4] 2011. Paxton, CGM., Mackenzie, ML., Burt, ML., Rexstad, E. and Thomas, L. Phase II Data Analysis of Joint Cetacean Protocol Data Resource. http://jncc.defra.gov.uk/pdf/JCP_Phase_II_report.pdf.

2.2 MODEL INFERENCE

The input data are collected along transects and consecutive measurements on these transects are closely linked in space and time. Additionally, due to environmental/prey conditions (which are likely unknown to us) the abundance of marine mammals at any particular location is likely to be more similar for points close together in time compared with points distant in time. Models fitted to the count data attempt to explain animal abundance at any particular location, but the information (covariate data) that describes why animals are found in high/low numbers at particular locations is often missing from the model. This leaves pattern in the noise component – as evidenced by model residuals. Further, these patterns are likely to be similar along the track lines. This correlation in model residuals along the track lines violates a critical assumption for standard statistical models (such as GLMs/GAMs) which require an independent set of residuals. Further, ignoring this violation can invalidate all model-based estimates of precision (e.g. standard errors, confidence intervals and *p*-values). Given positive correlation is typical, the models will tend to be over-complicated and statistical significance may be attributed to random fluctuations in the data.

For this reason, a modelling framework with incorporates this autocorrelation was used to obtain realistic model-based estimates of precision in this analysis (Generalized Estimating Equations; GEEs)[5]. GEEs are designed to explicitly estimate and incorporate residual autocorrelation within the transects. To ensure this extra complexity was required, a runs-test[6] was employed in each case to test for statistically significant levels of spatio-temporal autocorrelation in model residuals along the transects. In the case that statistically significant levels of autocorrelation were found, 'flights' were used to define the panel/blocking structure. In a GEE setting, correlation is permitted within 'flights' but independence between 'flights' is assumed.

The GEE method adjusts model-based estimates of precision (e.g. 95% confidence intervals) for the autocorrelation observed in the model residuals (via empirical sandwich estimates of variance) to give robust results and helps ensure model inference is realistic. A substantial amount of temporal autocorrelation was evident in model residuals for all species, and this was determined to be statistically significant at the 1% level in all cases (see details in each species-specific results section).

The GEE model estimates and measures of precision were used to generate 5000 parametric bootstrap predictions to each grid cell, and the central 95% of the predictions in each grid cell used to give upper and lower 95% confidence limits. Note, these geo-referenced confidence intervals include the uncertainty in model parameters, spatio-temporal autocorrelation and extra-Poisson variation (overdispersion).

5 2002. Hardin, J and Hilbe, J. Generalized Estimating Equations. Chapman and Hall, CRC Press.

6 1982. Mendenhall, W. Statistics for Management and Economics, 4th Ed., 801-807, Duxbury Press, Boston

2.3 CORRECTING FOR AVAILABILITY

The model predictions outputted by the spatially adaptive models assume that all animals present at the surface were seen by the high definition video equipment and identified correctly, subsequent to capture on video. However, animals in the ocean are most often underwater and are therefore typically unavailable to be seen at the surface. This must be accounted for when estimating genuine animal abundances.

The availability of each animal species to be seen at the surface was incorporated by inflating the fitted surfaces by an availability correction, e.g. if animals were available to be seen only 8.8% of the time, then an abundance estimate for the survey area of say 10 animals was inflated to be 10/0.08=125 animals. The 95% confidence bounds for the abundance estimate were adjusted in the same way.

Uncertainty in the availability estimates was not accounted for here (due to a lack of reliable published data), but could be under this modelling scheme in future, should this data become available. For instance, a distribution for the precision of the availability estimate could be assumed, and availability values generated from this process. The new abundance estimates for each grid cell could then be calculated under these random realisations and combined with the uncertainty from the model fitting process.

The following instantaneous availabilities were assumed for the species being considered:

SPECIES	PROBABILITY OF BEING AVAILABLE TO BE SEEN AT THE SEA SURFACE
Minke Whale	0.0882[7]
White Beaked Dolphin	0.352[8]
Harbour Porpoise	0.434[9,10]
Grey Seal	0.1[11,12]

7 1989. Joyce, G.G., Øien, N., Calambokides, J. and Cubbage, J. C. 1989. Surfacing rates of minke whales in Norwegian waters. Report of the International Whaling Commission 39, 431 – 434.

8 1995. Mate, B. R., Rossbach, K. A., Nieukirk, S. L., Wells, R. S., Irvine, A. B., Scott, M. D., and Read, A.J. Satellite-monitored movements and dive behavior of a bottlenose dolphin (Tursiops truncatus) in Tampa Bay, Florida. Marine Mammal Science, 11, 452-463.

9 1995. Westgate, A. J., Read, A. J., Berggren, P., Koopman, H. N., and Gaskin, D. E. Diving behaviour of harbour porpoises, Phocoena phocoena. Canadian Journal of Fisheries and Aquatic Sciences, 52:1064–1073.

10 2006. Thomsen, F., Laczny M. and Piper, W. A recovery of harbour porpoises (Phocoena phocoena) in the southern North Sea? A case study off Eastern Frisia, Germany.

11 2006. Harrison, P.J, Buckland, S.T. Thomas, L., Harris, R. Pomeroy, P. and Harwood, J. Incorporating movement into models of grey seal population dynamics. Journal of Animal Ecology, 75: 634–645. doi: 10.1111/j.1365-2656.2006.01084.x

12 1991. Thompson, D., Hammond, P.S., Nicholas, KS and Fedak, MA, Movements, diving and foraging behaviour of grey seals (Halichoerus grypus). Journal of Zoology, 224, 223-232.

3 MODELLING RESULTS

We present here graphical summaries of the density surface modelling for the requested species and species groups. The associated data are provided as deliverables in conjunction with this report.

3.1 HARBOUR PORPOISE

A relatively complex spatial surface, with a mix of both local and global reaching trends, was selected for this species, and the overall densities were permitted to vary from year to year. Month was also fitted as a factor in the model to allow predictions to change across months. There was broad agreement between the observed data and the fitted values based on the model (Figure 2), however the fitted model is notably smoother than the raw input data (as evidenced by the units in Figure 2). The annual predictions have increased notably in the 2011-2012 relative to the two years prior, however the uncertainty about these fitted surfaces have also increased in these years (as evidenced by the 95% confidence intervals about the fitted surfaces; Figure 3). This uncertainty also considers the significant positive spatio-temporal autocorrelation found to be present in model residuals[13].

This increase in estimated numbers is also evident in Figure 4 and Figure 5, however the increase from estimated total numbers in 2011 relative to 2010 appears to have stabilised in 2012. Only two months were surveyed in 2009 and thus do not offer a robust comparison with subsequent years. Monthly estimates of abundance for Harbour Porpoise in this area (Figure 4) appear to peak annually in May-June, while suggesting lower numbers in January and November-December of each year.

Across all years, and after adjusting for availability, results suggest that total Harbour Porpoise numbers in this survey area are approximately 8200 on average (Table 1) and this distribution tends to concentrate on south-western side of the area (Figure 2 and Figure 3).

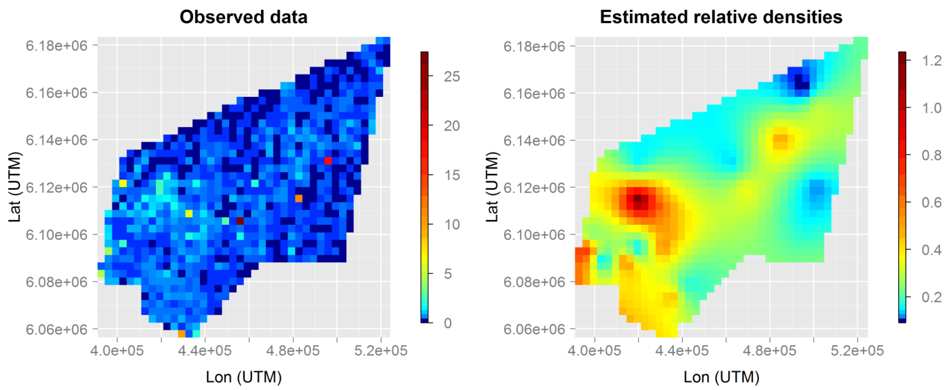

Figure 2: Observed counts of Harbour Porpoise averaged in each grid cell across years (left-hand plot) and estimates of relative abundance across years, averaged in each grid cell (right-hand plot). Plots are shown with the same level of resolution for comparison purposes. Note: the estimates referred to here are the estimated counts per km^2 multiplied by the area (in km^2) associated with each count

13 (the runs test returned a p-value<0.000001).

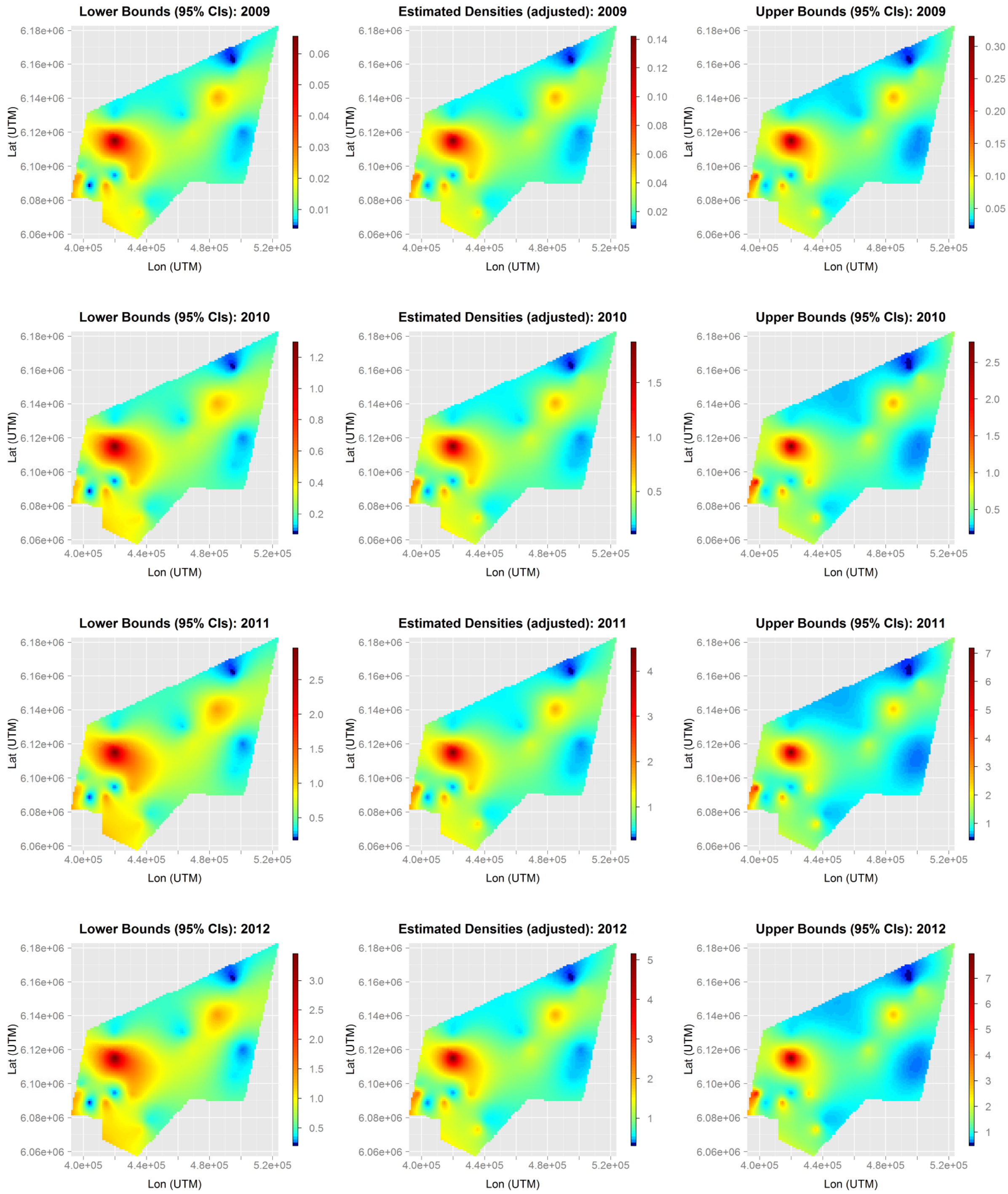

Figure 3: Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of Harbour Porpoise (on a fine grid) per km^2 in each year, averaged in each grid cell after adjusting for availability.

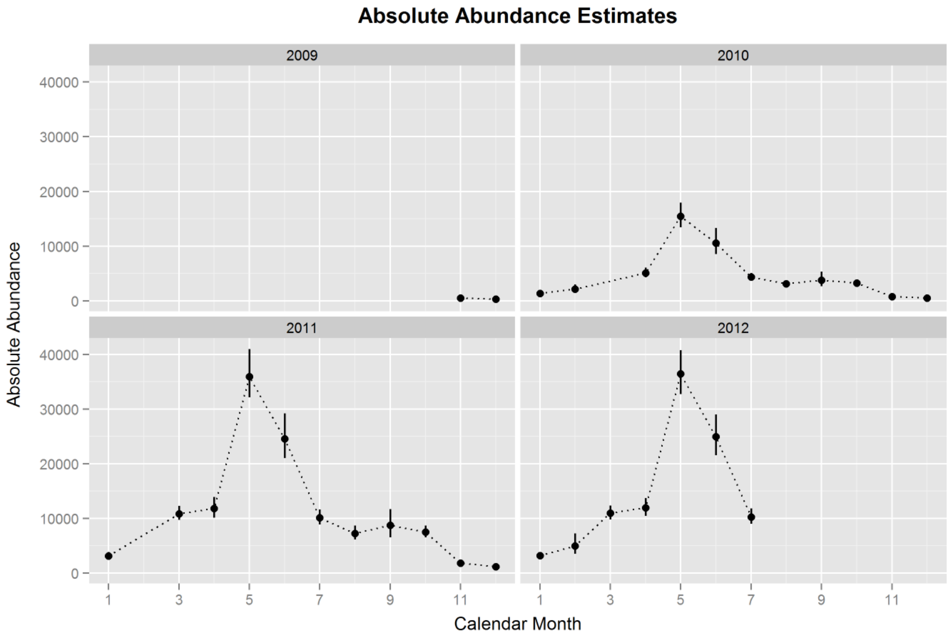

Figure 4: Estimates of monthly absolute abundance (after adjusting for availability), together with associated 95% confidence intervals, of positively identified Harbour Porpoise.

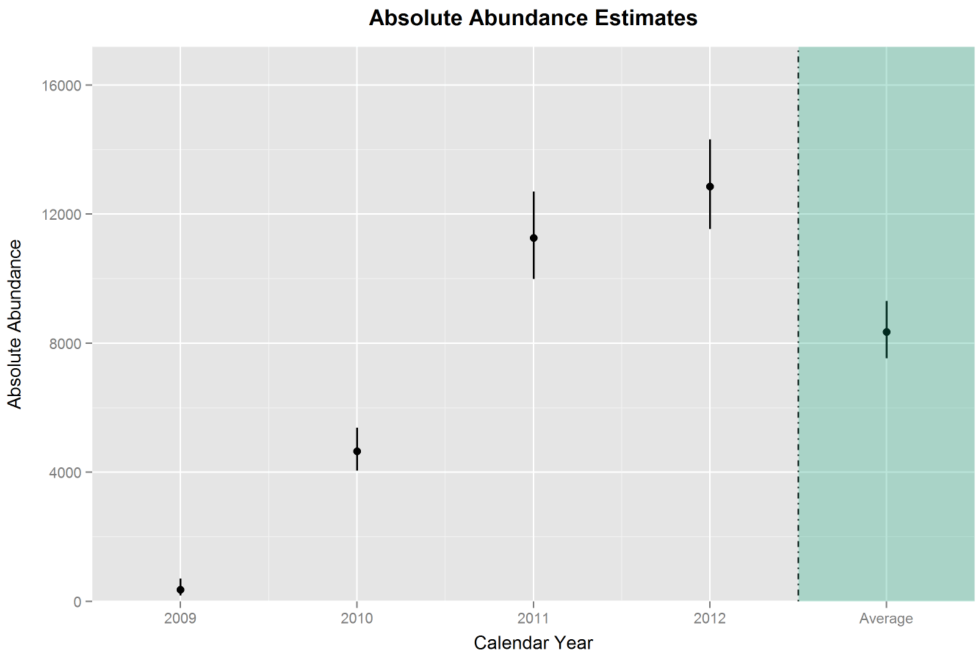

Figure 5: Estimates of annual absolute abundance and absolute abundance averaged across years (green-shaded area of plot), together with associated 95% confidence intervals, of positively identified Harbour Porpoise, after adjusting for availability.

3.2 POTENTIAL HARBOUR PORPOISE

A relatively complex spatial surface, with a mix of both local and global trends, was selected for this species group and this surface was permitted to increase or decrease, on average, annually. Month was also fitted as a factor in the model to allow predictions to change across months. Despite the relatively complex input data, the estimated spatial surface for the distribution of potential Harbour Porpoise, during the surveyed years, shows good agreement with the observed data (Figure 6).

There is a reasonable amount of uncertainty in the geo-referenced predictions (as evidenced by the upper and lower confidence limits across years; Figure 7), however relatively high numbers in the south-western part of the survey area were still persistent despite this uncertainty. This general favouring of these areas by the animals was also seen with the positively identified Harbour Porpoise, albeit with more precision in the Harbour Porpoise case. The level of precision associated with these annual predictions (which incorporated the significantly positive spatio-temporal autocorrelation[14]) was similar across years (Figure 7).

Monthly estimates of abundance for potential Harbour Porpoise in this area (Figure 8) appear to also peak annually in May-June, immediately followed by relatively lower levels in July-August. Results also suggest that the abundance of potential Harbour Porpoise is at its lowest in December of each year. Annual estimates of abundance for potential Harbour Porpoise in this area (Figure 9) are somewhat cyclical and appear to have peaked in 2010 and returned to around 2009 levels in 2012. Notably, the general increase in animal numbers from 2010 to 2011 seen with Harbour Porpoise (Figure 5) is not apparent here.

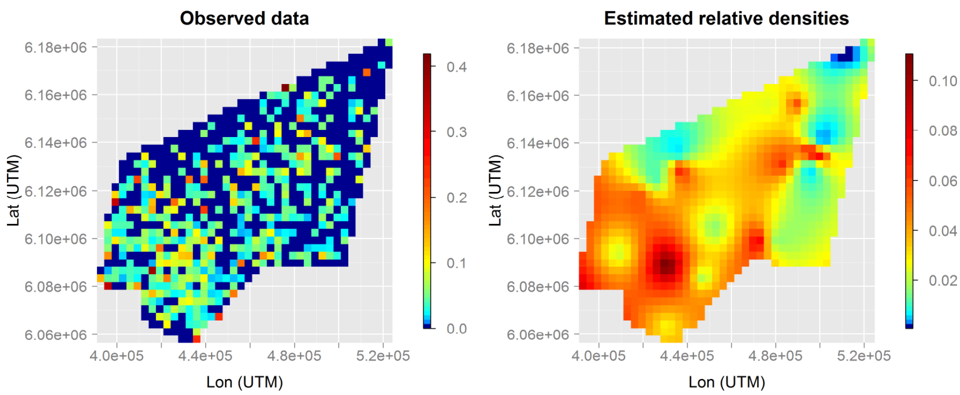

Figure 6: Observed counts of potential Harbour Porpoise averaged in each grid cell across years (left-hand plot) and estimates of relative abundance across years, averaged in each grid cell (right-hand plot). Plots are shown with the same level of resolution for comparison purposes. Note: the estimates referred to here are the estimated counts per km^2 multiplied by the area (in km^2) associated with each count.

14 (the runs test returned a p-value<0.000001).

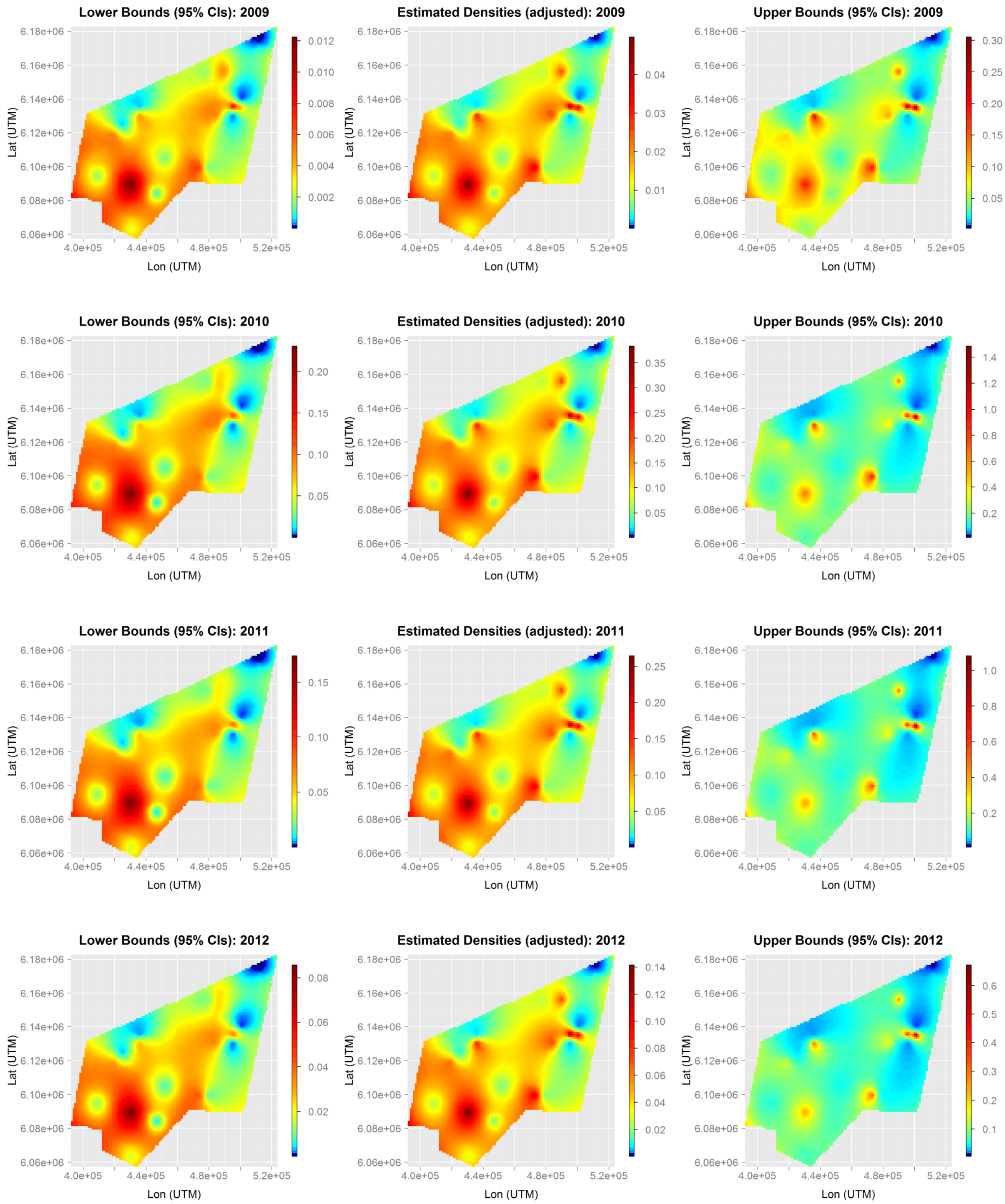

Figure 7: Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of potential Harbour Porpoise (on a fine grid) per km^2 in each year, averaged in each grid cell after adjusting for availability.

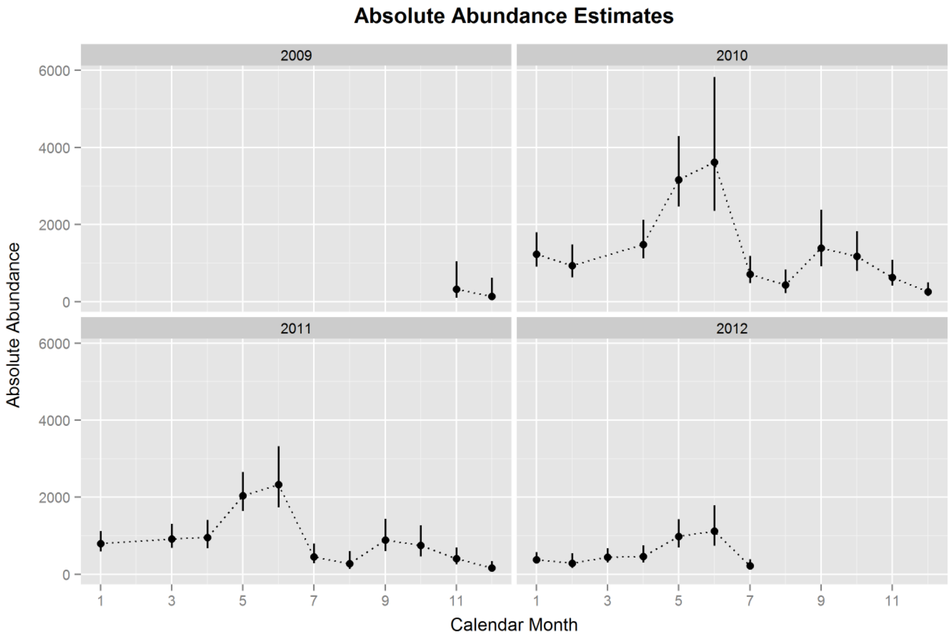

Figure 8: Estimates of monthly absolute abundance (after adjusting for availability), together with associated 95% confidence intervals, of potential Harbour Porpoise.

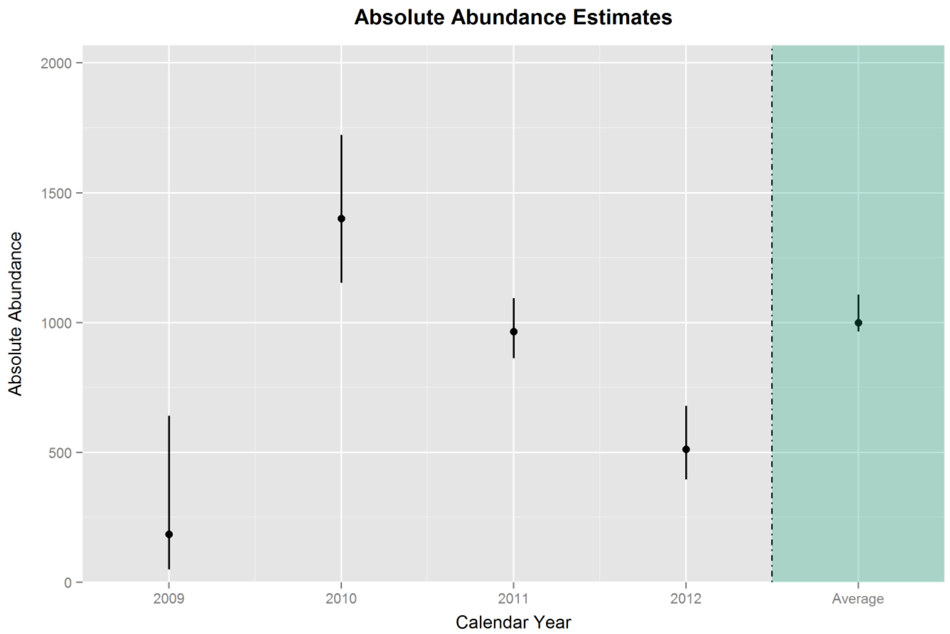

Figure 9: Estimates of annual absolute abundance and absolute abundance averaged across years (green-shaded area of plot), together with associated 95% confidence intervals, of potential Harbour Porpoise, after adjusting for availability.

3.3 HARBOUR PORPOISE & POTENTIAL HARBOUR PORPOISE COMBINED

A slightly less complicated spatial surface was chosen for Harbour Porpoise and Potential Harbour Porpoise combined. Naturally, the spatial patterns obtained for the combined data (Figure 10 and Figure 11) are similar to the spatial surfaces seen earlier for the positively identified Harbour Porpoise (Figure 2 and Figure 3). There is also reasonable visual agreement between the fitted values as a result of the analysis and the observed data (Figure 10).

The 95% confidence intervals about the fitted annual surfaces indicate lower precision for estimated distributions in more recent years (2011 and 2012, Figure 11). As with the previous two sets of models, there was significant positive spatial autocorrelation[15] included in these measures of uncertainty.

In agreement with the trends presented in the previous two sections, monthly estimates of abundance for positively identified and potential Harbour Porpoise combined look to peak annually in May-June (Figure 12), while decaying to the lowest levels in January and November-December of each year. Estimates of annual abundance for the combined data in the whole area appear to be higher in years 2011 and 2012 compared with 2010 (Figure 13). However, as mentioned in Section 3.1, these numbers appear to have stabilised in the last two years. The results based on the small survey effort in 2009 do not offer a robust comparison for results in later years.

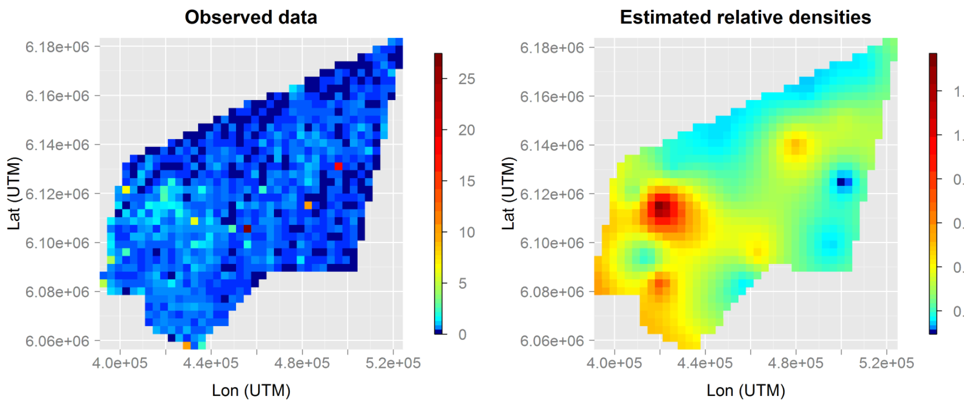

Figure 10: Observed counts of positively identified and potential Harbour Porpoise combined, averaged in each grid cell across years (left-hand plot) and estimates of relative abundance across years, averaged in each grid cell (right-hand plot). Plots are shown with the same level of resolution for comparison purposes. Note: the estimates referred to here are the estimated counts per km^2 multiplied by the area (in km^2) associated with each count

15 (the runs test returned a p-value<0.000001).

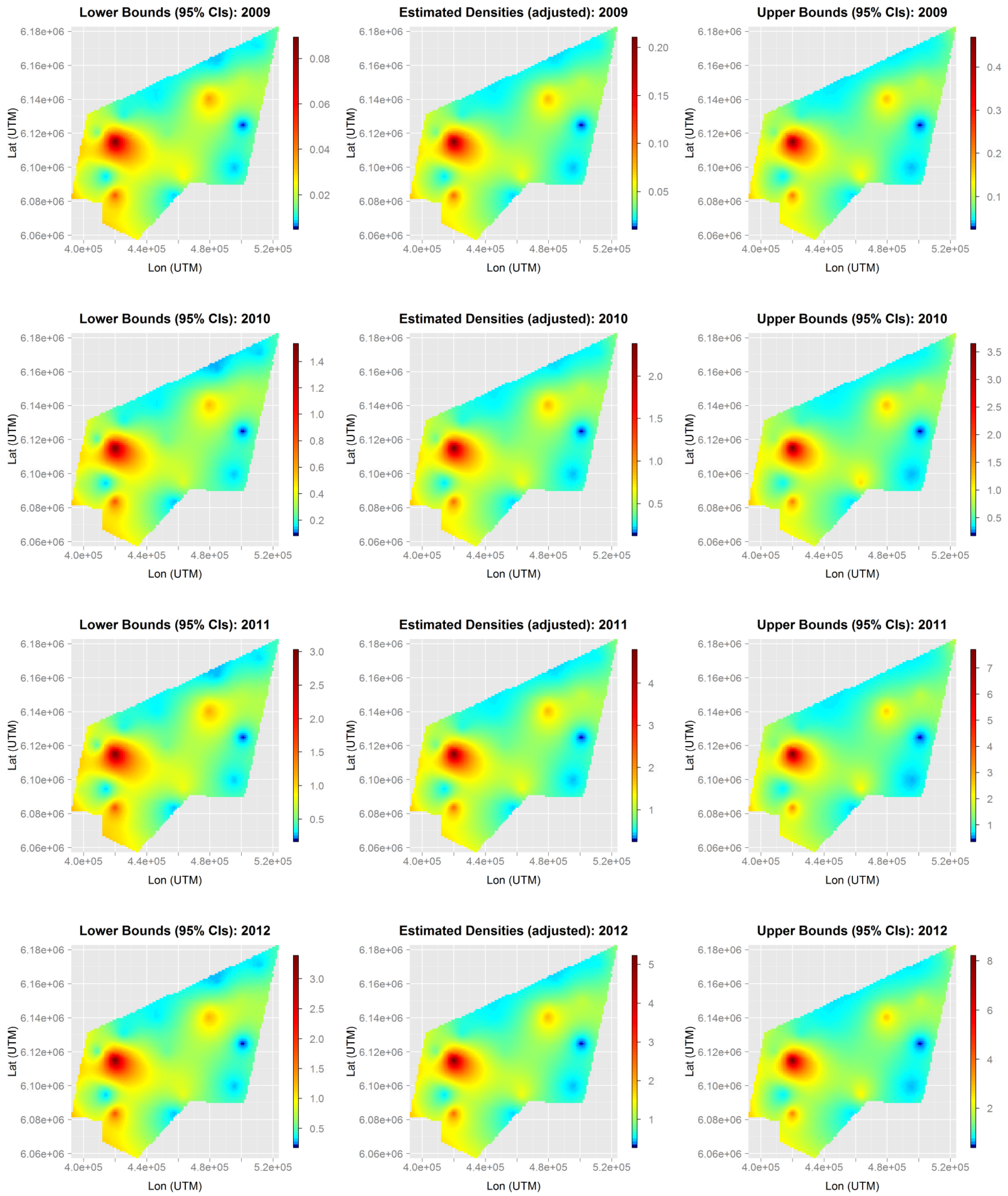

Figure 11: Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of positively identified and potential Harbour Porpoise combined (on a fine grid) per km^2 in each year, averaged in each grid cell after adjusting for availability.

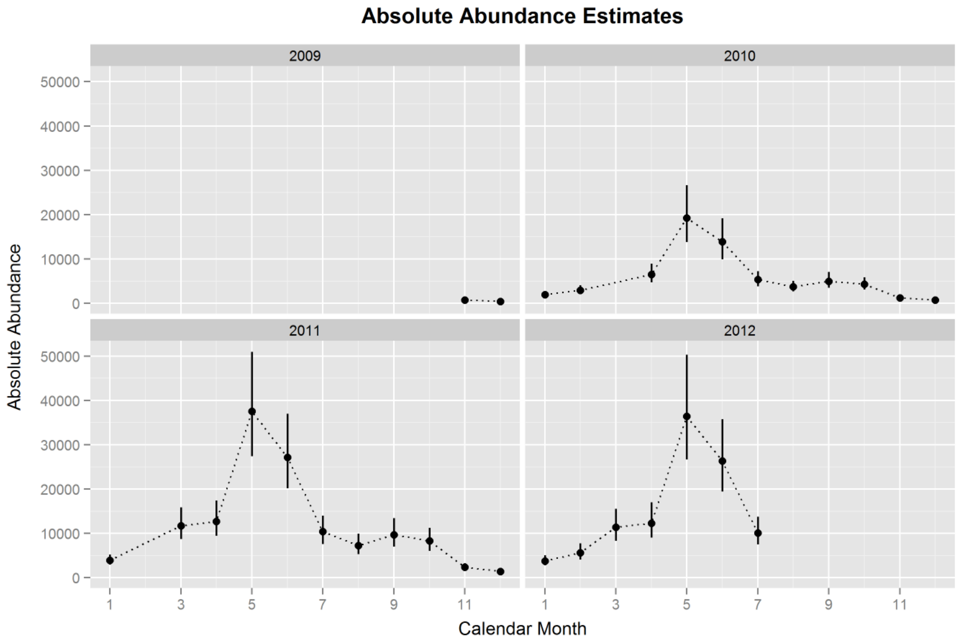

Figure 12: Estimates of monthly absolute abundance (after adjusting for availability), together with associated 95% confidence intervals, of positively identified and potential Harbour Porpoise combined.

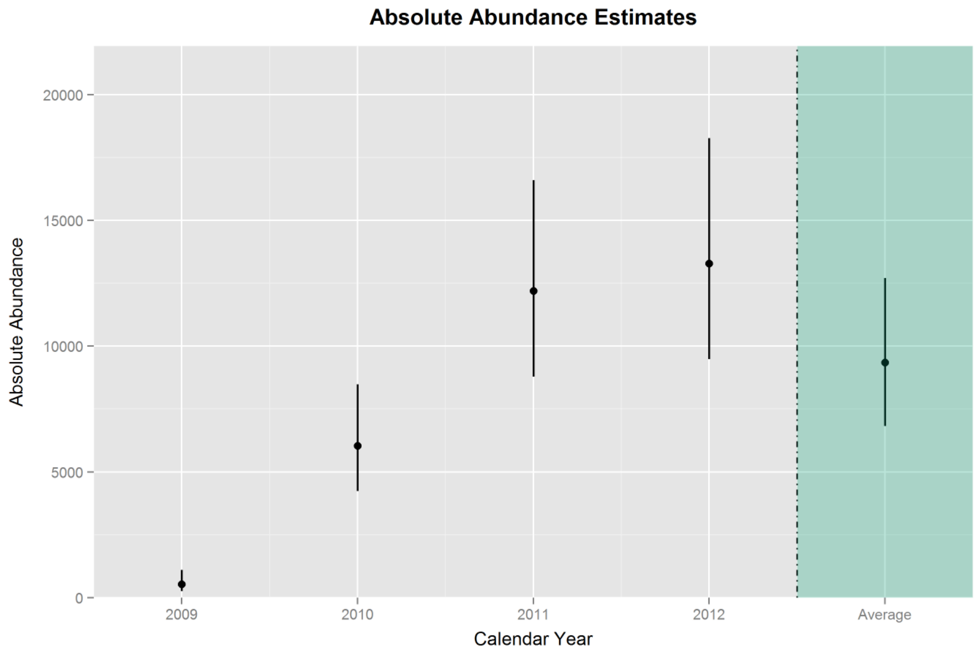

Figure 13: Estimates of annual absolute abundance and absolute abundance averaged across years (green-shaded area of plot), together with associated 95% confidence intervals, of positively identified and potential Harbour Porpoise combined, after adjusting for availability.

3.4 WHITE BEAKED DOLPHIN

An extremely smooth spatial surface was chosen for White Beaked Dolphins, due to very low numbers of animals seen across the survey area (Figure 16). Thus, while it was possible to estimate surfaces describing the overall spatial distribution of White Beaked Dolphins in the Dogger Bank area during the surveyed years (Figure 17) there was no support for a model which included a year-based term. There was still however, significant positive spatio-temporal autocorrelation in model residuals[16] (accounted for in this case by the GEE model).

Fitted surfaces suggest that the distribution of White Beaked Dolphins (averaging an estimated total of approximately 200 animals, Table 1, page 26) is primarily focused on the top north-western corner of the Dogger Bank area (Figure 16 and Figure 17).

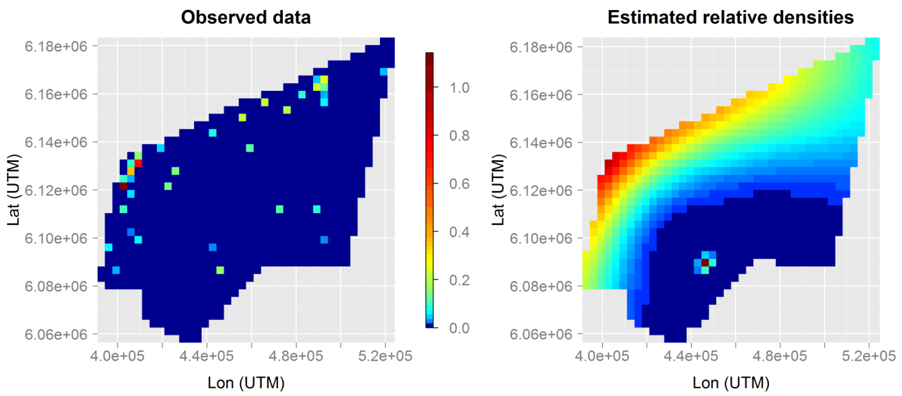

Figure 14: Observed counts of White Beaked Dolphin, averaged in each grid cell (left-hand plot) and estimates of relative abundance across years, averaged in each grid cell (right-hand plot). Plots are shown with the same level of resolution for comparison purposes. Note: the estimates referred to here are the estimated counts per km^2 multiplied by the area (in km^2) associated with each count

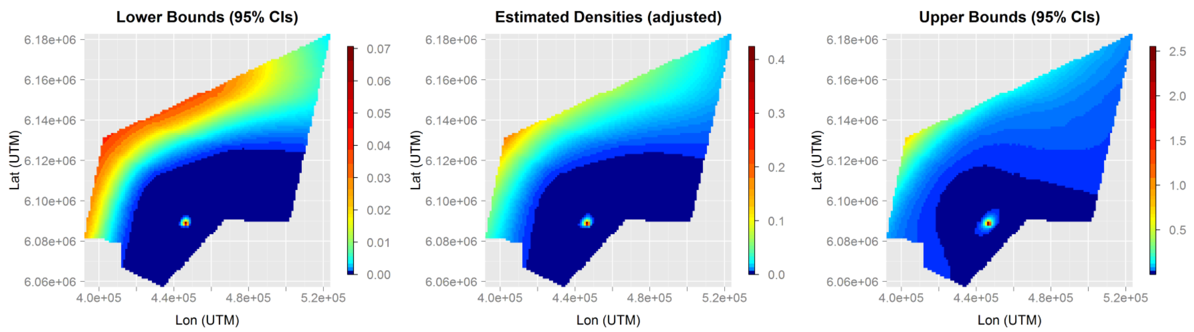

Figure 15: Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of White Beaked Dolphin (on a fine grid) per km^2 across the surveyed years, averaged in each grid cell after adjusting for availability.

[16] (a runs test returned a p-value<0.00001).

3.5 MINKE WHALE

The very low numbers of Minke Whales resulted in the selection of an extremely smooth spatial surface (Figure 16). Thus, while an average surface across the surveyed years is available (Figure 17) annual surfaces were not supported by the data. Based on the pooled data, there was significant positive spatio-temporal autocorrelation in model residuals[17] which was accounted by the GEE model.

Fitted surfaces suggest that the distribution of Minke Whales (averaging an estimated total of 120 animals, Table 1, page 26) is mainly concentrated in the south-eastern corner of the Dogger Bank area, with also an important region of assembly in the southern central part of the area (Figure 16 and Figure 17).

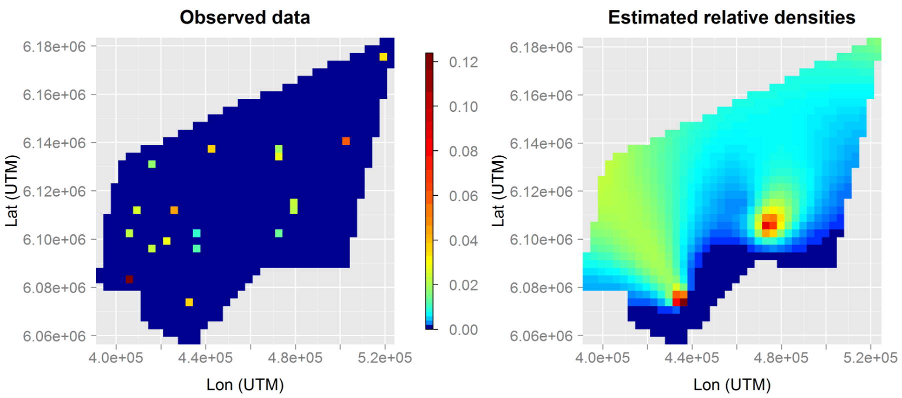

Figure 16: Observed counts of Minke Whale, averaged in each grid cell (left-hand plot) and estimates of relative abundance across years, averaged in each grid cell (right-hand plot). Plots are shown with the same level of resolution for comparison purposes. Note: the estimates referred to here are the estimated counts per km^2 multiplied by the area (in km^2) associated with each count.

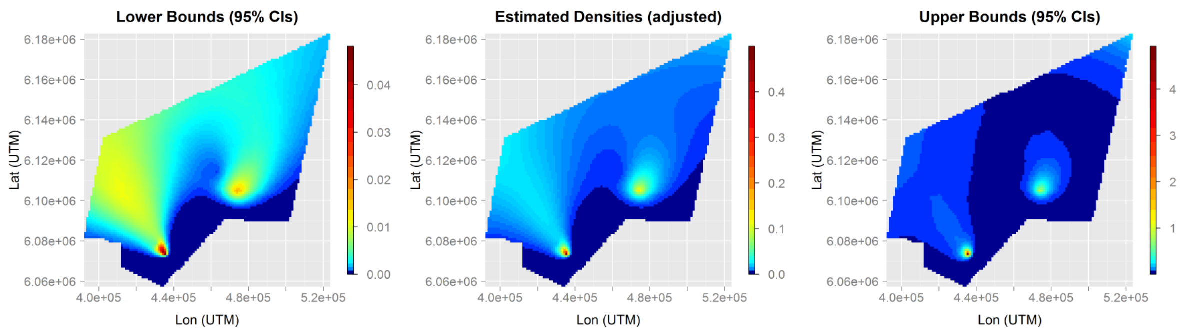

Figure 17: Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of Minke Whale (on a fine grid) per km^2 across the surveyed years, averaged in each grid cell after adjusting for availability.

[17] (a runs test returned p-value<0.00001).

3.6 GREY SEALS

Due to low numbers of Grey Seals, a very smooth spatial surface was selected in this case (Figure 18), however animal numbers were permitted to change annually via a factor-based variable for year (Figure 19). There was also statistically significant levels of spatio-temporal autocorrelation[18] present in model residuals, which was accounted for under the GEE model.

There was good agreement between the observed data and the fitted values based on the model (Figure 18) and variable levels of precision about the annual estimates (Figure 19). The results suggest that the distribution of Grey Seals tends to concentrate about two separated regions of the Dogger Bank, around the western limit and in a very condensed zone located towards the eastern side of the area (Figure 18 and Figure 19).

The abundance of Grey Seals appears to be successively higher in 2011 and 2012 compared with 2010 numbers but statistically indistinguishable from numbers estimated based on the survey carried out in May 2009 (Figure 20). The precision for the 2009 estimate is notably poor, due to the low amount of survey effort for that time period.

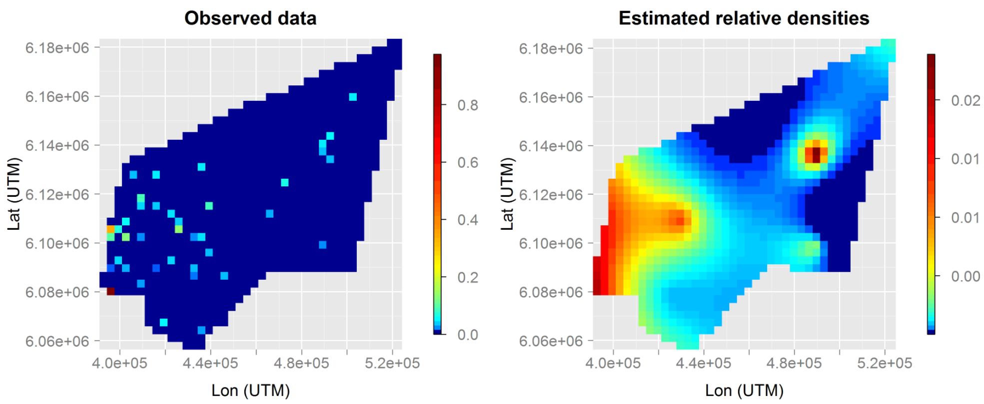

Figure 18: : Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of Grey Seals (on a fine grid) per km^2 in each year, averaged in each grid cell after adjusting for availability.

[18] (a runs test returned a p-value<0.00001).

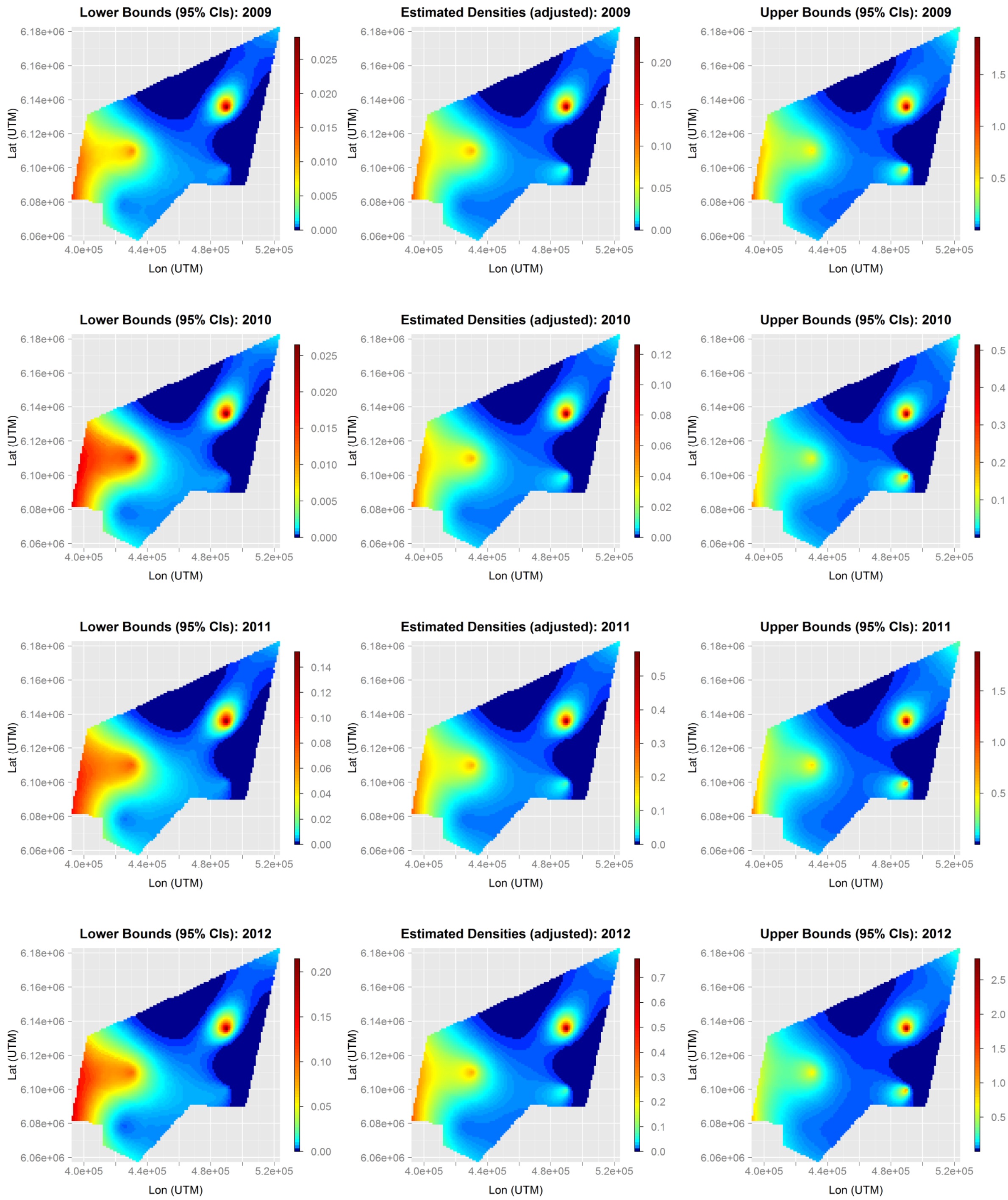

Figure 19: Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals, of Grey Seals (on a fine grid) per km^2 in each year, averaged in each grid cell after adjusting for availability.

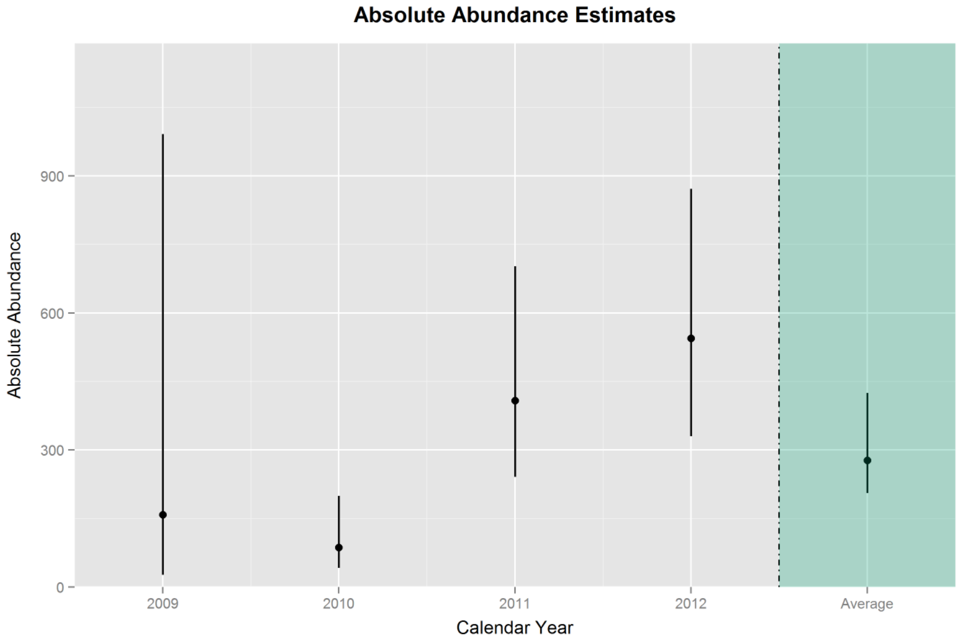

Figure 20: Estimates of annual absolute abundance and absolute abundance averaged across years (green-shaded area of plot), together with associated 95% confidence intervals, of Grey Seals, after adjusting for availability.

3.7 AVERAGE ESTIMATES

The tables in this section contain estimates of relative/absolute abundance and unadjusted/adjusted density based on summing predictions across the grid cells in the survey area, based on a model fitted to data pooled across years. The availability corrections used to make the adjustment are contained in the tables.

Table 1: Estimated relative abundance and absolute abundances for the focal species in the survey area, using the availability measures shown.

	Relative abundance			Availability	Absolute abundance		
Species	Estimate	Lower CI	Upper CI		Estimate	Lower CI	Upper CI
Grey seal	27.76	20.54	42.50	0.1	278	205	425
Harbour porpoise	3627.26	3270.44	4040.60	0.434	8358	7536	9310
Harbour porpoise and potential harbour porpoise	4055.39	2960.91	5511.67	0.434	9344	6822	12700
Minke whales	9.93	6.88	19.10	0.0882	113	0	312
Potential harbour porpoise	433.67	419.20	481.03	0.434	999	966	1108
White-beaked dolphin	68.26	45.65	129.14	0.352	194	130	367

Table 2: Estimated average density (per square km) in the survey area both raw and adjusted for availability.

	Overall density unadj.			Availability	Overall density adjusted		
Species	Estimate	Lower CI	Upper CI		Estimate	Lower CI	Upper CI
Grey seal	0.002128	0.001574	0.003257	0.1	0.021306	0.015711	0.032572
Harbour porpoise	0.277994	0.250647	0.309672	0.434	0.640558	0.57756	0.713519
Harbour porpoise and potential harbour porpoise	0.310805	0.226924	0.422415	0.434	0.716125	0.522839	0.973329
Minke whales	0.000761	0.000527	0.001464	0.0882	0.00866	0	0.023912
Potential harbour porpoise	0.033237	0.032128	0.036866	0.434	0.076563	0.074034	0.084917
White-beaked dolphin	0.005231	0.003499	0.009897	0.352	0.014868	0.009963	0.028127