Marine Mammal Scientific Support Research Programme MMSS/002/15

Population scaling in 5 km x 5 km grey and harbour seal usage maps

Sea Mammal Research Unit

Note to Scottish Government

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Executive summary

Grey and harbour seal usage maps around the British Isles were produced at a spatial resolution of 5 km x 5 km. A paper was published describing how usage maps can be used and interpreted, the caveats and limitations, and methodology used to produce them, which is available to download:

Jones, E.L., McConnell, B.J., Smout, S., Hammond, P.S., Duck, C.D., Morris, C.D., Thompson, D., Russell, D.J.F., Vincent, C., Cronin, M., Sharples, R.J. & Matthiopoulos, J. (2015). Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series, 534, 235–249. doi:10.3354/meps11370

Usage maps have been made available to download in GeoTiff and shapefile formats. These are provided in a Universal Transverse Mercator 30^0 N World Geodetic System 1984 datum (UTM30N WGS84) projection. This note details how terrestrial count data were used to scale the usage maps up to population levels, and how the maps should be interpreted. Readers should first be familiar with Jones *et al*. (2015) to contextualise details described below.

Aerial surveys count grey and harbour seals along a coastline on an annual basis during the harbour seal moult in August. Animals are counted and their locations are recorded to an accuracy of 50m. Not all the coastline is surveyed in any one year. The locations of survey effort are recorded. Usage maps use these historical count data to scale each onshore 5 km x 5 km grid cell in which seals are hauled out to a local population estimate for all usage associated with that onshore cell. The count data used in this analysis were coded in such a way that a missing value for an onshore grid cell can either mean the cell was not surveyed that year or it was surveyed but no animals were observed. Currently, the algorithm used to generate usage maps treats every missing value as though no survey effort was expended, meaning that observations where the count was 0 were not included. This may bias population estimates in instances where missing values in the count data represent no animals being observed (i.e. the count for the onshore grid cell was observed to be 0 at some point). This may particularly affect areas where the local population is fluctuating or decreasing (where 0 counts are more likely). Note that this misinterpretation is limited to usage map generation and does not affect annual population assessments to Special Committee on Seals (SCOS). Work is currently being undertaken in the Sea Mammal Research Unit, St Andrews to explicitly synthesise count and effort data, which will be rolled out in the next planned release of the usage maps. To gauge the potential impact of using non-0 count data in the usage maps, testing was carried out in two areas.

For the test case areas, variation in the population estimates of both species when using non-0 count and 0 count data ranged from -14.8% to +1.5% over the regions of Orkney and the Western Isles. The population estimate will also change with the inclusion of 0 count data when a recent count is 0; the estimate will be extrapolated to the current year (i.e. 2013), and may be higher or lower than when non-0 count data are used.

Contents

1. Testing methodology

The harbour seal population has been in decline in some areas around the UK since 2000. Animals within the Orkney and the North Coast management region have been particularly affected with numbers decreasing by 78% between 2000 and 2013 (Duck *et al*., 2015), with a total count of 1,865 in 2013. In contrast, in the Western Isles of Scotland, the harbour seal count increased from 1,804 in 2008 to 2,739 in 2011. In these two areas, there are large populations of grey seals (7,840 in Orkney in 2013; 4,038 in the Western Isles in 2011; Duck and Morris, 2016). These areas were chosen as sites to test the methodology, as they reflect stable, decreasing, and potentially increasing populations of seals through time, and so the effects of using 0 count and non-0 count data can be assessed within these contexts.

Survey effort and terrestrial count data between 1996 and 2013 for grey and harbour seals were extracted for Orkney and the Western Isles in Scotland. These data included information about survey effort for each 5 km x 5 km onshore grid cell, such that counts of 0 were shown explicitly, distinct from 'missing' observations where no survey data were available in a given cell and year. Seal populations (and associated uncertainty) for each onshore grid cell were then predicted for 2013 using the methodology described in Jones *et al*. (2015).

Firstly, survey effort was mapped over the two testing areas. Surveys that were incomplete over a 5 km x 5 km grid cell in any year were removed. Surveys between 1996 and 2013 were included by grid cell for each species (Figures 1-3). To provide a population estimate for each onshore grid cell, the usage map algorithm uses a log-likelihood distribution along with a defined population range (minimum = N, maximum = $100N$, where N is the terrestrial count from a grid cell). If the count in an onshore grid cell is 0, the software is unable to provide a population estimate. Therefore, 0 counts were changed to 1 (temporary fix for testing purposes). Counts were processed using the algorithm from the usage maps to estimate the population and uncertainty, scaled to 2013. Counts that were originally 0 were then removed from the data and this analysis was repeated so that population estimates using 0 counts and using non-0 counts (analogous to methodology used in Jones *et al*., 2015) could be compared.

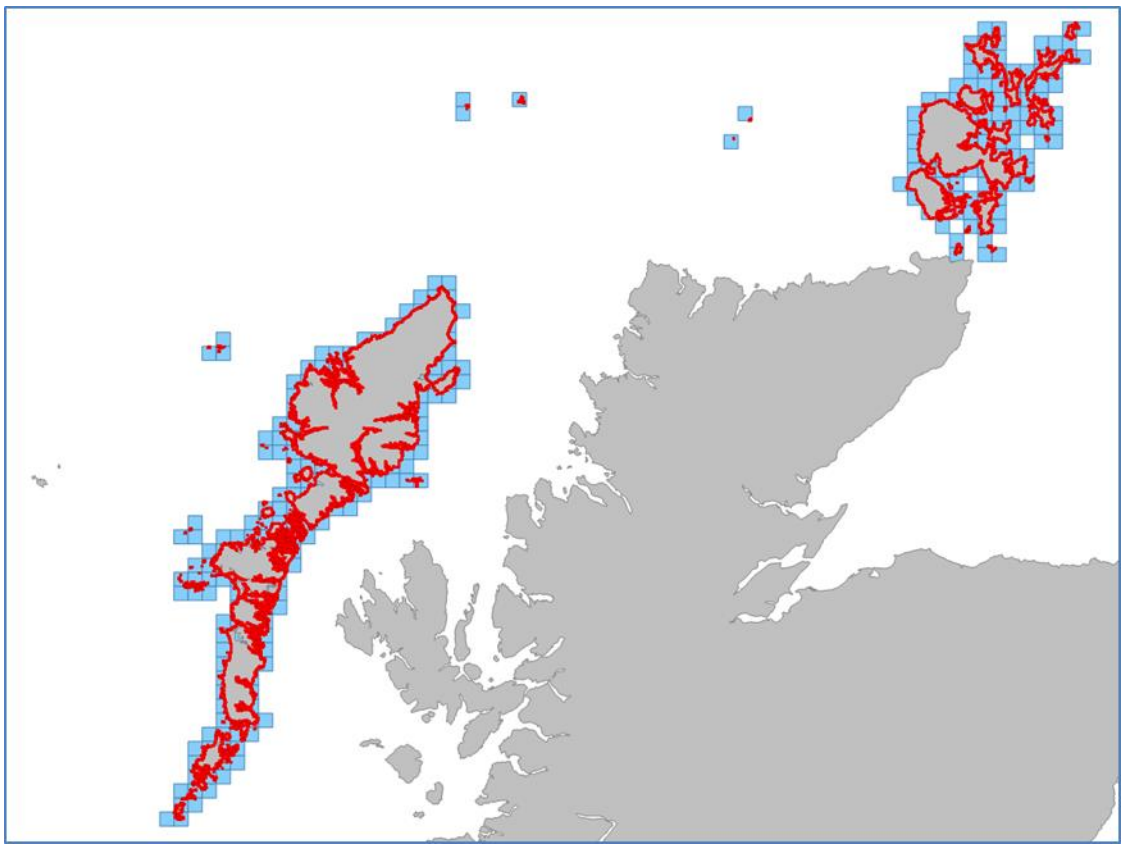

Figure 1. 5 km x 5 km onshore grid cells used in testing for the Western Isles and Orkney.

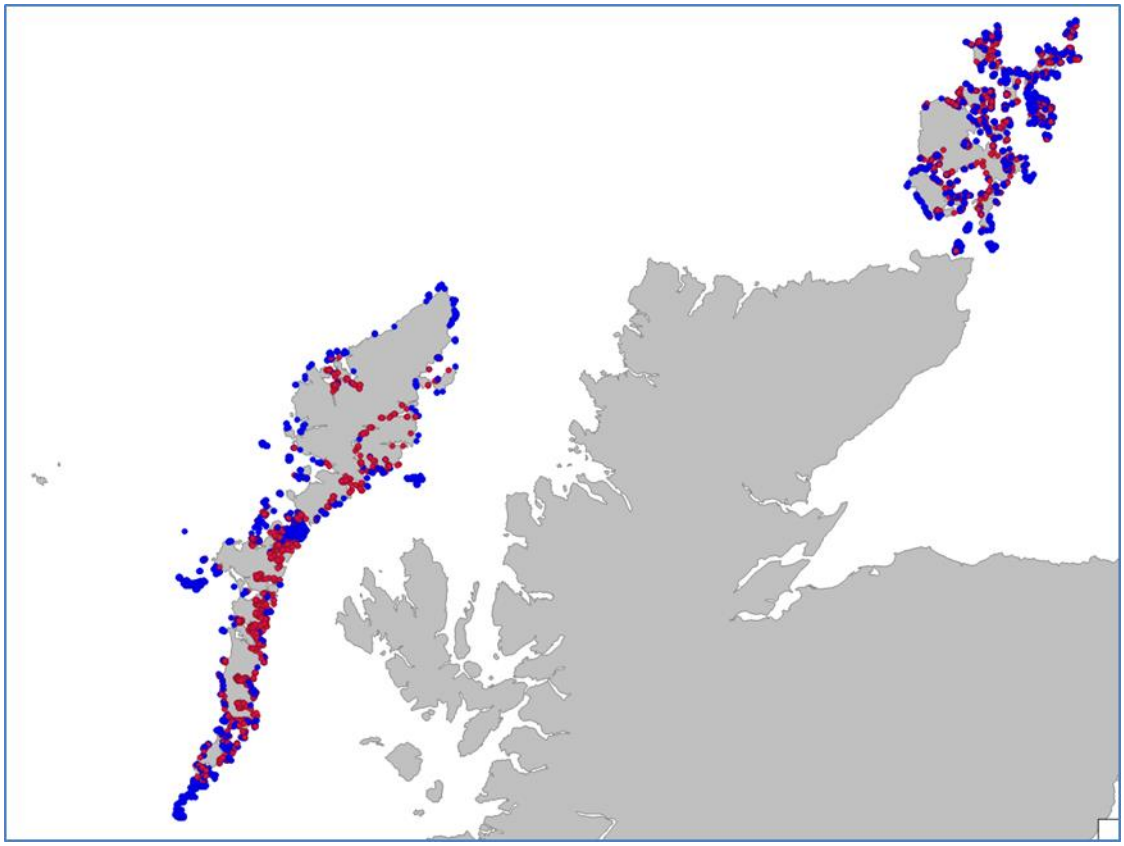

Figure 2. Grey seal (blue points) and harbour seal (red points) terrestrial counts used in testing.

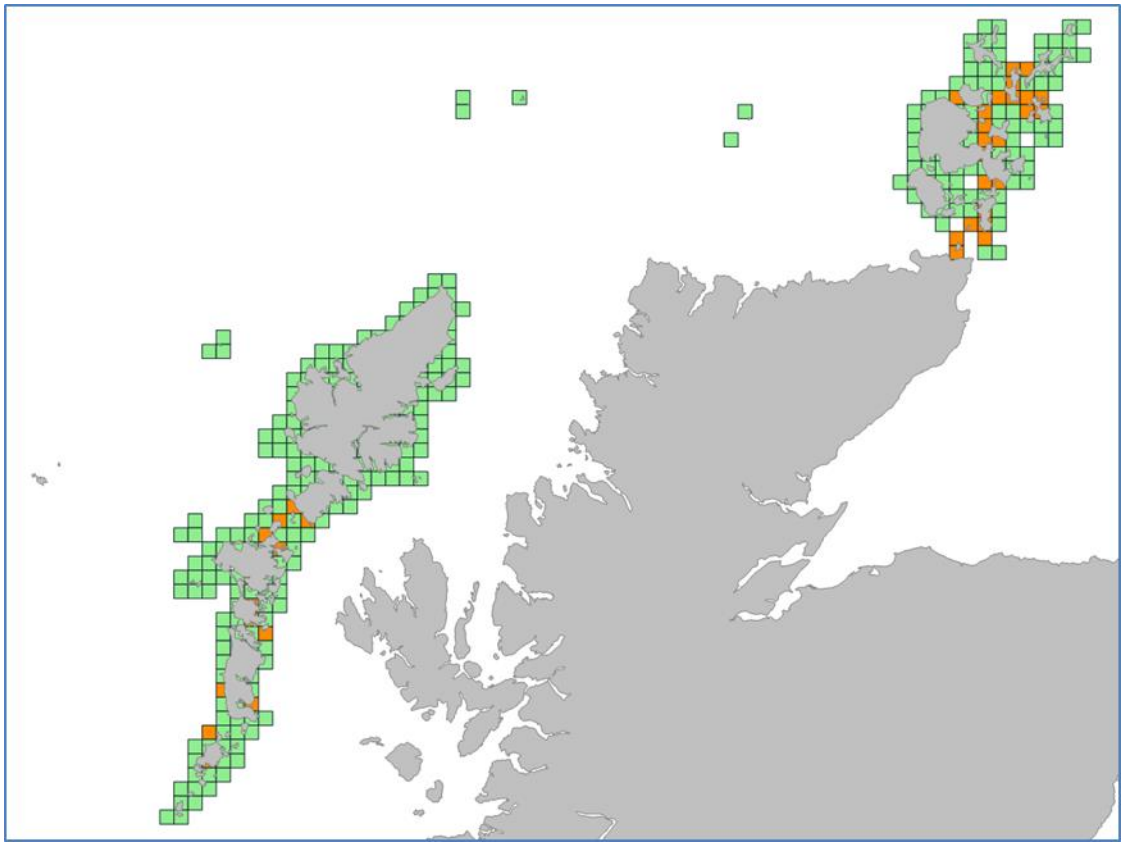

Figure 3. Grid cells where some data have been excluded (orange) due to incomplete surveys in one or more years. In these cases, a cell was considered "not surveyed" in that year.

2. Results

Table 1 shows totals for both species in Orkney and the Western Isles, Scotland, comparing non-0 count (original) with 0 counts (new). There are two points to note with interpretation of this analysis:

(1) Usage maps use a decision tree (Figure 8) to produce a population estimate for each 5 km x 5 km onshore grid cell. Where additional 0 count data have been included, this can prompt the decision tree to change the prediction for that cell. For instance, where the last (non-0) count was 2008, the decision tree originally predicted the population at 2008. If 0 counts from 2011 are now included, a curve will be fitted to the time-series data to extrapolate the prediction to 2013. Population estimates for many grid cells are likely to change (some increasing, some decreasing) when 0 counts are used.

(2) Onshore grid cell aggregation (grouping cells that are close together) has not been used in the analysis (as this was not used in the paper), and therefore the impact of 0 counts has been assessed at a 5 km x 5 km onshore grid cell resolution.

For grey seals in Orkney, including 0 counts increases the population estimate from 35,540 (Figure 4) to 36,088 (Figure 5), a difference of 548 animals (+1.5%). In the Western Isles, including 0 counts decreases the population from 15,393 (Figure 4) to 14,292 (Figure 5), a difference of 1,101 (-7.2%).

For harbour seals, using 0 counts reduced the population estimate from 3,154 (Figure 6) to 2,687 (Figure 7) in Orkney, a difference of 467 animals (-14.8%), and from 3,962 (Figure 6) to 3,801 (Figure 7) in the Western Isles, a difference of 161 animals (-4.1%). Note that in Figure 7 many grid cells are pale blue. This is an artefact of changing 0 counts to 1 when processing through the usage map software.

Table 1. Results using counts with only non-0 values and with 0 values included, for Orkney and the Western Isles, for grey and harbour seals.

Region	Grey seals		Harbour seals	
	Non-0 counts (95% CI)	With 0 counts included (95% CI)	Non-0 counts (95% CI)	With 0 counts included (95% CI)
Orkney	35540 (34649; 36432)	36088 (36066; 36110)	3154 (3024; 3284)	2687 (2665; 2709)
Western Isles	15393 (14975; 15812)	14292 (14263; 14322)	3962 (3860; 4063)	3801 (3772; 3830)

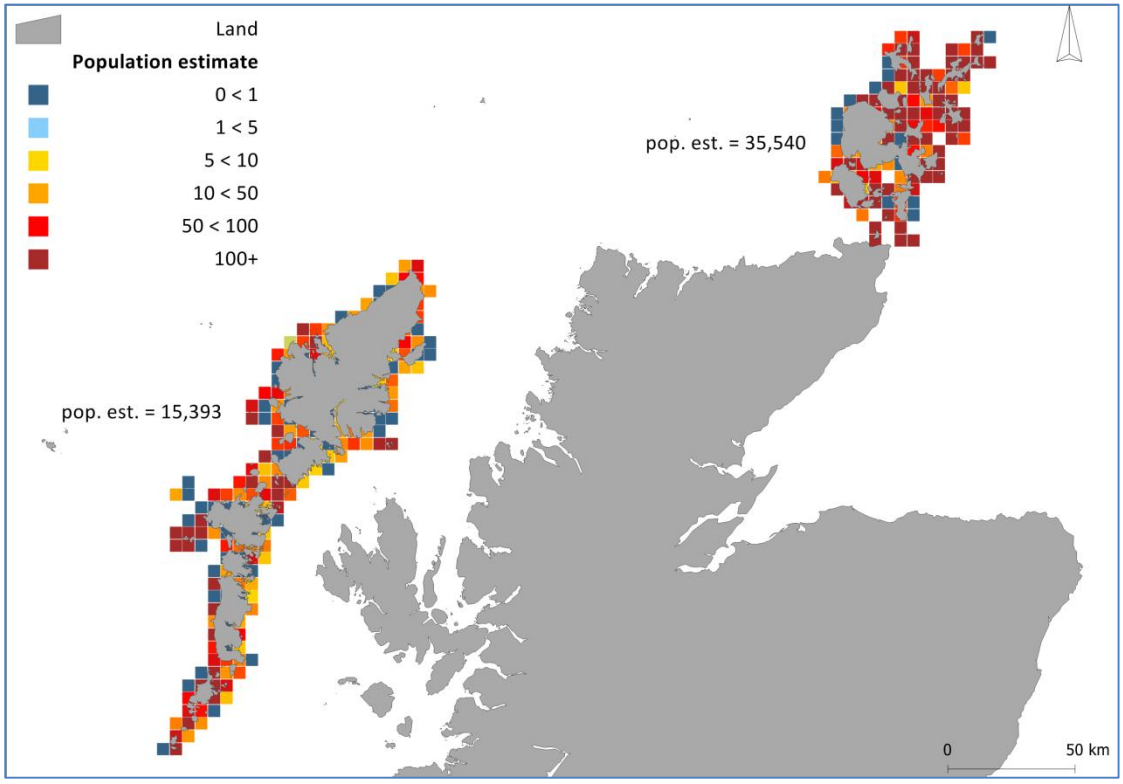

Figure 4. Grey seal population estimates in Orkney and the Western Isles using non-0 count data (analogous to data from Jones *et al.*, 2015).

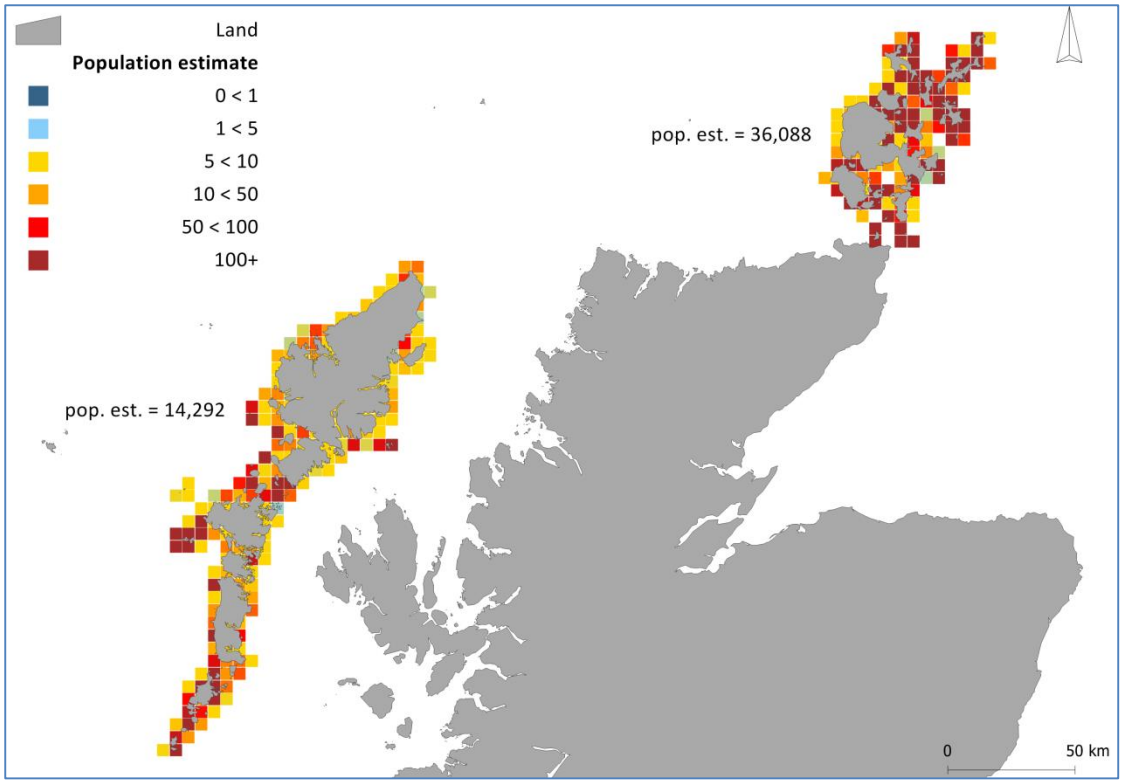

Figure 5. Grey seal population estimates in Orkney and the Western Isles using 0 count data.

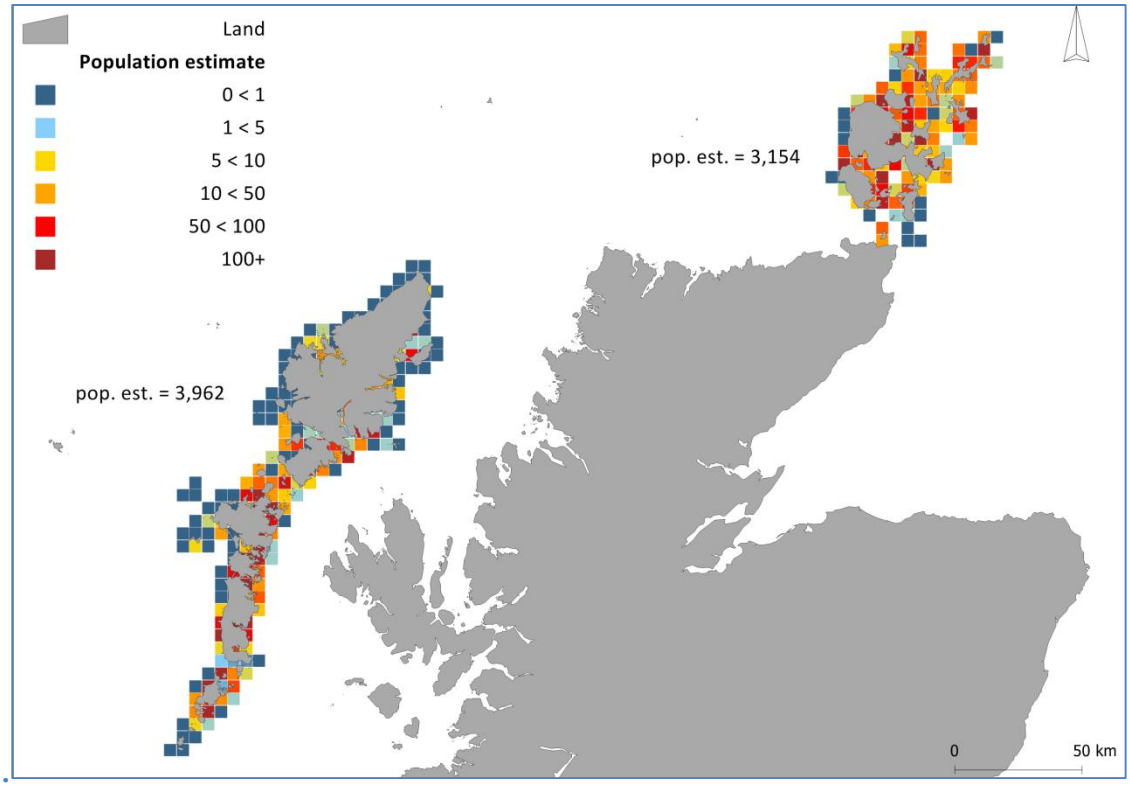

Figure 6. Harbour seal population estimates in Orkney and the Western Isles using non-0 count data (analogous to data from Jones *et al.*, 2015).

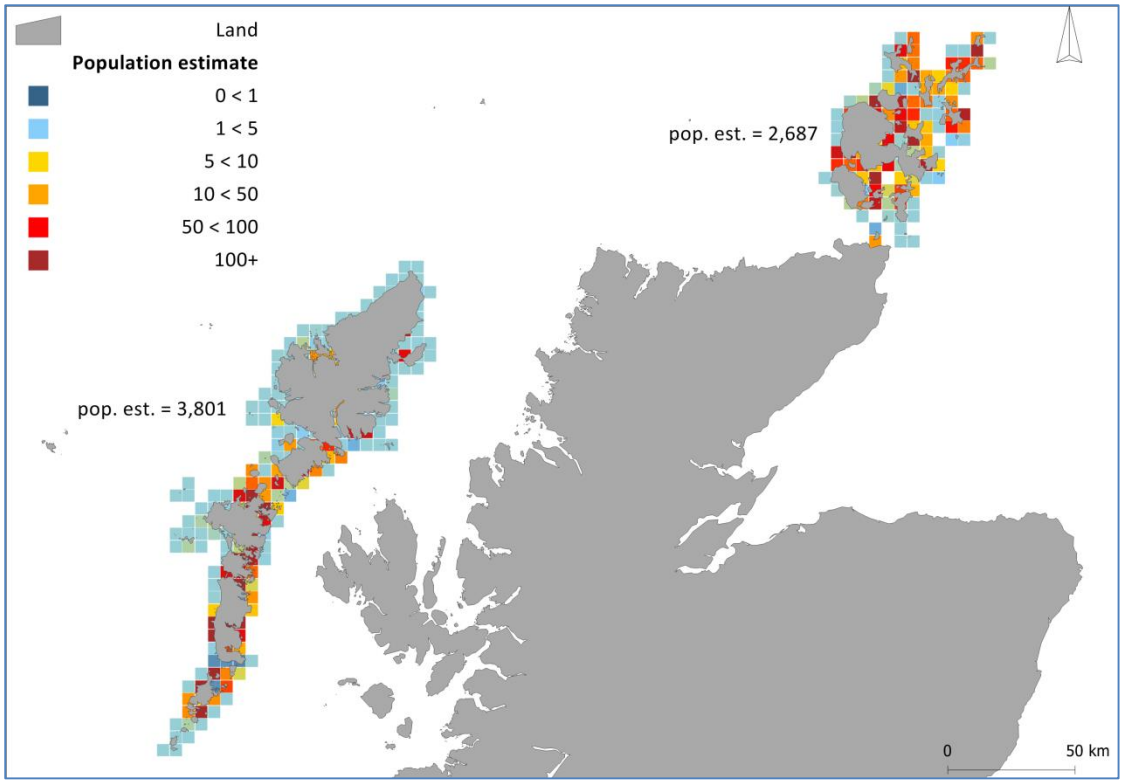

Figure 7. Harbour seal population estimates in Orkney and the Western Isles using 0 count data.

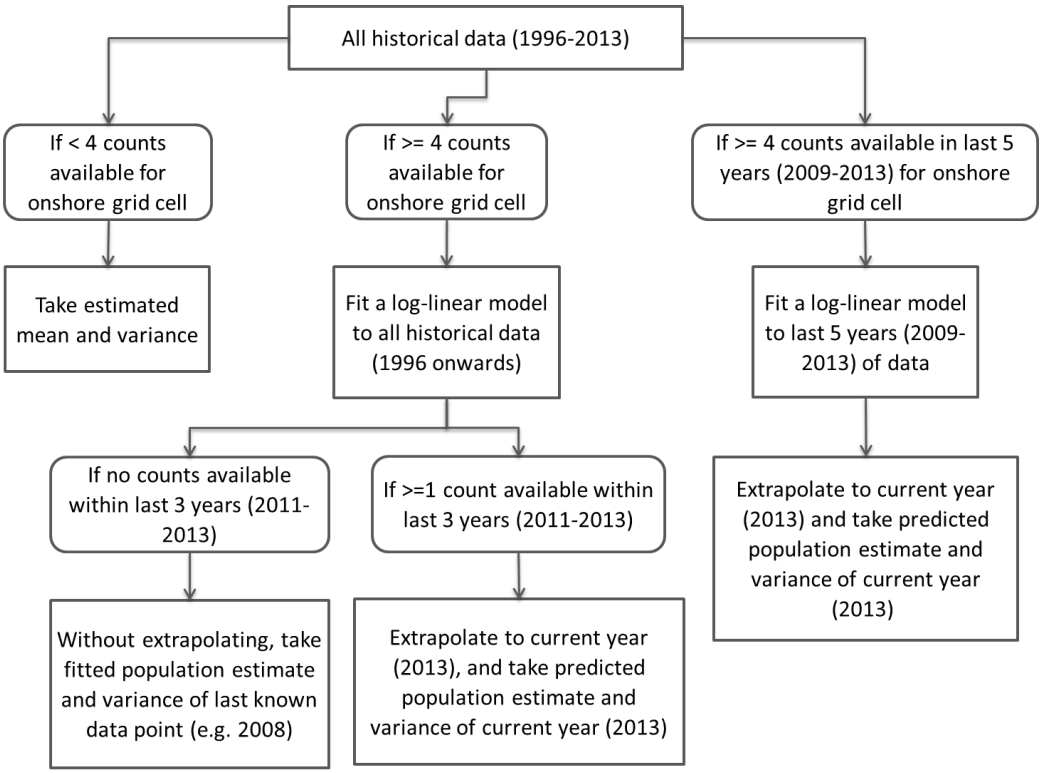

Figure 8. Decision tree used to determine how terrestrial counts from each onshore grid cell are assessed to produce a population estimate. Adapted from Jones *et al.* (2015), Supplementary Figure S4.

3. Interpretation

Using 0 counts can affect population estimates in the usage maps, which were originally based on using non-0 terrestrial counts. Population estimates may increase, decrease, or remain the same. If there are many 0 counts in the count data over a temporal period (e.g. the number of seals at an onshore grid cell fluctuates or decreases over time), then including 0 counts in the count data will decrease the population estimate. A decision tree is used to determine how to produce a population estimate for each onshore grid cell. The population estimate will also change with the inclusion of 0 count data when a recent count is 0; the estimate will be extrapolated to the current year (i.e. 2013), and may be higher or lower than when non-0 count data are used. For the test cases used, variation in the population estimates when using non-0 count and 0 count data ranged from -14.8% to +1.5% over the regions of Orkney and the Western Isles.

When usage maps are used to assess population estimates of seals in a focused area (e.g. for marine renewable development assessments), the results of these tests should be acknowledged. It is important to note that the underlying movement (telemetry) data used in the maps will not be affected. However, the contribution of these data are scaled according to local population estimates (defined by the onshore grid cells), and this scaling can vary according to whether 0 count or non-0 count data are used (see Jones et al., 2015 for scaling methodology).

4. References

Duck, C.D. and Morris, C.D. 2016. Surveys of harbour and grey seals on the south-east (border to Aberlady Bay) and south-west (Sound of Jura to Solway Firth) coasts of Scotland, in Shetland , in the Moray Firth and in the Firth of Tay in August 2015. Scottish Nat. Herit. Comm. Rep. No. 929 pp 36.

Duck, C.D., Morris, C.D. and Thompson, D. 2015. The status of UK harbour seal populations in 2014, including summer counts of grey seals. Spec. Commitee Seals BP 15/04, 92–118.

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