Section S1. Species taxonomy, breeding and foraging ecology

Table S1. Species taxonomy, breeding and foraging ecology. Species-specific breeding seasons and foraging ranges after (Campbell & Ferguson-Lees 1972) and (Woodward et al. 2019). * breeding season for Mediterranean gull as for black-headed gull (see Methods). † seabird foraging range from Thaxter et al. (2012) instead (see Methods).

Common name	Scientific name	Family	Breeding season	Foraging range (km)	Feeding ecology	Habitat specialism
Fulmar	*Fulmarus glacialis*	Procellariidae	May-Sep	542.3	Surface feeding	Marine specialist
Manx shearwater	*Puffinus puffinus*	Procellariidae	May-Oct	1346.8	Diving	Marine specialist
Leach's storm-petrel	*Oceanodroma leucorhoa*	Hydrobatidae	May-Oct	91.7†	Surface feeding	Marine specialist
Storm-petrel	*Hydrobates pelagicus*	Hydrobatidae	May-Oct	336.0	Surface feeding	Marine specialist
Gannet	*Morus bassanus*	Sulidae	Apr-Oct	315.2	Diving	Marine specialist
Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	Mar-Sep	25.6	Diving	Generalist
Shag	*Gulosus aristotelis*	Phalacrocoracidae	Jan-Oct	13.2	Diving	Marine specialist
Arctic skua	*Stercorarius parasiticus*	Stercorariidae	May-Aug	62.5†	Surface feeding	Marine specialist
Great skua	*Stercorarius skua*	Stercorariidae	May-Sep	443.3	Surface feeding	Marine specialist
Black-headed gull	*Chroicocephalus ridibundus*	Laridae	Apr-Sep	18.5	Surface feeding	Generalist
Common gull	*Larus canus*	Laridae	Apr-Aug	50.0	Surface feeding	Generalist
Great black-backed gull	*Larus marinus*	Laridae	Apr-Aug	73.0	Surface feeding	Generalist
Herring gull	*Larus argentatus*	Laridae	Apr-Aug	58.8	Surface feeding	Generalist
Kittiwake	*Rissa tridactyla*	Laridae	May-Sep	156.1	Surface feeding	Marine specialist
Lesser black-backed gull	*Larus fuscus*	Laridae	Apr-Sep	127.0	Surface feeding	Generalist
Mediterranean gull	*Ichthyaetus melanocephalus*	Laridae	Apr-Sep*	20.0	Surface feeding	Generalist
Arctic tern	*Sterna paradisaea*	Laridae	May-Aug	25.7	Surface feeding	Marine specialist

Common tern	*Sterna hirundo*	Laridae	May-Sep	18.0	Surface feeding	Generalist
Little tern	*Sternula albifrons*	Laridae	May-Sep	5.0	Surface feeding	Marine specialist
Roseate tern	*Sterna dougallii*	Laridae	June-Aug	12.6	Surface feeding	Marine specialist
Sandwich tern	*Thalasseus sandvicensis*	Laridae	Apr-Sep	34.3	Surface feeding	Marine specialist
Black guillemot	*Cepphus grylle*	Alcidae	May-Sep	4.8	Diving	Marine specialist
Guillemot	*Uria aalge*	Alcidae	Apr-Aug	73.2	Diving	Marine specialist
Puffin	*Fratercula arctica*	Alcidae	Apr-Sep	137.1	Diving	Marine specialist
Razorbill	*Alca torda*	Alcidae	Apr-Aug	88.7	Diving	Marine specialist

Section S2. Cropping of potential energy anomaly data

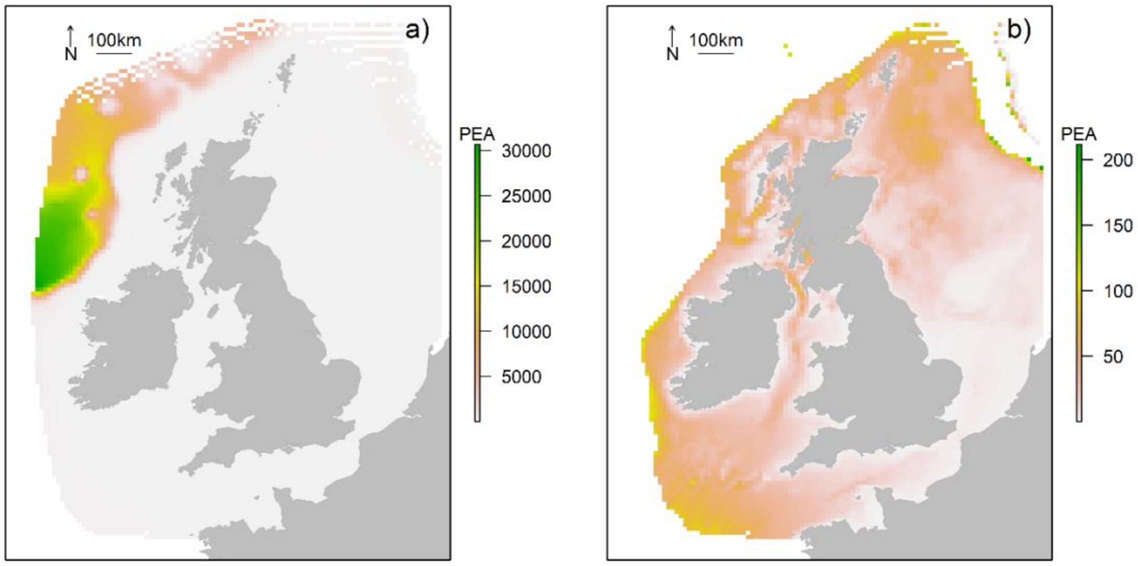

Figure S1. Example potential energy anomaly surfaces (Scottish Shelf Model data aggregated to 12 km grid; January, 1990-2014) a) before and b) after cropping to continental margin (see 2.4).

Section S3. Specifications of spatial random effect

The spatial random effect (here, a Gaussian random field) with Matérn spatial covariance structure was approximated using the SPDE approach (Lindgren et al. 2011, Bakka et al. 2018). This approach makes a simplified representation of a continuous Gaussian random field in terms of a number of linear basis functions. For this approach, a two-dimensional mesh must be specified in order to define the basis functions. The mesh was defined according to the geographical locations of the data-contributing cells. The coordinates of these locations were transformed to a projected coordinate reference system (WGS84 / UTM 30N) so that the scale was the same for both dimensions. The parameters of the mesh were defined in such a way that: the inner portion of the mesh included all of the census points for that species; the inner portion of the mesh was covered by regular small triangles (but not too small that model runtime was unacceptably high); and a large buffer was left outside the inner portion in order to avoid boundary effects in the spatial random field within the area of interest. Once the mesh had been created, a projector matrix was then specified to link the spatial random effect to the locations of the observed data.

Section S4. Results for data-poor species with unusual model behaviour

For the four data-poor species with unusual model behaviour, presence/absence was predicted by the model with good or excellent accuracy (Table S3), with AUC values from 0.794 (Sandwich tern) to 0.984 (Arctic skua). Abundance was predicted with very poor to moderate accuracy, with R^2 values from 0.003 (storm-petrel) to 0.097 (Arctic skua).

Table S2. Model fit. Median AUC (presence/absence component) and R^2 (abundance component) from 20 iterations of model.

Species	AUC	R^2
Storm-petrel	0.926	0.003
Arctic skua	0.984	0.097
Little tern	0.908	0.014
Sandwich tern	0.794	0.011

All four of the data-poor species (storm-petrel, Arctic skua, little tern and Sandwich tern) are predicted to decline by more than 50% (Table S4). Storm-petrel is predicted to decline by more than 80%, and Arctic skua is predicted to decline to extinction. Arctic skua was the only species of all 19 modelled for which the 95% credible interval for future abundance did not overlap with current abundance.

Table S3. Projected future abundance and presence change for 19 seabird species under climate change.

Species	Seabird 2000 total count (GB&I)	Predicted GB&I population size, 2050 (median and 95% CI)	Predicted abundance change (median %, GB&I)	Predicted presence probability change for unoccupied cells (median %, GB&I)
Storm-petrel	82818	14799 (20 – 27142284)	-82.1	-25.8
Arctic skua	2136	0 (0 - 0)	-100.0	-100.0
Little tern	2093	995 (38 – 26521)	-52.5	-69.8
Sandwich tern	13977	4300 (41 – 4413284)	-69.2	-33.5

Section S5. Indicators of poor model fit

Table S4. Indicators of poor model fit: A, extreme parameter values; B, extreme absolute projections; C, predicted median presence change in cells occupied at Seabird 2000 has absolute value >5% and is of opposite sign to that of predicted abundance change; D, poor or very poor R^2; E, overprediction at low observed abundances.

Species	A	B	C	D	E	Sum	Model fit
Fulmar	0	0	0	0	1	1	Better
Storm-petrel	1	1	0	1	1	4	Omitted from main text
Cormorant	0	0	1	1	0	2	Poorer
Shag	0	0	0	1	1	2	Poorer
Arctic skua	1	1	0	0	0	2	Omitted from main text
Black-headed gull	0	0	1	1	0	2	Poorer
Common gull	0	0	0	0	0	0	Better
Great black-backed gull	0	0	0	0	1	1	Better
Herring gull	0	0	0	1	0	1	Poorer
Kittiwake	0	0	0	1	1	2	Poorer
Lesser black-backed gull	0	0	0	1	1	2	Poorer
Arctic tern	0	0	0	0	1	1	Better
Common tern	0	0	0	0	1	1	Better
Little tern	0	1	0	1	0	2	Omitted from main text
Sandwich tern	1	1	0	1	0	3	Omitted from main text
Black guillemot	0	0	0	0	1	1	Better

Guillemot	0	0	0	1	0	1	Poorer
Puffin	0	0	0	0	1	1	Better
Razorbill	0	0	0	1	0	1	Poorer

Section S6. By-species maps of projected abundance change

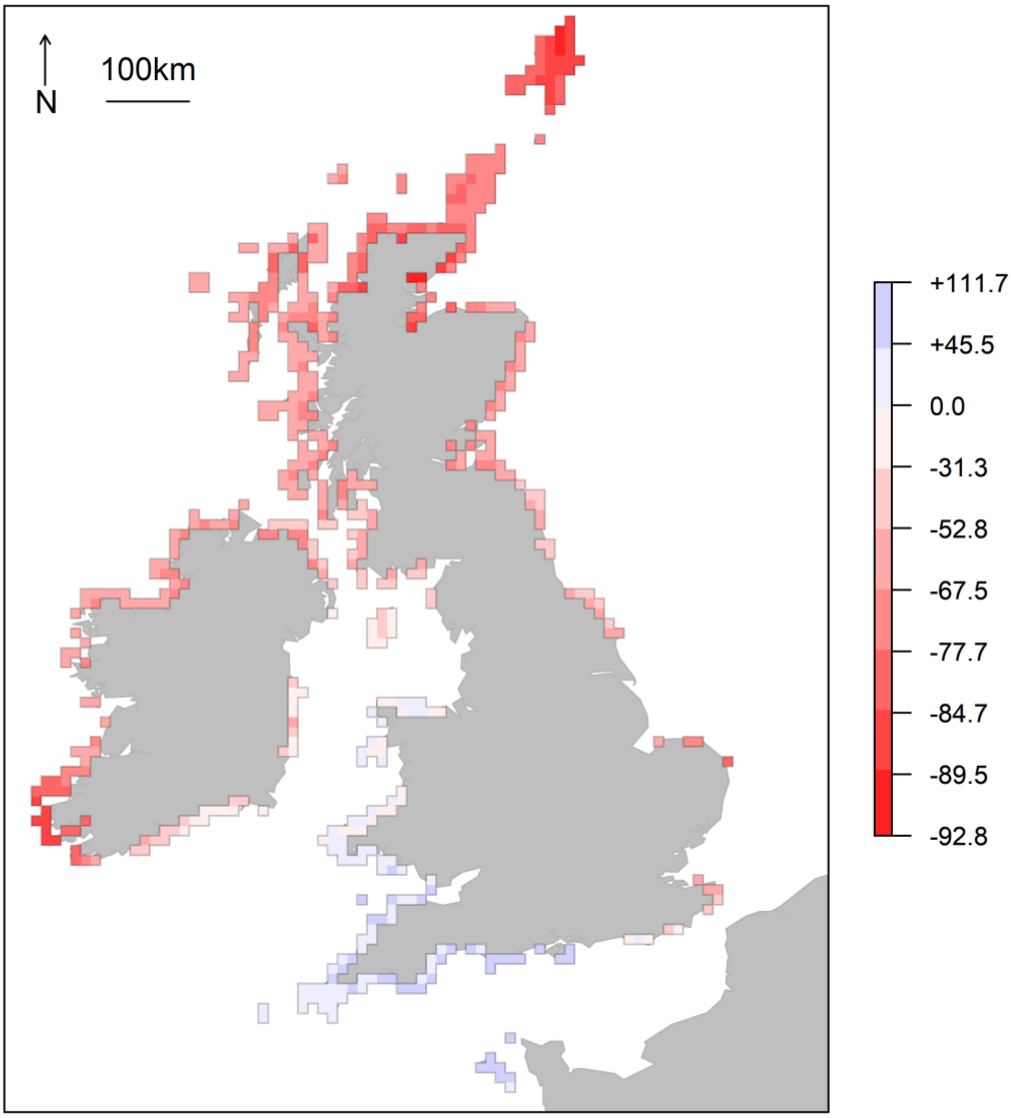

Figure S2. Projected % change (1998-2002 to 2050) in fulmar breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of higher confidence for this species (see 3.1).

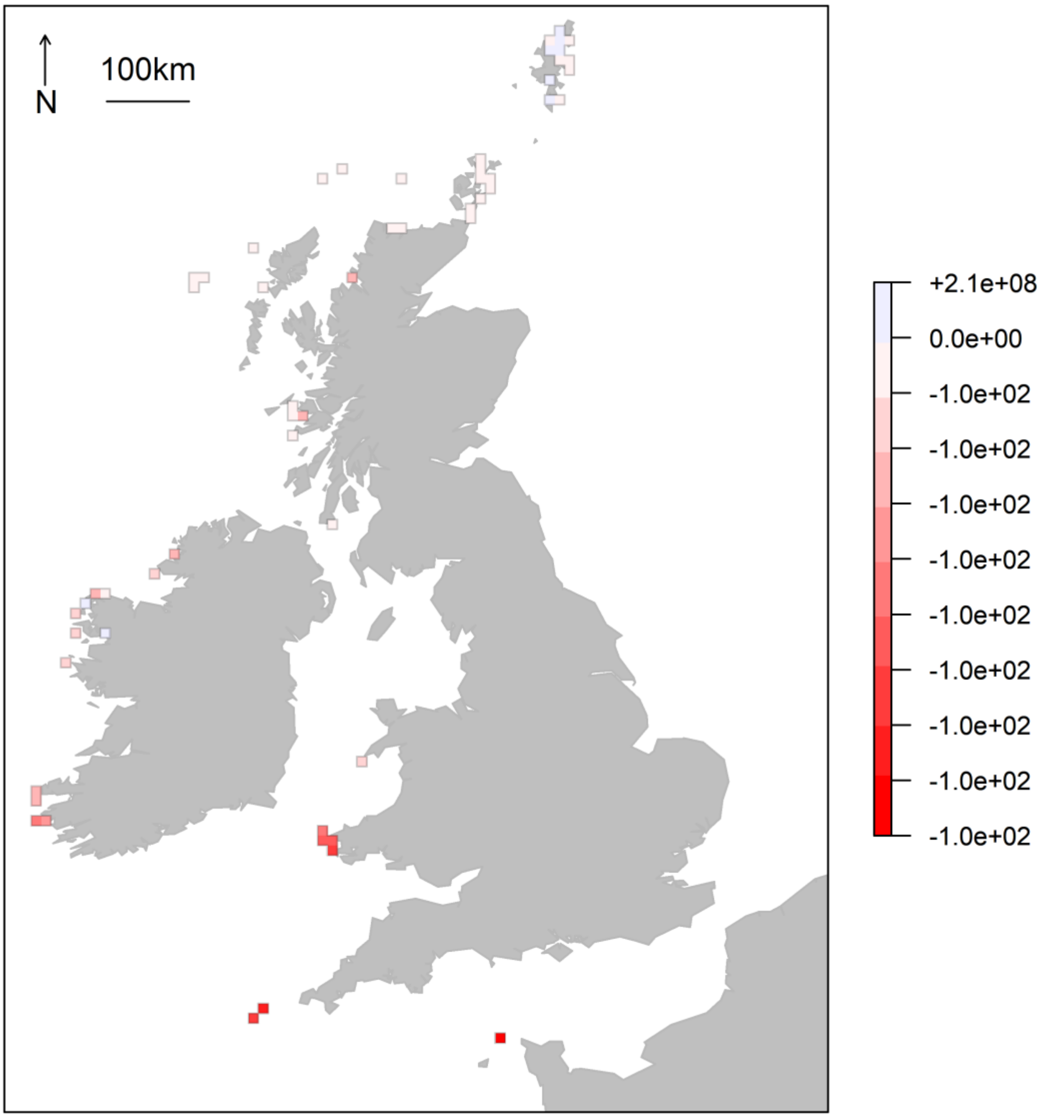

Figure S3. Projected % change (1998-2002 to 2050) in storm-petrel breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. NB this data-poor species is not included in composite Figure 1a.

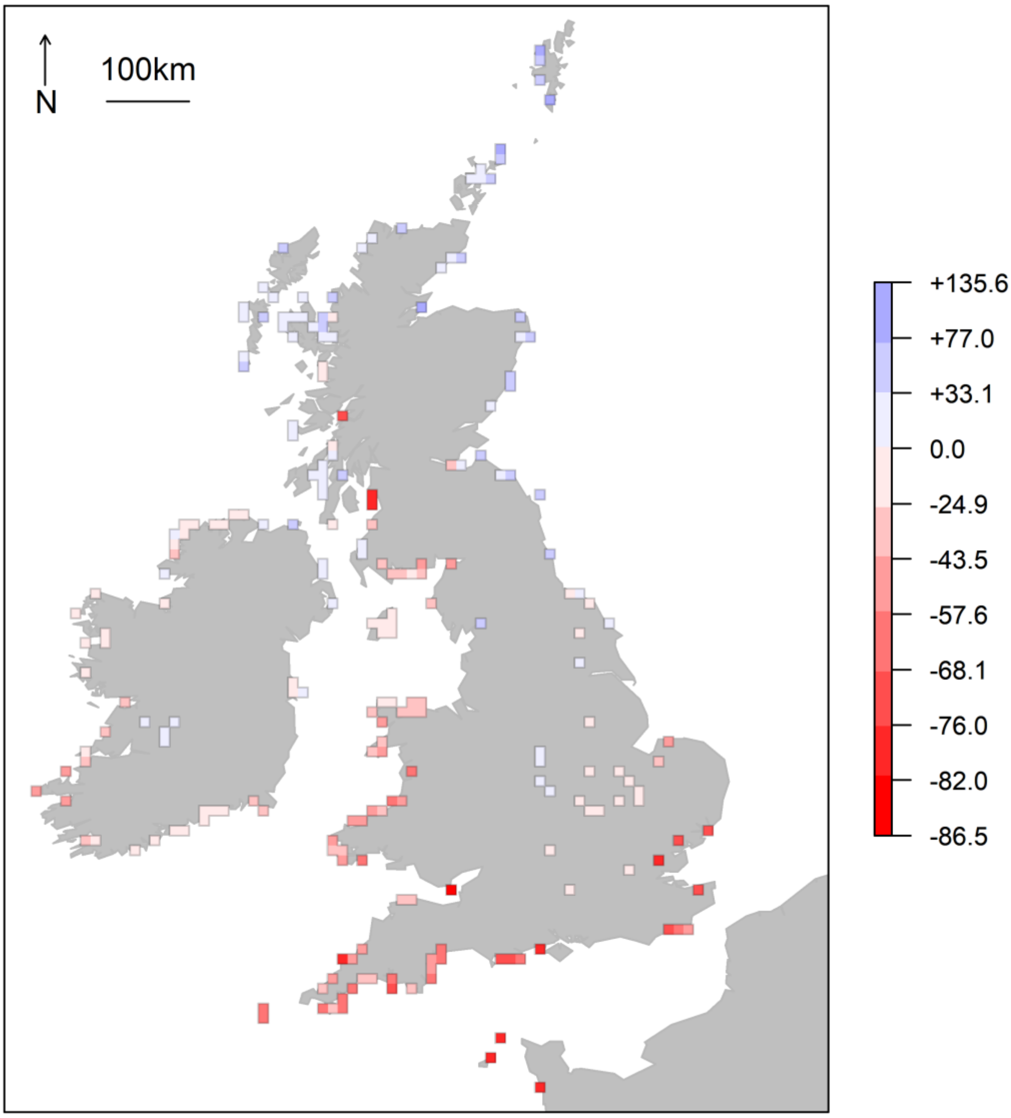

Figure S4. Projected % change (1998-2002 to 2050) in cormorant breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of lower confidence for this species (see 3.1).

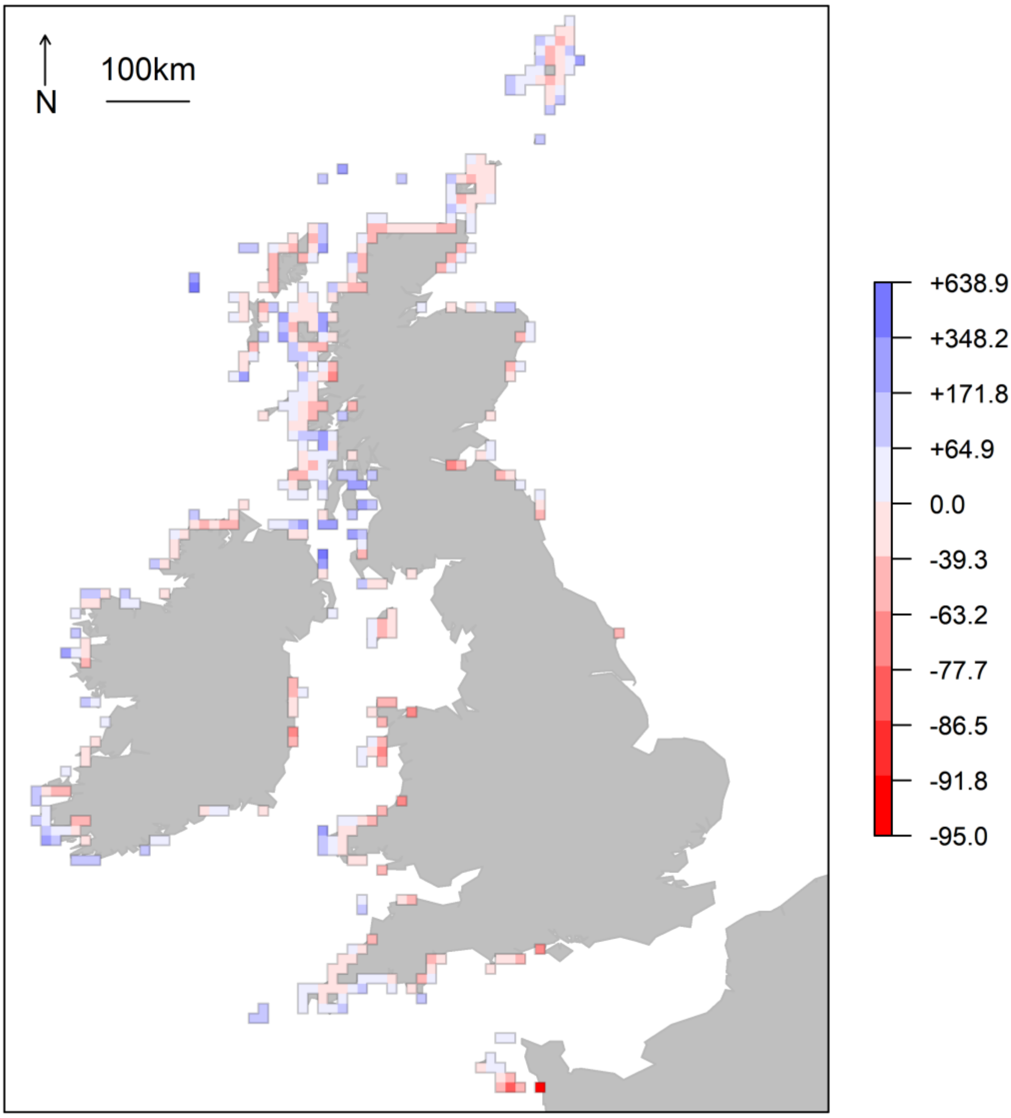

Figure S5. Projected % change (1998-2002 to 2050) in shag breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of lower confidence for this species (see 3.1).

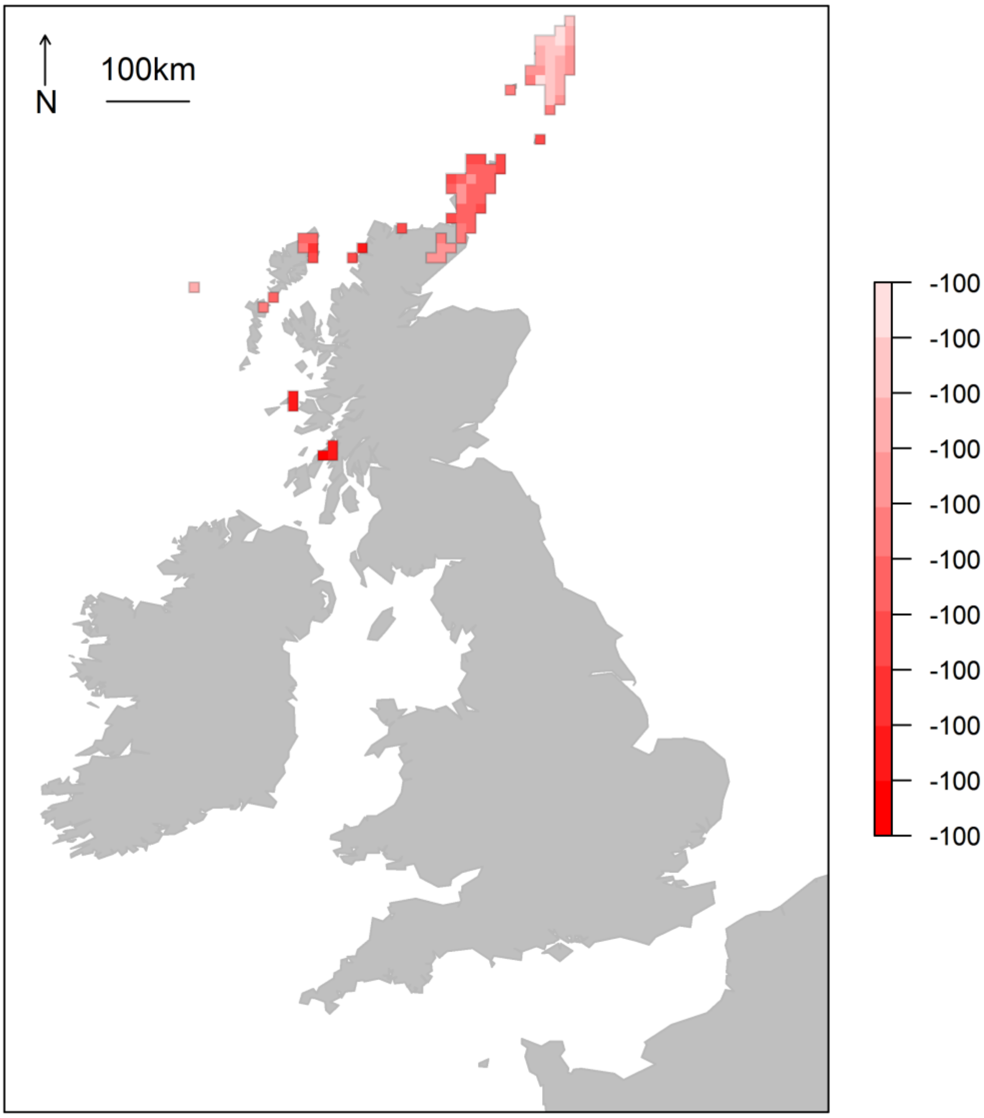

Figure S6. Projected % change (1998-2002 to 2050) in Arctic skua breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. NB this data-poor species is not included in composite Figure 1a.

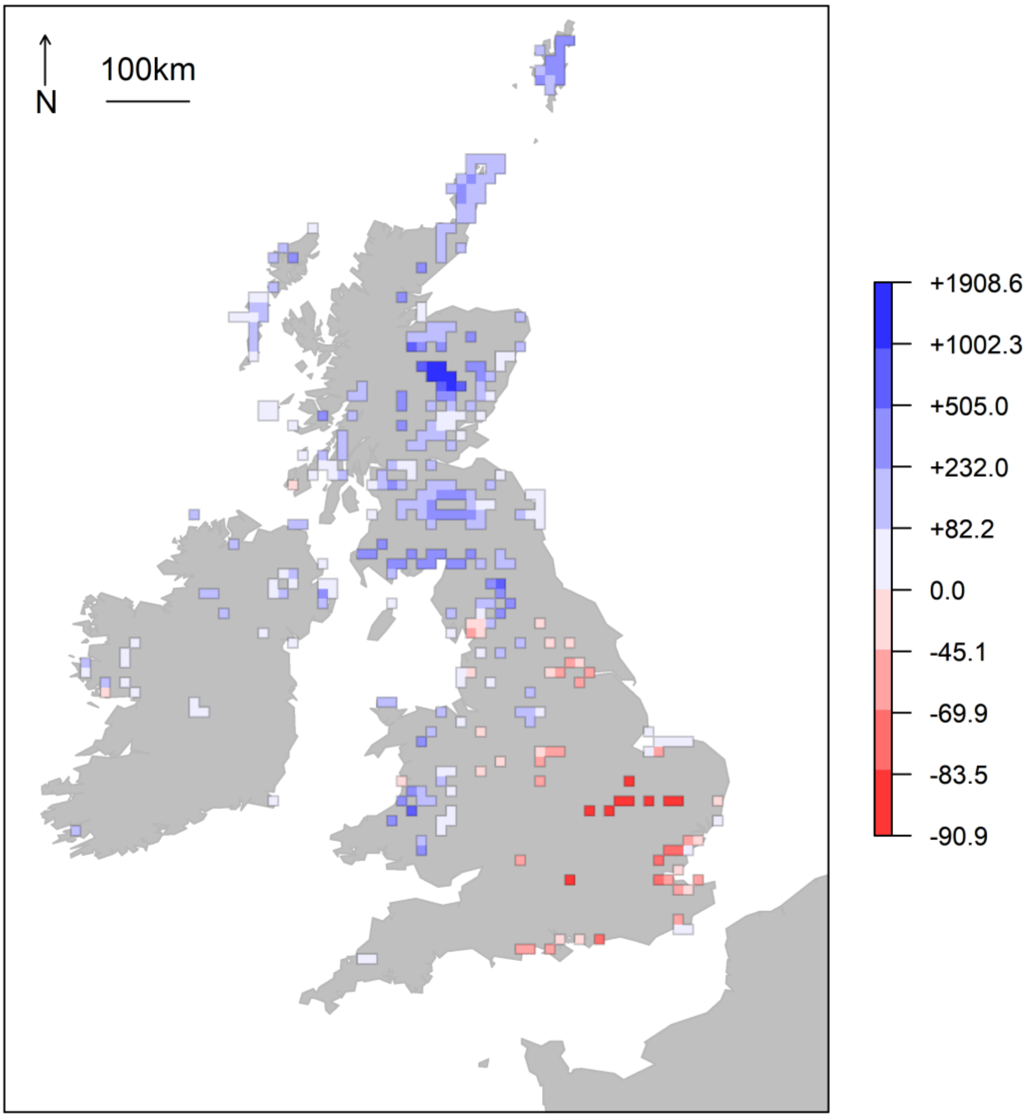

Figure S7. Projected % change (1998-2002 to 2050) in black-headed gull breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of lower confidence for this species (see 3.1).

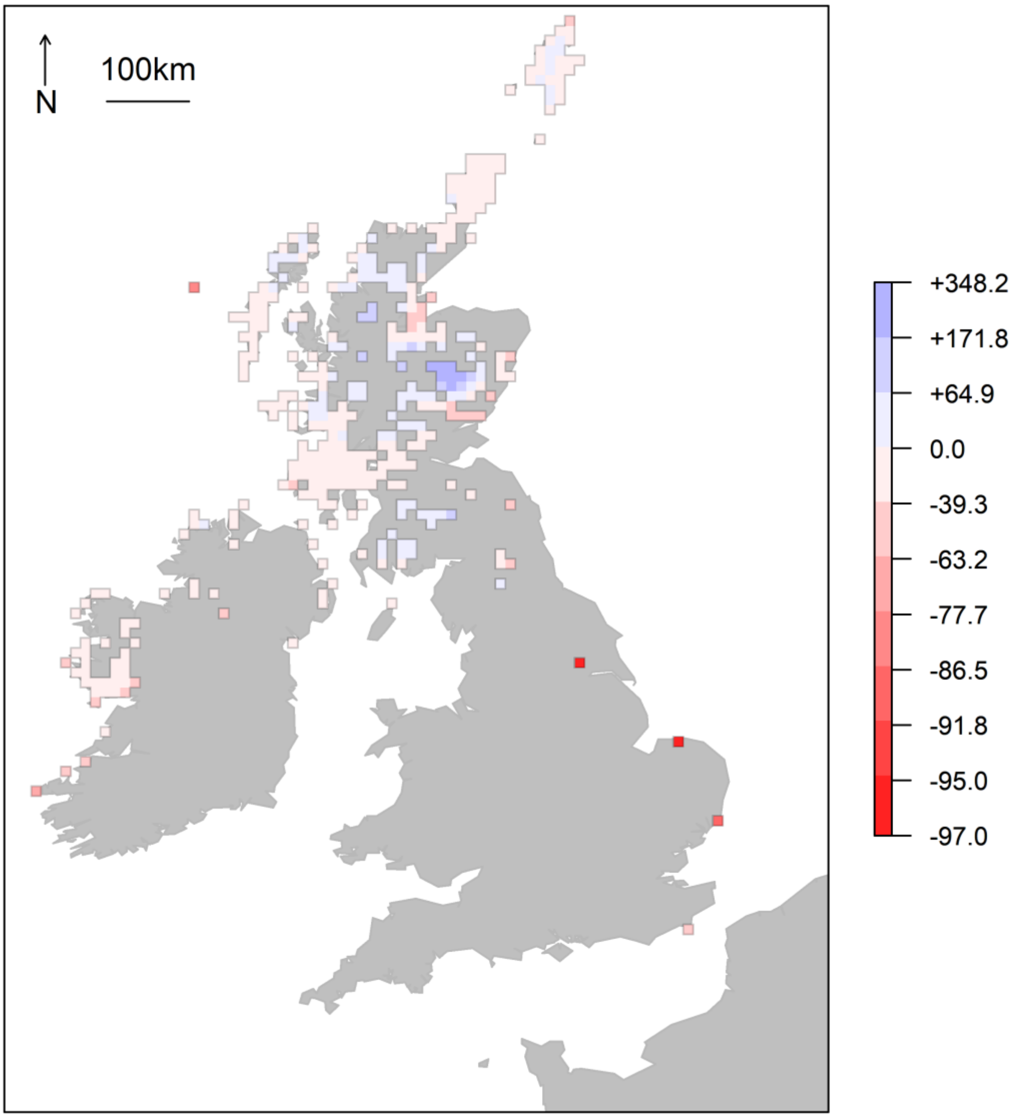

Figure S8. Projected % change (1998-2002 to 2050) in common gull breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of intermediate confidence for this species (see 3.1).

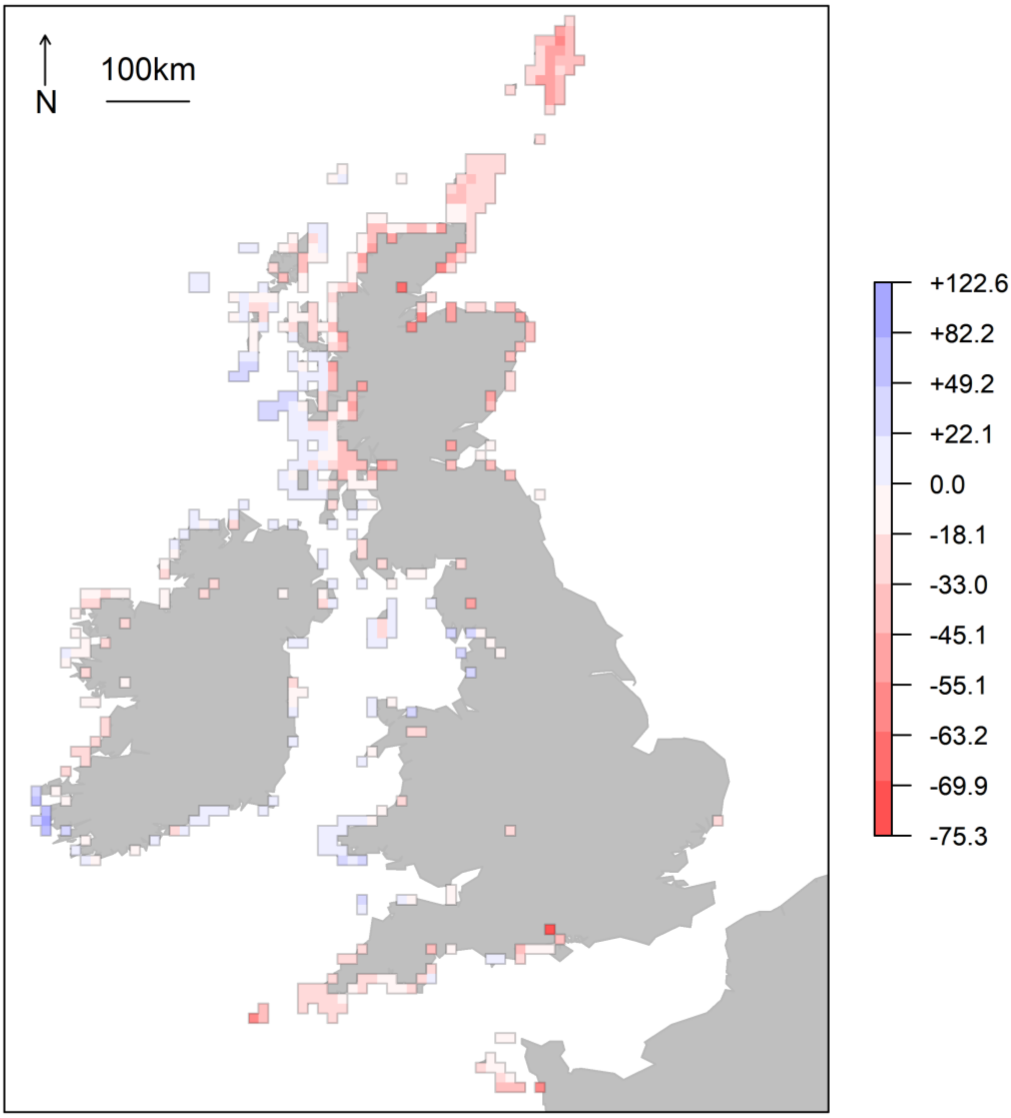

Figure S9. Projected % change (1998-2002 to 2050) in great black-backed gull breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of intermediate confidence for this species (see 3.1).

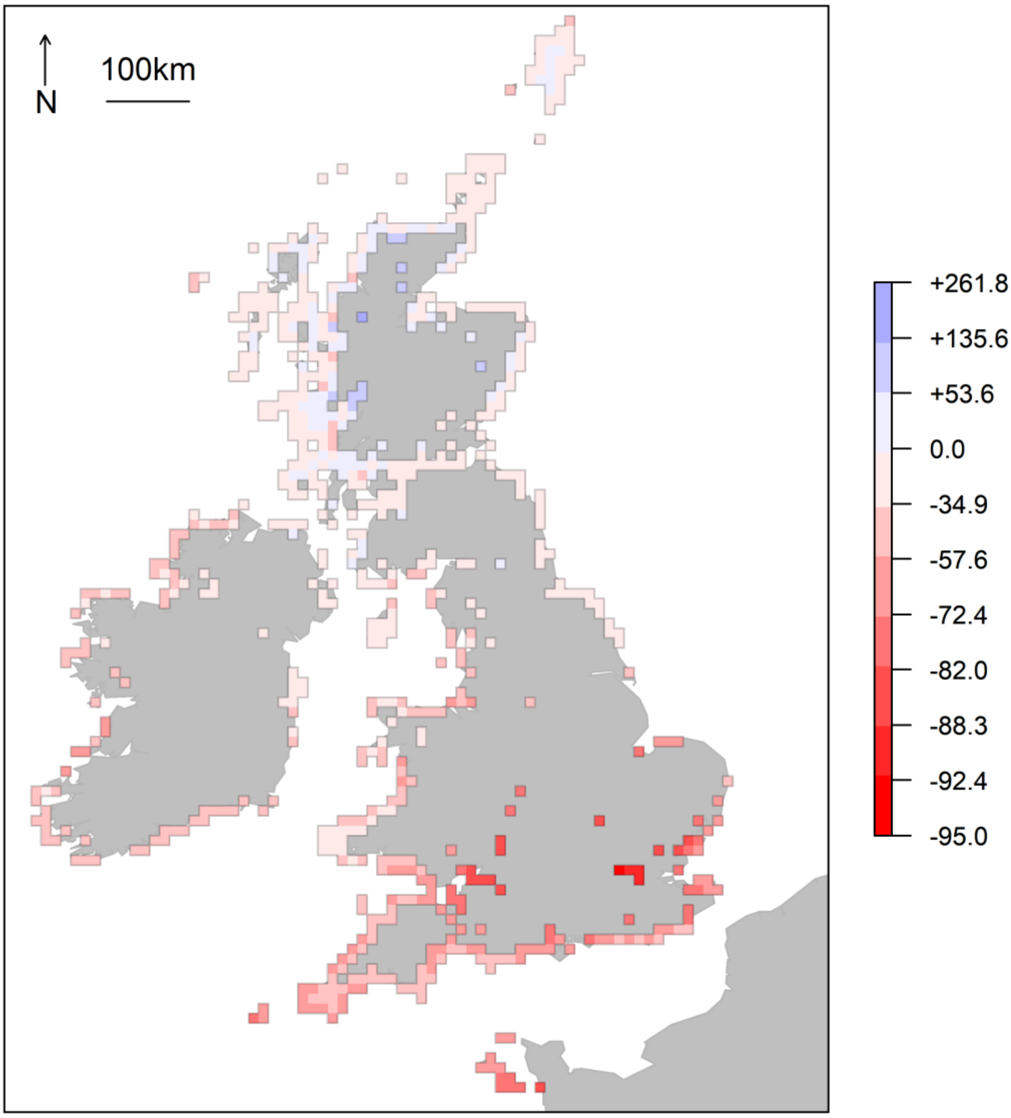

Figure S10. Projected % change (1998-2002 to 2050) in herring gull breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of lower confidence for this species (see 3.1).

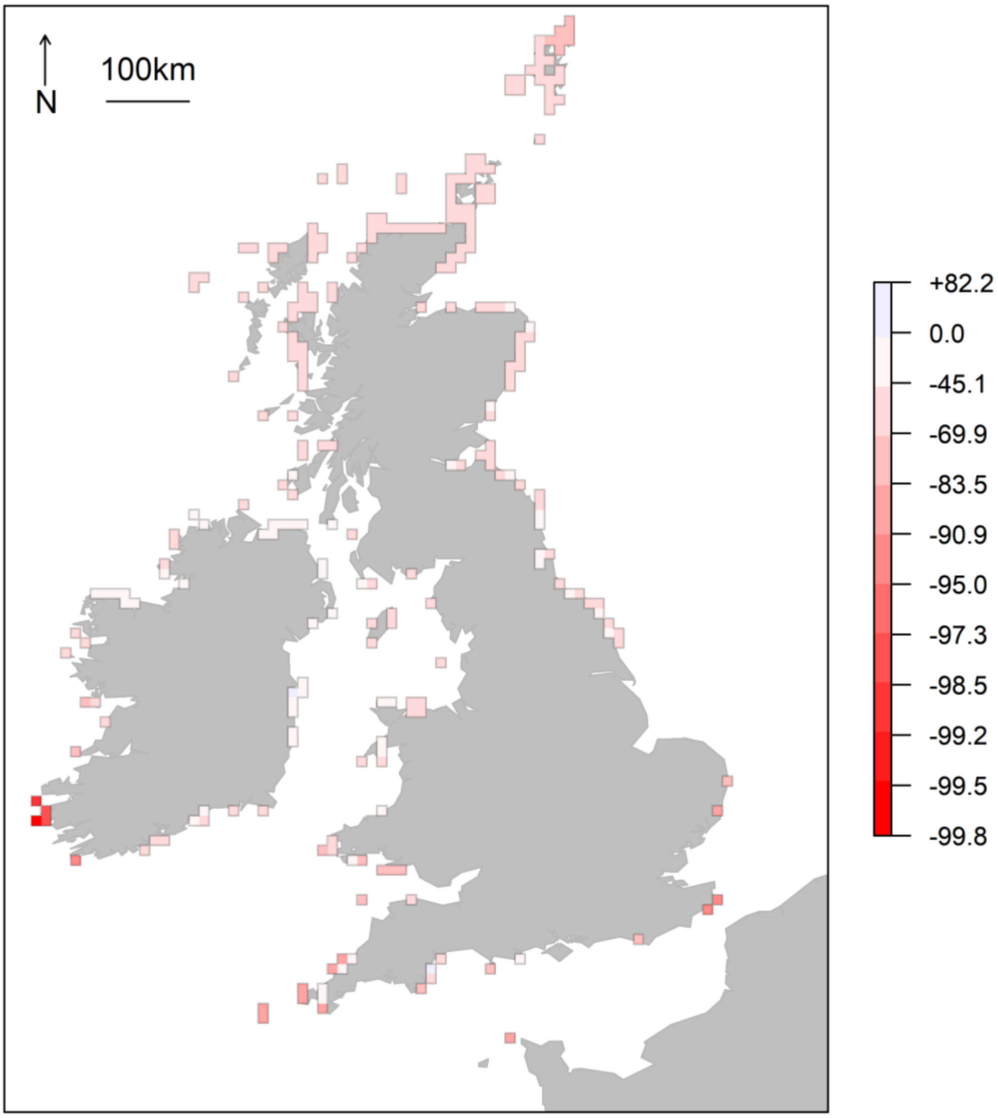

Figure S11. Projected % change (1998-2002 to 2050) in kittiwake breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of intermediate confidence for this species (see 3.1).

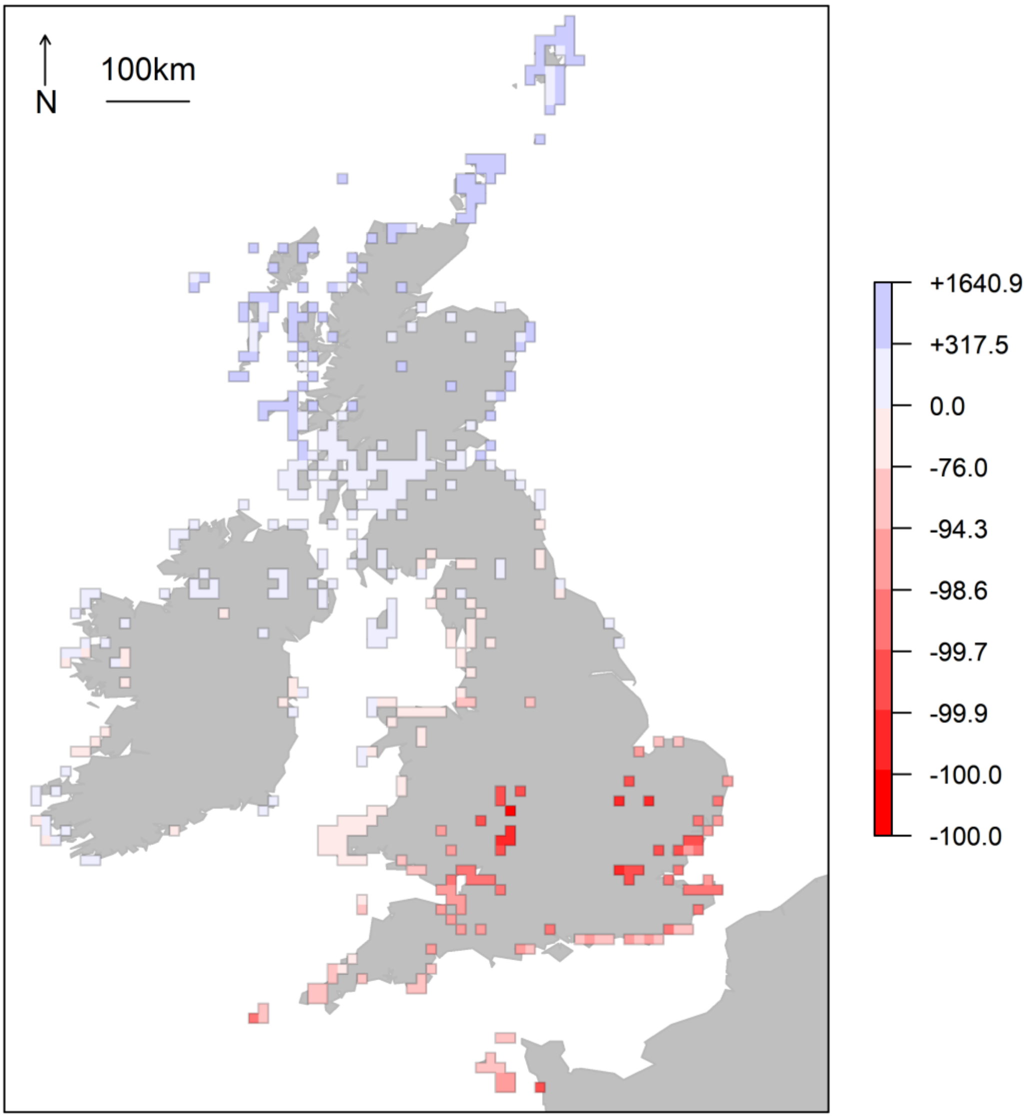

Figure S12. Projected % change (1998-2002 to 2050) in lesser black-backed gull breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of lower confidence for this species (see 3.1).

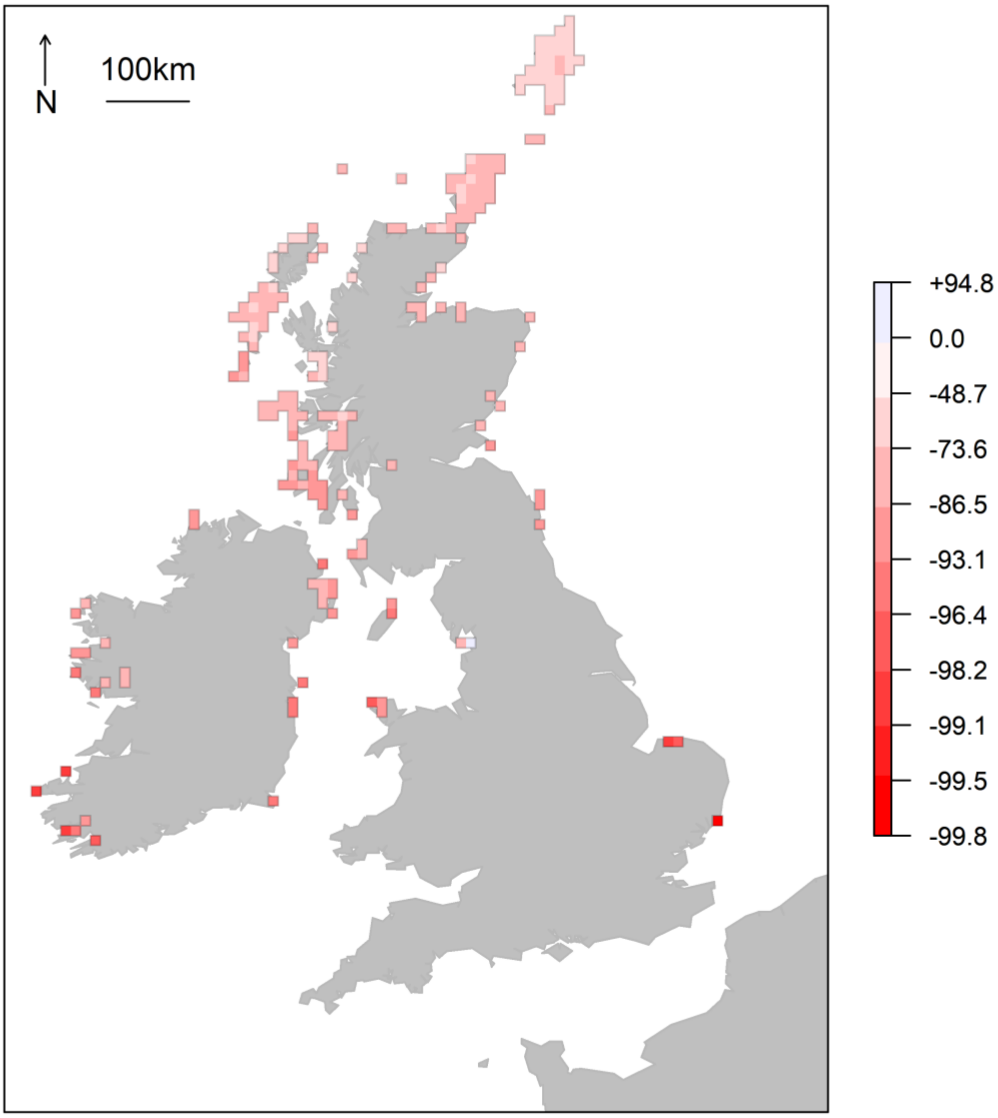

Figure S13. Projected % change (1998-2002 to 2050) in Arctic tern breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of higher confidence for this species (see 3.1).

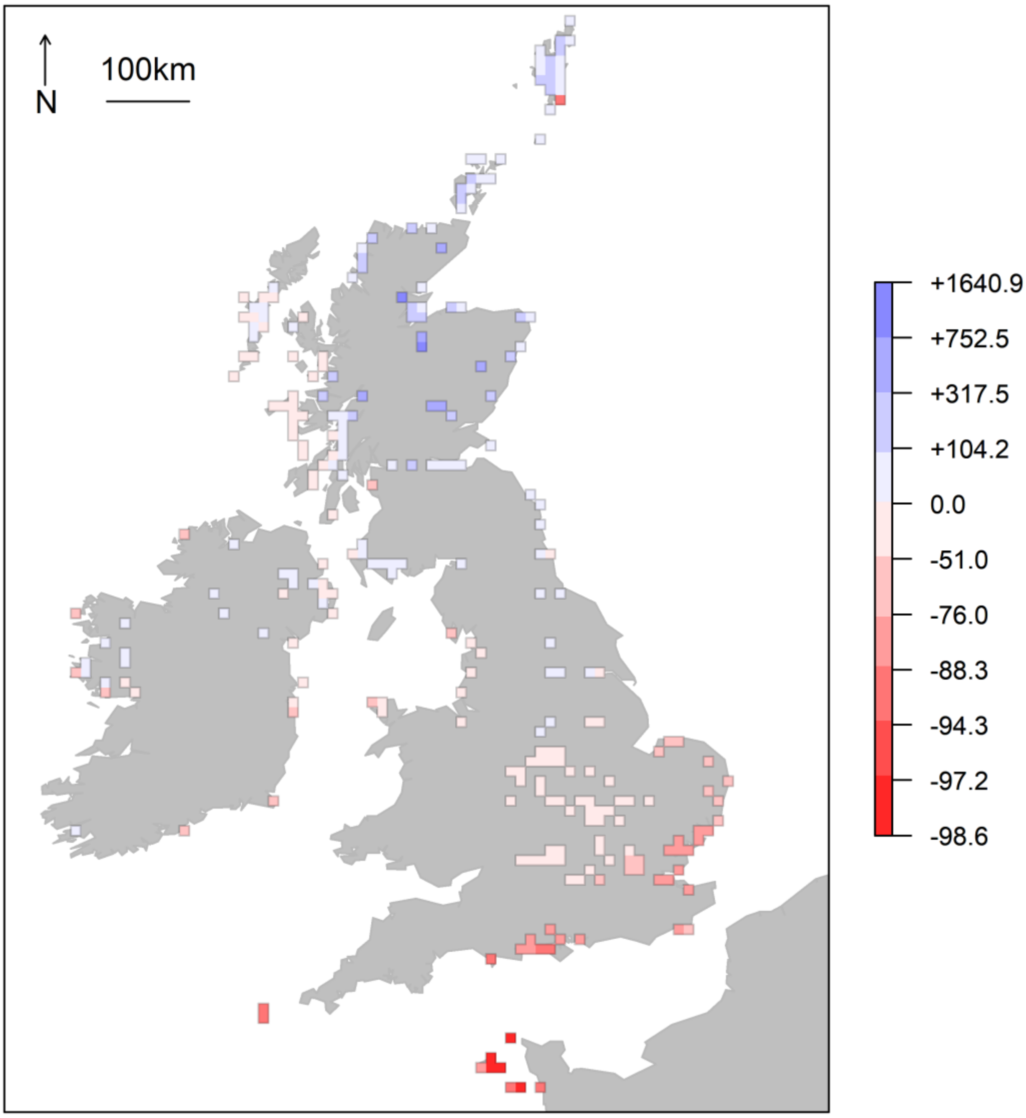

Figure S14. Projected % change (1998-2002 to 2050) in common tern breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of intermediate confidence for this species (see 3.1).

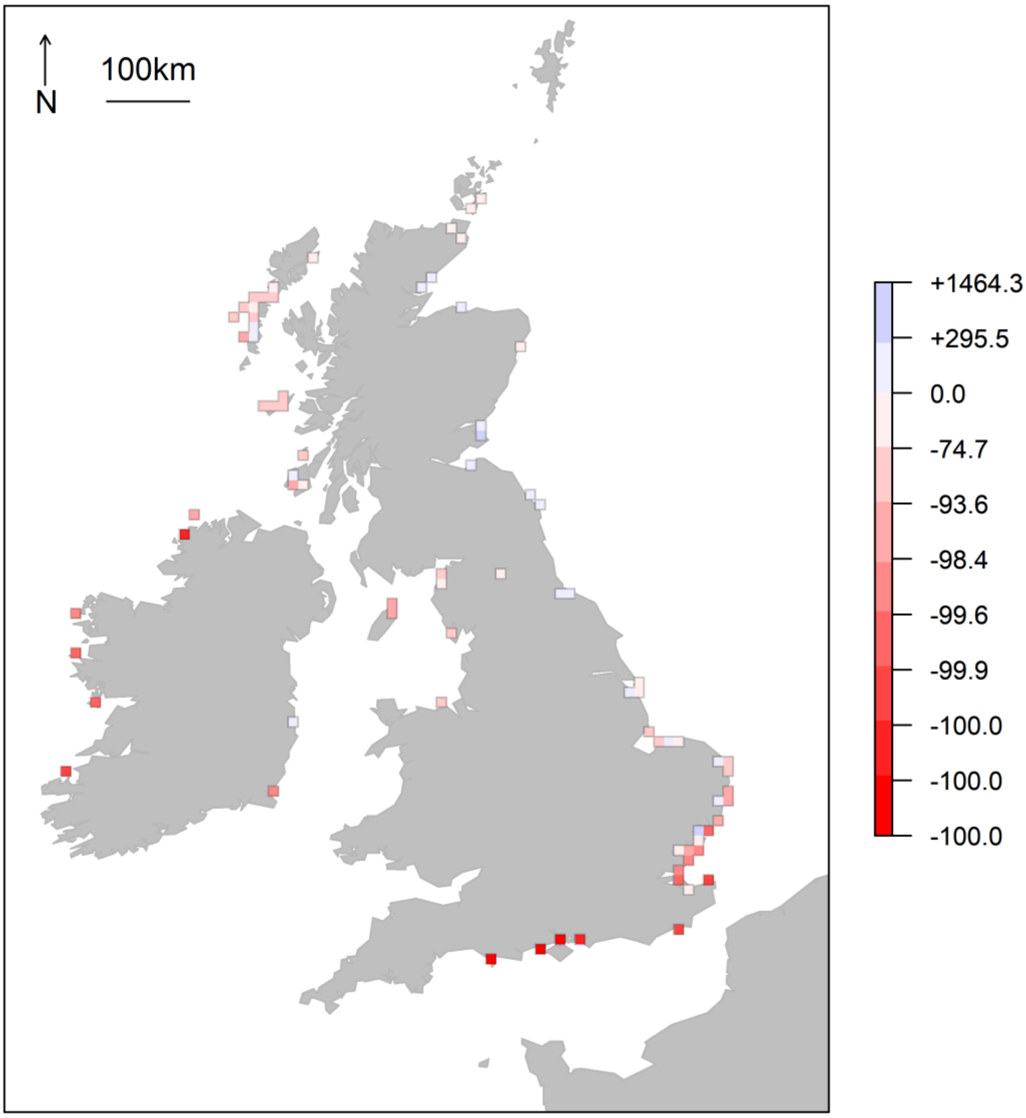

Figure S15. Projected % change (1998-2002 to 2050) in little tern breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. NB this data-poor species is not included in composite Figure 1a or 1c.

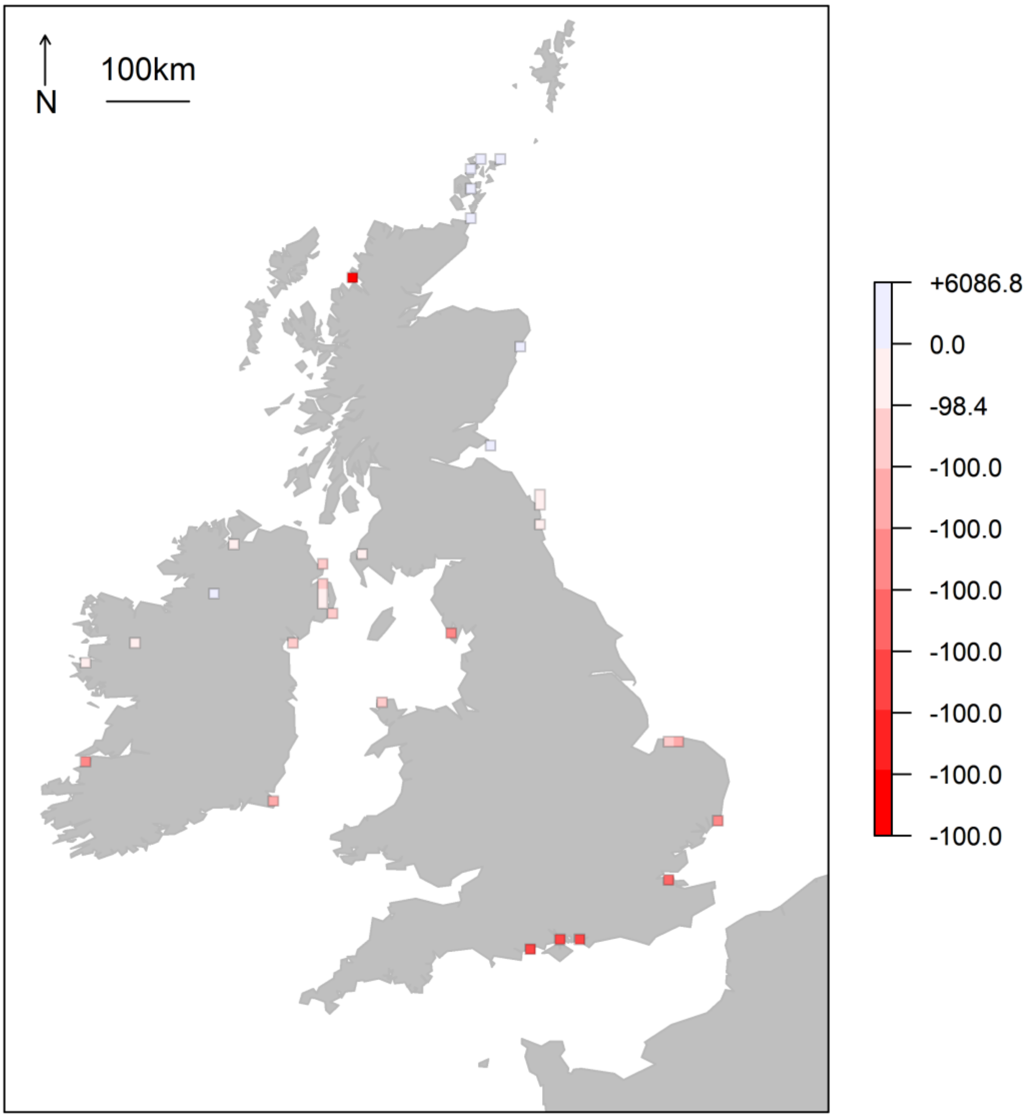

Figure S16. Projected % change (1998-2002 to 2050) in Sandwich tern breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. NB this data-poor species is not included in composite Figure 1a or 1c.

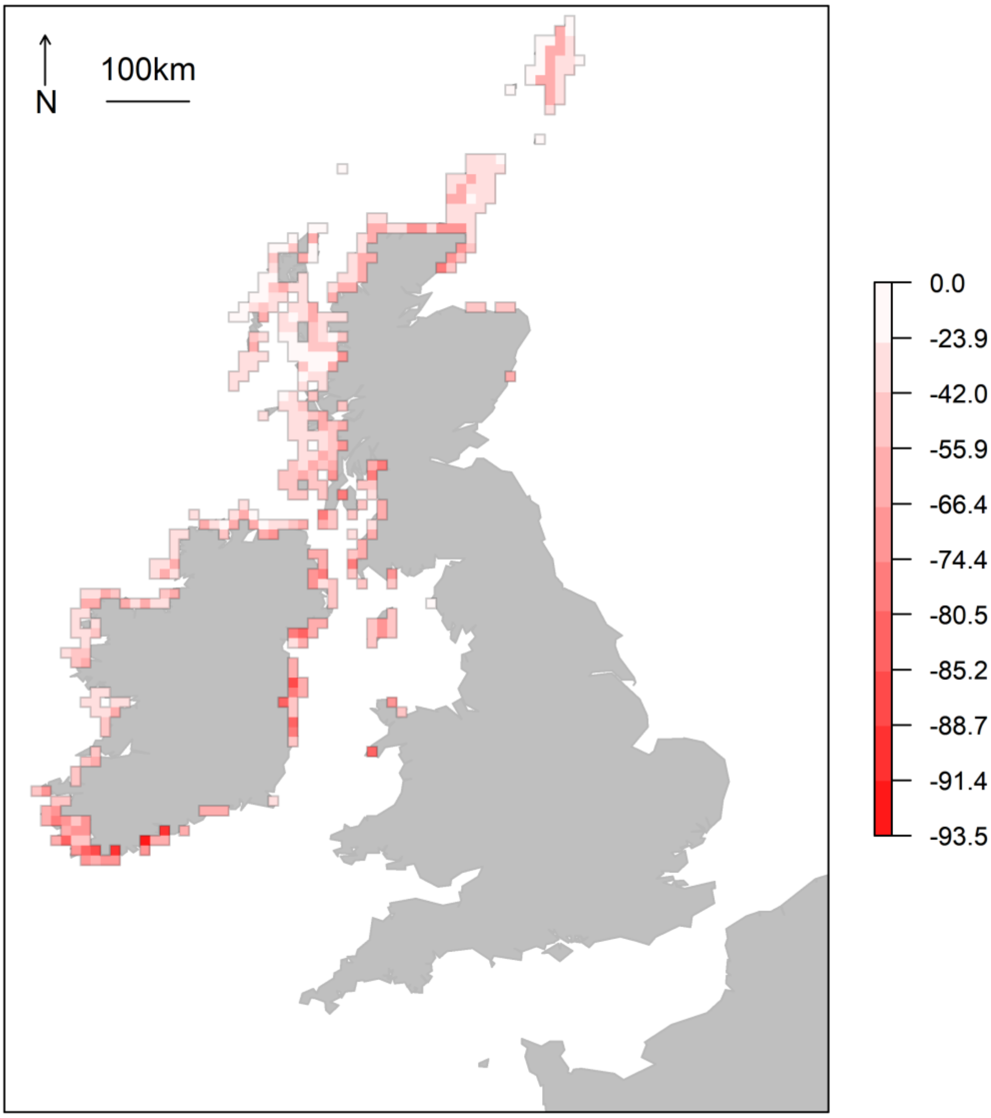

Figure S17. Projected % change (1998-2002 to 2050) in black guillemot breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of higher confidence for this species (see 3.1).

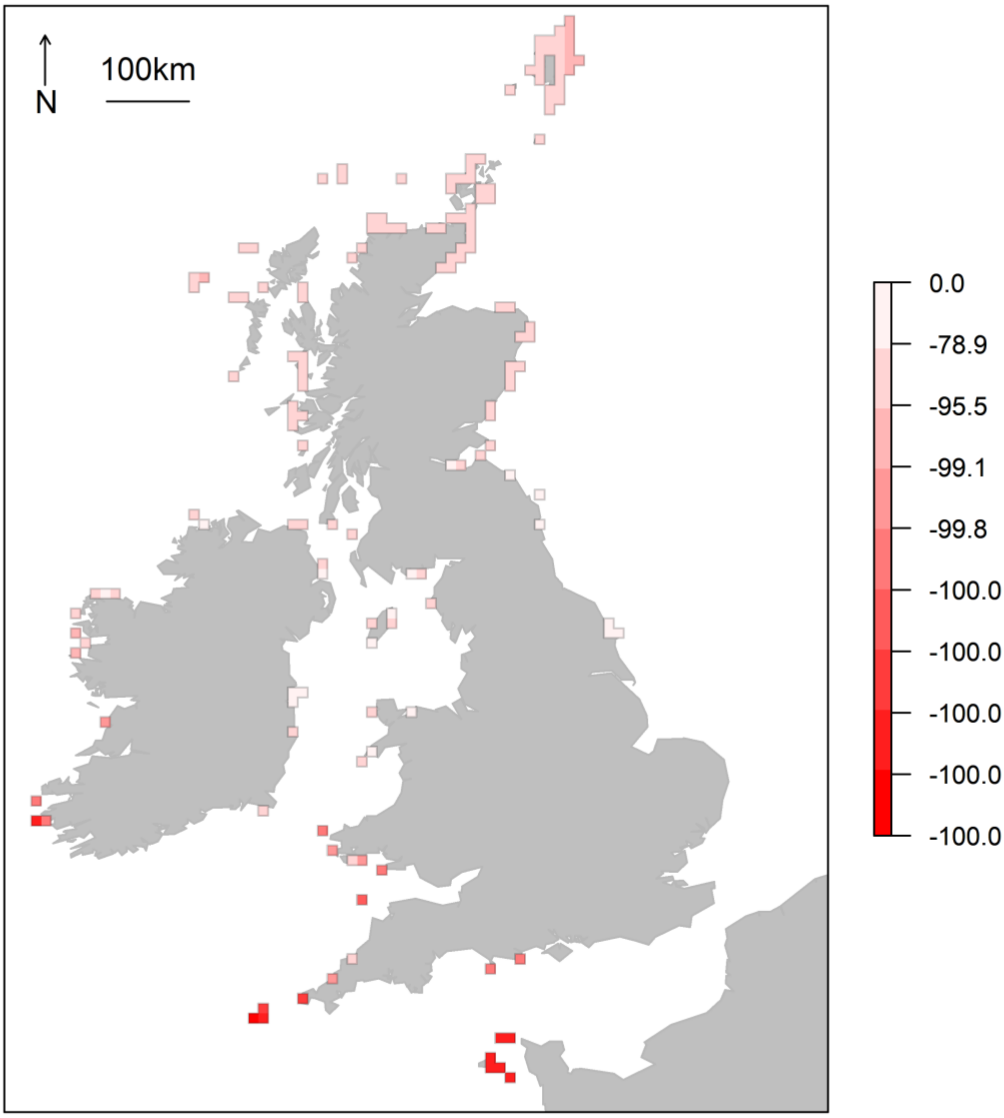

Figure S18. Projected % change (1998-2002 to 2050) in puffin breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of higher confidence for this species (see 3.1).

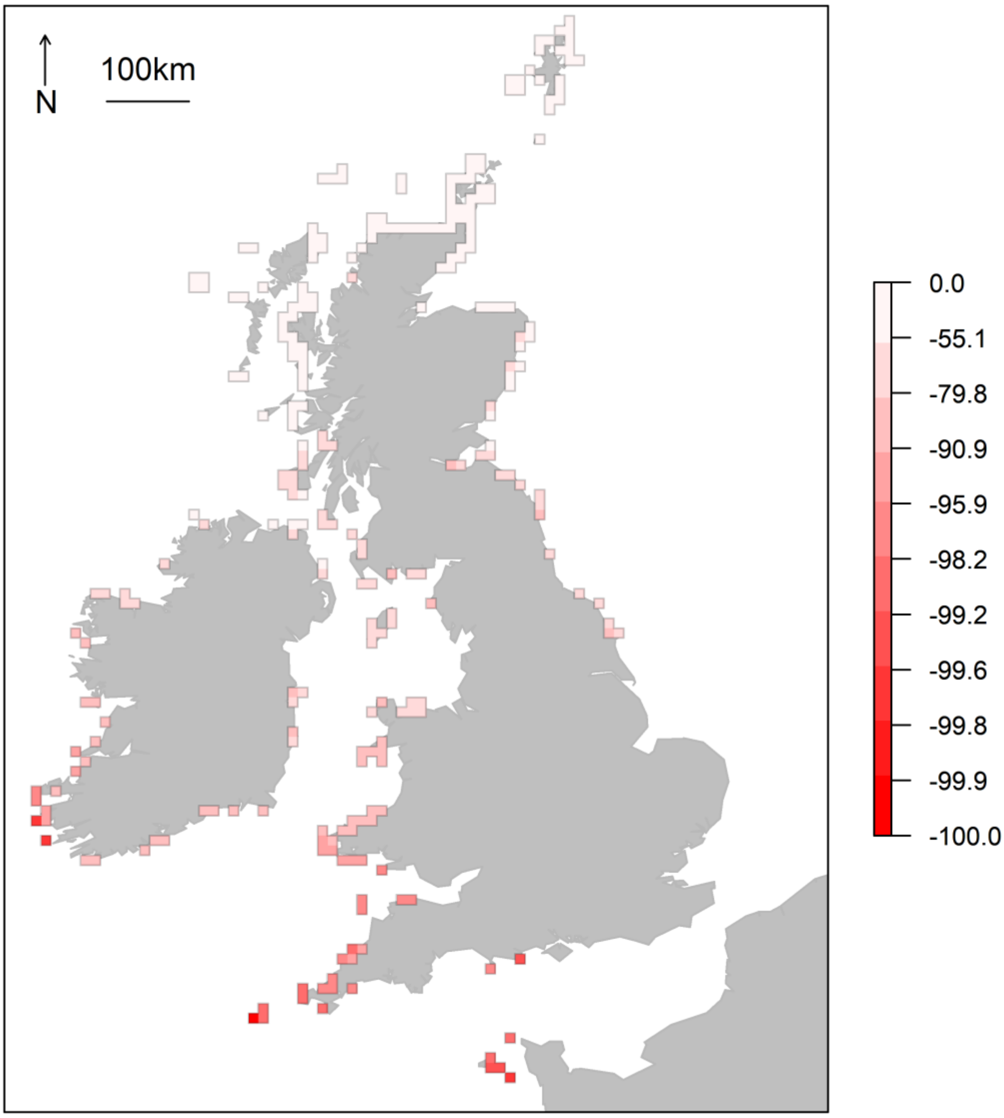

Figure S19. Projected % change (1998-2002 to 2050) in razorbill breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of intermediate confidence for this species (see 3.1).

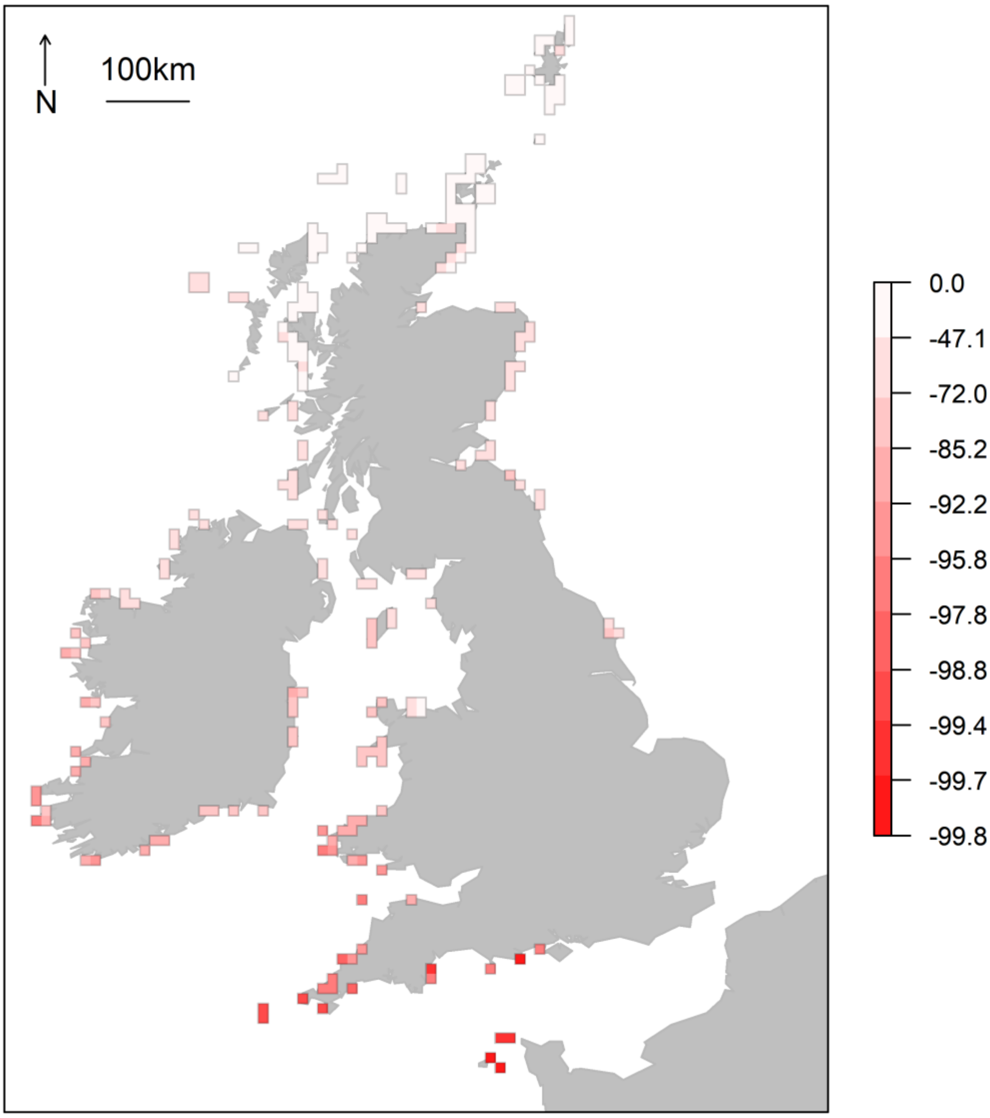

Figure S20. Projected % change (1998-2002 to 2050) in guillemot breeding pairs in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease. The overall population projections were categorised to be of intermediate confidence for this species (see 3.1).

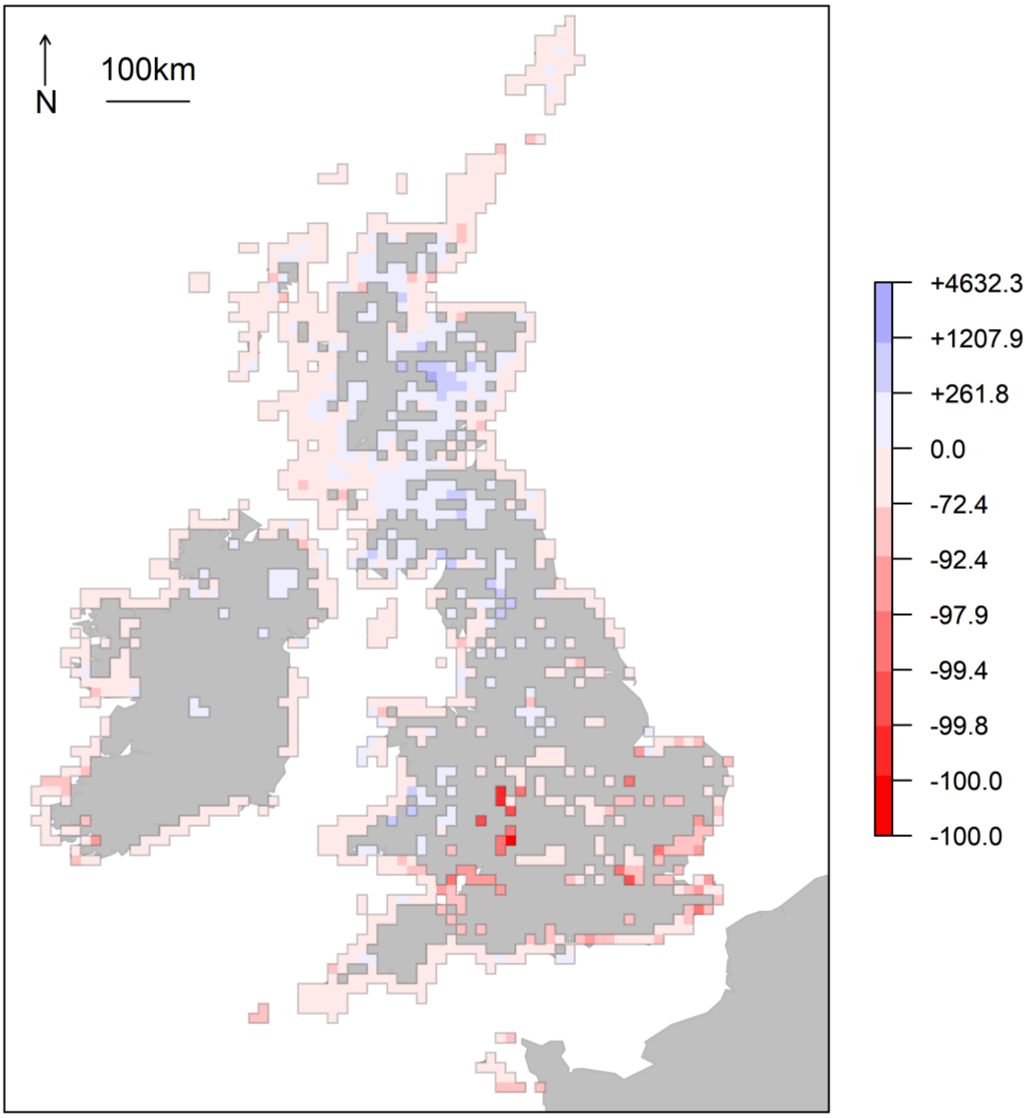

Figure S21. Projected % change (1998-2002 to 2050) in breeding pairs of surface feeding species in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease.

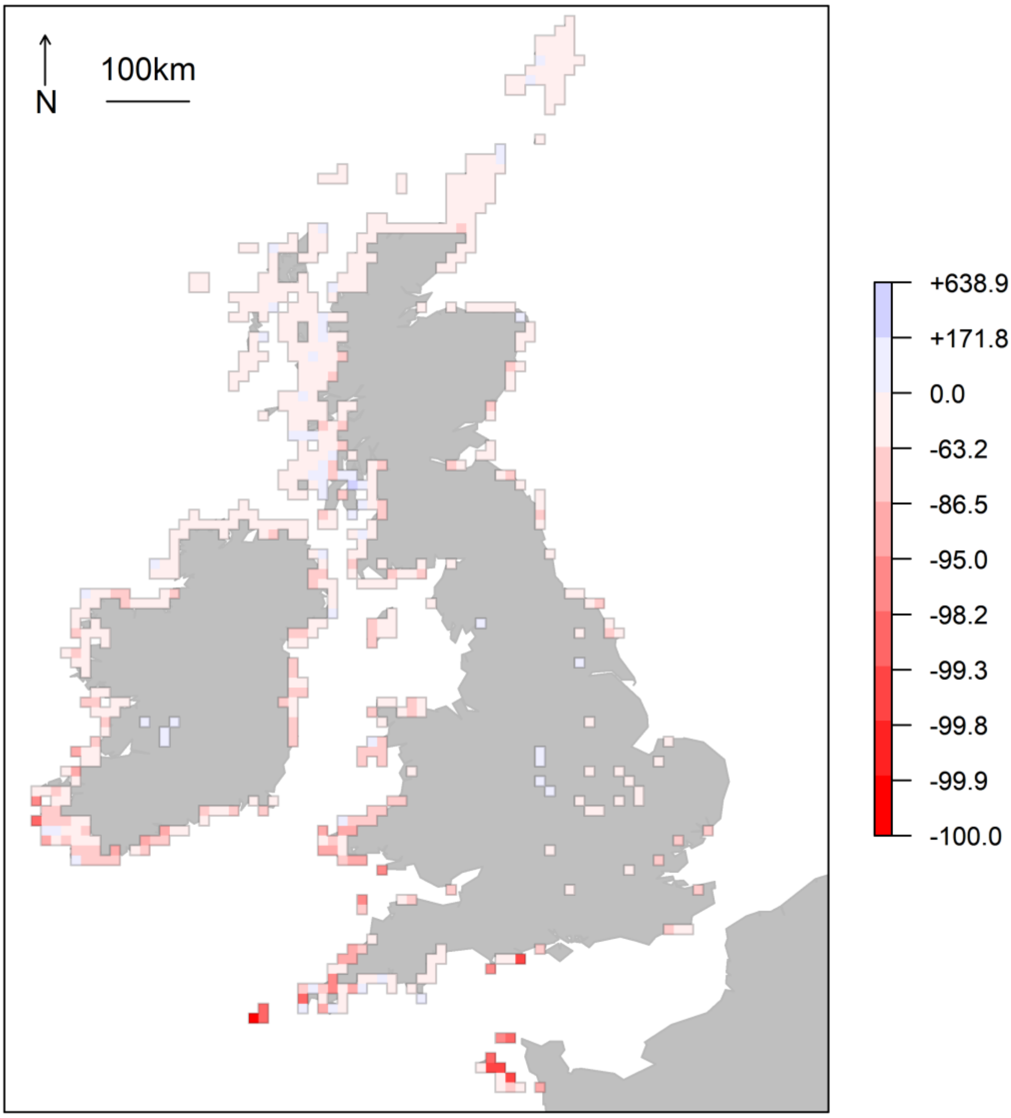

Figure S22. Projected % change (1998-2002 to 2050) in breeding pairs of diving species in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease.

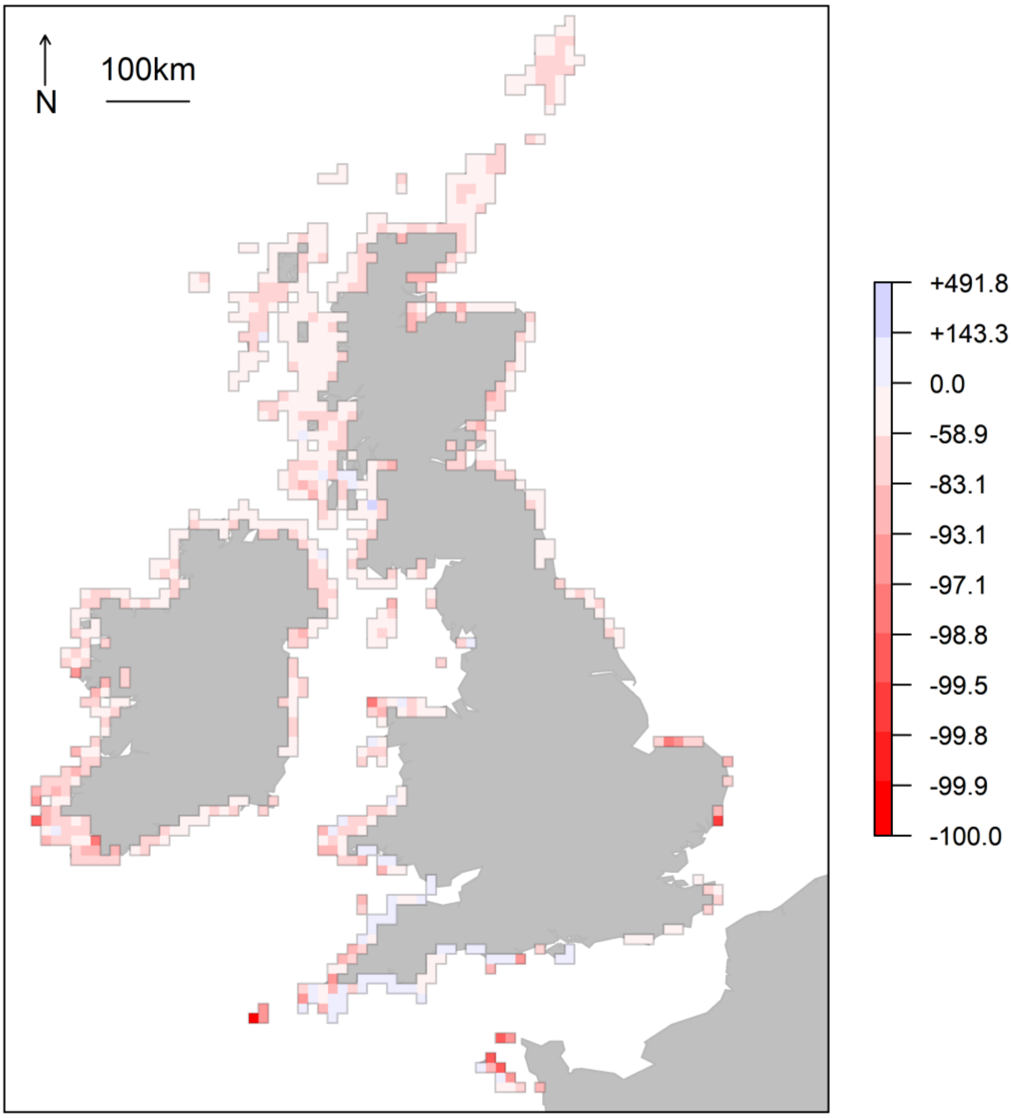

Figure S23. Projected % change (1998-2002 to 2050) in breeding pairs of marine specialists in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease.

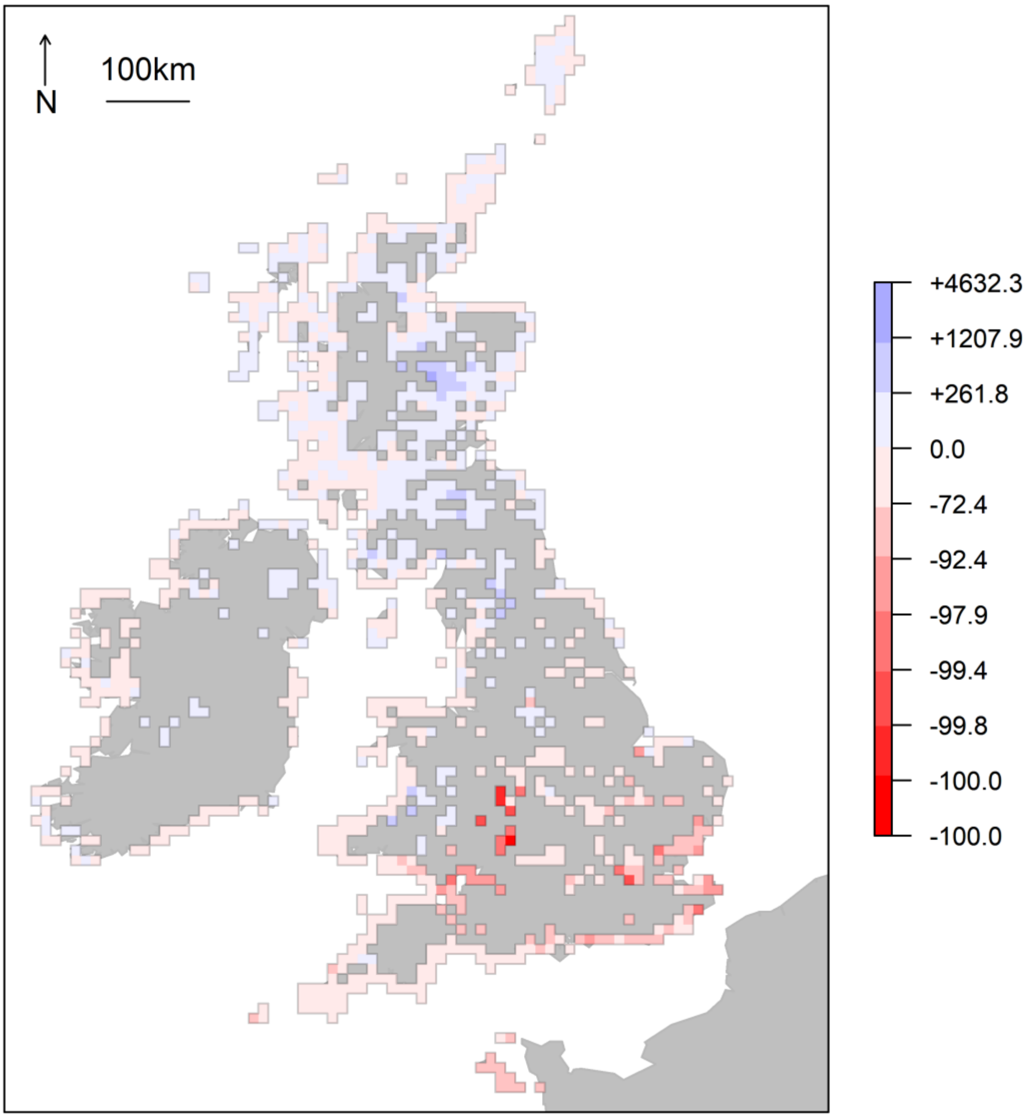

Figure S24. Projected % change (1998-2002 to 2050) in breeding pairs of habitat generalists in Britain and Ireland, for all cells where species was present in 1998-2002. Blue = increase, red = decrease.

Section S7. Parameter estimates for fitted climate/oceanography-presence/abundance relationship

Table S5. Archived at https://zenodo.org/record/7464558#.Y8fTehXMI2w; DOI: 10.5281/zenodo.7464558. 'Variable' = variable name, ('_bin', presence; '_cifp', abundance; 'sq', quadratic term); 'q.025' = 2.5th percentile of credible interval for parameter estimate; 'q.5'=median of credible interval for parameter estimate; 'q.975' = 97.5th percentile of credible interval for parameter estimate; 'Species' = species scientific name.

Literature cited

Bakka H, Rue H, Fuglstad GA, Riebler A, Bolin D, Illian J, Krainski E, Simpson D, Lindgren F (2018) Spatial modeling with R-INLA: A review. Wiley Interdiscip Rev Comput Stat 10:e1443.

Campbell B, Ferguson-Lees J (1972) A field guide to birds' nests. Constable and Company Ltd, London.

Lindgren F, Rue H, Lindström J (2011) An explicit link between gaussian fields and gaussian markov random fields: The stochastic partial differential equation approach. J R Stat Soc Ser B Stat Methodol 73:423–498.

Thaxter CB, Lascelles B, Sugar K, Cook ASCP, Roos S, Bolton M, Langston RHW, Burton NHK (2012) Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. Biol Conserv 156:53–61.

Woodward I, Thaxter CB, Owen E, Cook ASCP (2019) Desk-based revision of seabird foraging ranges used for HRA screening. British Trust for Ornithology, Thetford.