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Debbie J F Russell, Esther L Jones and Chris D Morris.

Sea Mammal Research Unit  
Scottish Oceans Institute,  
University of St Andrews, St Andrews, Fife, KY16 8LB, UK



marinescotland



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## Introduction

For a previous Scottish Government funded project (MMSS/001/11), seal telemetry data were combined with haul-out specific population data to generate usage maps for both grey and harbour seals around the United Kingdom (UK) and Republic of Ireland (ROI) at a spatial resolution of 5 x 5 km (Jones *et al.*, 2013). These maps provided estimates of seal abundance (and associated confidence intervals) aggregated between 1988 and 2012, thus taking into account changes in population size through time. For Jones *et al.* (2015), maps were generated which were scaled to the estimated population size in 2013, resulting in the most up-to-date understanding of current seal usage at that time. The Department of Business and Industrial Strategy (BEIS) funded a large deployment of tags on grey seals in the southern North Sea and subsequently commissioned an updated North Sea usage map reflecting the estimated grey seal population size in 2015 (Jones and Russell, 2016). At the request of Scottish Government, usage maps have been generated for Orkney on a finer spatial resolution (0.6 x 0.6 km; Jones *et al.*, 2016; Jones *et al.*, 2017).

## Changes

A requirement to update the UK and ROI usage maps was identified. As part of this, three updates were proposed: (1) inclusion of additional telemetry data (up to 2016); (2) improvement in how count data are incorporated into the usage map framework (Jones *et al.*, 2016; Jones *et al.*, 2017) and updating count data resulting in estimates of usage scaled to the estimated population size in 2015; and (3) clustering of haul-out sites to increase the proportion of sites for which there are associated telemetry data (Jones and Russell, 2016).

## Updated Telemetry Data

Jones *et al.* (2015) used telemetry data from 259 grey seals and 277 harbour seals. These included data from seals tagged in ROI and France (39 grey seals and 39 harbour seals). Here, only tags deployed within UK were included although some of these individuals subsequently hauled out in ROI<sup>1</sup>. The majority of the tag data from the Moray Firth were collected in collaboration with P Thompson, University of Aberdeen. In total, data from 270 grey seals and 330 harbour seals have been included (Table 1 and Figure 1). This represents a marked increase (grey seals:

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<sup>1</sup> The telemetry data in ROI waters are from seals tagged in the UK. These data do not represent the full data set for seals within the ROI marine area.

23%; harbour seals: 39%) in sample size for the UK, in comparison to Jones *et al.* (2015).

### **Updated Count Data and Method of Incorporation**

For Jones *et al.* (2015), count data between 1996 and 2013 were used. These count data were provided per haul-out site; the changes in the exact location of haul-out sites from year to year made it challenging to define effort historically. For count data between 1996 and 2015 (Figure 2), effort data (which is the same for both species) has now been defined on a (5 x 5 km) cell-by-cell basis (Figure 3). Thus for each year and cell, either a count ( $\geq 0$ ) or a NA (not surveyed) was assigned. This has resulted in an increase in the accuracy of population estimates for each cell. Using these count data, the mean abundance of seals in 2015 has been estimated for each grid cell (see Jones *et al.* (2015) for detailed methods). The count data used in these maps were collated from multiple sources: UK aerial survey data (Marine Current Turbines, Northern Ireland Environment Agency, SMRU, Zoological Society of London), ROI aerial survey data (Department of Arts, Heritage and the Gaeltacht; Cronin *et al.*, 2004; Duck and Morris, 2013a; Duck and Morris, 2013b); and ground counts (Westcott, 2002; Westcott & Stringell, 2004; Westcott, 2008; Westcott, 2009; Leeney *et al.*, 2010; Sayer, 2010; Sayer, 2011; Sayer, 2012a; Sayer, 2012b; Sayer *et al.*, 2012; Büche & Stubbings, 2014; Bond, 2015; unpublished data - see Acknowledgements).

### **Haul-out Clustering**

Some 5 x 5 km cells which contain a seal haul-out had no associated telemetry data, i.e. no telemetry tagged individuals hauled out within the cell. Usage emanating from such cells was predicted based on a relationship between usage and distance to haul-outs, obtained by fitting a model to telemetry data from those haul-out site cells for which telemetry data were available (Jones *et al.*, 2013; Jones *et al.*, 2015; Jones and Russell, 2016). This predicted usage is referred to as null usage. A decrease in the proportion of total usage that is made up of null usage would result in increased accuracy of usage estimates. To reduce the reliance on null usage, following Jones and Russell (2016), haul-out sites were clustered, resulting in a greater proportion of haul-out cells being associated with telemetry data.

### **Output**

For each species, two estimates of usage are provided (Figures 4 to 7): at-sea usage and total usage. At-sea usage represents the mean number of grey (Figure 4) and harbour (Figure 6) seals estimated to be in the water in each cell at any given time. Total usage reflects the combined estimated of number of grey (Figure 5) and harbour (Figure 7) seals on land and at-sea. Thus, the at-sea and total usage only

differ in cells which encompass haul-out sites. These figures (Figures 4 to 7) are available as downloadable shape-files (Table A1 in Appendix 1). Upon their use, please reference this report. All figures and shape-files are in Universal Transverse Mercator zone 30 (North), World Geodetic System 1984 datum (UTM30N WGS84) projection.

## **Interpretation and Caveats**

Below is a summary of how the usage maps should be interpreted and the associated caveats. For more details, please see publications described above.

### **What are the Estimates?**

The estimates reflect the expected mean number of seals in each 5 x 5 km cell at any given time. The estimates do not distinguish between type of usage, e.g. foraging or travelling behaviour and the same usage could be a result of many individuals using an area a small amount, or a small number of individuals using an area intensively. Temporal variation in usage (seasonally or annually) is not represented. The confidence intervals reflect confidence in the estimate of **mean** usage in each cell, rather than showing the variability in usage. Thus, the confidence intervals are **per cell** and so do not represent uncertainty in distribution across the maps. Telemetry data were aggregated in order to provide the most complete spatio-temporal coverage of species distribution; thus, any differences in distribution by sex or age are not reflected. These maps only reflect estimates of usage resulting from seals that haul out in the UK and ROI; usage emanating from continental Europe is not considered.

### **Count Data**

Usage maps are scaled to population estimates using terrestrial count data from surveys in August and therefore do not account for any seasonal movements of the population. The population estimates underlying these maps are predicated on the species-specific scalars used to scale the haul-out counts of seals to population size. These scalars are based on estimates of the proportion of the population hauled out during the counts, derived from UK telemetry data. This proportion is currently subject to further analyses in the light of the higher quality of data available. Preliminary investigations suggest that population size, and thus grey seal usage per cell, may be currently underestimated by approximately 30% (Russell *et al.*, 2016).

### **Null Usage**

For haul-out aggregations for which there are no telemetry data, usage is predicted based on the UK-wide 'usage/distance to haul-out site' relationship. For such cells, the confidence intervals are generated using (1) the uncertainty surrounding the



aforementioned 'usage/distance to haul-out site' relationship and (2) the uncertainty in the 2015 population estimates. Such predictions are particularly common in West Scotland, where there are a large number of haul-outs with no associated telemetry data. With the exception of haul-outs visited by seals tagged in the UK, predicted usage emanating from ROI is a result of null usage. Usage predicted in this way simply decreases with distance from the haul-out and thus hotspots of usage will not be represented in the mean predictions.

### **Estimating Usage On-Land**

As with previous versions of the usage maps, because seals inhabit both the terrestrial and marine environments, land could not be used as a barrier to usage. Thus, as a result of track smoothing, there is some leakage of usage inland. This may result in an underestimation of coastal usage.

## Acknowledgements

Telemetry tags and their deployment were funded by BBC Wildlife Fund, Beatrice Offshore Windfarm Limited, Crown Estate, Department for Business, Energy & Industrial Strategy (and previous incarnations), European Commission, Hampshire and Isle of Wight Wildlife Trust, Highlands & Islands Enterprise, Marine Current Turbines, Marine Scotland, Moray Firth Offshore Renewables Limited, Natural Environment Research Council (NERC), SITA Trust, Scottish Natural Heritage (SNH), SMRU, SMRU Instrumentation, Vodafone UK, and Welsh Assembly Government. We would also like to thank our collaborators: Professor Paul Thompson, University of Aberdeen; Natural Resources Wales; and the Zoological Society of London (ZSL).

UK aerial surveys conducted by SMRU were funded by NERC (grant no. SMRU1001) and SNH. Ground count data were provided by Chichester Harbour Conservancy, Hampshire and Isle of Wight Wildlife Trust, Hilbre Bird Observatory, Langstone Harbour Board, Royal Society for the Protection of Birds and ZSL.

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## Tables and Figures

**Table 1**

Summary of telemetry deployments by year for (a) grey and (b) harbour seals. Tag type denotes satellite relay data logger (SRDL) or global positioning satellite (GPS).

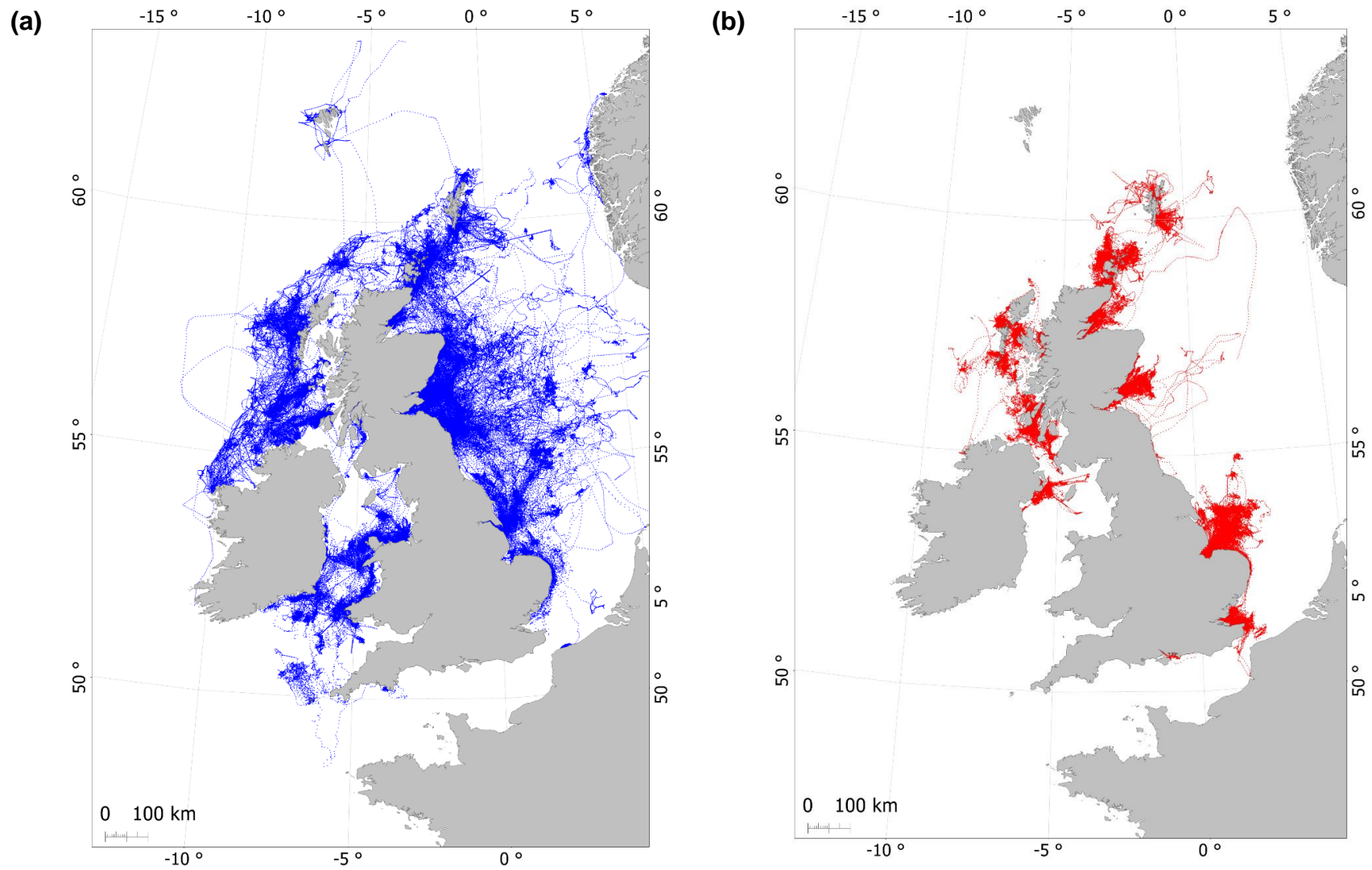
a) Grey seals.

Year	Tag type	Number of tags	Sex ratio (M:F)	Age (adult:pup)	Tagging regions
1991	SRDL	5	4 : 1	5 : 0	NE England
1992	SRDL	12	8 : 4	12 : 0	Moray Firth, NE England
1993	SRDL	5	2 : 3	2 : 3	NE England, SE Scotland
1994	SRDL	4	2 : 2	0 : 4	NE England
1995	SRDL	22	15 : 7	15 : 7	Western Isles
1996	SRDL	20	8 : 12	20 : 0	Orkney & N coast, SE Scotland, Western Isles
1997	SRDL	7	4 : 3	7 : 0	NE England, SE Scotland
1998	SRDL	24	17 : 7	24 : 0	Orkney & N coast, SE Scotland, Shetland
2001	SRDL	12	6 : 6	1 : 11	SE Scotland
2002	SRDL	12	5 : 7	2 : 10	SE Scotland
2003	SRDL	22	14 : 8	22 : 0	W Scotland
2004	SRDL	31	14 : 17	31 : 0	SE Scotland, W England & Wales, W Scotland
2005	SRDL/GPS	14	6 : 7	14 : 0	SE England, SE Scotland
2006	SRDL	2	1 : 1	2 : 0	SE Scotland
2008	SRDL/GPS	19	9 : 10	19 : 0	NE England, SE Scotland
2009	GPS	5	2 : 3	0 : 5	W England & Wales
2010	GPS	26	10 : 16	0 : 26	Orkney & N coast, W England & Wales
2013	GPS	5	3 : 2	4 : 1	SE Scotland
2015	GPS	21	8 : 15	21 : 0	SE England
2016	GPS	2	1 : 1	2 : 0	SE Scotland
<b>Total</b>		<b>270</b>	<b>130:139*</b>	<b>203:67</b>	

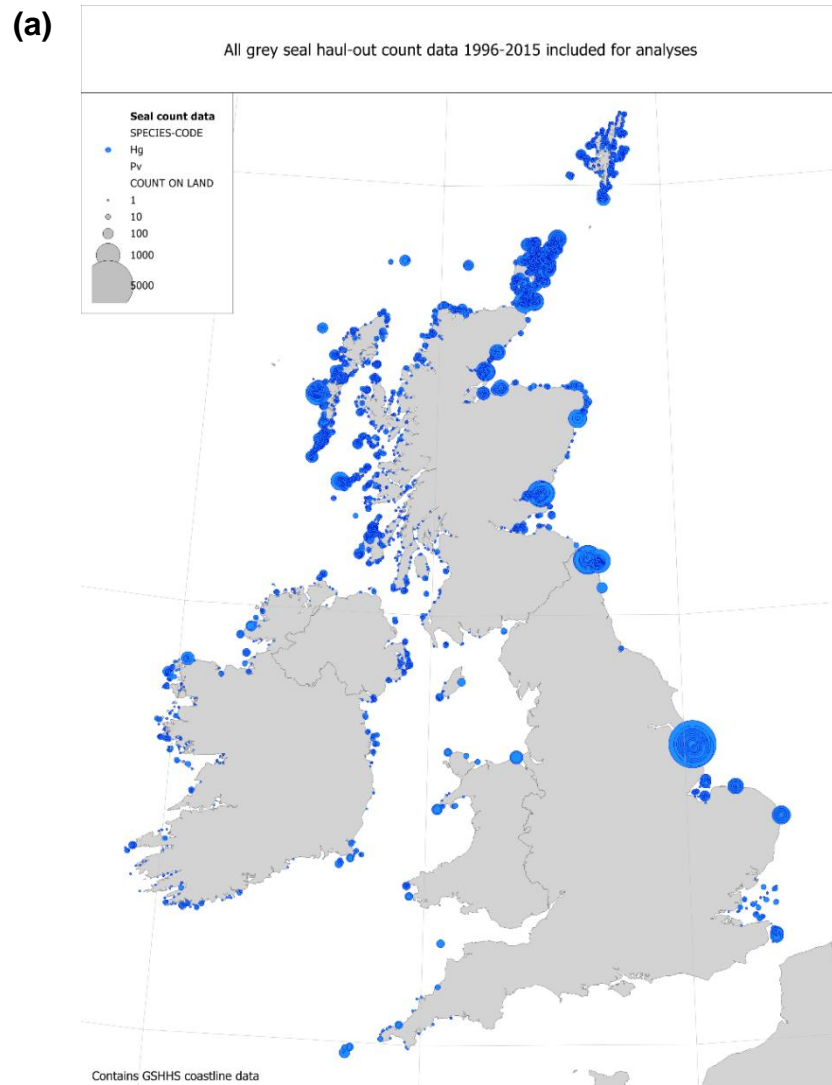
\* For one individual sex was unknown.

b) Harbour seals.

Year	Tag type	Number of tags	Sex ratio (M:F)	Age (adult:pup)	Tagging regions
2001	SRDL	10	5 : 5	10 : 0	SE Scotland
2002	SRDL	5	4 : 1	5 : 0	SE Scotland
2003	SRDL	36	15 : 21	36 : 0	Orkney & N coast, SE England, SE Scotland, Shetland, W Scotland
2004	SRDL	29	15 : 14	29 : 0	Orkney & N coast, SE England, Shetland, W Scotland
2005	SRDL	21	12 : 9	21 : 0	Moray Firth, SE England, W Scotland
2006	SRDL/GPS	43	24 : 19	43 : 0	Moray Firth, N Ireland, SE England
2007	SRDL	1	0 : 1	1 : 0	Moray Firth
2008	GPS	15	8 : 7	15 : 0	N Ireland, SE Scotland
2009	GPS	11	4 : 7	11 : 0	Moray Firth, W England & Wales, W Scotland
2010	GPS	10	8 : 2	10 : 0	N Ireland
2011	GPS	33	22 : 11	33 : 0	Orkney & N coast, SE Scotland, W Scotland
2012	GPS	68	40 : 28	68 : 0	Orkney & N coast, SE England, SE Scotland, W Scotland
2013	GPS	8	6 : 2	8 : 0	Moray Firth, SE Scotland
2014	GPS	19	3 : 16	19 : 0	Moray Firth, Orkney & N coast, W Scotland
2015	GPS	13	6 : 7	13 : 0	Moray Firth
2016	GPS	8	3 : 5	8 : 0	Orkney
<b>Total</b>	<b>SRDL/GPS</b>	<b>330</b>	<b>175:155</b>	<b>330:0</b>	

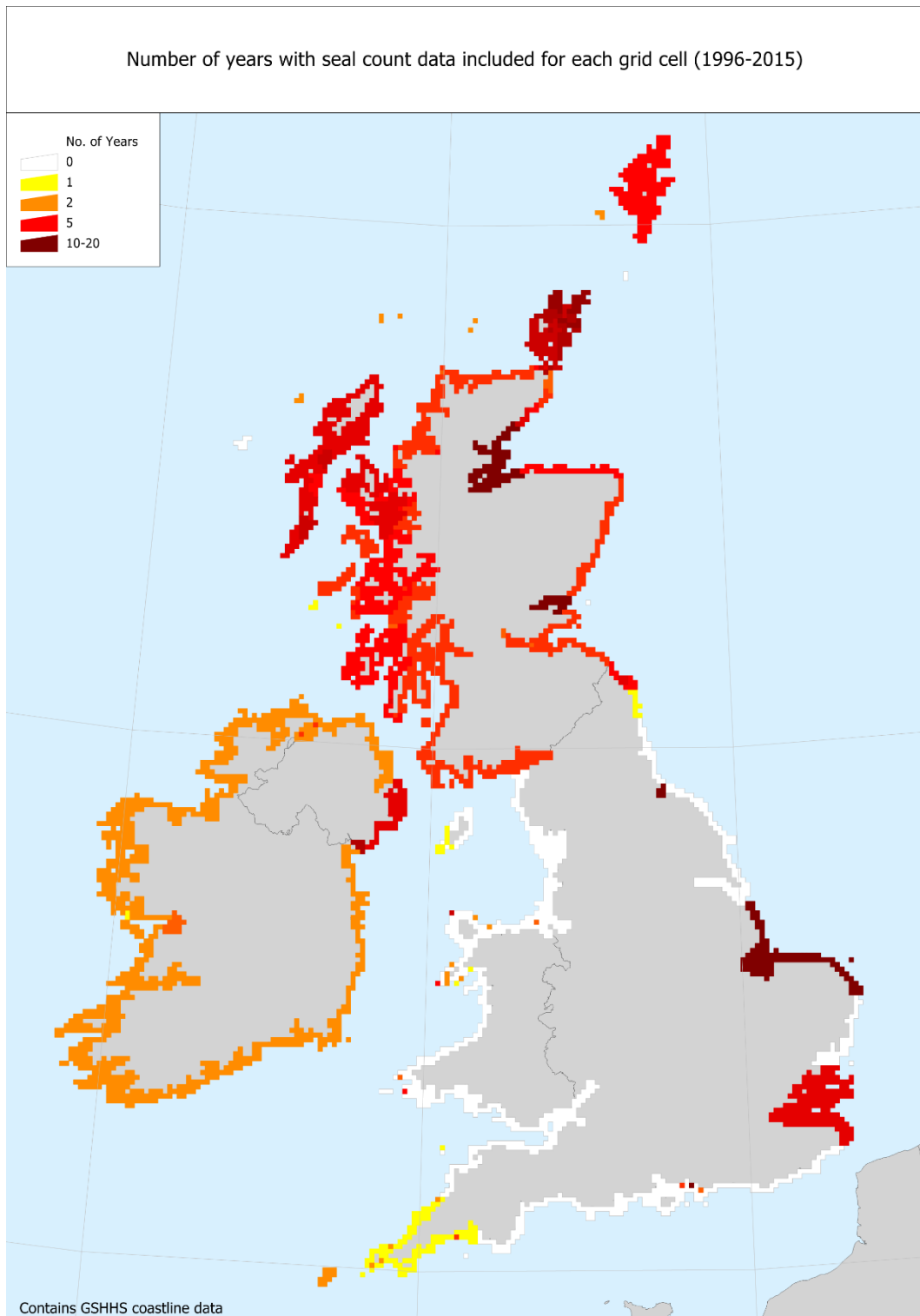


**Figure 1:** The tracks of (a) 270 grey seals (1991 to 2016) and (b) 330 harbour seals (2001 to 2016) tagged in the UK and used to generate the usage maps (see Table 1 for more details).



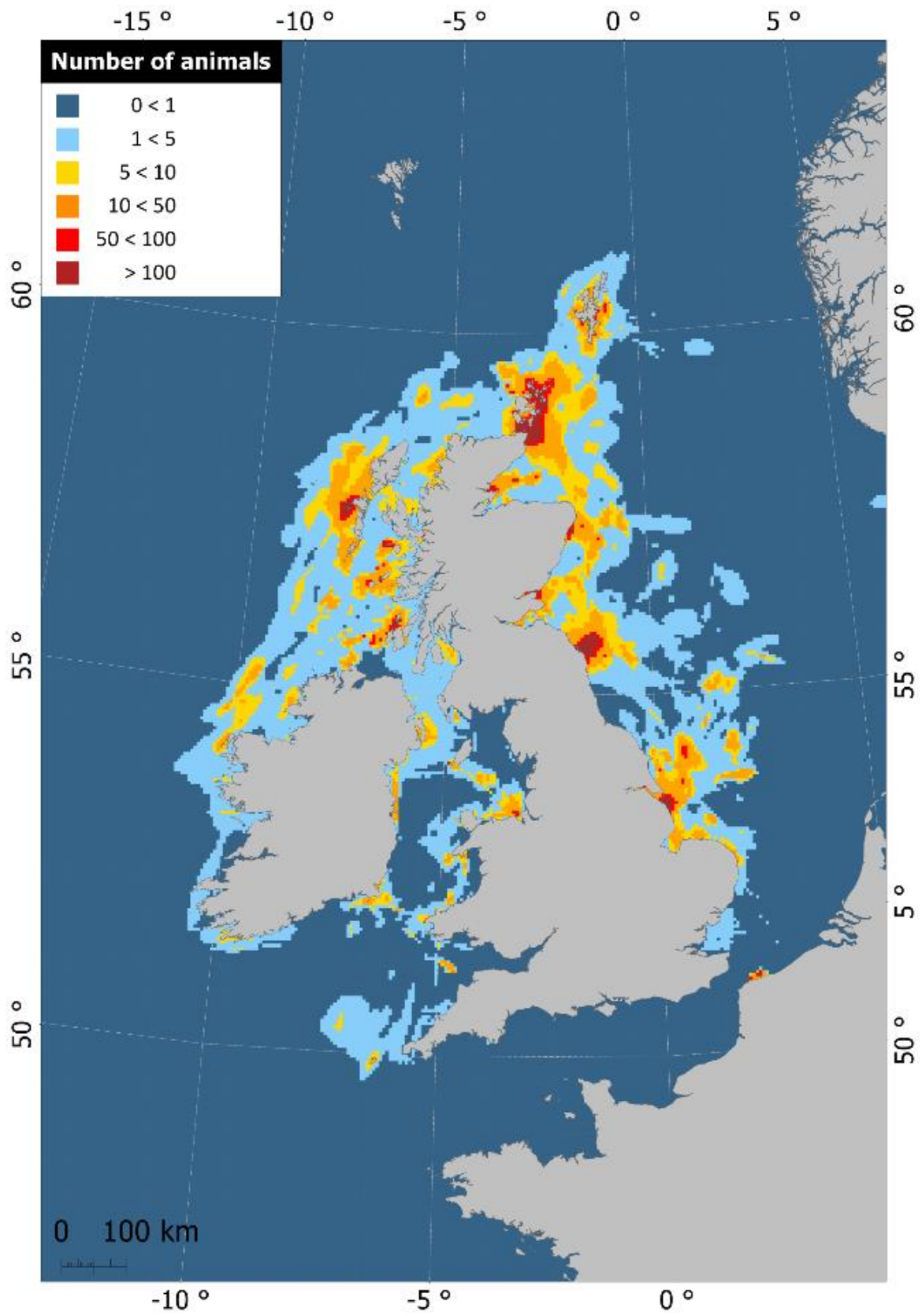
**Figure 2:** Maps showing the count data for (a) grey and (b) harbour (b) seals between 1996 and 2015.



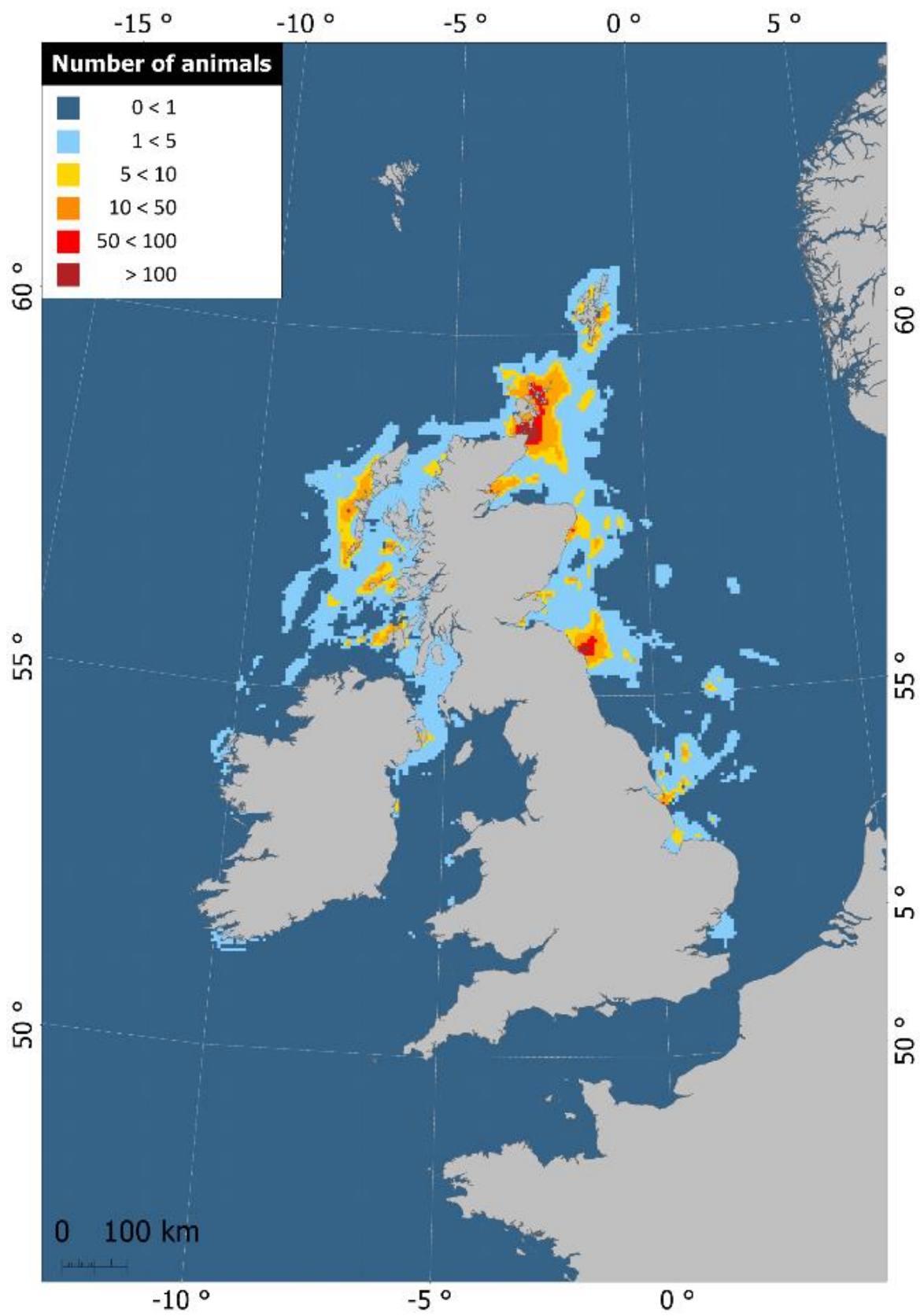


**Figure 3:** Effort (number of years surveyed) associated with each grid cell. Note that grid cells which have not been surveyed (in white) are either associated with areas where seals are sparse and rarely haul out (west and south England) or with distant offshore islands (e.g. St Kilda). For this exercise, cells which have not been surveyed are assumed not to contain any haul-out sites.

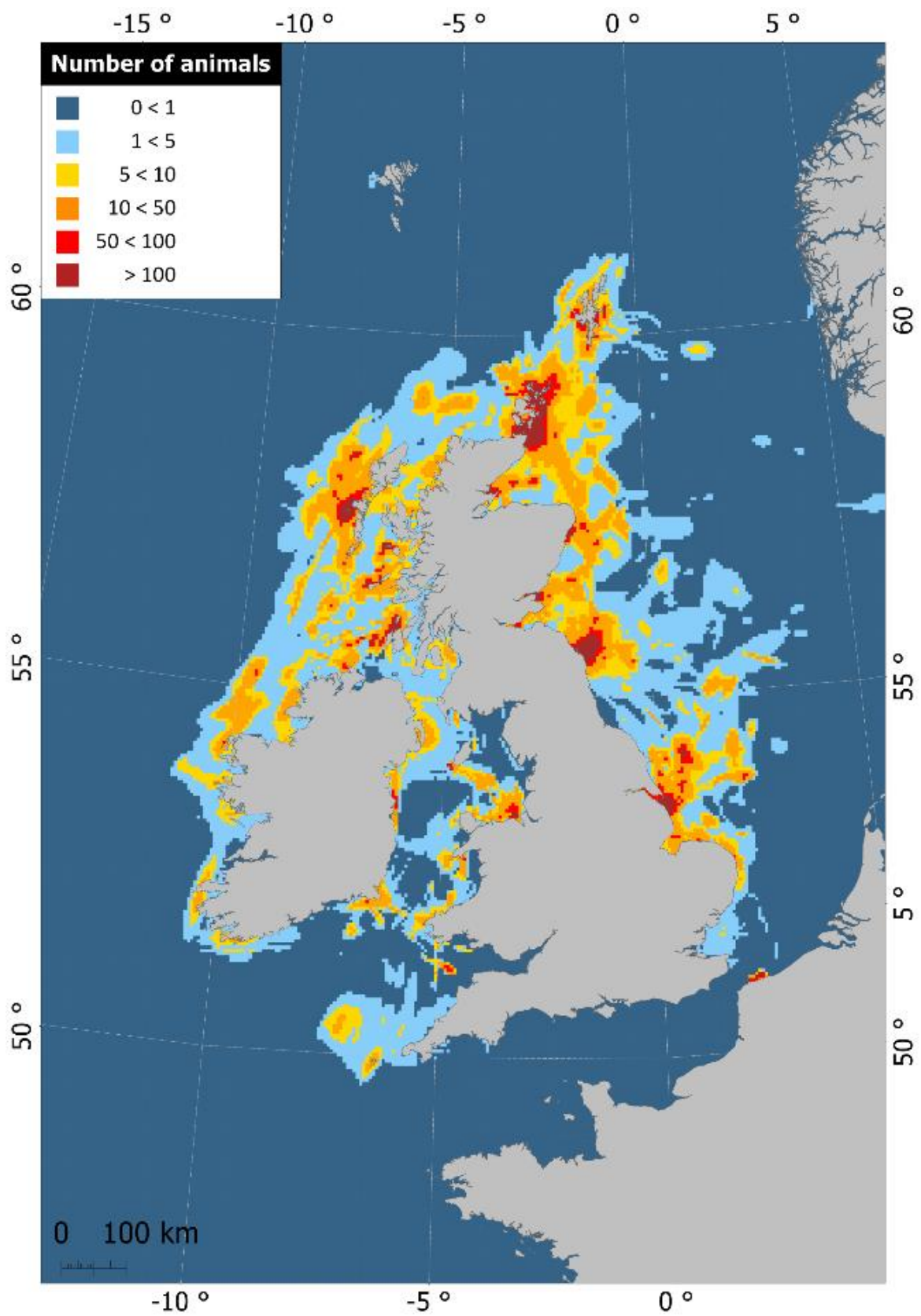
a) Grey seal at-sea usage: mean.



b) Grey seal at-sea usage: lower 95 % CI of mean.

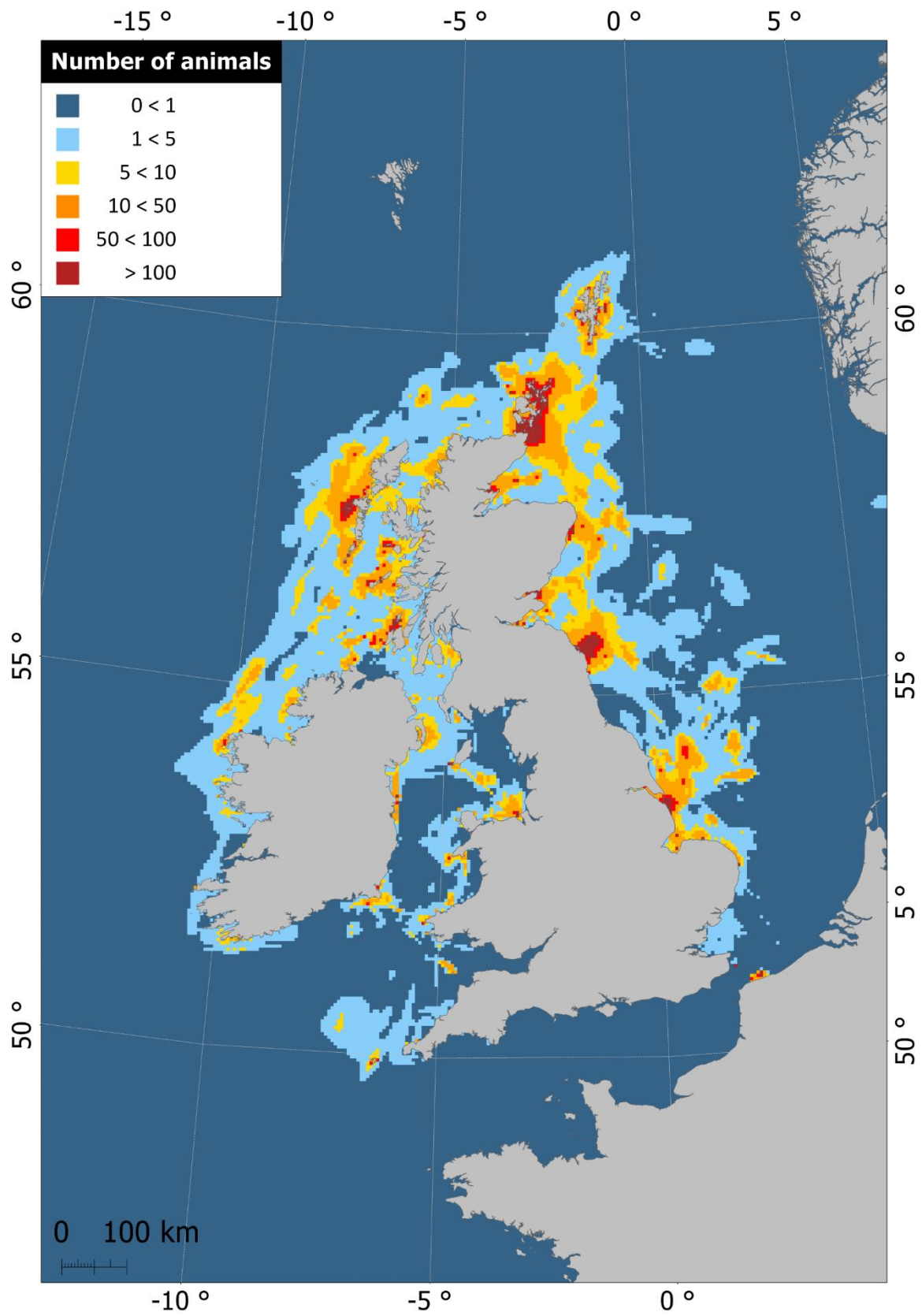


c) Grey seal at-sea usage: upper 95 % CI of mean.

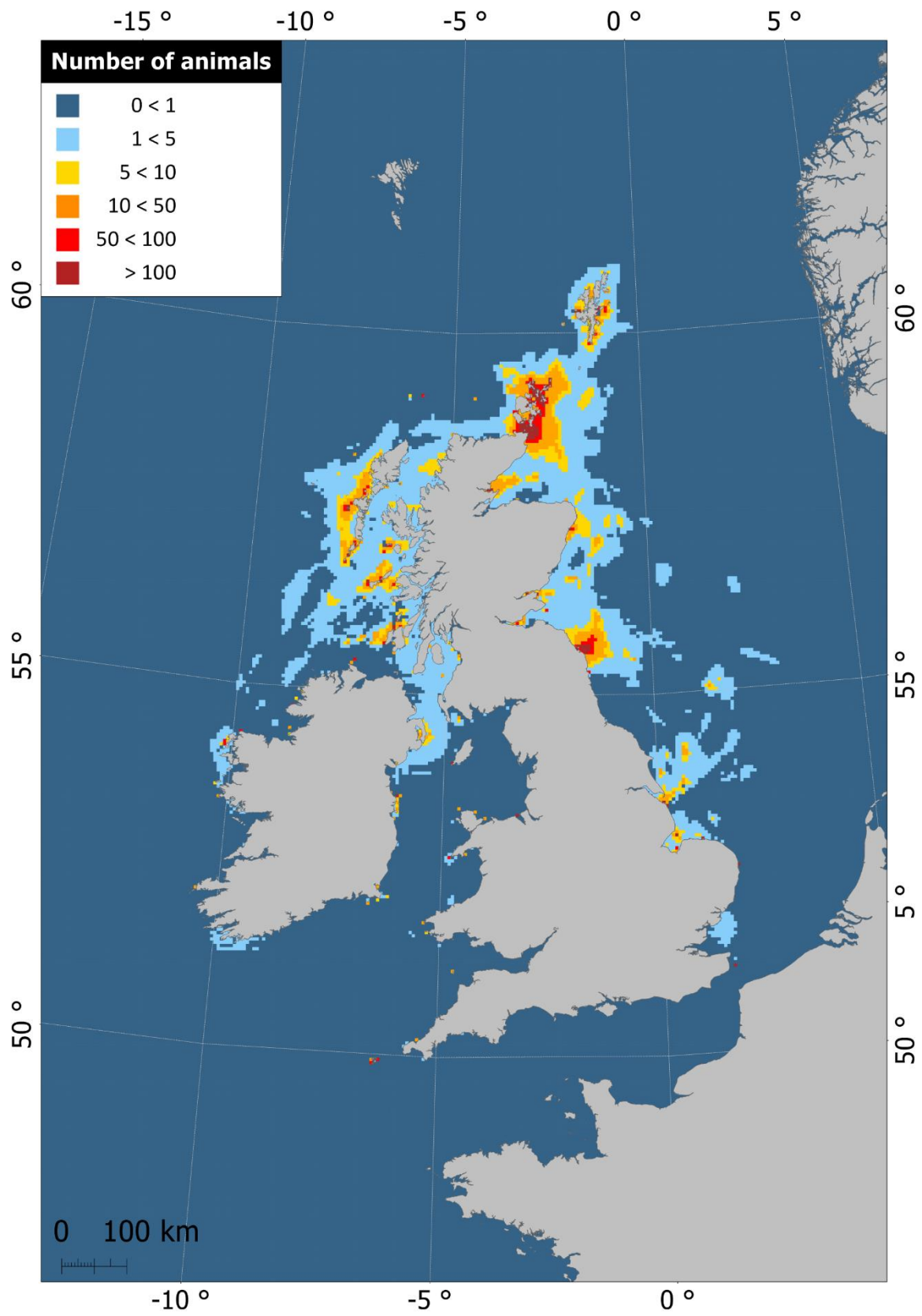


**Figure 4:** Grey seal at-sea usage showing predicted (a) mean number of animals in each 5 x 5 km grid cell and the (b) lower and (c) upper 95 % confidence intervals of the mean.

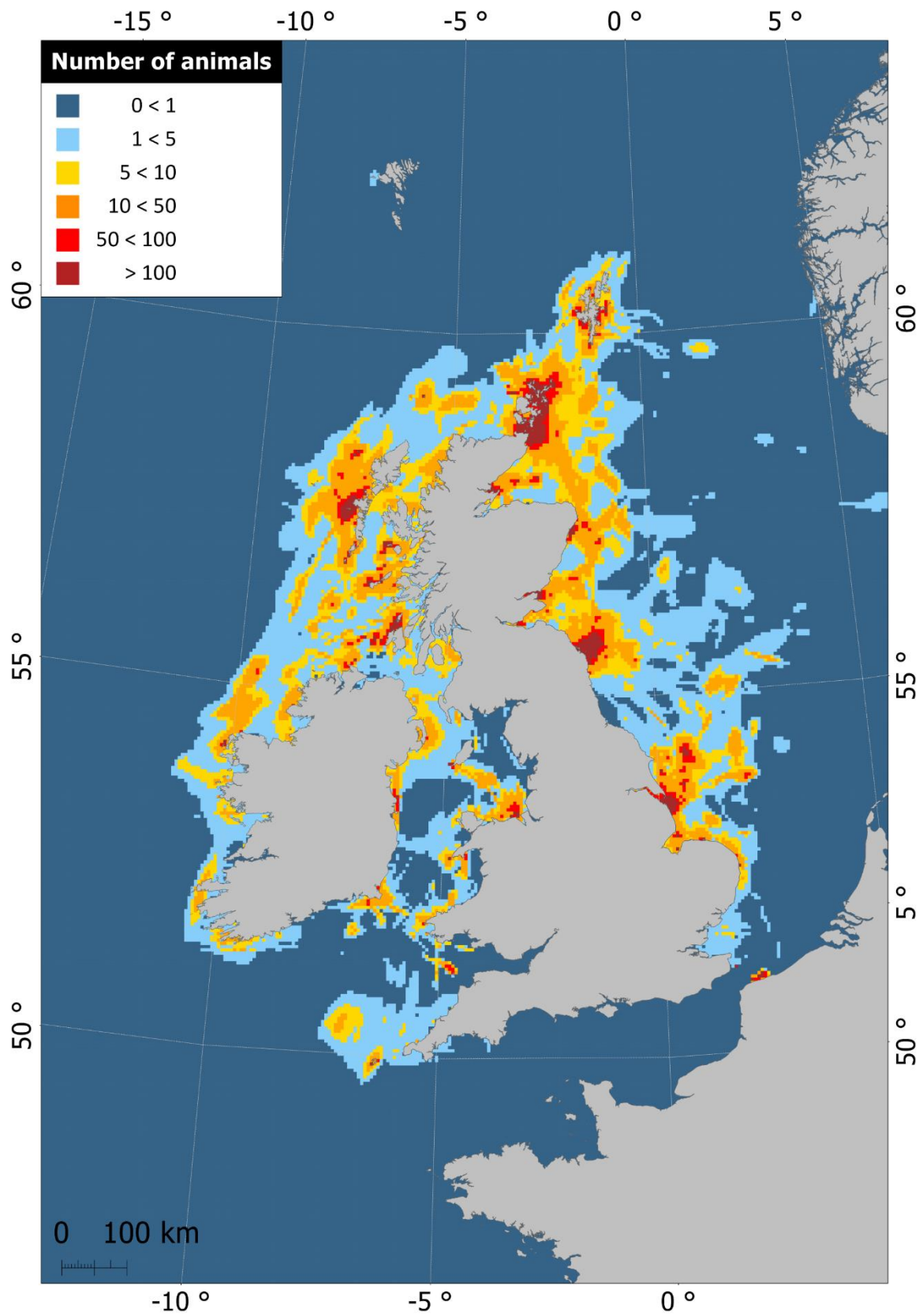
a) Grey seal total usage: mean.



b) Grey seal total usage: lower 95 % CI of mean.

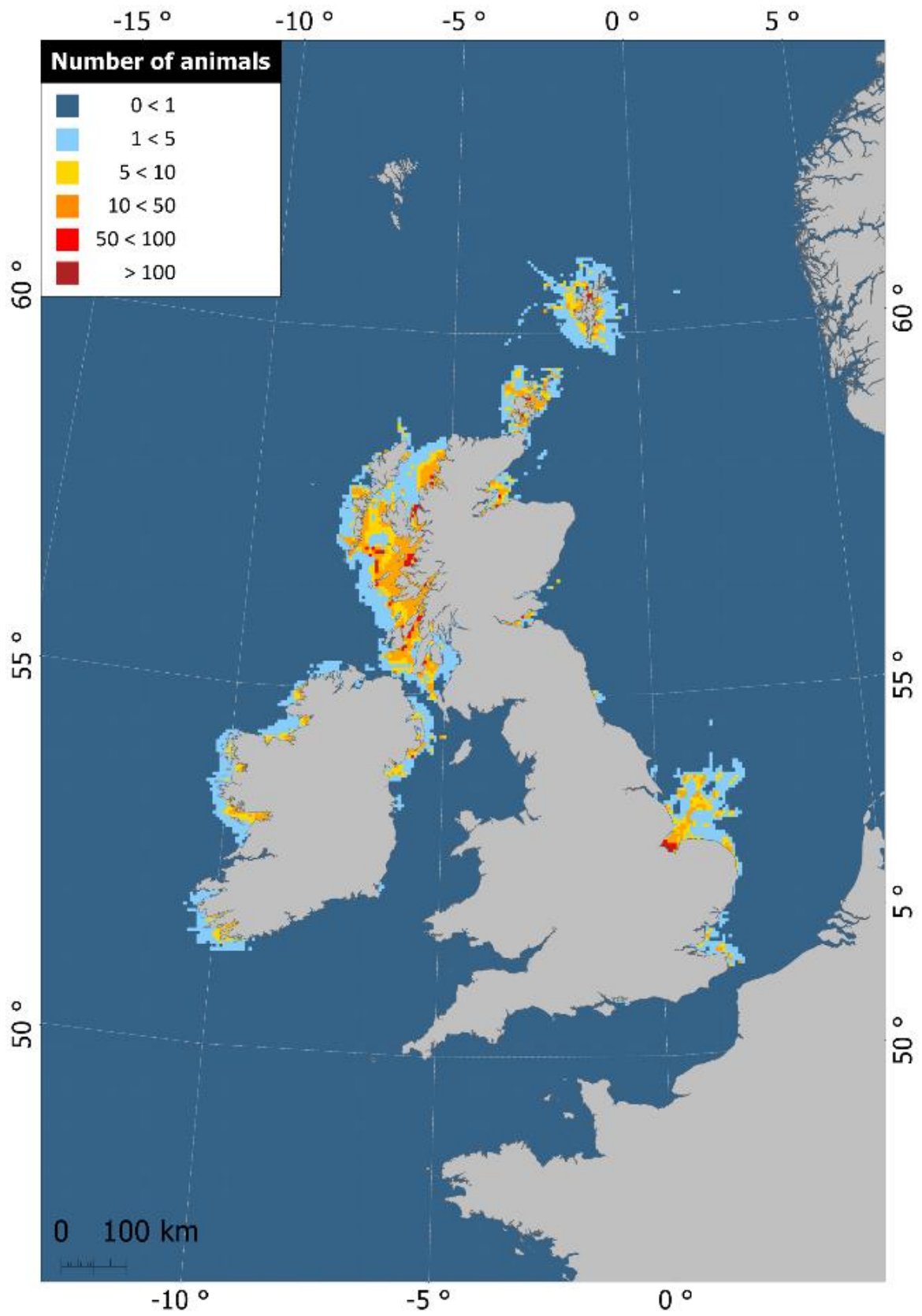


c) Grey seal total usage: upper 95 % CI of mean.



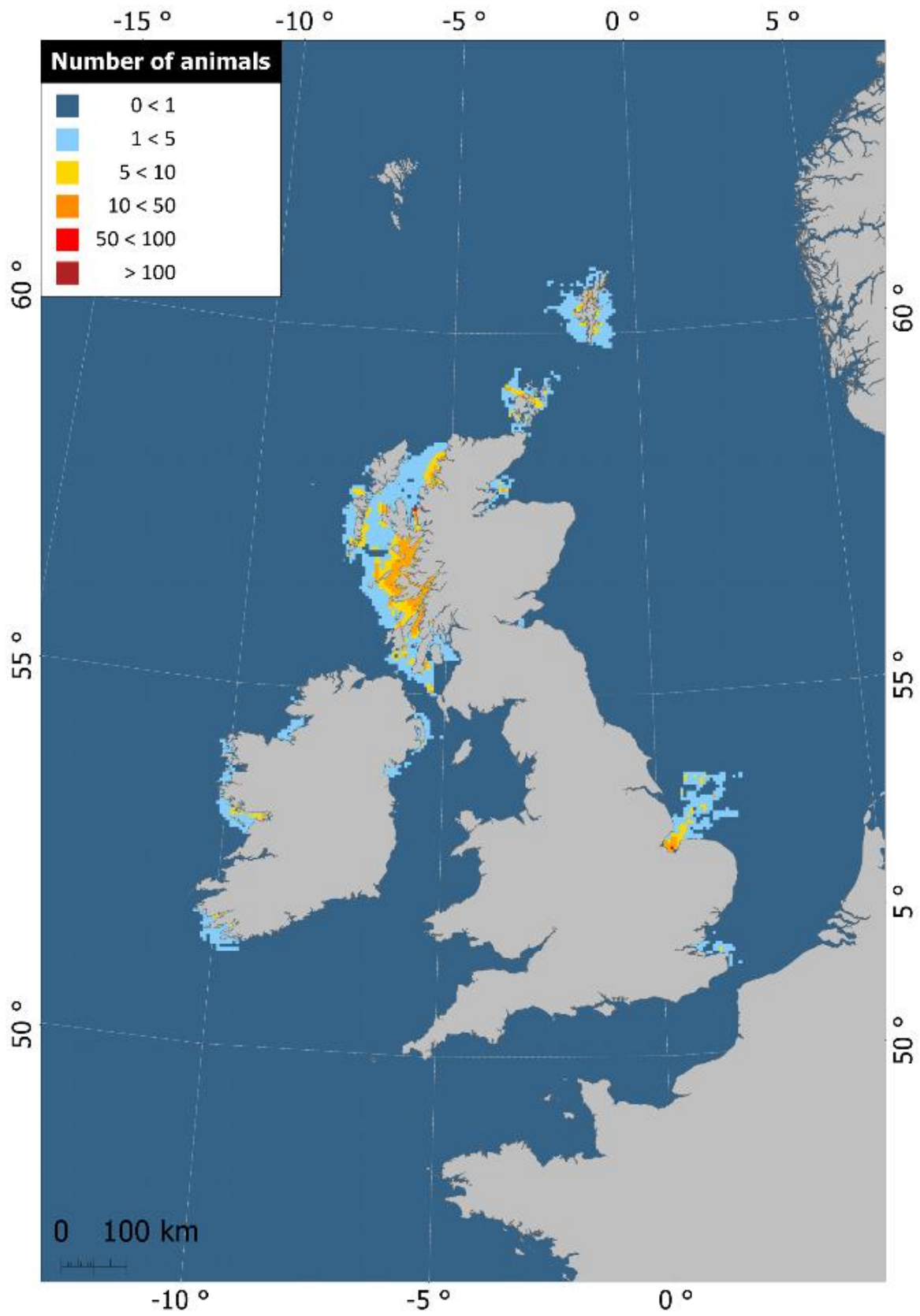
**Figure 5:** Grey seal total usage showing predicted (a) mean number of animals in each 5 x 5 km grid cell and the (b) lower and (c) upper 95 % confidence intervals of the mean.

a) Harbour seal at-sea usage: mean.

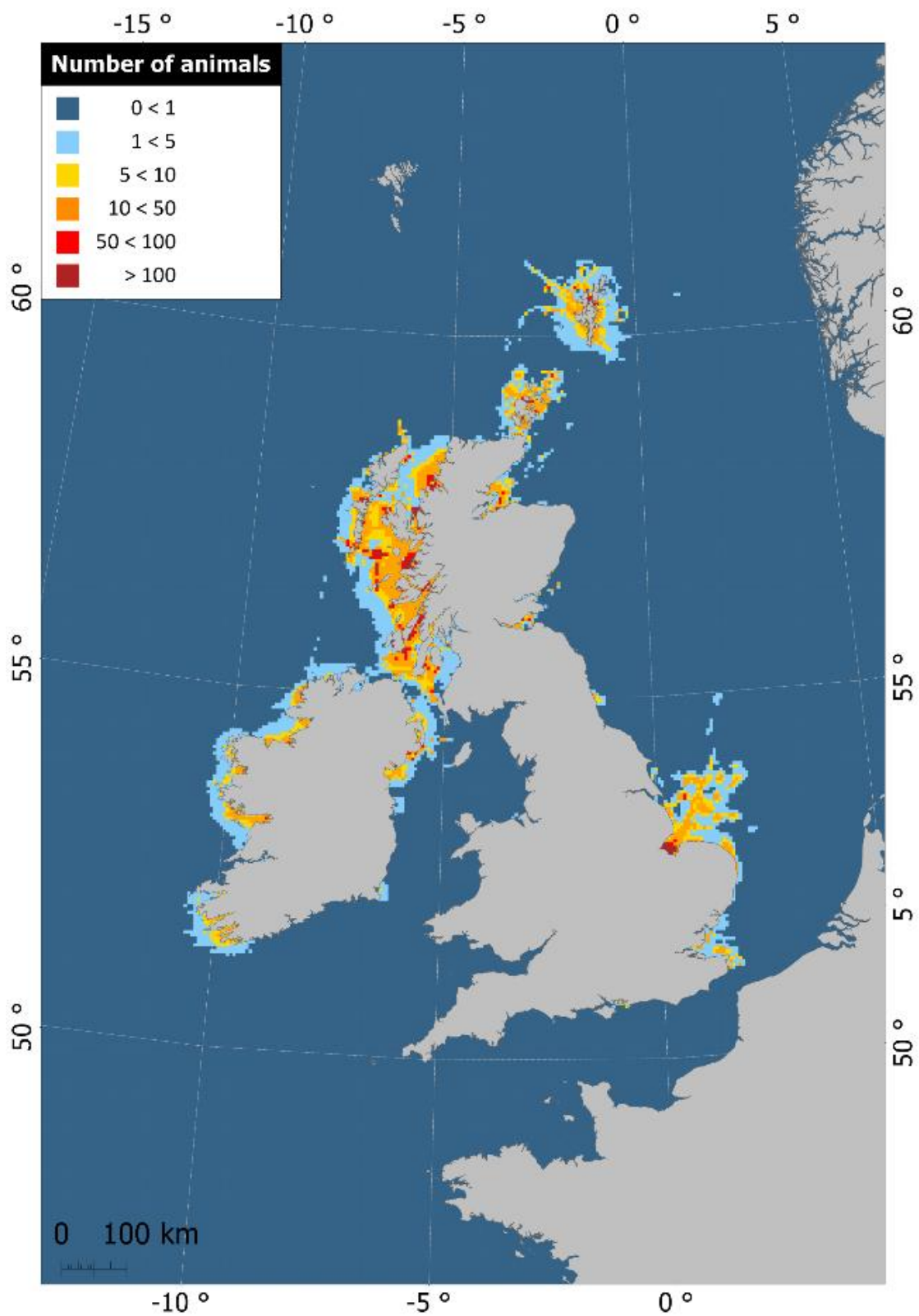




b) Harbour seal at-sea usage: lower 95 % CI of mean.

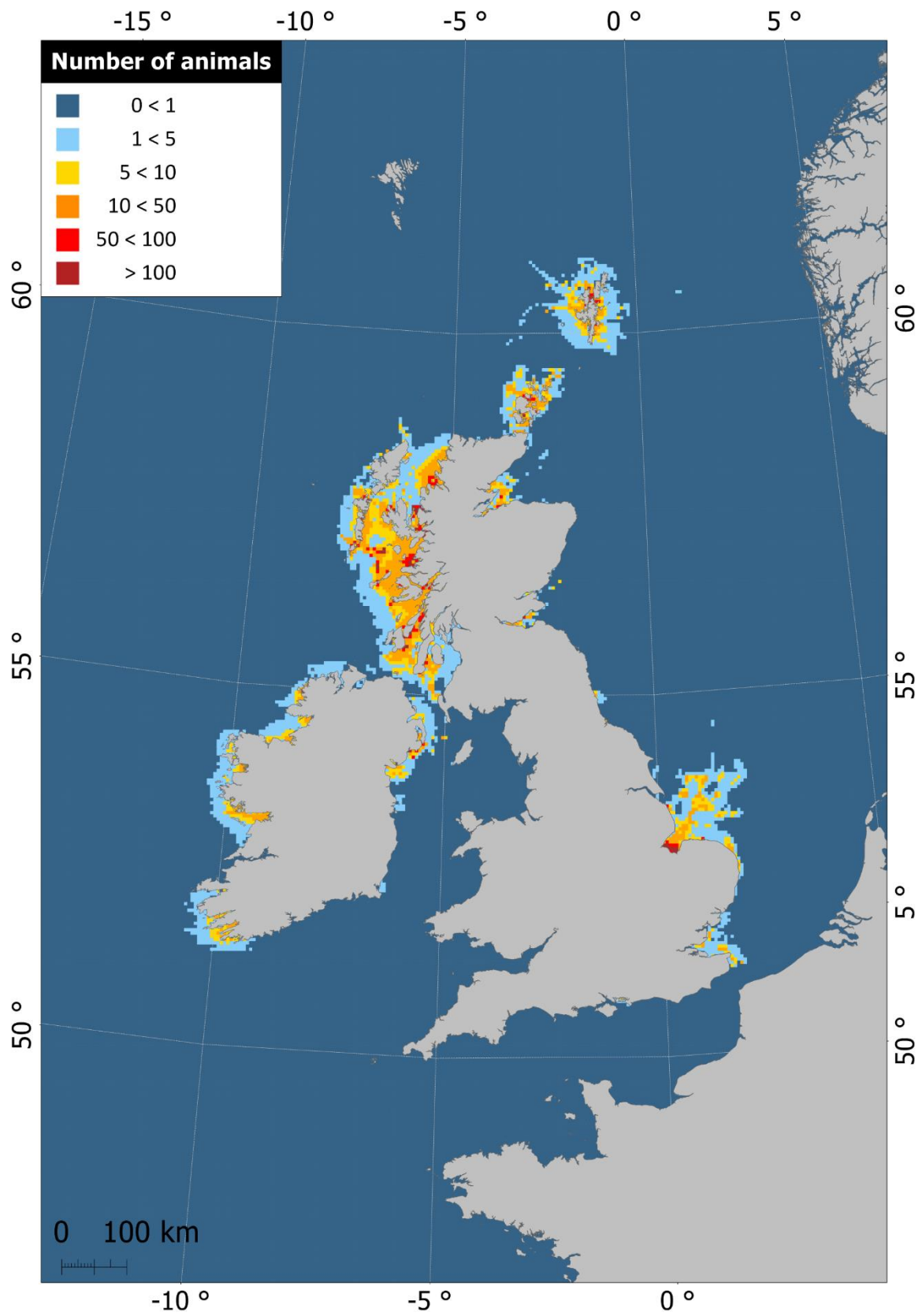


c) Harbour seal at-sea usage: upper 95 % CI of mean.

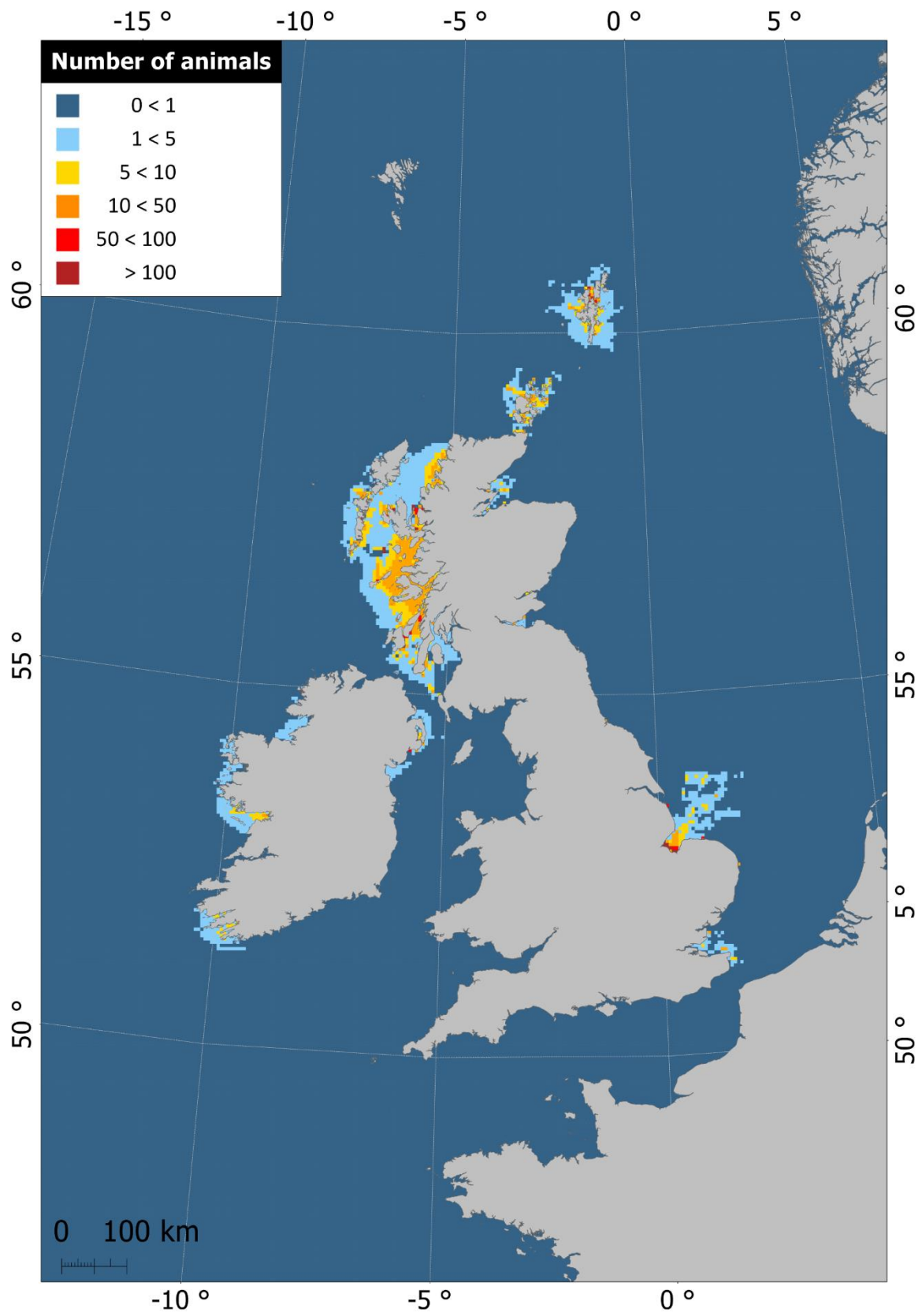


**Figure 6:** Harbour seal at-sea usage showing predicted (a) mean number of animals in each 5 x 5 km grid cell and the (b) lower and (c) upper 95 % confidence intervals of the mean.

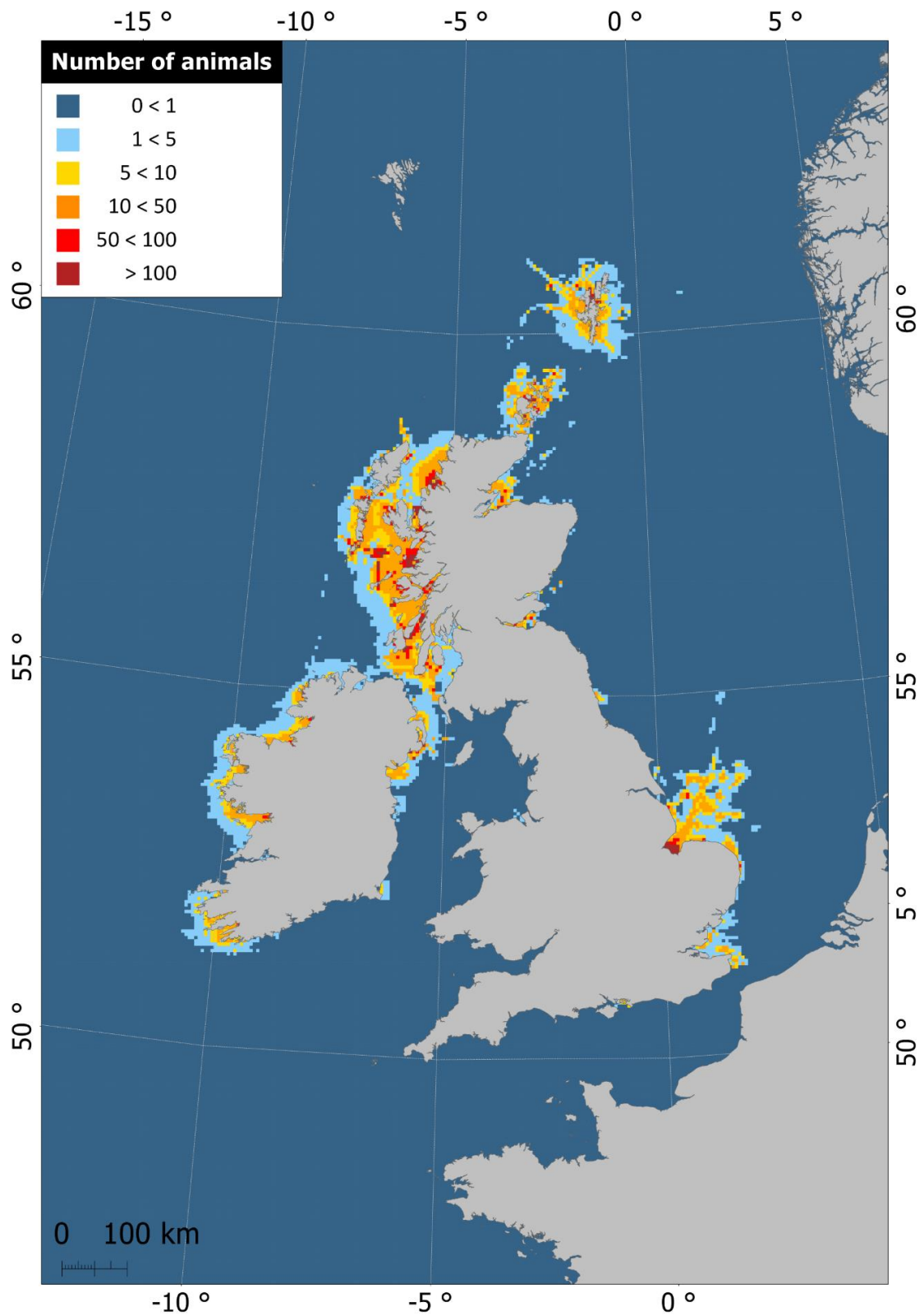
a) Harbour seal total usage: mean.



b) Harbour seal total usage: lower 95 % CI of mean.



c) Harbour seal total usage: upper 95 % CI of mean.



**Figure 7:** Harbour seal total usage showing predicted (a) mean number of animals in each 5 x 5 km grid cell and the (b) lower and (c) upper 95 % confidence intervals of the mean.

## Appendix 1

**Table A1**

Shape-file names are given along with the associated figure number.

<b>File name</b>	<b>Figure</b>
HgSeaUsage	4a
HgSeaLower	4b
HgSeaUpper	4c
HgTotUsage	5a
HgTotLower	5b
HgTotUpper	5c
PvSeaUsage	6a
PvSeaLower	6b
PvSeaUpper	6c
PvTotUsage	7a
PvTotLower	7b
PvTotUpper	7c