LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 6: Appendix 22A – Marine Ornithology Baseline

August 2024

Prepared by: Llŷr Floating Wind Ltd

FLOVENTIS ENERGY

Document Status

Version	Authored by	Reviewed by	Approved by	Date
FINAL	HiDef Aerial Surveying Ltd	HiDef Aerial Surveying Ltd	AECOM	August 2024

Approval for Issue

Prepared by	HiDef Aerial Surveying Ltd
Prepared for	Llŷr Floating Wind Limited
Approved by	Jay Hilton-Miller

Acronyms and abbreviations

Acronym or abbreviation	Definition	Acronym or abbreviation	Definition
%	Percentage	Llŷr	Llŷr Floating Offshore Wind Project
ASL	Above Sea Level	m	Metre
BDMPS	Biologically Defined Minimum Population Scales	MSP	Mean Seasonal Peak
CI	Confidence or Credible Interval	n	Number
CL	Confidence or Credible Limit	NRW	Natural Resources Wales
cm	Centimetre	NRW (A)	Natural Resources Wales Advisory
CRM	Collision Risk Modelling	PVA	Population Viability Analysis
CV	Coefficient of Variation	QA	Quality Assurance
DAS	Digital Aerial Survey	RIAA	Report to Inform Appropriate Assessment
EIA	Environmental Impact Assessment	S01	Survey one
ES	Environmental Statement	S02	Survey two
HiDef	HiDef Aerial Surveying Ltd	SD	Standard Deviation
HRA	Habitats Regulation Assessment	SPA	Special Protection Area
JNCC	Joint Nature Conservation Committee	SSSP	Skomer, Skokholm and the Seas off Pembrokeshire
km	Kilometre	UCL	Upper Confidence/Credible Limit
km^2	Square kilometre	UK	United Kingdom
LCL	Lower Confidence/Credible Limit	WTG	Wind Turbine Generator

Glossary of project terms

Term	Definition
The Applicant	The developer of the Project, Llŷr Floating Wind Limited.
Array	All wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the Array Area, as defined, when considered collectively, excluding the offshore export cable(s).
Array Area	The area within which the wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure will be located
Floventis Energy	A joint venture company between Cierco Ltd and SBM Offshore Ltd of which Llŷr Floating Wind Ltd is a wholly owned subsidiary.
Landfall	The location where the offshore export cable(s) from the Array Area, as defined, are brought onshore and connected to the onshore export cables (as defined) via the transition joint bays (TJB).
Llŷr 1	The proposed Project, for which the Applicant is applying for Section 36 and Marine Licence consents. Including all offshore and onshore infrastructure and activities, and all project phases.
Marine Licence	A licence required under the Marine and Coastal Access Act 2009 for marine works which is administered by Natural Resources Wales (NRW) Marine Licensing Team (MLT) on behalf of the Welsh Ministers.

Term	Definition
Offshore Development Area	The footprint of the offshore infrastructure and associated temporary works, comprised of the Array Area and the Offshore Export Cable Corridor, as defined, that forms the offshore boundary for the S36 Consent and Marine Licence application
Offshore Export Cable	The cable(s) that transmit electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OfECC)	The area within which the offshore export cable circuit(s) will be located, from the Array Area to the Landfall.
Onshore Development Area	The footprint of the onshore infrastructure and associated temporary works, comprised of the Onshore Export Cable Corridor and the Onshore Substation, as defined, and including new access routes and visibility splays, that forms the onshore boundary for the planning application.
Onshore Export Cable(s)	The cable(s) that transmit electricity from the landfall to the onshore substation
Onshore Export Cable Corridor (OnECC)	The area within which the onshore export cable circuit(s) will be located.
proposed Project	All aspects of the Llŷr 1 development (i.e. the onshore and offshore components).
Onshore Substation	Located within the Onshore Development Area, converts high voltage generated electricity into low voltage electricity that can be used for the grid and domestic consumption.
Section 36 consent	Consent to construct and operate an offshore generating station, under Section 36 (S.36) of the Electricity Act 1989. This includes deemed planning permission for onshore works.
Density estimate (n/km^2 or $birds/km^2$)	The average number of birds per square km surveyed over a defined area.
Population estimate (number)	The mean number of birds estimated within the defined area.
95% Confidence/Credible Interval (CI)	A measure of uncertainty in the mean value. If the analysis was repeated, 95% of the time the mean population estimate would fall within this range. The smaller the CI range the more confident we can be that the mean estimate is an accurate reflection of the true population size.
Confidence Limit (CL)	The upper and lower values that define the range of the 95% confidence interval.
Standard Deviation (SD)	The amount of variation or dispersion of a set of values. A low SD indicates that the bootstrap values tend to be close to the mean of the set.
Coefficient of Variation (CV) (%)	A standard measure that describes the dispersion of data points around the mean. The lower the CV the more precise the estimate. It is calculated as the SD / mean.
Relative abundance	This is the estimated population size based on animals recorded on or above the sea surface and does not account for any that may be diving and thus submerged at the time of survey.
Absolute abundance	The estimated population size including an estimate of the number of submerged birds at the time of survey.

Contents

List of Figures

List of Tables

22-A APPENDIX 22A: MARINE ORNITHOLOGY BASELINE

22.1 Introduction

1. This **Appendix 22A: Marine Ornithology Baseline** characterises the Llŷr 1 Floating Offshore Wind Farm (hereafter referred to as the proposed Project) in relation to marine ornithological receptors, presenting the seabird density and site population estimates taken forward for assessment in **Chapter 22: Marine Ornithology** and **Appendix 8E: Habitats Regulations Assessment (HRA) Report to Inform Appropriate Assessment (RIAA)**, including their supporting appendices[1].

2. **Chapter 22: Marine Ornithology** includes a summary of the statutory advice and pre-application dialogue carried out with Natural Resources Wales Advisory (NRW (A)) and the Joint Nature Conservation Committee (JNCC) as well as the wider stakeholder liaison (including the Royal Society for the Protection of Birds and the Wildlife Trusts) (**Table 22-4**, scoping and **Table 22-5**, pre-application consultation in **Chapter 22: Marine Ornithology**).

3. Digital video aerial surveys (DAS) were undertaken by HiDef Aerial Surveying Ltd (hereafter 'HiDef') between March 2020 and March 2022, providing 24 months, or two years, of survey data[2]. Surveys covered the full Llŷr marine ornithology survey area, containing the focal area – the Array Area within it – in which the wind turbines are proposed (**Figure 22A-1**).

4. **Table 22-1** sets out the species which have been scoped into assessments. This is primarily based on the abundance of each species observed during the DAS, as well as the conservation status of each species and their known utilisation of the area for foraging, reproducing and commuting. A total of seven species are assessed in this application for collision and / or displacement impact, with European storm-petrel and Balearic shearwater also included for qualitative assessment, and design-based estimates presented for great black-backed gull and herring gull at the request of NRW (A) (**Chapter 22: Table 22-5**, pre-application consultation).

5. The density and abundance estimates presented in this **Appendix 22A: Marine Ornithology Baseline** are derived from model-based survey data analysis methods (in this case '*Inlabru*') as discussed in more detail in **Section 22.2.2** below, and in supporting **Annex B – Technical Notes on Survey Design and Data Analysis** (particularly **Technical Paper 1a: Design and Model-Based Analysis Methods** as detailed and signposted below).

6. The supporting Annexes to this **Appendix 22A: Marine Ornithology Baseline** are as follows:

    - **Annex A – All Seabird Observations at Llŷr.**

      Annex A, Table 22-A1 to **Annex A**, Table 22-A8 in this Annex provide all the raw observations of birds recorded in the full Llŷr marine ornithology survey area during the two years of DAS. The tables include those birds identified to species level, as well as 'non-ID' birds recorded to species group (see **Section 2.2** on **Methods** for further explanation).

1. [1] Impact modelling is presented in Appendix 22C relating to Marine Ornithology Collision Risk Modelling and in Appendix 22D relating to Marine Ornithology Displacement Assessment and then Appendix F presenting the Marine Ornithology Population Modelling.

[2] These surveys have also been used to inform the marine mammals' assessment; **Chapter 21: Marine Mammals** and **Technical Appendix 21A: Marine Mammal Baseline**.

- **Annex B – Technical Papers on Survey Design and Data Analysis**

  As requested during pre-application consultation (**Chapter 22, Table 22-5**), HiDef has produced a series of technical papers on survey design and data analysis which are collated in this Annex as follows:

  Technical Paper 1a: Design and Model-Based Analysis Methods

  This paper sets out the reasons for selecting a model-based method for survey data analysis, and why *Inlabru* was chosen in this regard. It also provides an explanation of the *Inlabru* modelling method. The paper was requested by NRW (A) at the first marine ornithology (and mammals) pre-application meeting held on 8 February 2023, with the paper issued to them on 16 March 2023, forwarded to JNCC on 18 May 2023 and then discussed together at the meeting held on 24 May 2023 (including a presentation on *Inlabru* provided by HiDef and DMP Stats).

  Technical Paper 1b: Marine Ornithology – Comparison of Model (Inlabru) and Design-Based Estimates

  This paper presents model (*Inlabru*) and design-based estimates for the seven seabird species addressed in quantitative assessment (as noted in **Table 22A-1** below). It was requested by NRW (A) and JNCC at the meeting of 24 May 2023 (discussing *Inlabru*) and issued to them on 14 June 2023. (Note that some of these comparison estimates relate to the original Llŷr 1 proposed Array Area which has since been revised.)

  Technical Paper 1c: Marine Mammals – Comparison of Model (Inlabru) and Design-Based Estimates from Digital Aerial Survey Work and Advice on Density Estimates to Use in Noise Assessment

  This paper (also issued on 14 June 2023) was part of NRW (A) and JNCC's request made at the meeting of 24 May 2023. It includes model (*Inlabru*) and design-based estimates for harbour porpoise (*Phocoena phocoena*) and common dolphin (*Delphinus delphis*). (The key estimates are for the full survey area; as above, the ones produced for the Array Area + 4 km buffer relate to the original Llŷr 1 proposal which has since been revised.)

  Technical Paper 2: Survey Coverage Comparison (12.5% and 25%)

  This paper (issued 18 March 2024) was requested by NRW (A) and JNCC at the meeting held on 16 August 2023 and provides a comparison of density estimates (with associated precision) derived from digital aerial survey data at 12.5% (two cameras) and 25% (four cameras) survey coverage.

  Technical Paper 3: Accounting for Uncertainty in Monthly Seabird Density Estimates and Mean Seasonal Peaks

  This paper (issued 18 March 2024) was requested at the Teams call of 16 November 2023 and deals with the treatment of uncertainty in marine ornithological impact modelling (collision risk and displacement) addressing matters raised by NRW (A) and JNCC during pre-application discussion and set out in detail in their advice note of 8 December 2023.

- **Annex C – Additional Model-Based Maps**

  This Annex presents the additional model-based density estimate maps (lower and upper 95% credible limits and coefficient of variation (CV)) for the seven key seabird

species taken forward for quantitative assessment in **Chapter 22: Marine Ornithology**.

- **Annex D – Design-Based Estimates**

  For information and context, this Annex presents design-based density and abundance estimates[3] for all species in **Table 22A-1** recorded during the monthly DAS surveys (i.e., all listed species apart from Balearic shearwater). This Annex also presents design-based density and abundance estimates for the 'Infrequently Recorded Species Screened out of Further Assessment'; these are calculated for the full survey area only (as observations of these species are so sparse).

Table 22A-1. Summary of the key seabird species scoped into assessment and addressed in this baseline characterisation (which provides the required information for impact modelling)

Species	Latin name	Collision risk	Displacement
Black-legged kittiwake (hereafter 'kittiwake')	*Rissa tridactyla*	✓	*
Great black-backed gull	*Larus marinus*	^	-
Herring gull	*Larus argentatus*	^	-
Lesser black-backed gull	*Larus fuscus*	✓	-
Common guillemot (hereafter 'guillemot')	*Uria aalge*	-	✓
Razorbill	*Alca torda*	-	✓
Atlantic puffin (hereafter 'puffin')	*Fratercula arctica*	-	✓
Manx shearwater	*Puffinus puffinus*	-	✓
Northern gannet (hereafter 'gannet')	*Morus bassanus*	✓	✓
European storm petrel (hereafter 'storm petrel')	*Hydrobates pelagicus*	-	Assessed qualitatively
Balearic shearwater	*Puffinus mauretanicus*	-	Assessed qualitatively

Included at the request of JNCC for information so that displacement mortality estimates can be referenced in future, if needed. See **Appendix 22D: Marine Ornithology Displacement Assessment*

*^Included at the request of NRW (A) for information so that collision mortality estimates can be referenced in future, if needed. See **Appendix 22C: Marine Ornithology Collision Risk Modelling**.*

[3] All design-based estimates include 'non-ID' birds and are corrected for availability bias.

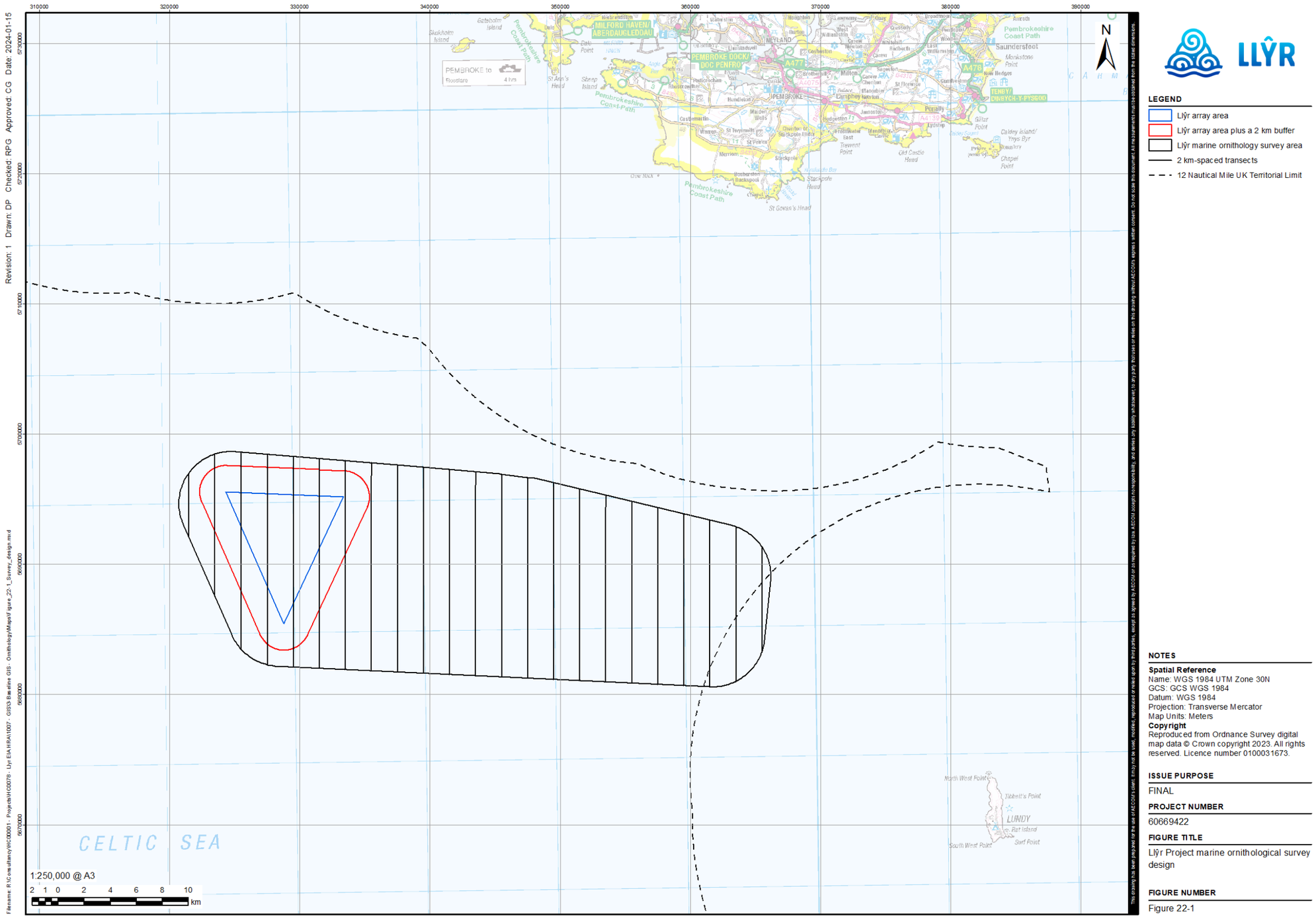


Figure 22A-1. Project marine ornithological survey design

22.2 Methodology

22.2.1. Digital Aerial Surveys (DAS)

7. In February 2020, Llŷr Floating Wind Limited commissioned HiDef to undertake a programme of high-resolution DAS focusing on marine ornithological (seabird) interests as well as marine mammals and other marine megafauna.

8. HiDef designed the survey methodology to provide information suitable for the proposed Project for which baseline characterisation and an associated assessment of abundance and distribution of seabirds and marine mammals is required to inform the Environmental Impact Assessment (EIA) and HRA.

Survey Flights

9. A series of 23 strip transects placed at 2 km intervals were flown monthly between March 2020 and March 2022. Survey coverage for the Llŷr marine ornithology survey area (640.92 km^2) and Array Area (44.90 km^2) are presented in **Table 22A-2**. The survey design aimed to achieve 12.5% coverage of the overall site. The recommended minimum coverage for site characterisation surveys of birds and marine mammals for the purposes of EIA/HRA is 10%.

10. This minimum threshold is currently industry standard (e.g. during the Hornsea Three inspection, the Inspector favoured 10% coverage as being sufficient) and is the minimum target set out in NRW survey guidance (2022) (as per Webb and Nehls, 2019). Aiming for a percentage coverage slightly higher than this minimum ensured that this target was achieved in all surveys (**Table 22A-2**), accounting for any minor variations in survey effort due to weather conditions, etc. See **Appendix 22A: Annex B – Technical Papers on Survey Design and Data Analysis** for further detail on site survey coverage, including the work requested by NRW (A) to compare the two camera data for an example month with that obtained from four cameras in order to see whether it results in any significant change to the precision of density and abundance estimates.

11. Four surveys were flown outside of their intended month, due to no available weather windows. Rescheduled surveys were conducted in as close a time frame as possible, except for March 2021 when this could not be achieved. Therefore, two surveys were flown in June 2020 (survey one (S01) on 08 June 2020, and survey two (S02) on 24 June 2020); in January 2021 (S01 on 10 January 2021 and S02 on 25 January 2021); in May 2021 (S01 on 14 May 2021 and S02 on 27 May 2021) and an additional survey was flown in March 2022 (**Table 22A-2**). For data analysis purposes, each rescheduled survey was used to represent a missed month as described in **Table 22A-3** and agreed with NRW (A) at the meeting held on 08 February 2023 (discussing the survey summary paper issued 20 January 2023; **Chapter 22, Table 22-5**).

12. In June S01 2020, two transects were cut shorter in the west of the Llŷr marine ornithology survey area due to a camera fault, resulting in slightly reduced coverage. In January 2022, two transects were missed in the east of the Array Area due to a camera fault, resulting in slightly reduced coverage (**Figure 22A-2** and **Table 22A-2**).

13. Transects extended roughly north to south, perpendicular to the depth contours along the coast. Such a design ensured that each transect sampled a similar range of habitats (primarily relating to water depth), aiming to reduce the variation in bird and mammal abundance estimates between transects.

14. Surveys were flown using an aircraft equipped with four HiDef Gen II digital video cameras with sensors set to a resolution of 2 cm ground sample distance. Each camera sampled a strip

of 125 m width, separated from the next camera by ~25 m, thus providing a combined sampled width of 500 m within a 575 m overall strip. Data captured from two cameras out of the four cameras were reviewed and used in data analysis.

15. The surveys were flown along the transect pattern shown in **Figure 22A-1** at a height of approximately 550 m (1,800') above sea level (ASL). Flying at this height ensured that there was no risk of flushing species that are easily disturbed by aircraft noise. Thaxter *et al.* (2016) recommends a minimum flight altitude of 460 – 500 m ASL.

16. Position data for the aircraft were captured from a Garmin GPSMap 296 receiver with differential GPS facilitated 1 m accuracy for the positions and recording updates in location at one second intervals for later matching to bird observations.

Data Review and Object Identification

17. Data were viewed by trained reviewers who marked any objects in the footage as requiring further analysis, as well as determining which were birds, marine megafauna or anthropogenic objects such as ships or buoys.

18. As part of HiDef's quality assurance (QA) process, an additional 'blind' review of 20% of the raw data was performed and the results compared with those of the original review. If 90% agreement was not attained during the QA process, then corrective action was initiated: the remaining data set was reviewed and where appropriate, the failed reviewer's data discarded and all data re-reviewed. If required, additional training was given to improve performance.

19. Objects were only recorded where they reached a reference line (known as 'the red line') which defined the true transect width of 125 m for each camera. By excluding objects that did not cross the red line, biases to abundance estimates caused by flux (movement of objects in the video footage relative to the aircraft, such as where the survey craft is buffeted by airflow) were eliminated.

Object Identification

20. Images marked as requiring further analysis were reviewed by the ID Team; ornithologists[4] and marine mammal specialists[5] for identification to the lowest taxonomic level possible and for assessment of the approximate age and the sex of each animal, as well as any behaviour traits visible from the imagery.

21. At least 20% of all objects were selected at random and subjected to a separate 'blind' QA process. If less than 90% agreement was attained for any individual camera, then corrective action was initiated: if appropriate, the failed identifier's data were discarded, and the data re-identified. Any disputed identifications were passed to a third-party expert ornithologist/marine mammal specialist for a final decision. The level of agreement within the QA process is calculated as the final number of agreements as a percentage of all identifications subjected for QA for the entire survey.

[4] HiDef currently employs three current and former members of the British Birds Rarities Committee ('BBRC') as expert ornithologists.

[5] HiDef staff have long-standing experience in marine mammal identification, regularly undertaking boat surveys as part of ESAS (European Seabirds At Sea Partnership), SCANS and other programmes. They process thousands of cetacean images, hold regular internal training sessions and have access to marine specialists within our wider company BioConsult SH.

22. All objects were assigned to a species group and where possible, each of these then further identified to species level. The species identifications were given a confidence rating of 'possible', 'probable' or 'definite'[6].

23. It is important to note that confidence ratings are not standardised. The likelihood of achieving a definite or probable identification is not consistent for all component members of a species group. For example, someone undertaking identification of a large auk will find it easier to be confident of guillemot identification than razorbill. Confidence scores should not be used to filter or weight the probability of 'large auk' being one species or another in any analysis, as this will lead to biased results, particularly if the identification rate is low.

24. Any animals that could not be identified to species level were assigned to a category 'No ID' and only identified to group level. If, on occasion, the unidentified bird is suspected of belonging to two possible genera, then a broader group category may be used. For example, a bird would usually be assigned to the group category 'Shearwater species' if identified as a Manx shearwater, or to 'Large Auk species' if identified as a guillemot. However, if the bird has the potential to be either, then it would be assigned to a wider group category 'Shearwater / Auk species' and the species level recorded as 'No ID'.

25. In the case of birds, additional information was recorded on basic behaviour (i.e., whether the bird was sitting; loafing on land or other objects; flying; diving or taking off). Detail was recorded where possible on foraging behaviour, approximate age, sex and any other details of interest. Aging of birds was based on moults and was conducted where possible on species which show seasonal variation in plumage.

[6] Definite: as certain as reasonably possible. Probable: very likely to be this species or species group. Possible: more likely to be this species or species group than anything else.

Table 22A-2. Survey coverage of the Llŷr marine ornithology survey area and the Array Area over the two-year survey period

Survey date	Llŷr marine ornithology survey area				Array Area			
	Number of transects analysed	Total length of transects analysed (km)	Area covered (km²)	Area covered (%)	Number of transects analysed	Total length of transects analysed (km)	Area covered (km²)	Area covered (%)
25-Mar-20	23	322.87	80.72	12.60	4	22.10	5.52	12.30
14-Apr-20	23	321.84	80.46	12.56	4	22.05	5.51	12.28
08-Jun-20*	23	310.78	77.70	12.13	4	19.70	4.93	10.97
24-Jun-20	23	321.45	80.36	12.54	4	22.23	5.56	12.38
21-Jul-20	23	322.2	80.55	12.57	4	22.09	5.52	12.30
31-Aug-20	23	321.22	80.30	12.53	4	22.55	5.64	12.56
12-Sep-20	23	319.99	80.00	12.49	4	22.16	5.54	12.34
22-Oct-20	23	321.69	80.42	12.55	4	21.79	5.45	12.13
26-Nov-20	23	320.6	80.15	12.51	4	22.14	5.54	12.33
10-Jan-21	23	322.02	80.50	12.57	4	22.28	5.57	12.41
25-Jan-21	23	321.09	80.27	12.53	4	22.12	5.53	12.32
22-Feb-21	23	319.11	79.78	12.45	4	22.24	5.56	12.38
14-May-21	23	320.22	80.06	12.50	4	22.03	5.51	12.27
27-May-21	23	321.45	80.36	12.54	4	22.10	5.52	12.31
15-Jun-21	23	322.12	80.53	12.57	4	22.06	5.52	12.29
14-Jul-21	23	322.55	80.64	12.59	4	22.14	5.53	12.33
16-Aug-21	23	322.55	80.64	12.59	4	22.12	5.53	12.32
01-Sep-21	23	319.09	79.77	12.45	4	21.90	5.47	12.19
22-Oct-21	23	321.4	80.35	12.54	4	22.01	5.50	12.26
20-Nov-21	23	318.79	79.70	12.44	4	22.20	5.55	12.36
16-Dec-21	23	319.8	79.95	12.48	4	22.09	5.52	12.30
05-Jan-22*	21	290.55	72.64	11.34	3	18.07	4.52	10.06
26-Feb-22	23	317.53	79.39	12.39	4	22.21	5.55	12.37
20-Mar-22	23	321.74	80.43	12.55	4	22.09	5.52	12.30

**Reduced coverage due to technical issue*

Table 22A-3. Treatment of rescheduled surveys for data analysis

Survey name	Date flown	Used to represent	Date used in analysis
June S01 2020	08 June 2020	May 2020	08 May 2020
January S01 2021	10 January 2021	December 2020	10 December 2020
May S01 2021	14 May 2021	April 2021	14 April 2021
March 2022	20 March 2022	March 2021	20 March 2021

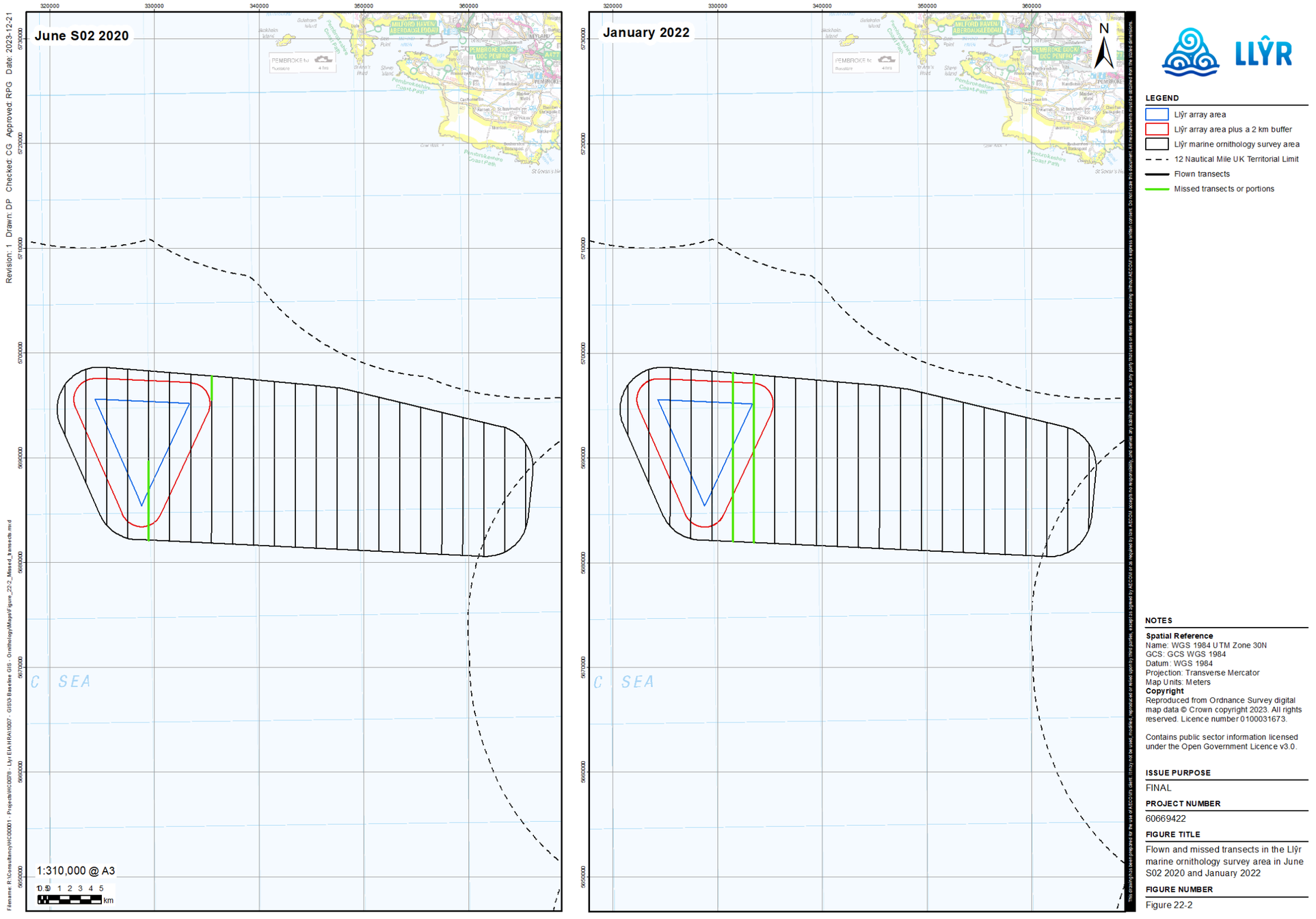


Figure 22A-2. Flown and missed portions or transects in the Llŷr marine ornithology survey area in June S02 2020 and January 2022

22.2.2. Data Analysis

26. The density and abundance estimates presented in this **Appendix 22A: Marine Ornithology Baseline** are derived from a model-based approach and taken forward for impact modelling (collision risk and displacement) and overall assessment as presented in **Chapter 22: Marine Ornithology** and **Appendix 8E: HRA RIAA** (and the supporting appendices for each).

27. The '*Inlabru*' R statistical package (Bachl *et al.*, 2019) was chosen for the survey data analysis in preference to MRSea (Scott-Hayward *et al.*, 2013) for the reasons given in **Appendix 22A: Annex B – Technical Paper 1a: Design and Model-Based Analysis Methods**.

28. In principle, '*Inlabru*' deals better with small sample sizes (low numbers of observations of seabirds and marine mammals) as is the case for a number of species recorded during surveys for the proposed Project. A summary of the '*Inlabru*' method and how it has been applied in the survey data analysis is provided in this section, with further supporting detail given in **Appendix 22A: Annex B – Technical Paper 1a: Design and Model-Based Analysis Methods**.

Apportioning of Unidentified Birds

29. Apportioning of 'unidentified' birds to species level was undertaken on all data for the purposes of calculating density and population estimates. The number of unidentified birds in each species group were assigned to species where appropriate, based on their respective abundance ratios. For example, if identified guillemots and razorbills occurred in a 4:1 ratio, then 80% of unidentified birds would be assigned to guillemot and 20% assigned to razorbill. Apportioning of unidentified birds was undertaken prior to calculation of design-based and model-based estimates. All estimates presented in this **Appendix 22A: Marine Ornithology Baseline** are those which include unidentified birds.

Model-based Population Estimates

30. Model-based abundance estimations were performed using spatial analysis in the '*Inlabru*' R statistical package (Bachl *et al.*, 2019) to overcome the problems of missing transects and smaller sample sizes within the Array Area.

31. The *Inlabru* package was developed to provide ecologists with easier access to modelling with spatial point processes (data localised in space or time), spatial counts, gridded and georeferenced data (Bachl *et al.,* 2019). It utilises Bayesian inference, which relies on previous knowledge to inform the models, as well as the data.

32. *Inlabru* allows users to model species distribution and estimate density and abundance with a variety of data types, such as complete spatial maps of the locations of individuals or groups, counts in plots, or points. (Buckland *et al*., 1993; Bachl *et al.,* 2019). A benefit of *Inlabru* is that it allows non-specialist users to apply Bayesian methods without needing to understand the complex statistical background behind it (Bachl *et al.,* 2019).

33. Bayesian inference is becoming more frequently used in ecology due to its ability to account for hierarchical structure, as well as uncertainties around observations and processes inherent in ecological systems (Ellison, 2004; Banner *et al.,* 2020). It is most used for estimating species richness and abundance from geographically or logistically constrained samples, or in response to expected environmental changes (Ellison, 2004).

34. Bayesian approaches differ from frequentist methods in several ways. Frequentist statistics, often considered most traditional, is defined as a type of statistical inference that draws conclusions from data by focusing on the frequency or proportion of findings in the data (Reflective Data, 2019). Unlike Bayesian statistics, it does not take into account knowledge from previous. The main difference between frequentist and Bayesian statistics is that

parameters are treated as random variables in Bayesian inference instead of fixed, "true" quantities as in frequentist methods (Ellison, 2004).

35. The use of random variables as parameters requires careful consideration to ensure that the specification of probability distributions reflect previous “a priori” knowledge about parameter uncertainty and existing data (Banner *et al.,* 2020). A prior distribution is the probability that would express the user’s beliefs about this quantity before evidence is examined. The ability to specify prior distributions and determine model parameters from current knowledge is another benefit of Bayesian methods, as the data can be combined with knowledge of previous results and findings, rather than just relying on the data itself.

36. *Inlabru* can be used to obtain abundance estimates and the mean, median, standard deviation (SD), and quantiles of these estimates. It uses a prediction method based on fast Monte Carlo sampling, a class of techniques for repeated random sampling to obtain numerical results. This method allows posterior prediction of general expressions of the latent variables (i.e., variables that cannot be measured directly).

37. This produces a posterior distribution, which is defined as the revised or updated probability of an event occurring after considering new information (Bachl *et al.,* 2018; Hayes, 2021). This compares to MRSea’s model outputs, which are used in the bootstrapping (random sampling) function from which the mean, median, SD, and quantiles are calculated. Model-fitting in *Inlabru* is generally computationally efficient, and the time taken has been found to be around three times quicker than MRSea (Keogan *et al.,* 2022).

38. The seabird species analysed for the proposed Project using *Inlabru* were:

- kittiwake;
- lesser black-backed gull;
- guillemot;
- razorbill;
- puffin;
- Manx shearwater; and
- gannet.

39. Models were fitted to the data within the Llŷr marine ornithology survey area to predict density throughout the full area, as well as the smaller Array Area with and without its 2 km buffer from the same models. Model-based density and abundance estimates have been used for impact assessment over the design-based estimates (which are presented for context only). This is because the aerial surveys were carried out over a much larger survey area than the resulting area being proposed for development. It is more robust to use such model-based estimates informed by the larger dataset, because it is not statistically sound to subset transects from a survey designed for a large area and apply design based methods to the very limited number of transects within the much smaller Array Area.

40. For all seabirds, a Poisson model was fitted to an individual data set for each survey. A Poisson model is defined as a discrete probability distribution (Johnson *et al.,* 1993) that indicates the probability of a number of events occurring within a fixed interval such as periods of time, distance or area (Dreassi, 2014). Each data set contained observation counts for each bird species across the whole Llŷr marine ornithology survey area. The counts were made over the transects, where each transect was split into segments of length 500 m and the counts of animals of each species were assigned to the mid-point of each segment.

41. Model outputs included density surfaces and abundance estimates for each individual survey, which were used for the calculation of mean seasonal peaks (MSPs) as required for the assessment of displacement. To make abundance predictions for the smaller Array Area with and without its 2 km buffer, the models fitted to the overall Llŷr marine ornithology survey area were used to predict abundance estimates for this site, where these abundance values were estimated by using the existing values in the data set. This was especially effective when predicting months where transects were missed from the Array Area, resulting in lower survey effort (see discussion in **Section 22.2.1** and footnotes to **Table 22A-2**).

42. Environmental covariates including bathymetry, slope, sea surface temperature, and seabed sediment were applied to the data sets by assigning the covariate values to the mid-point of each segment in the transects, as with the observation counts. These covariates were tested in the initial models but were not included in the final analysis. This was because the effects of the covariates on the models were small enough that there was no significant difference between the models with and without these covariates.

43. Availability bias corrections were applied to the outputs for the auk species (guillemot, puffin, razorbill) after models were fitted (see the relevant section on **Availability Bias** below).

Design-Based Population Estimates

44. The abundance of each species observed was also estimated separately using design-based strip transect analysis. A non-parametric block bootstrap method was used, with transect ID being the sampling unit, assuming that each transect represents an independent sampling unit (Buckland *et al.,* 2001).

45. For each iteration of the bootstrap transects were randomly sampled, with replacement, until their total length equalled approximately the same length as the total survey length (to ensure equal survey effort across each bootstrap iteration). For each of those sampled transects point estimates of animal densities were calculated by taking the animal counts within transects and dividing by transect area. The mean animal densities were then calculated from across the sampled transect point estimates, using the proportion of overall survey area that each transect covers as a weighting factor.

46. A total of 1,000 bootstrap iterations were performed from which the mean and SD of the sampled means were calculated, as well as the upper and lower Confidence Limits (CLs) and the relative standard error as defined by the SD divided by the mean (or the Coefficient of Variation; CV). Data were processed in the R programming language (version 4.2.1) (R Core team, 2022). Estimates were also extracted for sub-areas, such as the Array Area with and without a 2 km buffer.

47. The density estimate is expressed as the average number of birds per square km surveyed over the area of interest, and the population estimate is then calculated as the average density multiplied by the area of interest (e.g., the Array Area). The SD is a measure of the variance of the population estimate, standardised by the number of samples (transects). The upper and lower CLs define the range that the population estimate falls within 95% certainty. The CV is a measure of the precision of the population and density estimates.

48. Design-based estimates were then corrected for availability bias for auk species (guillemot, razorbill, and puffin, see below). As set out above, design-based estimates for the assessed species are presented for context in **Appendix 22A: Annex D – Design-Based Estimates** (which also addresses great black-backed gull, herring gull and storm petrel as requested by NRW (A) and JNCC).

Availability Bias

49. In wildlife surveys, a proportion of seabirds or marine mammals that spend any time underwater, especially while feeding, will not be detectable at the surface. This 'availability bias' leads to an under-estimate of their abundance during surveys. For species that make long dives underwater (e.g., guillemot), this bias might be significant. Within the proposed Project, availability bias was corrected for auk species (guillemot, razorbill and puffin).

50. Development of availability bias calculations are under consideration for other key diving species in offshore wind assessments (e.g., Manx shearwater and gannet), however, this work is not yet far enough developed to be able to apply any corrections for these species.

51. There are two main approaches to account for availability bias: by using double platform surveys (e.g., Borchers *et al.,* 2002) which can be logistically difficult to achieve and relatively expensive; and by using known data on time spent underwater to apply correction factors to abundance estimates (e.g., Barlow *et al.,* 1988).

52. Following Barlow *et al.* (1988) the probability that an animal is available at the surface is calculated as:

$$\Pr(being\ visible) = \frac{(s+t)}{(s+d)}$$

53. Where *s* is the average time spent at the surface, *t* is the window of time that the animal is within view and *d* is the average time below the surface. In the case of DAS, the value of *t* is negligibly small and is treated as 0.

54. Using Barlow's method (1988), the proportion of time that an animal was available at the surface was calculated (Pr(visible)) for guillemot and razorbill. Absolute density, corrected for availability, was then obtained by dividing the density of birds observed by Pr(visible).

55. For guillemots and razorbills, data obtained during the breeding season using data loggers were used to estimate availability bias. Thaxter *et al.* (2010) presents mean times for these species engaged in flying, feeding and underwater per trip during the chick-rearing period.

56. Thus, the proportion of time that guillemots and razorbills are available at the surface (Pr(visible)) was estimated at 0.7595 and 0.8182, respectively.

57. For puffins, the results from a study using data loggers reported in Spencer (2012) were used. The results show that puffins spend 14.16% of daylight time underwater. This infers that the proportion of time that puffins were available at the surface (Pr(visible)) was 0.8584.

58. The estimates of Pr(visible) for guillemots, razorbills and puffins were used to correct relative abundance estimates of birds sitting on the sea. These corrected abundance estimates for sitting birds were then added to the abundance estimate of flying birds to give an overall absolute abundance for the species.

59. It is these 'absolute' estimates that are presented for the auk species in **Section 22.3.2**, and used within impact assessment.

Age Class Proportions

60. To assess the proportion of birds in each age class (adult, immature, juvenile), the average number of birds recorded in each class was calculated across all surveys that occurred in each season. For example, if there were four surveys in the breeding season in Year 1 (2020 / 21) and four surveys in the breeding season in Year 2 (2021 / 22), then the average number of adult birds was calculated across eight surveys in total. This was conducted using all data within the Llŷr marine ornithology survey area.

61. The resulting proportion in each class was calculated as a proportion of the sum of the average number in each age class. This is presented for species where aging was possible, namely flying gulls and gannets. For this proposed Project, age-class information from DAS is available for gannet, kittiwake, great black-backed gull, herring gull and lesser-black-backed gull. Aging auks and Manx shearwaters is not possible using DAS data, therefore, no age-class information is provided for these species and it will be precautionarily assumed that all birds are breeding adults, as per the NRW (A) advice note dated 5 April 2023 (see **Chapter 22: Marine Ornithology, Table 22-5**, pre-application consultation).

22.2.3. Model-based Estimates for Impact Assessment

Seasonality

62. Seasonal definitions were agreed during pre-application consultation with NRW (A) and JNCC (**Chapter 22, Table 22-5**) and are based on the Biologically Defined Minimum Population Scale (BDMPS) of Furness (2015) (**Table 22A-4** below). The full UK breeding season was used, with the non-breeding seasons adjusted accordingly, to avoid overlapping months and 'double-counting'.

Table 22A-4. Seasons used in analysis (Furness, 2015)

Species	UK breeding season	Adjusted BDMPS		
		Autumn migration	Non-breeding	Spring migration
Kittiwake	Mar – Aug	Sep – Dec	-	Jan – Feb
Great black-backed gull	Mar – Aug	-	Sep – Feb	-
Herring gull	Mar – Aug	-	Sep – Feb	-
Lesser black-backed gull	Apr – Aug	Sep – Oct	Nov – Feb	Mar
Guillemot	Mar – July	-	Aug – Feb	-
Razorbill	Apr – July	Aug – Oct	Nov – Dec	Jan – Mar
Puffin	Apr – Aug	-	Sep – Mar	-
Manx shearwater	Apr – Aug	Sep – Oct	-	Mar
Gannet	Mar – Sep	Oct – Nov	-	Dec – Feb

Displacement

63. During the pre-application consultation with NRW (A) and JNCC (**Table 22-5 of Chapter 22: Marine Ornithology**), it was agreed that the key species to address in a semi-quantitative displacement analysis for the proposed Project, are:

- guillemot;
- razorbill;
- puffin;
- Manx shearwater; and
- gannet.

64. As set out in **Chapter 22: Marine Ornithology**, this is based on known species sensitivity to displacement (Furness *et al.,* 2013) and being protected features of important nearby colonies (e.g., Skomer, Skokholm and the Seas off Pembrokeshire (SSSP) Special Protection Area (SPA) and Grassholm SPA). Information on kittiwake in respect of displacement has also been included at the request of JNCC (**Chapter 22, Table 22-5**, pre-application consultation).

65. Storm petrel is also included for qualitative displacement assessment as a feature of the SSSP SPA, and Balearic shearwater are likewise included given their protected status as an SPA feature on the continent and known foraging activity in the Celtic Sea (see also the discussion in **Section 22.2.2** presented above).

66. The approach to displacement assessment follows current good practice guidance (SNCB, 2022), and is set out in **Appendix 22D: Marine Ornithology Displacement Assessment**. It requires the following information:

- MSP population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer.

67. Model-based MSP population estimates were calculated for each species in each season (**Table 22A-4**), taken as an average of the peak monthly estimates over the two years of

surveying within the relevant season. For example, the MSP population estimate for the breeding season was calculated as the average of the peak abundance in the breeding season in Year 1 and the peak count in the breeding season in Year 2.

68. To calculate the Confidence Intervals (CIs) for each MSP, a truncated normal distribution was characterised for each of the peak months using the abundance estimate and its associated SD, with the lower bound of the distribution fixed at zero. A total of 1,000 random samples from these distributions were drawn, with the two peak months samples pooled to create a single distribution for the MSP. The 0.025 and 0.975 quantiles of this distribution were then obtained, which serve as estimates of upper and lower CI.

69. As explained in **Section 22.2.1**, some surveys were missed due to weather and flown at the next available opportunity. **Table 22A-3** sets out how such surveys are dated for analysis. The years of survey run as follows: Year 1 = March 2020 to February 2021 and Year 2 = March 2021 to February 2022.

Collision Risk Modelling

70. During pre-application consultation with NRW (A) and JNCC (**Chapter 22, Table 22-5**).), it was agreed that the key species to address in collision risk modelling (CRM) for the proposed Project are:

- kittiwake;
- lesser black-backed gull; and
- gannet.

71. This is based on the species known susceptibility to collision (Furness *et al.,* 2013) and the species being protected features of important nearby colonies (e.g., SSSP SPA and Grassholm SPA), as set out in **Chapter 22: Marine Ornithology.**

72. During pre-application consultation, NRW (A) also requested that CRM be undertaken for great black-backed gull and herring gull for potential reference by future projects (**Table 22-5** of **Chapter 22: Marine Ornithology**). Note that the latter species was not recorded within the Array Area during the two years of digital aerial survey work and therefore drops out of this assessment (**Appendix 22A: Annex D – Design-Based Estimates**). CRM for great black-backed gull has to be based on the design-based density estimates due to sparsity of observations for this species (**Appendix 22A: Annex D – Design-Based Estimates**).

73. The approach to CRM follows McGregor *et al.* (2018) and is set out in **Appendix 22C: Marine Ornithology Collision Risk Modelling**. It requires the following information:

- Monthly densities of flying birds in the Array Area.

74. As set out in **Appendix 22C: Marine Ornithology Collision Risk Modelling**, the modelling has been done using the generic flight height data given in Johnston *et al.* (2014a; 2014b). These flight height data have been collated from seabird surveys at 32 offshore wind farms in the UK and Europe. Most surveys were boat-based, with the height measurements undertaken visually and assigned into height bands, to derive continuous flight height distributions for 25 seabird species. As such, site-specific flight heights are not required for the Llŷr marine ornithological assessment, and therefore, have not been calculated for this report.

22.3 Baseline Characterisation

22.3.1. Raw Counts

75. Detailed raw counts for all unidentified birds and all birds assigned to species level during the surveys in the Llŷr marine ornithology survey area and the Array Area are presented in **Appendix 22A: Annex A**. Summaries of these observations are provided in **Table 22A-5** and **Table 22A-6**, for each observed species and species group, per area and survey year.

76. Within the Llŷr marine ornithology survey area and Array Area, a total of 17 and 12 seabird species were recorded, amounting to a total of 46,921 and 3,620 birds, respectively. In general, more birds were recorded in Year 1 of the survey compared to Year 2, in both areas. Guillemot was the most abundant species recorded in both areas, followed by Manx shearwater, razorbill, kittiwake, gannet and puffin (**Table 22A-5**).

77. Within the Llŷr marine ornithology survey area and Array Area, a total of 14 and seven seabird species group were recorded, amounting to a total of 1,598 and 123 unidentified seabirds, respectively. Overall, unidentified birds represented approximately 2% to 4% of the total number of identified birds, in both years and areas (**Table 22A-6**).

Table 22A-5. Summary of the number of seabirds detected per survey year at Llŷr that were assigned to species level

Species	Latin name	Year 1 (Mar-2020 to Feb-2021)		Year 2 (May-S01-2021 to Mar-2022)	
		Array Area	Llŷr marine ornithology survey area	Array Area	Llŷr marine ornithology survey area
Kittiwake	*Rissa tridactyla*	189	1,437	119	1,456
Black-headed gull	*Chroicocephalus ridibundus*	0	2	0	0
Great black-backed gull	*Larus marinus*	2	73	2	16
Common gull	*Larus canus*	0	7	3	16
Herring gull	*Larus argentatus*	0	151	0	32
Lesser black-backed gull	*Larus fuscus*	0	160	4	42
Common tern	*Sterna hirundo*	0	7	0	2
Arctic tern	*Sterna paradisaea*	0	1	0	14
Great skua	*Sterceorarius skua*	1	6	0	0
Guillemot	*Uria aalge*	1,641	17,030	598	9,120
Razorbill	*Alca torda*	105	1,397	160	1,623
Puffin	*Fratercula arctica*	62	491	15	290
Storm petrel	*Hydrobates pelagicus*	0	3	1	2
Fulmar	*Fulmarus glacialis*	0	67	1	31
Manx shearwater	*Puffinus puffinus*	231	8,382	363	3,695
Gannet	*Morus bassanus*	45	577	78	786
Shag	*Gulosus aristotelis*	0	1	0	3
Total		**2,276**	**29,792**	**1,344**	**17,128**

Table 22A-6. Summary of the number of unidentified seabirds detected per survey year at Llŷr. Percentage of the total number of seabirds observed for same area and year are provided in brackets

Species group	Year 1 (Mar-2020 to Feb-2021)		Year 2 (May-S01-2021 to Mar-2022)	
	Array Area	Llŷr marine ornithology survey area	Array Area	Llŷr marine ornithology survey area
Arctic / common tern	0 (0.00%)	9 (0.03%)	0 (0.00%)	9 (0.05%)
Auk / shearwater species	8 (0.35%)	206 (0.69%)	11 (0.82%)	93 (0.54%)
Auk / small gull species	0 (0.00%)	19 (0.06%)	1 (0.07%)	13 (0.08%)
Auk species	27 (1.19%)	254 (0.85%)	8 (0.60%)	86 (0.50%)
Black-backed gull species	0 (0.00%)	1 (0.00%)	0 (0.00%)	0 (0.00%)
Fulmar / gull species	0 (0.00%)	3 (0.01%)	0 (0.00%)	5 (0.03%)
Gull species	0 (0.00%)	1 (0.00%)	1 (0.07%)	1 (0.01%)
Large auk species	26 (1.14%)	536 (1.80%)	37 (2.75%)	328 (1.91%)
Large gull species	0 (0.00%)	9 (0.03%)	0 (0.00%)	3 (0.02%)
Passerine species	3 (0.13%)	3 (0.01%)	0 (0.00%)	0 (0.00%)
Shearwater species	0 (0.00%)	1 (0.00%)	0 (0.00%)	0 (0.00%)
Small gull species	1 (0.04%)	3 (0.01%)	0 (0.00%)	5 (0.03%)
Tern / small gull species	0 (0.00%)	4 (0.01%)	0 (0.00%)	0 (0.00%)
Wader species	0 (0.00%)	5 (0.02%)	0 (0.00%)	1 (0.01%)
Total	**65 (2.86%)**	**1,054 (3.54%)**	**58 (4.32%)**	**544 (3.18%)**

22.3.2. Species Accounts

Kittiwake

Density and Population Estimates

78. Model-based densities and abundances of all kittiwakes within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-7**. The highest abundances of kittiwake were generally observed during the wider non-breeding season (**Table 22A-7** and **Appendix 22A: Annex A**). Densities reached a peak of 11.21 birds/km^2 (95% CI 10.33 – 12.00; October 2021) and 13.10 birds/km^2 (95% CI 10.80 – 15.79; October 2020) in the two boundaries, respectively.

79. Albeit following similar temporal distribution as the Erebus wind farm (hereafter 'Erebus') data, peak estimates in the Llŷr marine ornithology survey area are relatively lower than those estimated at Erebus (19.55 bird/km^2 in October 2019; HiDef Aerial Surveying Ltd, 2021).

80. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-7. Kittiwake monthly model-based density and population estimates of all birds (flying and sitting) at Llŷr

Kittiwake	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	0.36	0.25	0.49	230	160	315	44	19.1
14-Apr-20	0.03	0.01	0.08	17	3	52	14	81.9
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.06	0.03	0.12	40	17	79	17	41.5
21-Jul-20	0.02	0.00	0.08	10	1	52	12	124.8
31-Aug-20	0.48	0.31	0.67	306	199	430	60	19.7
12-Sep-20	0.42	0.27	0.72	269	175	464	65	24.0
22-Oct-20	6.52	5.85	7.47	4,181	3,749	4,790	286	6.8
26-Nov-20	4.77	4.32	5.26	3,056	2,766	3,369	181	5.9
10-Jan-21	2.78	2.43	3.16	1,780	1,556	2,028	124	7.0
25-Jan-21	3.57	3.22	3.99	2,290	2,063	2,555	131	5.7
22-Feb-21	0.56	0.38	0.85	358	246	547	75	20.9
14-May-21	0.04	0.01	0.12	28	7	76	20	69.9
27-May-21	0.02	0.01	0.07	14	3	43	10	68.3
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.02	0.01	0.05	13	3	31	8	62.4
16-Aug-21	0.01	0.00	0.06	8	1	38	10	124.2
01-Sep-21	0.01	0.00	0.04	7	1	26	7	98.9
22-Oct-21	11.21	10.33	12.00	7,186	6,622	7,688	291	4.0
20-Nov-21	6.34	5.57	7.65	4,062	3,567	4,900	309	7.6
16-Dec-21	0.07	0.03	0.14	45	19	90	21	45.7
05-Jan-22	0.14	0.08	0.22	91	52	142	30	28.1
26-Feb-22	0.25	0.15	0.42	161	94	271	40	29.3
20-Mar-22	1.26	1.00	1.57	805	638	1,005	103	11.7
Array Area								
25-Mar-20	0.27	0.13	0.45	12	6	20	4	31.7
14-Apr-20	0.02	0.00	0.07	1	0	3	1	90.9
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.07	0.02	0.13	3	1	6	1	44.4
21-Jul-20	0.02	0.00	0.05	1	0	2	1	71.6
31-Aug-20	0.09	0.02	0.36	4	1	16	4	110.9
12-Sep-20	0.05	0.00	0.27	2	0	12	4	185.8
22-Oct-20	13.10	10.80	15.79	588	485	709	65	11.1
26-Nov-20	3.12	2.12	4.81	140	95	216	32	22.6
10-Jan-21	2.27	1.38	3.56	102	62	160	28	27.3

Kittiwake	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Jan-21	2.81	1.69	4.03	126	76	181	28	22.5
22-Feb-21	0.31	0.07	1.02	14	3	46	12	86.3
14-May-21	0.02	0.00	0.07	1	0	3	1	116.5
27-May-21	0.02	0.00	0.09	1	0	4	1	96.4
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.02	0.00	0.09	1	0	4	1	112.5
16-Aug-21	0.02	0.00	0.07	1	0	3	1	65.3
01-Sep-21	0.02	0.00	0.07	1	0	3	1	68.9
22-Oct-21	10.40	8.28	13.12	467	372	589	60	12.8
20-Nov-21	7.37	5.52	9.60	331	248	431	53	16.0
16-Dec-21	0.07	0.02	0.13	3	1	6	1	45.4
05-Jan-22	0.13	0.07	0.27	6	3	12	2	38.1
26-Feb-22	0.69	0.25	1.40	31	11	63	15	49.5
20-Mar-22	1.16	0.58	2.16	52	26	97	18	35.4
Array Area plus 2km buffer								
25-Mar-20	0.27	0.15	0.39	32	18	47	8	24.0
14-Apr-20	0.03	0.01	0.08	3	1	9	2	77.9
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.07	0.03	0.16	8	3	19	4	49.7
21-Jul-20	0.01	0.00	0.04	1	0	5	1	126.2
31-Aug-20	0.14	0.04	0.40	17	5	48	15	85.8
12-Sep-20	0.04	0.00	0.18	5	0	21	5	108.9
22-Oct-20	16.14	12.17	21.26	1,924	1,450	2,534	325	16.9
26-Nov-20	2.65	2.05	3.52	316	244	420	47	15.0
10-Jan-21	1.96	1.38	2.72	233	164	324	45	19.3
25-Jan-21	2.78	2.22	3.63	331	265	432	45	13.5
22-Feb-21	0.25	0.08	0.58	30	10	69	18	58.9
14-May-21	0.02	0.00	0.15	2	0	18	5	258.4
27-May-21	0.03	0.01	0.07	3	1	8	2	66.2
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.03	0.01	0.07	3	1	8	3	86.6
16-Aug-21	0.02	0.00	0.05	2	0	6	2	105.0
01-Sep-21	0.02	0.00	0.06	2	0	7	2	104.8
22-Oct-21	16.48	14.47	19.06	1,964	1,724	2,272	140	7.1
20-Nov-21	6.22	5.06	7.67	741	603	914	85	11.5
16-Dec-21	0.08	0.03	0.15	9	4	18	4	43.5
05-Jan-22	0.14	0.08	0.24	17	9	28	5	31.1

Kittiwake	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
26-Feb-22	0.68	0.37	1.17	81	44	139	27	32.8
20-Mar-22	1.20	0.76	1.88	143	90	224	35	24.7

n = number, LCL = Lower 95% Credible Limit, UCL = Upper 95% Credible Limit, SD = Standard Deviation, CV = Coefficient of Variation

Distribution and Spatial Densities

81. Kittiwakes were recorded throughout the Llŷr marine ornithology survey area with, on average, more birds observed in the east of the Llŷr marine ornithology survey area, rather than within the Array Area (**Figure 22A-3** to **Figure 22A-6**).

82. Mean model-based density surfaces of kittiwakes are presented in **Figure 22A-7** to **Figure 22A-10**. In general, the highest densities were observed in the northwest and east of the Llŷr marine ornithology survey area, overlapping with the Array Area plus a 2 km buffer.

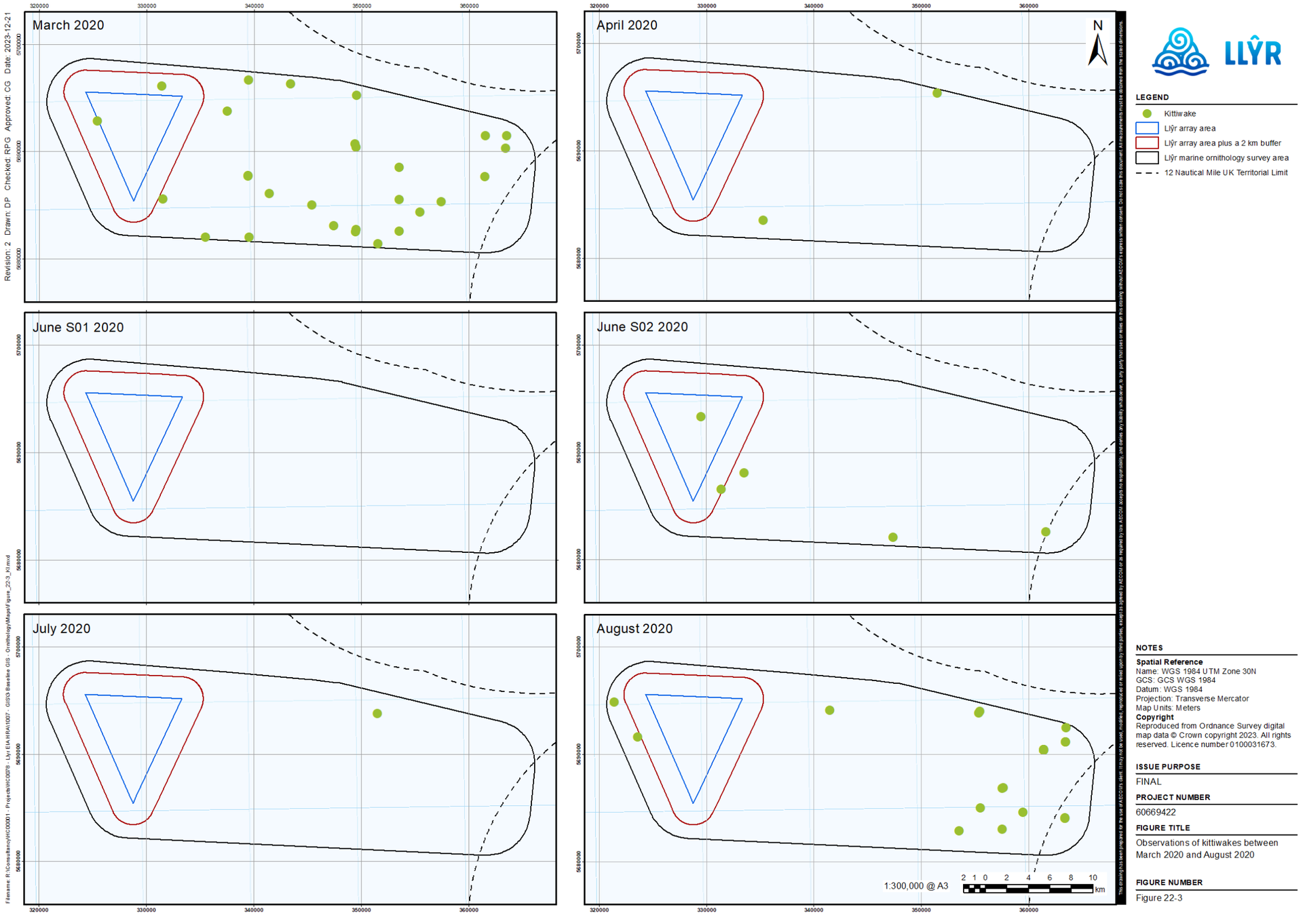


Figure 22A-3. Distribution map of recorded kittiwakes within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

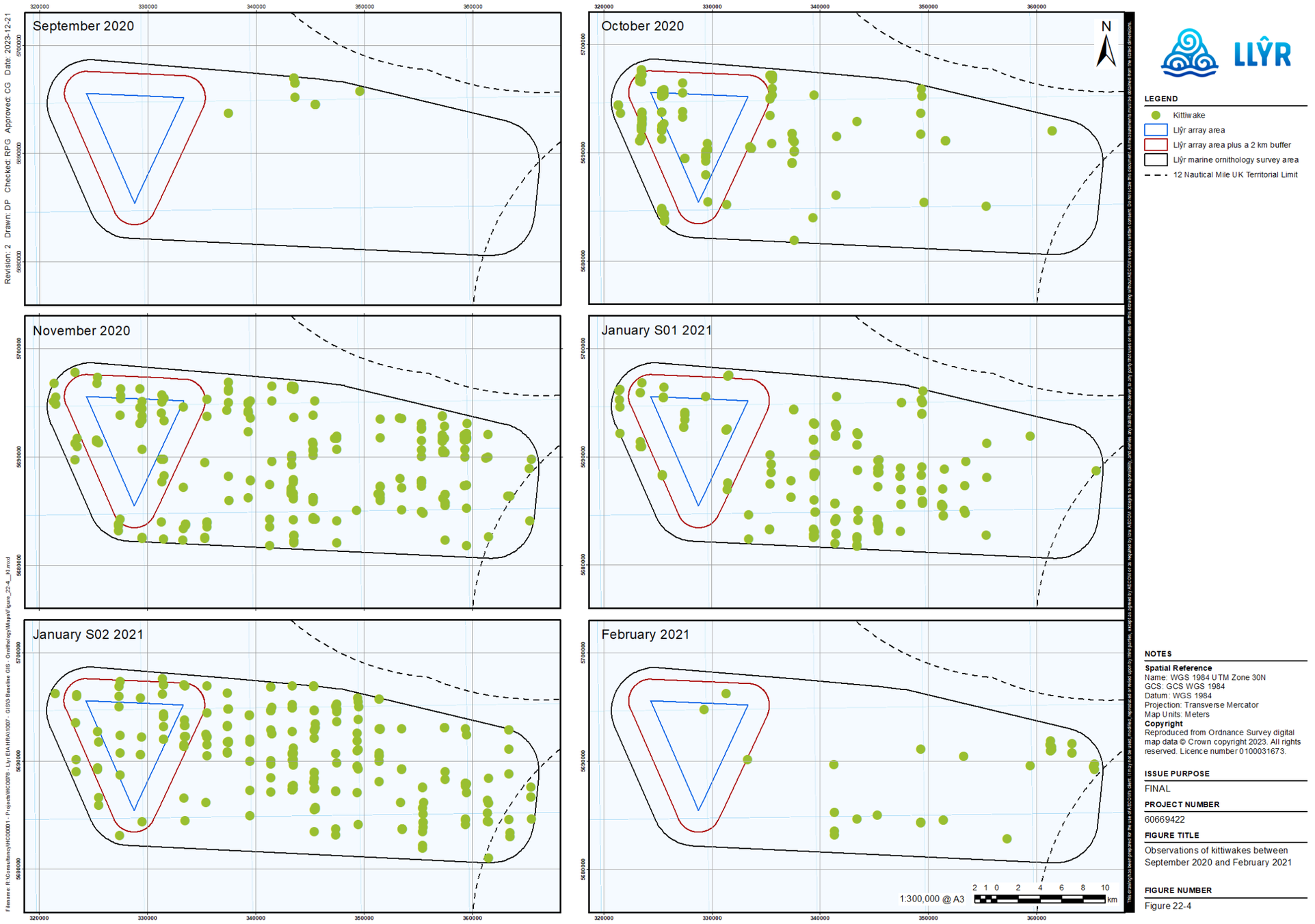


Figure 22A-4. Distribution map of recorded kittiwakes within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

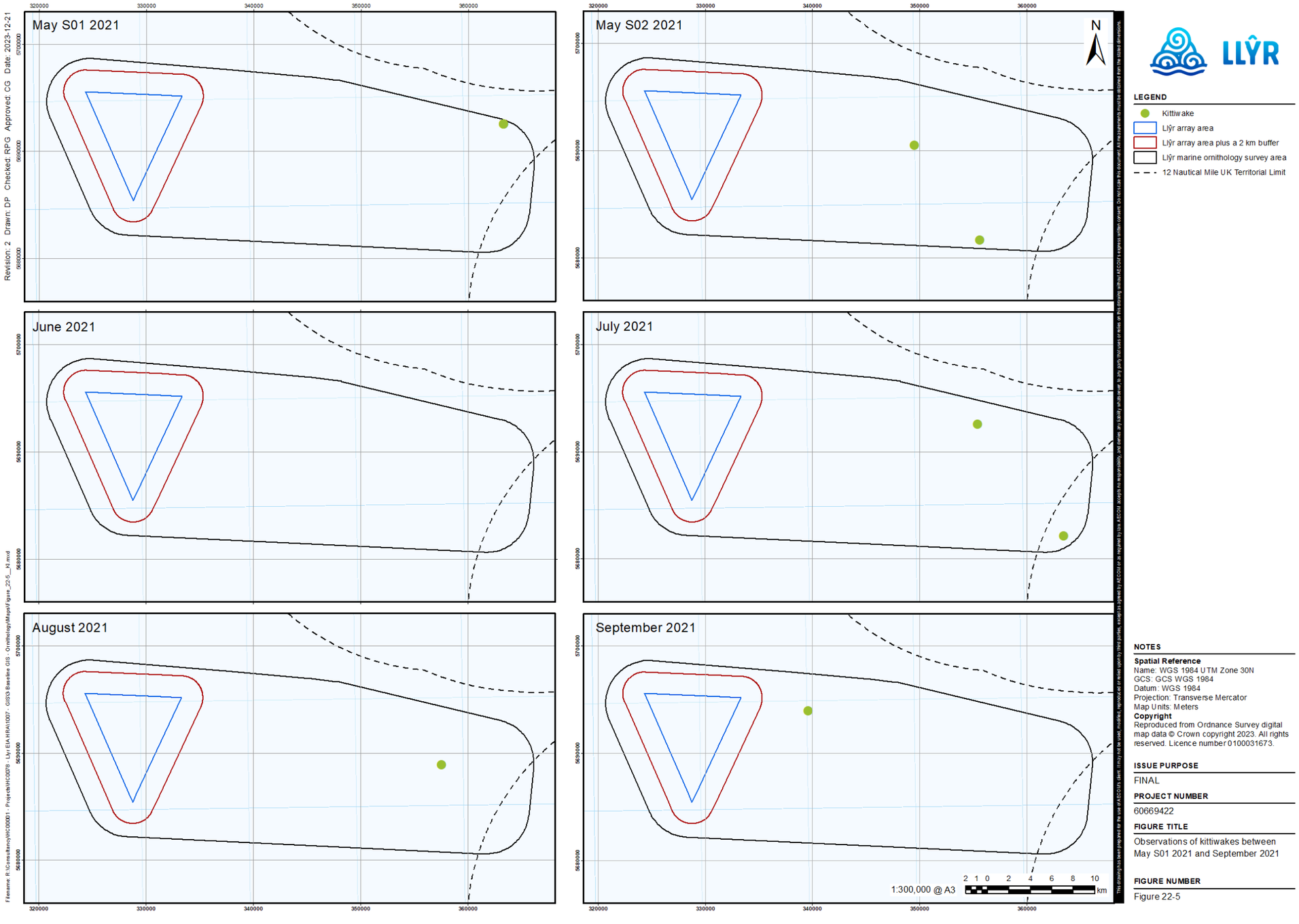


Figure 22A-5. Distribution map of recorded kittiwakes within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

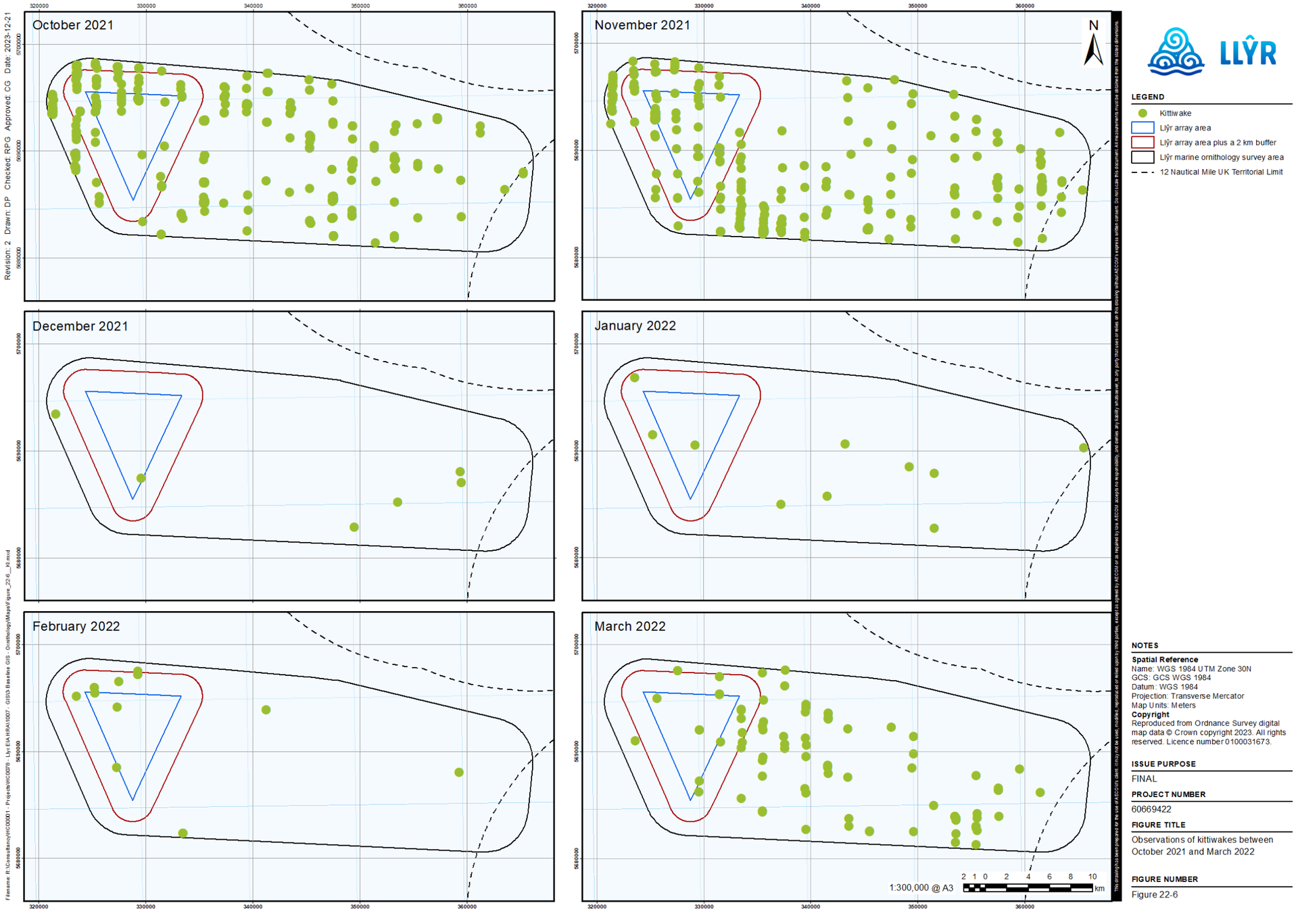
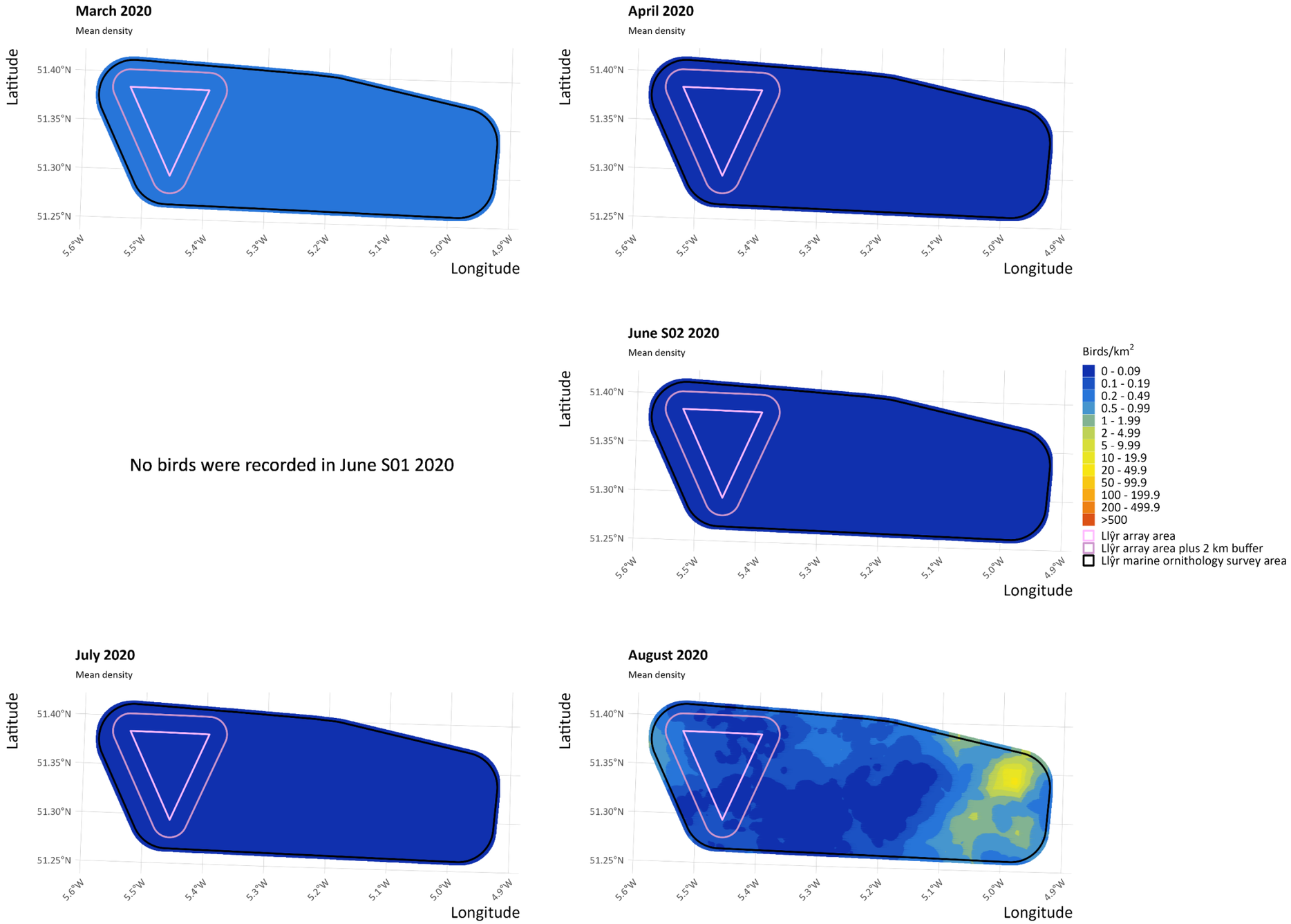


Figure 22A-6. Distribution map of recorded kittiwakes within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)



No birds were recorded in June S01 2020

Figure 22A-7. Mean model-based density surfaces for all kittiwakes (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

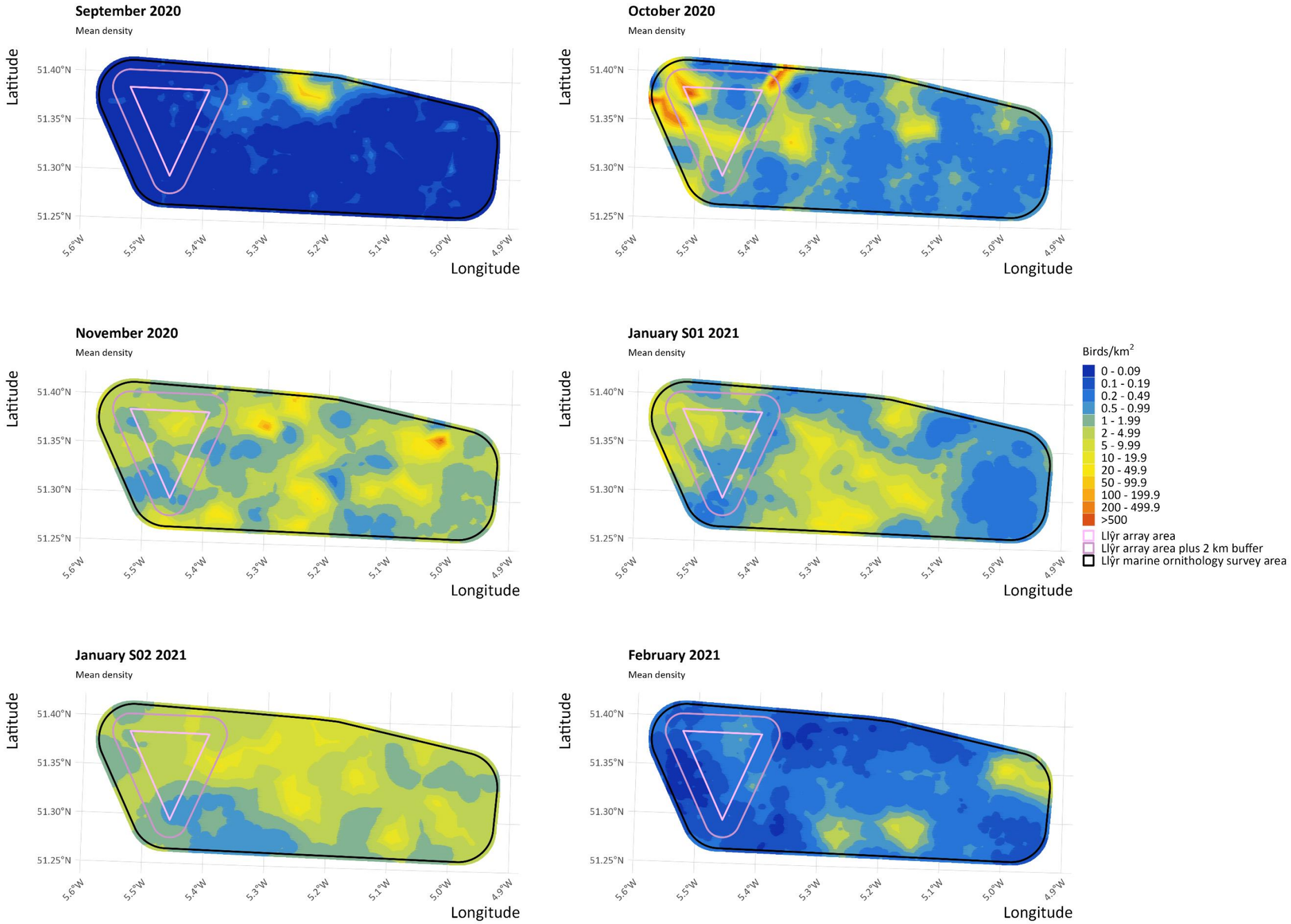


Figure 22A-8. Mean model-based density surfaces for all kittiwakes (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

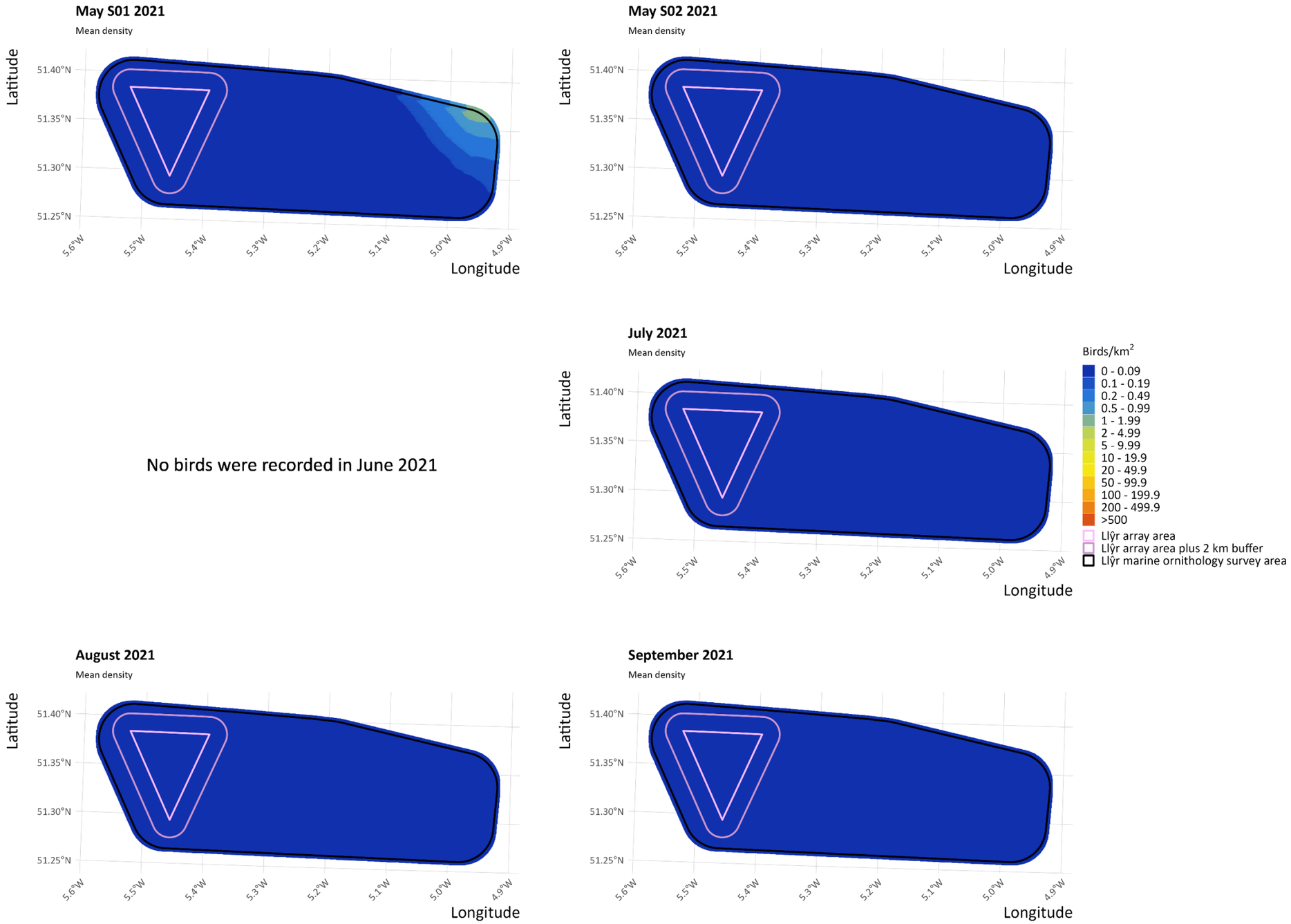


Figure 22A-9. Mean model-based density surfaces for all kittiwakes (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

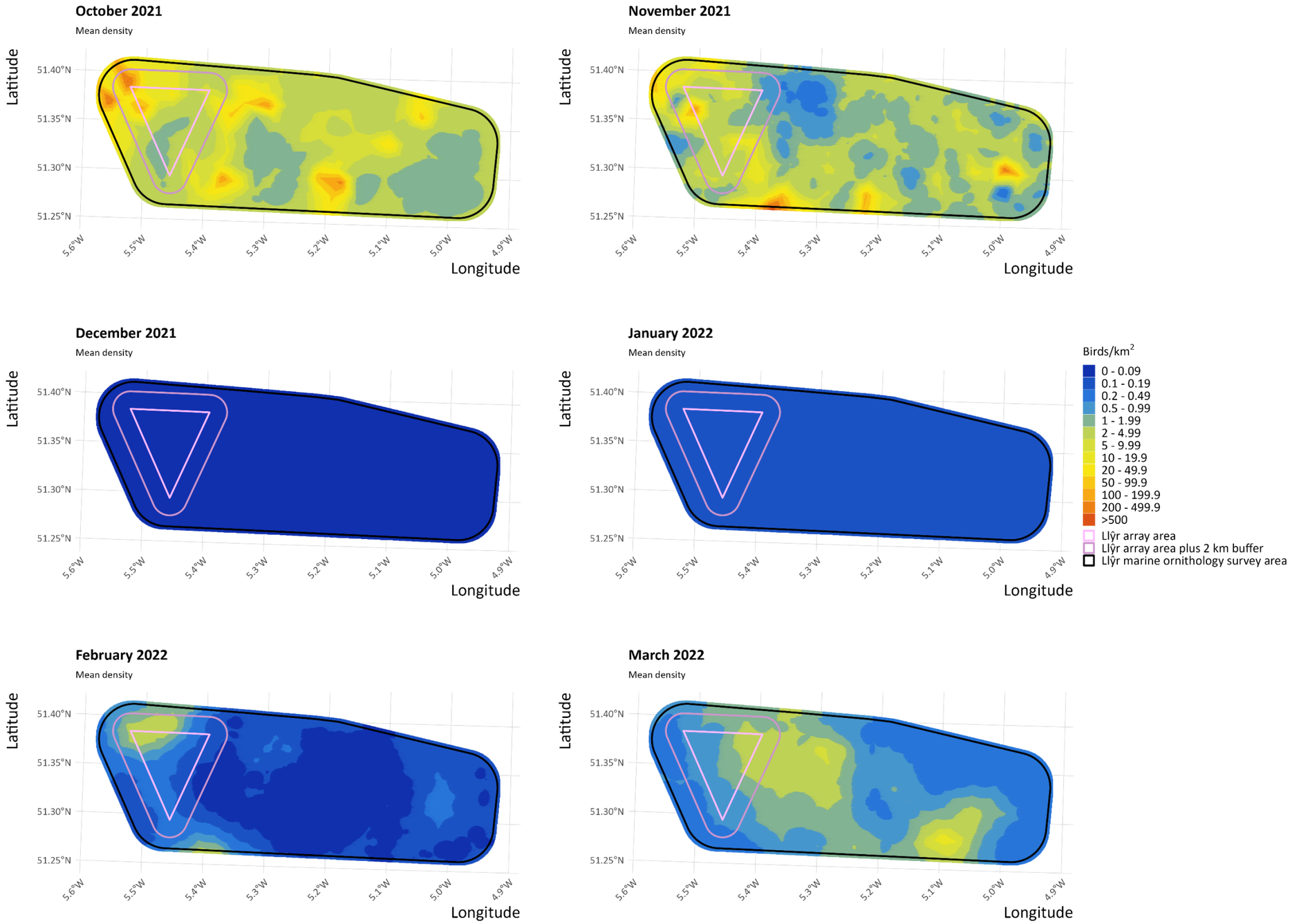


Figure 22A-10. Mean model-based density surfaces for all kittiwakes (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

Input Densities for CRM

83. Model-based density estimates of flying kittiwakes within the Array Area are provided as a mean (n/km^2) with associated SD for input into CRM (**Appendix 22C: Marine Ornithology Collision Risk Modelling**).

84. The maximum model-based flying density estimate in the Array Area was recorded in the autumn migration period, with 9.11 birds/km^2 (1.43 SD; October 2021) (**Table 22A-8**, **Figure 22A-11**). Comparative design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-8. Model-based density estimates of flying kittiwakes within the Array Area

Kittiwake	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	SD (n/km²)	CV density (%)
25-Mar-20	0.25	0.11	0.42	0.08	32.2
14-Apr-20	0.00	0.00	0.05	0.00	0.0
08-Jun-20	0.00	0.00	0.00	0.00	0.0
24-Jun-20	0.05	0.02	0.11	0.03	73.0
21-Jul-20	0.00	0.00	0.00	0.00	0.0
31-Aug-20	0.09	0.05	0.27	0.06	67.0
12-Sep-20	0.02	0.00	0.05	0.01	62.6
22-Oct-20	3.19	2.05	4.88	0.69	21.6
26-Nov-20	3.36	2.07	5.48	0.93	27.6
10-Jan-21	1.11	0.58	2.12	0.44	39.3
25-Jan-21	1.76	1.20	2.63	0.36	20.4
22-Feb-21	0.18	0.05	0.49	0.11	60.9
14-May-21	0.00	0.00	0.00	0.00	0.0
27-May-21	0.00	0.00	0.05	0.00	0.0
15-Jun-21	0.00	0.00	0.00	0.00	0.0
14-Jul-21	0.02	0.00	0.07	0.02	76.3
16-Aug-21	0.02	0.00	0.05	0.01	60.0
01-Sep-21	0.02	0.00	0.07	0.02	76.9
22-Oct-21	9.11	6.41	11.78	1.43	15.7
20-Nov-21	5.99	4.25	8.60	1.17	19.5
16-Dec-21	0.07	0.02	0.18	0.04	58.4
05-Jan-22	0.13	0.07	0.25	0.05	40.1
26-Feb-22	0.38	0.09	0.98	0.22	56.7
20-Mar-22	0.65	0.33	1.05	0.21	32.0

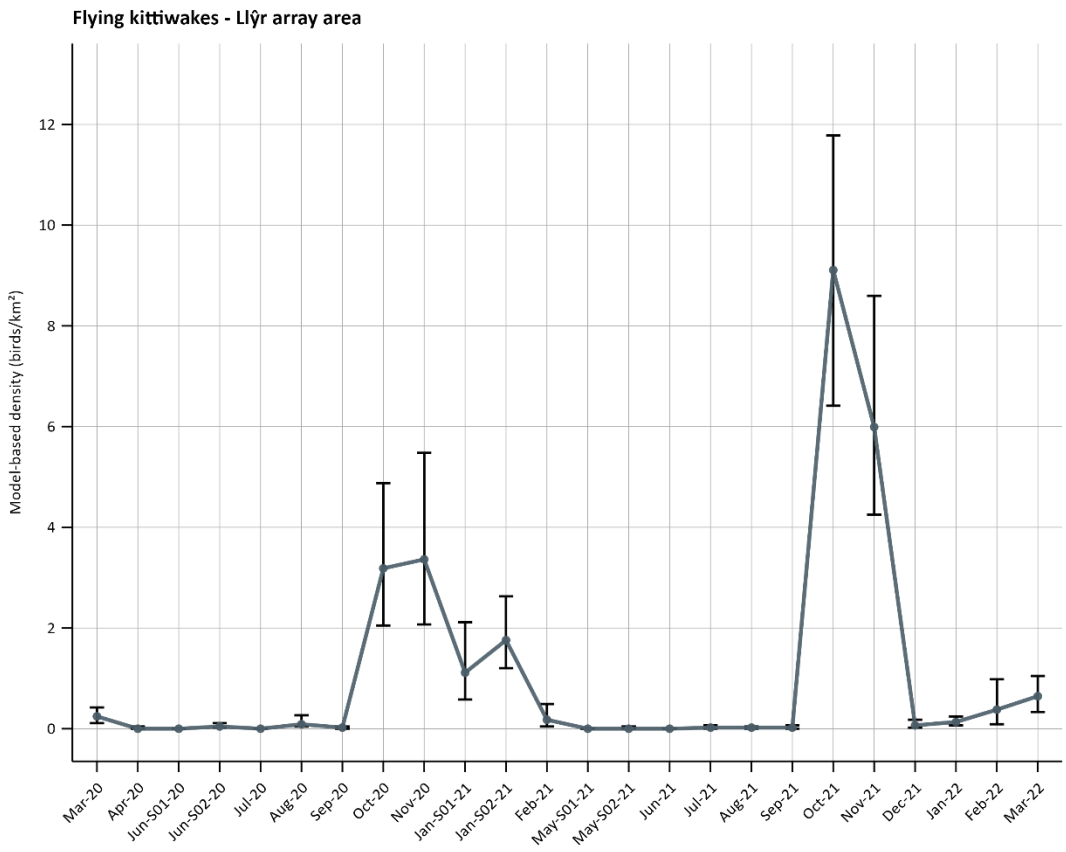


Figure 22A-11. Monthly model-based densities of flying kittiwakes within the Array Area (associated credible intervals are represented by error bars)

MSP Population Estimates for Displacement

85. MSP population estimates for the Array Area plus a 2 km buffer are provided for kittiwakes for information in respect of displacement assessment (**Appendix 22D: Marine Ornithology Displacement Assessment**), as per JNCC request (**Table 22-5** of **Chapter 22: Marine Ornithology**).

86. The maximum model-based absolute population estimate of all kittiwakes (flying and sitting) in the Array Area plus a 2 km buffer was recorded in the autumn migration season, with 1,964 birds (95% CI 1,724 – 2,272; October 2021) (**Table 22A-9**). Comparative design-based absolute estimates are presented in **Appendix 22A: Annex D** for context.

87. Accordingly, the highest MSP population estimate of all birds within the Array Area plus a 2 km buffer occurred in the autumn migration season at 1,944 birds (95% CI 1,598 – 2,275) (**Table 22A-10**).

Table 22A-9. Kittiwake monthly model-based absolute population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer

Kittiwake	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	32	18	47	8	24.0
14-Apr-20	3	1	9	2	77.9
08-Jun-20	0	0	0	0	0.0
24-Jun-20	8	3	19	4	49.7
21-Jul-20	1	0	5	1	126.2

Kittiwake	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
31-Aug-20	17	5	48	15	85.8
12-Sep-20	5	0	21	5	108.9
22-Oct-20	1,924	1,450	2,534	325	16.9
26-Nov-20	316	244	420	47	15.0
10-Jan-21	233	164	324	45	19.3
25-Jan-21	331	265	432	45	13.5
22-Feb-21	30	10	69	18	58.9
14-May-21	2	0	18	5	258.4
27-May-21	3	1	8	2	66.2
15-Jun-21	0	0	0	0	0.0
14-Jul-21	3	1	8	3	86.6
16-Aug-21	2	0	6	2	105.0
01-Sep-21	2	0	7	2	104.8
22-Oct-21	1,964	1,724	2,272	140	7.1
20-Nov-21	741	603	914	85	11.5
16-Dec-21	9	4	18	4	43.5
05-Jan-22	17	9	28	5	31.1
26-Feb-22	81	44	139	27	32.8
20-Mar-22	143	90	224	35	24.7

Table 22A-10. Model-based MSP population estimate of all kittiwakes (flying and sitting) in each season within the Array Area plus a 2 km buffer

Razorbill	Year 1 Peak (n)	Year 2 Peak (n)	MSP Population (n)	MSP LCL (n)	MSP UCL (n)
Breeding season	*Mar 2020 – 32*	*Mar 2022* – 143*	88	54	124
Autumn migration	*Oct 2020 – 1,924*	*Oct 2021 – 1,964*	1,944	1,598	2,275
Spring migration	*Jan 2021 – 331*	*Feb 2022 – 81*	206	154	256

**Used to represent March 2021*

Site-based Age Information for PVA

88. Across the Llŷr marine ornithology survey area, the majority of kittiwakes were aged as adults, comprising 77%, 87% and 97% of aged birds in the breeding season, autumn and spring migration seasons, respectively (**Table 22A-11**).

Table 22A-11. Percentage of aged kittiwakes in each age class averaged across all surveys in each season in the Llŷr marine ornithology survey area

Season	Adult (%)	Immature (%)	Juvenile (%)
Breeding season	77.39	16.52	6.09
Autumn migration	86.60	0.49	12.91
Spring migration	97.14	2.45	0.41

Great Black-Backed Gull

Density and Population Estimates

89. Great black-backed gulls are not being taken forward for assessment of significant effects and, as such, modelling was not conducted. However, design-based density estimates are presented in this **Appendix 22A: Marine Ornithology Baseline** so that these are available for use in any potential cumulative collision assessments by future projects. Any future assessment should keep in mind the limitations of the design-based methodology, owing to the low number of transects intersecting the Array Area (**Table 22A-2**); the missing transects; and the subsequently larger confidence intervals surrounding the mean estimates.

90. Great black-backed gulls were recorded in relatively small numbers throughout the Llŷr marine ornithology survey area, with the highest numbers recorded during the non-breeding season, between October and November in both Year 1 and 2 (**Table 22A-5** and **Appendix 22A: Annex A**). In the Llŷr marine ornithology survey area and the Array Area, peaks of great black-backed gulls occurred mainly during the non-breeding season, with peak density estimates equating to 0.47 birds/km^2 (95% CI 0.10 – 0.97; October 2020) and 0.18 birds/km^2 (95% CI 0.00 – 0.58 in April 2020; 0.00 – 0.42 in January S01 2021; and 0.00 – 0.41 in November 2021), respectively. These densities equated to population estimates of 302 birds (95% CI 63 – 623; October 2021) and 8 birds (95% CI 0 – 27 in April 2020; 0 – 19 in January S01 2021) and 9 birds (95% CI 0 – 19 in November 2021), respectively (**Appendix 22A: Annex D**).

91. Albeit following similar temporal distribution as the Erebus data, peak density estimates in the Llŷr marine ornithology survey area are relatively lower than those estimated at Erebus (0.94 bird/km^2 in October 2019; HiDef Aerial Surveying Ltd, 2021).

Table 22A-12. Great black-backed gull monthly design-based density and population estimates of all birds (flying and sitting) at Llŷr

Great black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	0.01	0.00	0.04	9	0	24	9	101.9
14-Apr-20	0.04	0.00	0.10	24	0	61	17	69.9
08-Jun-20	0.09	0.00	0.27	60	0	176	58	97.0
24-Jun-20	0.06	0.00	0.24	42	0	152	41	97.7
21-Jul-20	0.00	0.00	0.00	0	0	0	0	0.0
31-Aug-20	0.03	0.00	0.06	17	0	39	11	63.3
12-Sep-20	0.01	0.00	0.04	8	0	24	8	91.1
22-Oct-20	0.47	0.10	0.97	302	63	623	145	48.1

Great black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
26-Nov-20	0.19	0.00	0.52	125	1	335	101	80.7
10-Jan-21	0.01	0.00	0.04	8	0	24	8	96.2
25-Jan-21	0.03	0.00	0.06	17	0	39	11	66.2
22-Feb-21	0.00	0.00	0.00	0	0	0	0	0.0
14-May-21	0.03	0.00	0.06	17	0	40	11	66.3
27-May-21	0.04	0.00	0.08	25	0	54	13	52.6
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.00	0.00	0.00	0	0	0	0	0.0
16-Aug-21	0.04	0.00	0.10	23	0	62	17	70.8
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.06	0.01	0.13	40	8	81	20	50.4
20-Nov-21	0.05	0.00	0.10	29	1	61	16	52.8
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.00	0.00	0.00	0	0	0	0	0.0
Array Area								
25-Mar-20	0.00	0.00	0.00	0	0	0	0	0.0
14-Apr-20	0.18	0.00	0.58	8	0	27	8	97.1
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
21-Jul-20	0.00	0.00	0.00	0	0	0	0	0.0
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.00	0.00	0.00	0	0	0	0	0.0
26-Nov-20	0.00	0.00	0.00	0	0	0	0	0.0
10-Jan-21	0.18	0.00	0.42	8	0	19	6	69.9
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.00	0.00	0.00	0	0	0	0	0.0
14-May-21	0.00	0.00	0.00	0	0	0	0	0.0
27-May-21	0.00	0.00	0.00	0	0	0	0	0.0
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.00	0.00	0.00	0	0	0	0	0.0
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.00	0.00	0.00	0	0	0	0	0.0
20-Nov-21	0.18	0.00	0.41	9	0	19	6	69.0

Great black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.00	0.00	0.00	0	0	0	0	0.0
Array Area plus 2km buffer								
25-Mar-20	0.00	0.00	0.00	0	0	0	0	0.0
14-Apr-20	0.07	0.00	0.20	8	0	24	8	90.6
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
21-Jul-20	0.00	0.00	0.00	0	0	0	0	0.0
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.34	0.00	0.94	41	0	112	31	75.9
26-Nov-20	0.07	0.00	0.20	9	0	24	8	86.9
10-Jan-21	0.07	0.00	0.18	8	0	22	7	78.5
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.00	0.00	0.00	0	0	0	0	0.0
14-May-21	0.06	0.00	0.20	8	0	24	8	92.1
27-May-21	0.00	0.00	0.00	0	0	0	0	0.0
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.00	0.00	0.00	0	0	0	0	0.0
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.14	0.00	0.33	18	0	40	11	62.9
20-Nov-21	0.07	0.00	0.19	8	0	23	7	84.7
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.00	0.00	0.00	0	0	0	0	0.0

Distributions

92. Great black-backed gulls were recorded sporadically throughout the Llŷr marine ornithology survey area with no clear pattern in distribution (**Figure 22A-12** to **Figure 22A-15**). Generally, more birds were recorded in the 2 km buffer area rather than in the Array Area.

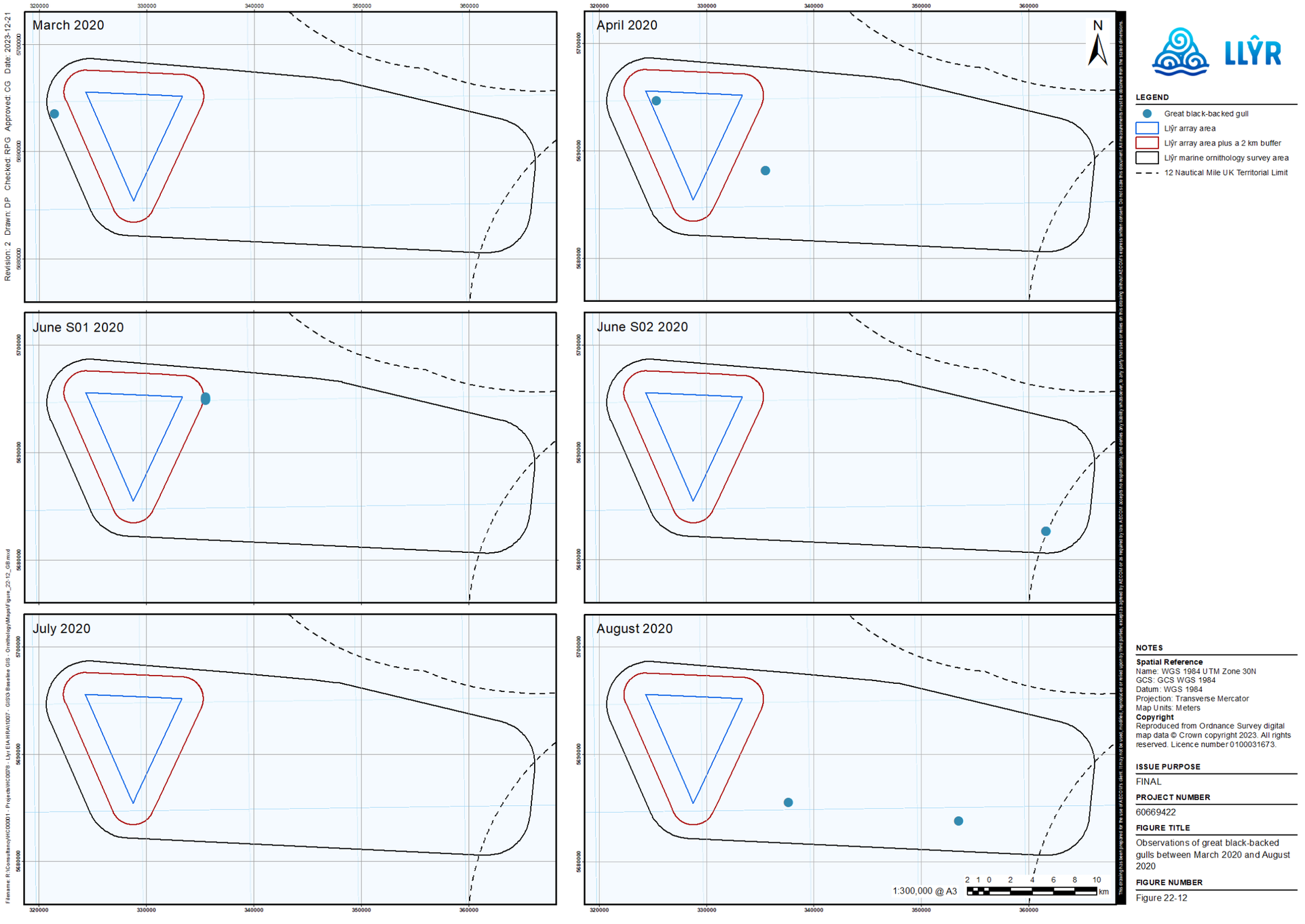


Figure 22A-12. Distribution map of recorded great black-backed gulls within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

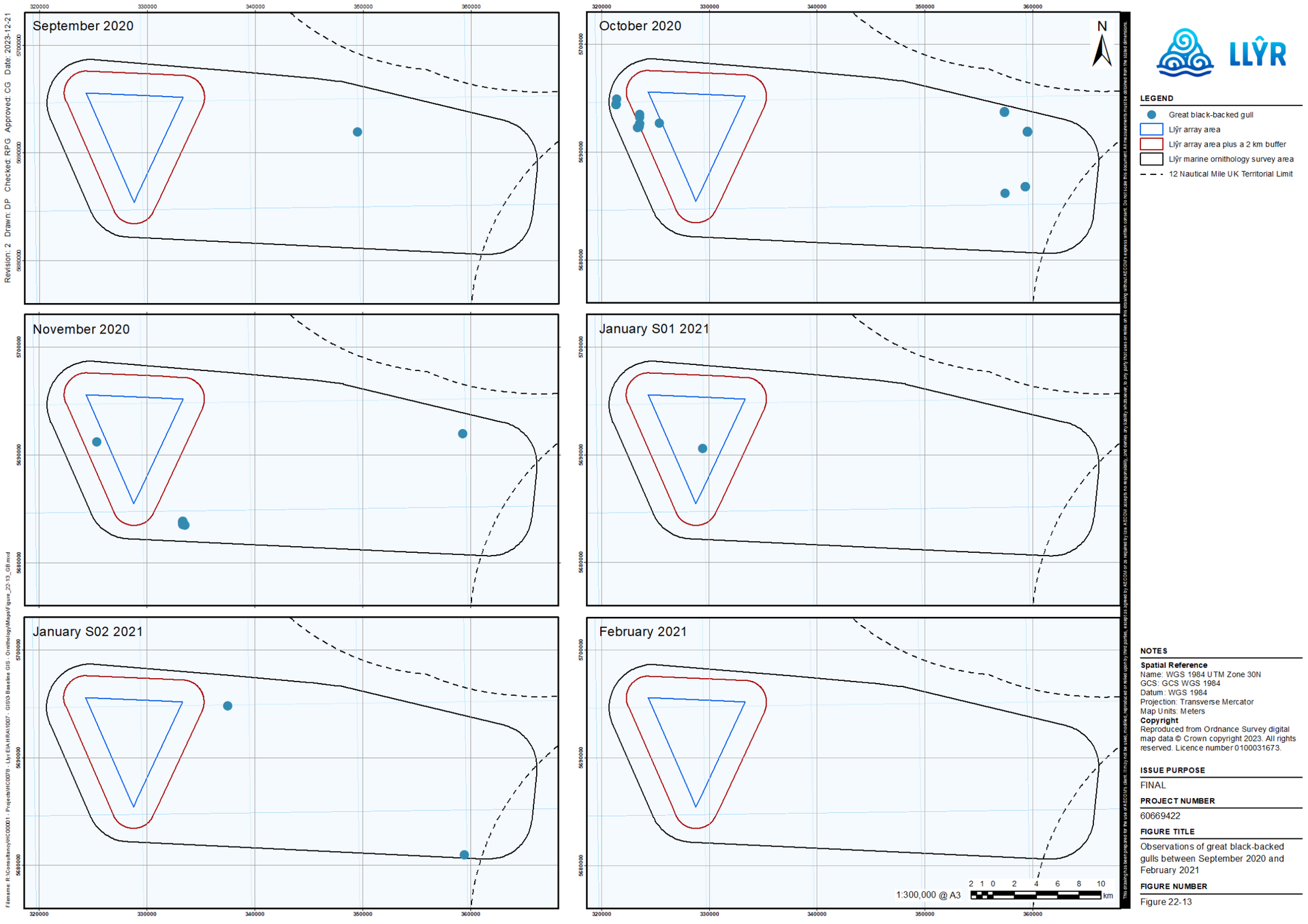


Figure 22A-13. Distribution map of recorded great black-backed gulls within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

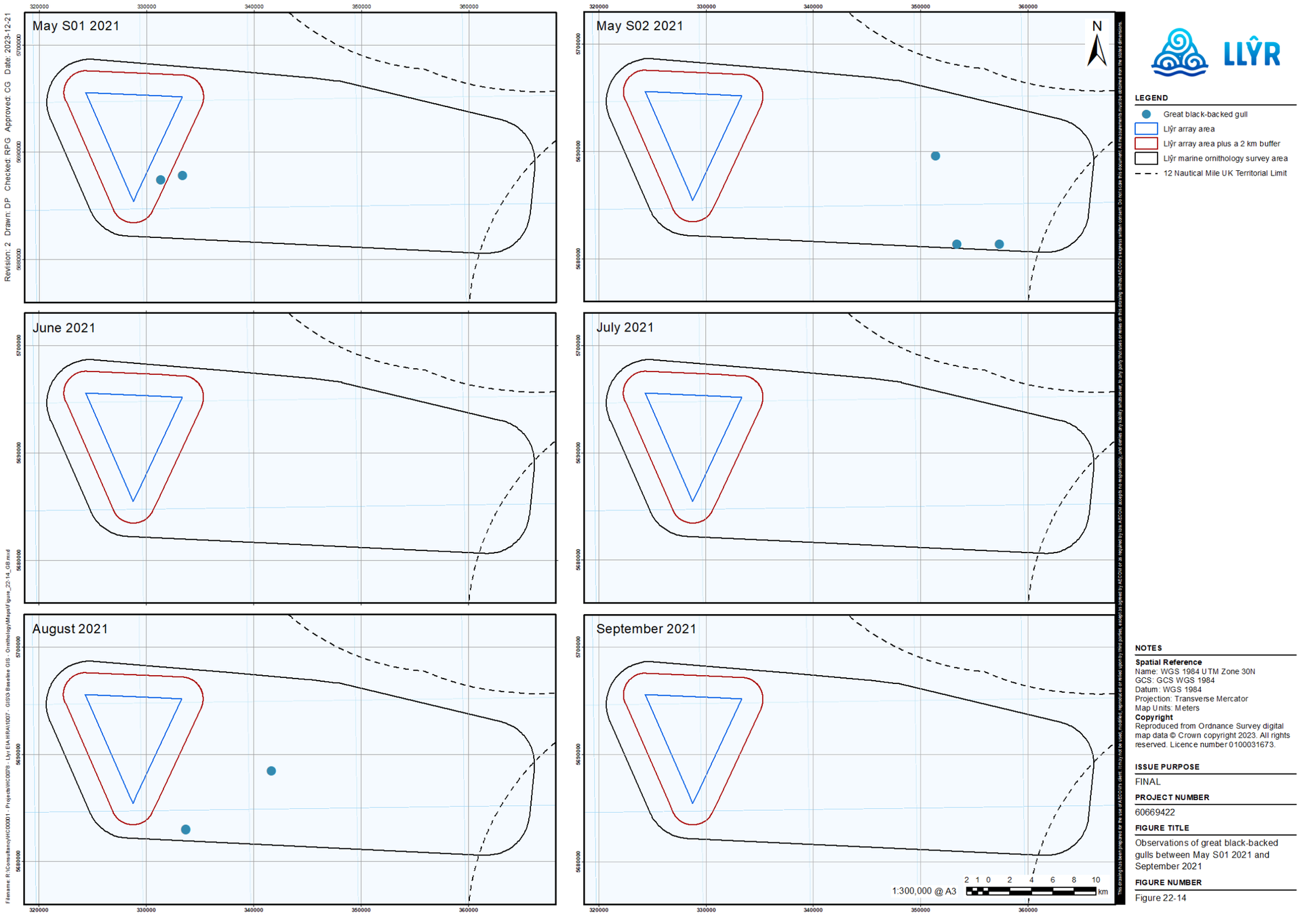


Figure 22A-14. Distribution map of recorded great black-backed gulls within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

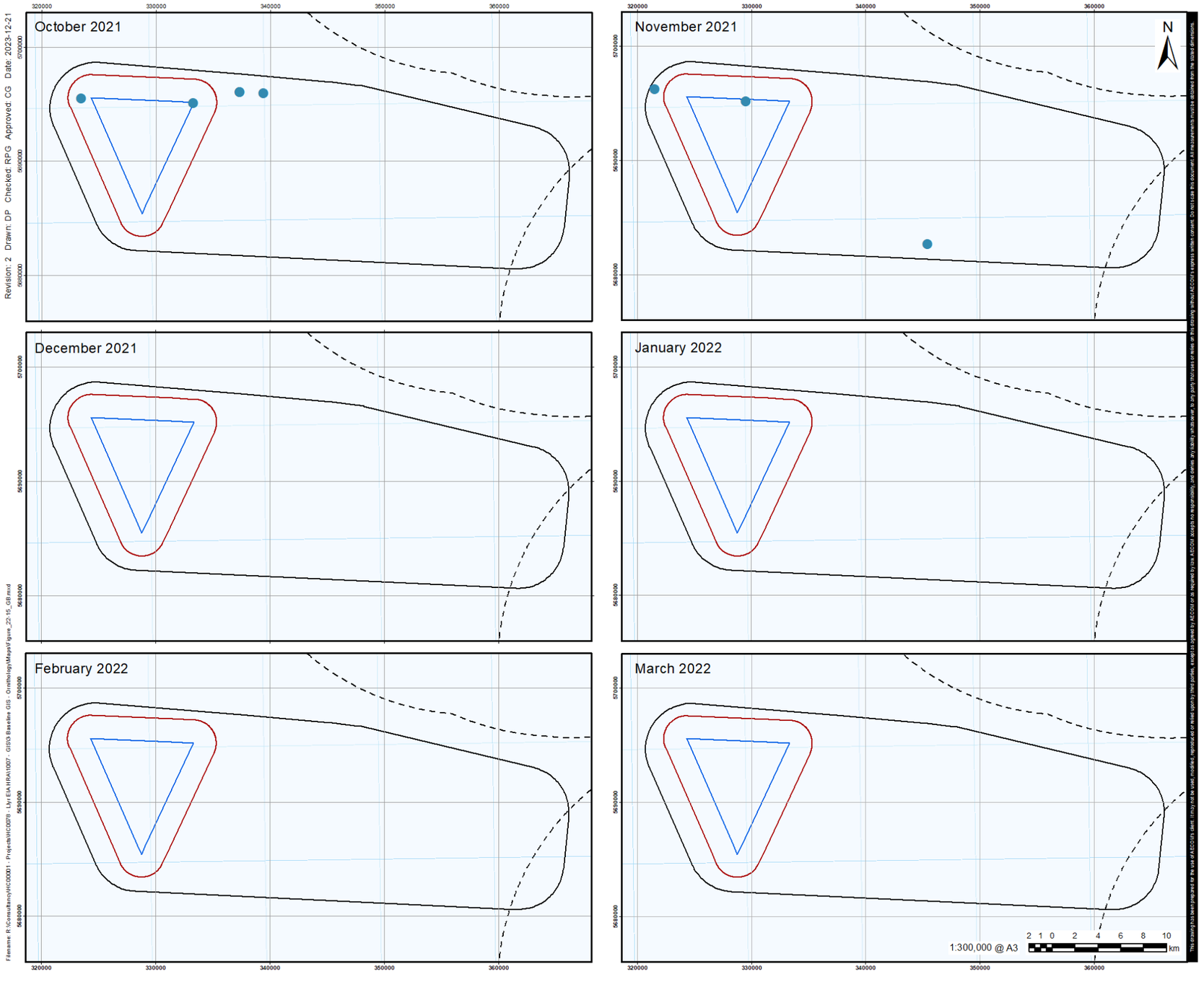


Figure 22A-15. Distribution map of recorded great black-backed gulls within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

Input Densities for CRM

93. In the Array Area, flying birds were only recorded in three months throughout the entire survey period. Maximum density of flying birds in the Array Area was estimated as 0.19 birds/km^2 (95% CI 0.00 – 0.58) in April 2020 (**Figure 22A-16** and **Table 22A-13**).

Table 22A-13. Design-based density estimates of flying great black-backed gulls within the Array Area

Great black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	SD (n/km²)	CV density (%)
25-Mar-20	0.00	0.00	0.00	0.00	0.0
14-Apr-20	0.19	0.00	0.58	0.18	93.8
08-Jun-20	0.00	0.00	0.00	0.00	0.0
24-Jun-20	0.00	0.00	0.00	0.00	0.0
21-Jul-20	0.00	0.00	0.00	0.00	0.0
31-Aug-20	0.00	0.00	0.00	0.00	0.0
12-Sep-20	0.00	0.00	0.00	0.00	0.0
22-Oct-20	0.00	0.00	0.00	0.00	0.0
26-Nov-20	0.00	0.00	0.00	0.00	0.0
10-Jan-21	0.18	0.00	0.42	0.13	74.2
25-Jan-21	0.00	0.00	0.00	0.00	0.0
22-Feb-21	0.00	0.00	0.00	0.00	0.0
14-May-21	0.00	0.00	0.00	0.00	0.0
27-May-21	0.00	0.00	0.00	0.00	0.0
15-Jun-21	0.00	0.00	0.00	0.00	0.0
14-Jul-21	0.00	0.00	0.00	0.00	0.0
16-Aug-21	0.00	0.00	0.00	0.00	0.0
01-Sep-21	0.00	0.00	0.00	0.00	0.0
22-Oct-21	0.00	0.00	0.00	0.00	0.0
20-Nov-21	0.18	0.00	0.44	0.13	74.2
16-Dec-21	0.00	0.00	0.00	0.00	0.0
05-Jan-22	0.00	0.00	0.00	0.00	0.0
26-Feb-22	0.00	0.00	0.00	0.00	0.0
20-Mar-22	0.00	0.00	0.00	0.00	0.0

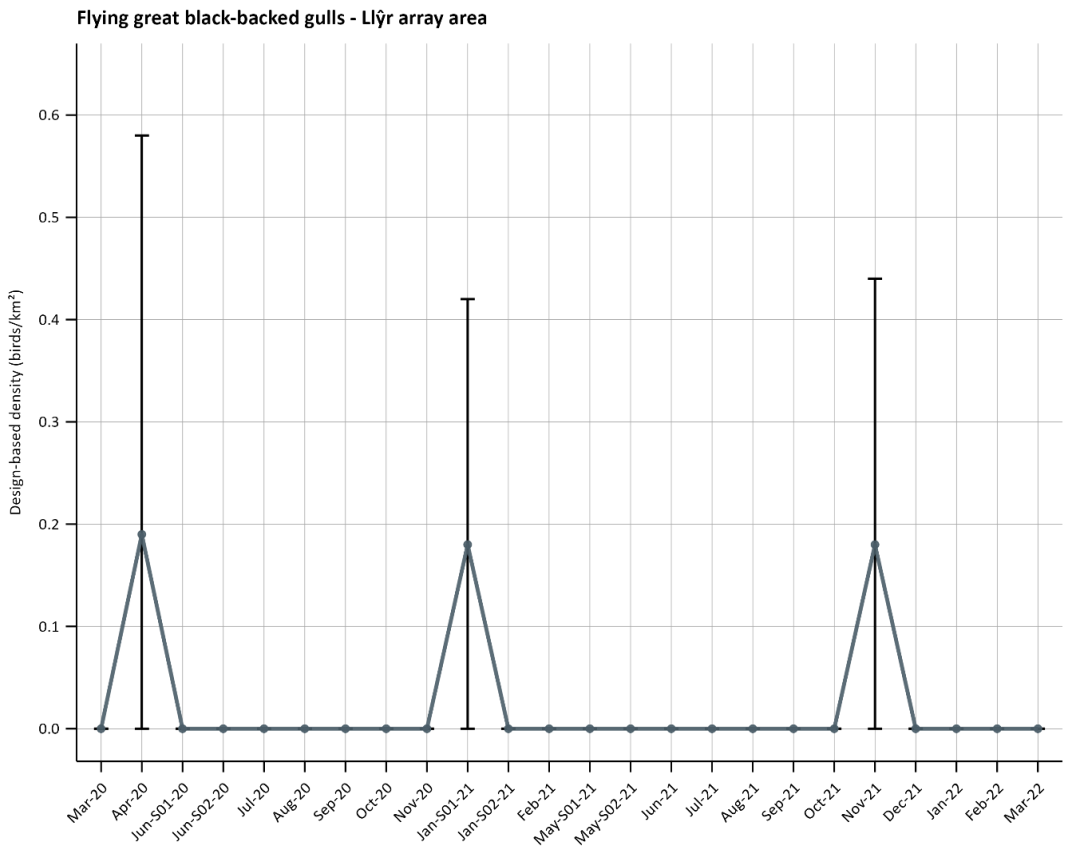


Figure 22A-16. Monthly design-based densities of flying great black-backed gulls within the Array Area (associated confidence intervals are represented by error bars)

Herring Gull

Distribution, Density and Population Estimates

94. Herring gulls were recorded throughout the Llŷr marine ornithology survey area, but all birds were recorded outside the Array Area (**Figure 22A-17** to **Figure 22A-20**). Therefore, density and population estimates are calculated for the Llŷr marine ornithology survey area only, and CRM will not be progressed for this species given that the Array Area estimates are zero. Full design-based estimates are presented within **Appendix 22A: Annex D**.

95. Herring gull abundance within the Llŷr marine ornithology survey area fluctuated throughout the survey period, with influxes in May/June and again in winter (~October/November). However, the majority of birds were observed during Year 1 of the survey period (**Table 22A-5** and **Appendix 22A: Annex A**).

96. In the Llŷr marine ornithology survey area, herring gulls peaked during the non-breeding season, with a density estimate equating to 1.16 birds/km^2 (95% CI 0.07 – 3.19) in November 2020 (**Table 22A-14**). This peak density equated to a population estimate of 739 birds (95% CI 46 – 2,039). No herring gulls were recorded in the Array Area throughout the survey period.

97. Peak estimates in the Llŷr marine ornithology survey area are relatively comparable to those estimated at Erebus (unapportioned 0.99 bird/km^2 in February 2021; HiDef Aerial Surveying Ltd, 2021).

Table 22A-14. Herring gull monthly design-based density and population estimates of all birds (flying and sitting) within the Llŷr marine ornithology survey area and the Array Area plus a 2km buffer

Herring gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	0.00	0.00	0.00	0	0	0	0	0.0
14-Apr-20	0.00	0.00	0.00	0	0	0	0	0.0
08-Jun-20	0.21	0.00	0.59	138	0	377	122	88.4
24-Jun-20	0.16	0.00	0.57	103	0	367	98	95.2
21-Jul-20	0.01	0.00	0.04	8	0	24	8	96.8
31-Aug-20	0.02	0.00	0.07	16	0	48	16	97.2
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.25	0.05	0.53	161	32	337	79	49.0
26-Nov-20	1.16	0.07	3.19	739	46	2,039	629	85.2
10-Jan-21	0.01	0.00	0.04	8	0	24	8	94.5
25-Jan-21	0.11	0.00	0.24	72	0	156	40	54.9
22-Feb-21	0.03	0.00	0.06	17	0	40	11	64.3
14-May-21	0.06	0.00	0.12	36	0	79	21	58.2
27-May-21	0.08	0.00	0.19	49	0	125	34	68.6
15-Jun-21	0.07	0.00	0.18	42	0	115	32	76.2
14-Jul-21	0.02	0.00	0.06	16	0	40	11	66.9
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.01	0.00	0.04	8	0	24	8	94.0
20-Nov-21	0.19	0.05	0.44	122	30	278	69	56.6
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.00	0.00	0.00	0	0	0	0	0.0
Array Area plus 2 km buffer								
25-Mar-20	0.00	0.00	0.00	0	0	0	0	0.0
14-Apr-20	0.00	0.00	0.00	0	0	0	0	0.0
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
21-Jul-20	0.07	0.00	0.20	9	0	25	8	92.6
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.07	0.00	0.20	8	0	25	8	95.1
26-Nov-20	0.07	0.00	0.19	9	0	23	7	80.2
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0

Herring gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.00	0.00	0.00	0	0	0	0	0.0
14-May-21	0.00	0.00	0.00	0	0	0	0	0.0
27-May-21	0.00	0.00	0.00	0	0	0	0	0.0
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.00	0.00	0.00	0	0	0	0	0.0
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.00	0.00	0.00	0	0	0	0	0.0
20-Nov-21	0.20	0.06	0.36	25	8	43	10	37.9
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.00	0.00	0.00	0	0	0	0	0.0

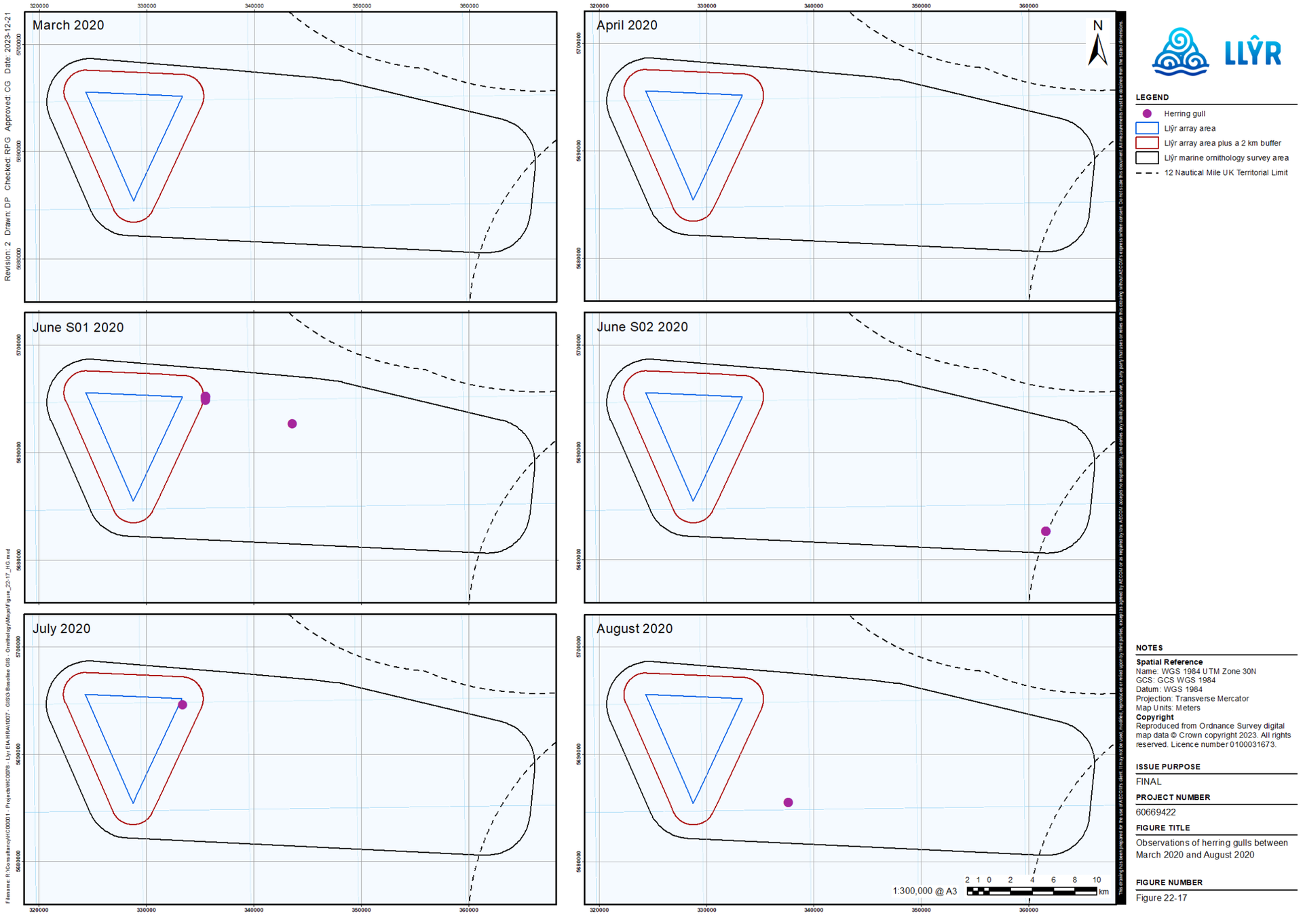


Figure 22A-17. Distribution map of recorded herring gulls within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

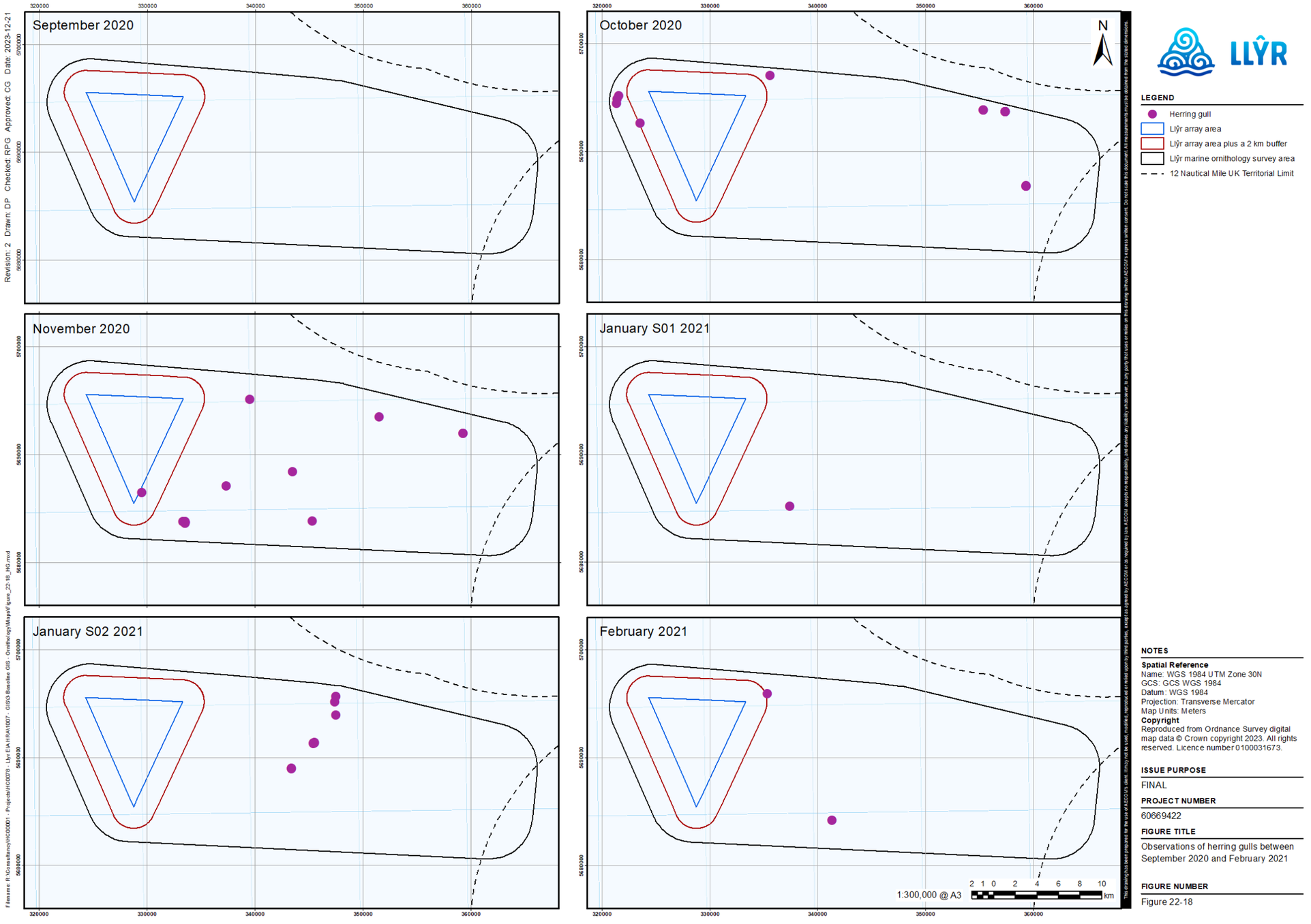


Figure 22A-18. Distribution map of recorded herring gulls within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

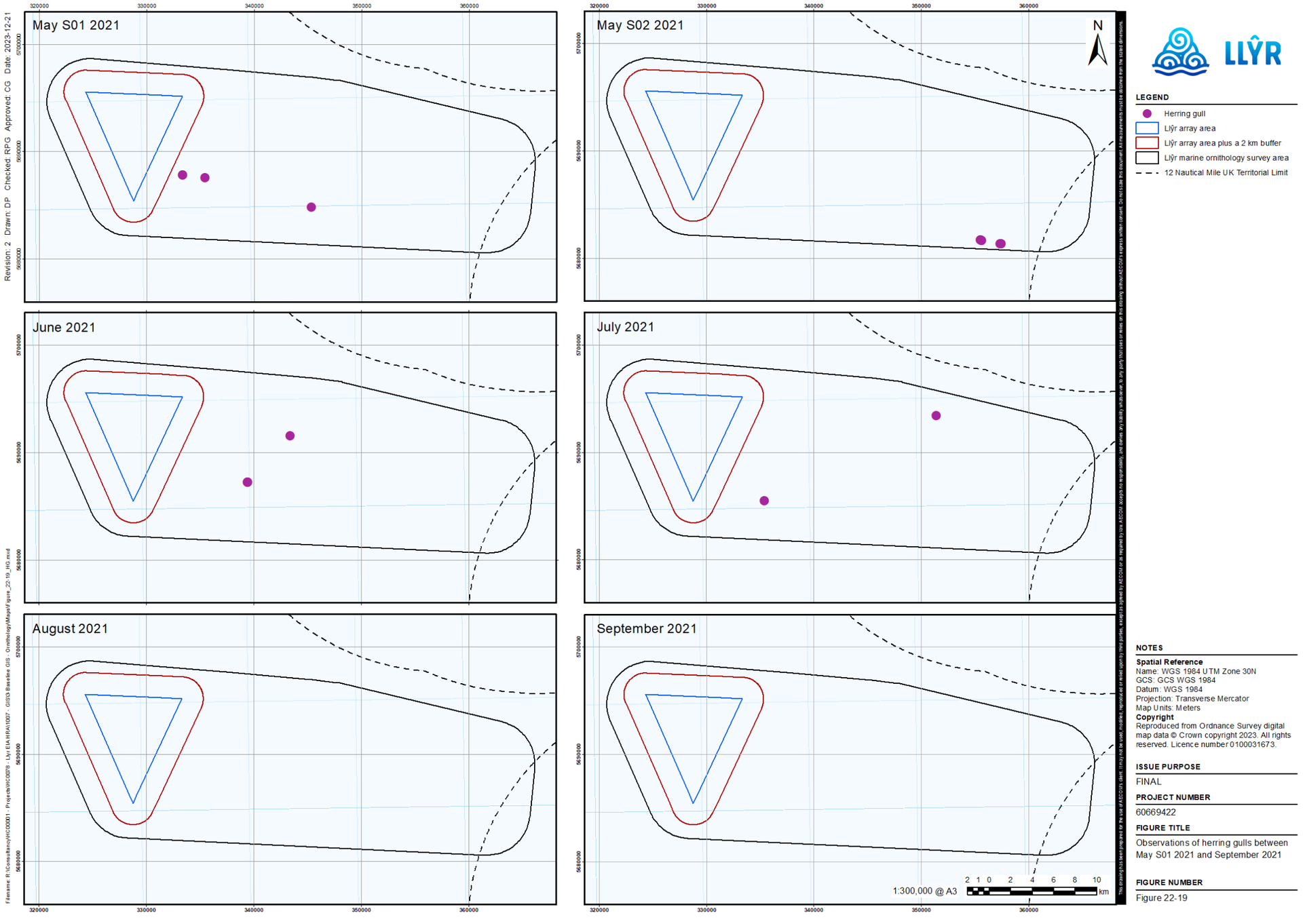


Figure 22A-19. Distribution map of recorded herring gulls within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

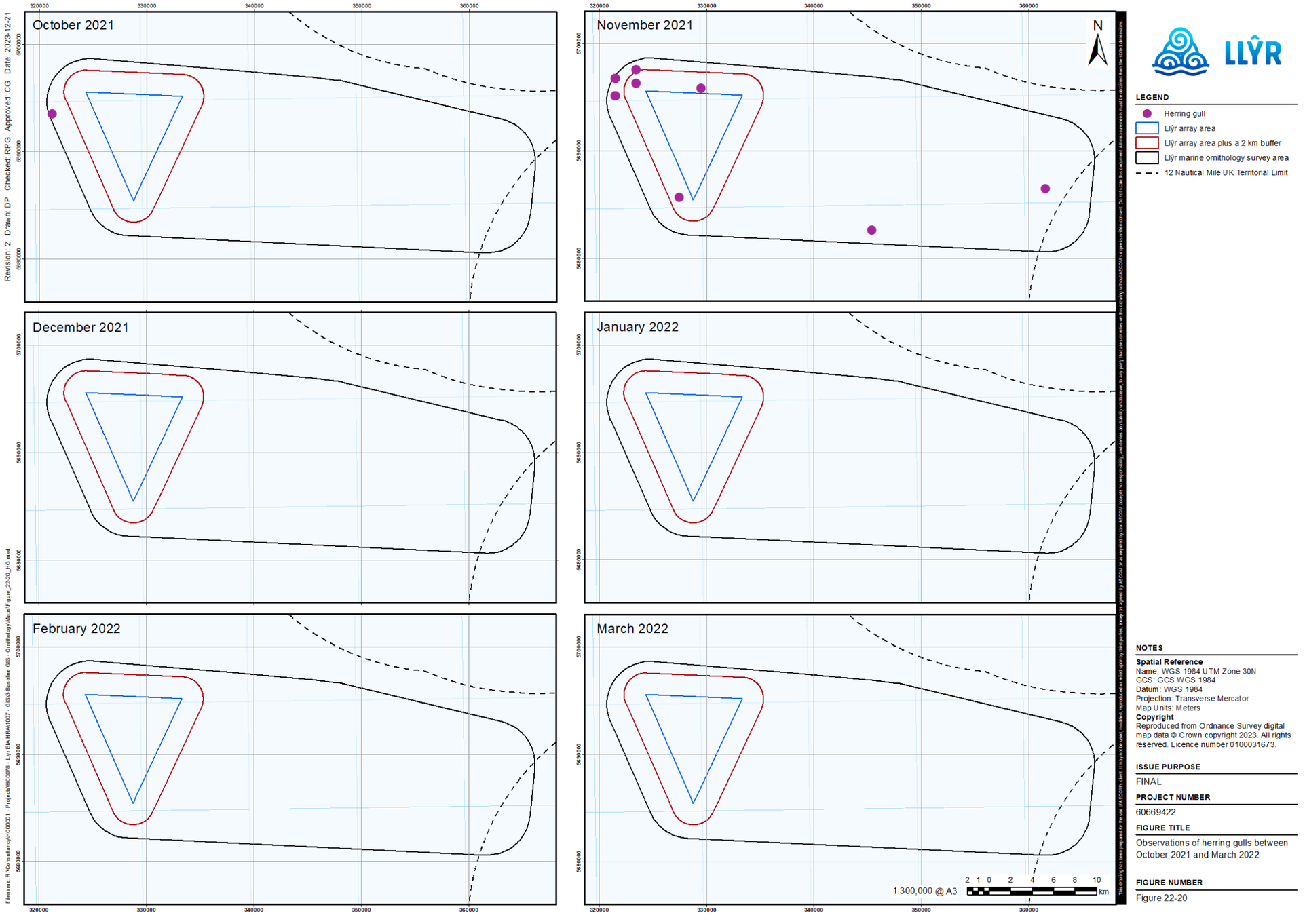


Figure 22A-20. Distribution map of recorded herring gulls within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

Input Densities for CRM

98. In the Array Area, no herring gulls were recorded, therefore, no input densities for CRM can be provided.

Site-based Age Information for PVA

99. Across the Llŷr marine ornithology survey area, the majority of herring gulls were aged as adults, comprising 57% and 82% of aged birds in the breeding and non-breeding season, respectively (**Table 22A-15**). A relatively large proportion of immature birds were also recorded in the breeding season (36%).

Table 22A-15. Percentage of aged herring gulls in each age class averaged across all surveys in each season in the Llŷr marine ornithology survey area

Season	Adult (%)	Immature (%)	Juvenile (%)
Breeding season	57.14	35.71	7.14
Non-breeding season	81.68	16.03	2.29

Lesser Black-Backed Gull

Density and Population Estimates

100. Model-based densities and abundances of all lesser black-backed gulls within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-16**. The highest abundance of lesser black-backed gulls were generally observed during the UK breeding season (**Table 22A-16** and **Appendix 22A: Annex A**). Densities reached a peak of 1.40 birds/km^2 (95% CI 1.07 – 1.78; June S01 2020) and 0.18 birds/km^2 (95% CI 0.11 – 0.29; June S02 2020) in both boundaries, respectively.

101. Albeit following similar distribution as the Erebus data, peak estimates in the Llŷr marine ornithology survey area are relatively higher than those estimated at Erebus (0.57 bird/km^2 in July 2020; HiDef Aerial Surveying Ltd, 2021).

102. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-16. Lesser black-backed gull monthly model-based density and population estimates of all birds (flying and sitting) at Llŷr

Lesser black-backed gull	Density (n/km^2)	LCL (n/km^2)	UCL (n/km^2)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	0.05	0.02	0.12	32	14	79	17	54.1
14-Apr-20	0.05	0.01	0.11	32	8	69	16	50.4
08-Jun-20	1.40	1.07	1.78	899	684	1,142	117	13.0
24-Jun-20	0.18	0.11	0.28	115	68	181	29	25.6
21-Jul-20	0.03	0.01	0.07	16	3	43	11	71.0
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.08	0.04	0.16	53	26	105	23	43.6
26-Nov-20	0.04	0.01	0.12	26	7	76	16	63.2
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.01	0.00	0.06	9	1	35	15	163.3
22-Feb-21	0.01	0.00	0.06	9	1	37	11	120.5

Lesser black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
14-May-21	0.11	0.06	0.20	69	35	130	26	37.8
27-May-21	0.05	0.02	0.09	31	11	56	18	59.1
15-Jun-21	0.10	0.05	0.18	62	31	117	24	39.3
14-Jul-21	0.01	0.00	0.06	9	1	39	11	117.5
16-Aug-21	0.02	0.01	0.06	15	3	41	10	66.0
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.05	0.01	0.09	29	8	57	13	43.5
20-Nov-21	0.01	0.00	0.06	8	1	35	10	128.8
16-Dec-21	0.03	0.01	0.07	16	3	46	14	85.2
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.08	0.03	0.15	48	22	95	19	38.8
20-Mar-22	0.09	0.04	0.18	55	27	115	22	40.6
Array Area								
25-Mar-20	0.05	0.02	0.11	2	1	5	1	63.2
14-Apr-20	0.05	0.02	0.13	2	1	6	2	80.9
08-Jun-20	0.13	0.05	0.29	6	2	13	3	49.9
24-Jun-20	0.18	0.11	0.29	8	5	13	2	25.7
21-Jul-20	0.02	0.00	0.09	1	0	4	1	125.8
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.09	0.05	0.18	4	2	8	2	43.6
26-Nov-20	0.05	0.00	0.09	2	0	4	2	78.2
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.02	0.00	0.07	1	0	3	1	121.7
22-Feb-21	0.02	0.00	0.05	1	0	2	1	68.9
14-May-21	0.13	0.05	0.38	6	2	17	4	69.7
27-May-21	0.05	0.02	0.13	2	1	6	1	68.6
15-Jun-21	0.09	0.05	0.18	4	2	8	2	43.1
14-Jul-21	0.02	0.00	0.07	1	0	3	1	103.0
16-Aug-21	0.02	0.00	0.07	1	0	3	1	99.8
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.05	0.02	0.09	2	1	4	1	53.4
20-Nov-21	0.00	0.00	0.05	0	0	2	1	0.0
16-Dec-21	0.02	0.00	0.07	1	0	3	1	73.1
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.07	0.02	0.16	3	1	7	2	52.0
20-Mar-22	0.13	0.05	0.22	6	2	10	2	39.6
Array Area plus 2 km buffer								
25-Mar-20	0.04	0.02	0.08	5	2	10	2	49.3
14-Apr-20	0.05	0.02	0.11	6	2	13	3	51.7
08-Jun-20	1.12	0.70	1.89	134	83	225	39	28.9
24-Jun-20	0.19	0.11	0.30	22	13	36	6	26.5
21-Jul-20	0.03	0.01	0.08	3	1	10	3	87.8
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0

Lesser black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
22-Oct-20	0.10	0.03	0.21	12	4	25	5	42.6
26-Nov-20	0.04	0.01	0.12	5	1	14	4	70.8
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.01	0.00	0.03	1	0	4	1	144.2
22-Feb-21	0.01	0.00	0.04	1	0	5	1	141.3
14-May-21	0.19	0.06	0.46	22	7	55	12	52.9
27-May-21	0.05	0.02	0.13	6	2	16	3	57.0
15-Jun-21	0.09	0.04	0.17	11	5	20	4	36.3
14-Jul-21	0.02	0.00	0.08	2	0	9	2	107.7
16-Aug-21	0.03	0.01	0.08	3	1	10	3	93.9
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.05	0.02	0.13	6	2	15	4	73.0
20-Nov-21	0.02	0.00	0.04	2	0	5	7	358.4
16-Dec-21	0.03	0.01	0.07	3	1	8	2	60.5
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.08	0.03	0.16	9	4	19	4	43.3
20-Mar-22	0.13	0.05	0.27	15	6	32	7	47.7

Distribution and Spatial Densities

103. Lesser black-backed gulls were recorded throughout the Llŷr marine ornithology survey area, primarily to the east and south of the Array Area and were observed during both the breeding and non-breeding seasons (**Figure 22A-21** to **Figure 22A-24**).

104. Mean model-based density surfaces of lesser black-backed gulls are presented in **Figure 22A-25** to **Figure 22A-28**. In general, higher densities were observed in the 2 km buffer around the Array Area, albeit no significant trend can be concluded due to the small densities estimated.

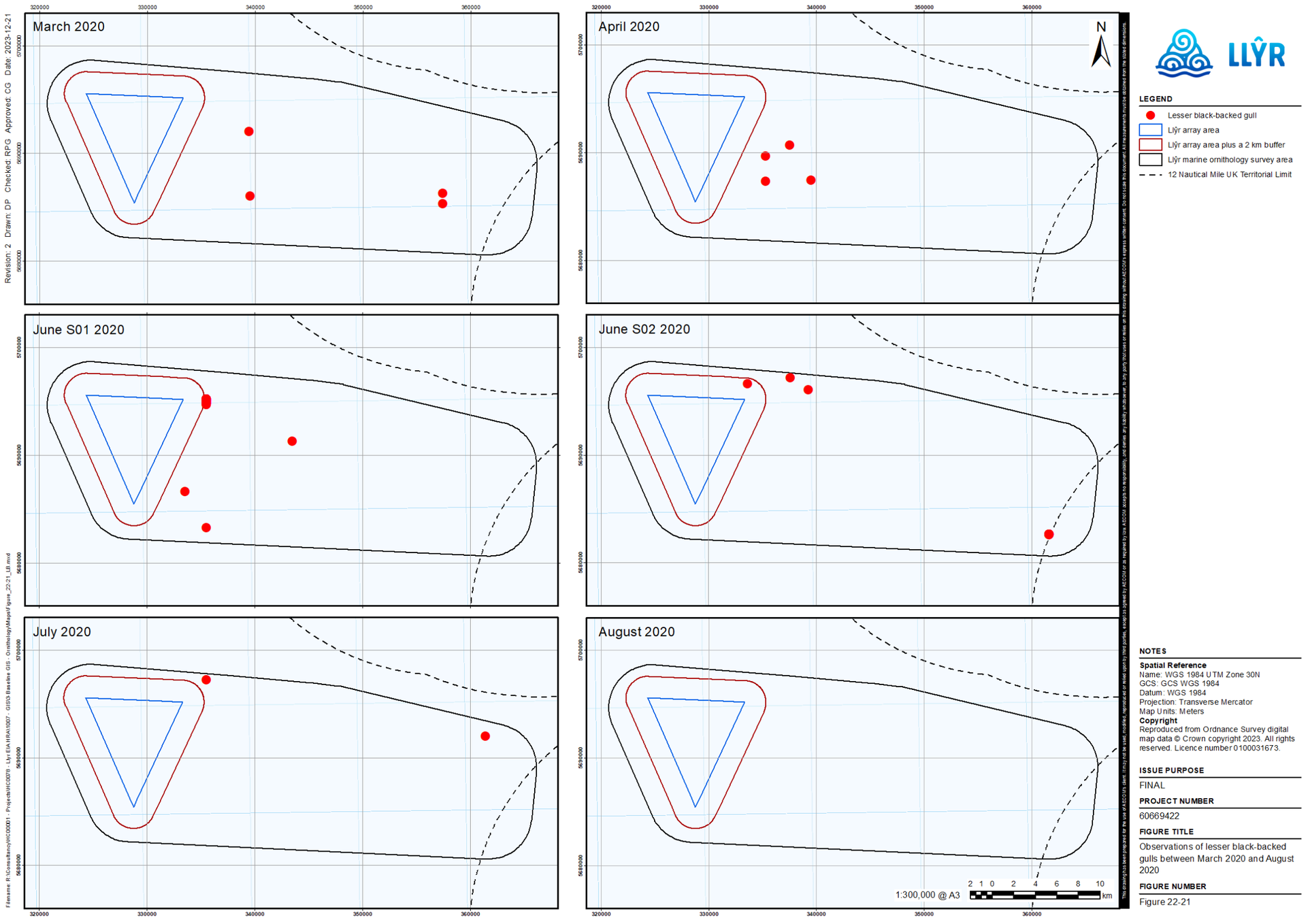


Figure 22A-21. Distribution map of recorded lesser black-backed gulls within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

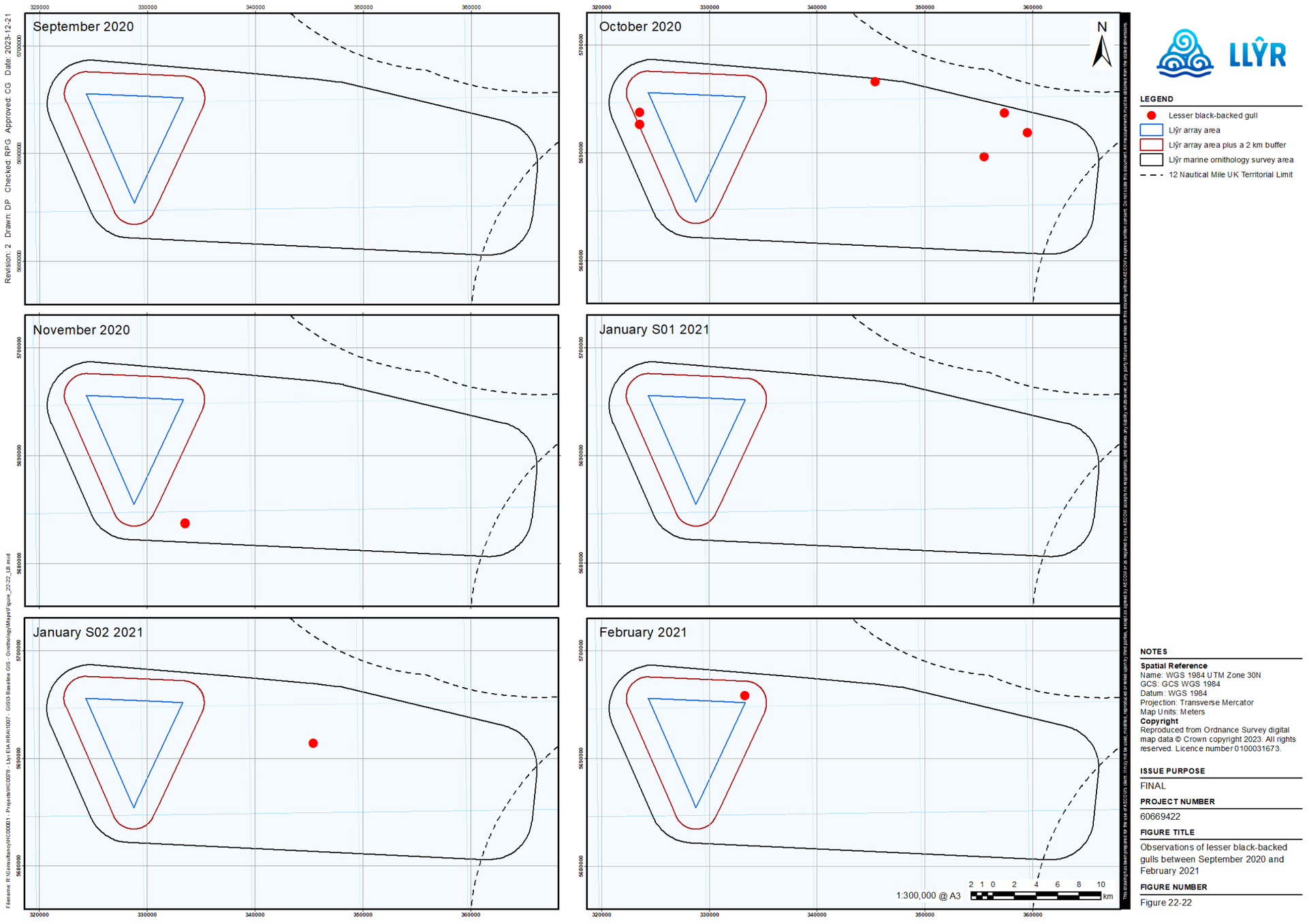


Figure 22A-22. Distribution map of recorded lesser black-backed gulls within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

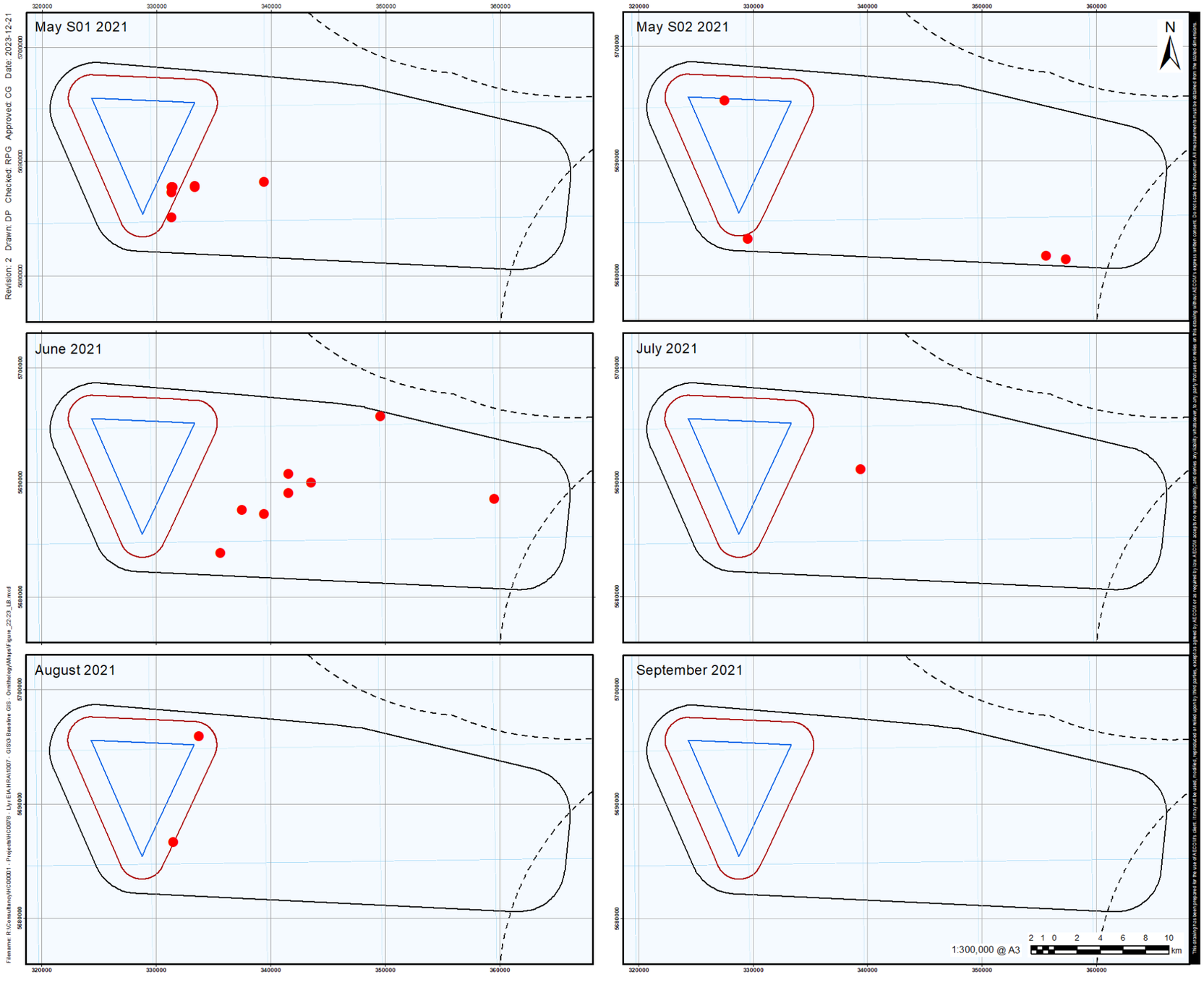


Figure 22A-23. Distribution map of recorded lesser black-backed gulls within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

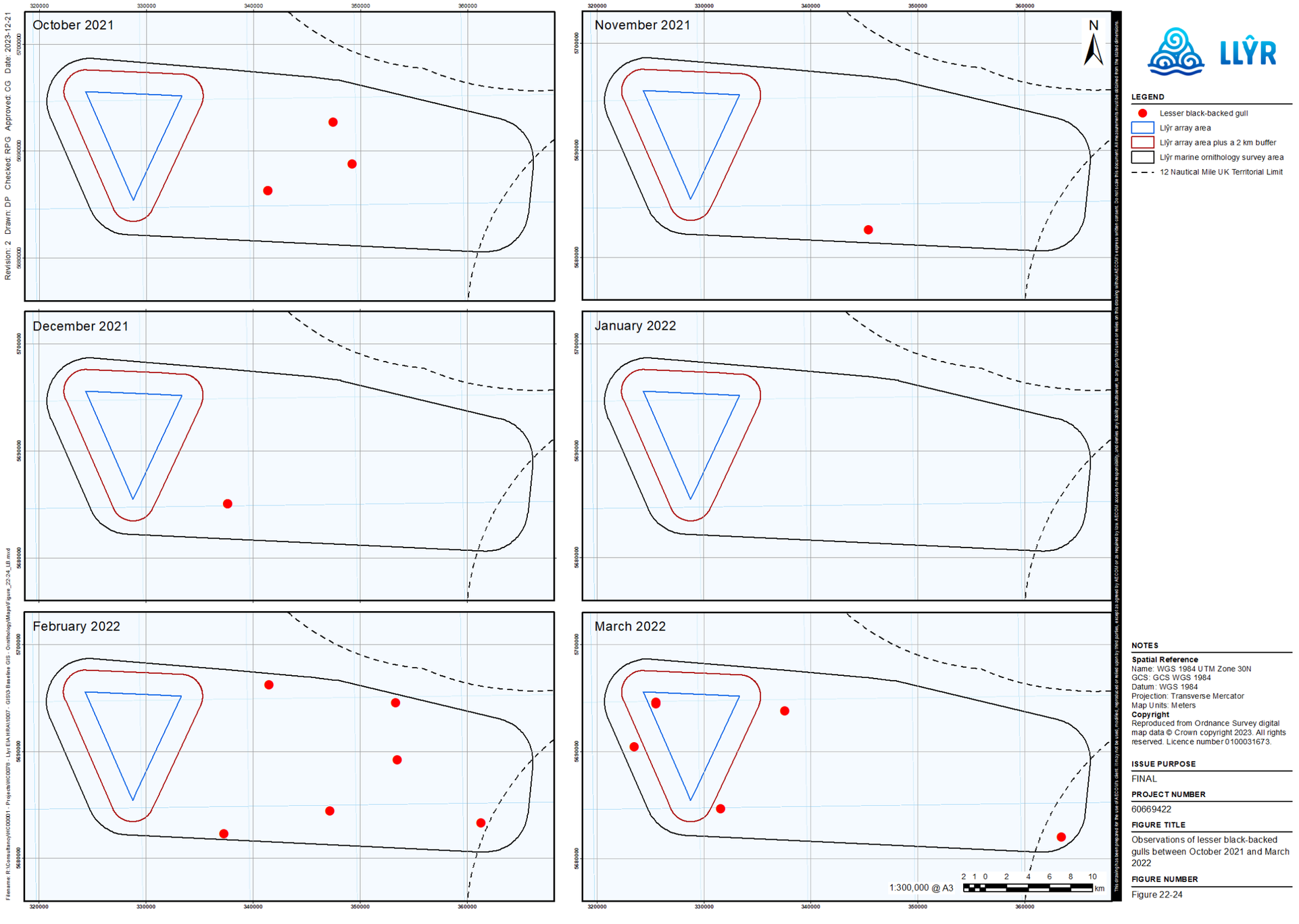


Figure 22A-24. Distribution map of recorded lesser black-backed gulls within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

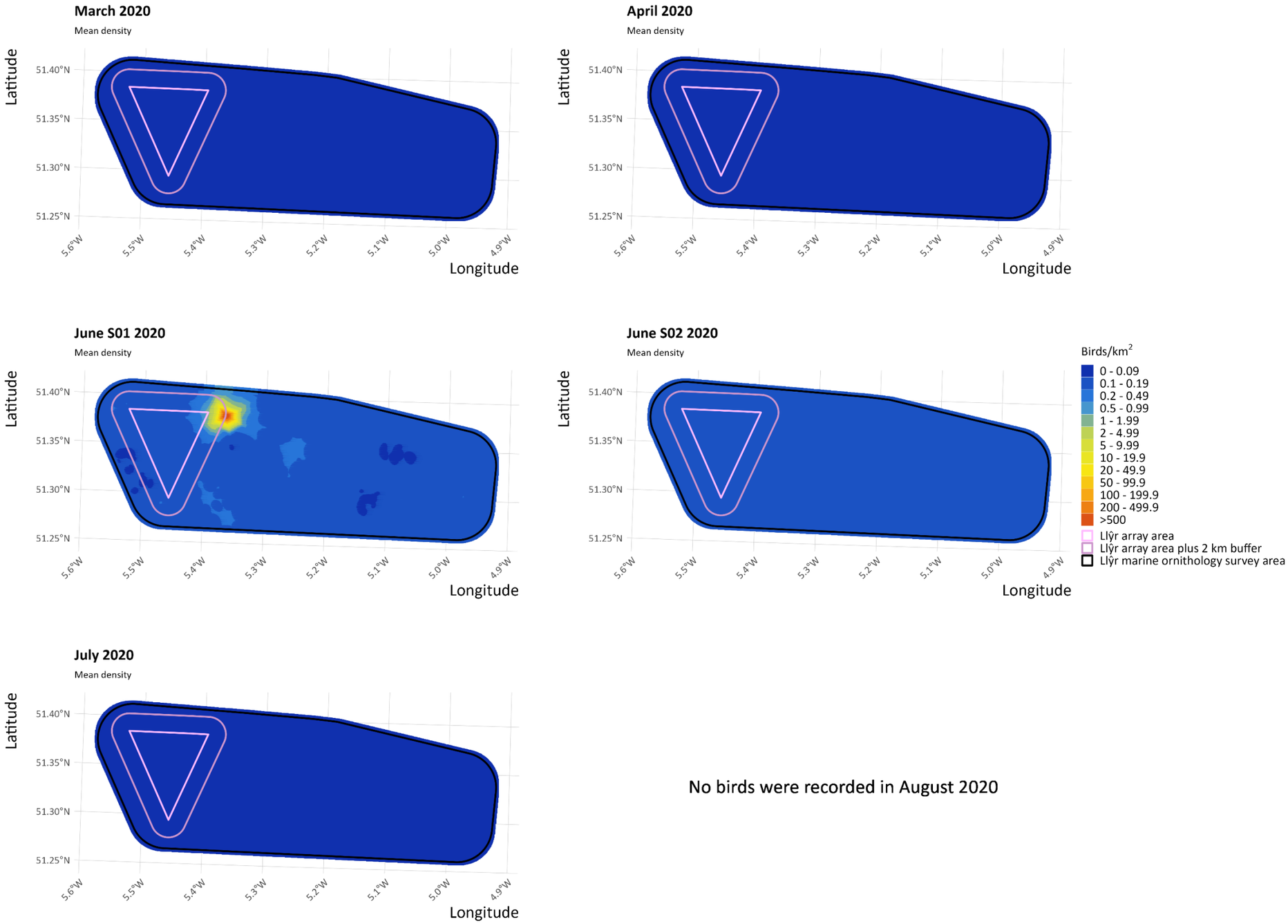
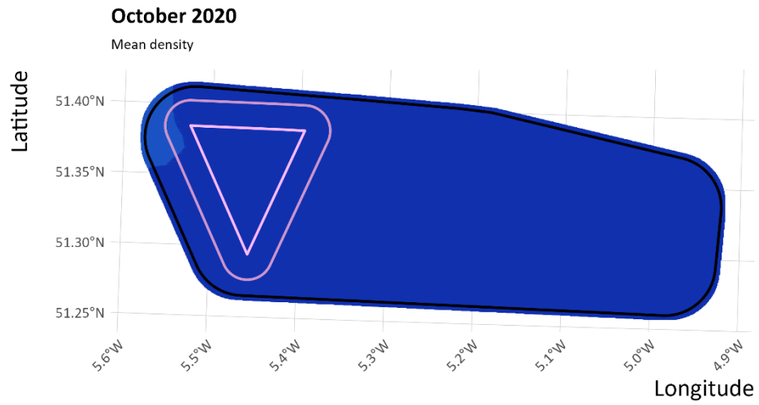
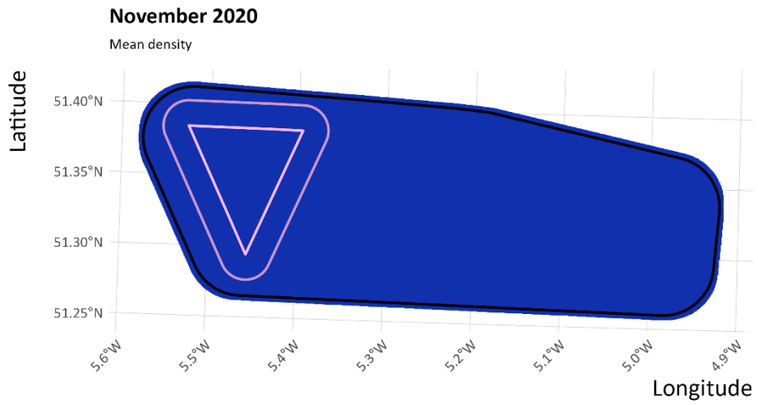


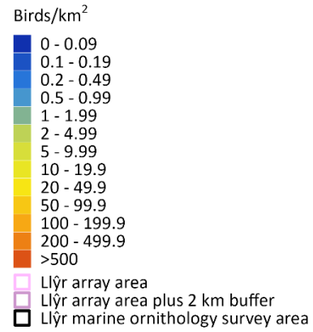
Figure 22A-25. Mean model-based density surfaces for all lesser black-backed gulls (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

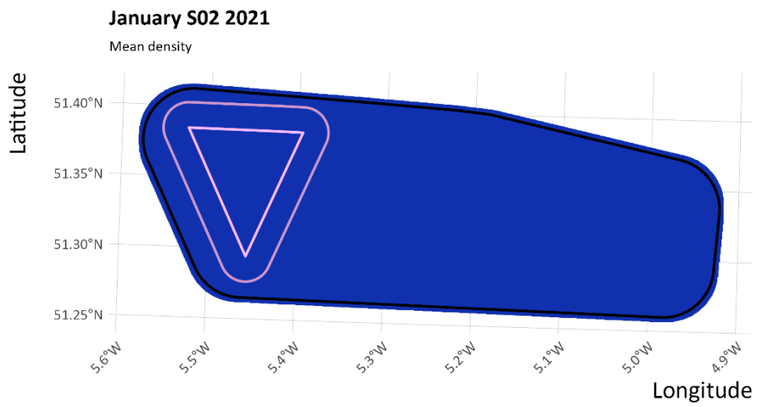
No birds were recorded in September 2020





No birds were recorded in January S01 2021





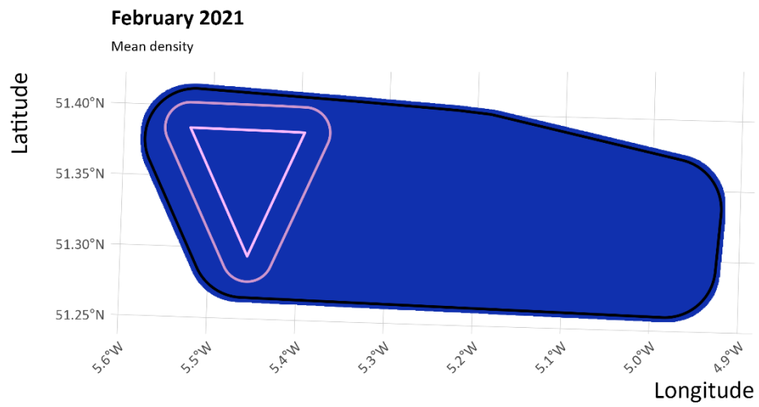


Figure 22A-26. Mean model-based density surfaces for all lesser black-backed gulls (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

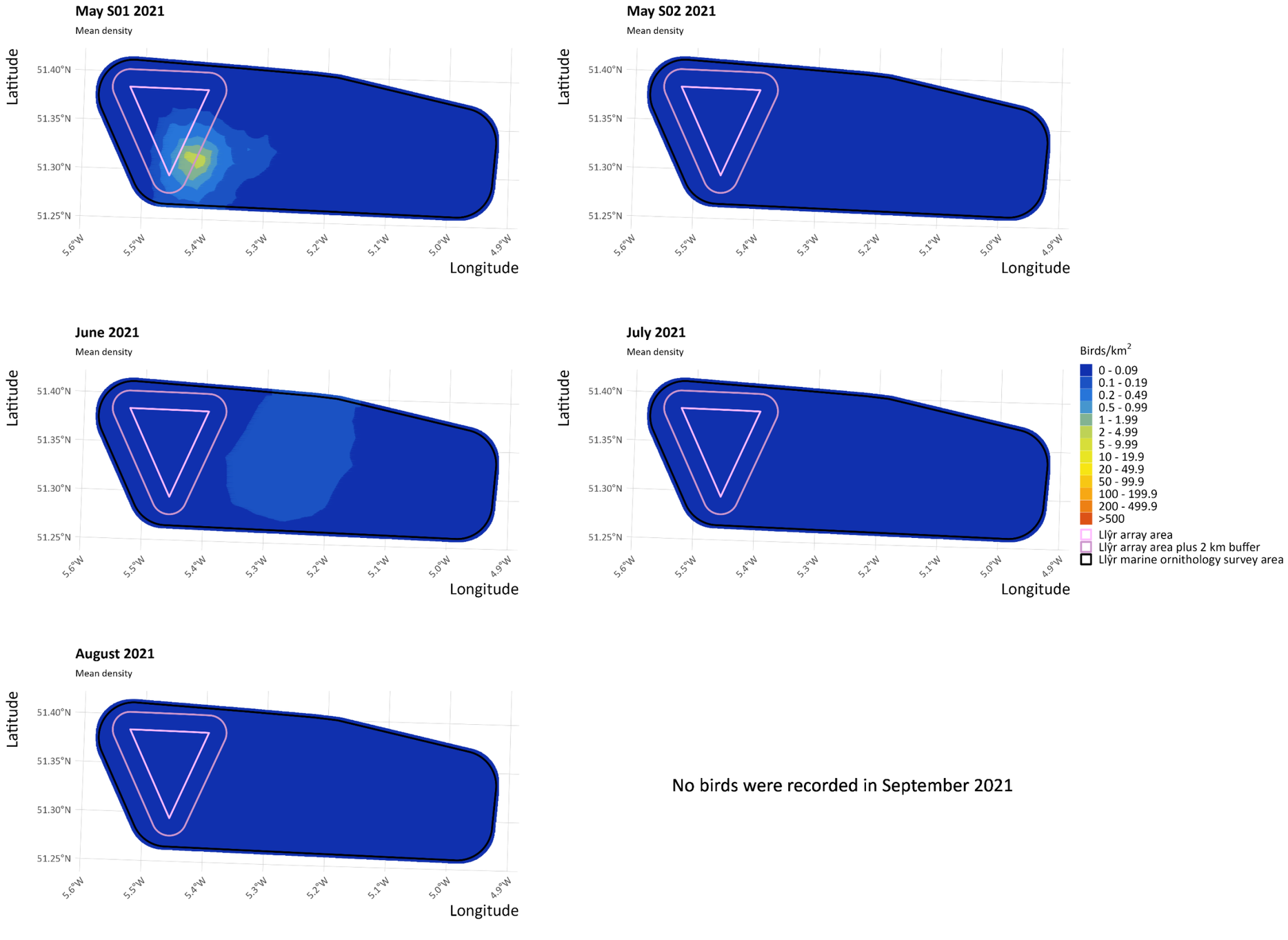


Figure 22A-27. Mean model-based density surfaces for all lesser black-backed gulls (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

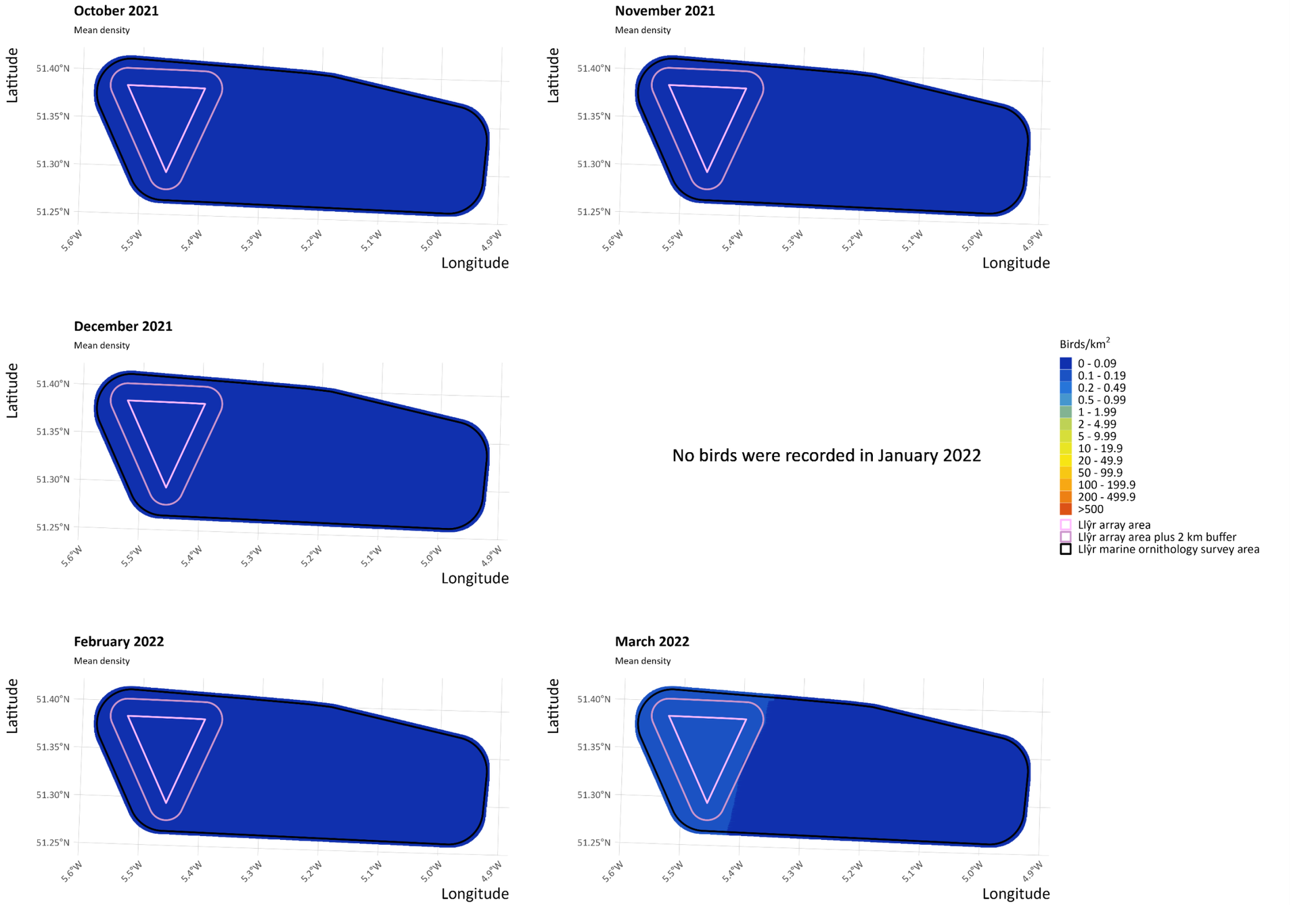


Figure 22A-28. Mean model-based density surfaces for all lesser black-backed gulls (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

Input Densities for CRM

105. Model-based density estimates of flying lesser black-backed gulls within the Array Area are provided as a mean (n/km^2) with associated SD for input into CRM (**Appendix 22C: Marine Ornithology Collision Risk Modelling**).

106. The maximum model-based flying density estimate in the Array Area was recorded in the UK breeding season and spring migration period, with 0.13 birds/km^2 (0.06 SD; June S01 2020 and March 2022) (**Table 22A-17** and **Figure 22A-29**). Comparative design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-17. Model-based density estimates of flying lesser black-backed gulls within the Array Area

Lesser black-backed gull	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	SD (n/km²)	CV density (%)
25-Mar-20	0.05	0.00	0.11	0.03	58.9
14-Apr-20	0.05	0.02	0.13	0.03	67.6
08-Jun-20	0.13	0.07	0.31	0.06	42.5
24-Jun-20	0.05	0.02	0.11	0.03	61.2
21-Jul-20	0.02	0.00	0.07	0.02	70.3
31-Aug-20	0.00	0.00	0.00	0.00	0.0
12-Sep-20	0.00	0.00	0.00	0.00	0.0
22-Oct-20	0.07	0.02	0.13	0.03	42.8
26-Nov-20	0.00	0.00	0.00	0.00	0.0
10-Jan-21	0.00	0.00	0.00	0.00	0.0
25-Jan-21	0.02	0.00	0.05	0.01	64.1
22-Feb-21	0.02	0.00	0.05	0.01	60.1
14-May-21	0.07	0.02	0.11	0.03	50.9
27-May-21	0.02	0.00	0.05	0.01	62.8
15-Jun-21	0.09	0.05	0.16	0.03	36.1
14-Jul-21	0.02	0.00	0.05	0.01	51.1
16-Aug-21	0.02	0.00	0.09	0.02	102.3
01-Sep-21	0.00	0.00	0.00	0.00	0.0
22-Oct-21	0.05	0.02	0.11	0.03	54.5
20-Nov-21	0.00	0.00	0.00	0.00	0.0
16-Dec-21	0.02	0.00	0.07	0.02	85.2
05-Jan-22	0.00	0.00	0.00	0.00	0.0
26-Feb-22	0.07	0.02	0.13	0.03	49.2
20-Mar-22	0.13	0.05	0.27	0.06	44.1

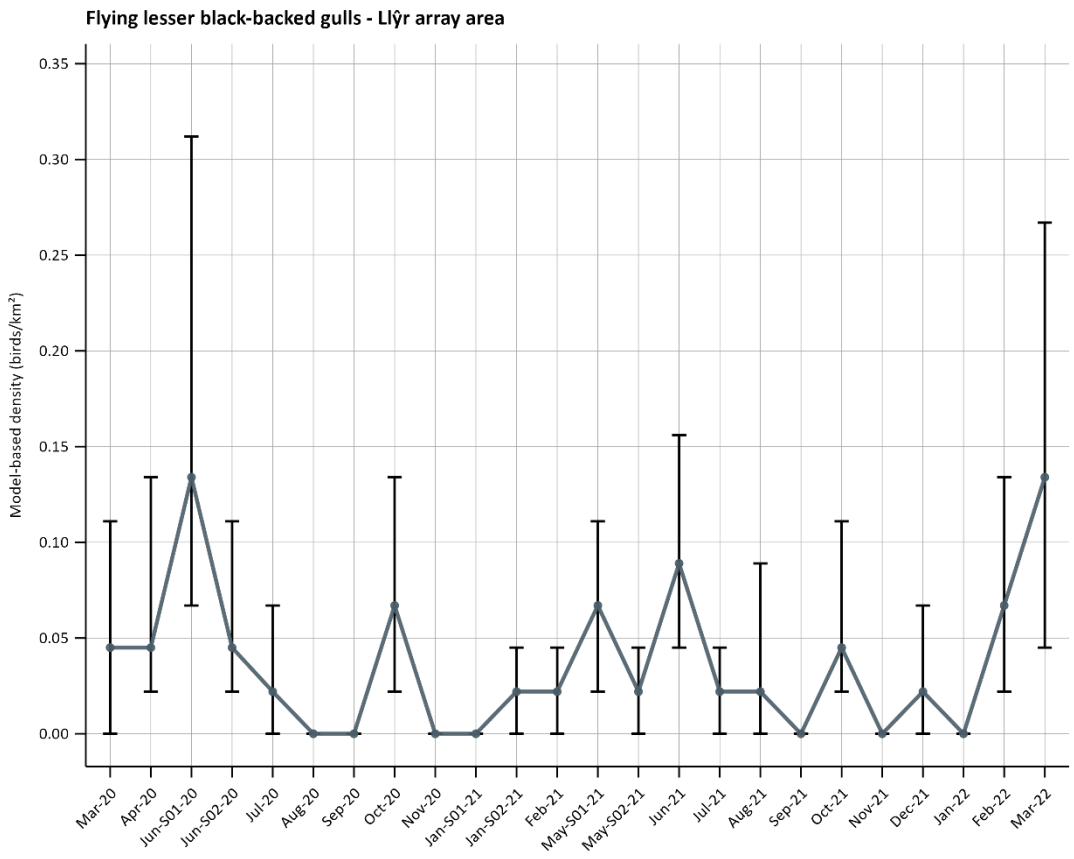


Figure 22A-29. Monthly model-based densities of flying lesser black-backed gulls within the Array Area (associated credible intervals are represented by error bars)

Site-based Age Information for PVA

107. Across the Llŷr marine ornithology survey area, the majority of lesser black-backed gulls were aged as adults, which made up for more than 80% of aged birds in the breeding season, non-breeding season and spring migration period. During the autumn migration, 45% of lesser black-backed gulls were recorded as adult and 55% were recorded as immatures (**Table 22A-18**).

Table 22A-18. Percentage of aged lesser black-backed gulls in each age class averaged across all surveys in each season in the Llŷr marine ornithology survey area

Season	Adult (%)	Immature (%)	Juvenile (%)
Breeding season	80.85	18.09	1.06
Autumn migration	45.45	54.55	0.00
Spring migration	100	0.00	0.00
Non-breeding season	92.31	7.69	0.00

Guillemot

Density and Population Estimates

108. Model-based absolute densities and abundances of all guillemots within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-19**. The highest abundance of guillemots were generally observed during the non-breeding season (**Table 22A-19** and **Appendix 22A: Annex A**). Densities reached a peak of 54.32 birds/km^2 (95% CI 44.25– 66.50) and 184.54 birds/km^2 (95% CI 165.54 – 207.38) in October 2020 in both boundaries, respectively.

109. Peak estimates in the Llŷr marine ornithology survey area are comparable to those estimated at Erebus (160.77 bird/km^2 in August 2020 and 64.76 bird/km^2 in October 2020; HiDef Aerial Surveying Ltd, 2021).

110. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-19. Guillemot monthly model-based absolute density and population estimates of all birds (flying and sitting) at Llŷr

Guillemot	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	14.11	9.33	21.35	10,218	9,339	11,181	2,104	23.3
14-Apr-20	19.33	14.60	25.58	13,117	12,211	14,031	1,900	15.3
08-Jun-20	1.64	0.89	2.75	1,064	821	1,367	321	30.6
24-Jun-20	17.74	13.47	23.11	11,688	10,941	12,485	1,639	14.4
21-Jul-20	9.12	6.29	12.91	6,067	5,504	6,574	1,135	19.4
31-Aug-20	22.32	16.66	29.48	14,657	13,766	15,491	2,186	15.3
12-Sep-20	30.46	23.72	38.84	20,923	20,082	21,958	2,577	13.2
22-Oct-20	54.32	44.25	66.50	36,797	35,465	38,101	3,800	10.9
26-Nov-20	31.52	24.22	40.60	20,990	19,986	22,099	2,806	13.9
10-Jan-21	13.59	9.41	19.30	9,044	8,371	9,891	1,705	19.6
25-Jan-21	29.44	22.54	37.96	19,137	18,187	20,116	2,620	13.9
22-Feb-21	25.13	20.14	31.08	16,024	14,876	17,059	1,860	11.5
14-May-21	8.09	6.06	10.57	5,184	4,681	5,835	775	15.0
27-May-21	9.64	6.50	13.85	6,227	5,593	6,824	1,252	20.3
15-Jun-21	7.65	5.15	11.09	4,990	4,465	5,554	1,020	20.8
14-Jul-21	5.79	3.81	8.61	3,869	3,436	4,332	830	22.4
16-Aug-21	2.64	1.61	4.24	1,791	1,537	2,094	453	26.8
01-Sep-21	0.23	0.06	0.67	160	91	285	110	75.7
22-Oct-21	43.28	34.05	54.65	29,753	28,470	31,239	3,517	12.7
20-Nov-21	39.32	30.33	50.53	26,842	25,540	28,210	3,469	13.8
16-Dec-21	0.39	0.10	1.05	273	157	439	170	68.5
05-Jan-22	0.77	0.35	1.55	505	355	710	210	42.5
26-Feb-22	0.70	0.17	1.98	519	336	731	328	72.8
20-Mar-22	24.02	17.97	31.76	16,012	15,099	16,959	2,342	15.2

Guillemot	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Array Area								
25-Mar-20	4.62	2.20	9.00	276	170	421	83	40.3
14-Apr-20	2.22	1.05	4.31	105	55	164	39	39.2
08-Jun-20	1.19	0.60	2.12	55	27	91	18	33.8
24-Jun-20	2.87	1.72	4.32	138	85	212	32	25.1
21-Jul-20	3.89	2.41	6.12	188	132	269	44	25.3
31-Aug-20	41.95	34.21	51.29	1,926	1,709	2,174	206	11.0
12-Sep-20	36.58	28.92	45.16	1,673	1,439	1,902	194	11.8
22-Oct-20	184.54	165.54	207.38	8,953	8,304	9,517	487	5.9
26-Nov-20	11.22	7.61	15.86	527	405	673	99	19.7
10-Jan-21	14.38	10.34	19.22	665	544	802	107	16.6
25-Jan-21	26.60	20.51	33.93	1,208	1,027	1,400	159	13.3
22-Feb-21	10.98	8.24	14.23	505	391	626	70	14.2
14-May-21	9.36	7.32	11.82	421	329	520	54	12.9
27-May-21	5.98	3.85	8.86	281	197	389	61	22.6
15-Jun-21	3.95	2.54	5.99	188	132	276	42	23.6
14-Jul-21	1.09	0.47	2.16	51	27	91	21	42.8
16-Aug-21	0.45	0.14	1.12	19	6	40	12	58.5
01-Sep-21	0.29	0.09	0.79	15	3	40	9	69.1
22-Oct-21	31.12	23.93	39.90	1,497	1,314	1,698	188	13.5
20-Nov-21	62.33	49.78	76.79	2,911	2,624	3,311	322	11.5
16-Dec-21	0.31	0.08	0.85	14	3	33	10	69.9
05-Jan-22	0.80	0.36	1.62	36	16	75	16	44.0
26-Feb-22	1.26	0.45	2.84	68	30	132	30	52.4
20-Mar-22	28.46	21.87	36.93	1,311	1,095	1,508	177	13.9
Array Area plus 2 km buffer								
25-Mar-20	5.20	2.53	9.94	761	567	1,023	242	39.1
14-Apr-20	2.85	1.43	5.12	363	260	529	120	35.4
08-Jun-20	1.25	0.66	2.13	152	95	224	47	31.8
24-Jun-20	3.01	1.73	4.89	367	258	485	101	28.1
21-Jul-20	4.15	2.59	6.31	518	389	689	118	23.8
31-Aug-20	41.27	32.96	50.78	5,104	4,679	5,620	563	11.5
12-Sep-20	37.96	30.03	47.51	4,671	4,232	5,112	558	12.3
22-Oct-20	130.26	113.16	149.09	16,823	15,933	17,755	1,134	7.3
26-Nov-20	12.75	8.48	18.16	1,584	1,319	1,888	309	20.3
10-Jan-21	13.80	9.48	19.16	1,701	1,466	1,978	307	18.6
25-Jan-21	27.33	21.10	34.89	3,302	2,947	3,694	433	13.3

Guillemot	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
22-Feb-21	11.39	8.66	14.87	1,358	1,128	1,605	196	14.4
14-May-21	9.01	6.99	11.53	1,105	938	1,314	145	13.5
27-May-21	6.36	4.11	9.52	778	605	950	172	22.7
15-Jun-21	4.20	2.67	6.31	509	378	661	118	23.5
14-Jul-21	1.18	0.55	2.32	158	96	251	57	40.5
16-Aug-21	0.42	0.14	0.98	53	19	100	28	54.7
01-Sep-21	0.34	0.10	0.86	47	17	97	25	61.5
22-Oct-21	40.30	31.72	50.49	5,196	4,746	5,681	599	12.5
20-Nov-21	73.60	60.14	88.70	9,196	8,490	9,881	912	10.4
16-Dec-21	0.41	0.11	1.13	48	16	102	32	67.1
05-Jan-22	0.79	0.34	1.60	93	49	169	40	42.7
26-Feb-22	1.08	0.33	2.69	172	90	284	78	60.4
20-Mar-22	26.50	20.02	34.56	3,291	2,946	3,623	463	14.7

Distribution and Spatial Densities

111. Guillemots were widespread across the Llŷr marine ornithology survey area, with observations in the Array Area as well as the 2 km buffer (**Figure 22A-30** to **Figure 22A-33**).

112. Mean model-based density surfaces of guillemots are presented in **Figure 22A-34** to **Figure 22A-37**. In general, higher densities occurred in the east of the Llŷr marine ornithology survey area during the spring and early summer months, with higher densities occurring in the west of the Llŷr marine ornithology survey area in late summer and autumn. The highest densities occurred across the Array Area and associated buffer in October and November.

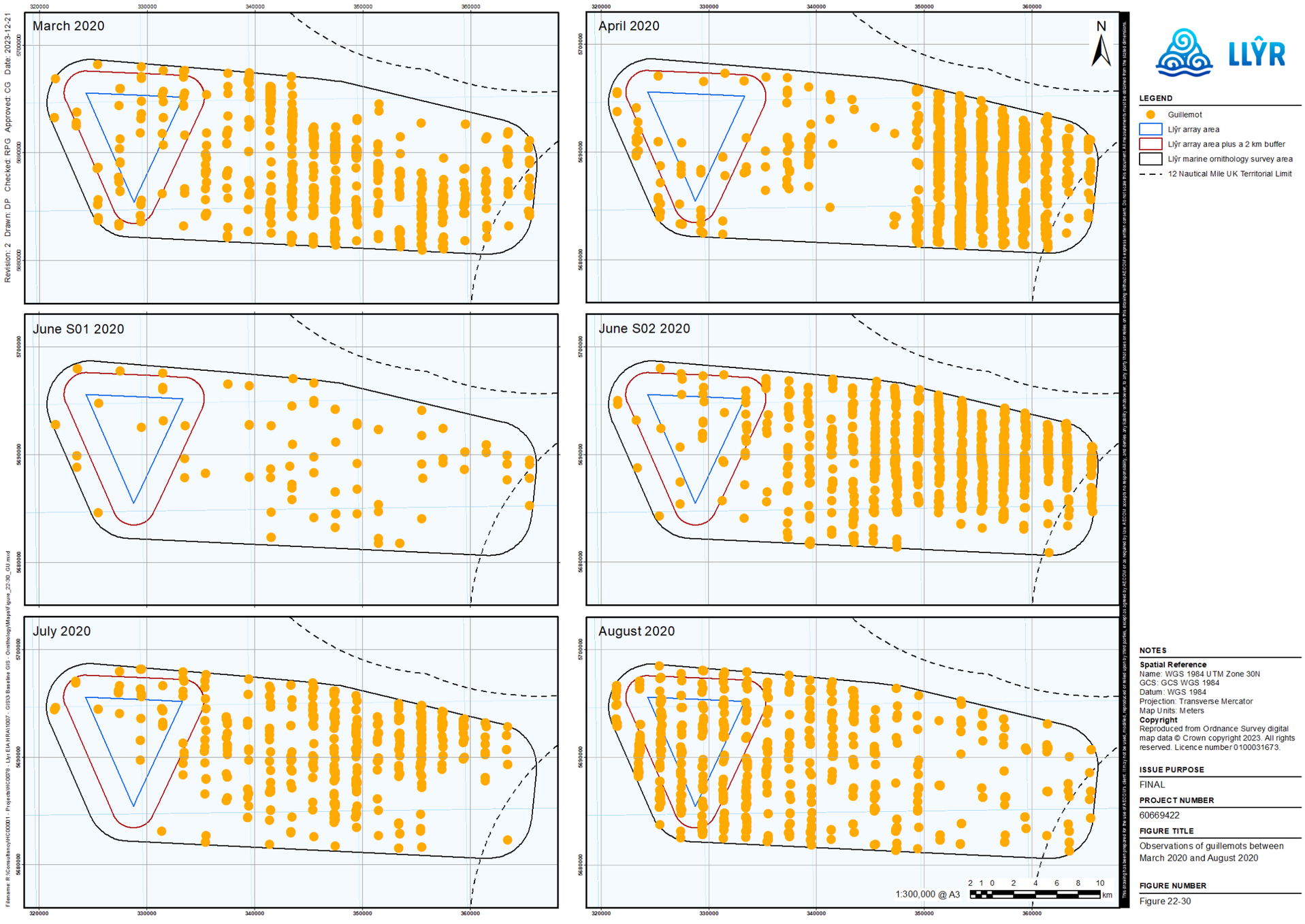


Figure 22A-30. Distribution map of recorded guillemots within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

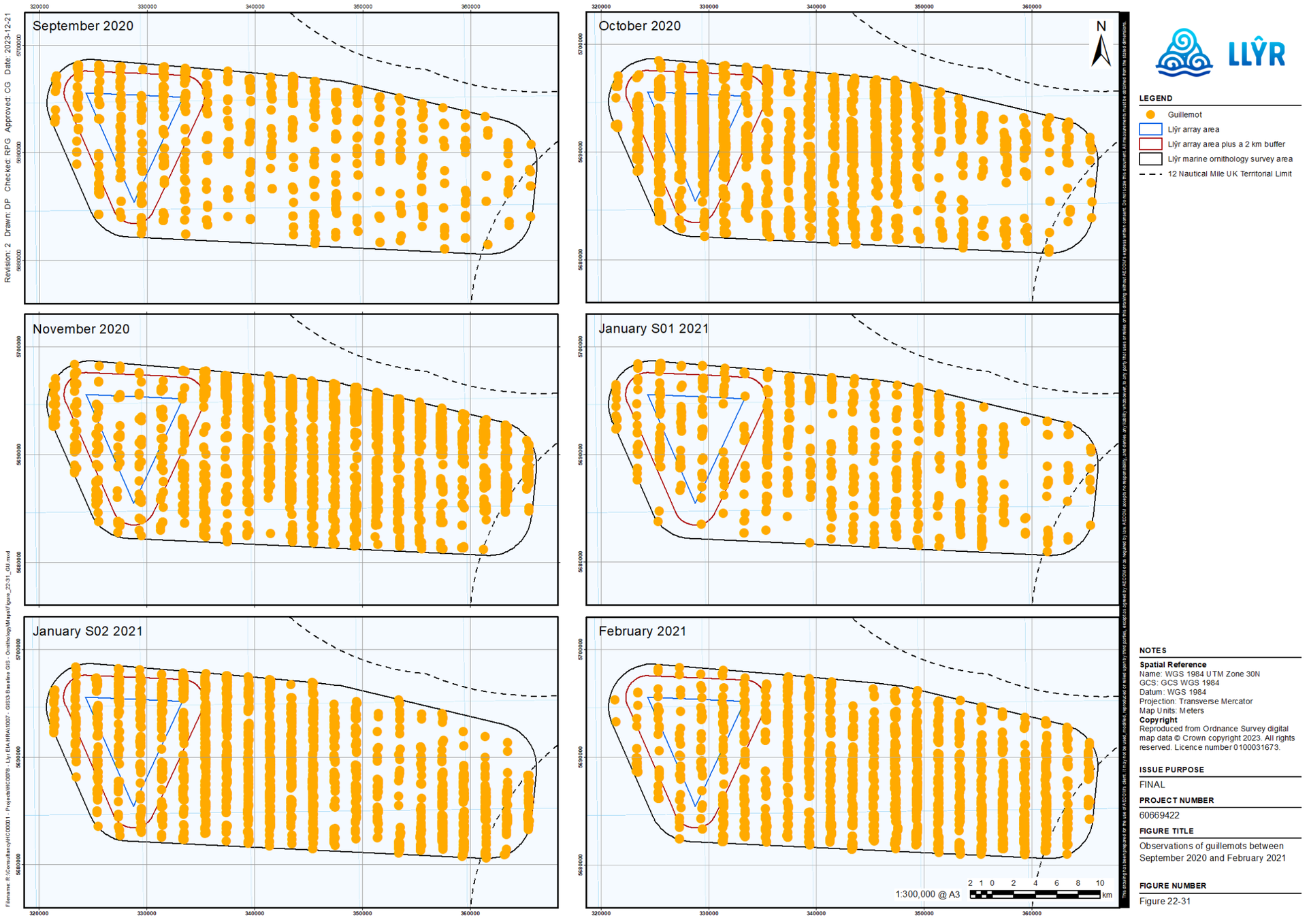


Figure 22A-31. Distribution map of recorded guillemots within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

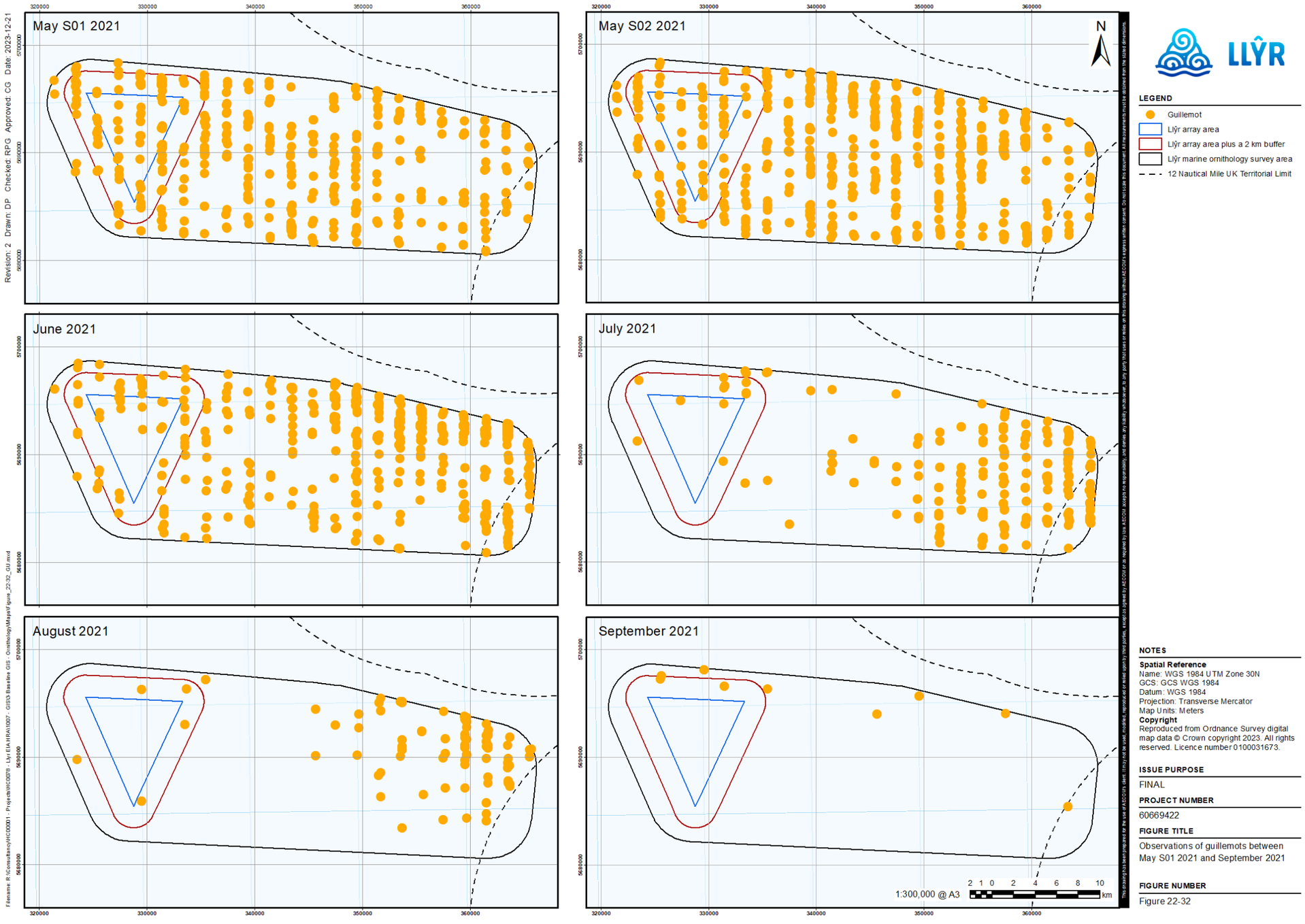


Figure 22A-32. Distribution map of recorded guillemots within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

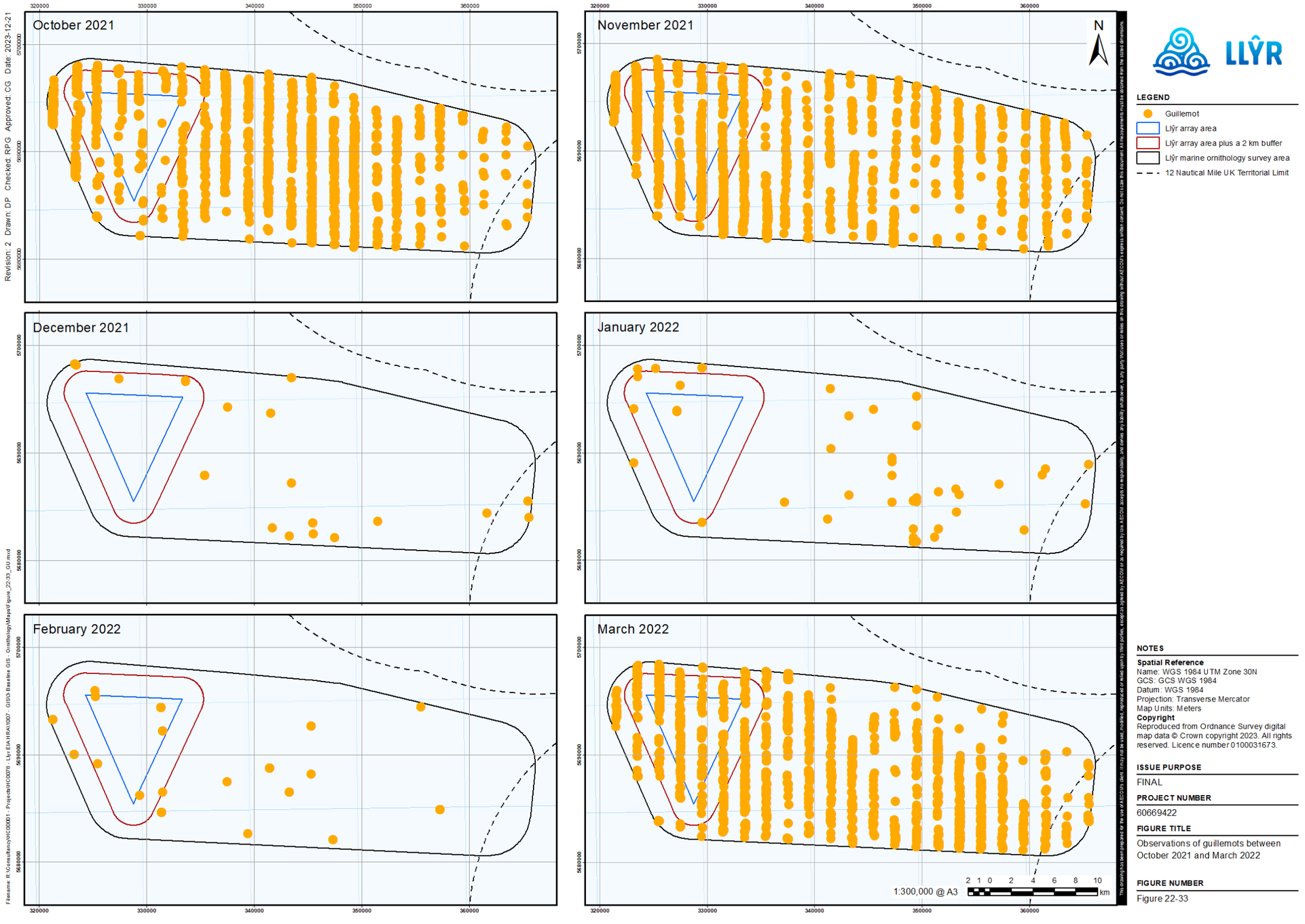


Figure 22A-33. Distribution map of recorded guillemots within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

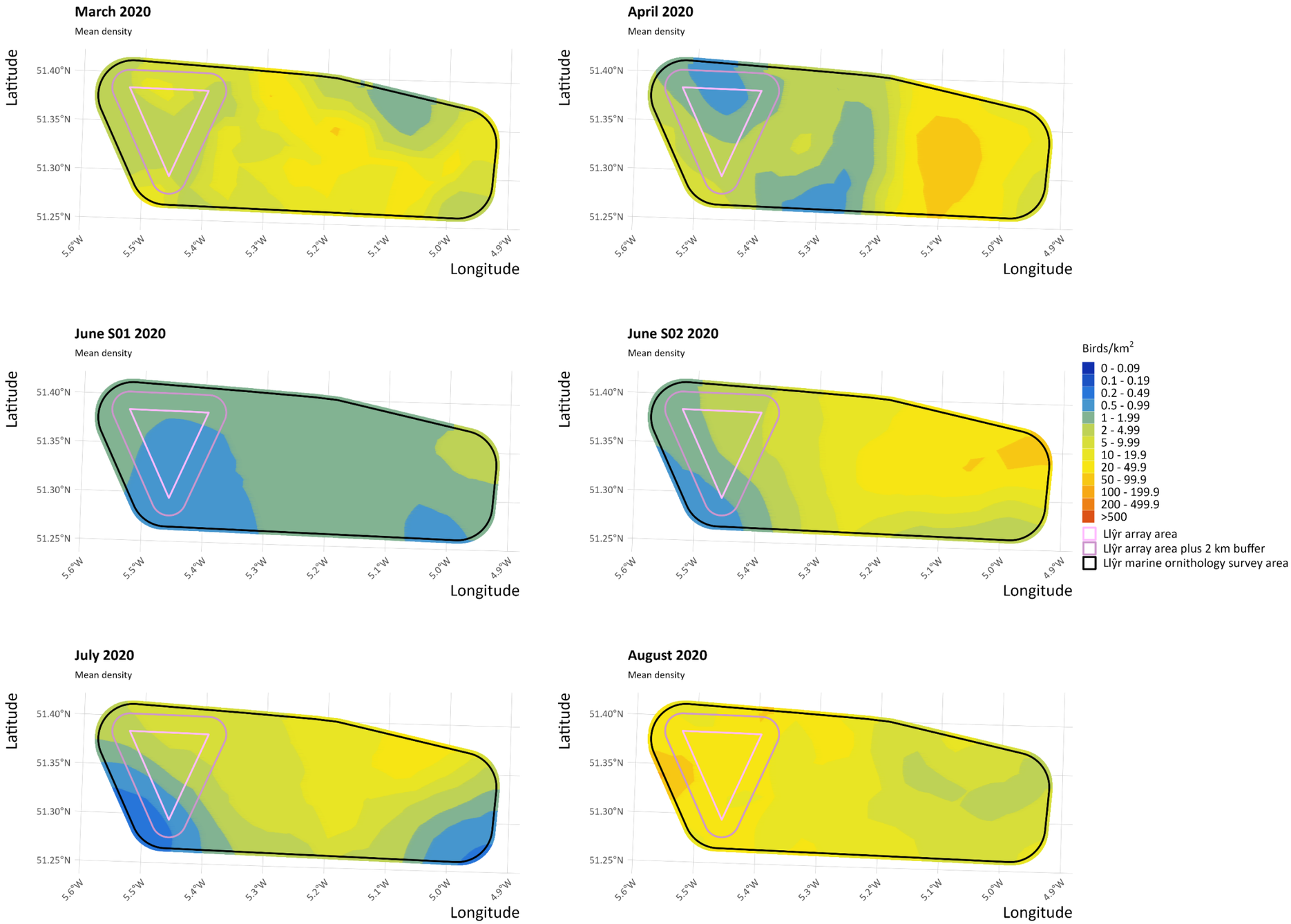


Figure 22A-34. Mean model-based density surfaces for all guillemots (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

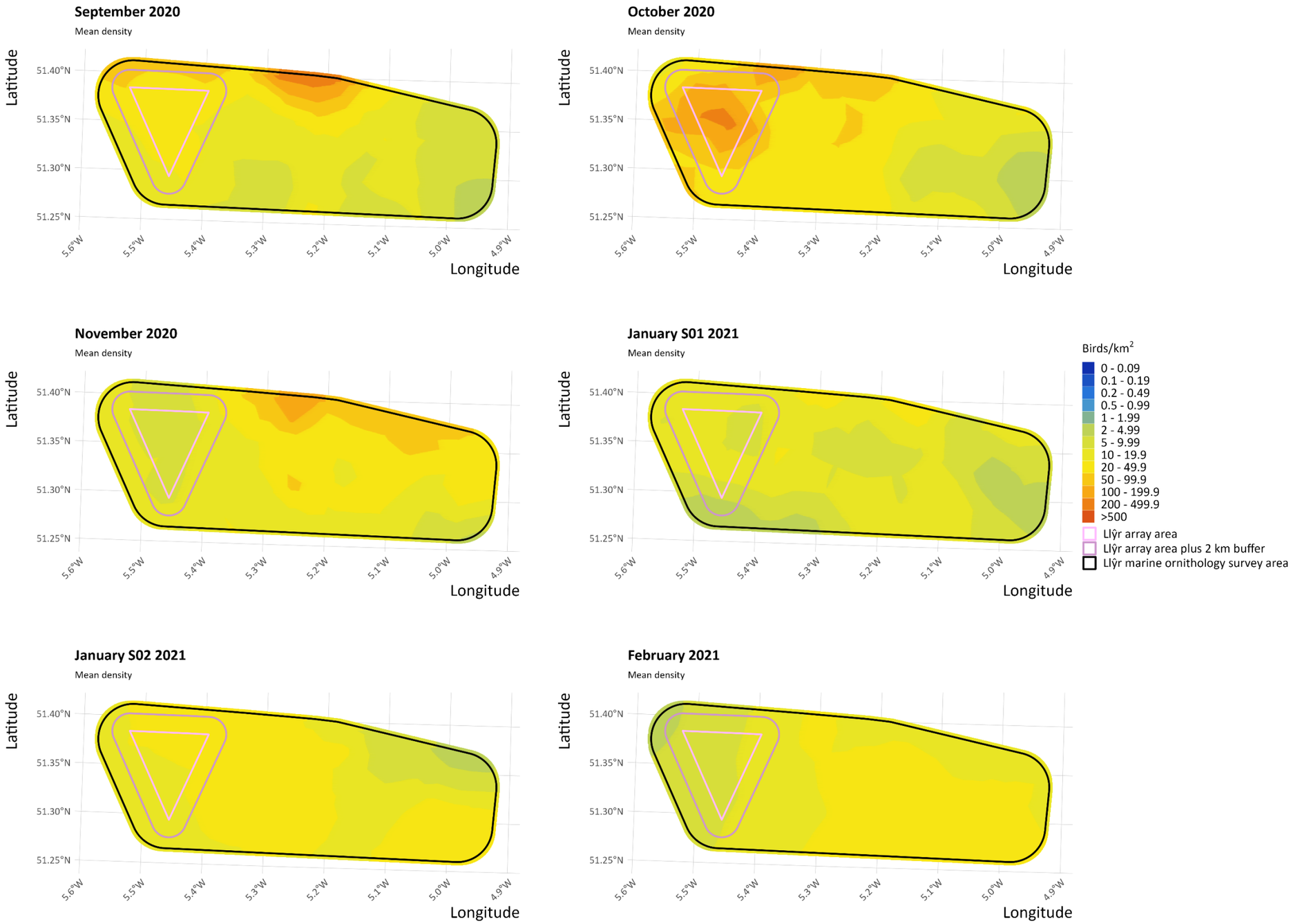


Figure 22A-35. Mean model-based density surfaces for all guillemots (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

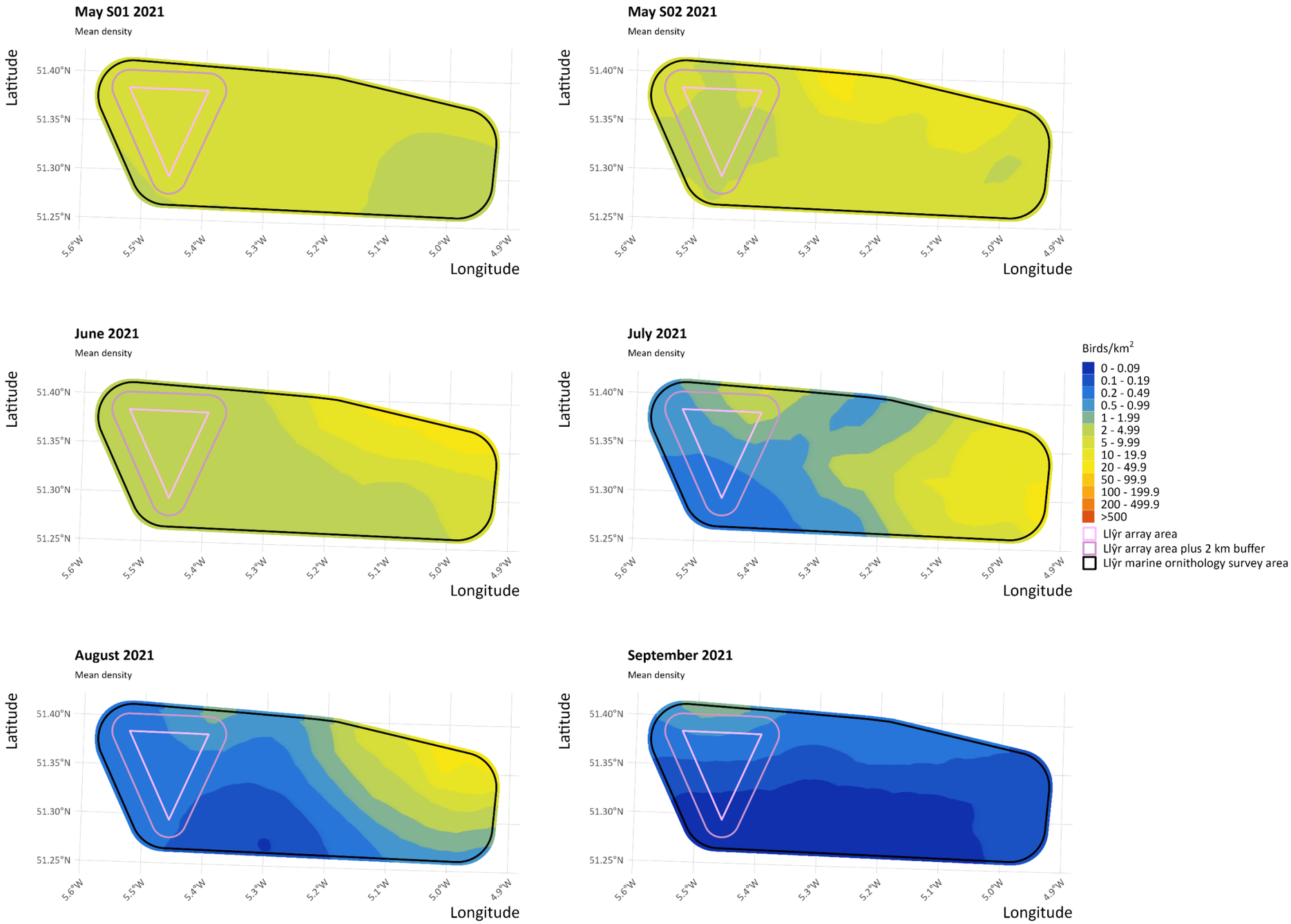


Figure 22A-36. Mean model-based density surfaces for all guillemots (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

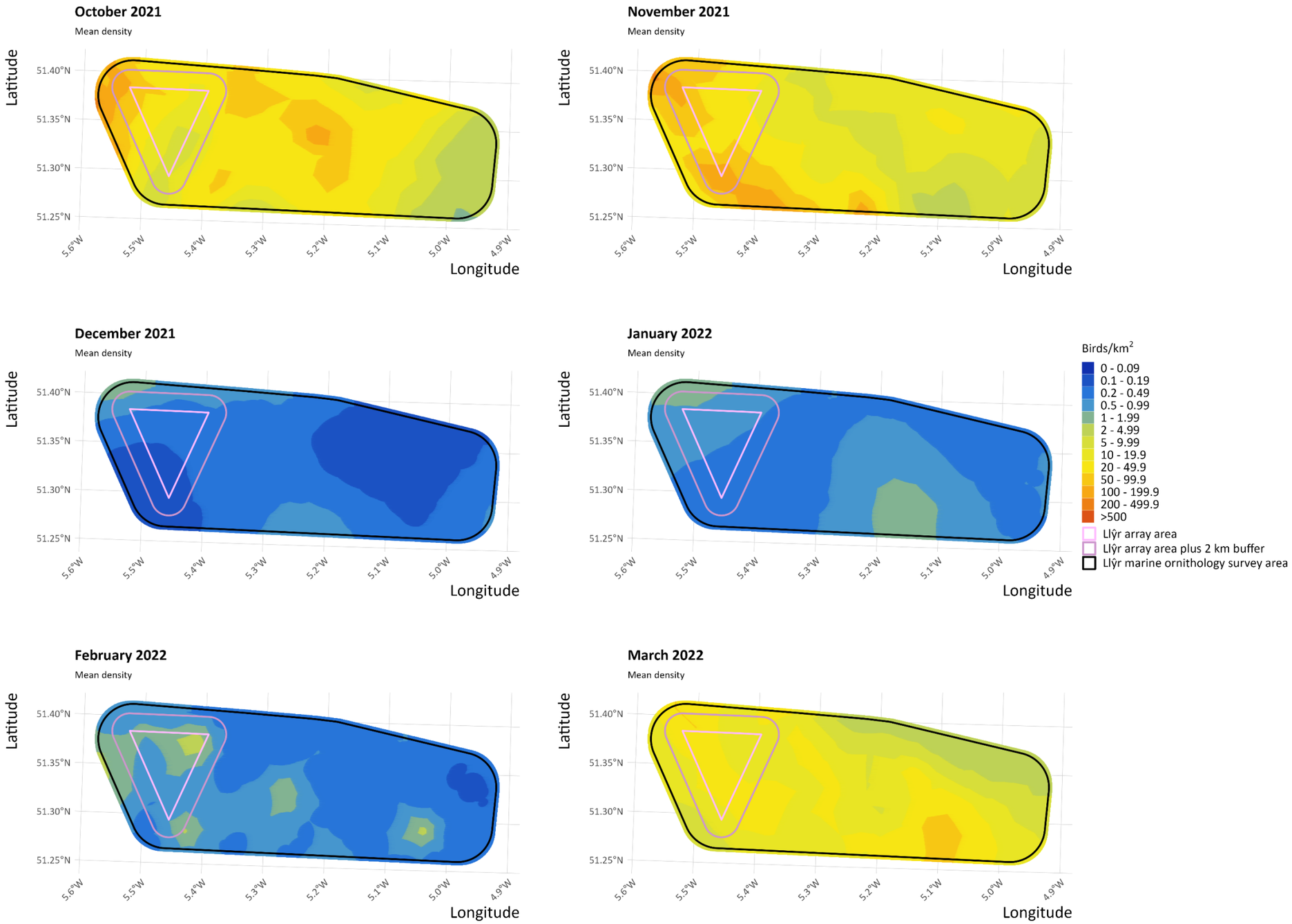


Figure 22A-37. Mean model-based density surfaces for all guillemots (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

MSP Population Estimates for Displacement

113. MSP population estimates for the Array Area plus a 2 km buffer are provided for guillemots for input into displacement assessment (**Appendix 22D: Marine Ornithology Displacement Assessment**).

114. The maximum model-based absolute population estimate of all guillemots (flying and sitting) in the Array Area plus a 2 km buffer was recorded in the non-breeding season, with 16,823 birds (95% CI 15,933 – 17,755; October 2020) (**Table 22A-20** and **Figure 22A-38**). Comparative design-based absolute estimates are presented in **Appendix 22A: Annex D** for context.

115. Accordingly, the highest MSP population estimate of all guillemots within the Array Area plus a 2 km buffer occurred in the non-breeding season at 13,009 birds (95% CI 11,546 – 14,532) (**Table 22A-21**).

Table 22A-20. Guillemot monthly model-based absolute population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer

Guillemot	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	761	567	1,023	242	39.1
14-Apr-20	363	260	529	120	35.5
08-Jun-20	152	95	224	47	31.8
24-Jun-20	367	258	485	101	28.1
21-Jul-20	518	389	689	118	23.8
31-Aug-20	5,104	4,679	5,620	563	11.5
12-Sep-20	4,671	4,232	5,112	558	12.3
22-Oct-20	16,823	15,933	17,755	1,134	7.3
26-Nov-20	1,584	1,319	1,888	309	20.3
10-Jan-21	1,701	1,466	1,978	307	18.6
25-Jan-21	3,302	2,947	3,694	433	13.3
22-Feb-21	1,358	1,128	1,605	196	14.4
14-May-21	1,105	938	1,314	145	13.5
27-May-21	778	605	950	172	22.8
15-Jun-21	509	378	661	118	23.5
14-Jul-21	158	96	251	57	40.5
16-Aug-21	53	19	100	28	54.7
01-Sep-21	47	17	97	25	61.5
22-Oct-21	5,196	4,746	5,681	599	12.5
20-Nov-21	9,196	8,490	9,881	912	10.4
16-Dec-21	48	16	102	32	67.1
05-Jan-22	93	49	169	40	42.7
26-Feb-22	172	90	284	78	60.4
20-Mar-22	3,291	2,946	3,623	463	14.7

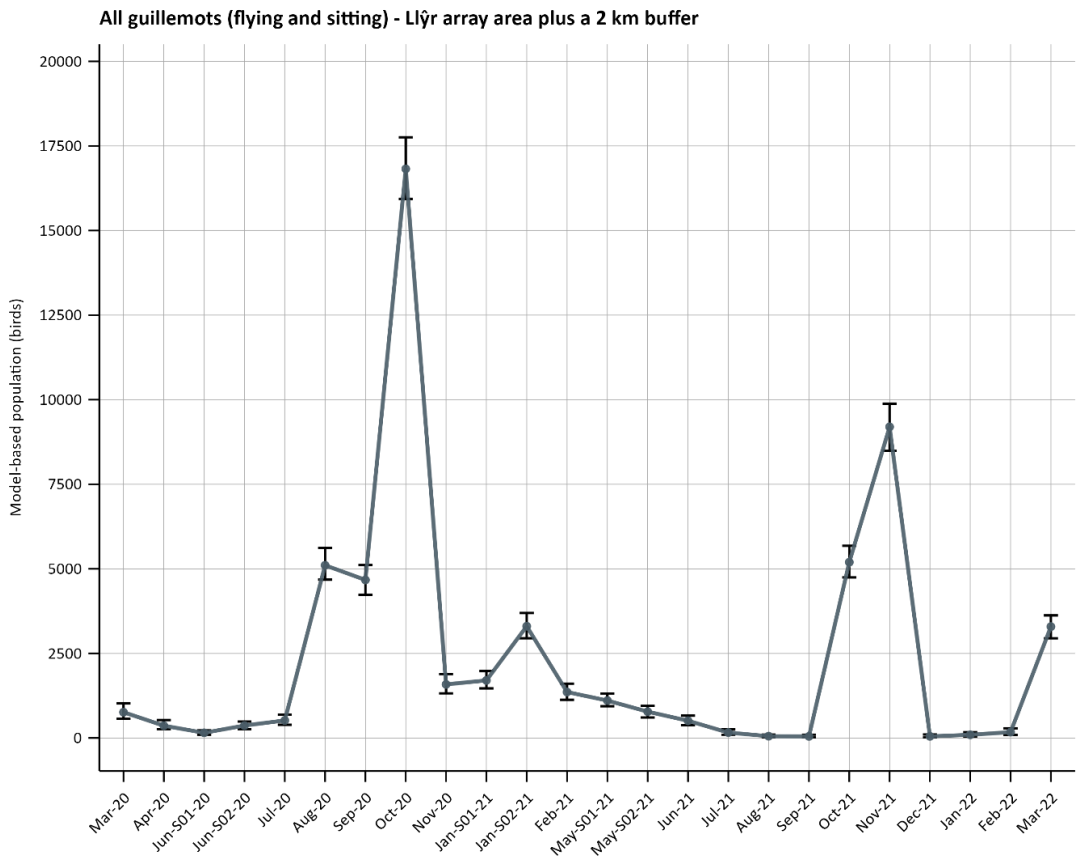


Figure 22A-38. Monthly model-based absolute population estimates of all guillemots (flying and sitting) within the new Array Area plus a 2 km buffer (associated credible intervals are represented by error bars)

Table 22A-21. Model-based MSP absolute population estimates of all guillemots (flying and sitting) in each season within the Array Area plus a 2 km buffer

Guillemot	Year 1 Peak (n)	Year 2 Peak (n)	MSP Population (n)	MSP LCL (n)	MSP UCL (n)
Breeding season	*Mar 2020 – 761*	*Mar 2022* – 3,291*	2,026	1,527	2,566
Non-breeding season	*Oct 2020 – 16,823*	*Nov 2021 – 9,196*	13,009	11,546	14,532

**Used to represent March 2021*

Site-based Age Information for PVA

116. Site-based age information will not be used for guillemot. In DAS footage, it is often only possible to age large auks when adults are accompanied by juveniles during post-breeding dispersal. As such, any age data collected is not representative of the true population throughout the survey period. For PVA, all guillemots will be precautionarily assigned as breeding adults.

Razorbill

Density and Population Estimates

117. Model-based absolute densities and abundances of all razorbills within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-22**. The highest

abundance of razorbills were generally observed during the non-breeding season (**Table 22A-22** and **Appendix 22A: Annex A**). Densities reached a peak of 11.39 birds/km^2 (95% CI 7.18 – 17.88; October 2021) and 12.62 birds/km^2 (95% CI 8.36 – 18.38; October 2020) in both boundaries, respectively.

118. Albeit following similar distribution as the Erebus data, peak estimates in the Llŷr marine ornithology survey area are relatively lower than those estimated at Erebus (15.53 bird/km^2 in October 2019; HiDef Aerial Surveying Ltd, 2021).

119. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-22. Razorbill monthly model-based absolute density and population estimates of all birds (flying and sitting) at Llŷr

Razorbill	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	4.93	2.70	8.42	3,425	2,959	3,835	988	31.2
14-Apr-20	0.58	0.23	1.26	398	258	566	177	47.6
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.07	0.02	0.14	38	12	89	27	63.9
21-Jul-20	0.01	0.00	0.06	11	0	55	11	116.1
31-Aug-20	0.14	0.05	0.31	84	38	145	46	50.1
12-Sep-20	0.89	0.31	2.03	629	471	841	303	53.3
22-Oct-20	3.73	2.00	6.71	2,674	2,295	3,124	828	34.7
26-Nov-20	3.14	1.57	5.88	2,473	2,122	2,859	761	37.7
10-Jan-21	2.27	1.13	4.22	1,594	1,341	1,899	539	37.1
25-Jan-21	1.65	0.67	3.47	1,237	959	1,519	493	46.6
22-Feb-21	2.43	1.32	4.22	1,644	1,311	2,037	500	32.1
14-May-21	0.07	0.03	0.17	48	16	103	25	53.1
27-May-21	0.31	0.15	0.55	187	98	352	68	34.5
15-Jun-21	0.03	0.01	0.09	21	2	111	15	79.4
14-Jul-21	0.05	0.01	0.19	31	3	115	33	99.4
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.03	0.01	0.09	18	2	53	13	69.7
22-Oct-21	11.39	7.18	17.88	9,373	8,627	10,210	1,858	25.5
20-Nov-21	3.81	2.18	6.48	2,769	2,461	3,095	748	30.6
16-Dec-21	0.06	0.02	0.13	37	11	77	27	68.9
05-Jan-22	0.05	0.01	0.17	34	6	81	29	86.4
26-Feb-22	0.91	0.35	1.94	608	406	851	277	47.6
20-Mar-22	4.34	2.55	7.06	3,005	2,655	3,436	775	27.9
Array Area								
25-Mar-20	2.50	1.17	4.80	124	71	191	42	37.7
14-Apr-20	0.06	0.01	0.20	4	0	13	2	90.0
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.06	0.02	0.15	3	0	9	2	59.5
21-Jul-20	0.01	0.00	0.04	1	0	4	1	118.2
31-Aug-20	0.13	0.05	0.29	6	1	15	3	50.4
12-Sep-20	1.33	0.55	2.77	64	32	111	27	44.5
22-Oct-20	12.62	8.36	18.38	602	472	764	123	21.7

Razorbill	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
26-Nov-20	0.49	0.10	1.51	25	7	55	18	82.8
10-Jan-21	2.47	1.20	4.64	117	66	186	41	37.0
25-Jan-21	0.91	0.32	2.18	51	24	95	23	56.3
22-Feb-21	0.85	0.39	1.64	40	16	77	16	40.9
14-May-21	0.07	0.02	0.18	4	0	11	2	55.5
27-May-21	0.30	0.15	0.56	13	3	28	5	38.9
15-Jun-21	0.03	0.01	0.08	2	0	7	1	68.7
14-Jul-21	0.05	0.00	0.16	3	0	11	2	104.4
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.03	0.01	0.10	2	0	6	1	81.5
22-Oct-21	10.94	6.99	16.73	859	702	1,035	121	24.6
20-Nov-21	6.76	4.18	10.17	366	263	481	72	23.8
16-Dec-21	0.06	0.02	0.13	3	0	8	1	43.7
05-Jan-22	0.05	0.01	0.18	3	0	11	3	111.2
26-Feb-22	1.13	0.48	2.35	56	25	99	23	45.6
20-Mar-22	0.92	0.39	1.86	43	19	76	18	43.8
Array Area plus 2 km buffer								
25-Mar-20	2.72	1.28	5.13	343	240	469	125	38.7
14-Apr-20	0.06	0.00	0.22	7	0	25	8	103.7
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.06	0.02	0.15	7	1	18	4	62.0
21-Jul-20	0.01	0.00	0.05	3	0	12	2	100.1
31-Aug-20	0.13	0.05	0.26	18	5	35	7	45.0
12-Sep-20	1.25	0.50	2.70	171	110	247	71	47.4
22-Oct-20	10.17	6.41	15.44	1,354	1,082	1,649	291	24.0
26-Nov-20	0.53	0.09	1.72	68	29	132	55	88.1
10-Jan-21	1.96	0.87	3.82	260	169	378	96	40.9
25-Jan-21	1.20	0.45	2.62	174	105	266	70	49.2
22-Feb-21	0.91	0.40	1.79	116	61	199	45	41.7
14-May-21	0.07	0.03	0.16	8	1	21	5	59.2
27-May-21	0.31	0.14	0.59	35	14	71	15	39.2
15-Jun-21	0.03	0.01	0.11	4	0	14	3	81.9
14-Jul-21	0.05	0.01	0.20	7	0	24	7	119.8
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.03	0.01	0.09	5	0	16	3	89.0
22-Oct-21	14.46	9.92	20.89	2,423	2,105	2,807	351	20.4
20-Nov-21	5.40	3.08	8.71	727	571	909	183	28.4
16-Dec-21	0.05	0.02	0.11	8	1	20	3	46.1
05-Jan-22	0.05	0.01	0.15	6	0	16	4	72.9
26-Feb-22	1.13	0.44	2.34	145	80	236	62	45.9
20-Mar-22	1.24	0.55	2.44	170	107	256	63	42.8

Distribution and Spatial Densities

120. Generally, razorbills were observed in both the Array Area and the 2 km buffer. Birds were also more present in the east of the Llŷr marine ornithology survey area 2 km (**Figure 22A-39** to **Figure 22A-42**).

121. Mean model-based density surfaces of razorbills are presented in **Figure 22A-43** to **Figure 22A-46.** In general, no conclusive trend can be determined on the density distribution of the species within the Llŷr marine ornithology survey area.

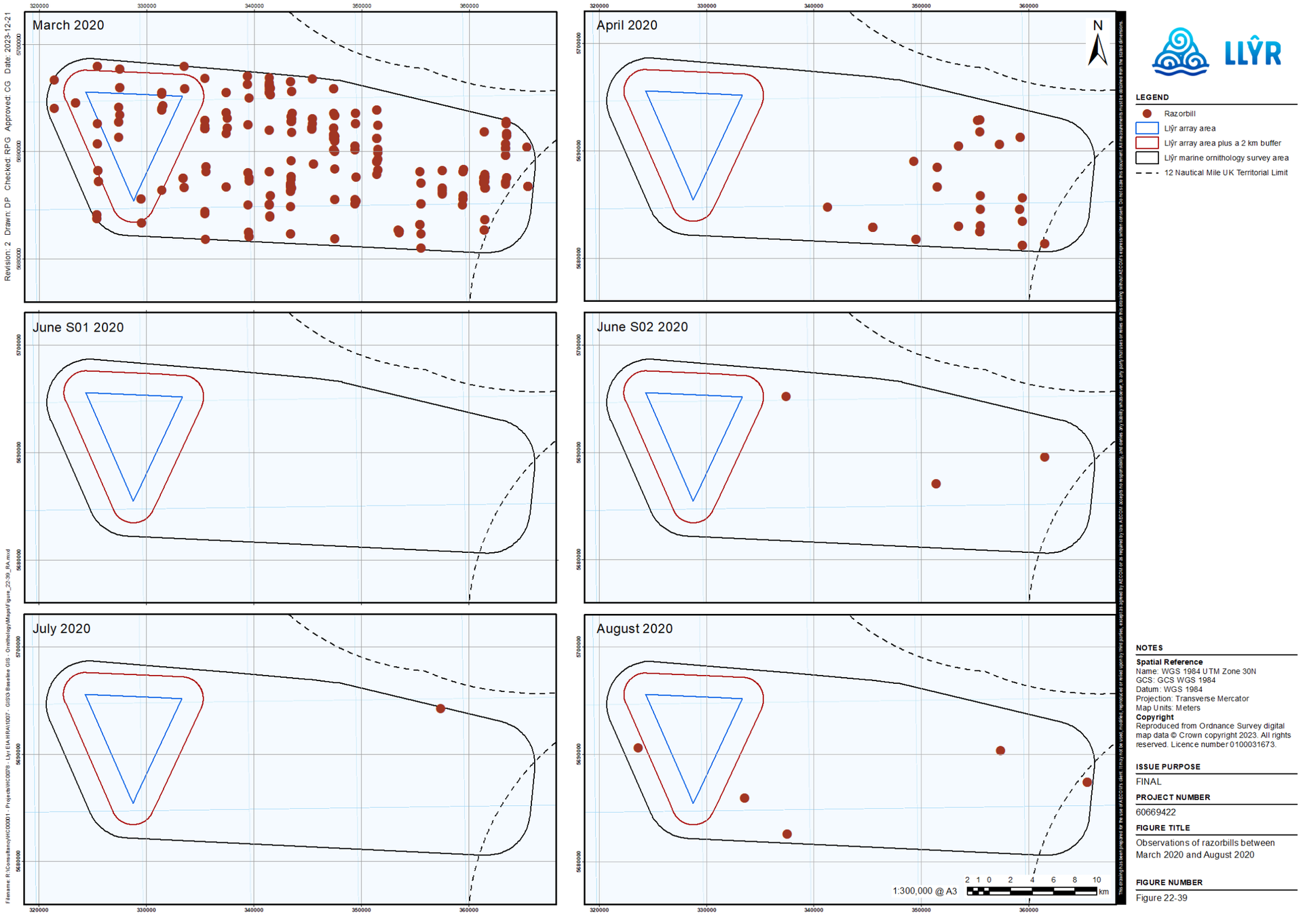


Figure 22A-39. Distribution map of recorded razorbills within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

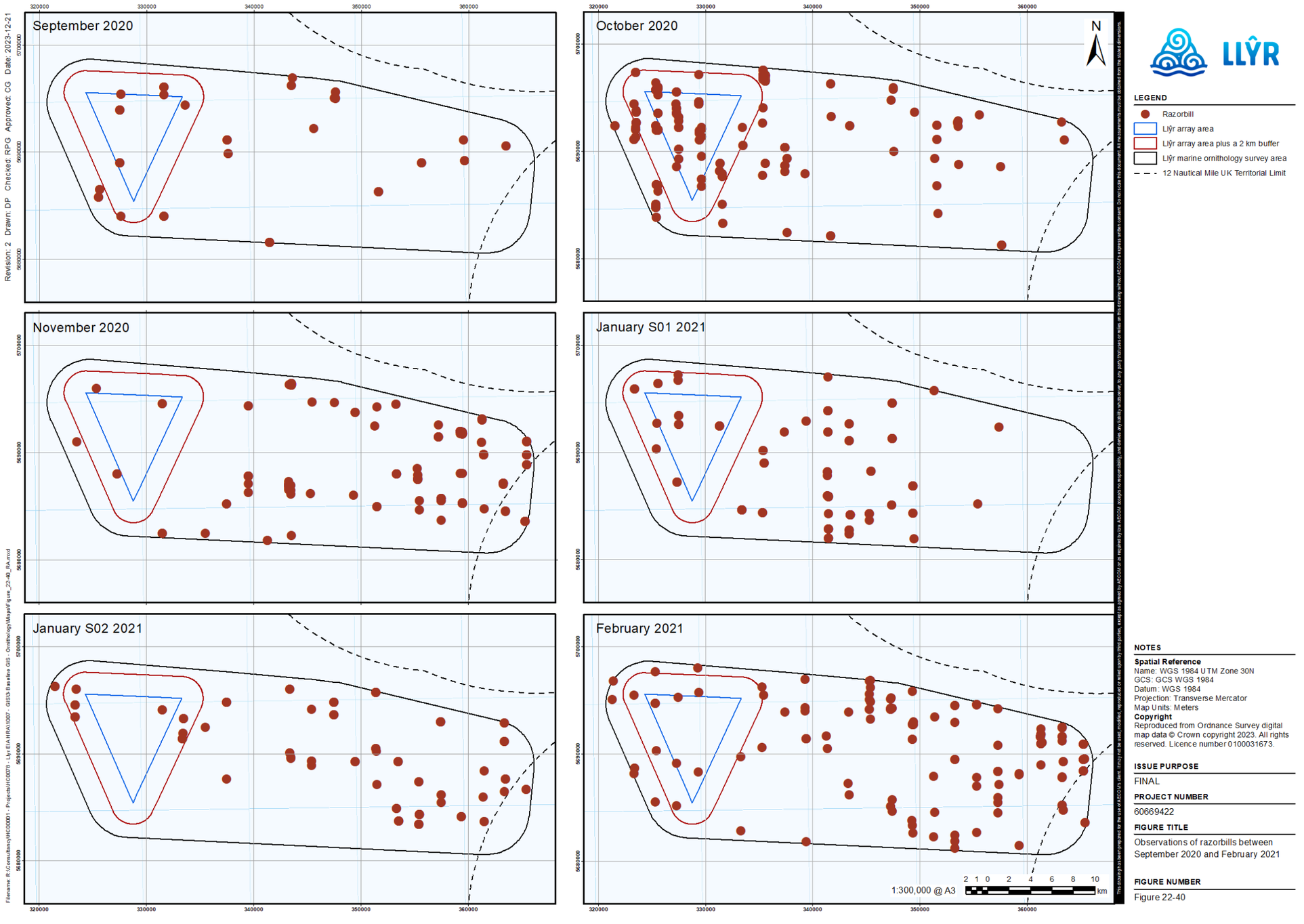


Figure 22A-40. Distribution map of recorded razorbills within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

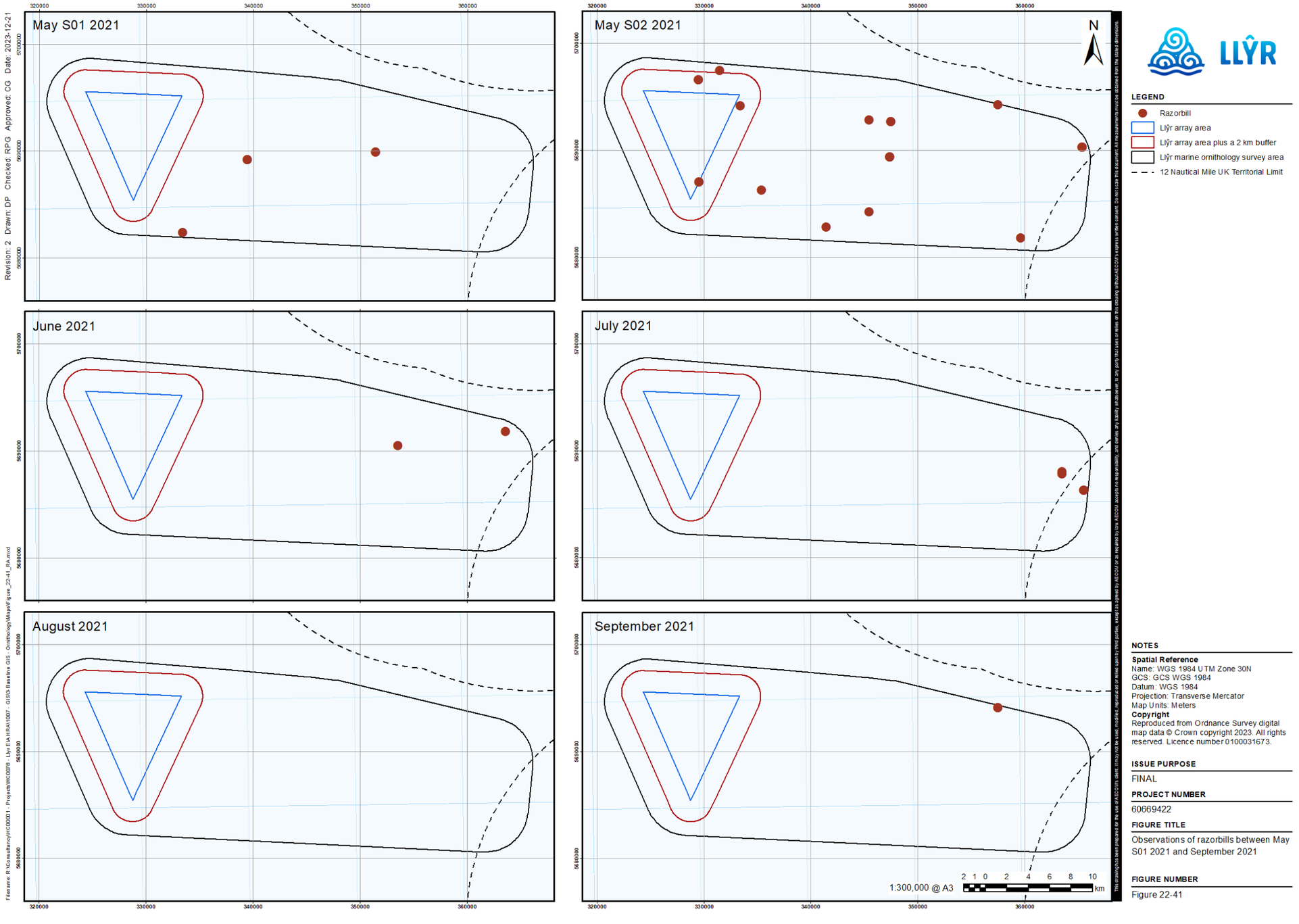


Figure 22A-41. Distribution map of recorded razorbills within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

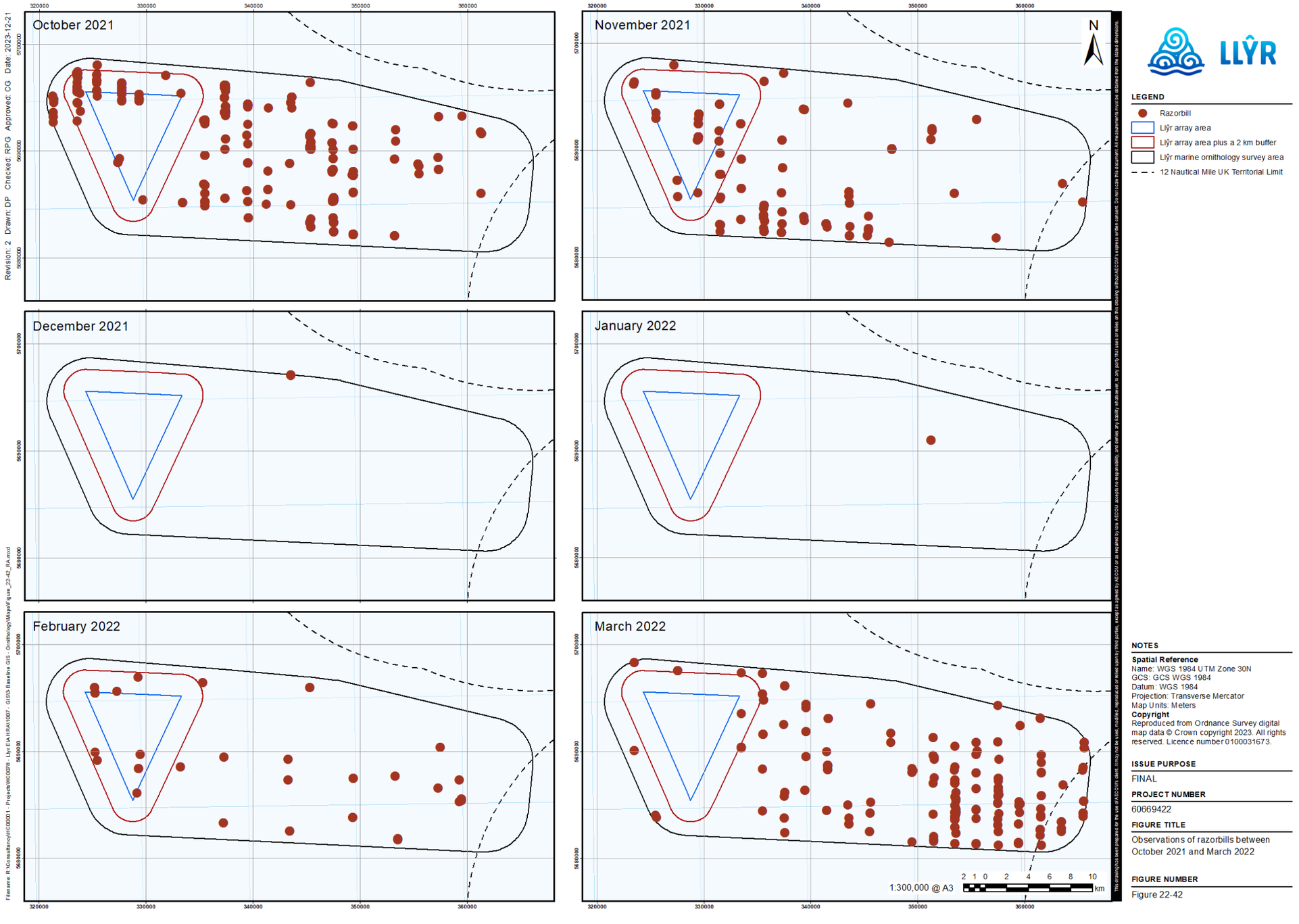
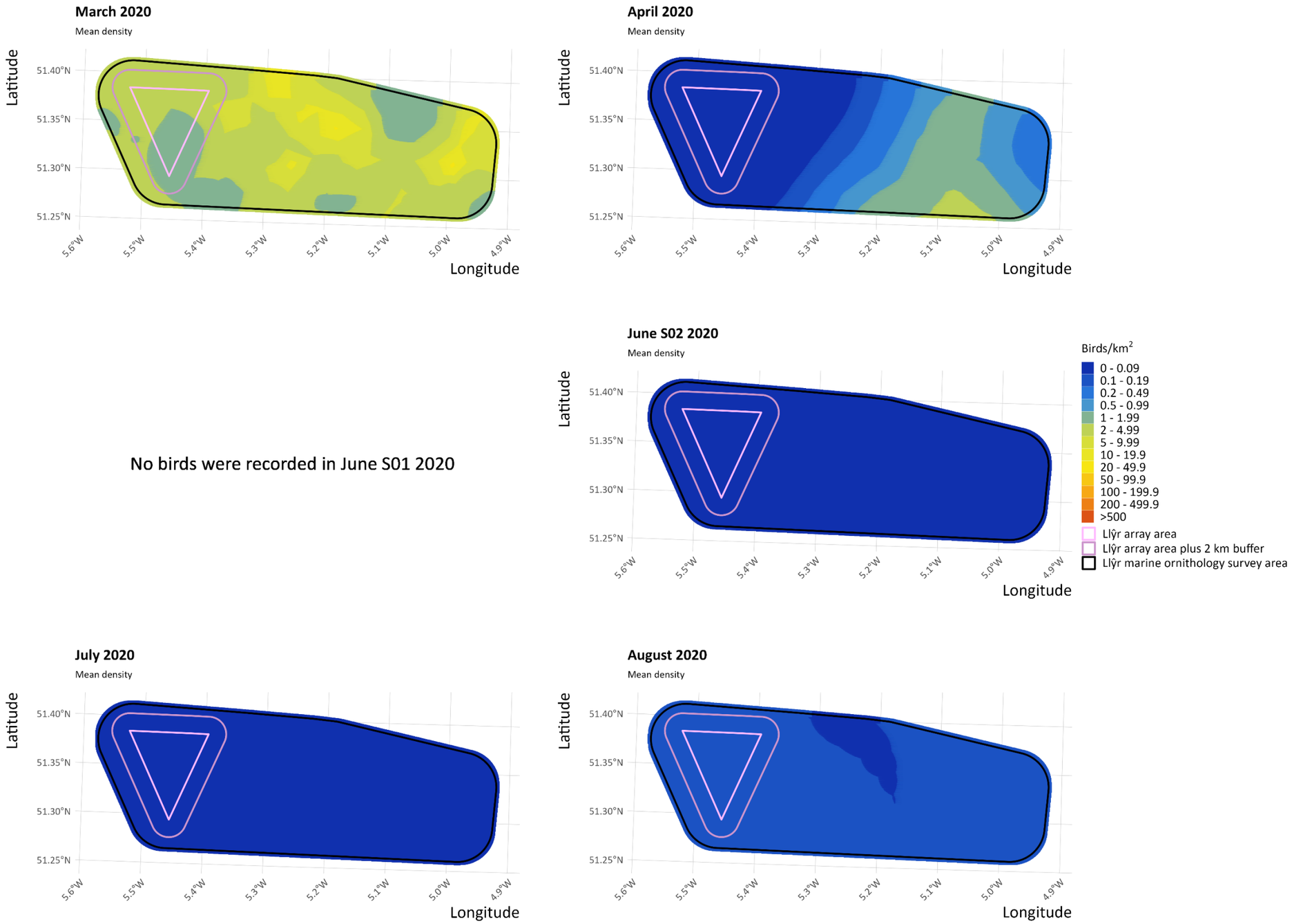


Figure 22A-42. Distribution map of recorded razorbills within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)



No birds were recorded in June S01 2020

Figure 22A-43. Mean model-based density surfaces for all razorbills (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

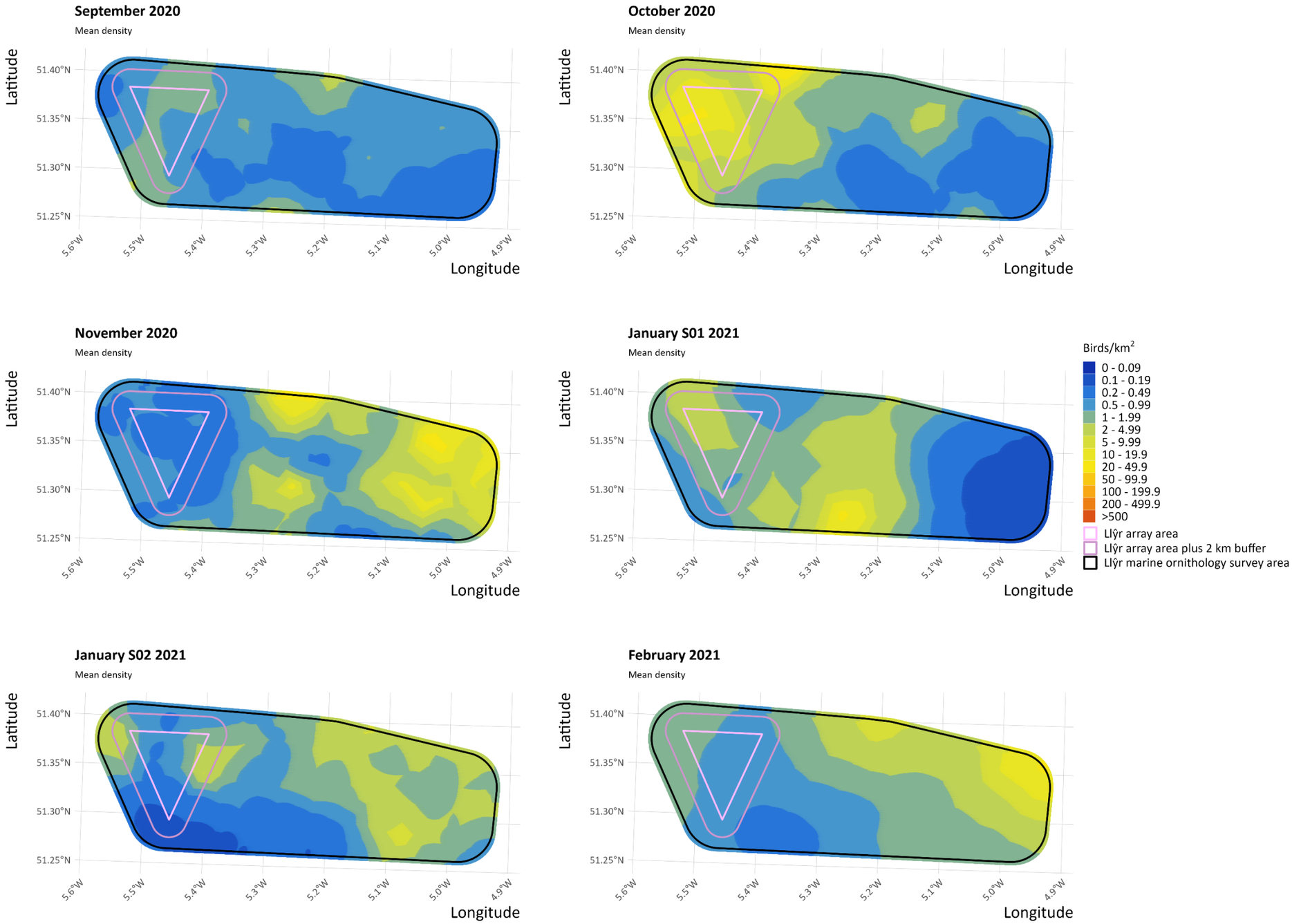
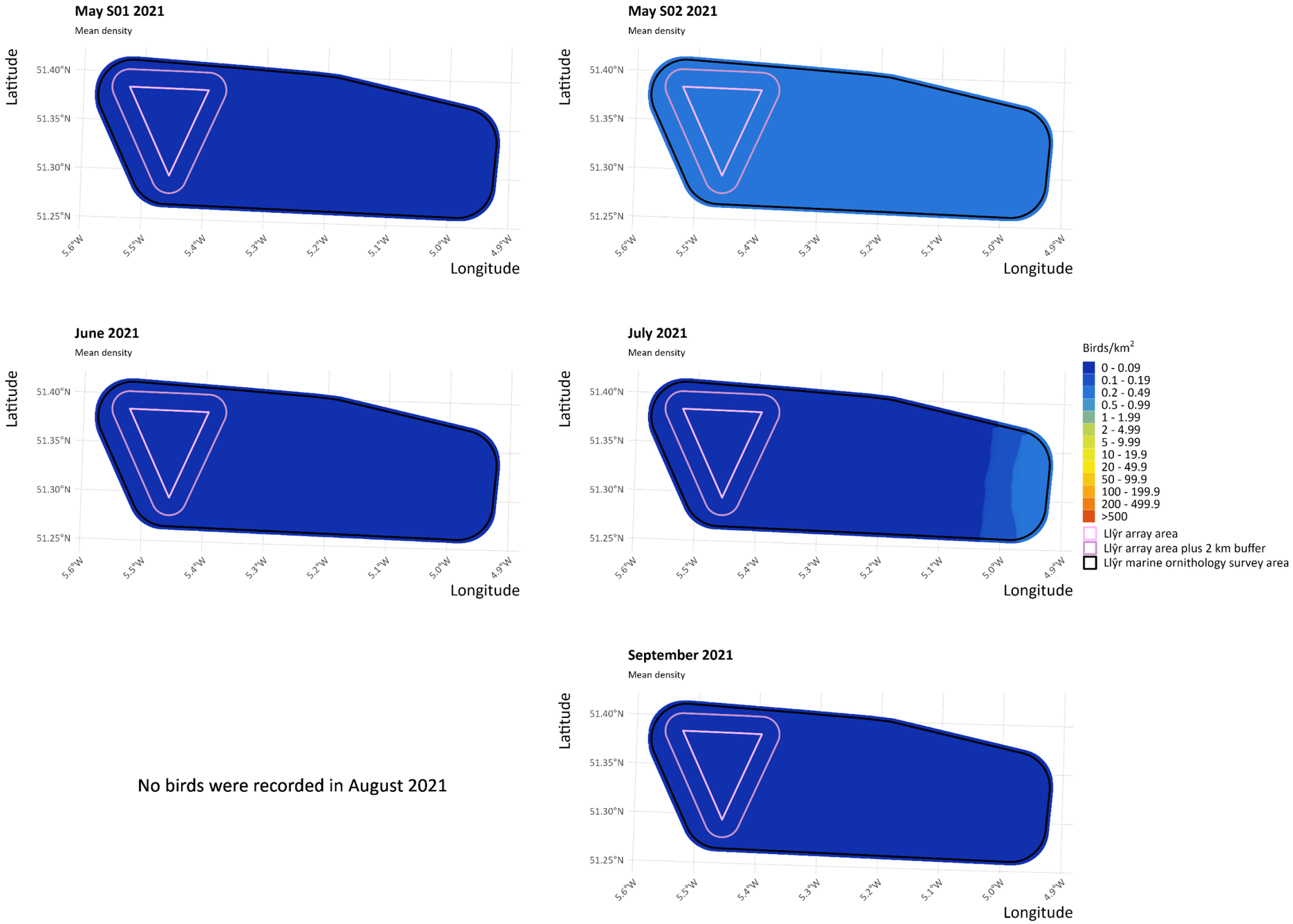


Figure 22A-44. Mean model-based density surfaces for all razorbills (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)



No birds were recorded in August 2021

Figure 22A-45. Mean model-based density surfaces for all razorbills (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

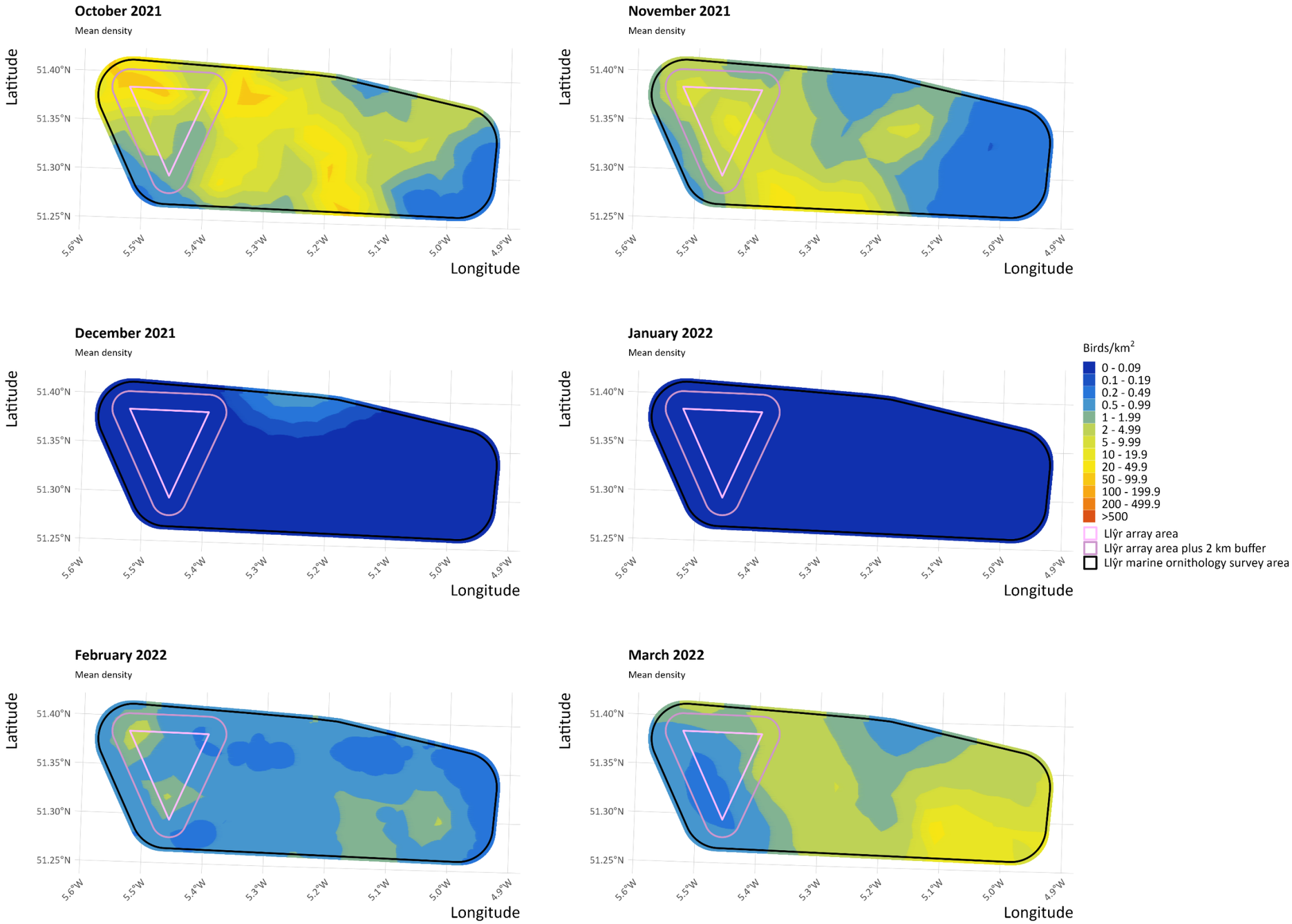


Figure 22A-46. Mean model-based density surfaces for all razorbills (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

MSP Population Estimates for Displacement

122. MSP population estimates for the Array Area plus a 2 km buffer are provided for razorbills for input into displacement assessment (**Appendix 22D: Marine Ornithology Displacement Assessment**).

123. The maximum model-based absolute population estimate of all razorbills (flying and sitting) in the Array Area plus a 2 km buffer was recorded at the end of the autumn migration season, with 2,423 birds (95% CI 2,105 – 2,807; October 2021) (**Table 22A-23** and **Figure 22A-47**). Comparative design-based absolute estimates are presented in **Appendix 22A: Annex D** for context.

124. Accordingly, the highest MSP population estimate of all birds within the Array Area plus a 2 km buffer occurred in the autumn migration season at 1,888 birds (95% CI 1,460 – 2,338) (**Table 22A-24**).

Table 22A-23. Razorbill monthly model-based absolute population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer

Razorbill	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	343	240	469	125	38.7
14-Apr-20	7	0	25	8	103.7
08-Jun-20	0	0	0	0	0.0
24-Jun-20	7	1	18	4	62.0
21-Jul-20	3	0	12	2	100.1
31-Aug-20	18	5	35	7	45.0
12-Sep-20	171	110	247	71	47.4
22-Oct-20	1,354	1,082	1,649	291	24.0
26-Nov-20	68	29	132	55	88.1
10-Jan-21	260	169	378	96	40.9
25-Jan-21	174	105	266	70	49.2
22-Feb-21	116	61	199	45	41.7
14-May-21	8	1	21	5	59.2
27-May-21	35	14	71	15	39.2
15-Jun-21	4	0	14	3	81.9
14-Jul-21	7	0	24	7	119.8
16-Aug-21	0	0	0	0	0.0
01-Sep-21	5	0	16	3	89.0
22-Oct-21	2,423	2,105	2,807	351	20.4
20-Nov-21	727	571	909	183	28.4
16-Dec-21	8	1	20	3	46.1
05-Jan-22	6	0	16	4	72.9
26-Feb-22	145	80	236	62	45.9
20-Mar-22	170	107	256	63	42.8

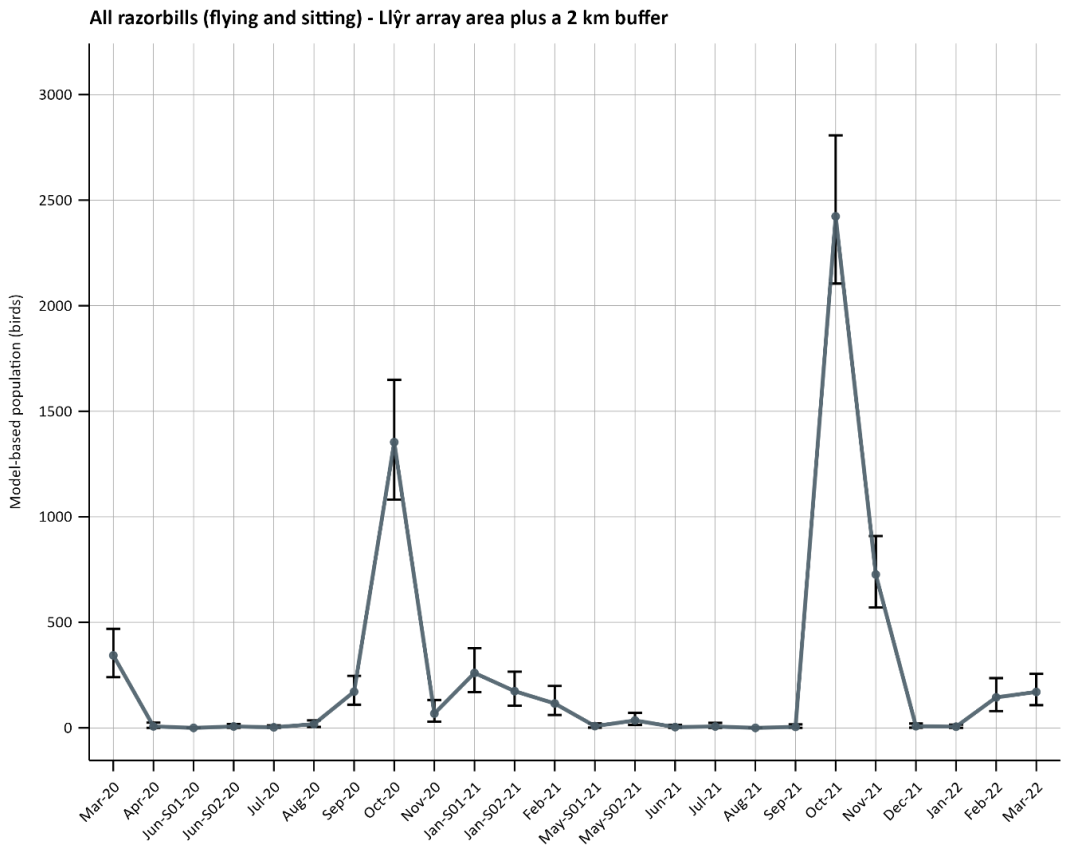


Figure 22A-47. Monthly model-based population estimates of all razorbills (flying and sitting) within the Array Area plus a 2 km buffer (associated credible intervals are represented by error bars)

Table 22A-24. Model-based MSP population estimate of all razorbills (flying and sitting) in each season within the Array Area plus a 2 km buffer

Razorbill	Year 1 Peak (n)	Year 2 Peak (n)	MSP Population (n)	MSP LCL (n)	MSP UCL (n)
Breeding season	*Apr 2020 – 7*	*May 2021 - 35*	21	7	37
Autumn migration	*Oct 2020 – 1,354*	*Oct 2021 – 2,423*	1,888	1,460	2,338
Spring migration	*Mar 2020 – 343*	*Mar 2022* – 170*	257	126	388
Non-breeding season	*JanS01 2021† – 260*	*Nov 2021 – 727*	493	305	694

**Used to represent March 2021*

†Used to represent December 2020

Site-based Age Information for PVA

125. Site-based age information will not be used for razorbill. In DAS footage, it is often only possible to age large auks when adults are accompanied by juveniles during post-breeding dispersal. As such, any age data collected is not representative of the true population

throughout the survey period. For PVA, all razorbills will be precautionarily assigned as breeding adults.

Puffin

Density and Population Estimates

126. Model-based absolute densities and abundances of all puffins within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-25**. The highest abundances of puffin were generally observed during the non-breeding season (**Table 22A-25** and **Appendix 22A: Annex A**). Densities reached a peak of 4.69 birds/km^2 (95% CI 4.17 – 5.28; March 2020) and 9.89 birds/km^2 (95% CI 7.64 – 12.00; March 2020) in both boundaries, respectively.

127. Peak estimates in the Llŷr marine ornithology survey area are relatively comparable to those estimated at Erebus (8.33 bird/km^2 in April 2020; HiDef Aerial Surveying Ltd, 2021).

128. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-25. Puffin monthly model-based absolute density and population estimates of all birds (flying and sitting) at Llŷr

Puffin	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	4.69	4.17	5.28	3,003	2,670	3,384	179	6.0
14-Apr-20	0.58	0.41	0.76	369	260	488	60	16.1
08-Jun-20	0.16	0.09	0.27	104	56	173	29	27.9
24-Jun-20	1.30	1.05	1.58	832	671	1011	97	11.6
21-Jul-20	0.23	0.15	0.34	150	95	218	35	23.3
31-Aug-20	0.04	0.01	0.09	25	6	56	13	52.8
12-Sep-20	0.42	0.30	0.64	268	190	407	56	20.8
22-Oct-20	0.64	0.42	0.86	407	269	553	80	19.7
26-Nov-20	0.50	0.34	0.75	321	216	483	72	22.5
10-Jan-21	0.08	0.03	0.18	51	17	118	31	60.1
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.18	0.11	0.29	112	71	186	30	26.5
14-May-21	0.86	0.66	1.15	552	423	737	86	15.6
27-May-21	0.29	0.21	0.42	188	137	266	36	19.2
15-Jun-21	2.16	1.80	2.41	1,383	1,155	1,545	104	7.5
14-Jul-21	0.16	0.09	0.25	100	58	161	27	26.7
16-Aug-21	0.11	0.04	0.20	69	28	130	28	41.3
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.04	0.01	0.08	23	8	54	12	52.5
20-Nov-21	0.03	0.01	0.08	17	3	49	14	80.3
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.64	0.48	0.80	413	308	513	54	13.1
Array Area								
25-Mar-20	9.89	7.64	12.00	444	343	539	57	12.8
14-Apr-20	0.22	0.07	0.42	10	3	19	5	52.7

Puffin	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
08-Jun-20	0.13	0.07	0.25	6	3	11	2	36.0
24-Jun-20	0.47	0.16	1.09	21	7	49	12	59.1
21-Jul-20	0.07	0.02	0.16	3	1	7	2	68.9
31-Aug-20	0.05	0.00	0.11	2	0	5	2	90.2
12-Sep-20	1.23	0.56	2.27	55	25	102	21	39.1
22-Oct-20	1.49	0.69	2.67	67	31	120	24	35.1
26-Nov-20	0.36	0.07	1.16	16	3	52	14	89.5
10-Jan-21	0.02	0.00	0.18	1	0	8	2	238.3
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.16	0.09	0.29	7	4	13	2	29.9
14-May-21	1.51	0.74	2.81	68	33	126	25	36.6
27-May-21	0.29	0.18	0.47	13	8	21	4	30.6
15-Jun-21	1.67	1.14	3.10	75	51	139	21	28.3
14-Jul-21	0.02	0.00	0.11	1	0	5	2	193.9
16-Aug-21	0.05	0.00	0.18	2	0	8	2	99.1
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.05	0.00	0.09	2	0	4	1	50.7
20-Nov-21	0.02	0.00	0.07	1	0	3	1	82.3
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.58	0.31	1.09	26	14	49	9	33.3
Array Area plus 2 km buffer								
25-Mar-20	9.30	7.69	11.23	1,108	916	1,338	102	9.2
14-Apr-20	0.23	0.11	0.50	27	13	60	11	40.0
08-Jun-20	0.13	0.07	0.28	16	8	33	6	38.3
24-Jun-20	0.78	0.41	1.49	93	49	178	38	40.8
21-Jul-20	0.07	0.02	0.18	8	2	21	5	60.4
31-Aug-20	0.03	0.01	0.09	4	1	11	3	68.9
12-Sep-20	0.71	0.37	1.22	84	44	145	27	32.2
22-Oct-20	1.53	0.97	2.36	182	116	281	48	26.3
26-Nov-20	0.45	0.16	1.12	53	19	134	30	56.5
10-Jan-21	0.03	0.00	0.19	4	0	23	8	204.7
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.18	0.10	0.29	21	12	35	7	31.5
14-May-21	1.50	0.98	2.32	179	117	276	40	22.6
27-May-21	0.27	0.16	0.41	32	19	49	9	27.0
15-Jun-21	1.76	1.27	2.63	210	151	313	41	19.5
14-Jul-21	0.03	0.01	0.10	3	1	12	3	98.6
16-Aug-21	0.06	0.02	0.17	7	2	20	5	78.4
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.04	0.01	0.09	5	1	11	3	53.0
20-Nov-21	0.03	0.01	0.08	3	1	9	2	80.6
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0

Puffin	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.64	0.38	0.87	76	45	104	16	21.5

Distribution and Spatial Densities

129. Birds were widespread across the Llŷr marine ornithology survey area with observations in the Array Area as well as within the 2 km buffer (**Figure 22A-48** to **Figure 22A-51**).

130. Mean model-based density surfaces of puffins are presented in **Figure 22A-52** to **Figure 22A-55**. In general, no conclusive trend can be concluded on the density distribution of the species within the Llŷr marine ornithology survey area and Array Area.

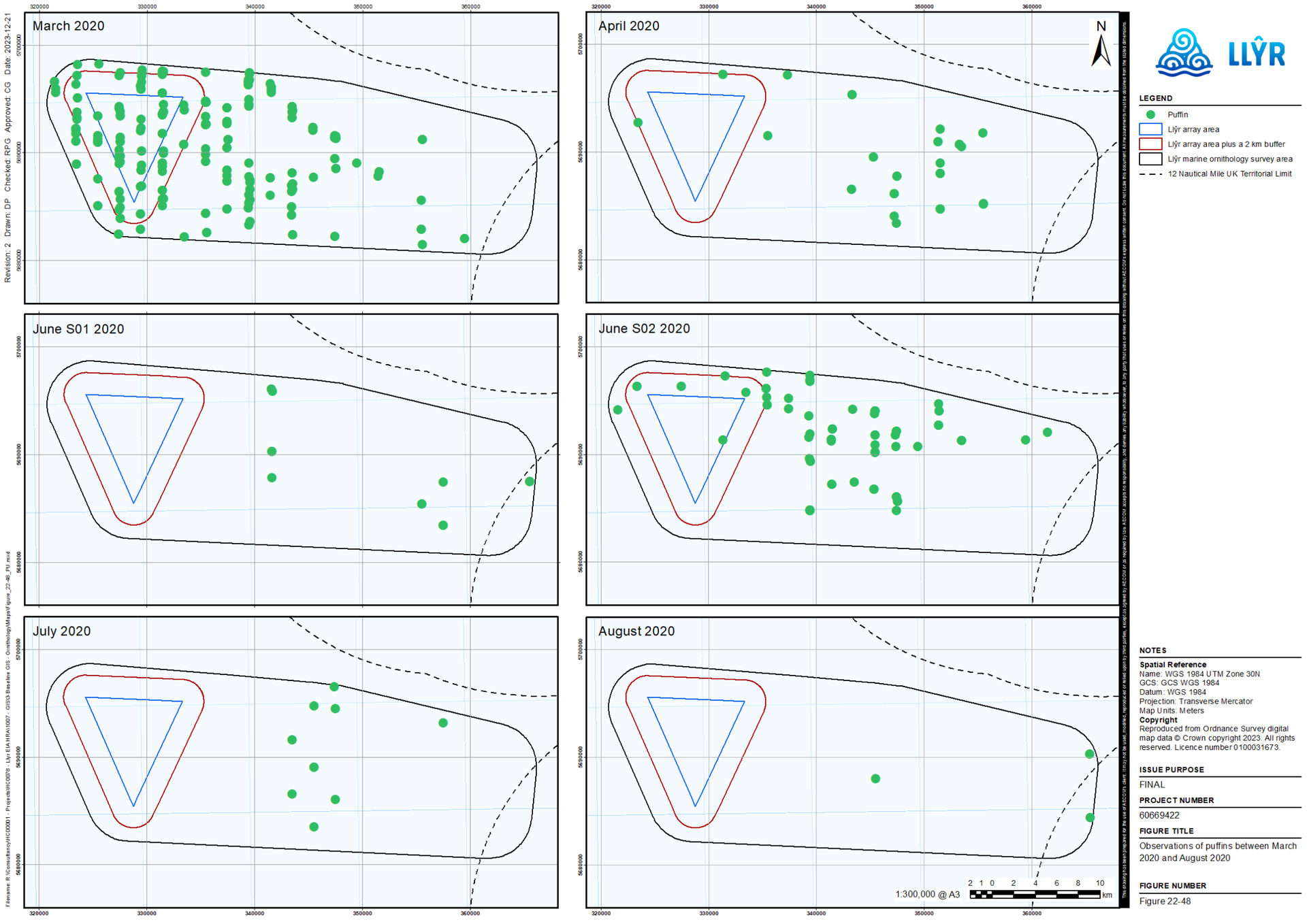


Figure 22A-48. Distribution map of recorded puffins within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

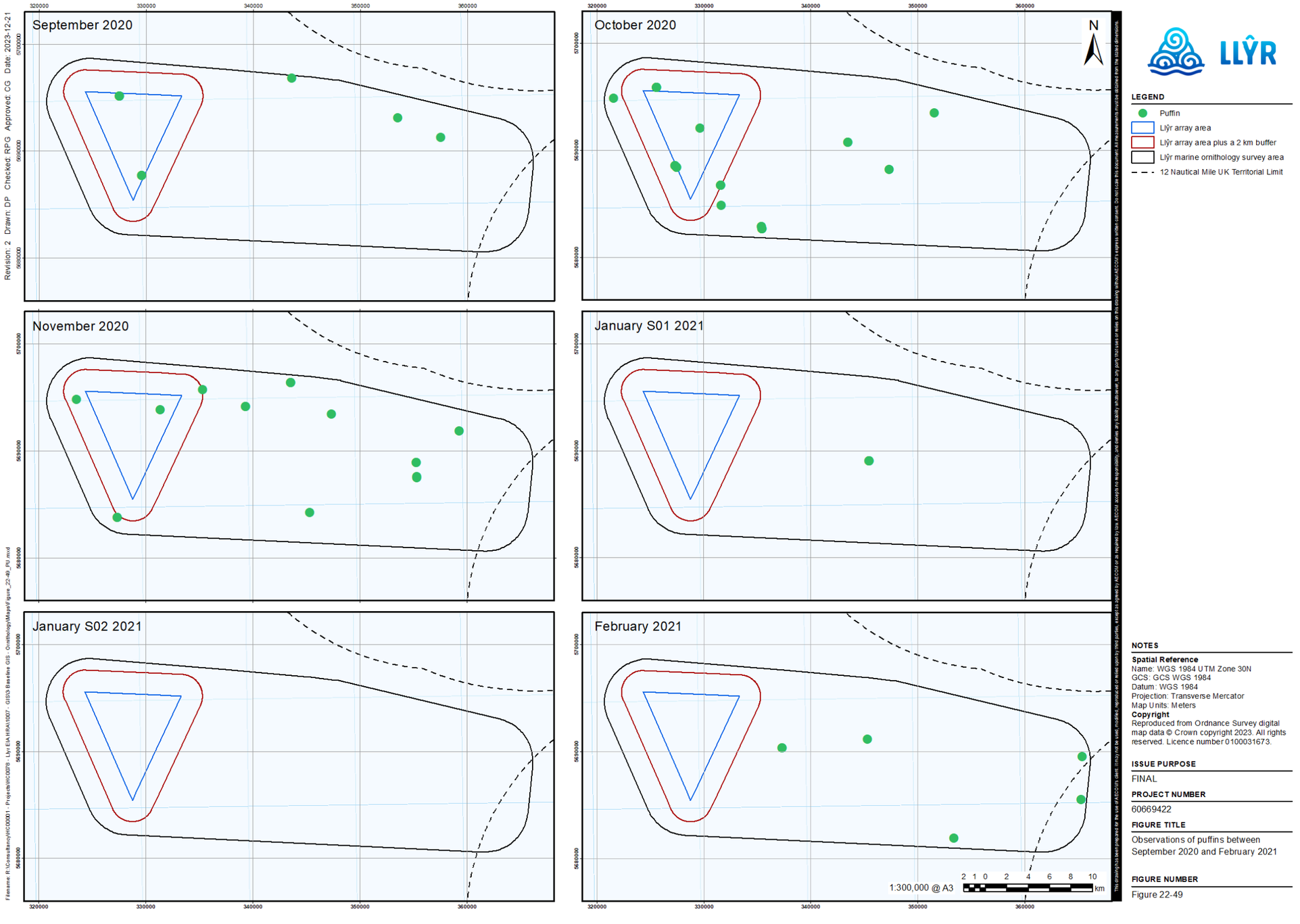


Figure 22A-49. Distribution map of recorded puffins within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

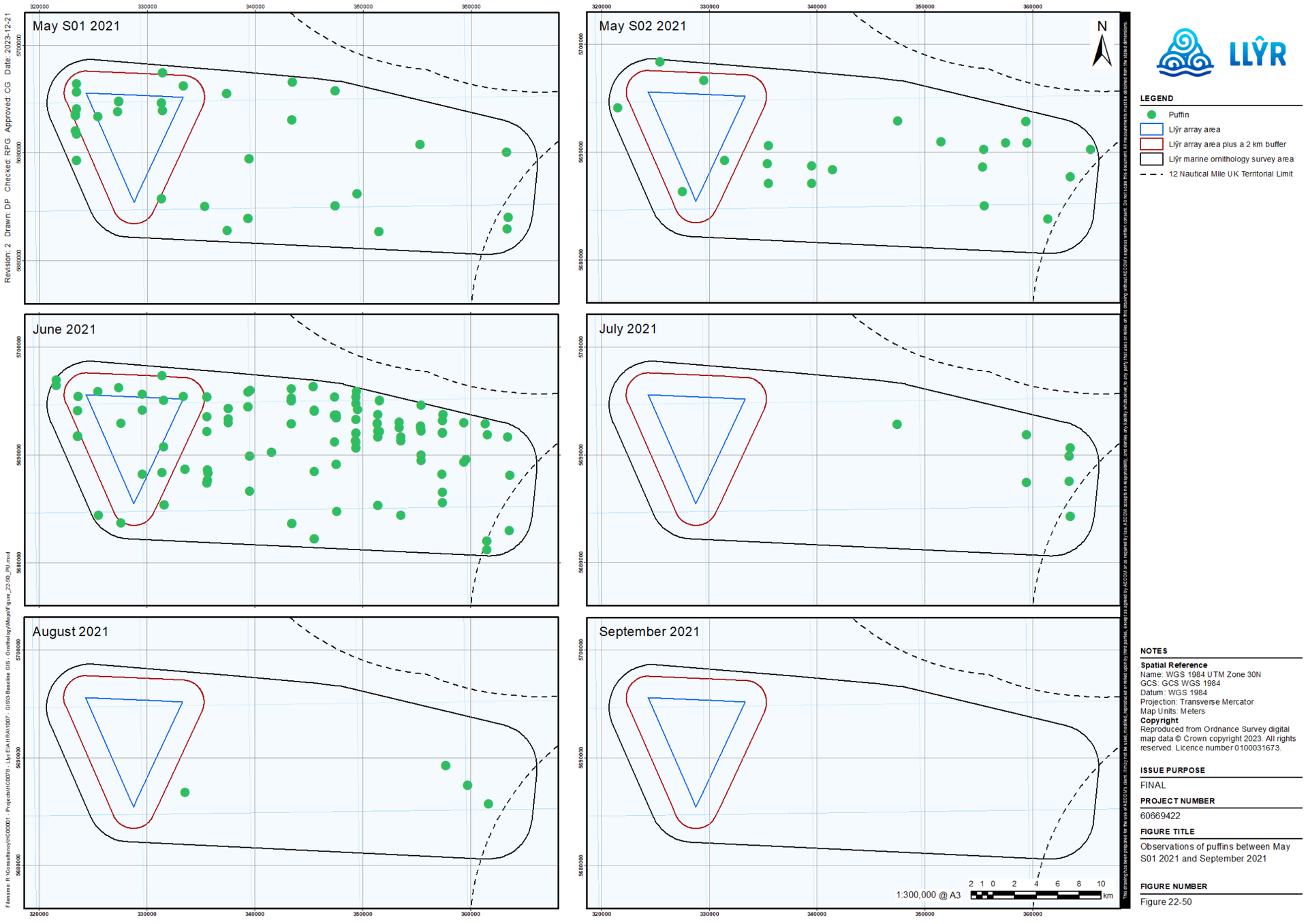


Figure 22A-50. Distribution map of recorded puffins within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

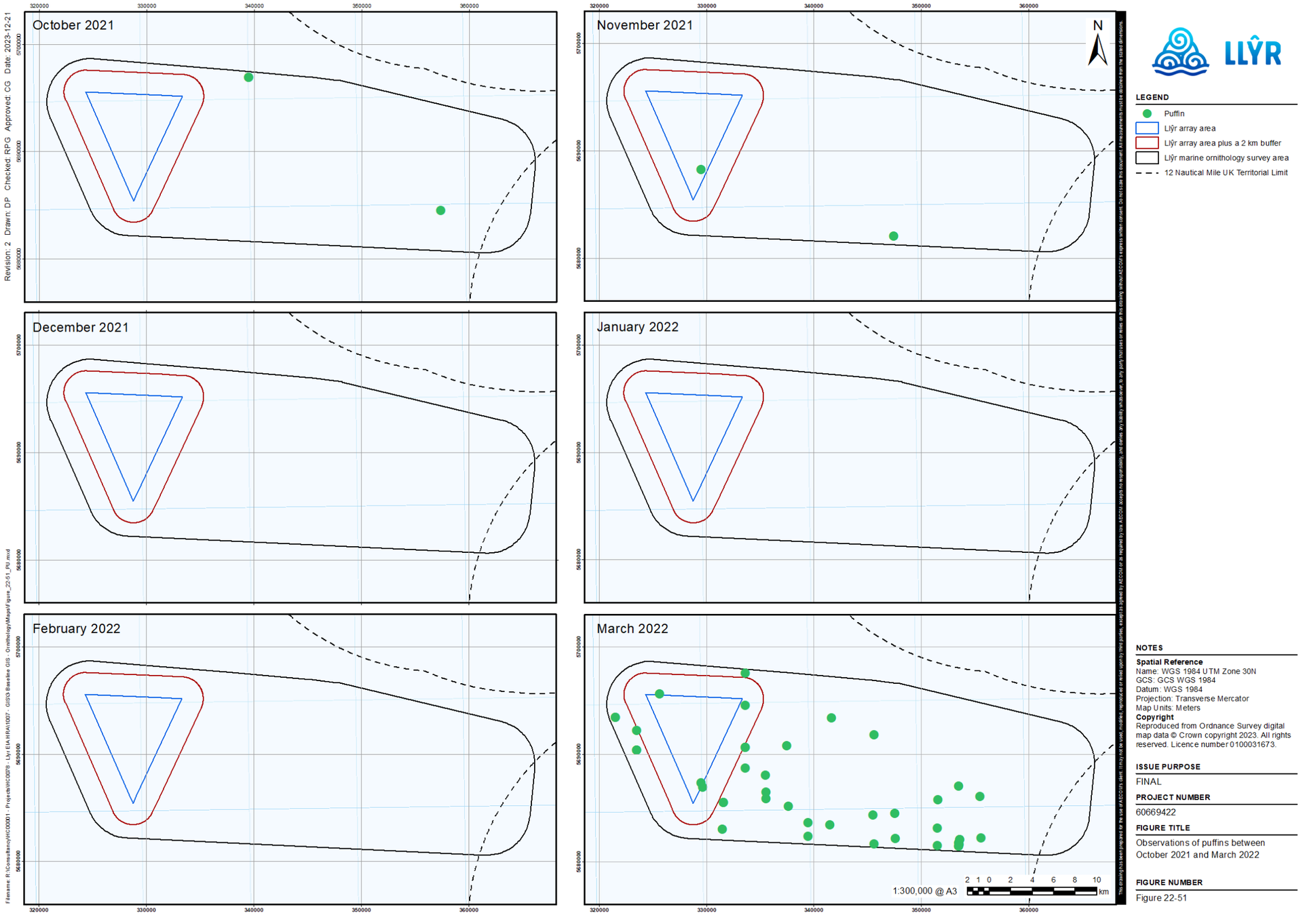


Figure 22A-51. Distribution map of recorded puffins within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

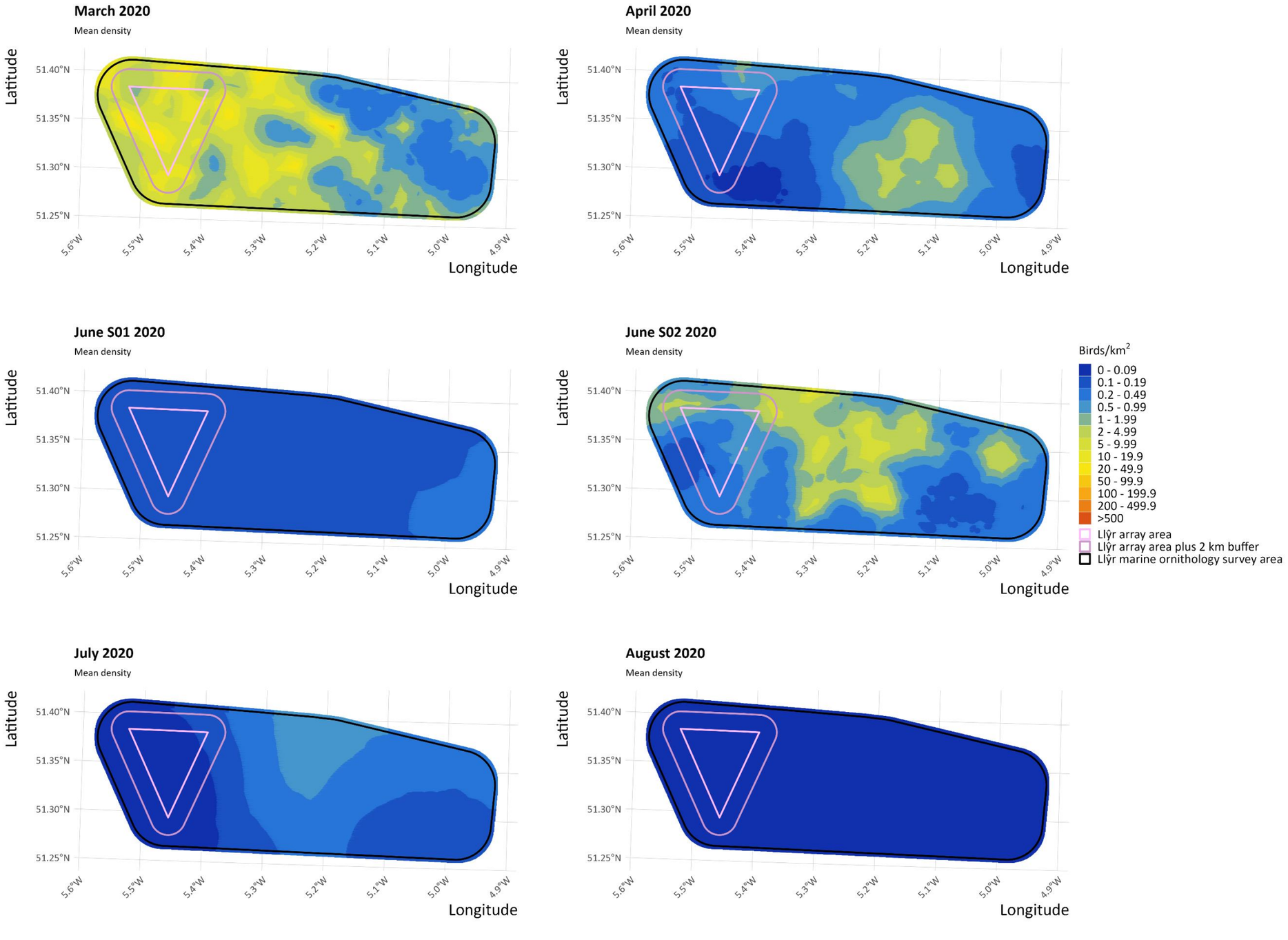


Figure 22A-52. Mean model-based density surfaces for all puffins (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

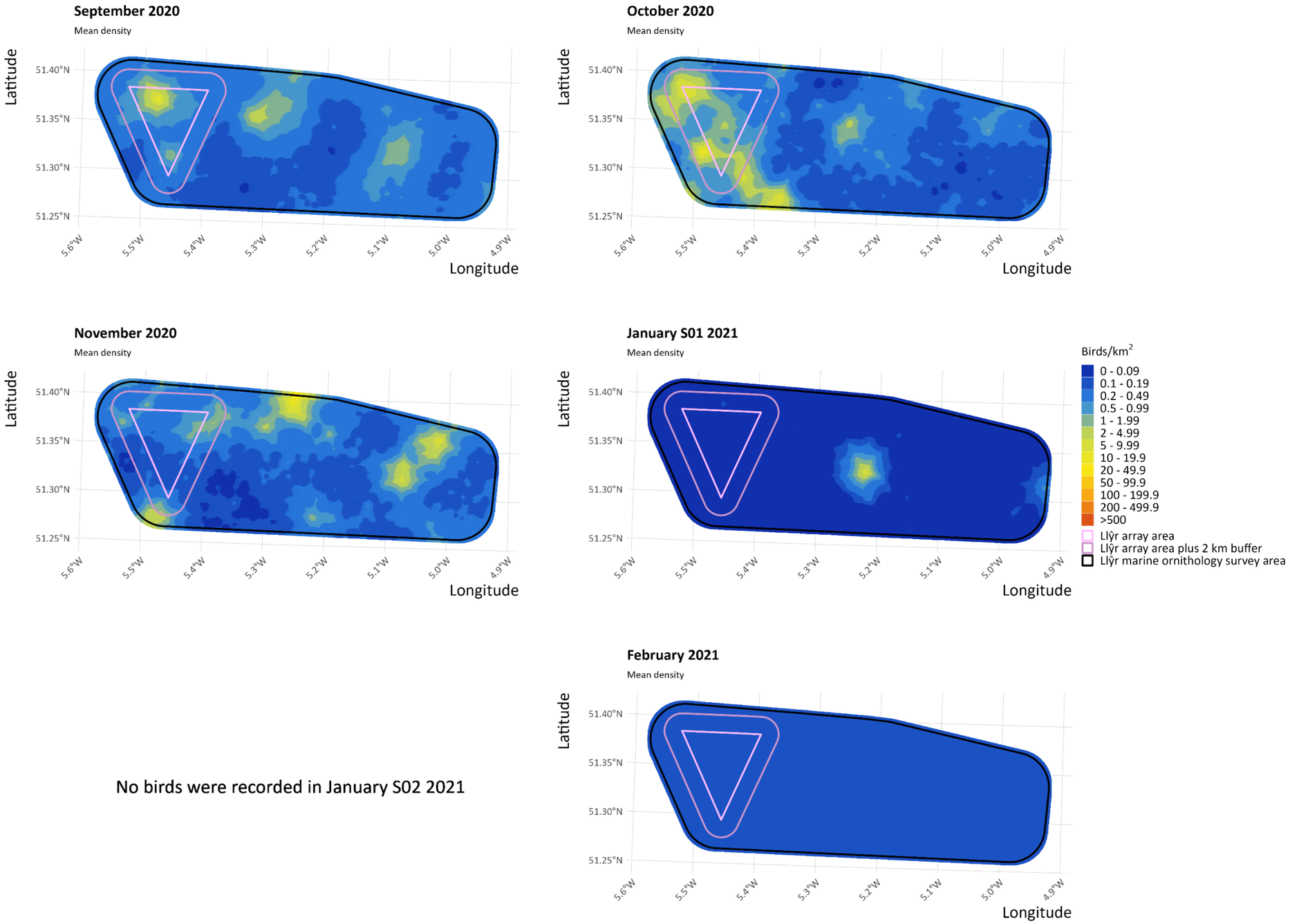


Figure 22A-53. Mean model-based density surfaces for all puffins (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

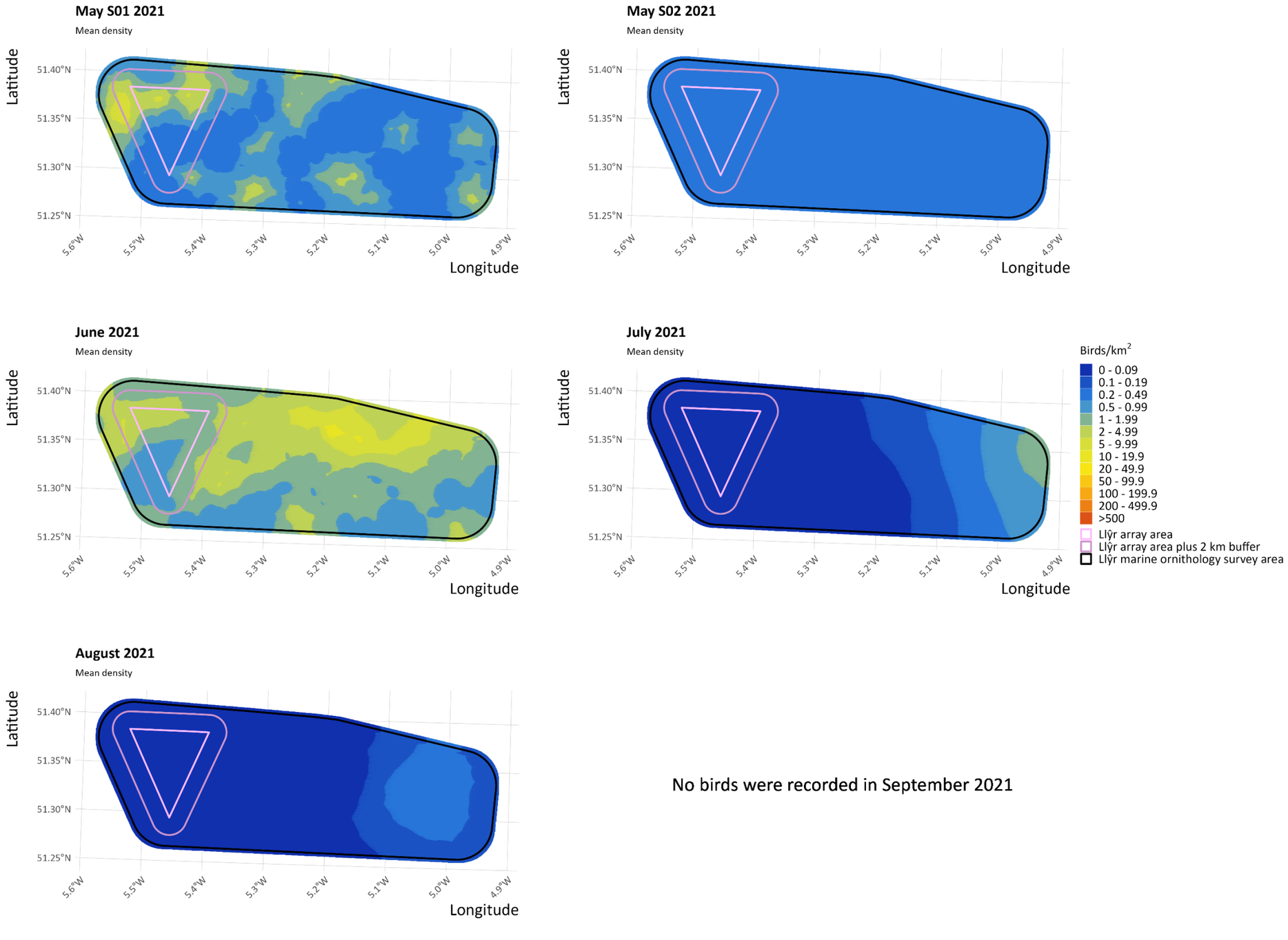


Figure 22A-54. Mean model-based density surfaces for all puffins (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

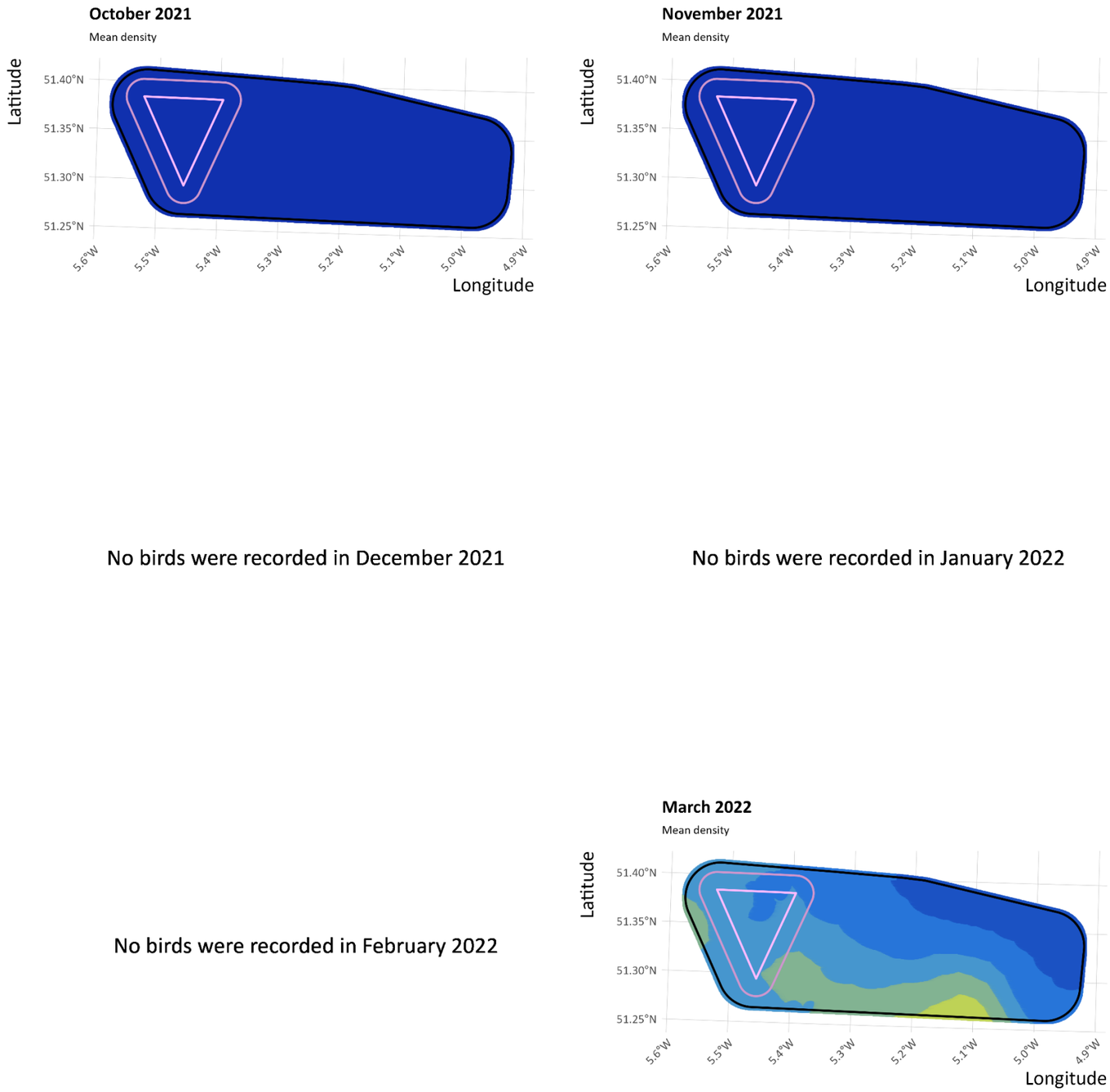


Figure 22A-55. Mean model-based density surfaces for all puffins (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

MSP Population Estimates for Displacement

131. MSP population estimates for the Array Area plus a 2 km buffer are provided for puffins for input into displacement assessment (**Appendix 22D: Marine Ornithology Displacement Assessment**).

132. The maximum model-based absolute population estimate of all puffins (flying and sitting) in the Array Area plus a 2 km buffer was recorded at the end of the non-breeding season, with 1,108 birds (95% CI 916 – 1,338; March 2020) (**Table 22A-26** and **Figure 22A-56**). Comparative design-based absolute estimates are presented in **Appendix 22A: Annex D** for context.

133. Accordingly, the highest MSP population estimate of all birds within the Array Area plus a 2 km buffer occurred in the non-breeding season at 592 birds (95% CI 485 – 698) (**Table 22A-27**).

Table 22A-26. Puffin monthly model-based absolute population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer

Puffin	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	1108	916	1338	102	9.2
14-Apr-20	27	13	60	11	40.0
08-Jun-20	16	8	33	6	38.3
24-Jun-20	93	49	178	38	40.8
21-Jul-20	8	2	21	5	60.4
31-Aug-20	4	1	11	3	68.9
12-Sep-20	84	44	145	27	32.2
22-Oct-20	182	116	281	48	26.3
26-Nov-20	53	19	134	30	56.5
10-Jan-21	4	0	23	8	204.7
25-Jan-21	0	0	0	0	0.0
22-Feb-21	21	12	35	7	31.5
14-May-21	179	117	276	40	22.6
27-May-21	32	19	49	9	27.0
15-Jun-21	210	151	313	41	19.5
14-Jul-21	3	1	12	3	98.6
16-Aug-21	7	2	20	5	78.4
01-Sep-21	0	0	0	0	0.0
22-Oct-21	5	1	11	3	53.0
20-Nov-21	3	1	9	2	80.6
16-Dec-21	0	0	0	0	0.0
05-Jan-22	0	0	0	0	0.0
26-Feb-22	0	0	0	0	0.0
20-Mar-22	76	45	104	16	21.5

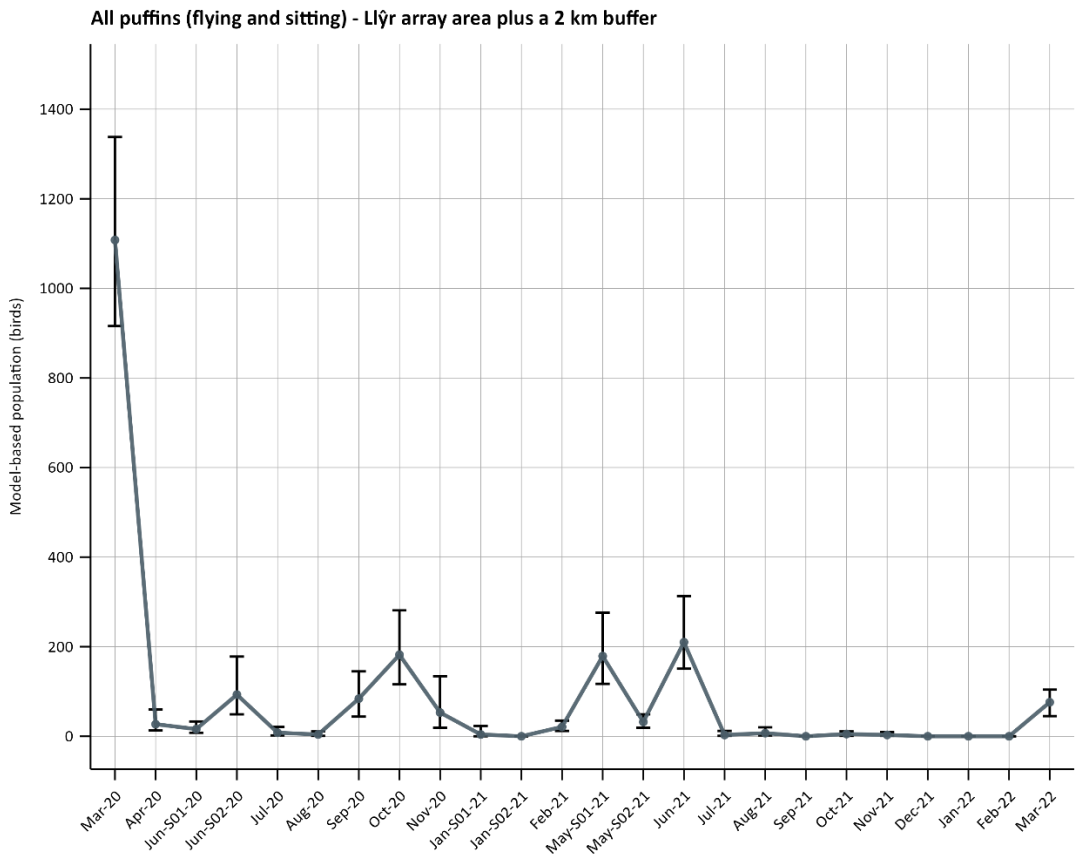


Figure 22A-56. Monthly model-based absolute population estimates of all puffins (flying and sitting) within the Array Area plus a 2 km buffer (associated credible intervals are represented by error bars)

Table 22A-27. Model-based MSP population estimate of all puffins (flying and sitting) in each season within the Array Area plus a 2 km buffer

Puffin	Year 1 Peak (n)	Year 2 Peak (n)	MSP Population (n)	MSP LCL (n)	MSP UCL (n)
Breeding season	*Jun 2020 – 16*	*Jun 2021 – 210*	152	101	205
Non-breeding season	*Mar 2020 – 1,108*	*Mar 2022* – 76*	592	485	698

**Used to represent March 2021*

Site-Based Age Information for PVA

134. Site-based age information will not be used for puffins. In DAS footage, the small size of puffins means the usual characteristics to age birds are hard to distinguish. As such, any age data collected is unlikely to be representative of the true population. For PVA, all puffins will be precautionarily assigned as breeding adults.

Manx Shearwater

Density and Population Estimates

135. Model-based densities and abundances of all Manx shearwaters within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-28**. The highest

abundance of Manx shearwaters were generally observed during the spring migration period and UK breeding season (**Table 22A-28** and **Appendix 22A: Annex A**). Densities reached a peak of 47.64 birds/km^2 (95% CI 44.24 – 51.16; June S02 2020) and 30.62 birds/km^2 (95% CI 26.48 – 35.45, March 2022) in both boundaries, respectively.

136. Albeit following similar temporal distribution as the Erebus data, peak estimates in the Llŷr marine ornithology survey area are relatively higher than those estimated at Erebus (13.99 bird/km^2 in September 2021; HiDef Aerial Surveying Ltd, 2021).

137. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-28. Manx shearwater monthly model-based density and population estimates of all birds (flying and sitting) at Llŷr

Manx shearwater	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	12.22	11.37	13.13	7,830	7,287	8,417	314	4.0
14-Apr-20	0.79	0.59	1.07	505	379	687	80	15.9
08-Jun-20	11.92	11.17	12.88	7,640	7,160	8,253	272	3.6
24-Jun-20	47.64	44.24	51.16	30,535	28,357	32,792	1,163	3.8
21-Jul-20	19.65	17.98	21.41	12,593	11,526	13,723	621	4.9
31-Aug-20	31.08	29.69	32.86	19,920	19,030	21,061	612	3.1
12-Sep-20	0.15	0.09	0.25	97	60	161	25	25.9
22-Oct-20	0.00	0.00	0.00	0	0	0	0	0.0
26-Nov-20	0.13	0.06	0.23	80	39	150	28	35.0
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.11	0.06	0.18	73	37	112	21	28.6
14-May-21	2.49	1.96	3.29	1,598	1,256	2,107	235	14.7
27-May-21	14.23	12.98	15.99	9,123	8,319	10,249	540	5.9
15-Jun-21	15.13	14.29	16.17	9,694	9,158	10,364	314	3.2
14-Jul-21	0.34	0.24	0.48	218	152	308	44	20.4
16-Aug-21	15.69	13.78	18.06	10,055	8,831	11,572	703	7.0
01-Sep-21	0.13	0.07	0.23	82	43	149	27	32.8
22-Oct-21	0.20	0.09	0.33	125	58	212	47	37.4
20-Nov-21	0.06	0.03	0.15	41	16	93	19	46.2
16-Dec-21	0.01	0.00	0.05	9	1	34	10	111.8
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	6.35	5.80	6.82	4,071	3,715	4,368	181	4.4
Array Area								
25-Mar-20	4.08	3.01	5.55	183	135	249	30	16.5
14-Apr-20	0.82	0.36	1.89	37	16	85	21	56.0
08-Jun-20	0.80	0.42	1.45	36	19	65	13	36.4
24-Jun-20	3.10	2.21	4.23	139	99	190	26	18.7
21-Jul-20	18.82	9.80	33.16	845	440	1489	265	31.4
31-Aug-20	20.91	17.55	23.61	939	788	1060	72	7.7
12-Sep-20	0.16	0.09	0.27	7	4	12	2	31.4
22-Oct-20	0.00	0.00	0.00	0	0	0	0	0.0

Manx shearwater	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
26-Nov-20	0.11	0.07	0.25	5	3	11	2	46.4
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.11	0.05	0.20	5	2	9	2	33.7
14-May-21	1.05	0.53	1.83	47	24	82	16	33.6
27-May-21	13.21	10.56	16.08	593	474	722	66	11.0
15-Jun-21	10.04	8.06	12.61	451	362	566	56	12.4
14-Jul-21	0.09	0.02	0.25	4	1	11	3	70.0
16-Aug-21	1.58	0.96	2.43	71	43	109	18	25.4
01-Sep-21	0.13	0.07	0.25	6	3	11	2	31.8
22-Oct-21	0.53	0.16	1.18	24	7	53	14	59.4
20-Nov-21	0.07	0.02	0.11	3	1	5	1	37.9
16-Dec-21	0.02	0.00	0.05	1	0	2	1	78.8
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	30.62	26.48	35.45	1,375	1,189	1,592	109	8.0
Array Area plus 2 km buffer								
25-Mar-20	3.99	3.21	4.79	476	383	571	51	10.7
14-Apr-20	0.90	0.46	1.37	107	55	163	34	31.5
08-Jun-20	1.40	0.95	1.86	167	113	222	29	17.1
24-Jun-20	5.41	4.22	6.54	645	503	779	77	12.0
21-Jul-20	26.05	20.67	35.32	3,105	2,464	4,210	453	14.6
31-Aug-20	40.93	33.42	49.70	4,878	3,983	5,924	515	10.5
12-Sep-20	0.16	0.08	0.26	19	10	31	5	28.8
22-Oct-20	0.00	0.00	0.00	0	0	0	0	0.0
26-Nov-20	0.12	0.05	0.19	14	6	23	5	32.5
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.10	0.06	0.17	12	7	20	4	30.4
14-May-21	1.14	0.70	1.80	136	83	215	37	27.5
27-May-21	16.69	12.43	23.56	1,989	1,482	2,808	364	18.3
15-Jun-21	9.21	7.80	10.97	1,098	930	1,308	97	8.8
14-Jul-21	0.08	0.03	0.16	10	3	19	5	45.7
16-Aug-21	2.95	2.22	3.82	352	265	455	53	15.0
01-Sep-21	0.13	0.07	0.22	15	8	26	4	29.2
22-Oct-21	0.29	0.08	0.66	34	10	79	18	51.9
20-Nov-21	0.07	0.03	0.15	8	3	18	4	46.6
16-Dec-21	0.02	0.00	0.08	2	0	10	3	168.6
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	17.27	15.51	19.83	2,058	1,848	2,363	138	6.7

Distribution and Spatial Densities

138. Birds were widespread across the Llŷr marine ornithology survey area with observations in the east as well as in the Array Area (**Figure 22A-57** to **Figure 22A-60**).

139. Mean model-based density surfaces of Manx shearwaters are presented in **Figure 22A-61** to **Figure 22A-64**. In general, higher densities were estimated in the eastern part of the Llŷr marine ornithology survey area and within the Array Area.

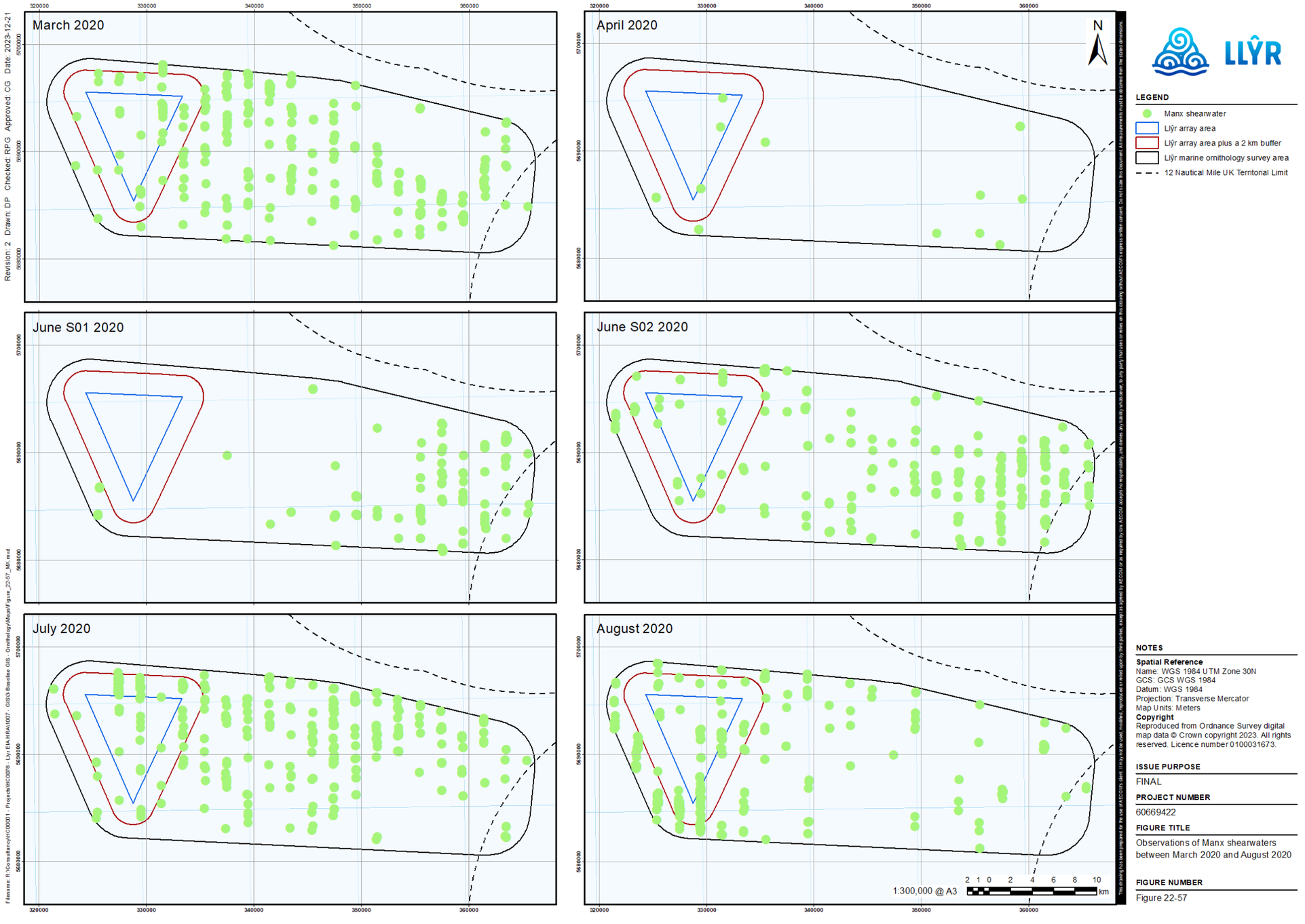


Figure 22A-57. Distribution map of recorded Manx shearwaters within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

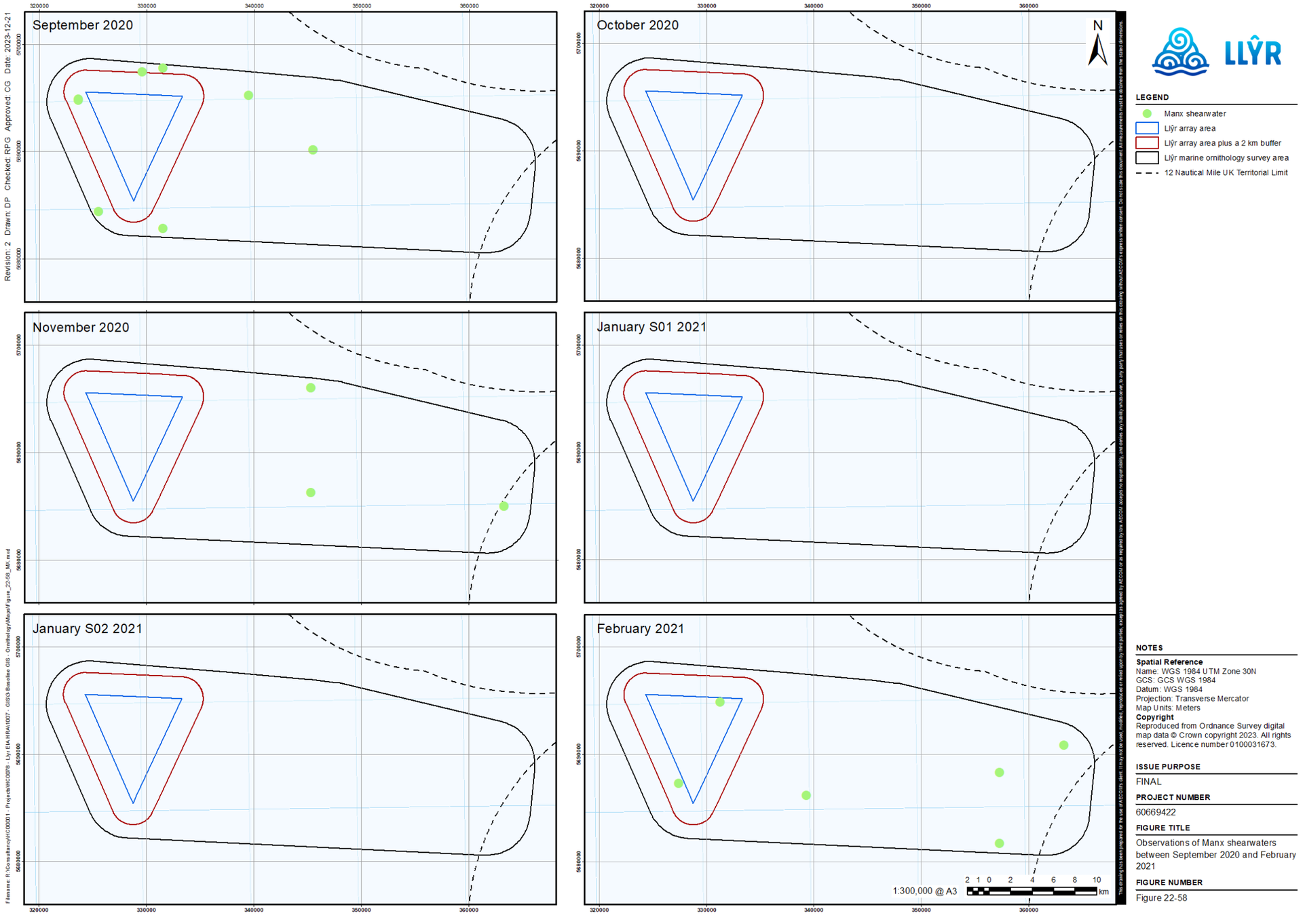


Figure 22A-58. Distribution map of recorded Manx shearwaters within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

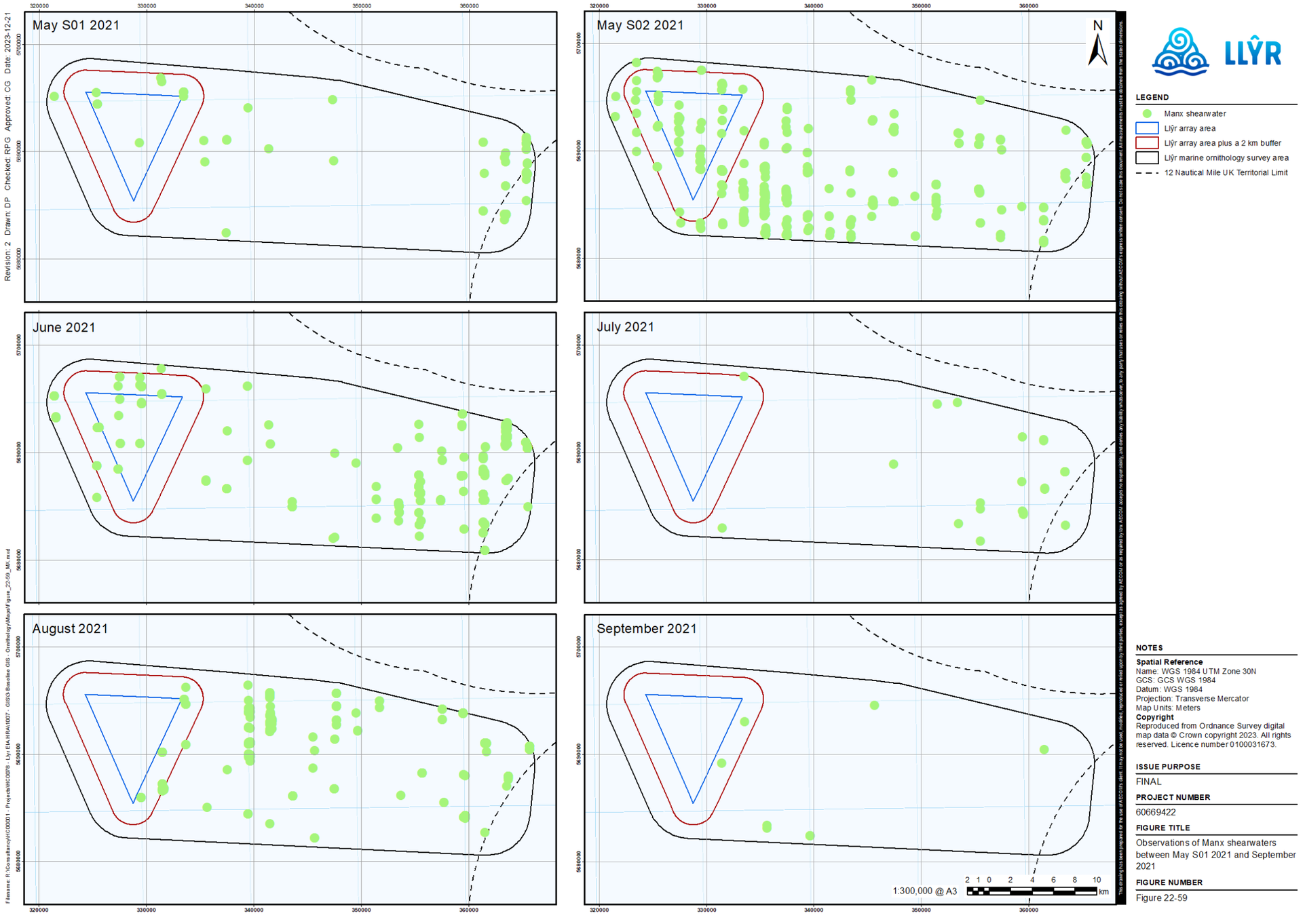


Figure 22A-59. Distribution map of recorded Manx shearwaters within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

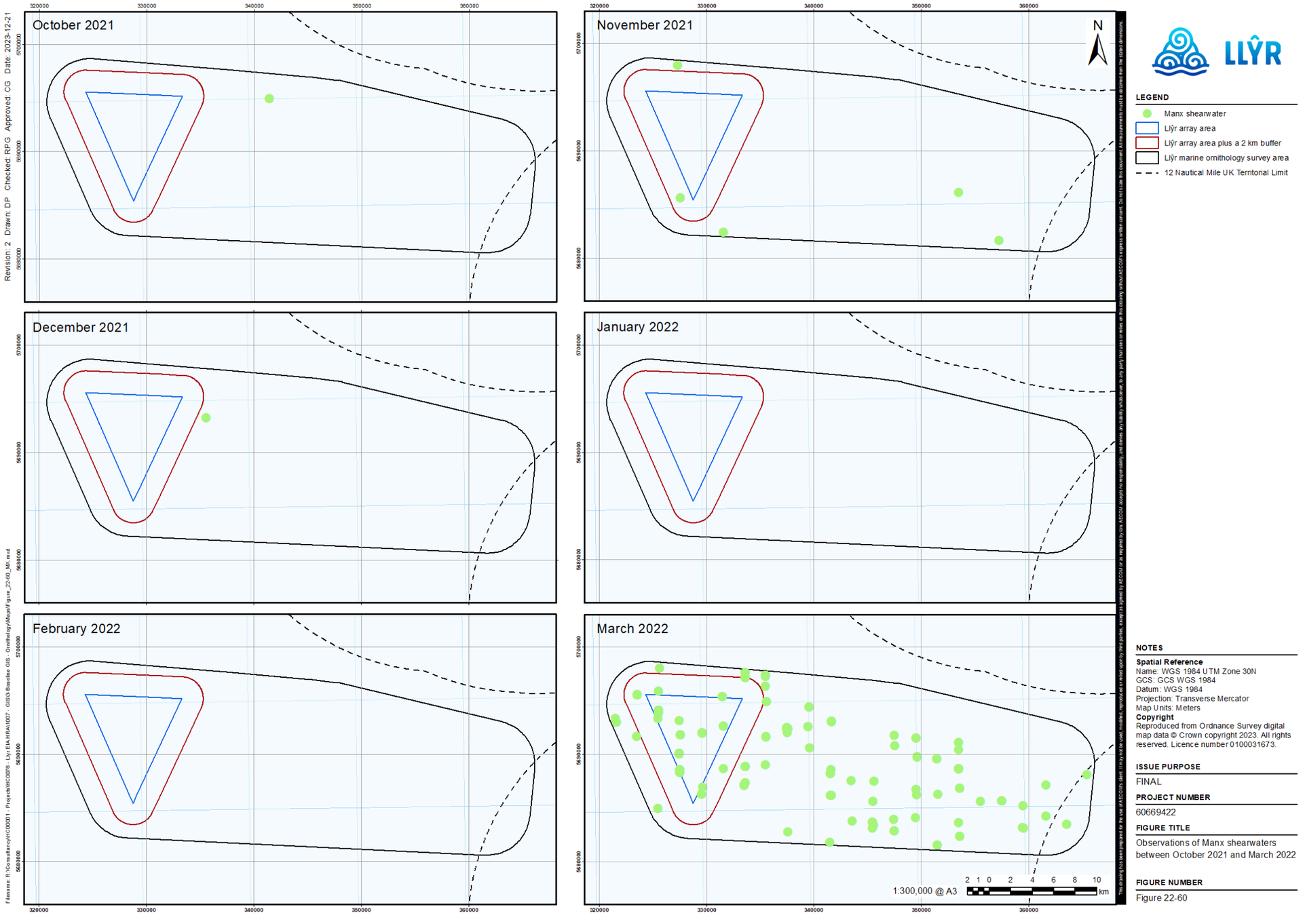


Figure 22A-60. Distribution map of recorded Manx shearwaters within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

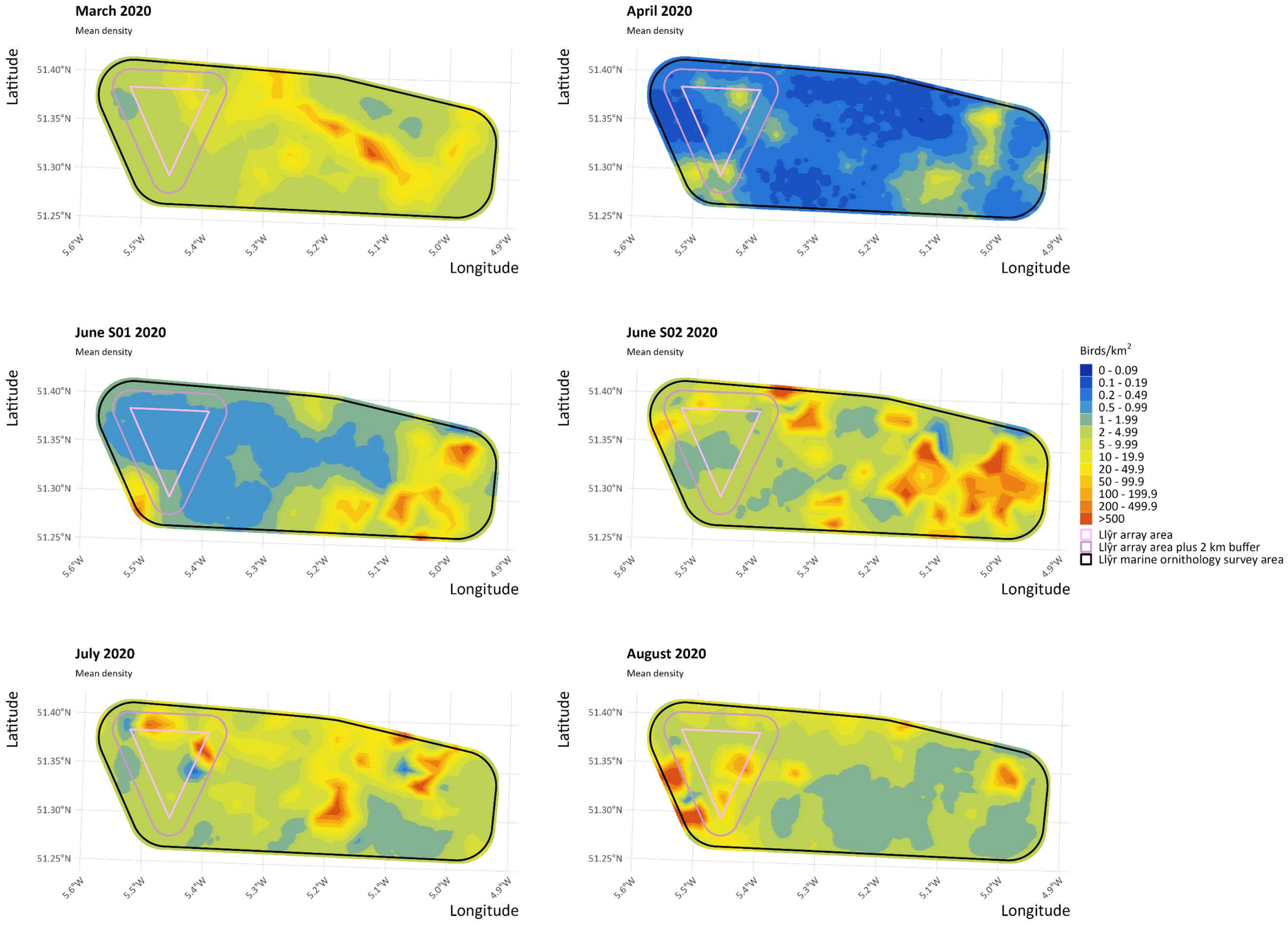
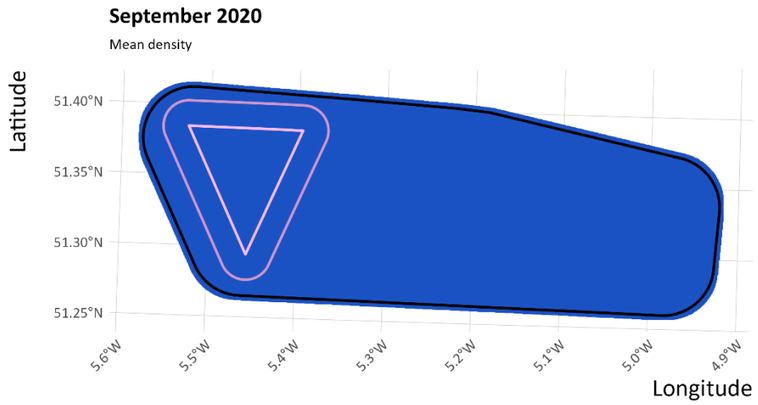
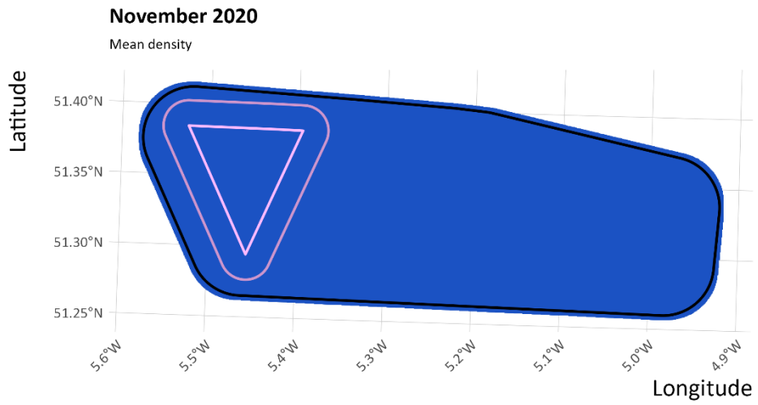


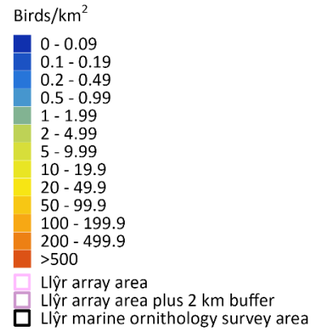
Figure 22A-61. Mean model-based density surfaces for all Manx shearwaters (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)



No birds were recorded in October 2020



No birds were recorded in January S01 2021



No birds were recorded in January S02 2021

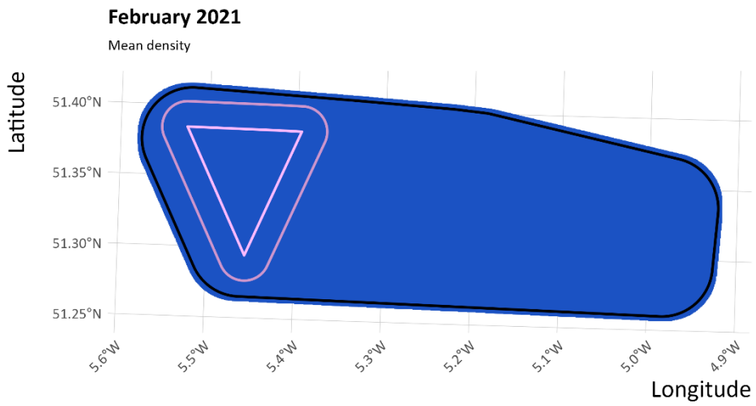


Figure 22A-62. Mean model-based density surfaces for all Manx shearwaters (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

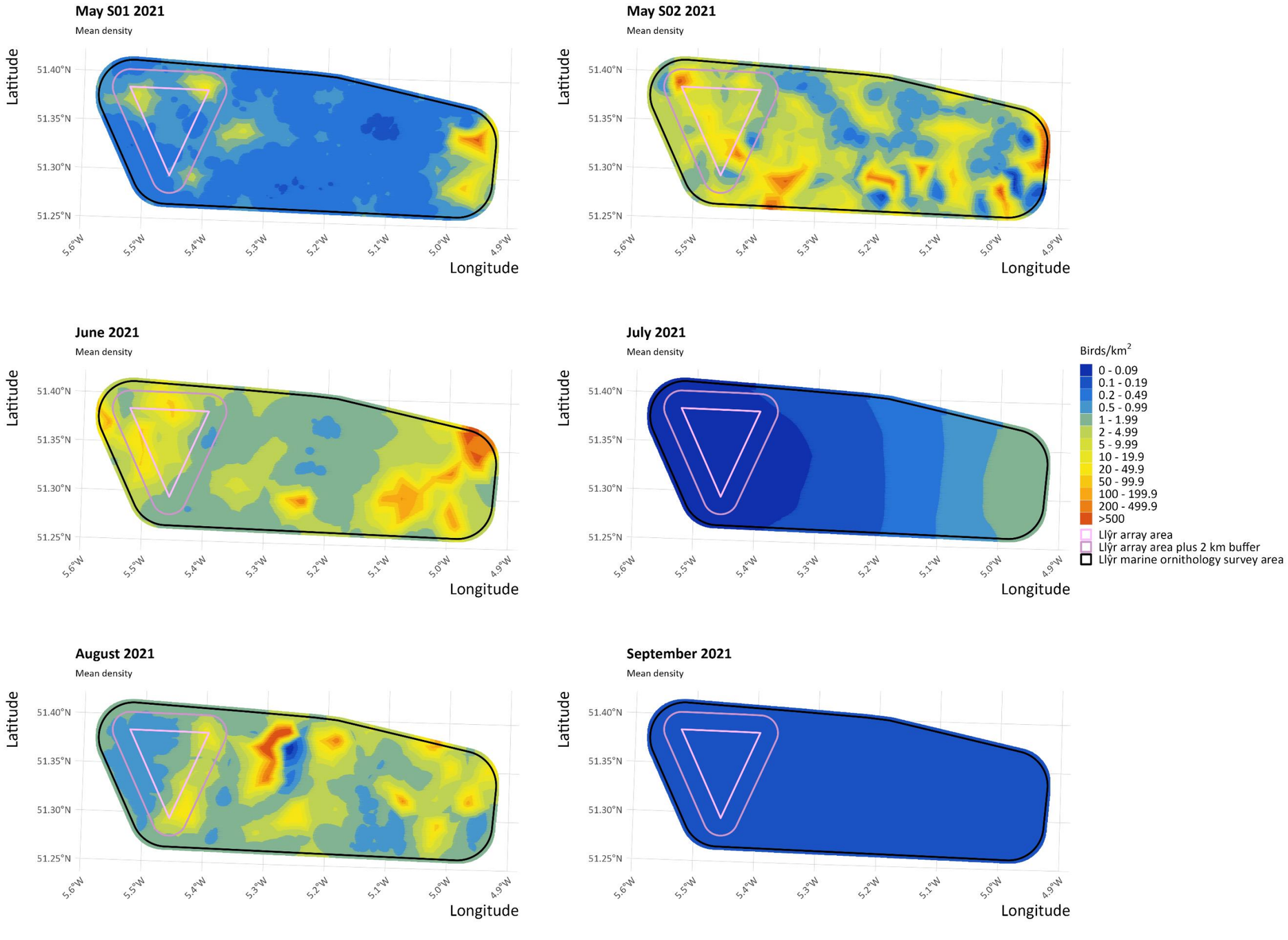


Figure 22A-63. Mean model-based density surfaces for all Manx shearwaters (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

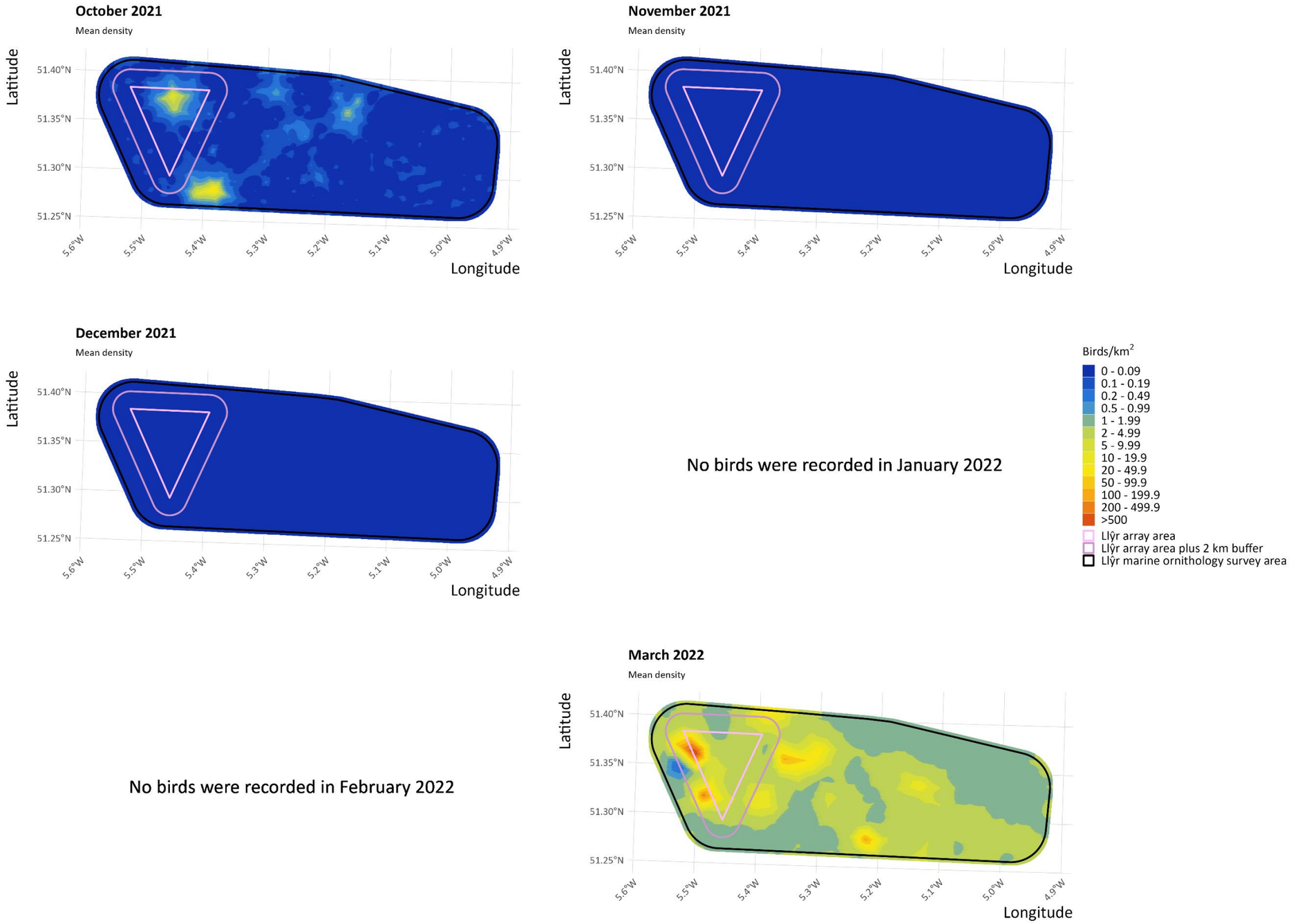


Figure 22A-64. Mean model-based density surfaces for all Manx shearwaters (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

MSP Population Estimates for Displacement

140. MSP population estimates for the Array Area plus a 2 km buffer are provided for Manx shearwaters for input into displacement assessment (**Appendix 22D: Marine Ornithology Displacement Assessment**).

141. The maximum model-based population estimate of all Manx shearwaters (flying and sitting) in the Array Area plus a 2 km buffer was recorded at the end of the UK breeding season, with 4,878 birds (95% CI 3,983 – 5,924; August 2020) (**Table 22A-29** and **Figure 22A-65**). Comparative design-based estimates are presented in **Appendix 22A: Annex D** for context.

142. Accordingly, the highest MSP population estimate of all birds within the Array Area plus a 2 km buffer occurred in the breeding season at 3,434 birds (95% CI 2,870 – 4,058) (**Table 22A-30**). MSP population estimates were also relatively high during the spring migration, dropping to only a few birds in the autumn migration season.

Table 22A-29. Manx shearwater monthly model-based population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer

Manx shearwater	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	476	383	571	51	10.7
14-Apr-20	107	55	163	34	31.5
08-Jun-20	167	113	222	29	17.1
24-Jun-20	645	503	779	77	12.0
21-Jul-20	3,105	2,464	4,210	453	14.6
31-Aug-20	4,878	3,983	5,924	515	10.5
12-Sep-20	19	10	31	5	28.8
22-Oct-20	0	0	0	0	0.0
26-Nov-20	14	6	23	5	32.5
10-Jan-21	0	0	0	0	0.0
25-Jan-21	0	0	0	0	0.0
22-Feb-21	12	7	20	4	30.4
14-May-21	136	83	215	37	27.5
27-May-21	1,989	1,482	2,808	364	18.3
15-Jun-21	1,098	930	1,308	97	8.8
14-Jul-21	10	3	19	5	45.7
16-Aug-21	352	265	455	53	15.0
01-Sep-21	15	8	26	4	29.2
22-Oct-21	34	10	79	18	51.9
20-Nov-21	8	3	18	4	46.6
16-Dec-21	2	0	10	3	168.6
05-Jan-22	0	0	0	0	0.0
26-Feb-22	0	0	0	0	0.0
20-Mar-22	2,058	1,848	2,363	138	6.7

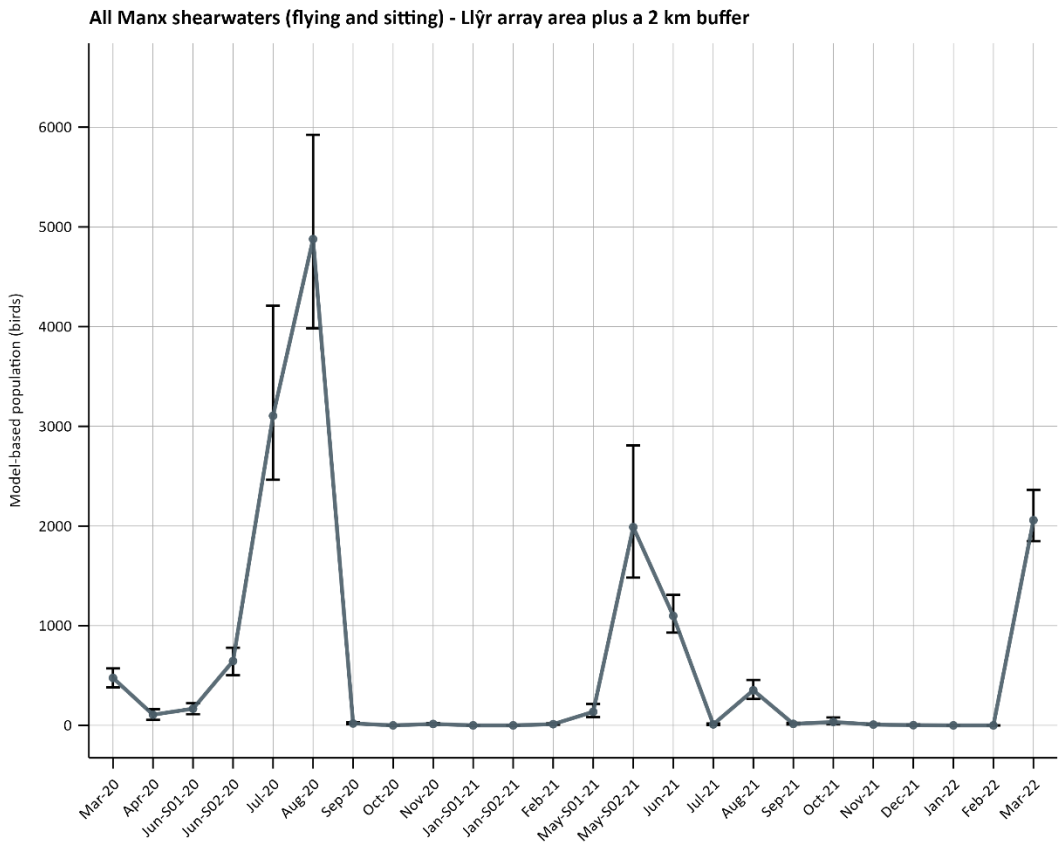


Figure 22A-65. Monthly model-based population estimates of all Manx shearwaters (flying and sitting) within the Array Area plus a 2 km buffer (associated credible intervals are represented by error bars)

Table 22A-30. Model-based MSP population estimate of all Manx shearwaters (flying and sitting) in each season within the Array Area plus a 2 km buffer

Manx shearwater	Year 1 Peak (n)	Year 2 Peak (n)	MSP Population (n)	MSP LCL (n)	MSP UCL (n)
Breeding season	*Aug 2020 – 4,878*	*May 2021 – 1,989*	3,434	2,870	4,058
Autumn migration	*Sep 2020 - 19*	*Oct 2021- 34*	27	12	45
Spring migration	*Mar 2020 – 476*	*Mar 2022* – 2,058*	1,267	1,124	1,410

**Used to represent March 2021*

Site-Based Age Information for PVA

143. It is generally not possible to age Manx shearwaters in DAS footage. As such, site-based age information will not be used for this species. For PVA, all Manx shearwaters will be precautionarily assigned as breeding adults.

Gannet

Density and Population Estimates

144. Model-based densities and abundances of all gannets within the Llŷr marine ornithology survey area and the Array Area are presented in **Table 22A-31**. The highest abundances of gannets were generally observed during the autumn migration period (**Table 22A-31** and **Appendix 22A: Annex A**). Densities reached a peak of 6.48 birds/km^2 (95% CI 5.25 – 8.78; October 2021) and 6.17 birds/km^2 (95% CI 4.50 – 8.49; October 2021) in both boundaries, respectively.

145. Albeit following similar distribution as the Erebus data, peak estimates in the Llŷr marine ornithology survey area are relatively higher than those estimated at Erebus (2.82 bird/km^2 in October 2019; HiDef Aerial Surveying Ltd, 2021).

146. Design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-31. Gannet monthly model-based density and population estimates of all birds (flying and sitting) at Llŷr

Gannet	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
Llŷr marine ornithology survey area								
25-Mar-20	0.49	0.34	0.65	316	219	415	49	15.6
14-Apr-20	0.82	0.60	1.16	526	384	744	93	17.6
08-Jun-20	0.95	0.61	1.48	611	392	950	180	29.5
24-Jun-20	0.63	0.43	0.94	402	274	599	92	22.9
21-Jul-20	0.59	0.41	0.82	379	265	526	70	18.4
31-Aug-20	0.99	0.71	1.39	636	454	891	113	17.7
12-Sep-20	2.29	1.77	3.27	1,465	1,131	2,097	312	21.3
22-Oct-20	1.44	1.21	1.73	925	773	1,110	94	10.1
26-Nov-20	0.45	0.31	0.62	286	200	398	49	17.0
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.06	0.02	0.16	40	15	101	21	52.3
22-Feb-21	0.44	0.29	0.64	280	184	413	57	20.4
14-May-21	1.26	0.99	1.65	809	636	1,055	112	13.9
27-May-21	0.84	0.35	1.73	537	223	1,106	281	52.2
15-Jun-21	0.25	0.15	0.42	160	93	267	47	29.3
14-Jul-21	0.37	0.22	0.55	239	143	349	61	25.3
16-Aug-21	1.71	1.38	2.16	1,097	885	1,383	128	11.7
01-Sep-21	0.29	0.19	0.41	183	123	261	37	20.2
22-Oct-21	6.59	5.26	8.89	4,224	3,371	5,699	606	14.3
20-Nov-21	0.82	0.64	1.05	528	412	674	72	13.6
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.06	0.03	0.12	41	17	75	17	40.8
26-Feb-22	0.30	0.22	0.45	194	140	287	37	19.3
20-Mar-22	0.13	0.07	0.22	86	44	139	27	31.9
Array Area								
25-Mar-20	1.07	0.76	1.47	48	34	66	9	19.2
14-Apr-20	0.82	0.33	1.72	37	15	77	17	46.2
08-Jun-20	0.78	0.18	2.21	35	8	99	33	93.4
24-Jun-20	0.58	0.20	1.45	26	9	65	14	54.7

Gannet	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
21-Jul-20	0.69	0.29	1.25	31	13	56	13	42.4
31-Aug-20	0.60	0.13	2.07	27	6	93	30	109.9
12-Sep-20	0.58	0.16	1.83	26	7	82	26	100.7
22-Oct-20	3.54	2.49	4.70	159	112	211	28	17.6
26-Nov-20	0.47	0.31	0.67	21	14	30	4	18.1
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.07	0.02	0.16	3	1	7	2	57.0
22-Feb-21	0.76	0.36	1.54	34	16	69	14	39.7
14-May-21	1.16	0.45	2.54	52	20	114	23	44.3
27-May-21	1.11	0.36	2.81	50	16	126	30	60.9
15-Jun-21	0.18	0.05	0.47	8	2	21	6	79.9
14-Jul-21	0.58	0.18	1.31	26	8	59	16	63.0
16-Aug-21	2.21	0.87	3.63	99	39	163	42	42.3
01-Sep-21	0.45	0.22	0.69	20	10	31	6	28.3
22-Oct-21	6.17	4.50	8.49	277	202	381	45	16.2
20-Nov-21	0.51	0.22	0.85	23	10	38	8	32.9
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.07	0.02	0.13	3	1	6	1	48.0
26-Feb-22	0.29	0.18	0.42	13	8	19	3	24.1
20-Mar-22	0.22	0.11	0.40	10	5	18	3	30.5
Array Area plus 2 km buffer								
25-Mar-20	1.09	0.79	1.55	130	94	185	24	18.6
14-Apr-20	0.85	0.48	1.35	101	57	161	30	29.3
08-Jun-20	1.31	0.54	2.81	156	64	335	71	45.4
24-Jun-20	0.81	0.42	1.46	97	50	174	33	34.4
21-Jul-20	1.08	0.67	1.69	129	80	201	33	25.5
31-Aug-20	0.46	0.17	1.03	55	20	123	28	50.8
12-Sep-20	0.58	0.21	1.38	69	25	164	38	55.7
22-Oct-20	4.25	3.42	5.32	507	408	634	59	11.7
26-Nov-20	0.47	0.35	0.62	56	42	74	8	14.5
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.07	0.03	0.17	8	3	20	4	51.0
22-Feb-21	0.79	0.49	1.43	94	58	170	30	32.3
14-May-21	2.81	2.01	3.94	335	240	470	70	20.8
27-May-21	0.83	0.29	2.51	99	35	299	69	70.0
15-Jun-21	0.22	0.08	0.45	26	9	53	11	43.3
14-Jul-21	0.70	0.37	1.33	83	44	158	32	38.2
16-Aug-21	2.30	1.50	3.42	274	179	408	58	21.0
01-Sep-21	0.45	0.27	0.77	54	32	92	16	29.3
22-Oct-21	7.74	6.38	9.32	922	760	1,111	97	10.5
20-Nov-21	0.68	0.39	1.17	81	47	139	23	28.7
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.07	0.03	0.14	8	3	17	4	46.5
26-Feb-22	0.29	0.17	0.45	35	20	54	8	23.9

Gannet	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
20-Mar-22	0.24	0.12	0.48	28	14	57	12	43.1
25-Mar-20	1.09	0.79	1.55	130	94	185	24	18.6

Distribution and Spatial Densities

147. Gannets were recorded throughout the Llŷr marine ornithology survey area, primarily within the 2 km buffer area and outside the Array Area and were observed during both the breeding and non-breeding seasons (**Figure 22A-66** to **Figure 22A-69**).

148. Mean model-based density surfaces of gannets are presented in **Figure 22A-70** to **Figure 22A-73**. In general, higher densities were sparse within the Llŷr marine ornithology survey area, with no conclusive trend. Higher densities tended, however, to be found on the edge of the Llŷr marine ornithology survey area boundary.

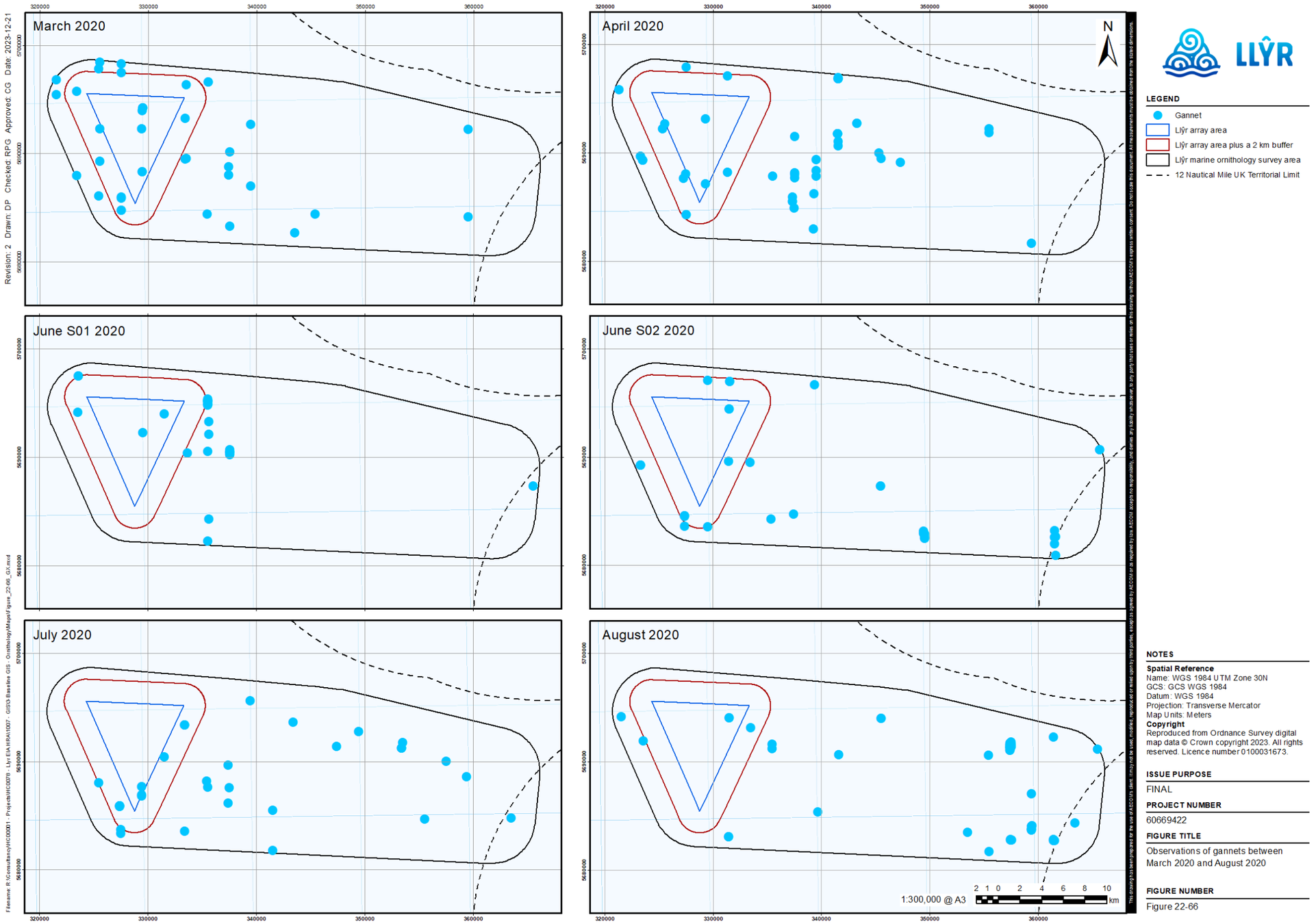


Figure 22A-66. Distribution map of recorded gannets within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

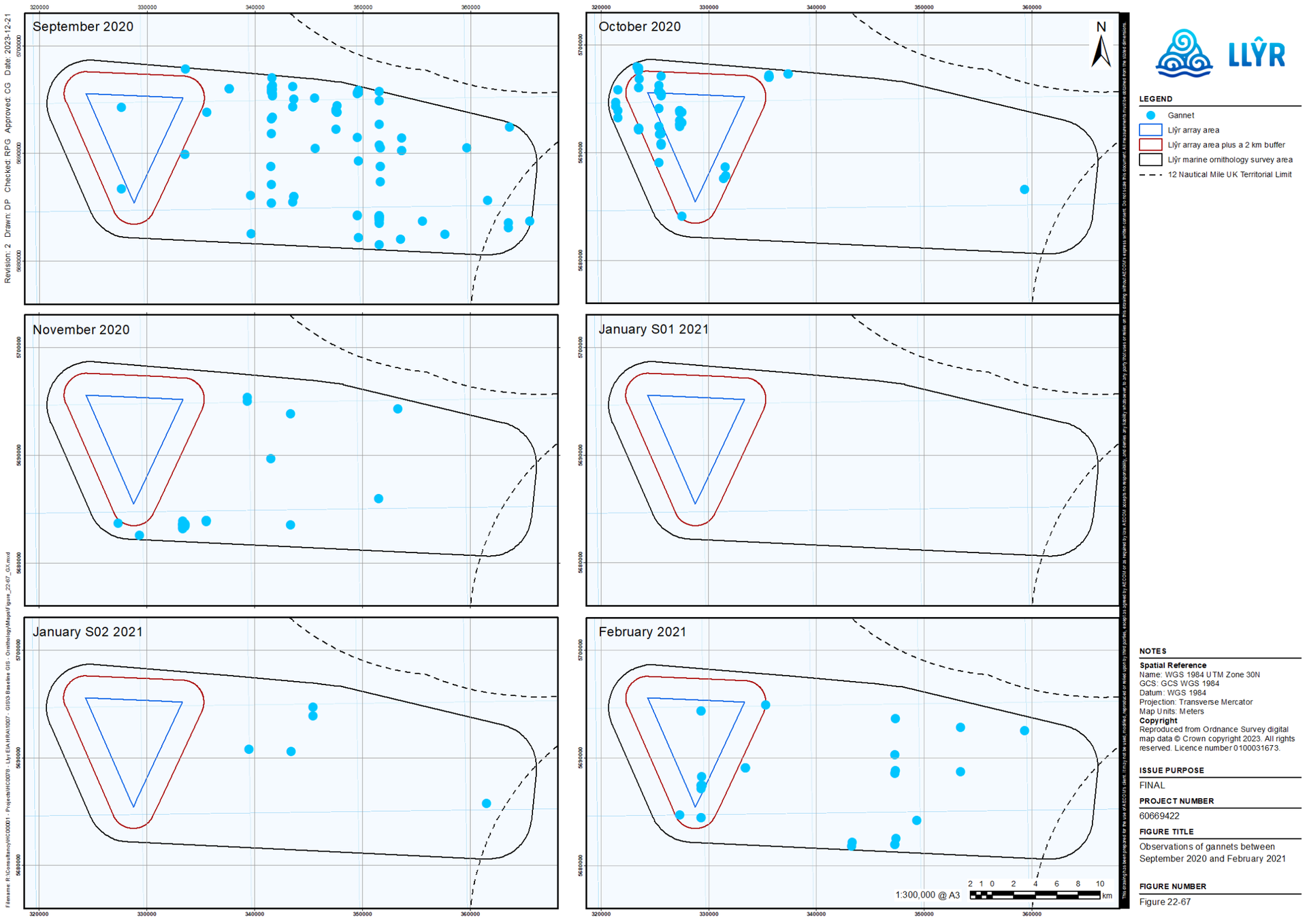


Figure 22A-67. Distribution map of recorded gannets within the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

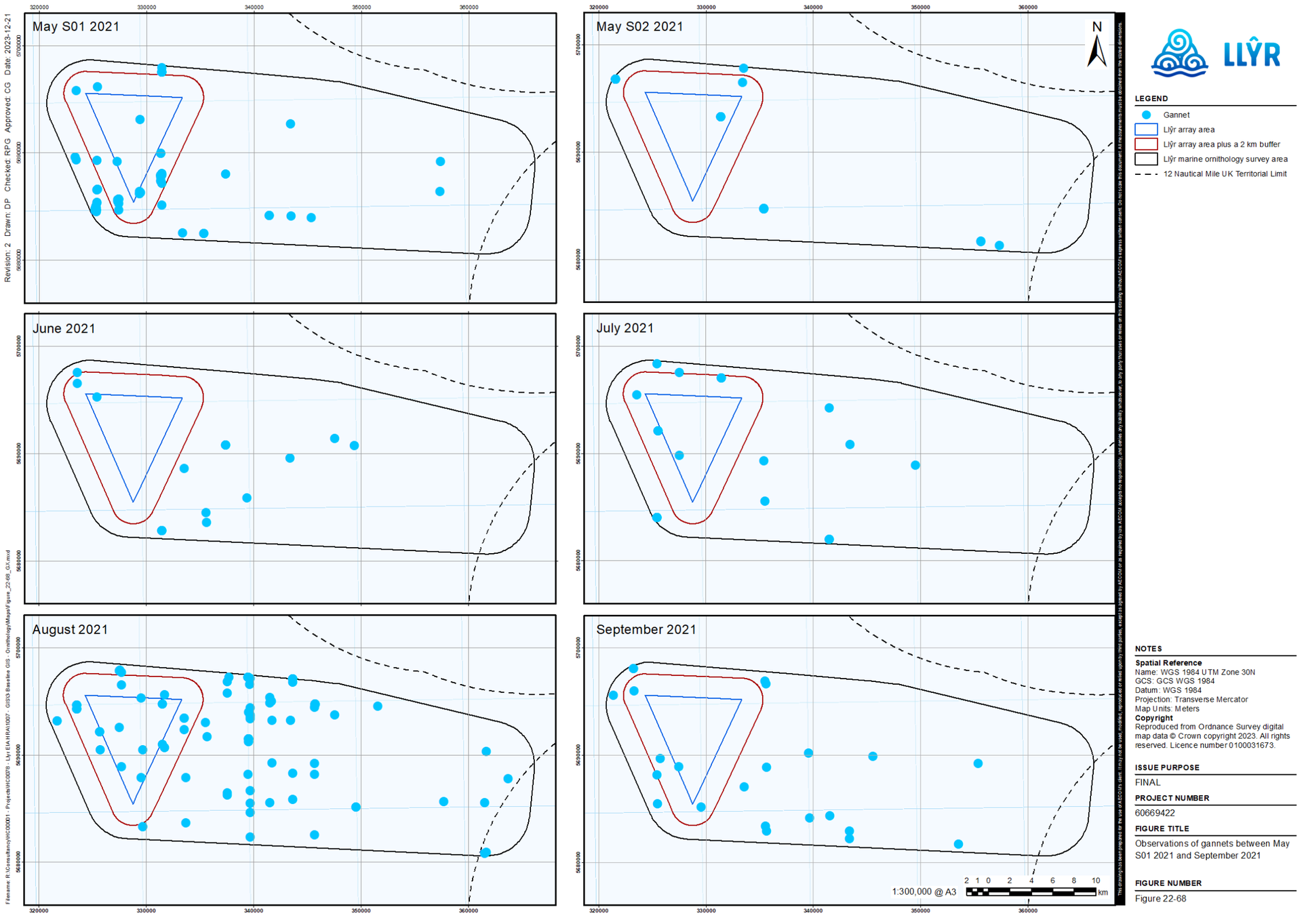


Figure 22A-68. Distribution map of recorded gannets within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

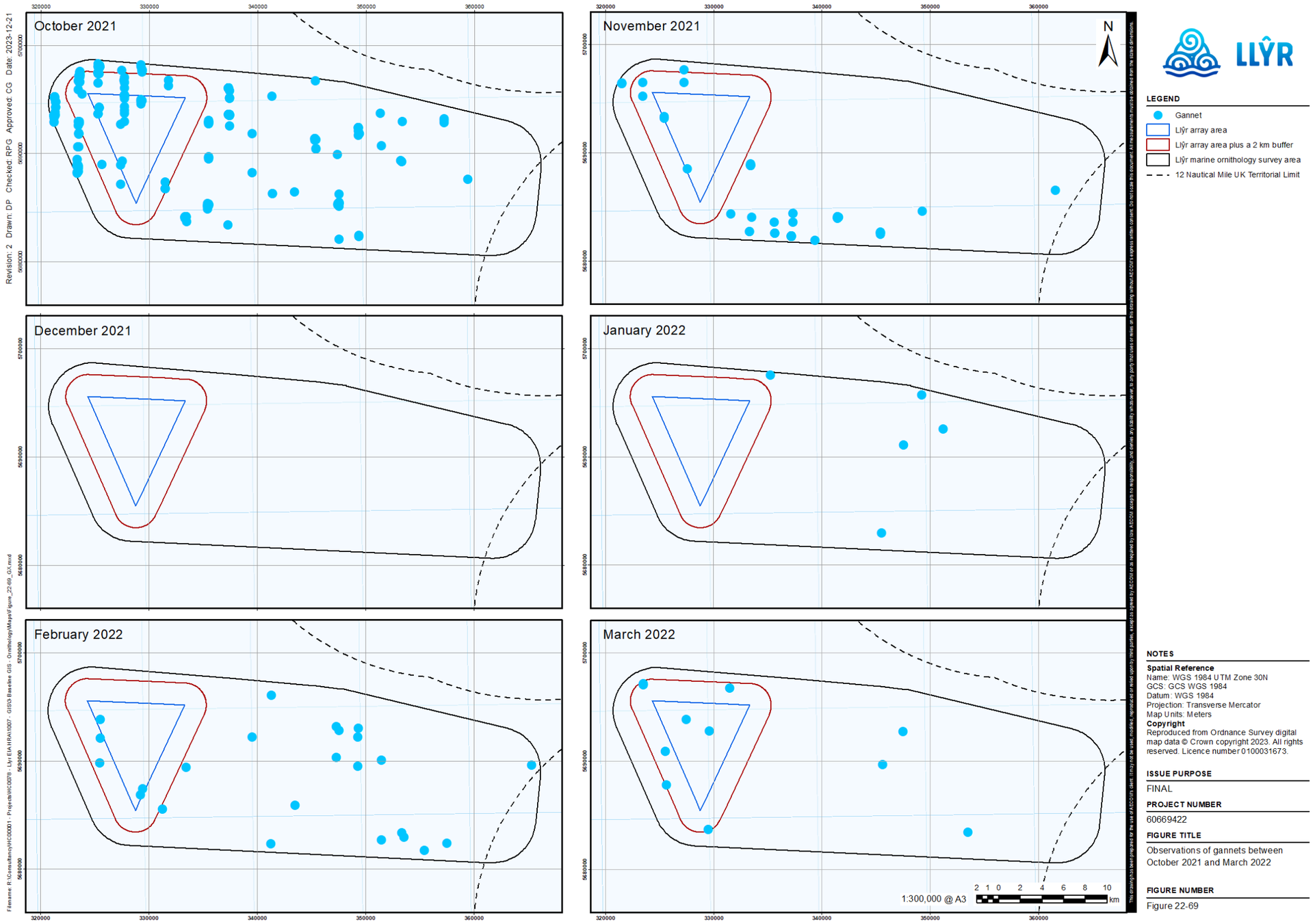


Figure 22A-69. Distribution map of recorded gannets within the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

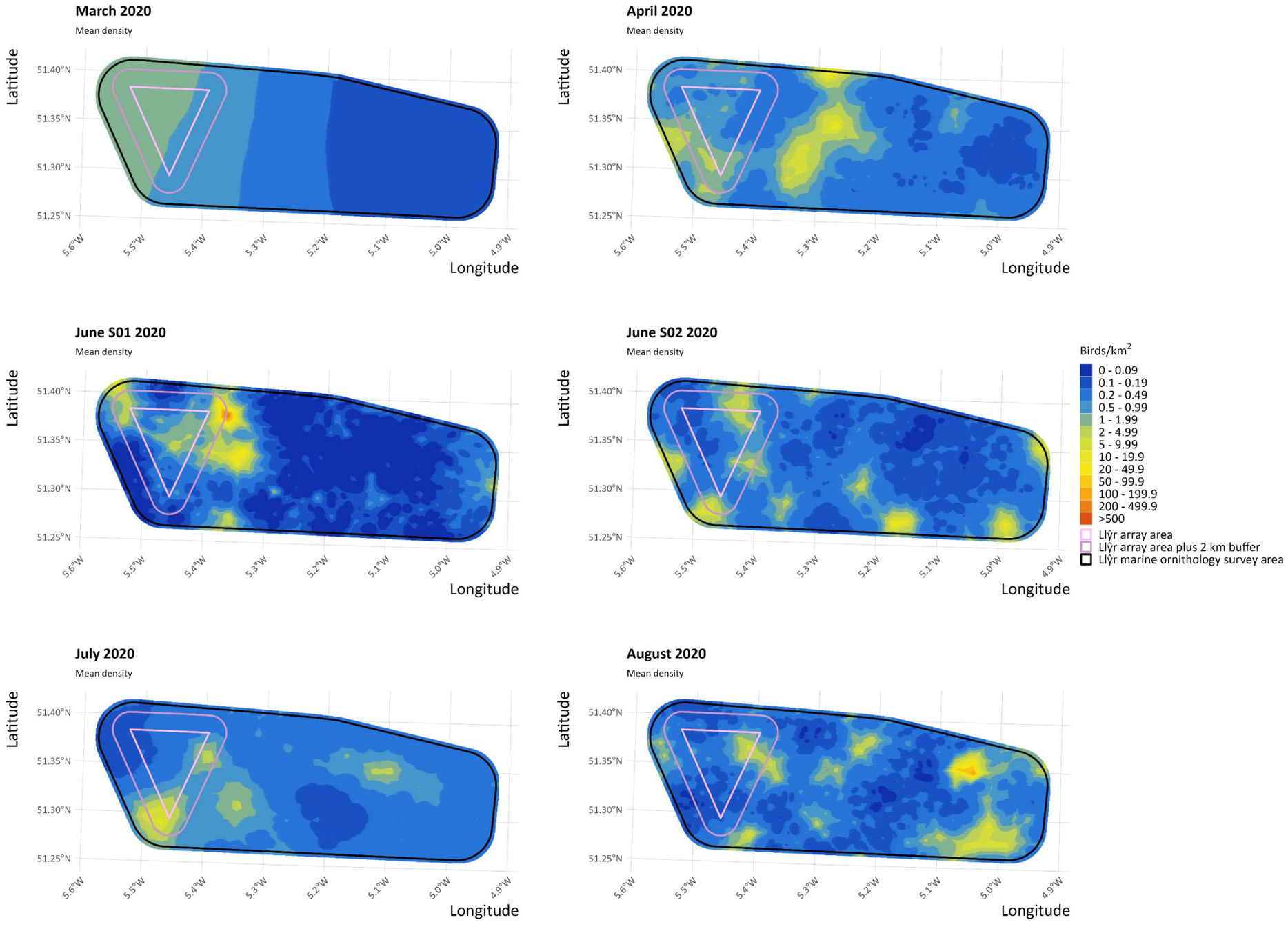


Figure 22A-70. Mean model-based density surfaces for all gannets (flying and sitting) in the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

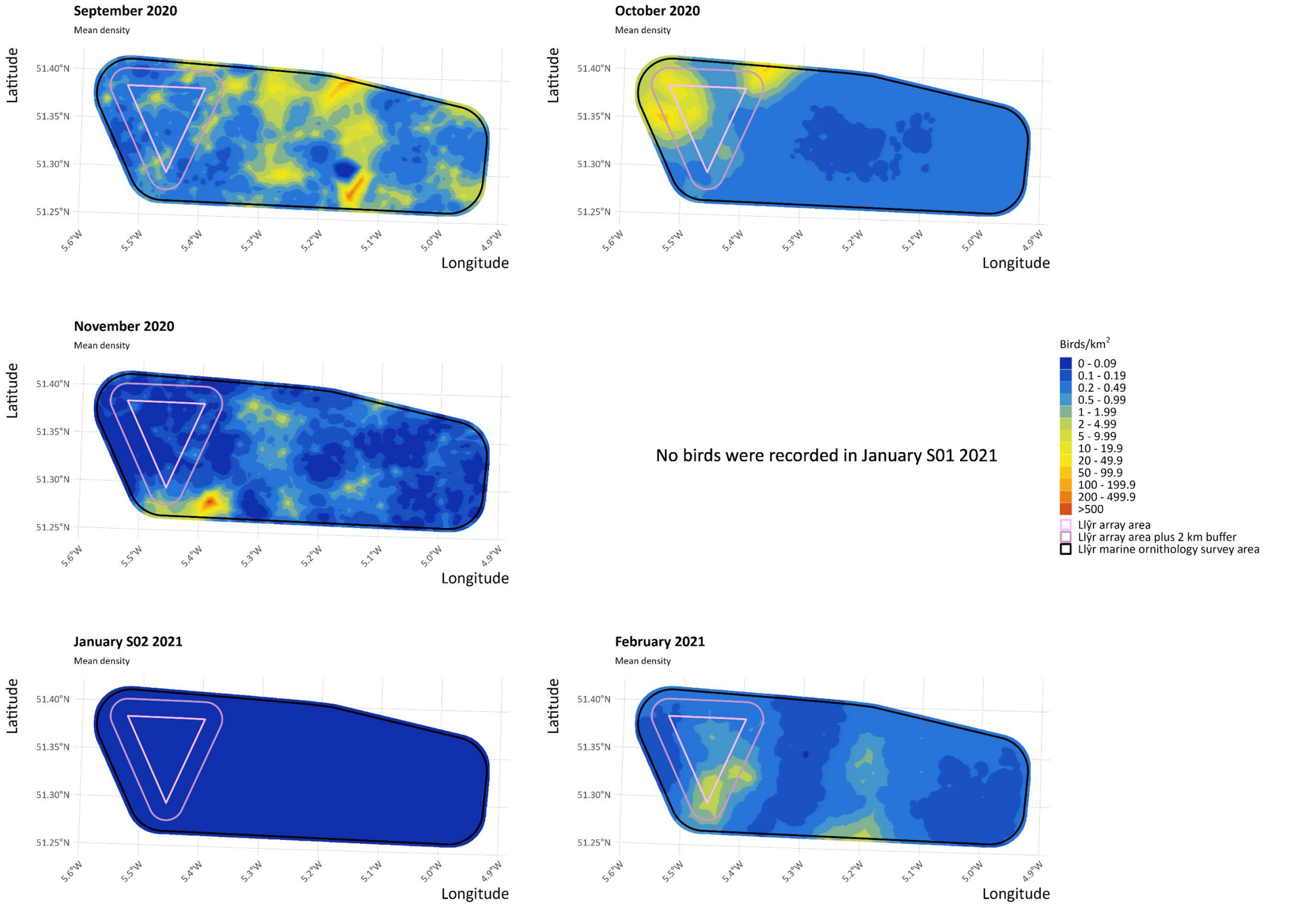


Figure 22A-71. Mean model-based density surfaces for all gannets (flying and sitting) in the Llŷr marine ornithology survey area between survey 7 (September 2020) and survey 12 (February 2021)

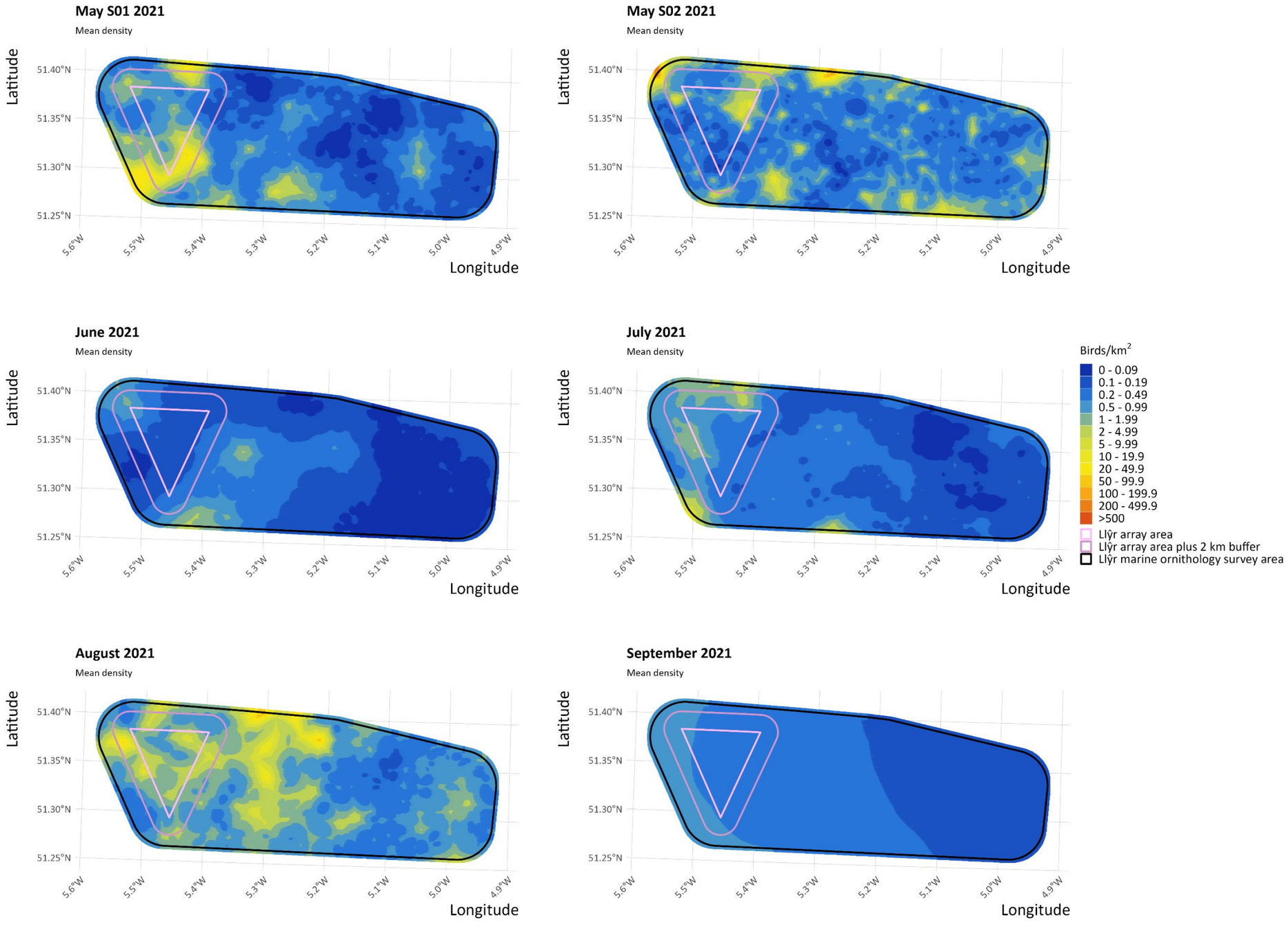
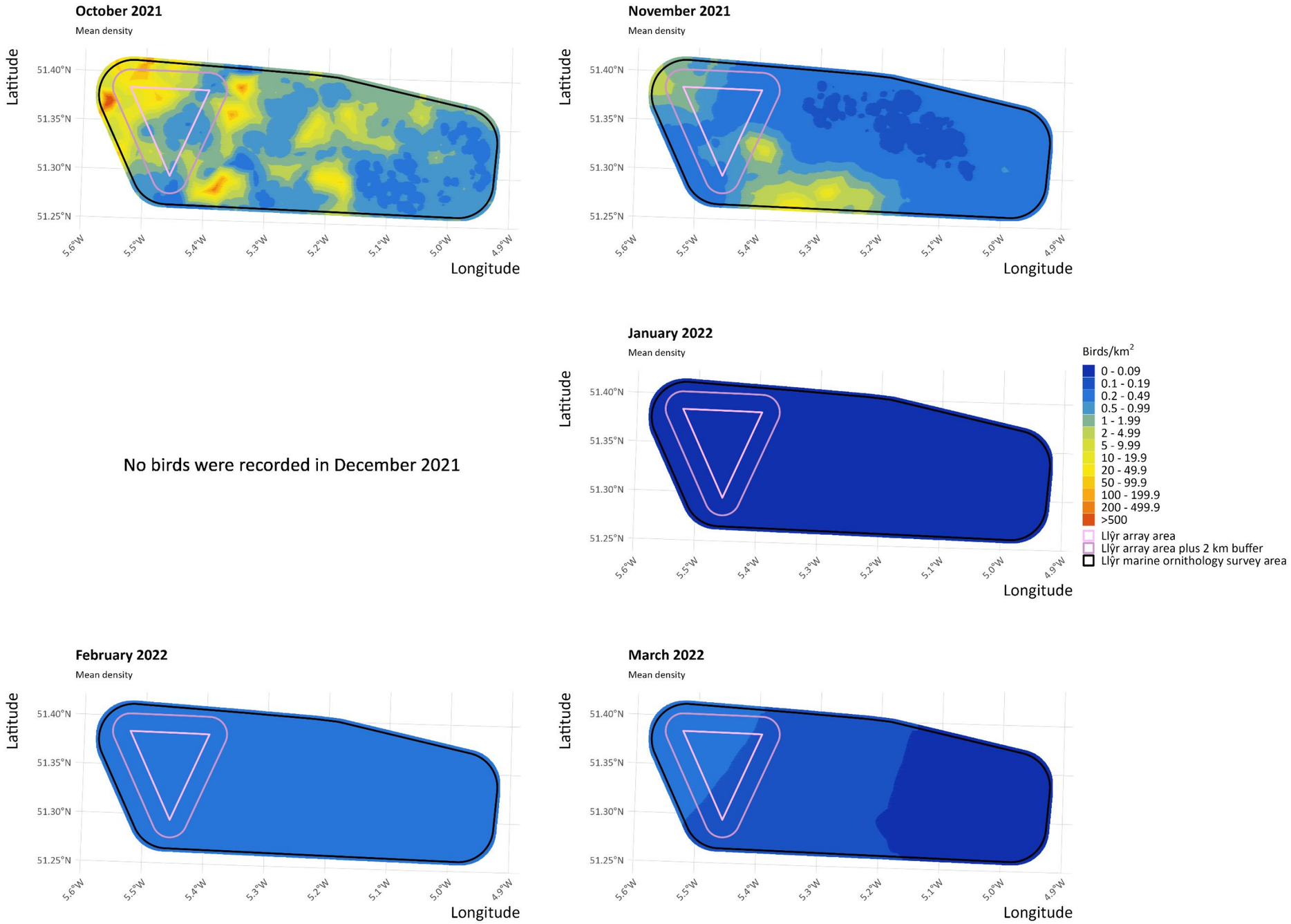


Figure 22A-72. Mean model-based density surfaces for all gannets (flying and sitting) in the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)



No birds were recorded in December 2021

Figure 22A-73. Mean model-based density surfaces for all gannets (flying and sitting) in the Llŷr marine ornithology survey area between survey 19 (October 2021) and survey 24 (March 2022)

Input Densities for CRM

149. Model-based density estimates of flying gannets within the Array Area are provided as a mean (n/km^2) with associated SD for input into CRM (**Appendix 22C: Marine Ornithology Collision Risk Monitoring**).

150. The maximum model-based flying density estimate in the Array Area was recorded in the UK breeding season, with 2.14 birds/km^2 (0.67 SD; August 2021) (**Table 22A-32** and **Figure 22A-74**). Comparative design-based estimates are presented in **Appendix 22A: Annex D** for context.

Table 22A-32. Model-based density estimates of flying gannets within the Array Area

Gannet	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	SD (n/km²)	CV density (%)
25-Mar-20	1.05	0.74	1.49	0.21	20.4
14-Apr-20	0.51	0.18	1.31	0.38	74.6
08-Jun-20	0.42	0.09	1.51	0.53	125.9
24-Jun-20	0.47	0.18	1.00	0.22	47.4
21-Jul-20	0.60	0.25	1.36	0.39	64.9
31-Aug-20	0.20	0.11	0.31	0.05	26.9
12-Sep-20	0.49	0.11	1.51	0.41	84.0
22-Oct-20	0.49	0.18	1.34	0.31	62.3
26-Nov-20	0.07	0.02	0.18	0.05	70.3
10-Jan-21	0.00	0.00	0.00	0.00	0.0
25-Jan-21	0.05	0.02	0.11	0.03	61.3
22-Feb-21	0.82	0.33	1.85	0.40	48.3
14-May-21	0.85	0.36	1.65	0.35	40.7
27-May-21	0.27	0.18	0.36	0.05	20.1
15-Jun-21	0.25	0.11	0.45	0.10	42.2
14-Jul-21	0.62	0.18	1.45	0.37	58.7
16-Aug-21	2.14	1.18	3.59	0.67	31.3
01-Sep-21	0.36	0.20	0.62	0.10	29.0
22-Oct-21	1.16	0.42	2.36	0.55	47.6
20-Nov-21	0.05	0.00	0.11	0.02	50.2
16-Dec-21	0.00	0.00	0.00	0.00	0.0
05-Jan-22	0.05	0.02	0.13	0.03	71.8
26-Feb-22	0.27	0.16	0.45	0.08	29.8
20-Mar-22	0.22	0.11	0.40	0.08	37.2

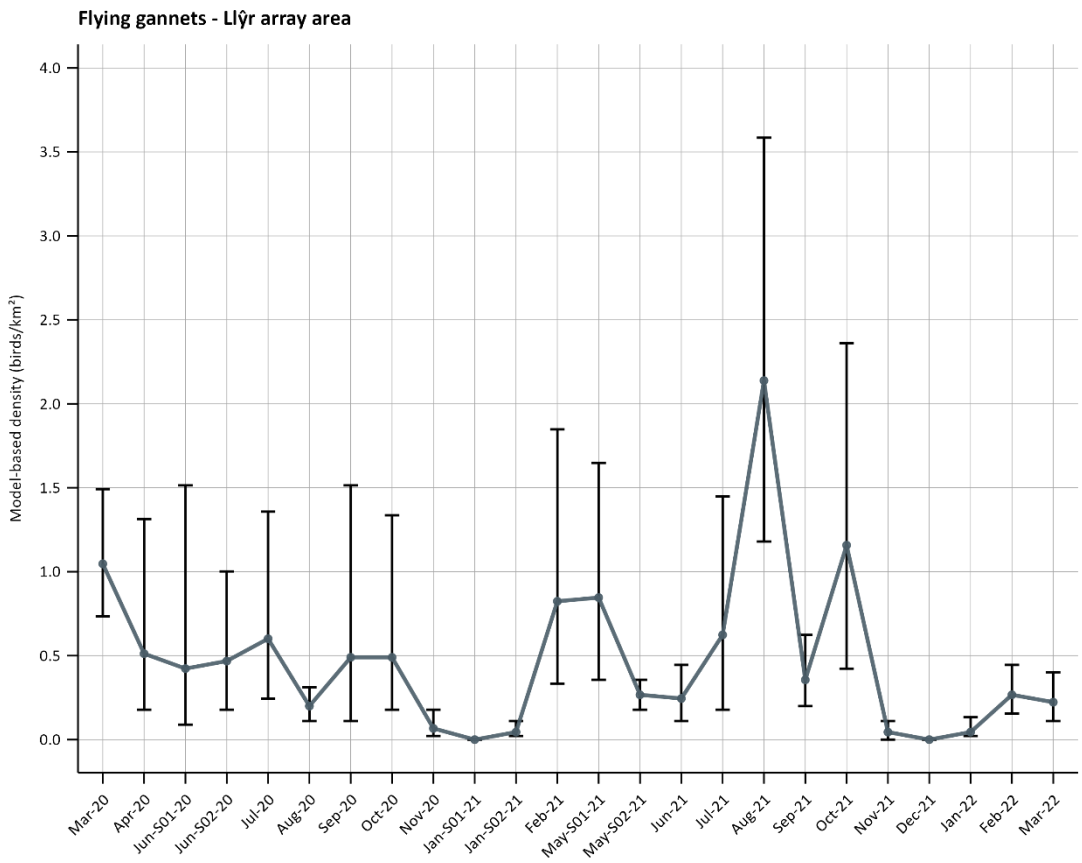


Figure 22A-74. Monthly model-based densities of flying gannets within the Array Area (associated credible intervals are represented by error bars)

MSP Population Estimates for Displacement

151. MSP population estimates for the Array Area plus a 2 km buffer are provided for gannets for input into displacement assessment (**Appendix 22D: Marine Ornithology Displacement Assessment**).

152. The maximum model-based population estimate of all birds (flying and sitting) in the Array Area plus a 2 km buffer was recorded at the beginning of the autumn migration period, with 922 birds (95% CI 760 – 1,111; October 2021) (**Table 22A-33** and **Figure 22A-75**). Comparative design-based estimates are presented in **Appendix 22A: Annex D** for context.

153. Accordingly, the highest MSP population estimate of all birds within the Array Area plus a 2 km buffer occurred in the autumn migration period at 715 birds (95% CI 611 – 831) (**Table 22A-34**). High numbers were also recorded in the breeding season, followed by smaller numbers recorded in the spring migration.

Table 22A-33. Gannet monthly model-based population estimates of all birds (flying and sitting) within the Array Area plus a 2 km buffer

Gannet	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	130	94	185	24	18.6
14-Apr-20	101	57	161	30	29.3
08-Jun-20	156	64	335	71	45.4
24-Jun-20	97	50	174	33	34.4
21-Jul-20	129	80	201	33	25.5
31-Aug-20	55	20	123	28	50.8
12-Sep-20	69	25	164	38	55.7
22-Oct-20	507	408	634	59	11.7
26-Nov-20	56	42	74	8	14.5
10-Jan-21	0	0	0	0	0.0
25-Jan-21	8	3	20	4	51.0
22-Feb-21	94	58	170	30	32.3
14-May-21	335	240	470	70	20.8
27-May-21	99	35	299	69	70.0
15-Jun-21	26	9	53	11	43.3
14-Jul-21	83	44	158	32	38.2
16-Aug-21	274	179	408	58	21.0
01-Sep-21	54	32	92	16	29.3
22-Oct-21	922	760	1,111	97	10.5
20-Nov-21	81	47	139	23	28.7
16-Dec-21	0	0	0	0	0.0
05-Jan-22	8	3	17	4	46.5
26-Feb-22	35	20	54	8	23.9
20-Mar-22	28	14	57	12	43.1

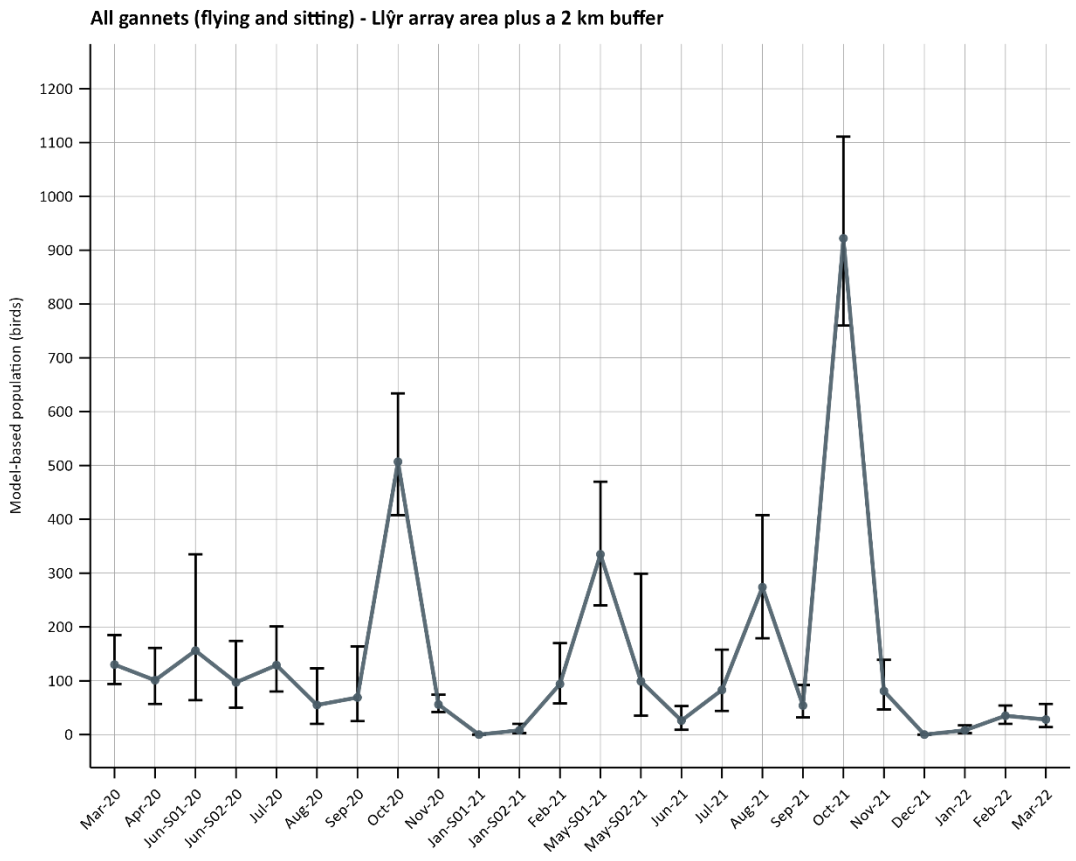


Figure 22A-75. Monthly model-based population estimates of all gannets (flying and sitting) within the Array Area plus a 2 km buffer (associated credible intervals are represented by error bars)

Table 22A-34. Model-based MSP population estimate of all gannets in each season within the Array Area plus a 2 km buffer

Gannet	Year 1 Peak (n)	Year 2 Peak (n)	MSP Population (n)	MSP LCL (n)	MSP UCL (n)
Breeding season	*Jun S01 2020** 156	*May S01 2021†* 335	246	158	338
Autumn migration	*Oct 2020* 507	*Oct 2021* 922	715	611	831
Spring migration	*Feb 2021* 94	*Feb 2022* 35	65	34	94

**Used to represent May 2020* *†Used to represent April 2021*

Site-based Age Information for PVA

154. In the Llŷr marine ornithology survey area, relatively few young birds were observed, with adults making up between 93% and 100% of all aged birds during the breeding season and spring and autumn migration periods (**Table 22A-35**).

Table 22A-35. Percentage of aged gannets in each age class averaged across all surveys in each season in the Llŷr marine ornithology survey area

Season	Adult (%)	Immature (%)	Juvenile (%)
Breeding season	95.99	3.66	0.35
Autumn migration	93.04	6.09	0.87
Spring migration	100	0.00	0.00

European Storm Petrel

Distribution, Density and Population Estimates

155. **Figure 22A-76** and **Figure 22A-77** present the distribution maps for storm petrel, with five birds recorded in the Llŷr marine ornithology survey area in total, three in July 2020 (Year 1) and two in May S02 2021 (Year 2). Within the latter observations, a single storm petrel was observed within the Array Area.

156. In the Llŷr marine ornithology survey area, the peak design-based density was recorded in July 2020, during the breeding season with 0.04 birds/km^2 (95% CI 0.00 – 0.10), equating to a population estimate of 25 birds (95% CI 0 – 63) (**Table 22A-36** and **Appendix 22A: Annex D**).

Table 22A-36. Monthly design-based density and population estimates of all storm petrels (flying and sitting) within the Llŷr marine ornithology survey area

Gannet	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
25-Mar-20	0.00	0.00	0.00	0	0	0	0	0.0
14-Apr-20	0.00	0.00	0.00	0	0	0	0	0.0
08-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
24-Jun-20	0.00	0.00	0.00	0	0	0	0	0.0
21-Jul-20	0.04	0.00	0.10	25	0	63	17	69.7
31-Aug-20	0.00	0.00	0.00	0	0	0	0	0.0
12-Sep-20	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-20	0.00	0.00	0.00	0	0	0	0	0.0
26-Nov-20	0.00	0.00	0.00	0	0	0	0	0.0
10-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
25-Jan-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Feb-21	0.00	0.00	0.00	0	0	0	0	0.0
14-May-21	0.00	0.00	0.00	0	0	0	0	0.0
27-May-21	0.02	0.00	0.06	16	0	39	11	66.2
15-Jun-21	0.00	0.00	0.00	0	0	0	0	0.0
14-Jul-21	0.00	0.00	0.00	0	0	0	0	0.0
16-Aug-21	0.00	0.00	0.00	0	0	0	0	0.0
01-Sep-21	0.00	0.00	0.00	0	0	0	0	0.0
22-Oct-21	0.00	0.00	0.00	0	0	0	0	0.0
20-Nov-21	0.00	0.00	0.00	0	0	0	0	0.0

Gannet	Density (n/km²)	LCL (n/km²)	UCL (n/km²)	Population (n)	LCL (n)	UCL (n)	SD (n)	CV pop. (%)
16-Dec-21	0.00	0.00	0.00	0	0	0	0	0.0
05-Jan-22	0.00	0.00	0.00	0	0	0	0	0.0
26-Feb-22	0.00	0.00	0.00	0	0	0	0	0.0
20-Mar-22	0.00	0.00	0.00	0	0	0	0	0.0

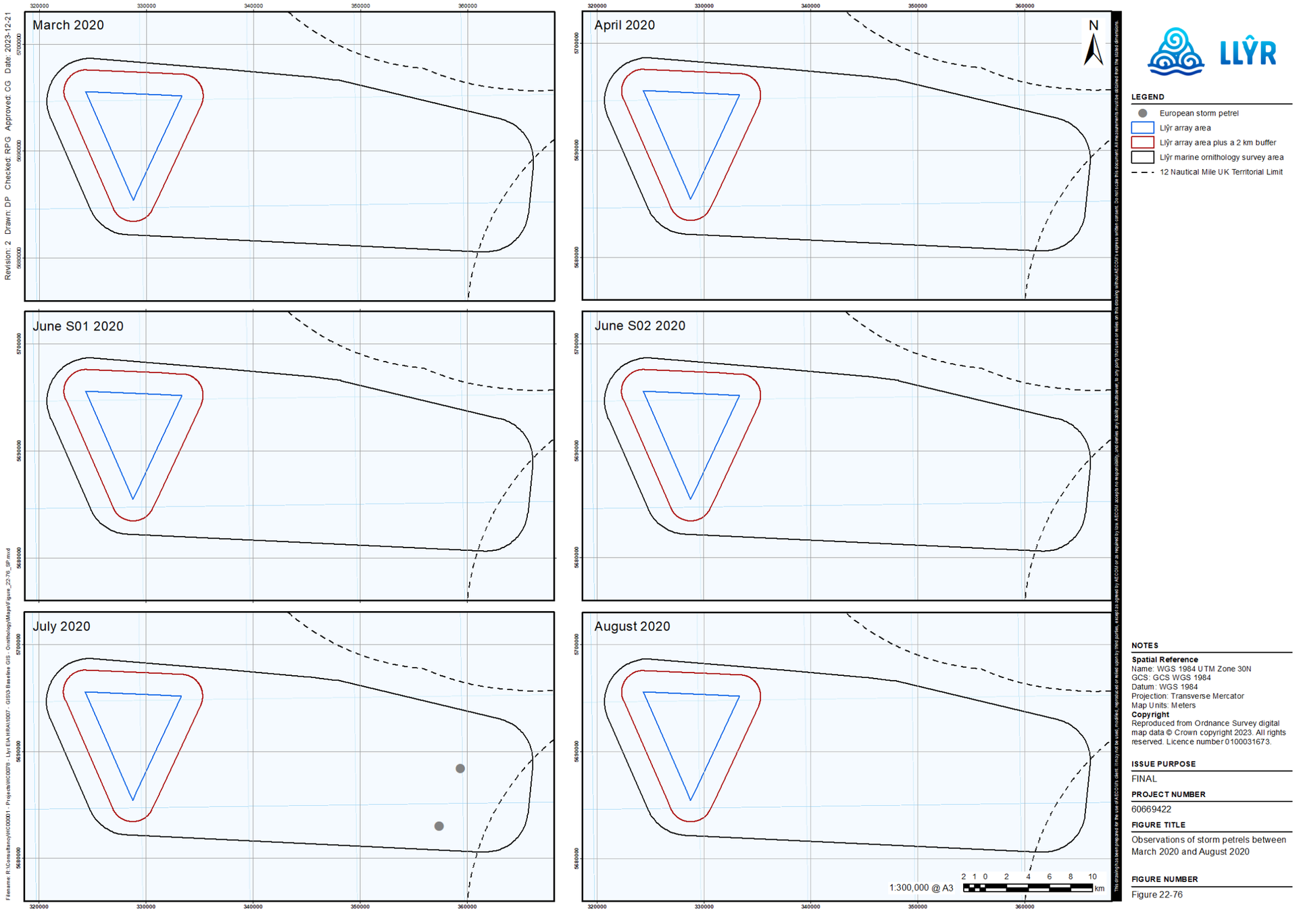


Figure 22A-76. Distribution map of recorded storm petrels within the Llŷr marine ornithology survey area between survey 1 (March 2020) and survey 6 (August 2020)

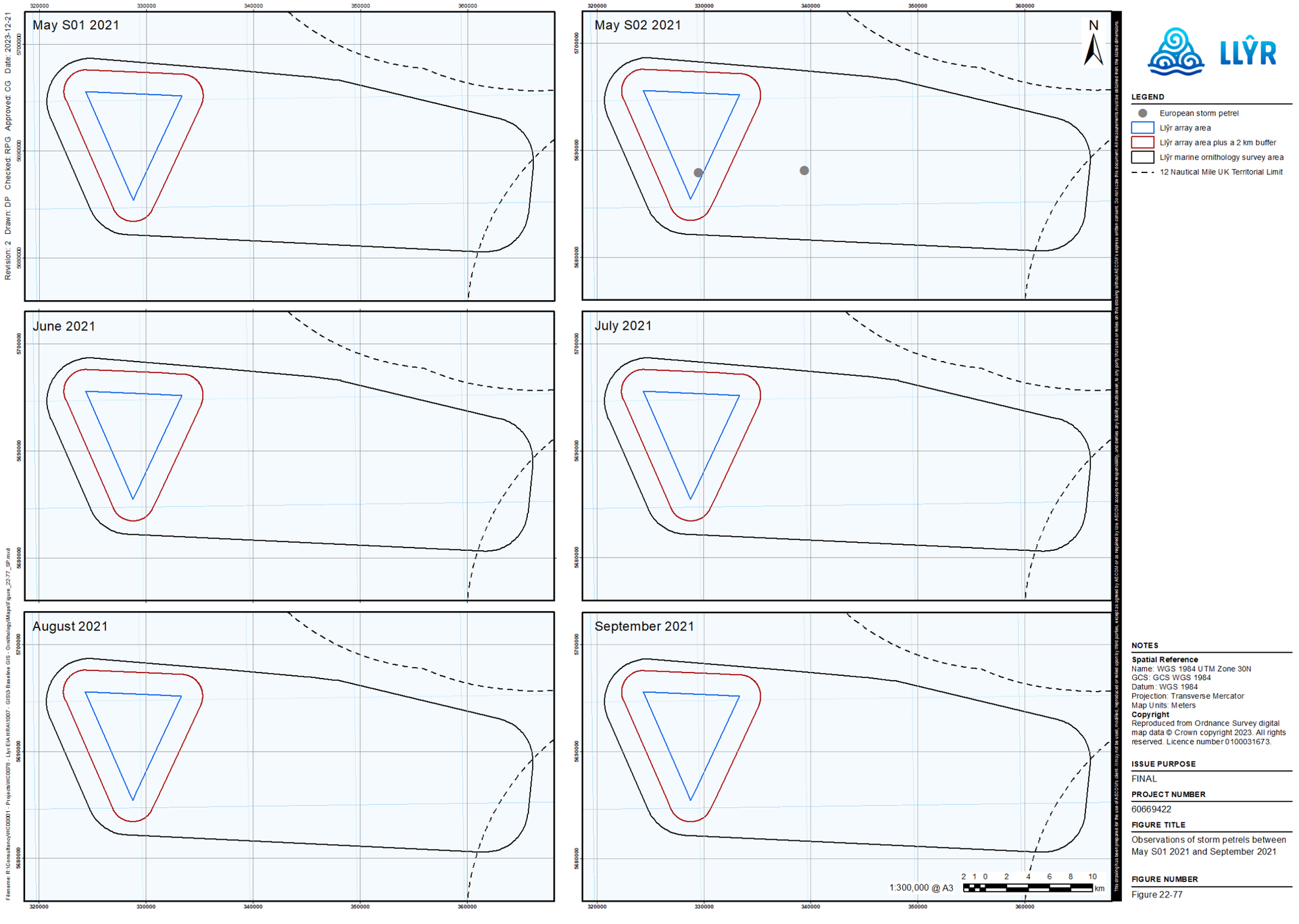


Figure 22A-77. Distribution map of recorded storm petrels within the Llŷr marine ornithology survey area between survey 13 (May S01 2021) and survey 18 (September 2021)

Balearic Shearwater

157. No Balearic shearwaters were observed in the Llŷr marine ornithology survey area during the survey period. As such, the species is to be considered qualitatively.

22.4 APPENDIX 22A: Annex A – All Seabird Observations at Llŷr

Annex A, Table 22-A1. Number of seabirds detected per survey assigned to species level in the Llŷr marine ornithology survey area between March 2020 and February 2021 (Year 1)

Species	Scientific name	Mar-20	Apr-20	Jun-S01-20	Jun-S02-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Jan-S01-21	Jan-S02-21	Feb-21	Total Year 1
Kittiwake	*Rissa tridactyla*	28	2	0	5	1	31	26	530	334	193	254	33	1,437
Black-headed gull	*Chroicocephalus ridibundus*	2	0	0	0	0	0	0	0	0	0	0	0	2
Great black-backed gull	*Larus marinus*	1	3	7	5	0	2	1	36	15	1	2	0	73
Common gull	*Larus canus*	2	0	0	0	0	0	0	1	1	0	3	0	7
Herring gull	*Larus argentatus*	0	0	15	11	1	2	0	19	91	1	9	2	151
Lesser black-backed gull	*Larus fuscus*	4	4	123	15	2	0	0	7	3	0	1	1	160
Common tern	*Sterna hirundo*	0	0	0	2	2	3	0	0	0	0	0	0	7
Arctic tern	*Sterna paradisaea*	0	0	0	0	1	0	0	0	0	0	0	0	1
Great skua	*Stercorarius skua*	0	0	0	0	0	1	1	2	1	0	0	1	6
Guillemot	*Uria aalge*	969	1,251	100	1,114	566	1,377	1,961	3,487	1,986	852	1,831	1,536	17,030
Razorbill	*Alca torda*	341	40	0	4	1	9	59	263	238	157	115	170	1,397
Puffin	*Fratercula arctica*	297	32	12	74	10	3	9	27	17	4	0	6	491
European storm petrel	*Hydrobates pelagicus*	0	0	0	0	3	0	0	0	0	0	0	0	3
Fulmar	*Fulmarus glacialis*	7	6	0	4	4	15	7	7	4	3	8	2	67
Manx shearwater	*Puffinus puffinus*	918	27	1,069	2,981	1,374	1,993	9	0	5	0	0	6	8,382
Gannet	*Morus bassanus*	39	51	43	35	38	56	140	106	36	0	5	28	577
Shag	*Gulosus aristotelis*	1	0	0	0	0	0	0	0	0	0	0	0	1
Total		**2,609**	**1,416**	**1,369**	**4,250**	**2,003**	**3,492**	**2,213**	**4,485**	**2,731**	**1,211**	**2,228**	**1,785**	**29,792**

Annex A, Table 22-A2. Number of seabirds detected per survey assigned to species level in the Llŷr marine ornithology survey area between May S01 2021 and March 2022 (Year 2)

Species	Scientific name	May-S01-21	May-S02-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Total Year 2
Kittiwake	*Rissa tridactyla*	3	2	0	2	1	1	858	468	6	10	16	89	1,456
Black-headed gull	*Chroicocephalus ridibundus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Great black-backed gull	*Larus marinus*	2	3	0	0	3	0	5	3	0	0	0	0	16
Common gull	*Larus canus*	0	0	0	0	0	0	2	14	0	0	0	0	16
Herring gull	*Larus argentatus*	4	6	5	2	0	0	1	14	0	0	0	0	32
Lesser black-backed gull	*Larus fuscus*	7	4	8	1	2	0	4	1	2	0	6	7	42
Common tern	*Sterna hirundo*	0	0	1	0	1	0	0	0	0	0	0	0	2
Arctic tern	*Sterna paradisaea*	7	6	0	0	1	0	0	0	0	0	0	0	14
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	0	0	0	0	0	0
Guillemot	*Uria aalge*	491	597	476	370	169	15	2,830	2,539	25	45	52	1,511	9,120
Razorbill	*Alca torda*	5	20	2	4	0	2	949	270	4	3	62	302	1,623
Puffin	*Fratercula arctica*	56	24	146	11	6	0	3	2	0	0	0	42	290
European storm petrel	*Hydrobates pelagicus*	0	2	0	0	0	0	0	0	0	0	0	0	2
Fulmar	*Fulmarus glacialis*	11	3	0	0	2	1	0	1	6	4	0	3	31
Manx shearwater	*Puffinus puffinus*	141	931	1,245	27	845	10	1	5	1	0	0	489	3,695
Gannet	*Morus bassanus*	79	24	17	24	107	23	412	60	0	5	24	11	786
Shag	*Gulosus aristotelis*	0	0	1	0	0	0	0	0	0	0	1	1	3
Total		**806**	**1,622**	**1,901**	**441**	**1,137**	**52**	**5,065**	**3,377**	**44**	**67**	**161**	**2,455**	**17,128**

Annex A, Table 22-A3. Number of unidentified seabirds detected per survey in the Llŷr marine ornithology survey area between March 2020 and February 2021 (Year 1)

Species group	Mar-20	Apr-20	Jun-S01-20	Jun-S02-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Jan-S01-21	Jan-S02-21	Feb-21	Total Year 1
Arctic / common tern	0	0	0	3	6	0	0	0	0	0	0	0	9
Auk / shearwater species	44	20	9	50	31	26	13	1	5	0	0	7	206
Auk / small gull species	0	0	0	0	6	0	1	1	6	1	3	1	19
Auk species	33	11	1	10	8	6	18	69	53	13	5	27	254
Black-backed gull species	0	0	0	0	0	0	0	1	0	0	0	0	1
Fulmar / gull species	0	0	0	0	0	0	0	1	1	0	0	1	3
Gull species	0	0	0	0	0	0	0	0	0	1	0	0	1
Large auk species	37	29	2	3	10	2	44	82	158	71	37	61	536
Large gull species	0	0	4	1	0	0	0	3	1	0	0	0	9
Passerine species	0	0	0	0	0	0	0	3	0	0	0	0	3
Shearwater species	0	0	0	0	0	1	0	0	0	0	0	0	1
Small gull species	1	0	0	0	0	0	0	0	1	0	1	0	3
Tern / small gull species	0	0	0	0	0	4	0	0	0	0	0	0	4
Wader species	0	0	0	0	0	0	0	0	0	0	0	5	5
Total	**115**	**60**	**16**	**67**	**61**	**39**	**76**	**161**	**225**	**86**	**46**	**102**	**1,054**

Annex A, Table 22-A4. Number of unidentified seabirds detected per survey in the Llŷr marine ornithology survey area between May S01 2021 and March 2022 (Year 2)

Species group	May-S01-21	May-S02-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Total Year 2
Arctic / common tern	2	0	0	0	7	0	0	0	0	0	0	0	9
Auk / shearwater species	5	10	13	0	13	0	12	6	0	0	2	32	93
Auk / small gull species	0	0	0	0	1	0	8	2	1	0	1	0	13
Auk species	0	0	15	2	2	2	20	34	0	0	4	7	86
Black-backed gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Fulmar / gull species	2	1	0	0	0	0	1	0	0	0	1	0	5
Gull species	0	0	0	0	0	0	0	1	0	0	0	0	1
Large auk species	1	4	0	1	0	1	166	99	1	0	2	53	328
Large gull species	1	0	0	0	0	0	0	2	0	0	0	0	3
Passerine species	0	0	0	0	0	0	0	0	0	0	0	0	0
Shearwater species	0	0	0	0	0	0	0	0	0	0	0	0	0
Small gull species	0	1	0	0	0	0	1	3	0	0	0	0	5
Tern / small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Wader species	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	**11**	**16**	**28**	**3**	**23**	**3**	**208**	**147**	**2**	**0**	**10**	**93**	**544**

Annex A, Table 22-A5. Number of seabirds detected per survey assigned to species level in the Array Area between March 2020 and February 2021 (Year 1)

Species	Scientific name	Mar-20	Apr-20	Jun-S01-20	Jun-S02-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Jan-S01-21	Jan-S02-21	Feb-21	Total Year 1
Kittiwake	*Rissa tridactyla*	0	0	0	1	0	0	0	147	13	13	14	1	189
Black-headed gull	*Chroicocephalus ridibundus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Great black-backed gull	*Larus marinus*	0	1	0	0	0	0	0	0	0	1	0	0	2
Common gull	*Larus canus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Herring gull	*Larus argentatus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Lesser black-backed gull	*Larus fuscus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Common tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	0	0	0	0	0	0	0
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	1	0	0	0	0	1
Guillemot	*Uria aalge*	17	4	3	10	18	212	145	965	41	63	110	53	1,641
Razorbill	*Alca torda*	9	0	0	0	0	0	9	64	2	13	2	6	105
Puffin	*Fratercula arctica*	50	0	0	1	0	0	6	4	1	0	0	0	62
European storm petrel	*Hydrobates pelagicus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Fulmar	*Fulmarus glacialis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Manx shearwater	*Puffinus puffinus*	17	4	0	10	15	184	0	0	0	0	0	1	231
Gannet	*Morus bassanus*	7	2	2	2	2	2	1	20	0	0	0	7	45
Shag	*Gulosus aristotelis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		**100**	**11**	**5**	**24**	**35**	**398**	**161**	**1,201**	**57**	**90**	**126**	**68**	**2,276**

Annex A, Table 22-A6. Number of seabirds detected per survey assigned to species level in the Array Area between May S01 2021 and March 2022 (Year 2)

Species	Scientific name	May-S01-21	May-S02-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Total Year 2
Kittiwake	*Rissa tridactyla*	0	0	0	0	0	0	74	37	1	1	3	3	119
Black-headed gull	*Chroicocephalus ridibundus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Great black-backed gull	*Larus marinus*	0	0	0	0	0	0	1	1	0	0	0	0	2
Common gull	*Larus canus*	0	0	0	0	0	0	0	3	0	0	0	0	3
Herring gull	*Larus argentatus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Lesser black-backed gull	*Larus fuscus*	0	1	0	0	0	0	0	0	0	0	0	3	4
Common tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	0	0	0	0	0	0	0
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	0	0	0	0	0	0
Guillemot	*Uria aalge*	27	30	14	4	0	0	121	257	0	3	15	127	598
Razorbill	*Alca torda*	0	0	0	0	0	0	99	49	0	0	12	0	160
Puffin	*Fratercula arctica*	9	0	4	0	0	0	0	1	0	0	0	1	15
European storm petrel	*Hydrobates pelagicus*	0	1	0	0	0	0	0	0	0	0	0	0	1
Fulmar	*Fulmarus glacialis*	1	0	0	0	0	0	0	0	0	0	0	0	1
Manx shearwater	*Puffinus puffinus*	6	73	36	0	0	0	0	0	0	0	0	248	363
Gannet	*Morus bassanus*	2	5	1	1	7	1	53	3	0	0	3	2	78
Shag	*Gulosus aristotelis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		**45**	**110**	**55**	**5**	**7**	**1**	**348**	**351**	**1**	**4**	**33**	**384**	**1,344**

Annex A, Table 22-A7. Number of unidentified seabirds detected per survey in the Array Area between March 2020 and February 2021 (Year 1)

Species group	Mar-20	Apr-20	Jun-S01-20	Jun-S02-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Jan-S01-21	Jan-S02-21	Feb-21	Total Year 1
Arctic / common tern	0	0	0	0	0	0	0	0	0	0	0	0	0
Auk / shearwater species	1	0	0	0	1	3	3	0	0	0	0	0	8
Auk / small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Auk species	3	0	0	0	0	0	4	15	0	1	2	2	27
Black-backed gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Fulmar / gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Large auk species	3	1	0	0	0	0	3	10	3	3	1	2	26
Large gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Passerine species	0	0	0	0	0	0	0	3	0	0	0	0	3
Shearwater species	0	0	0	0	0	0	0	0	0	0	0	0	0
Small gull species	0	0	0	0	0	0	0	0	1	0	0	0	1
Tern / small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Wader species	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**7**	**1**	**0**	**0**	**1**	**3**	**10**	**28**	**4**	**4**	**3**	**4**	**65**

Annex A, Table 22-A8. Number of unidentified seabirds detected per survey in the Array Area between May S01 2021 and March 2022 (Year 2)

Species group	May-S01-21	May-S02-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Total Year 2
Arctic / common tern	0	0	0	0	0	0	0	0	0	0	0	0	0
Auk / shearwater species	1	0	0	0	0	0	5	2	0	0	0	3	11
Auk / small gull species	0	0	0	0	0	0	0	1	0	0	0	0	1
Auk species	0	0	3	0	0	0	0	4	0	0	0	1	8
Black-backed gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Fulmar / gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Gull species	0	0	0	0	0	0	0	1	0	0	0	0	1
Large auk species	0	1	0	0	0	0	14	19	0	0	1	2	37
Large gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Passerine species	0	0	0	0	0	0	0	0	0	0	0	0	0
Shearwater species	0	0	0	0	0	0	0	0	0	0	0	0	0
Small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Tern / small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0
Wader species	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**1**	**1**	**3**	**0**	**0**	**0**	**19**	**27**	**0**	**0**	**1**	**6**	**58**

22.5 APPENDIX 22A: Annex B – Technical Notes on Survey Design and Data Analysis

Annex provided as a separate document.

22.6 APPENDIX 22A: Annex C – Additional Model-Based Maps

Annex provided as a separate document.

22.7 APPENDIX 22A: Annex D – Design-Based Estimates

Annex provided as a separate document.

References

Bachl, F.E, Lindgren, F., Borchers, D.L. and Illian, J.B., 2018. *Inlabru*. [Online]. Available at: https://sites.google.com/*Inlabru*.org/*Inlabru* [Accessed: 19 May 2023].

Bachl, F.E., Lindgren, F., Borchers, D.L. and Illian, J.B., 2019. *Inlabru*: an R package for Bayesian spatial modelling from ecological survey data. Methods in Ecology and Evolution, 10(6), 760-766.

Banner, K.M., Irvine, K.M. and Rodhouse, T.J., 2020. The use of Bayesian priors in Ecology: The good, the bad and the not great. Methods in Ecology and Evolution, 11(8), 882-889.

Barlow, J, Oliver, C.W., Jackson, T.D. and Taylor, B.L., 1988. Harbour porpoise Phocoena phocoena, abundance estimation for California, Oregon and Washington: II. Fishery Bulletin, 86, 433-444.

Borchers, D.L., Buckland, S.T. and Zucchini, W., 2002. Estimating Animal Abundance: Closed Populations. Springer, Berlin.

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. 1993. Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, London. 446pp.

Buckland, S.T., Anderson, D.R., Burnham, K. P., Laake, J.L., Borchers, D.L. and Thomas, L., 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, Oxford.

Dreassi, E., 2014. Poisson Models. Encyclopaedia of Quality of Life and Well-Being Research, pp. 4848-4850.

Ellison, A.M., 2004. Bayesian inference in ecology. Ecology Letters, 7, 509–520.

Furness, R. W., Wade, H. M. and Masden, E.A., 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management, 119, 56-66.

Furness, R.W., 2015. Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, Number 164.

Hayes, A., 2021. Posterior Probability: Definition, Formula for Calculation. [Online]. Available at: https://www.investopedia.com/terms/p/posterior-probability.asp#:~:text=A%20posterior%20probability%2C%20in%20Bayesian,prior%20probability%20using%20Bayes%27%20theorem [Accessed: 19 May 2023].

HiDef Aerial Surveying Ltd., 2021. Digital video aerial surveys of seabirds and marine mammals at Erebus: 2-year report – October 2019 to September 2021. [Online]. www.bluegemwind.com/wp-content/uploads/2020/07/Erebus-ES-Vol-3-Appendix-11.6-2-Year-Bird-Survey-Report-2.pdf. [Accessed: 30 August 2023].

Johnson, N.L., Kemp, A.W., Kotz, S. 1993. Univariate Discrete Distributions.

Johnston, A., Cook, A.S., Wright, L.J., Humphreys, E.M. and Burton, N.H., 2014a. Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology, 51(1), 31-41.

Johnston, A., Cook, A.S., Wright, L.J., Humphreys, E.M. and Burton, N.H., 2014b. Corrigendum to Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology, 51, 1126 -1130.

Keogan, K., Seaton, A., Scott-Hayward, L., Donovan, C., Mackenzie, M. and Humphries, G., 2022. A comparison of seabird species distribution modelling methods used by the offshore renewables industry. Poster Presentation at the Seabird Group Conference, Cork, August.

McGregor, R.M., King, S., Donovan, C.R., Caneco, B. and Webb, A., 2018. A Stochastic Collision Risk Model for Seabirds in Flight. Report for Marine Scotland.

NRW., 2022 At sea ornithological survey guidance. Ref GN055. Natural Resources Wales. [Online]. Available at: https://naturalresources.wales/media/695080/at-sea-ornithological-guidance-checked-accessible.pdf [Accessed: 06 October 2023].

R Core Team., 2022. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Reflective Data., 2019. Reflective Data. [Online]. Available at: https://reflectivedata.com [Accessed: 30 August 2023].

Scott-Hayward, L.A.S., Oedekoven, C.S., Mackenzie, M.L., Walker, C.G. and Rexstad, E., 2013. User Guide for the MRSea Package: Statistical Modelling of bird and cetacean distributions in offshore renewables development areas. University of St. Andrews contract for Marine Scotland, SB9 (CR/2012/05).

SNCB., 2022. Joint SNCB Interim Displacement Advice Note.

Spencer, S.M., 2012. Diving behavior and identification of sex of breeding Atlantic puffins (Fratercula arctica), and nest-site characteristics of Alcids on Petit Manan Island, Maine. MS thesis, University of Massachusetts Amherst, Amherst, MA.

Thaxter, C.B., Wanless, S., Daunt, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Grémillet, D. and Hamer, K.C., 2010. Influence of wing loading on the trade-off between pursuit-diving and flight in common guillemot and razorbill. The Journal of Experimental Biology, 213, 1018-1025.

Thaxter, C.B., Ross-Smith, V.H. and Cook, A.S.C.P., 2016. How high do birds fly? A review of current datasets and an appraisal of current methodologies for collecting flight height data: Literature review. BTO Research Report No. 666.

Webb, A and Nehls, G., 2019. Surveying seabirds. In: Perrow, M. (Ed.). Wildlife and Wind Farms-Conflicts and Solutions: Offshore: Monitoring and Mitigation. Pelagic Publishing, pp.330.