Final Report

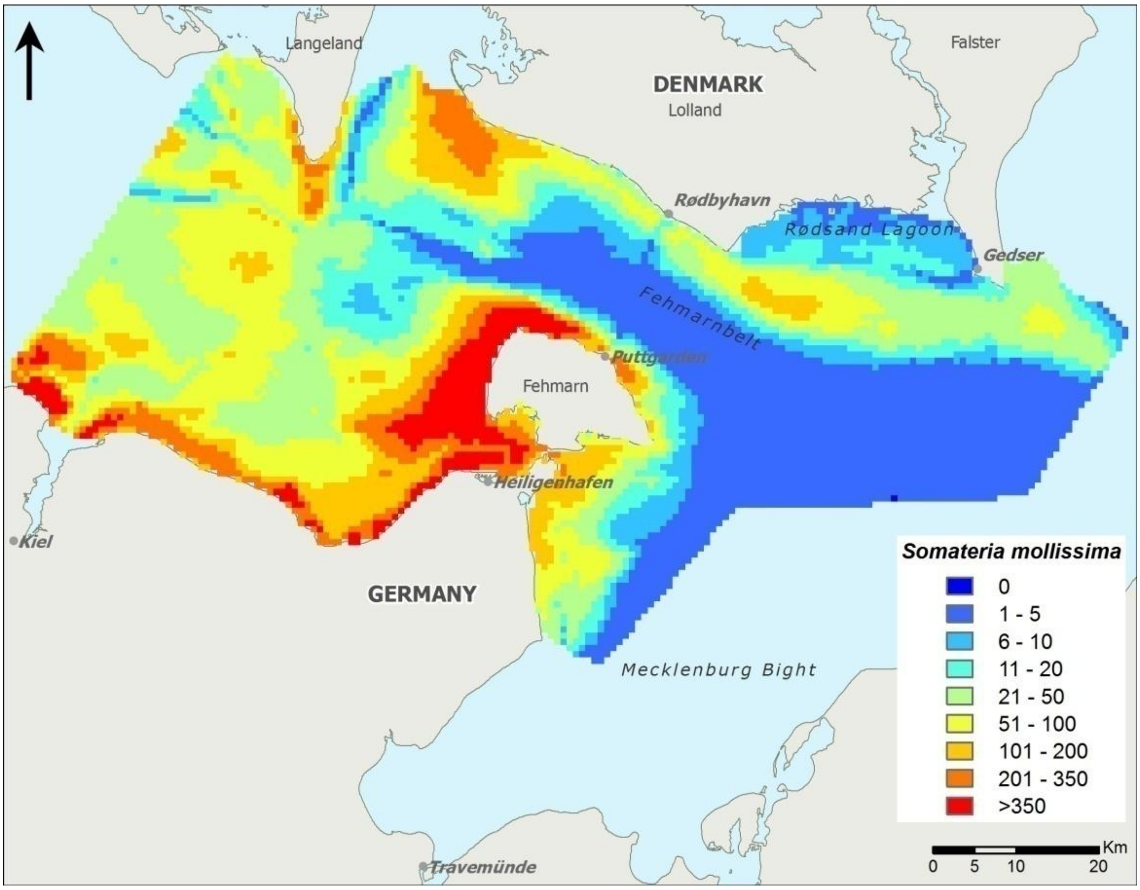
FEHMARNBELT FIXED LINK
BIRD SERVICES (FEBI)

Bird Investigations in Fehmarnbelt - Baseline

Waterbirds in Fehmarnbelt

E3TR0011 Volume II – Appendix III

Diagnostics of species distribution models



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Trans-European Transport Network (TEN-T)

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List of figures is included as the final pages

Note to the reader:
In this report the time for start of construction is artificially set to 1 October 2014 for the tunnel and 1 January 2015 for the bridge alternative. In the Danish EIA (VVM) and the German EIA (UVS/LBP) absolute year references are not used. Instead the time references are relative to start of construction works. In the VVM the same time reference is used for tunnel and bridge, i.e. year 0 corresponds to 2014/start of tunnel construction; year 1 corresponds to 2015/start of bridge construction etc. In the UVS/LBP individual time references are used for tunnel and bridge, i.e. for tunnel construction year 1 is equivalent to 2014 (construction starts 1 October in year 1) and for bridge construction year 1 is equivalent to 2015 (construction starts 1st January).

1 APPENDIX III

1.1.1 *Diagnostics of species distribution models Red-throated Diver/Black-throated Diver* – Gavia stellata/Gavia arctica

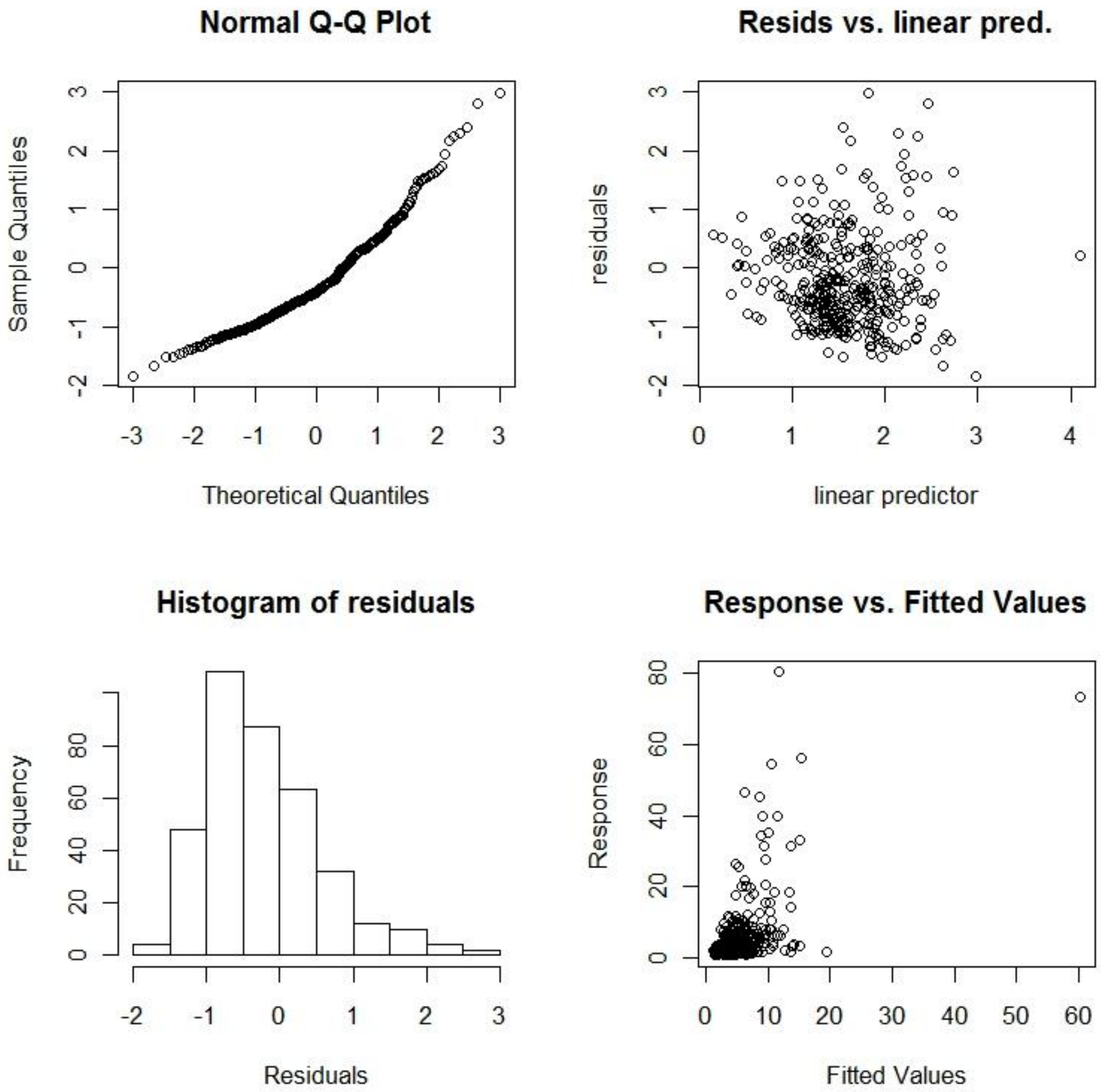
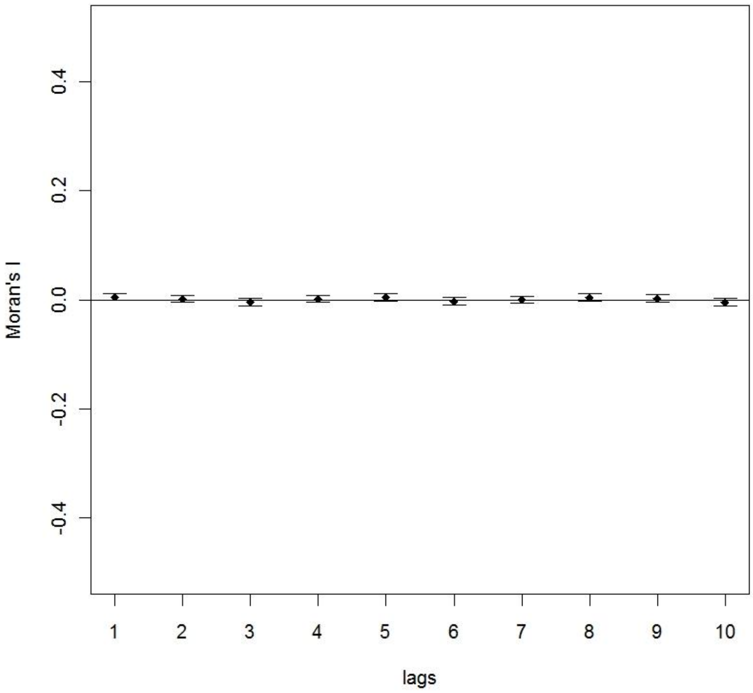


Figure 1.1 Diagnostic plots for the positive part of the two-part GAM for the Red-throated Diver/Black-throated Diver in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



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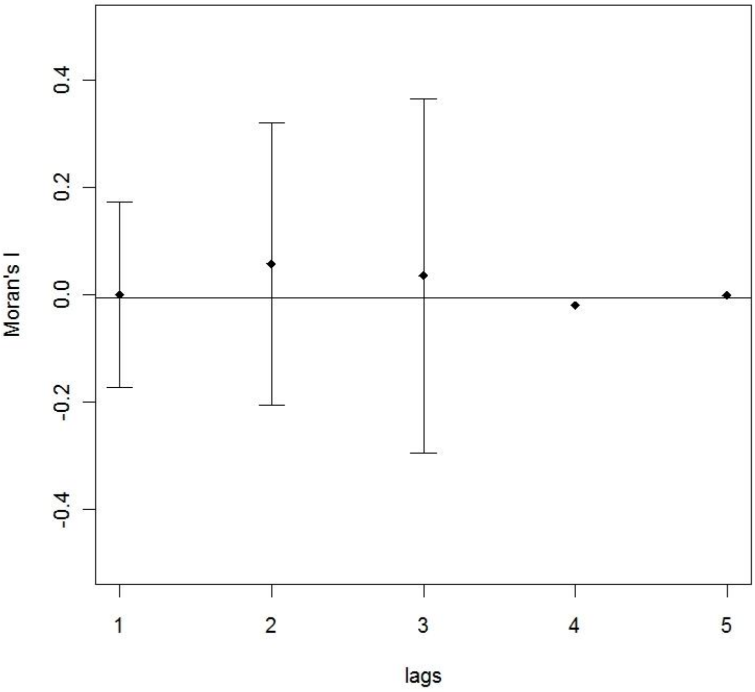
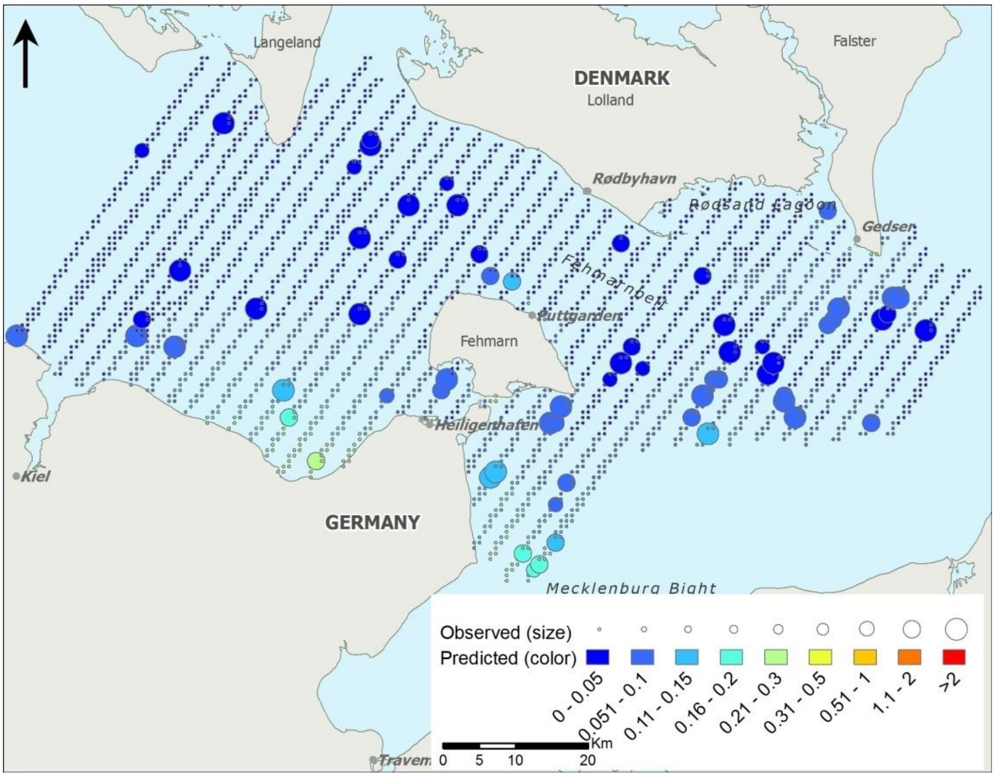


B

Figure 1.2 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Red-throated Diver/Black-throated Diver during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.



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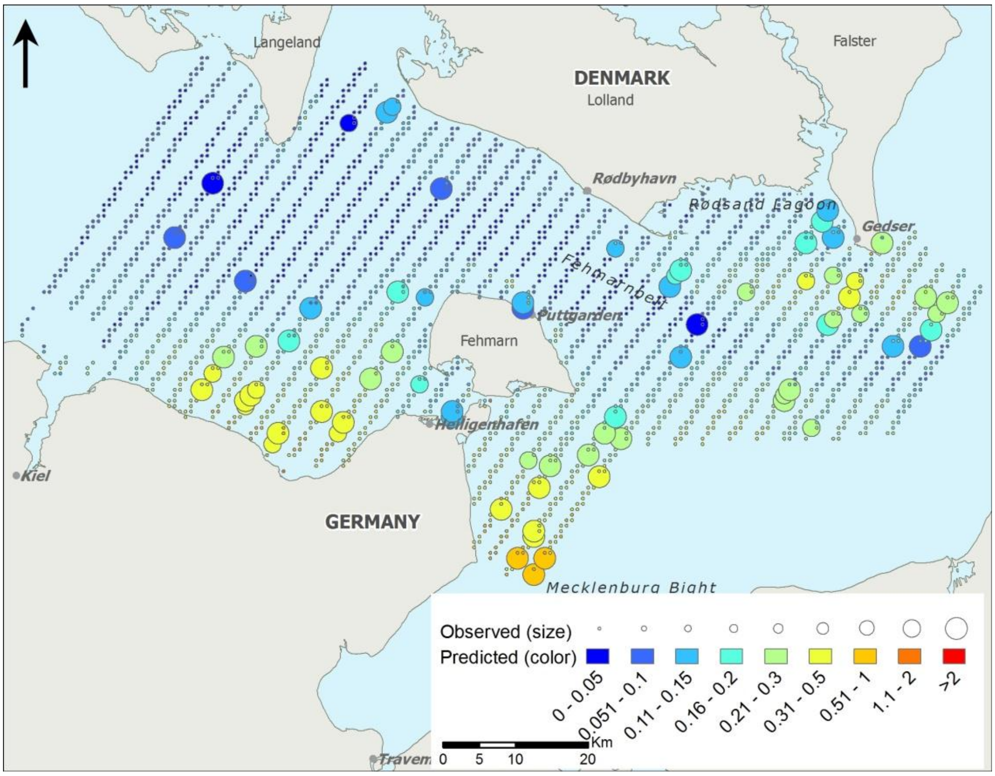
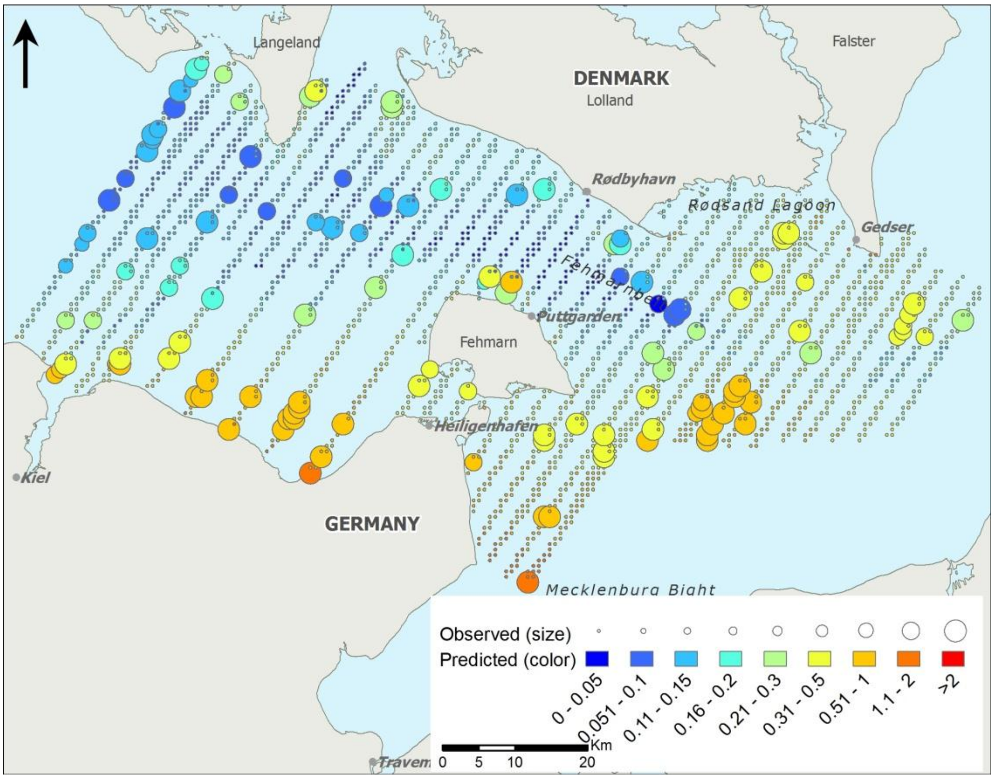


B

Figure 1.3 *Observed and predicted values of Red-throated Diver/Black-throated Diver densities (ind./km²) for season 1 (A) and season2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.*



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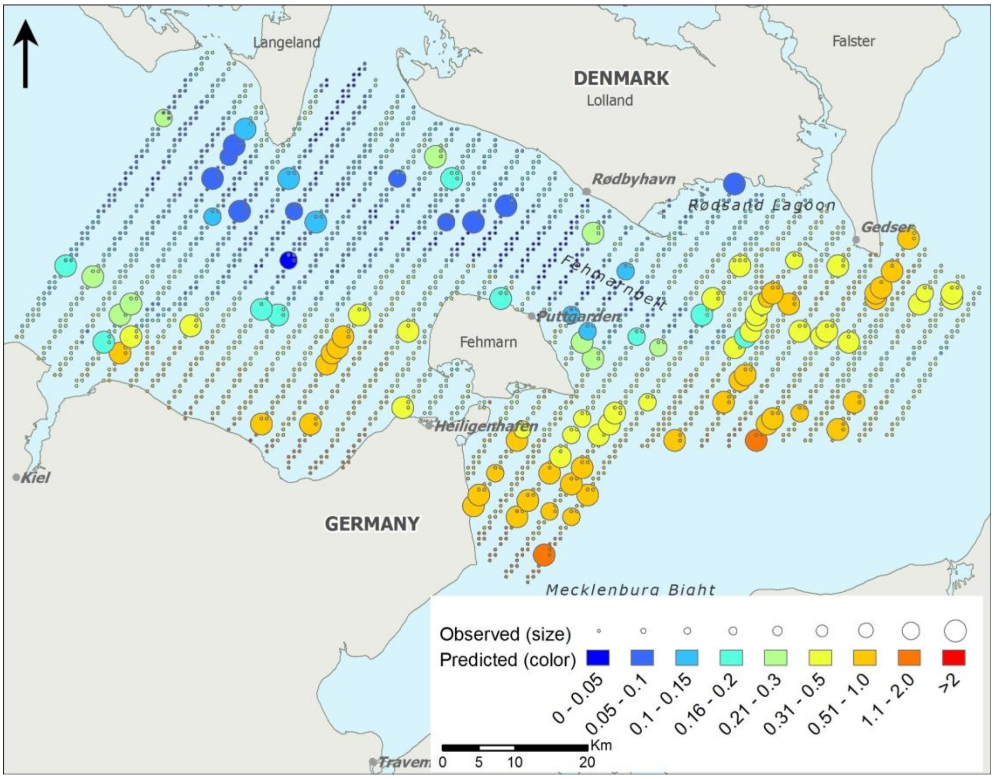

B

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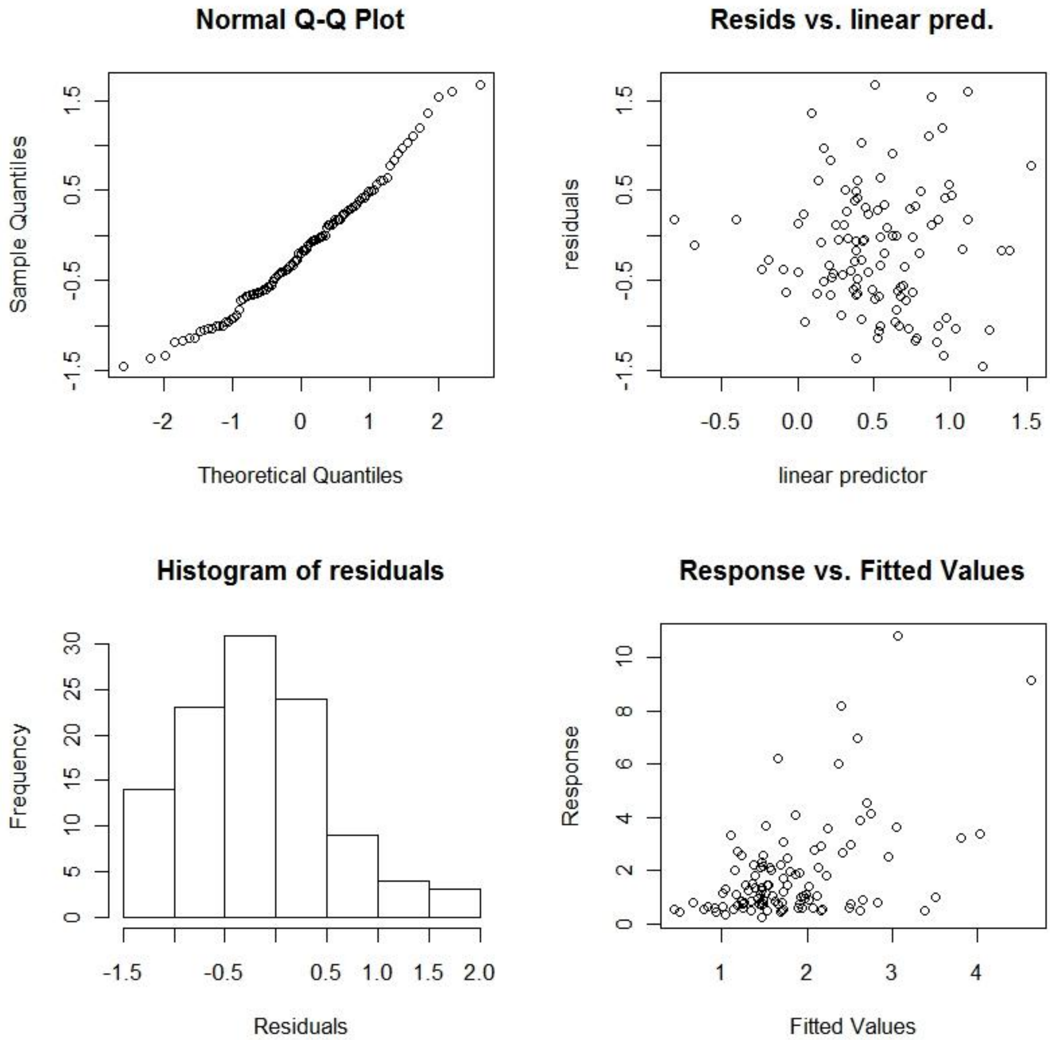
1.1.2 Great Crested Grebe – **Podiceps cristatus**



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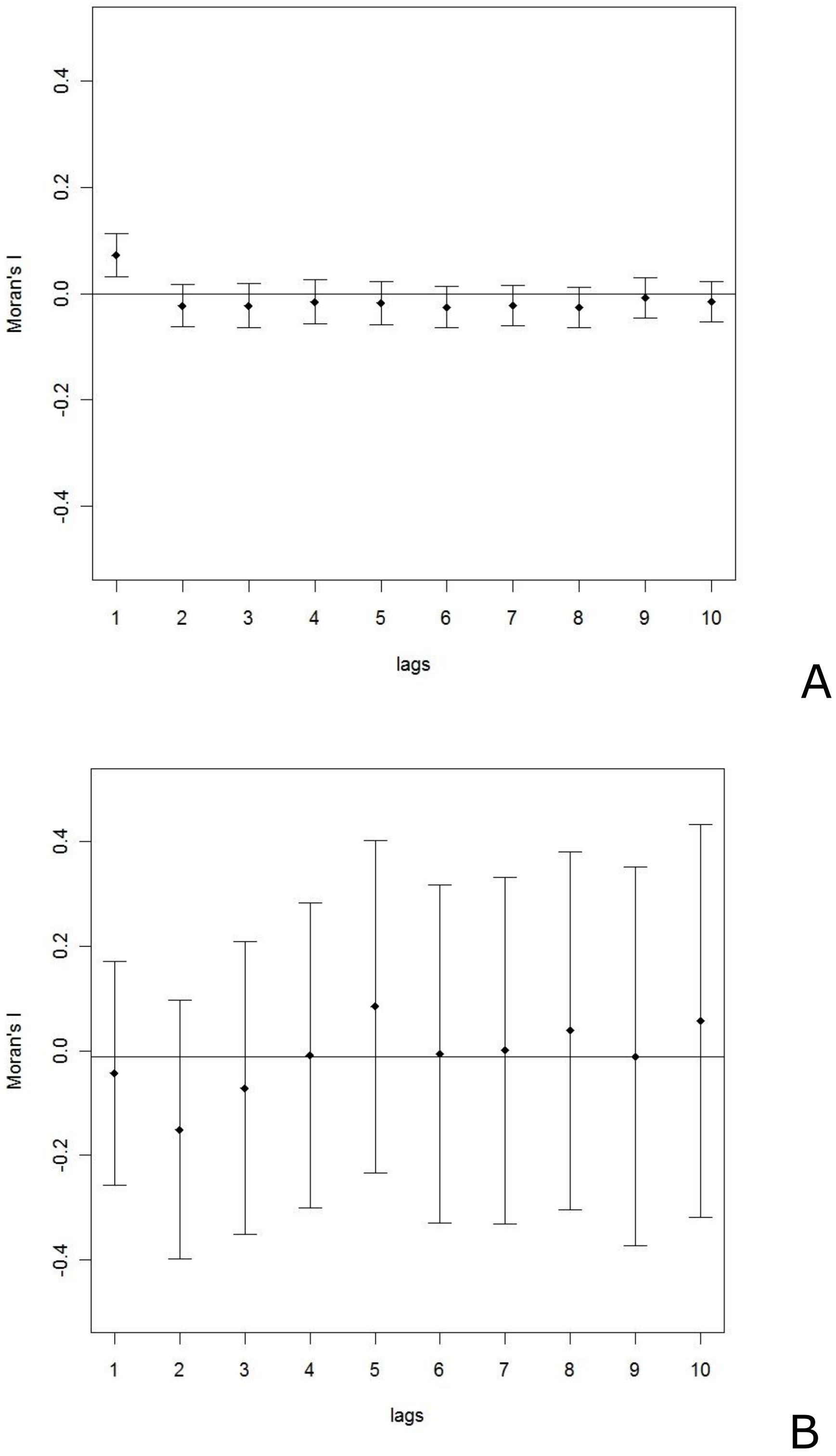


Figure 1.6 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Great Crested Grebe during the winter 2008/2009 in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

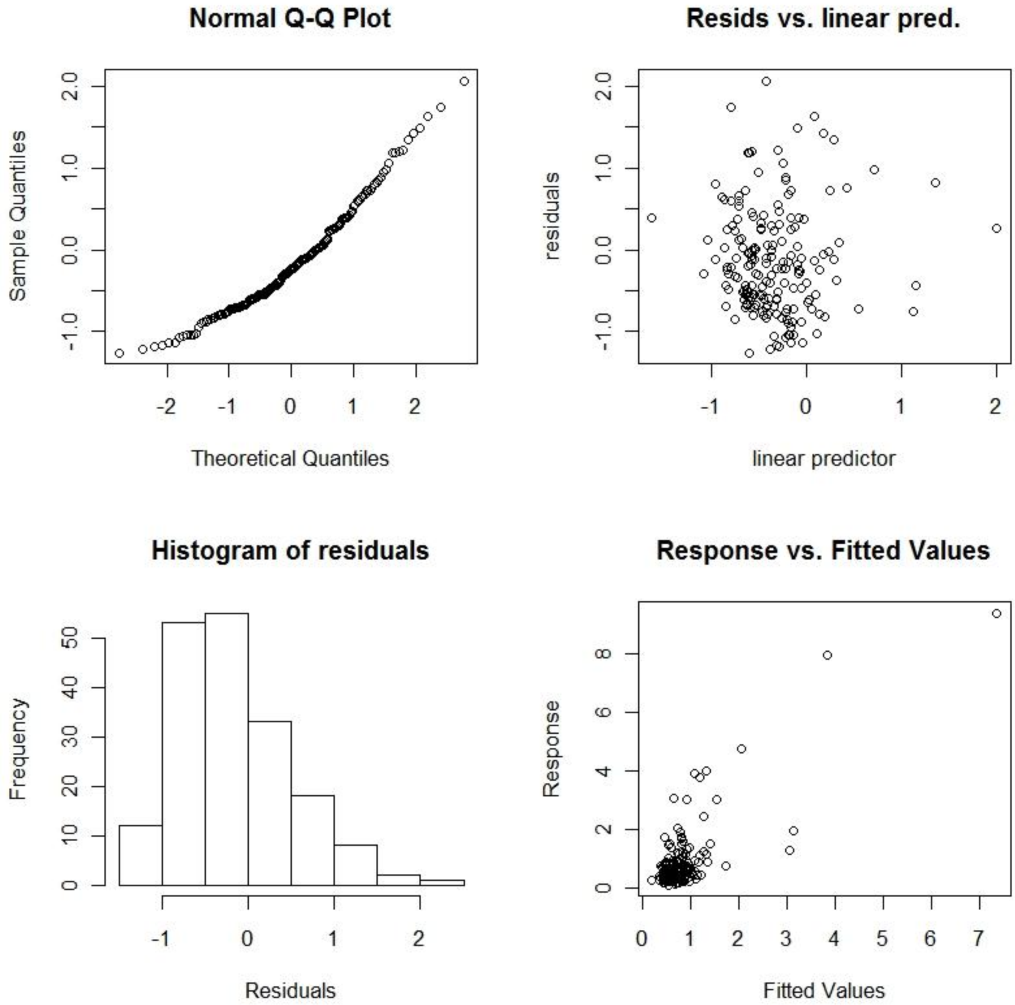
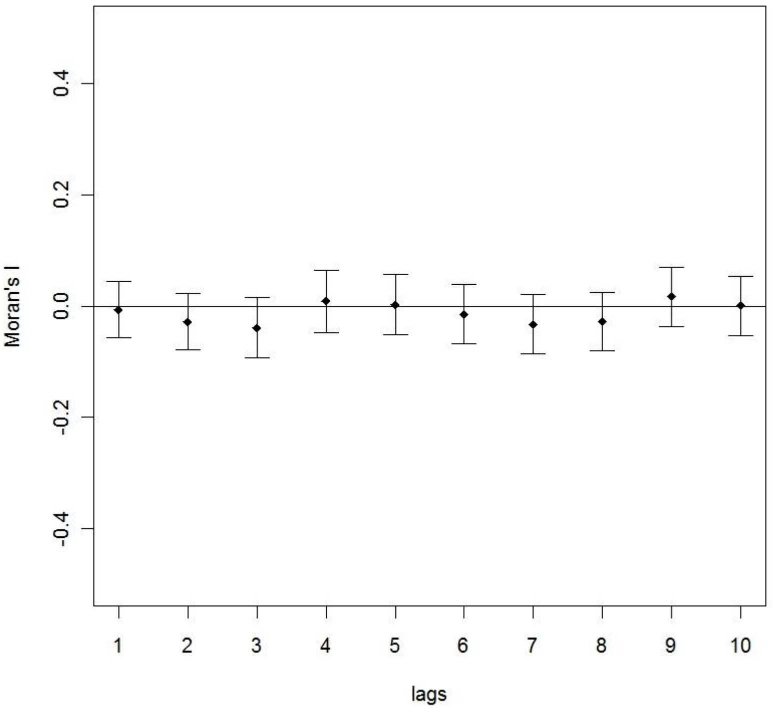


Figure 1.7 *Diagnostic plots for the positive part of the two-part GAM for the Great Crested Grebe in Fehmarnbelt during the winter 2009/2010. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.*



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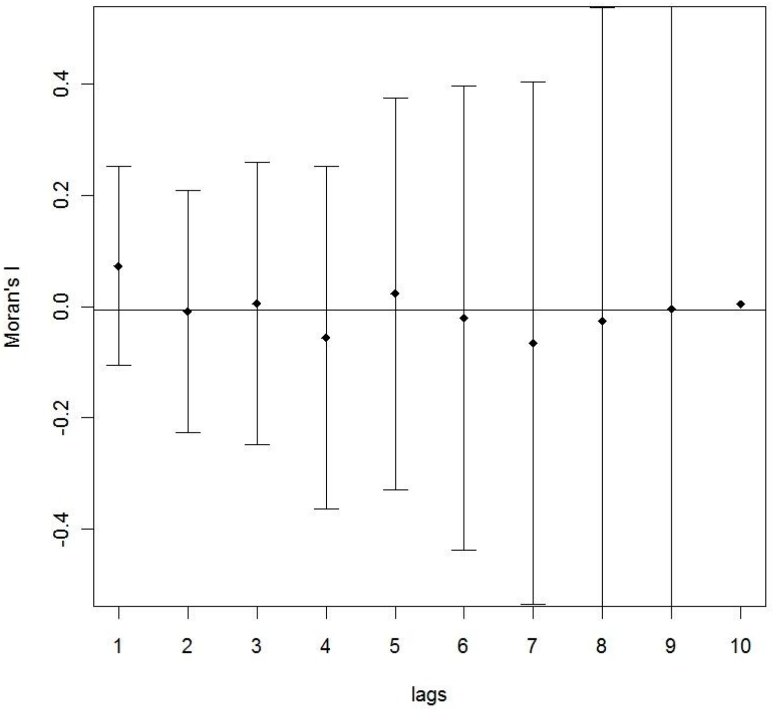


B

Figure 1.8 *Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Great Crested Grebe during the winter 2009/2010 in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.*

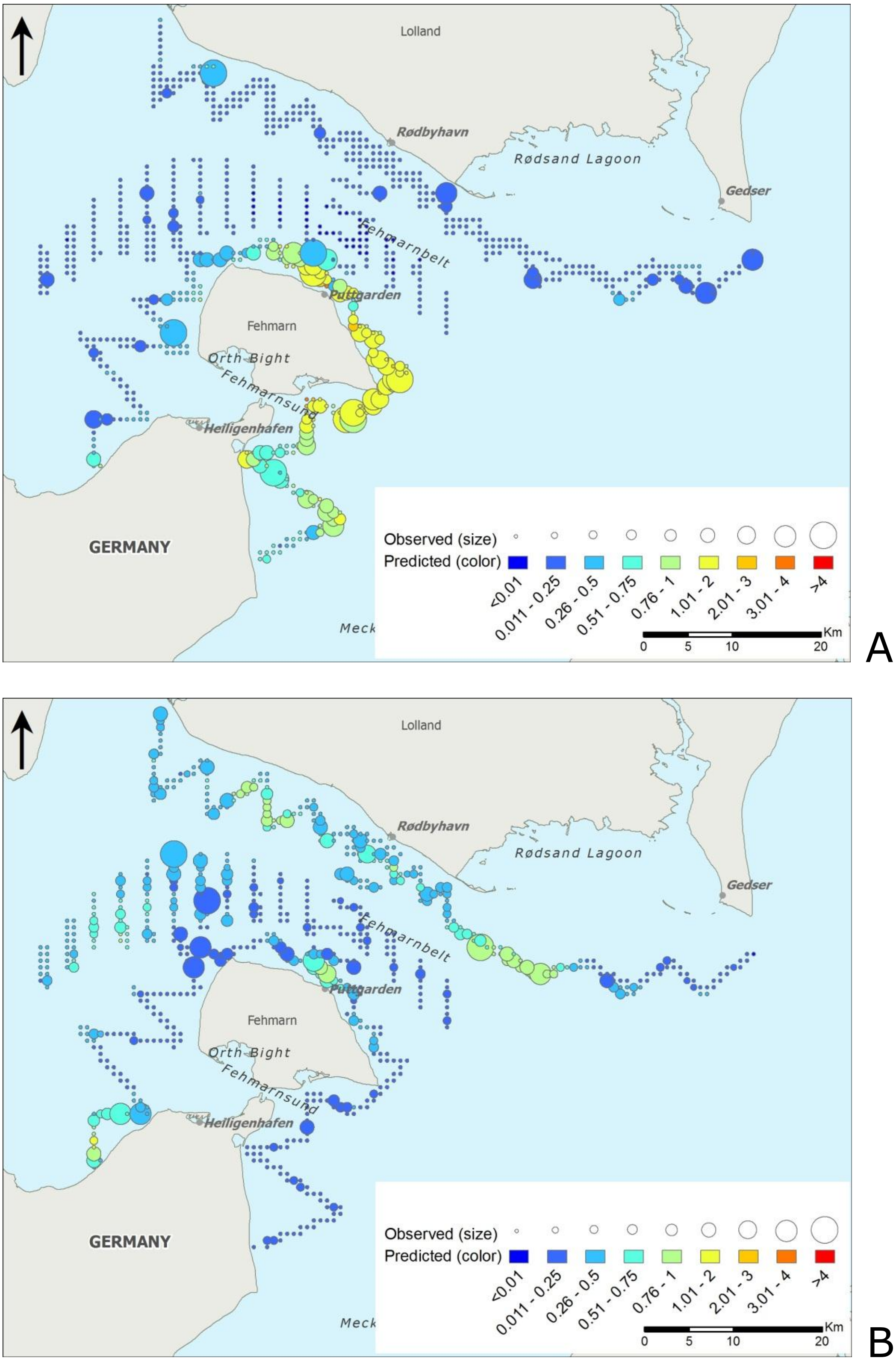
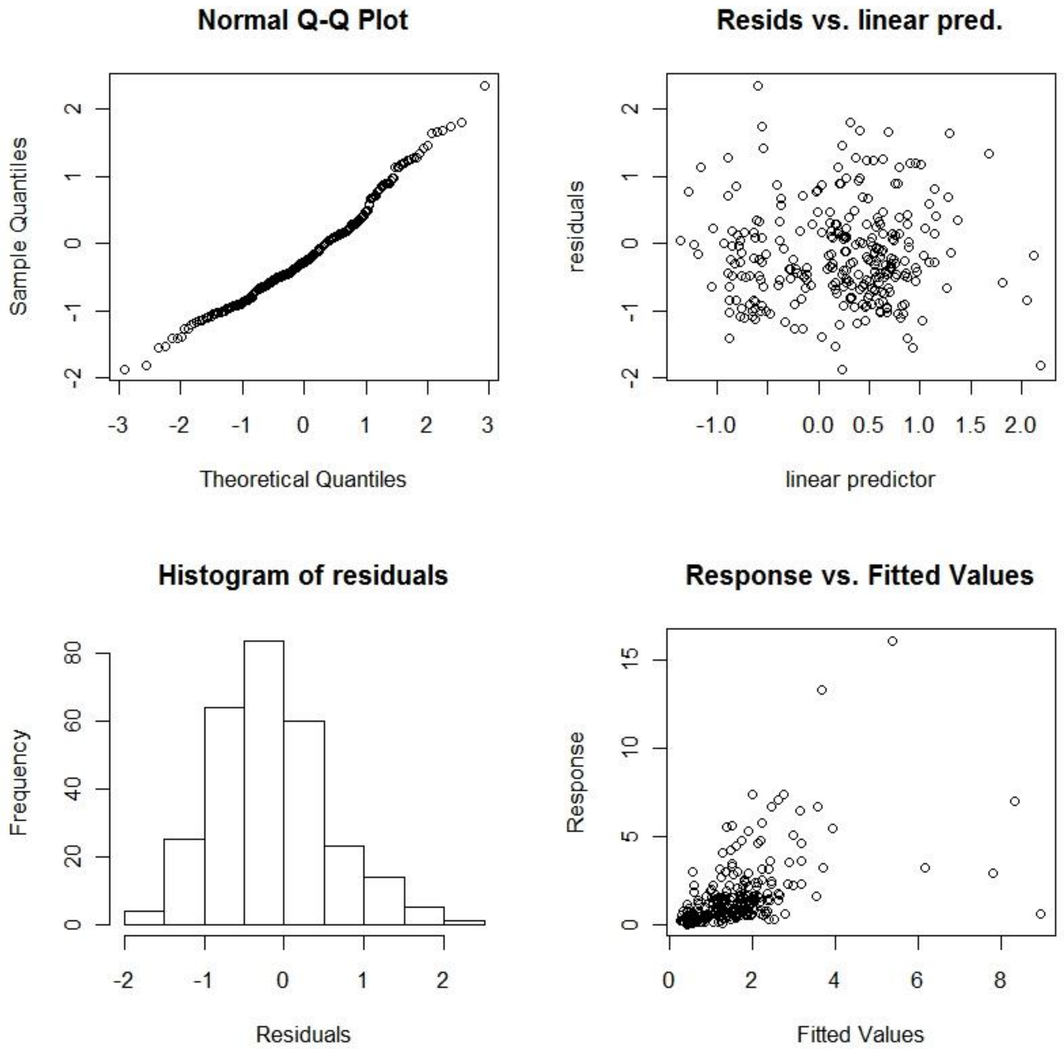


Figure 1.9 *Observed and predicted values of Great Crested Grebe densities (ind./km^2) for season 1(A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.*

Table 1.1 Variability of Great Crested Grebe density and abundance estimates for the season indicating the highest numbers (November 2008 – March 2009) according spatial modeling using ship-based survey data.

	Mean density		Total numbers	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	0.362	0.137	75	28
SPA Kiel Bight	0.329	0.152	144	67
SPA Baltic Sea east of Wagrien	1.138	0.398	361	127
SPA Hyllekrog-Rødsand	-	-	-	-
Residual area	0.165	0.086	251	130
Total	0.333	0.142	756	324

1.1.3 Red-necked Grebe – Podiceps grisegena



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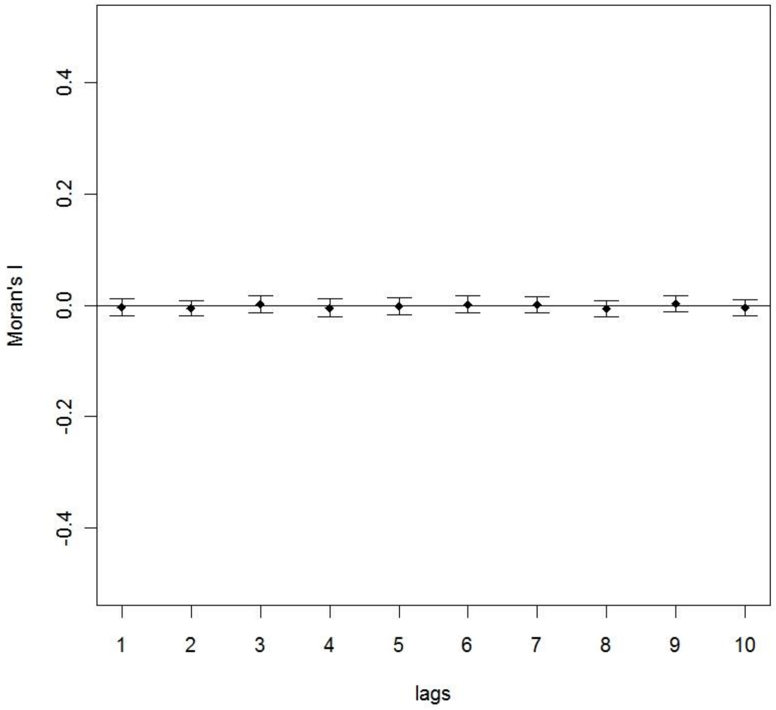

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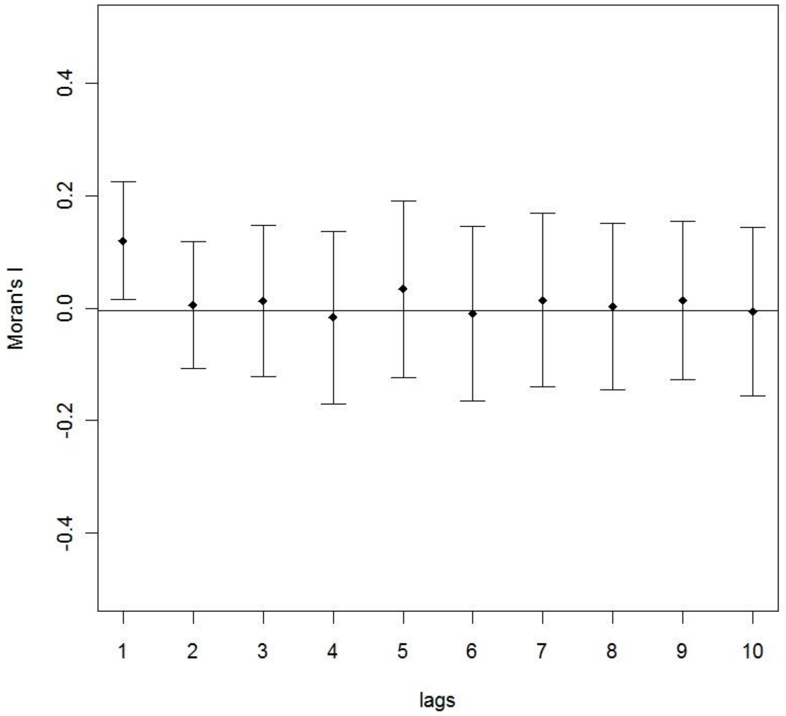

B

Figure 1.11 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Red-necked Grebe during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

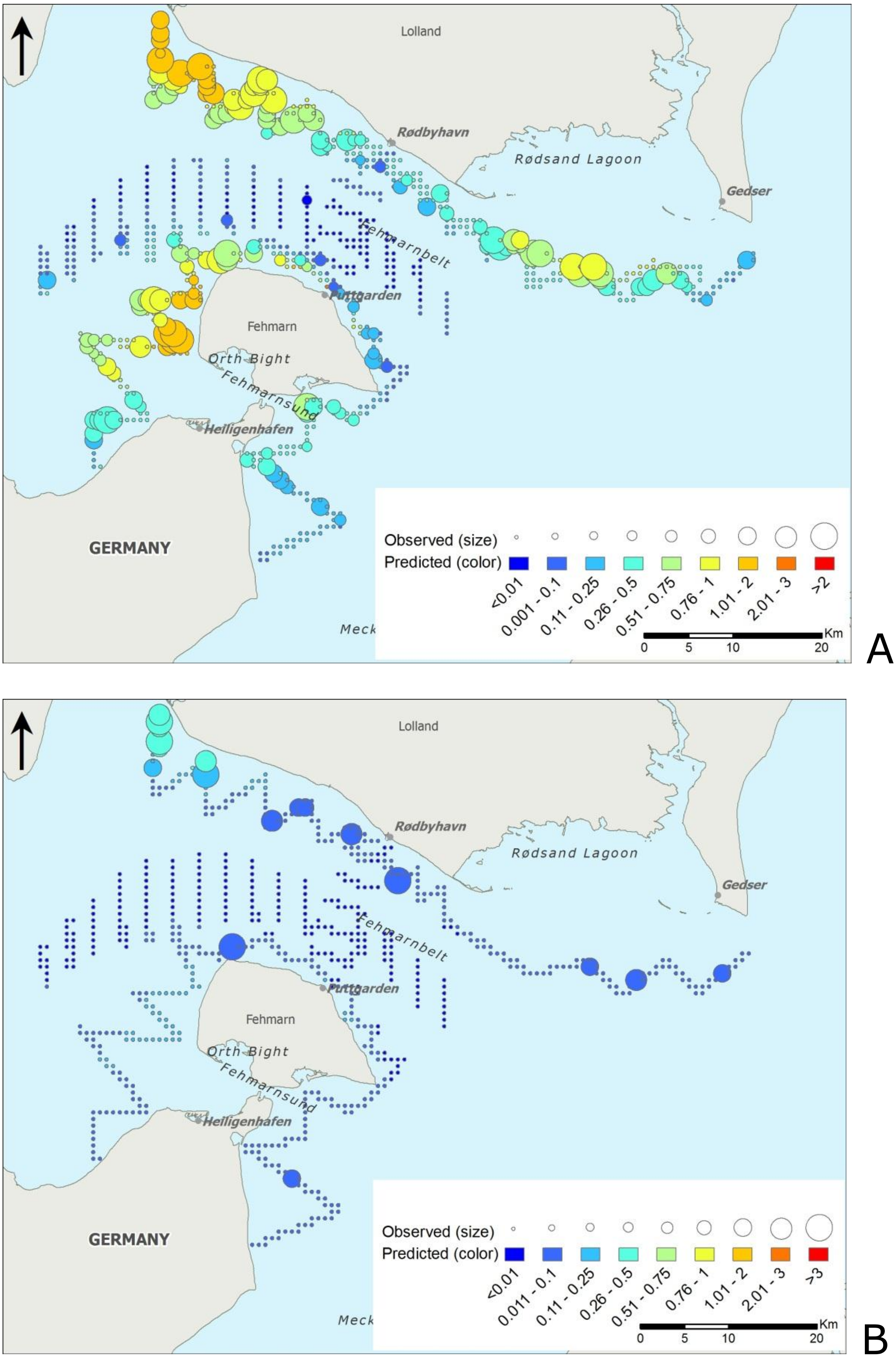

Figure 1.12 Observed and predicted values of Red-necked Grebe densities (ind./km²) for season 1 (Nov 2008 – Apr 2009) and season 2 (Aug – Sept 2009) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

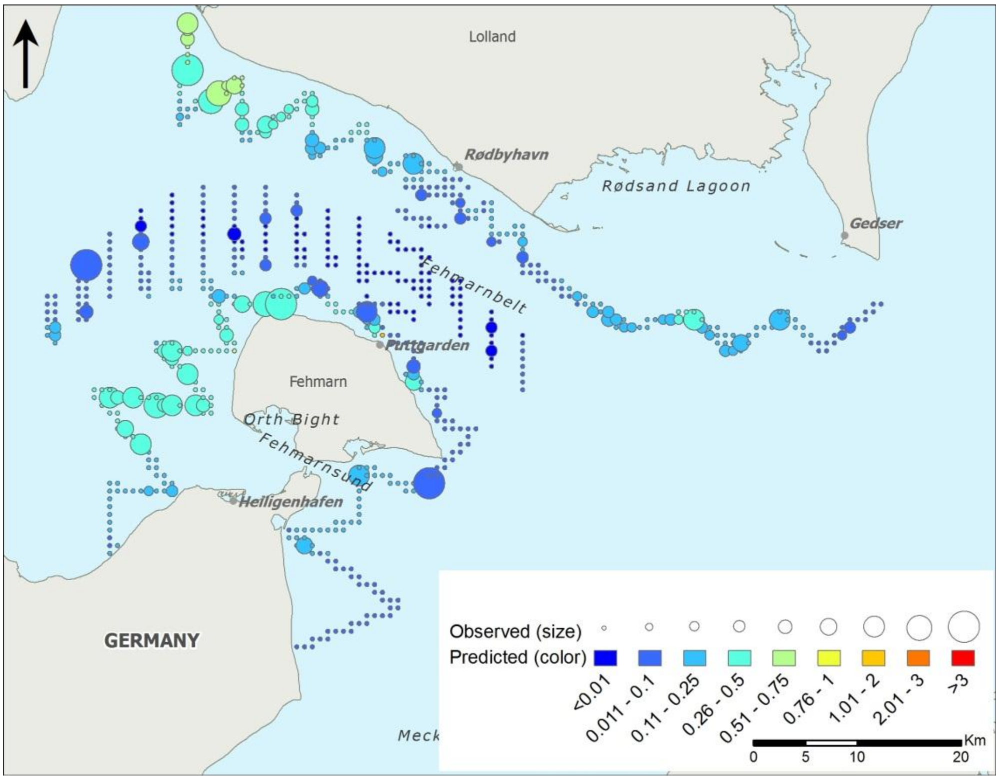

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Table 1.2 *Variability of Red-necked Grebe density and abundance estimates for the season indicating the highest numbers (November 2008 – March 2009) according spatial modeling using ship-based survey data.*

	Mean density		Total numbers	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	0.173	0.048	36	9
SPA Kiel Bight	0.564	0.111	248	48
SPA Baltic Sea east of Wagrien	0.217	0.062	69	20
SPA Hyllekrog-Rødsand	-	-	-	-
Residual area	0.293	0.066	445	100
Total	0.335	0.074	762	168

1.1.4 *Common Eider* – Somateria mollissima

Model on aerial surveys

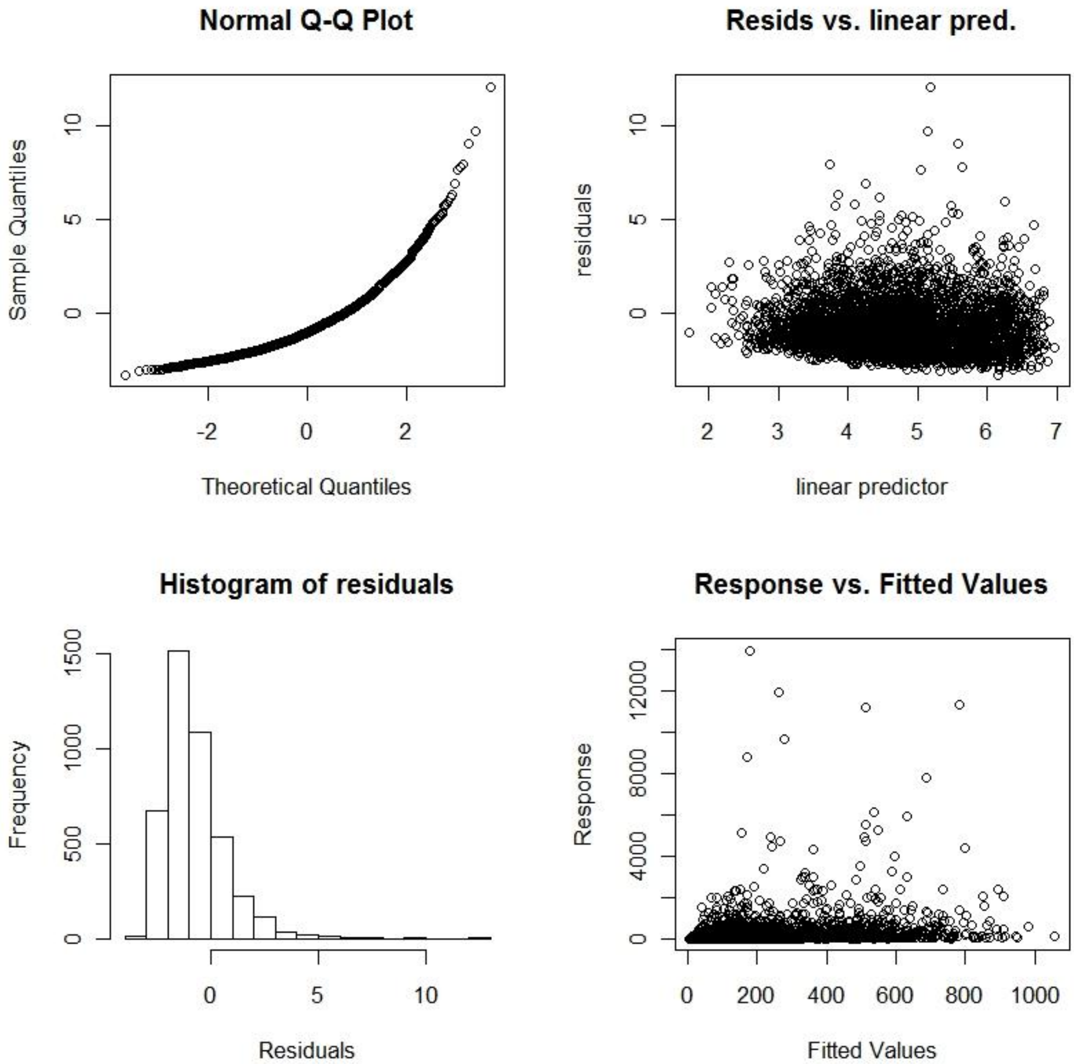
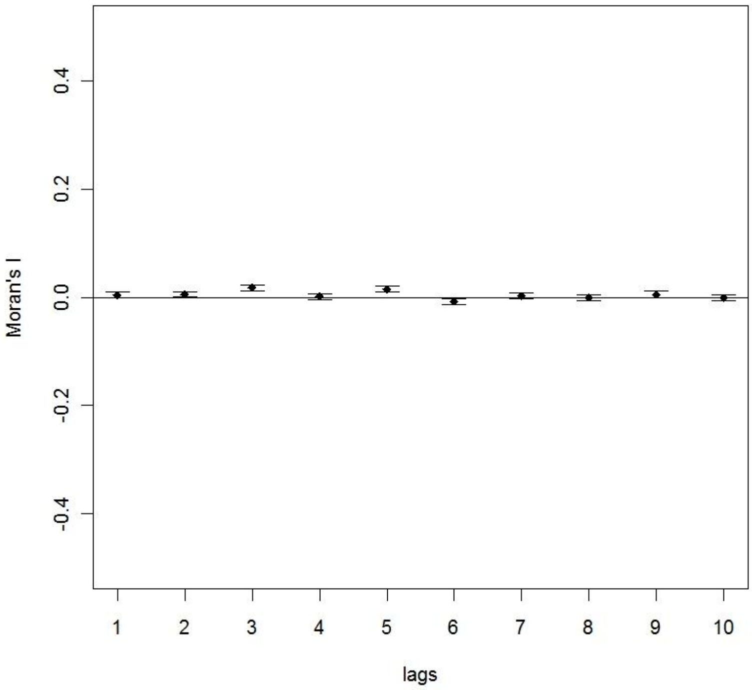


Figure 1.14 Diagnostic plots for the positive part of the two-part GAM for the Common Eider in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



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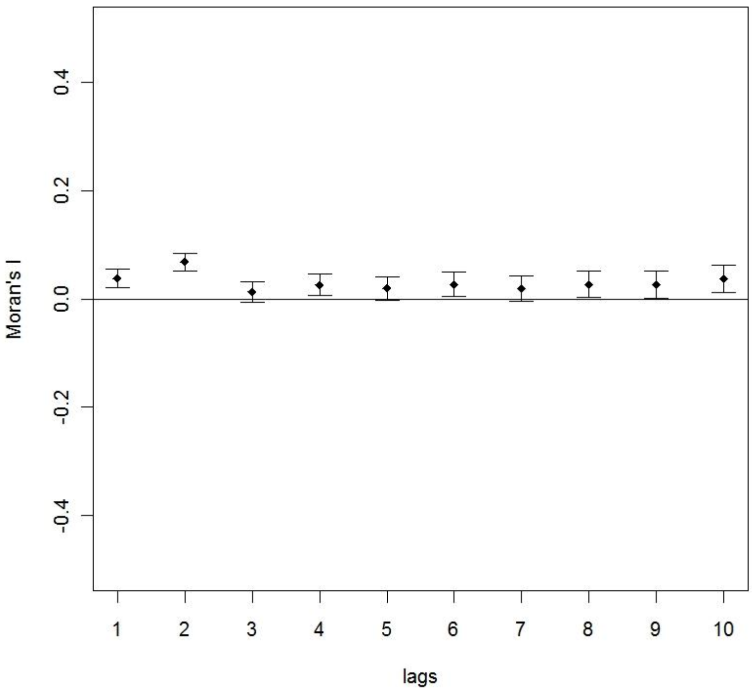


B

Figure 1.15 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Common Eider during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

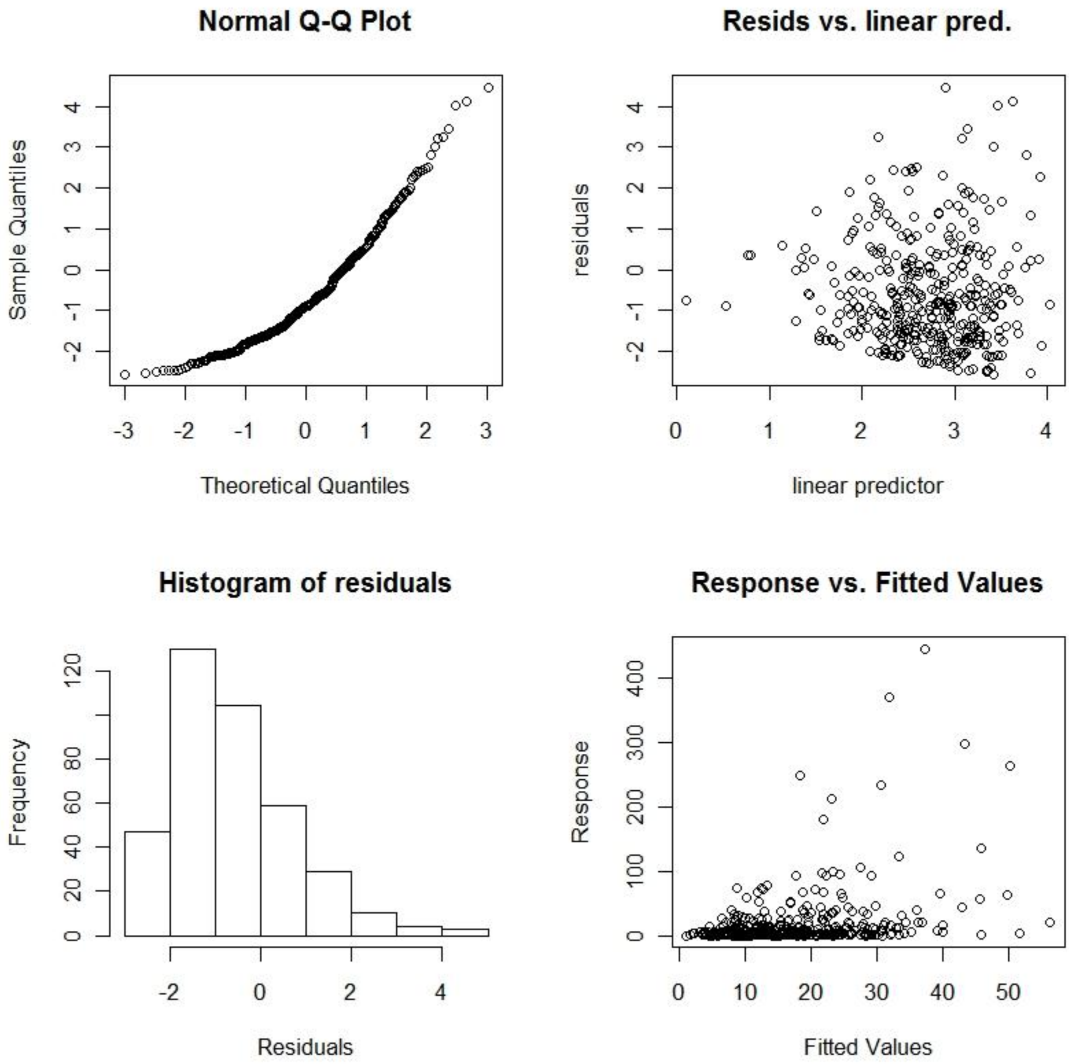
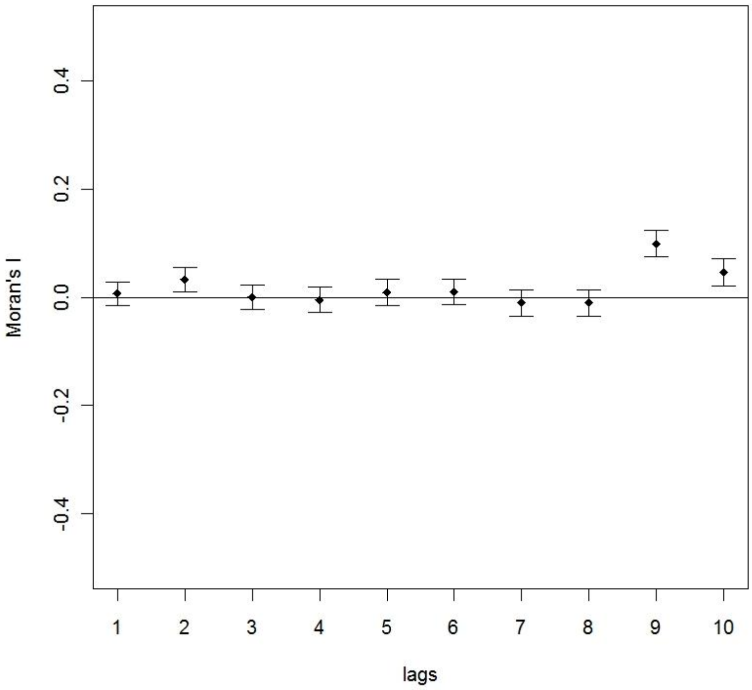


Figure 1.16 *Diagnostic plots for the positive part of the two-part GAM for the Common Eider in Fehmarnbelt during the summer period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.*



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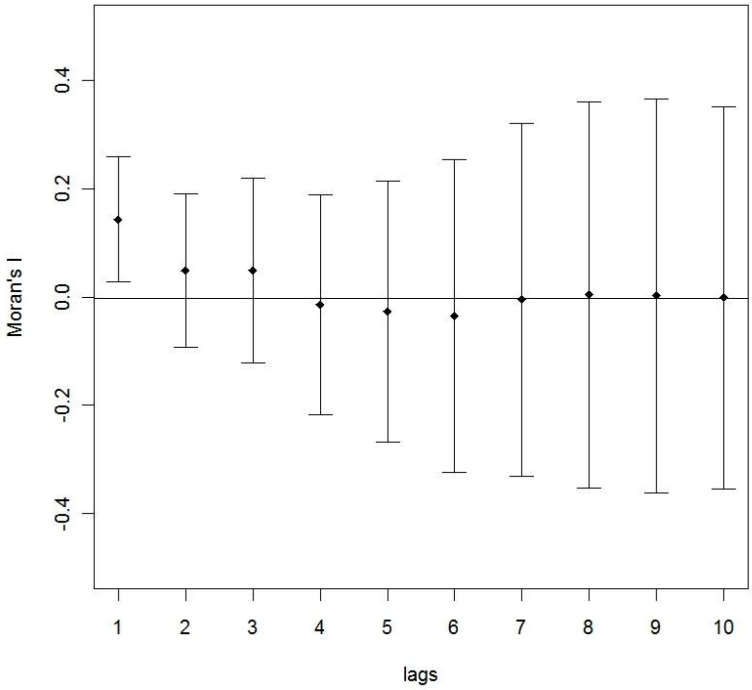
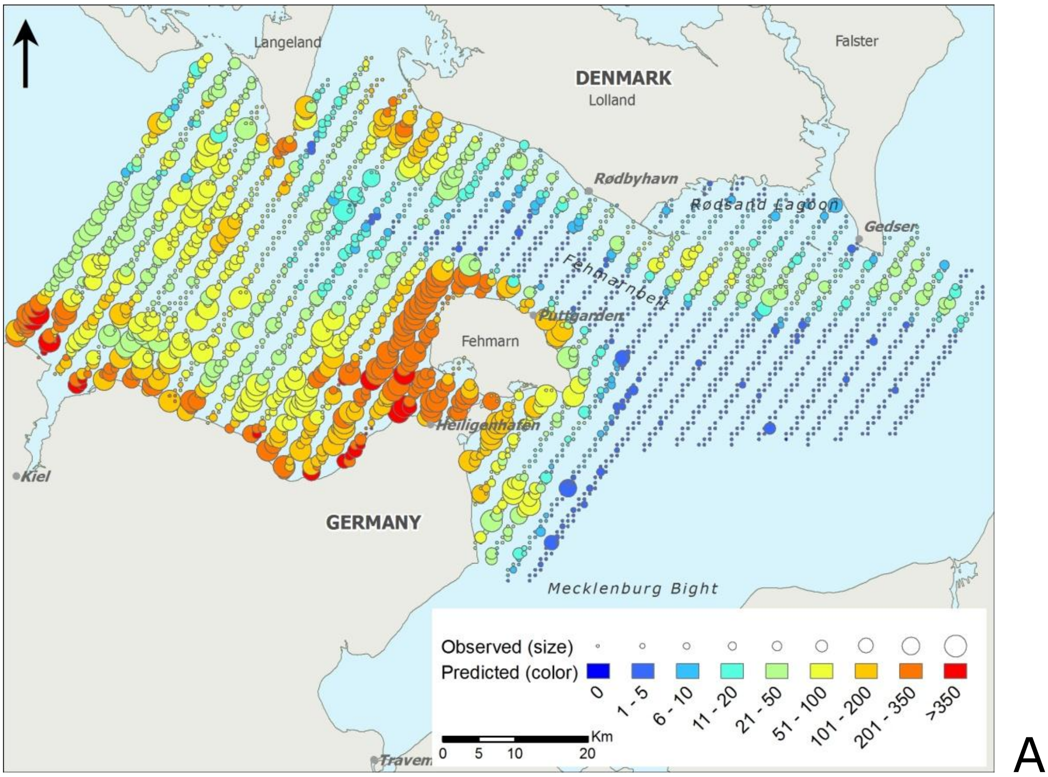


B

Figure 1.17 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Common Eider during the summer period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.



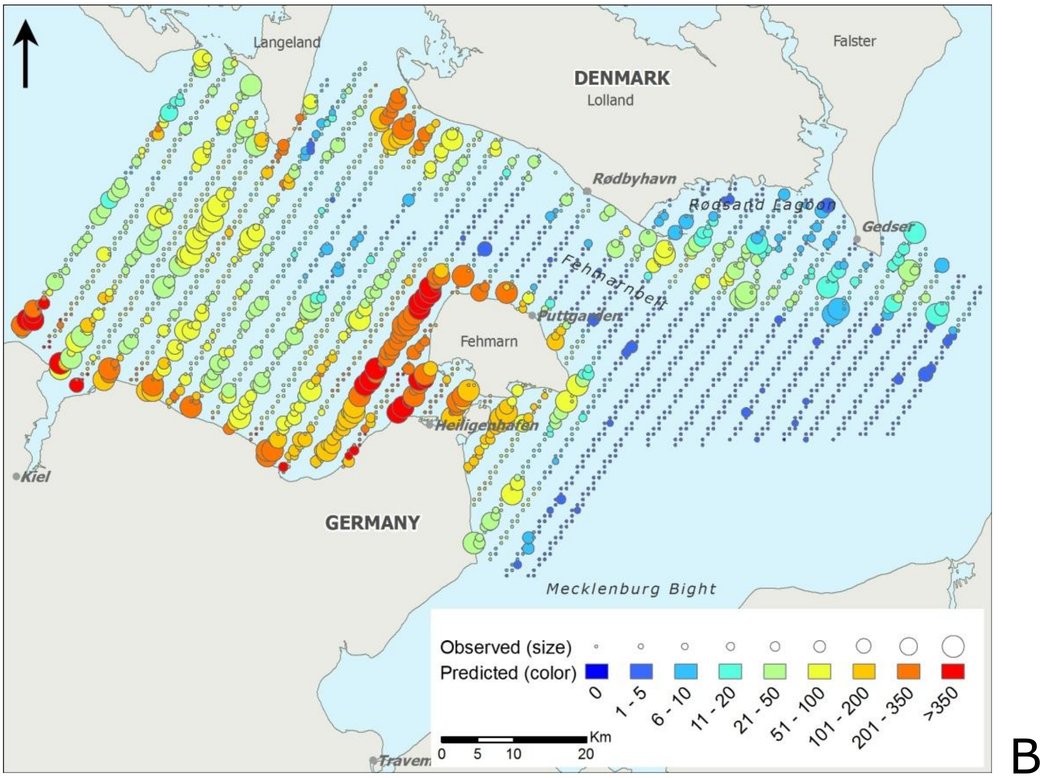


Figure 1.18 *Observed and predicted values of Common Eider densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.*

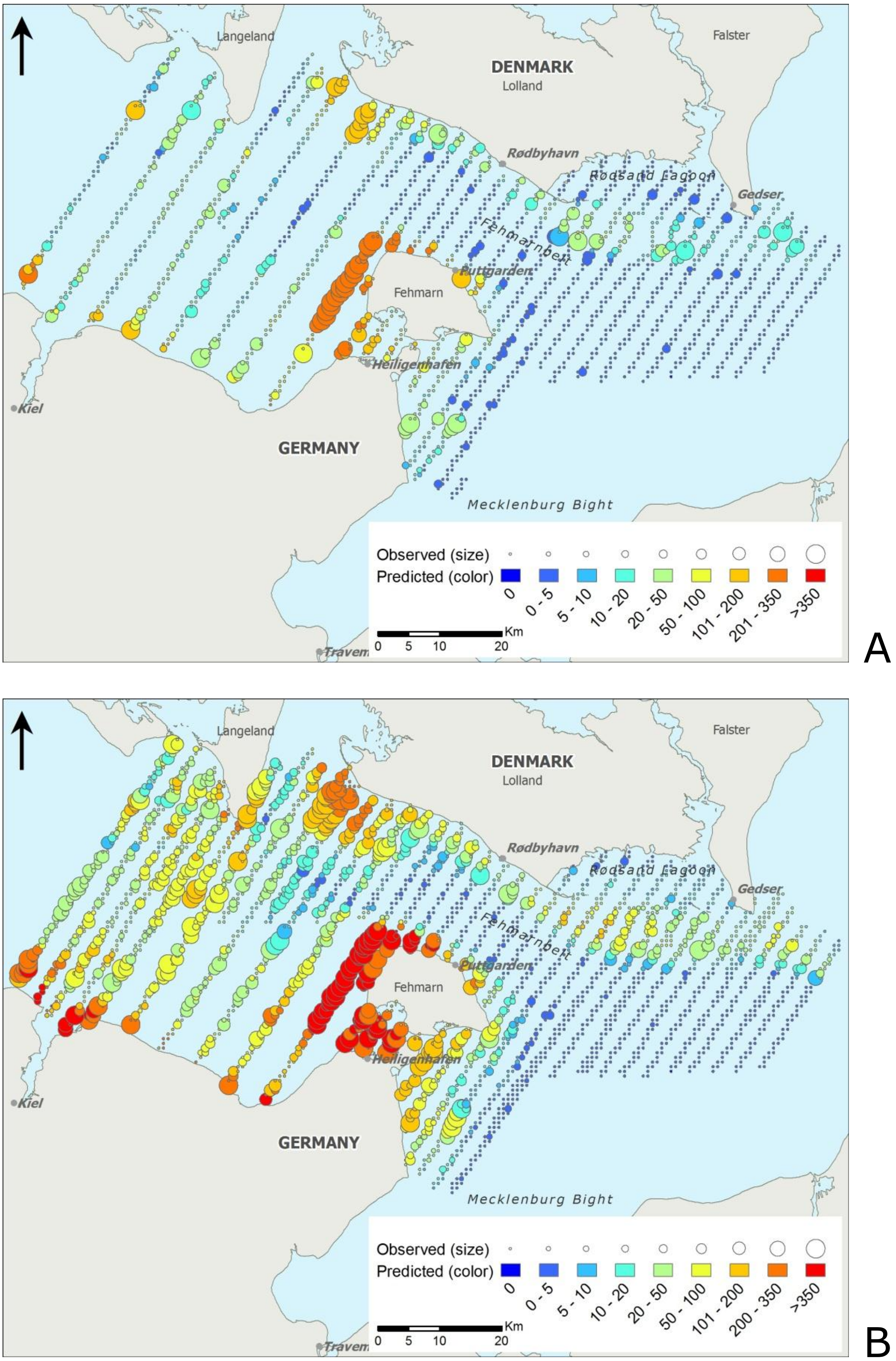


Figure 1.19 Observed and predicted values of Common Eider densities (ind./km^2) for Season 3 (A) and season 4 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

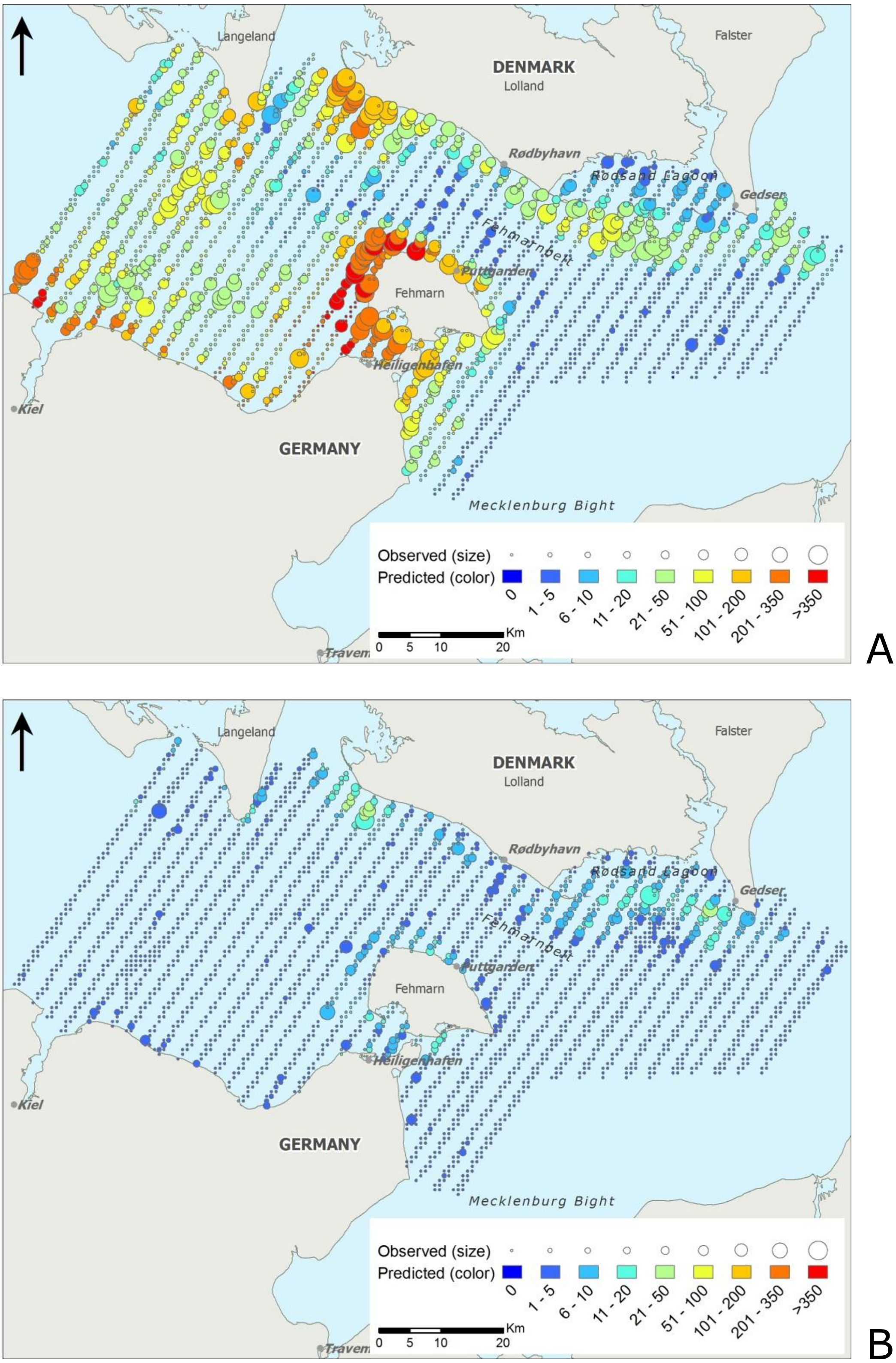


Figure 1.20 Observed and predicted values of Common Eider densities (ind./km^2) for season 5 (A) and the summer season (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

Table 1.3 Variability of Common Eider density and abundance estimates for the season indicating the highest numbers (November 2009 – March 2010) according spatial modeling using aerial survey data.

	Mean density		**Total numbers**	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	35.25	6.84	7,395	1,435
SPA Kiel Bight	226.66	37.08	160,262	26,220
SPA Baltic Sea east of Wagrien	48.75	7.95	17,908	2,921
SPA Hyllekrog-Rødsand	12.79	2.59	3,143	637
Residual area	41.32	6.79	146,192	24,016
Total	67.41	11.07	327,505	53,794

Model on ship-based surveys

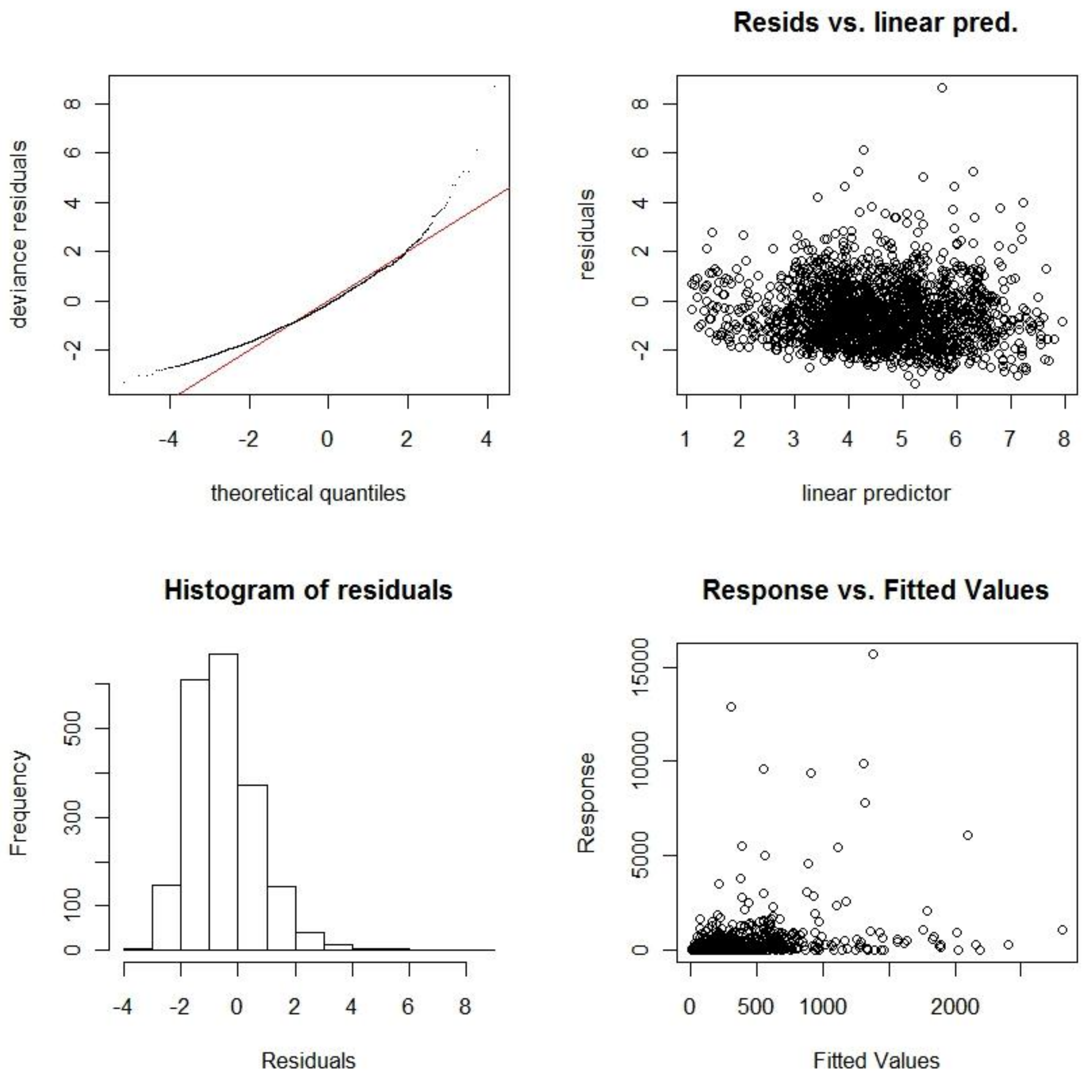


Figure 1.21 Diagnostic plots for the positive part of the two-part GAM for the Common Eider in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.

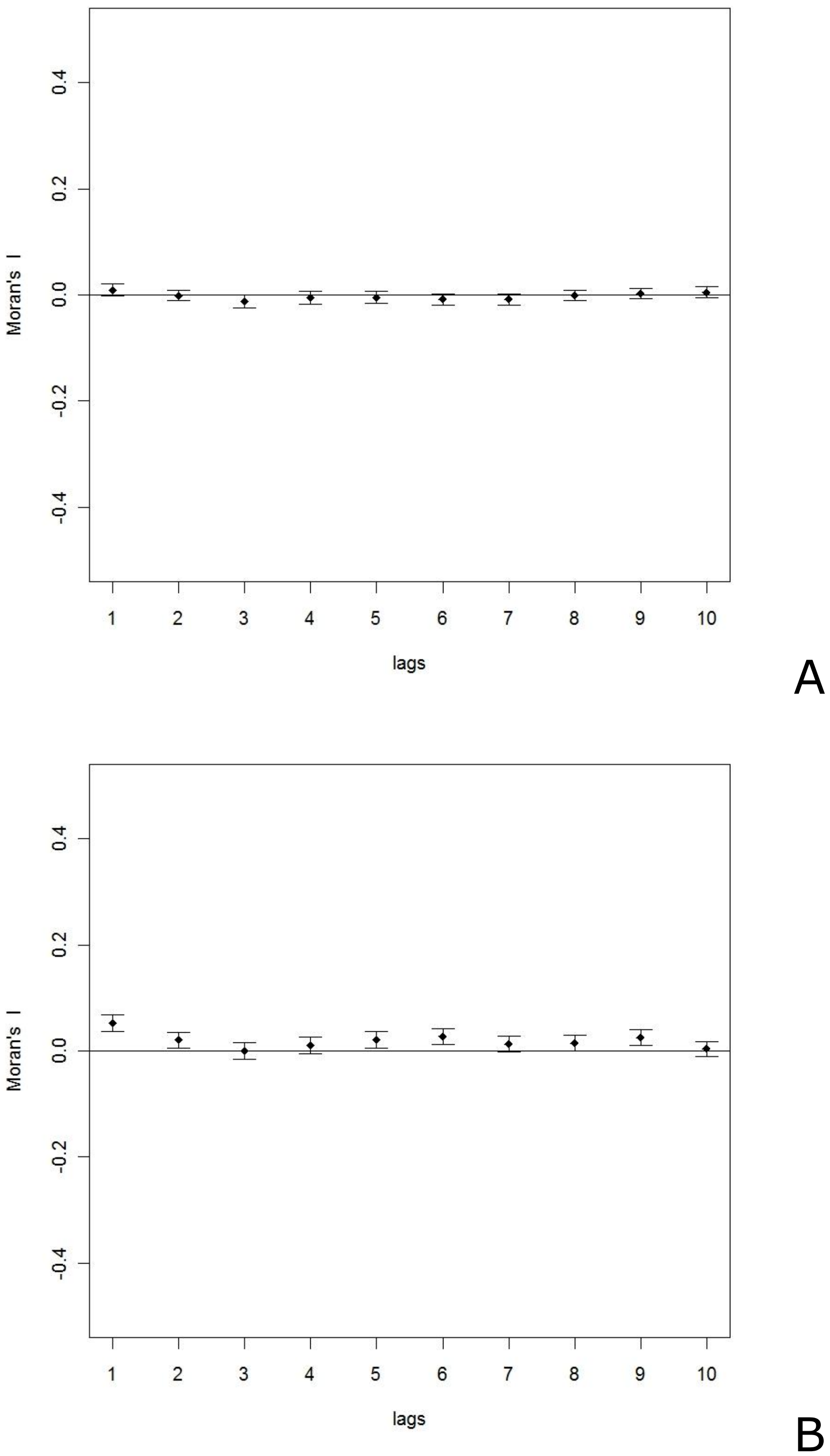


Figure 1.22 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Common Eider during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

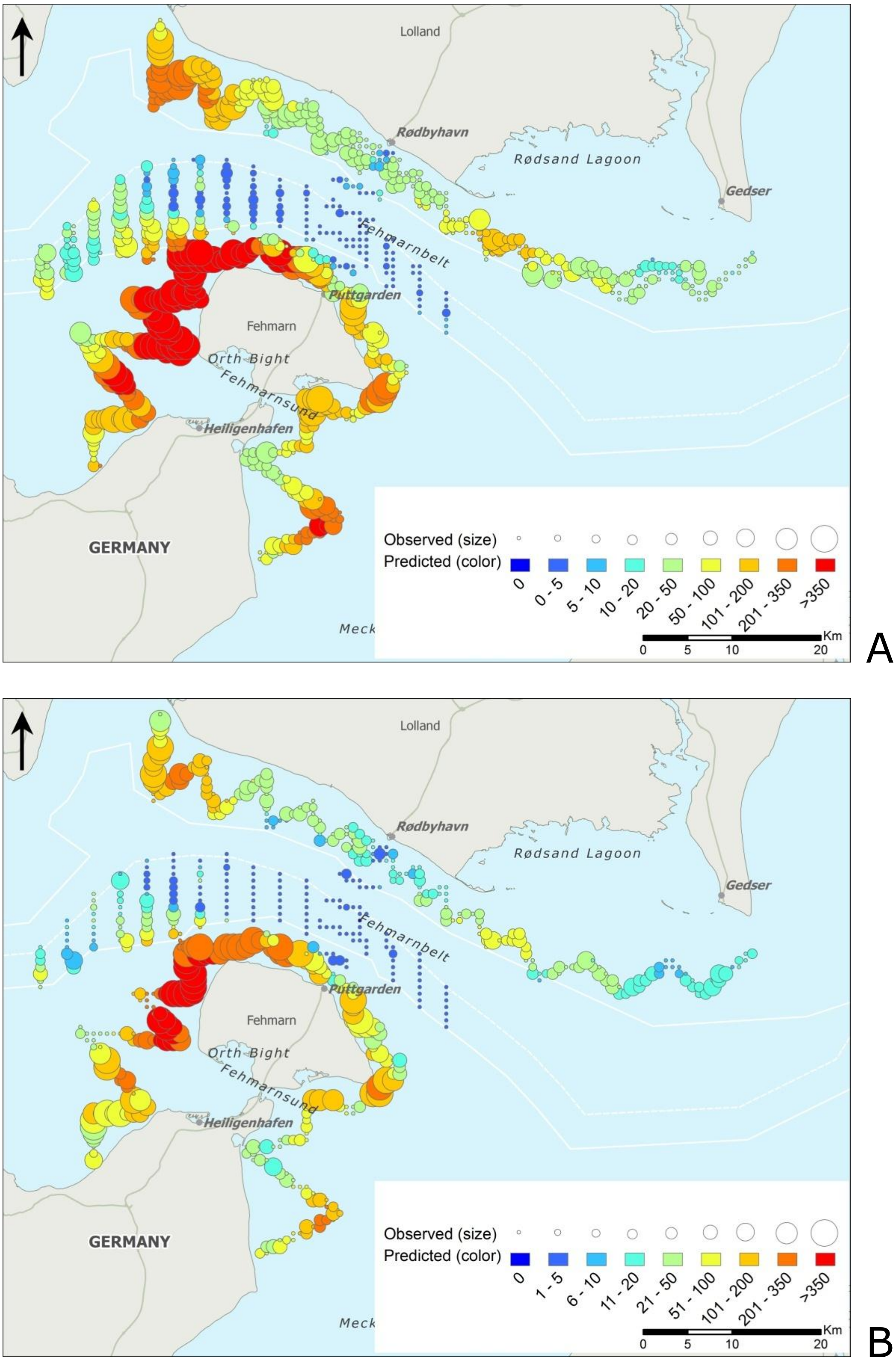
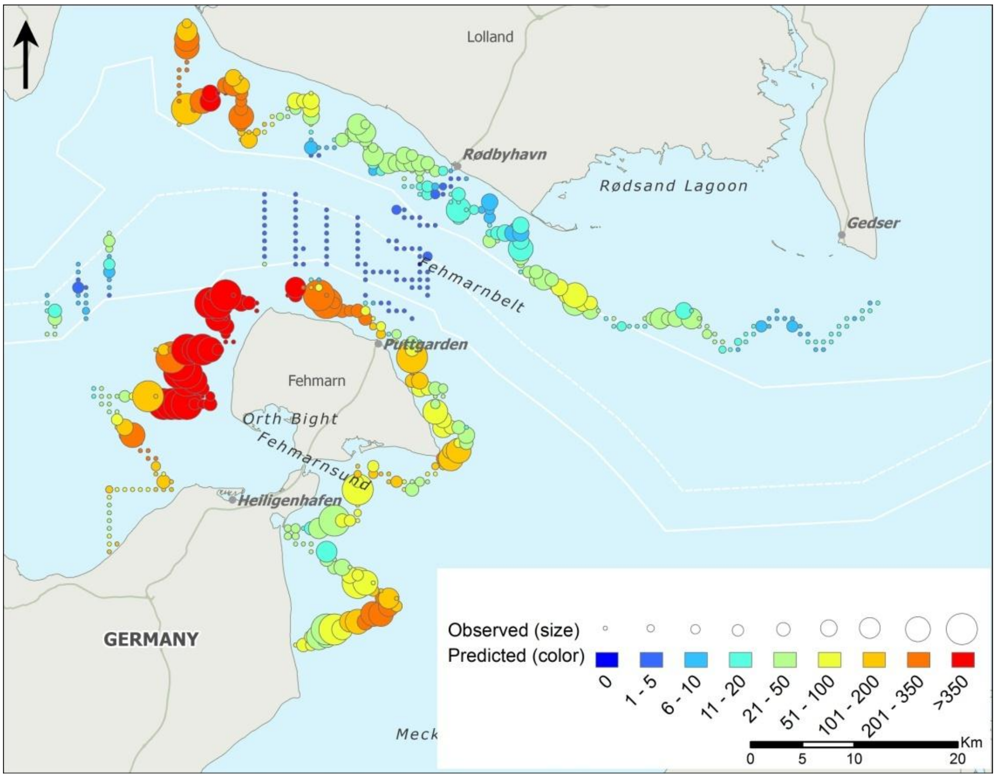


Figure 1.23 Observed and predicted values of Common Eider densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.



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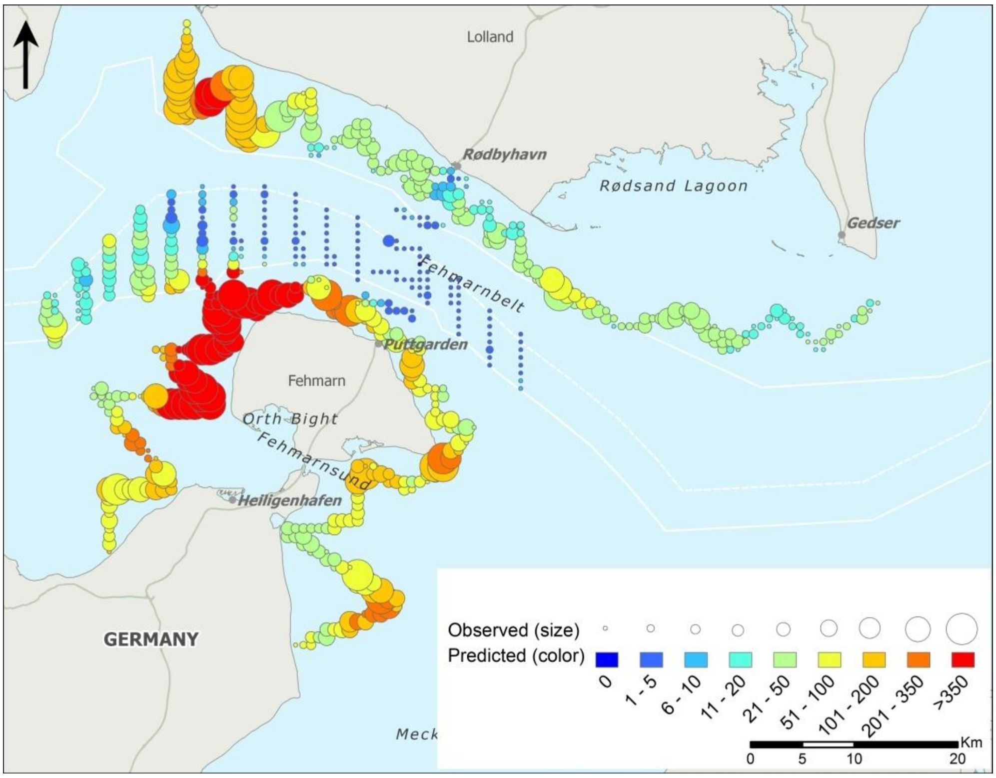


B

Figure 1.24 Observed and predicted values of Common Eider densities (ind./km^2) for season 3 (A) and season 4 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

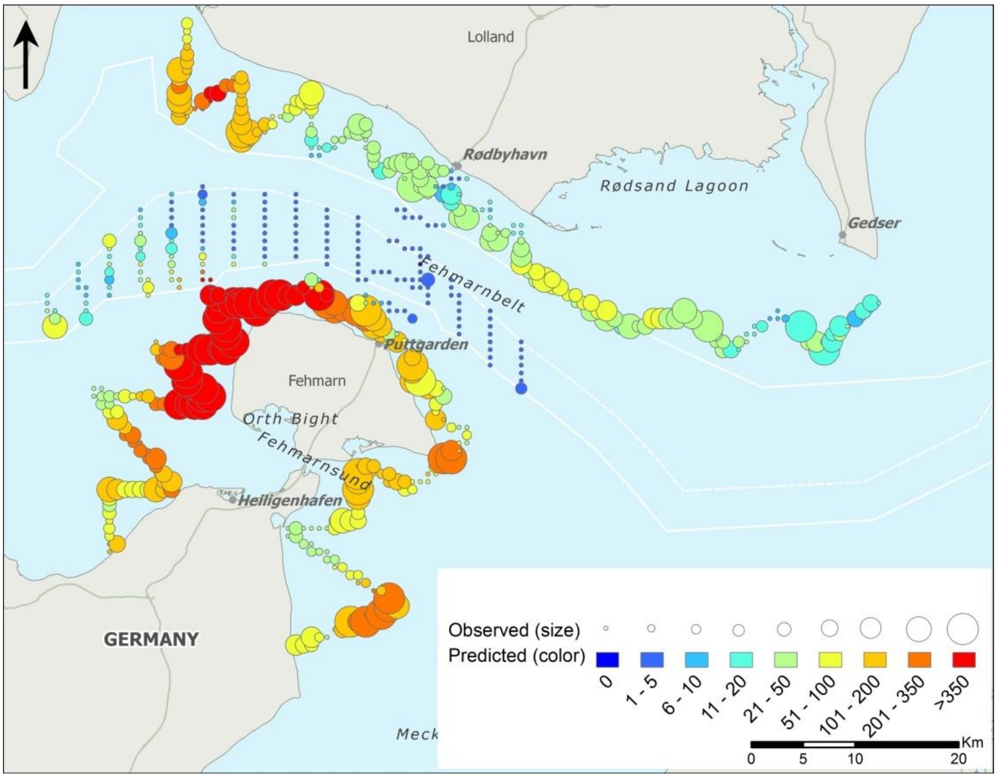


Figure 1.25 Observed and predicted values of Common Eider densities (ind./km^2) for season 5 visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

1.1.5 Long-tailed Duck – Clangula hyemalis

Model on aerial surveys

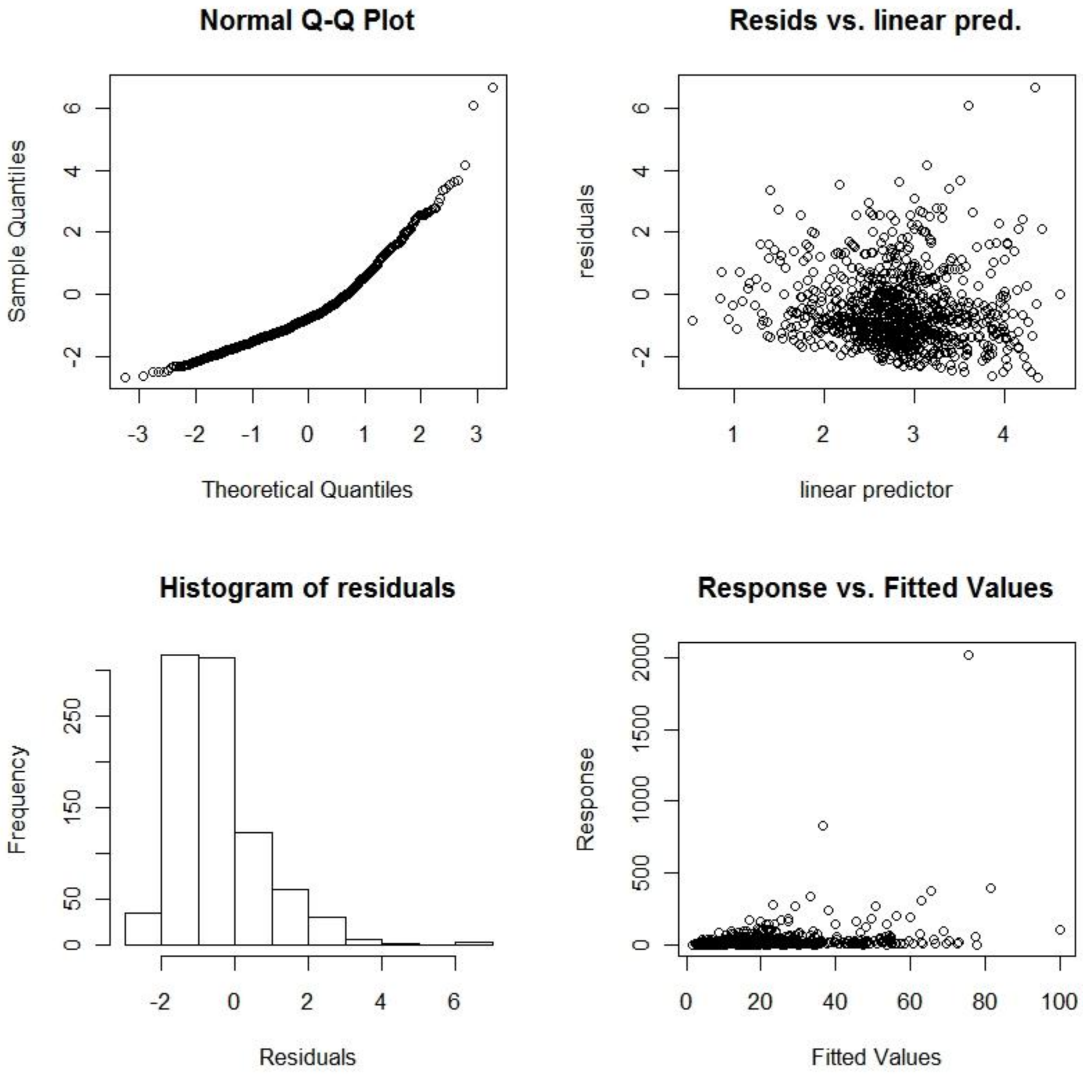
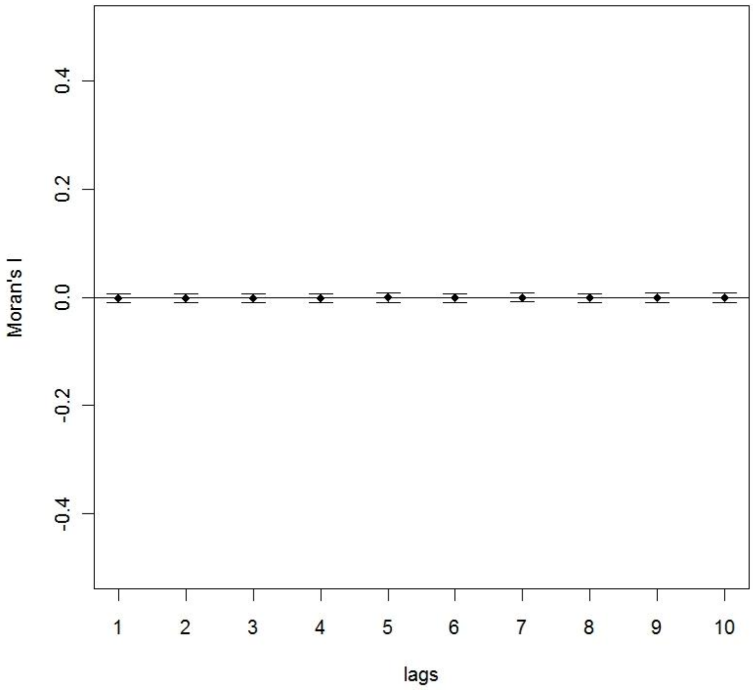


Figure 1.26 Diagnostic plots for the positive part of the two-part GAM for the Long-tailed Duck in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



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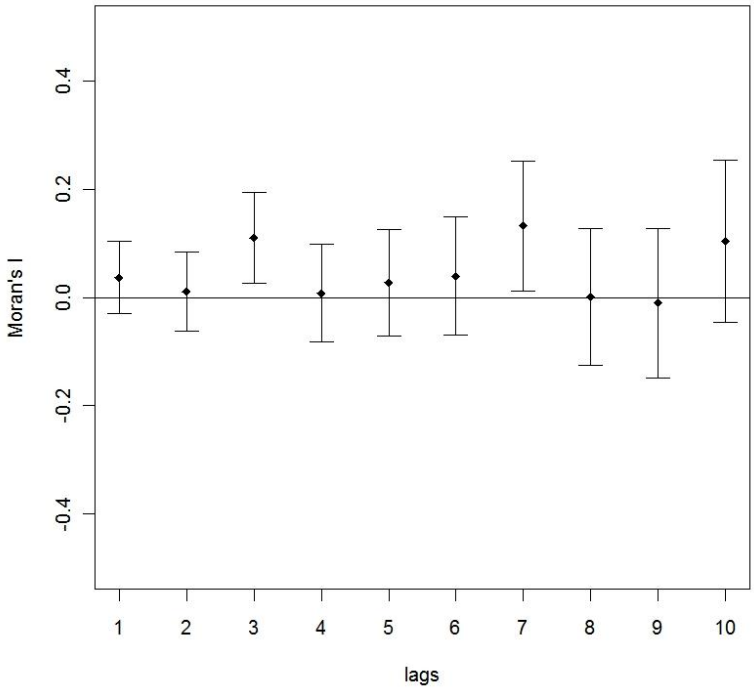
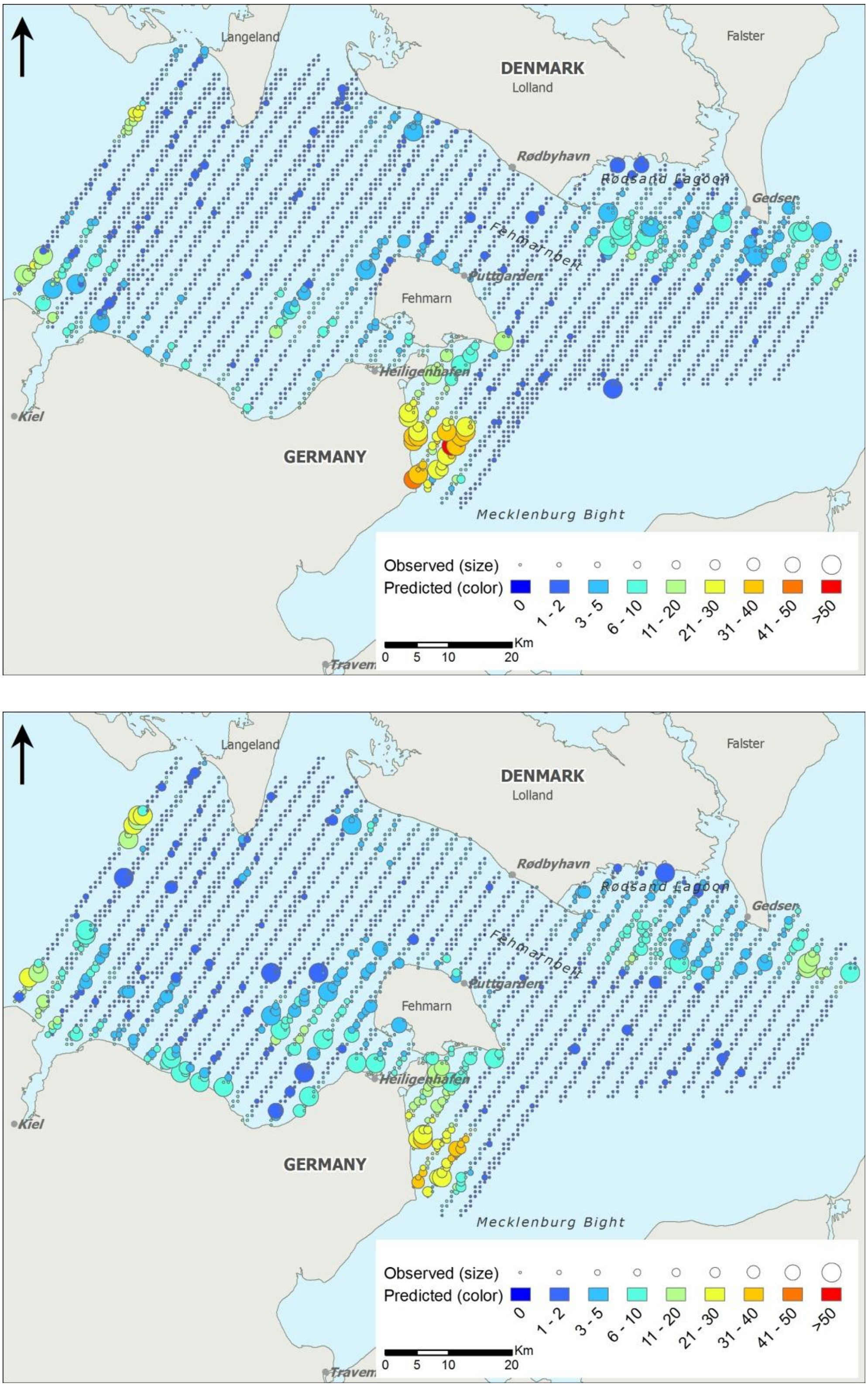


B

Figure 1.27 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Long-tailed Duck during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.



A

B

Figure 1.28 *Observed and predicted values of Long-tailed Duck densities (ind./km^2) for season1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.*

Model on ship-based surveys

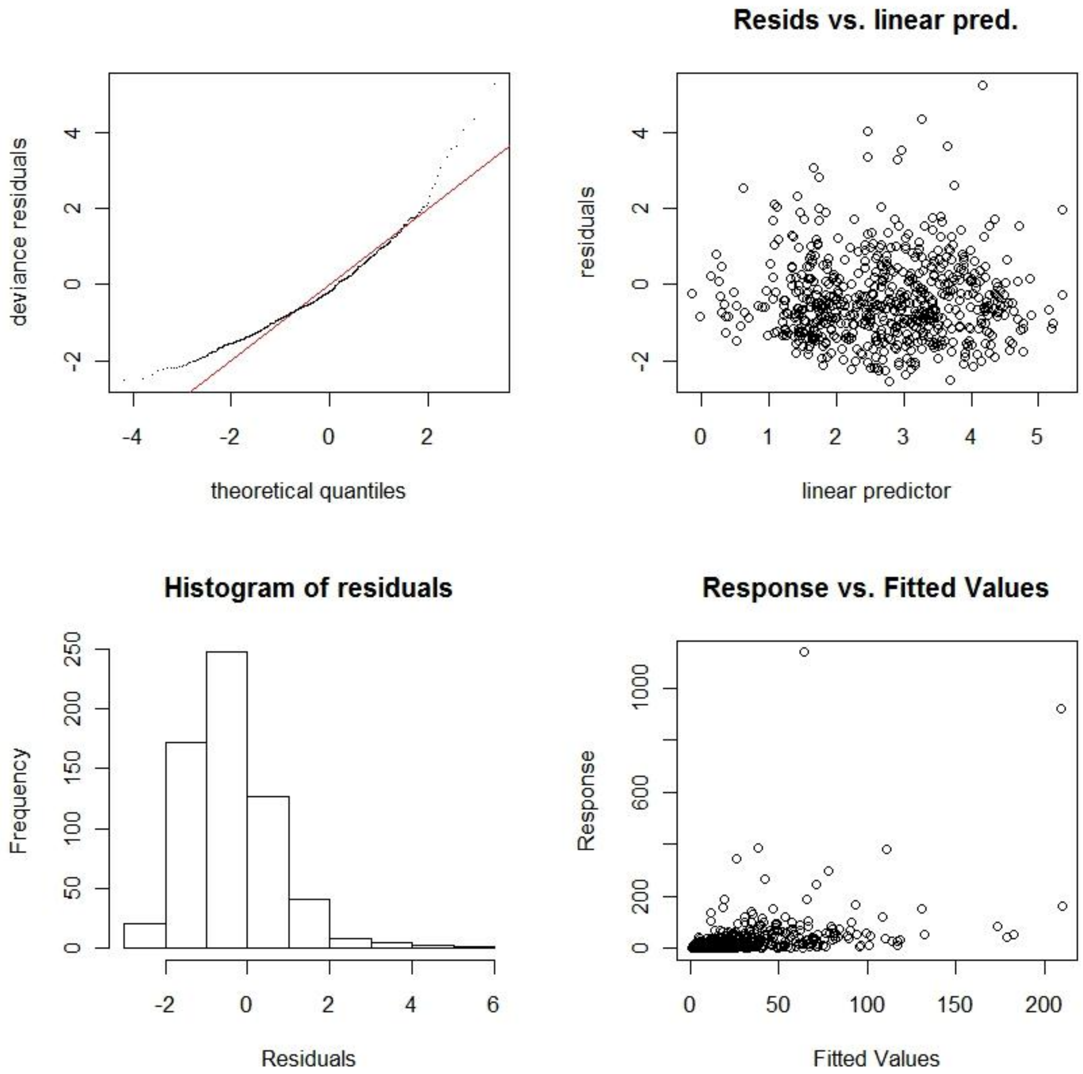


Figure 1.29 Diagnostic plots for the positive part of the two-part GAM for the Long-tailed Duck in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.

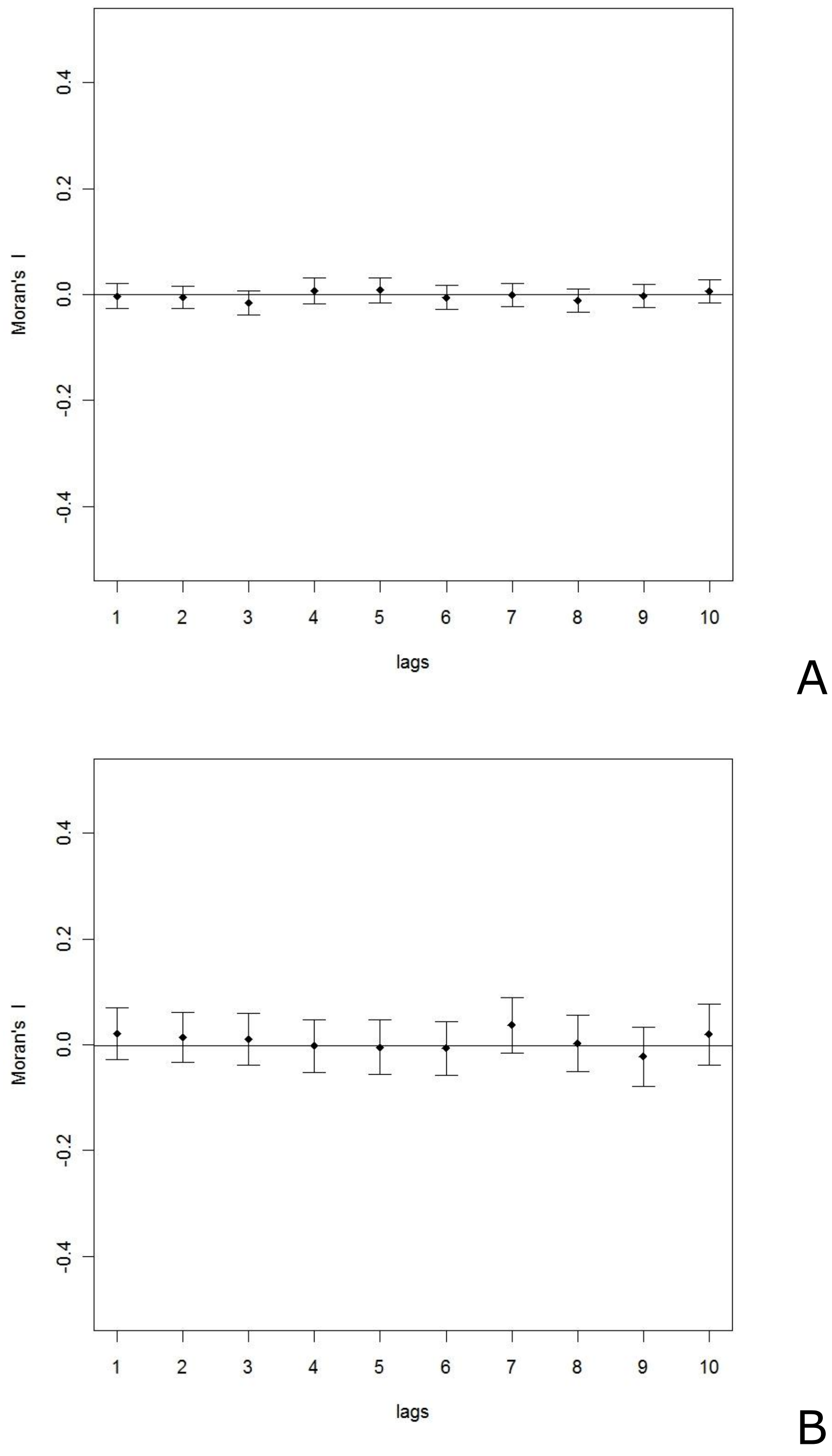


Figure 1.30 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Long-tailed Duck during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

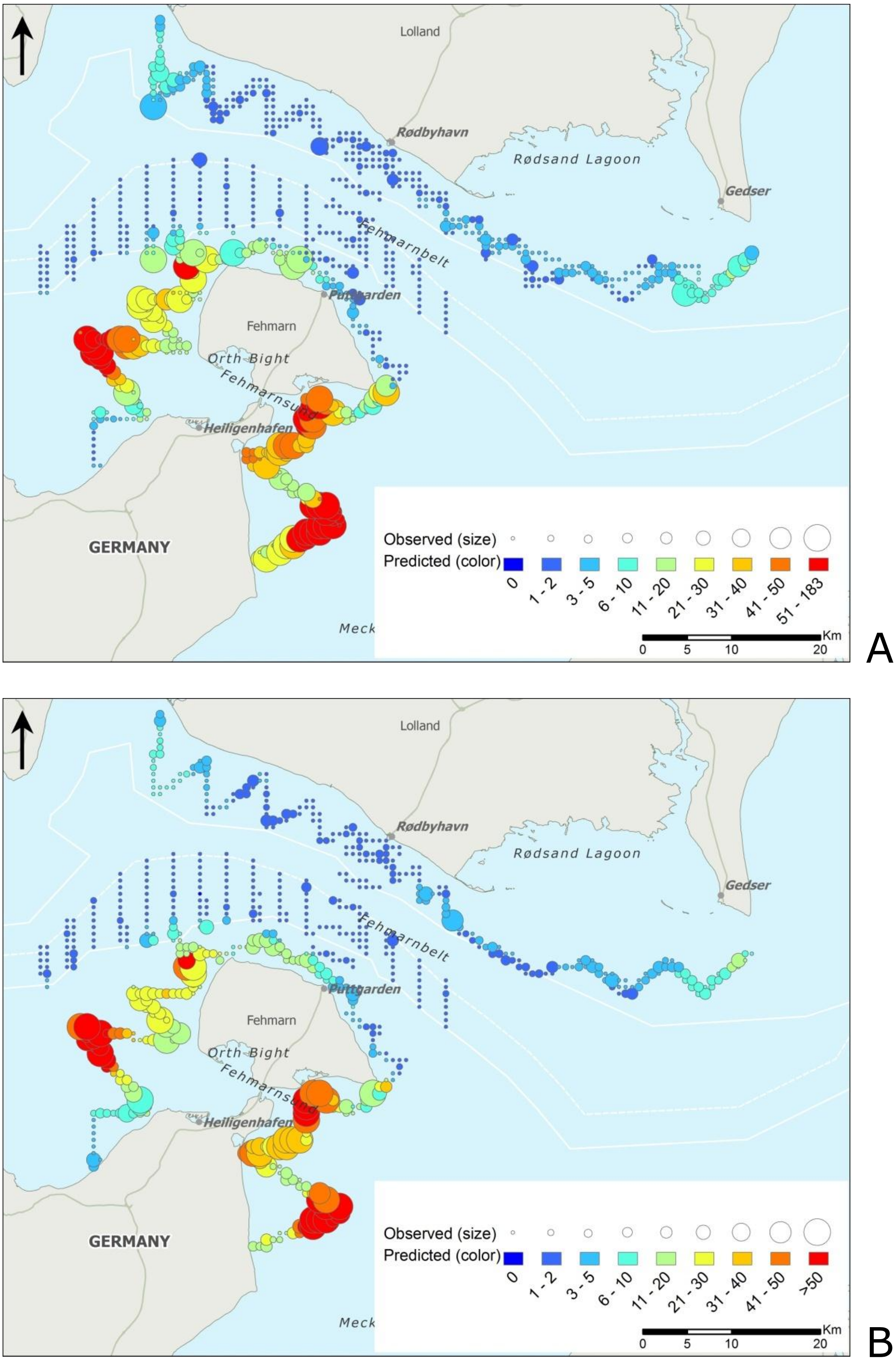


Figure 1.31 *Observed and predicted values of Long-tailed Duck densities (ind./km²) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.*

Table 1.4 Variability of Long-tailed Duck density and abundance estimates for the season indicating the highest numbers (November 2009 – March 2010) according spatial modeling using ship-based survey data.

	Mean density		Total numbers	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	1.31	0.53	277	111
SPA Kiel Bight	18.28	5.05	8,040	2,222
SPA Baltic Sea east of Wagrien	34.42	11.70	10,919	3,711
SPA Hyllekrog-Rødsand	-		-	
Residual area	2.69	1.26	4,108	1,927
Total	10.09	3.44	23,067	7,860

1.1.6 Common Scoter – Melanitta nigra

Model on aerial surveys

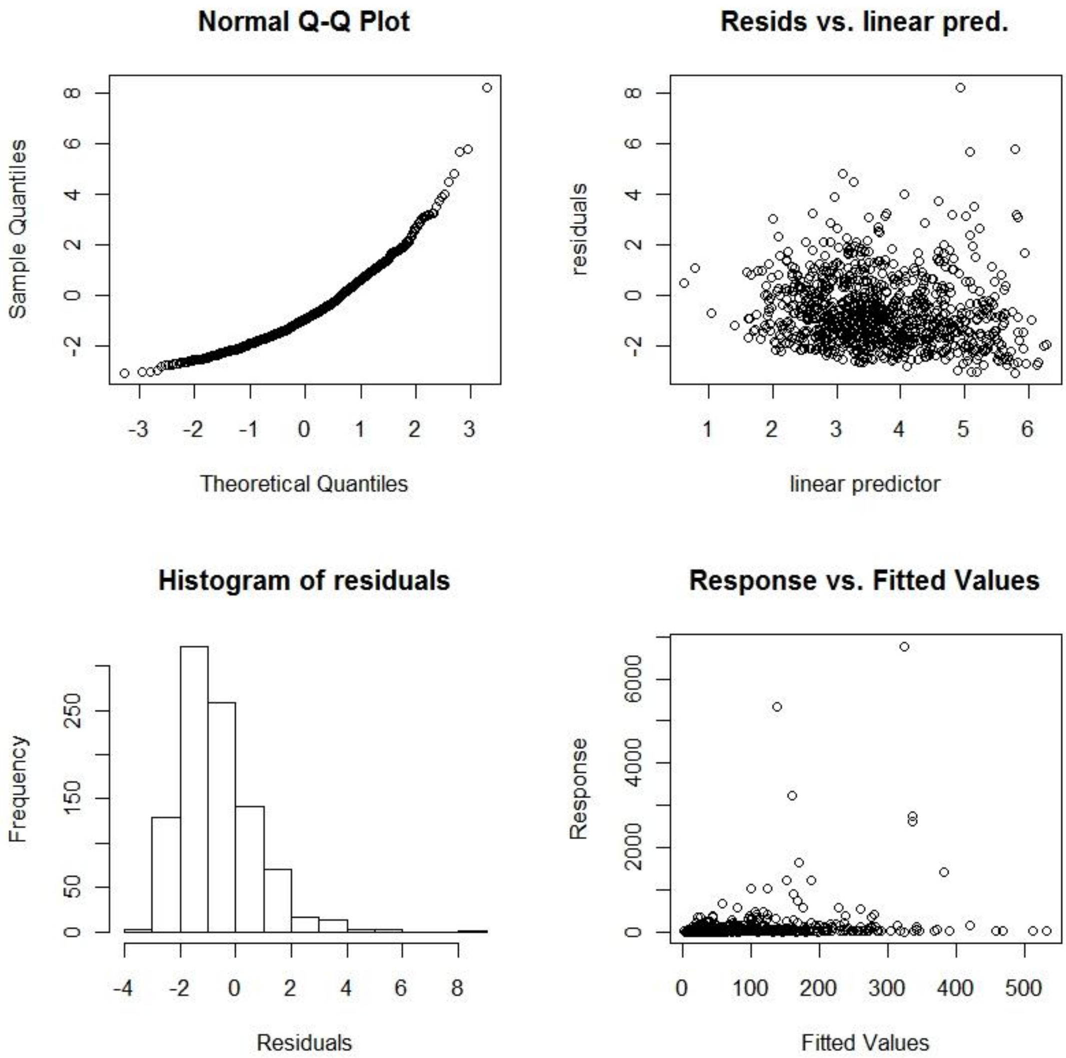
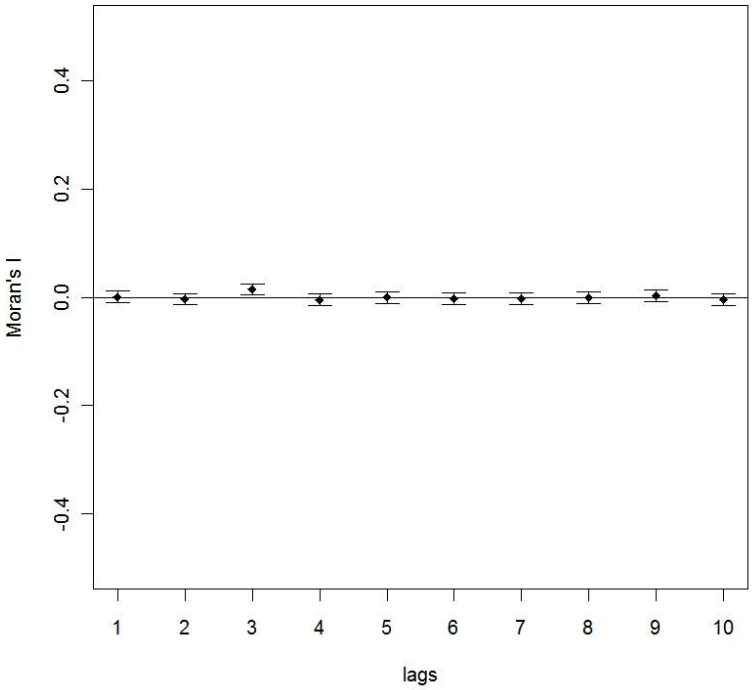
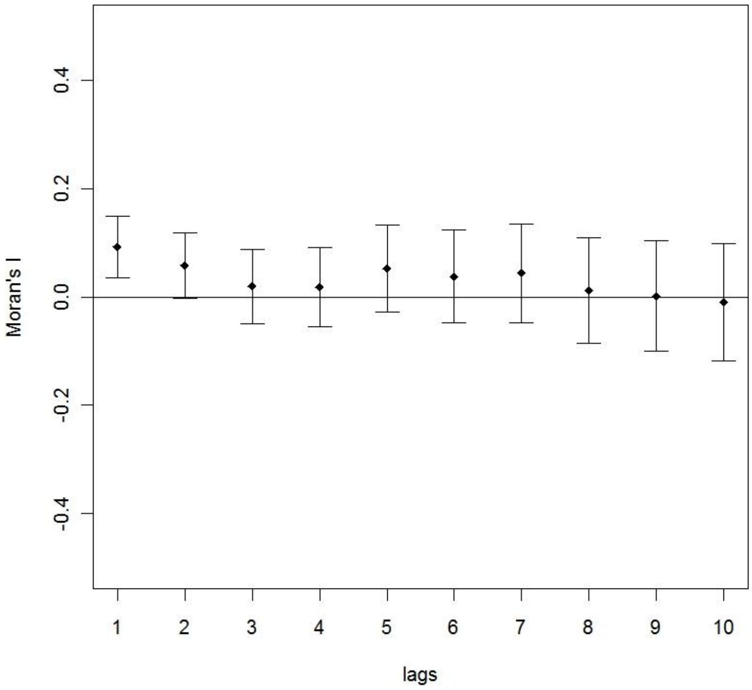


Figure 1.32 Diagnostic plots for the positive part of the two-part GAM for the Common Scoter in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



A



B

Figure 1.33 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Common Scoter during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

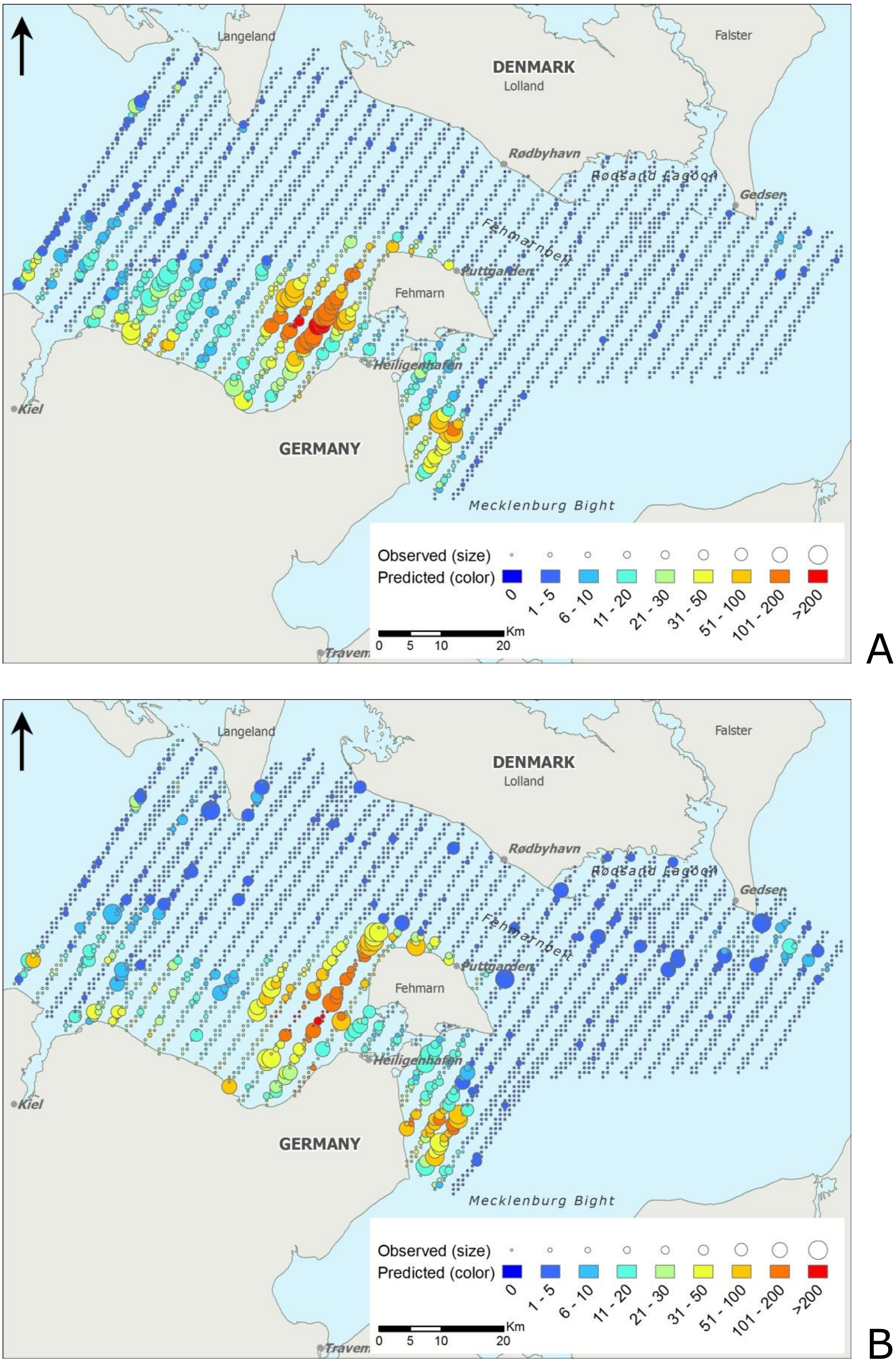


Figure 1.34 *Observed and predicted values of Common Scoter densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.*

Model on ship-based surveys

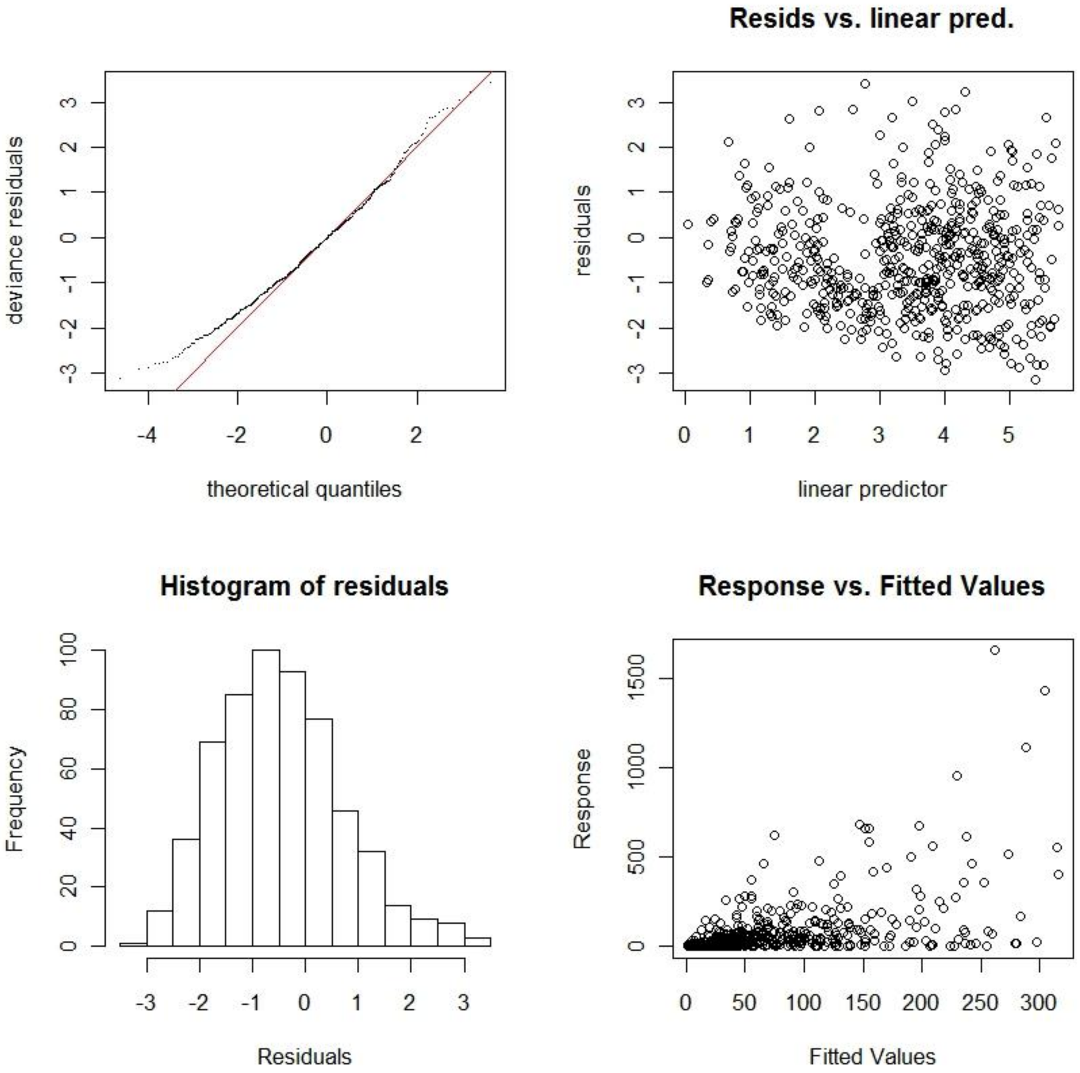
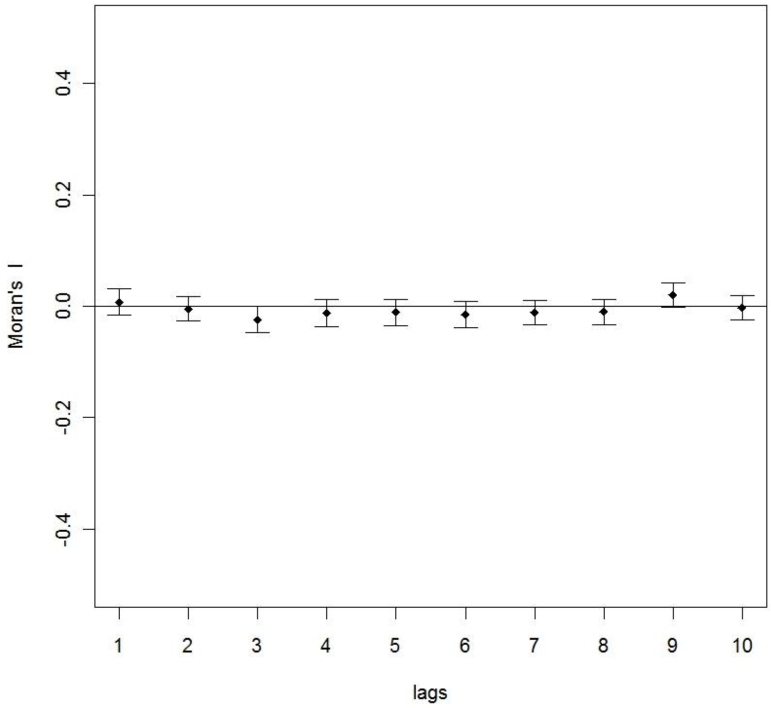
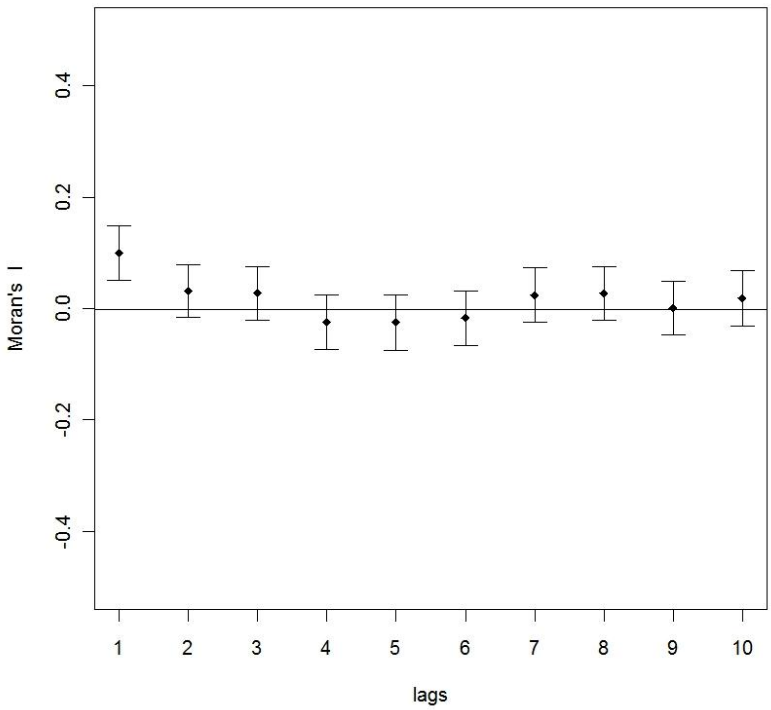


Figure 1.35 Diagnostic plots for the positive part of the two-part GAM for the Common Scoter in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



A



B

Figure 1.36 *Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Common Scoter during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.*

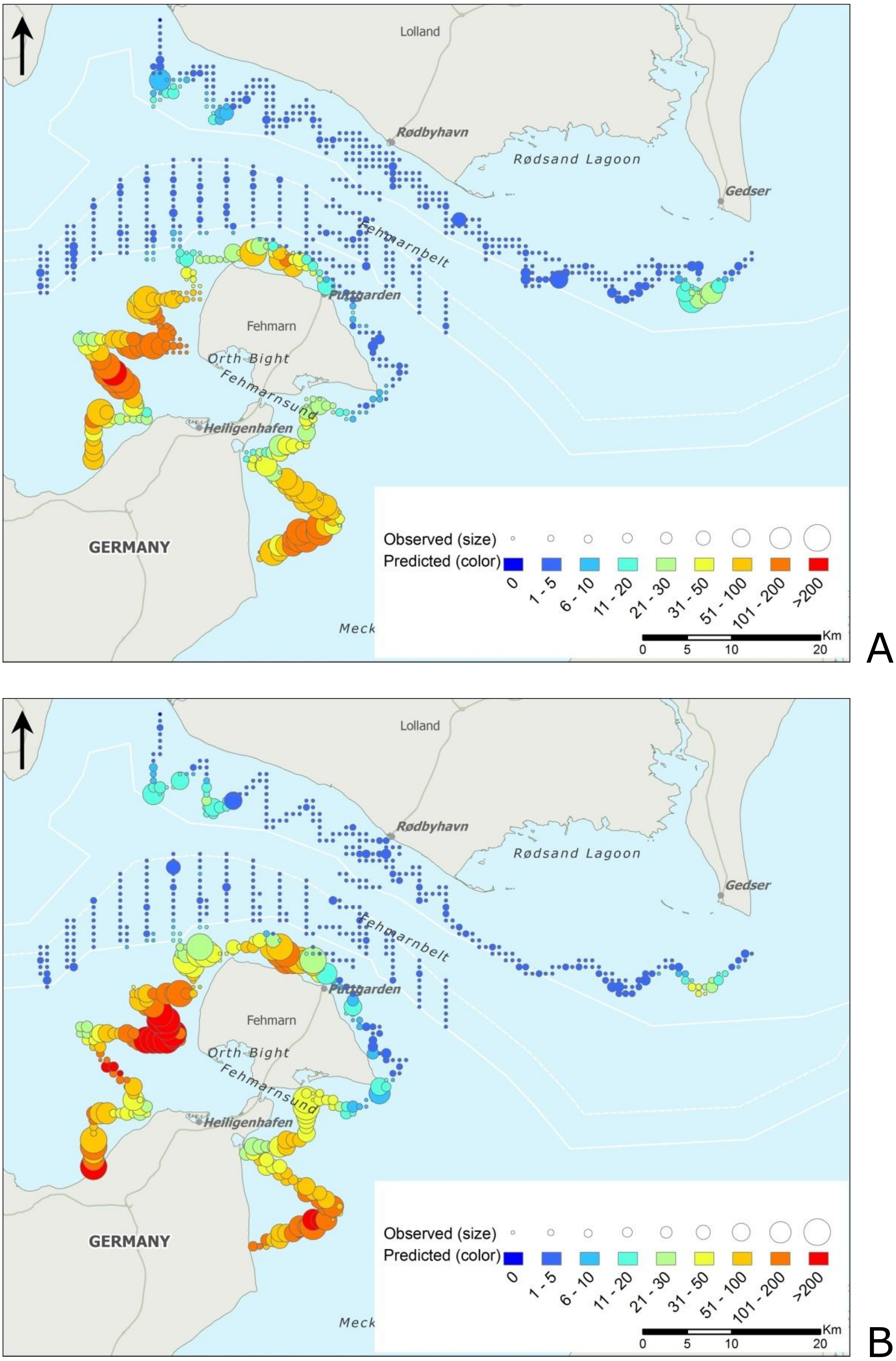


Figure 1.37 Observed and predicted values of Common Scoter densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

Table 1.5 Variability of Common Scoter density and abundance estimates for the season indicating the highest numbers (November 2009 – March 2010) according spatial modeling using ship-based survey data.

	Mean density		Total numbers	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	4.85	2.38	1,027	504
SPA Kiel Bight	89.62	30.80	39,420	13,548
SPA Baltic Sea east of Wagrien	65.01	23.03	20,623	7,306
SPA Hyllekrog-Rødsand	-	-	-	-
Residual area	3.94	2.13	6,018	3,248
Total	28.91	10.55	66,061	24,102

1.1.7 Common Goldeneye – Bucephala clangula

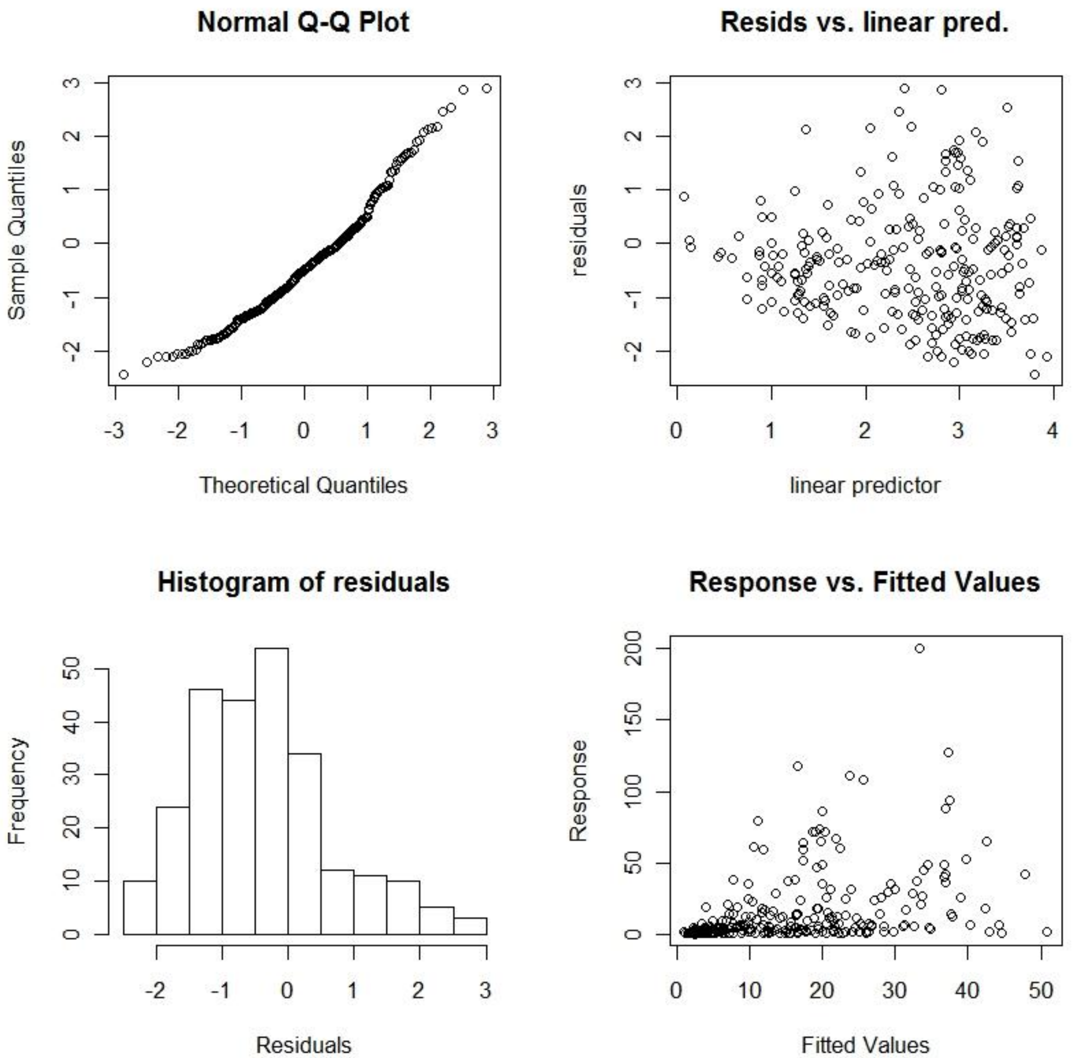
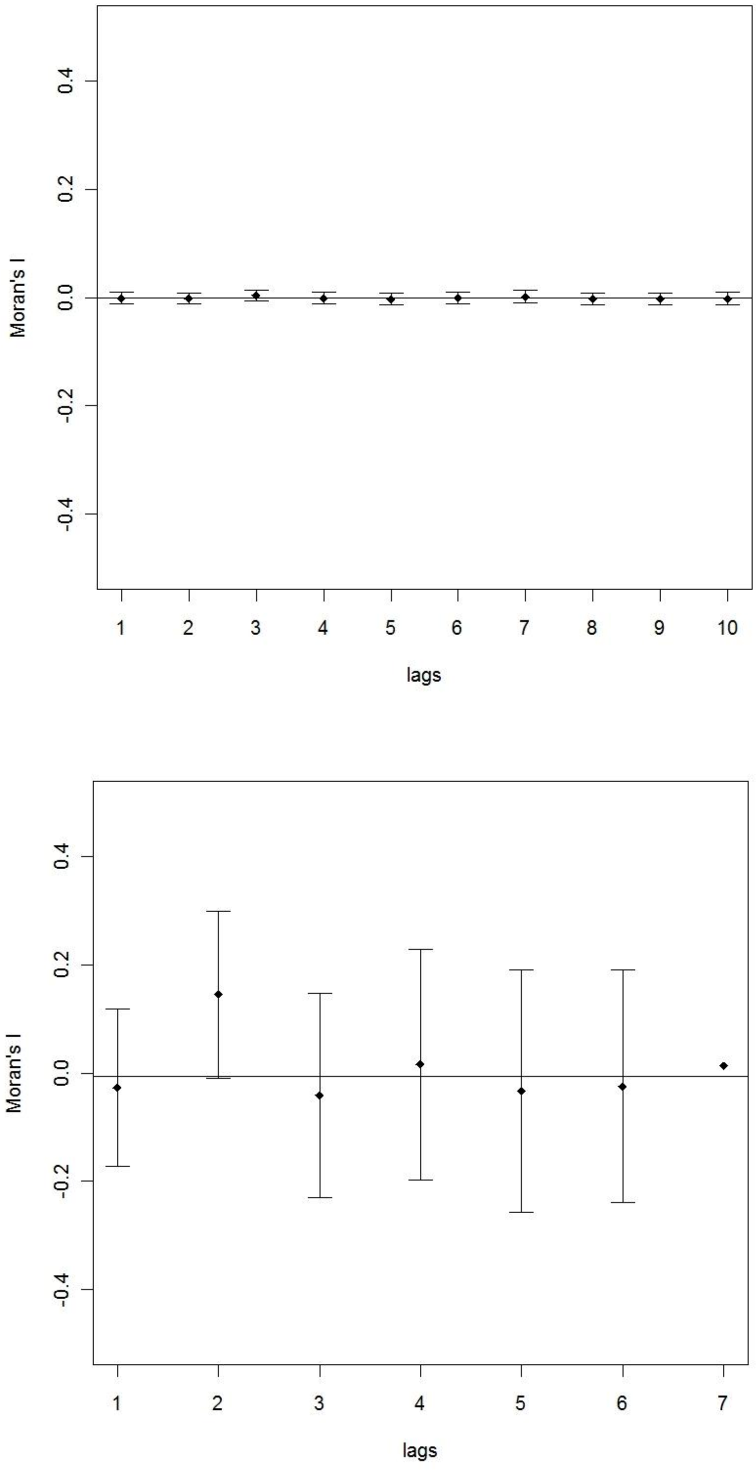


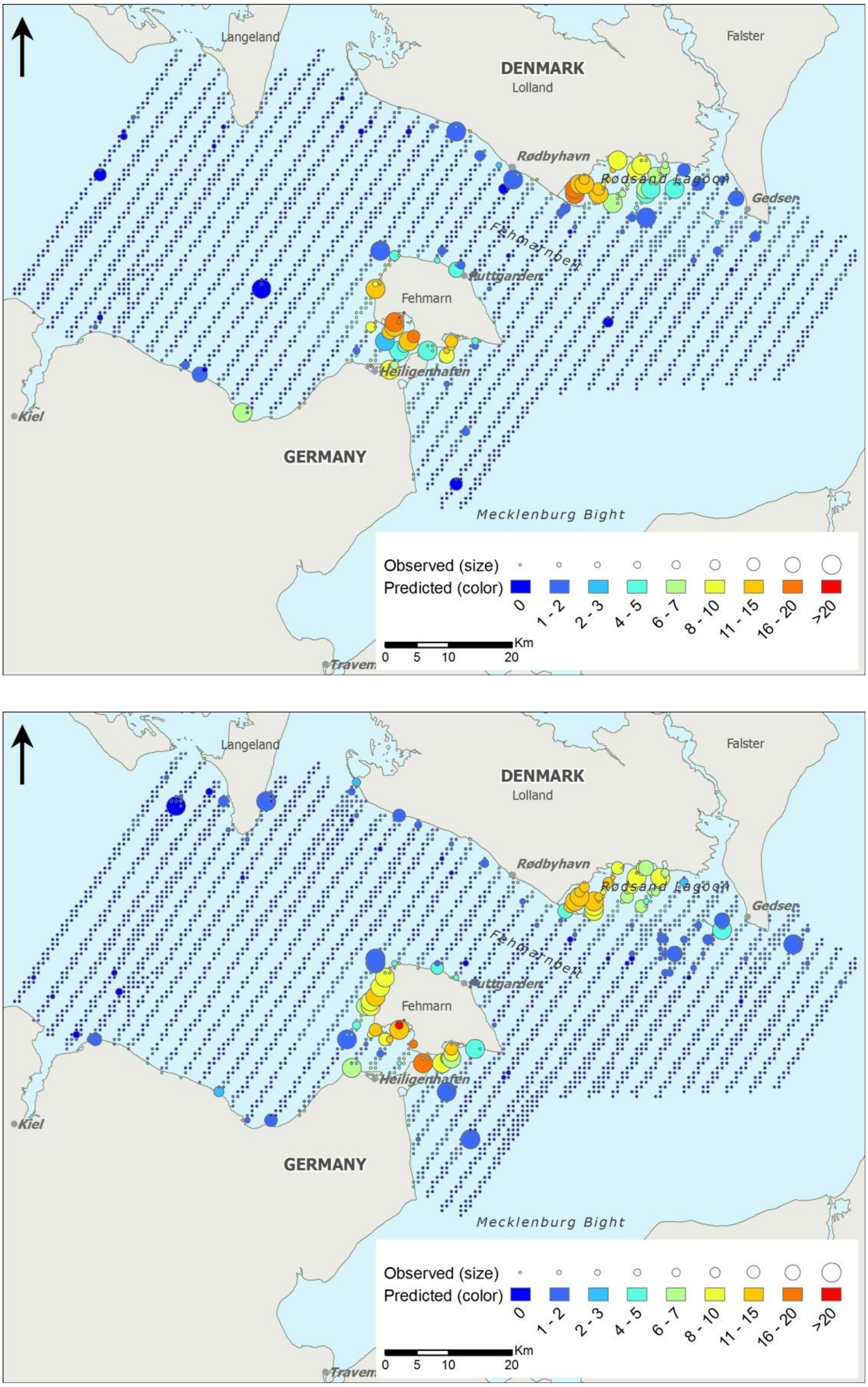
Figure 1.38 Diagnostic plots for the positive part of the two-part GAM for the Common Goldeneye in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



A

B

Figure 1.39 *Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Common Goldeneye during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.*



A

B

Figure 1.40 Observed and predicted values of Common Goldeneye densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

Table 1.6 Variability of Common Goldeneye density and abundance estimates for the season indicating the highest numbers (November 2009 – March 2010) according spatial modeling using aerial survey data.

	Mean density		Total numbers	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	0.51	0.20	107	41
SPA Kiel Bight	1.33	0.46	941	325
SPA Baltic Sea east of Wagrien	0.84	0.31	307	114
SPA Hyllekrog-Rødsand	4.87	1.38	1,196	339
Residual area	0.12	0.06	419	206
Total	0.59	0.20	2,863	984

1.1.8 Red-breasted Merganser – **Mergus serrator**

Model on aerial surveys

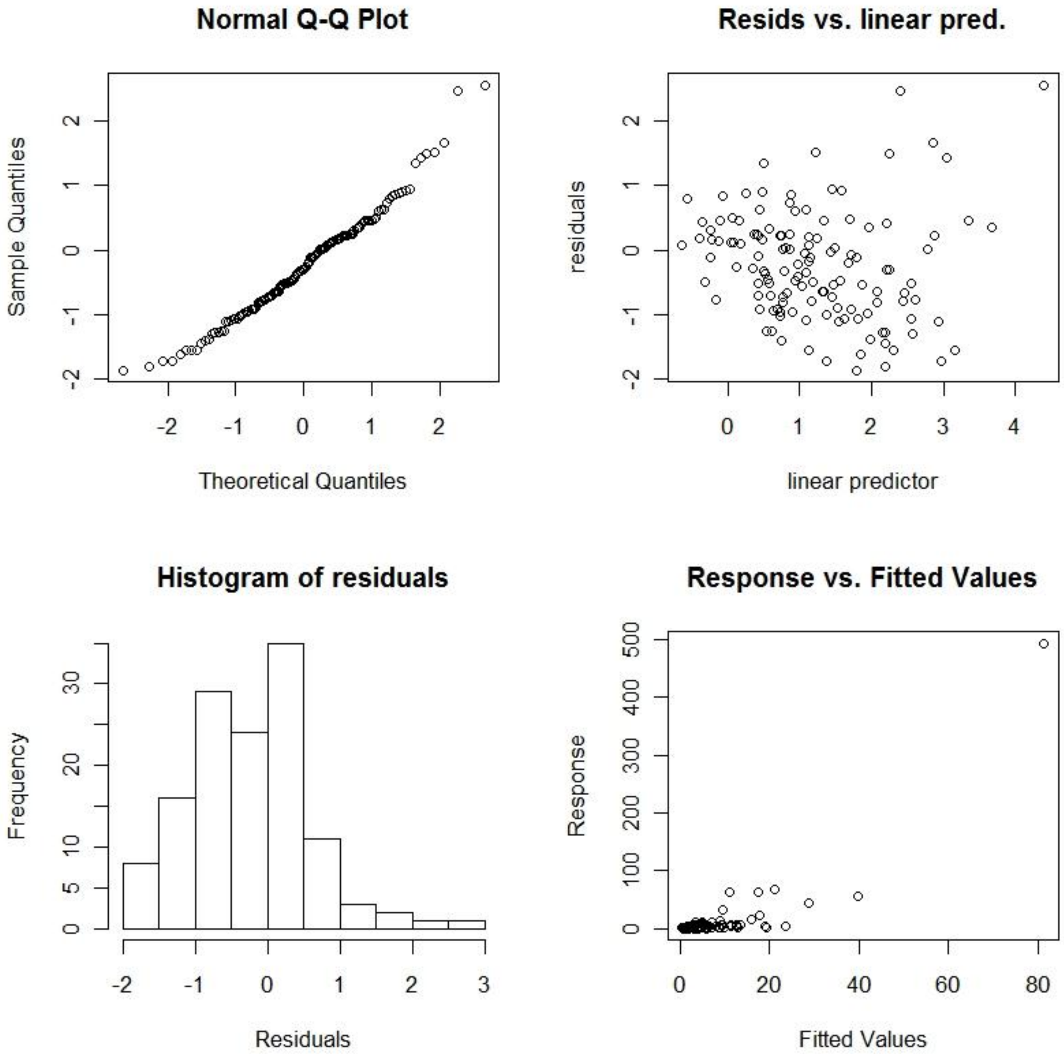
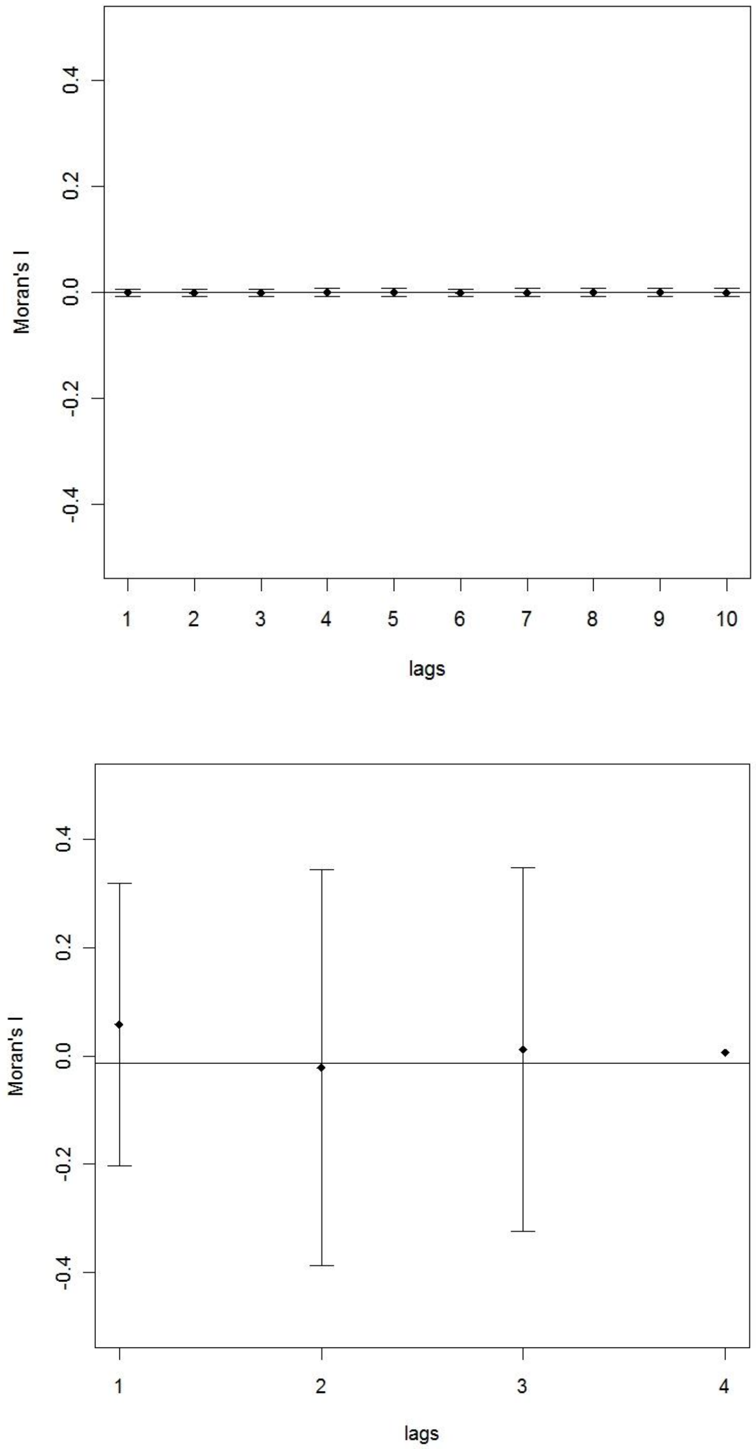


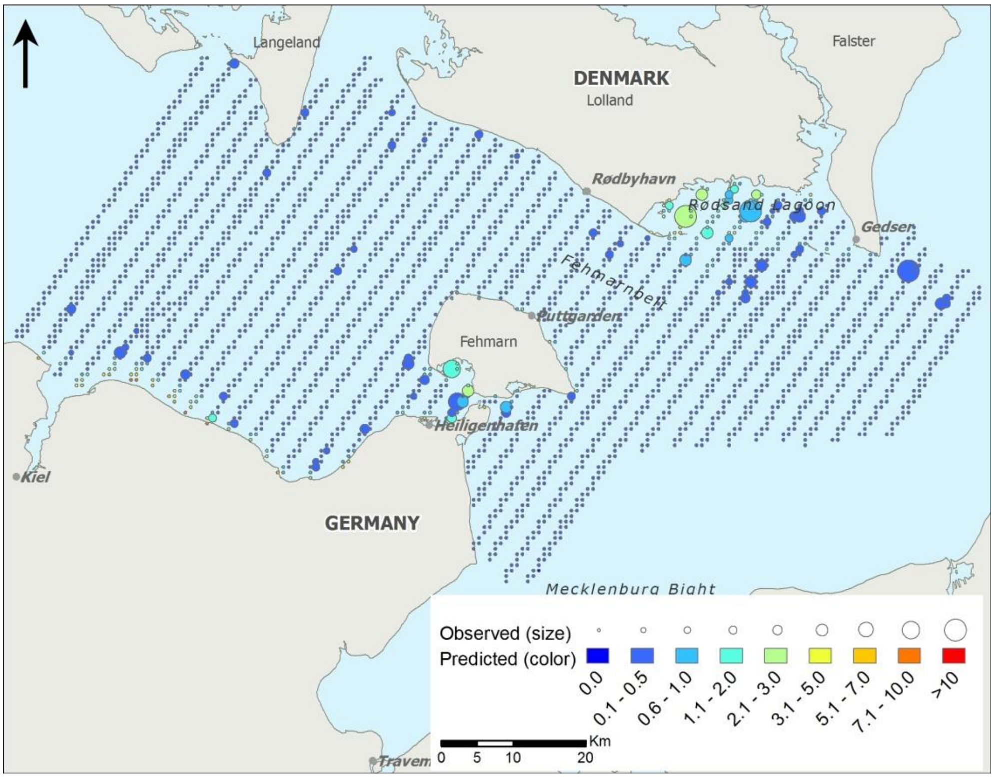
Figure 1.41 Diagnostic plots for the positive part of the two-part GAM for the Red-breasted Merganser in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



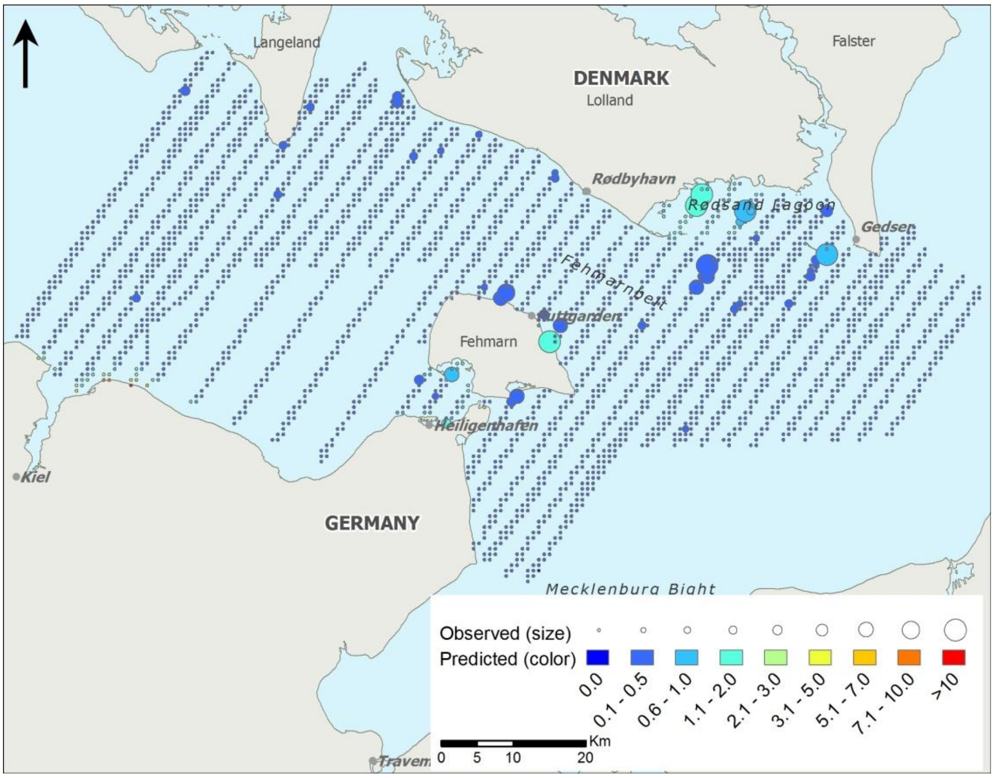
A

B

Figure 1.42 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Red-breasted Merganser during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.



A



B

Figure 1.43 Observed and predicted values of Red-breasted Merganser densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

Model on ship-based surveys

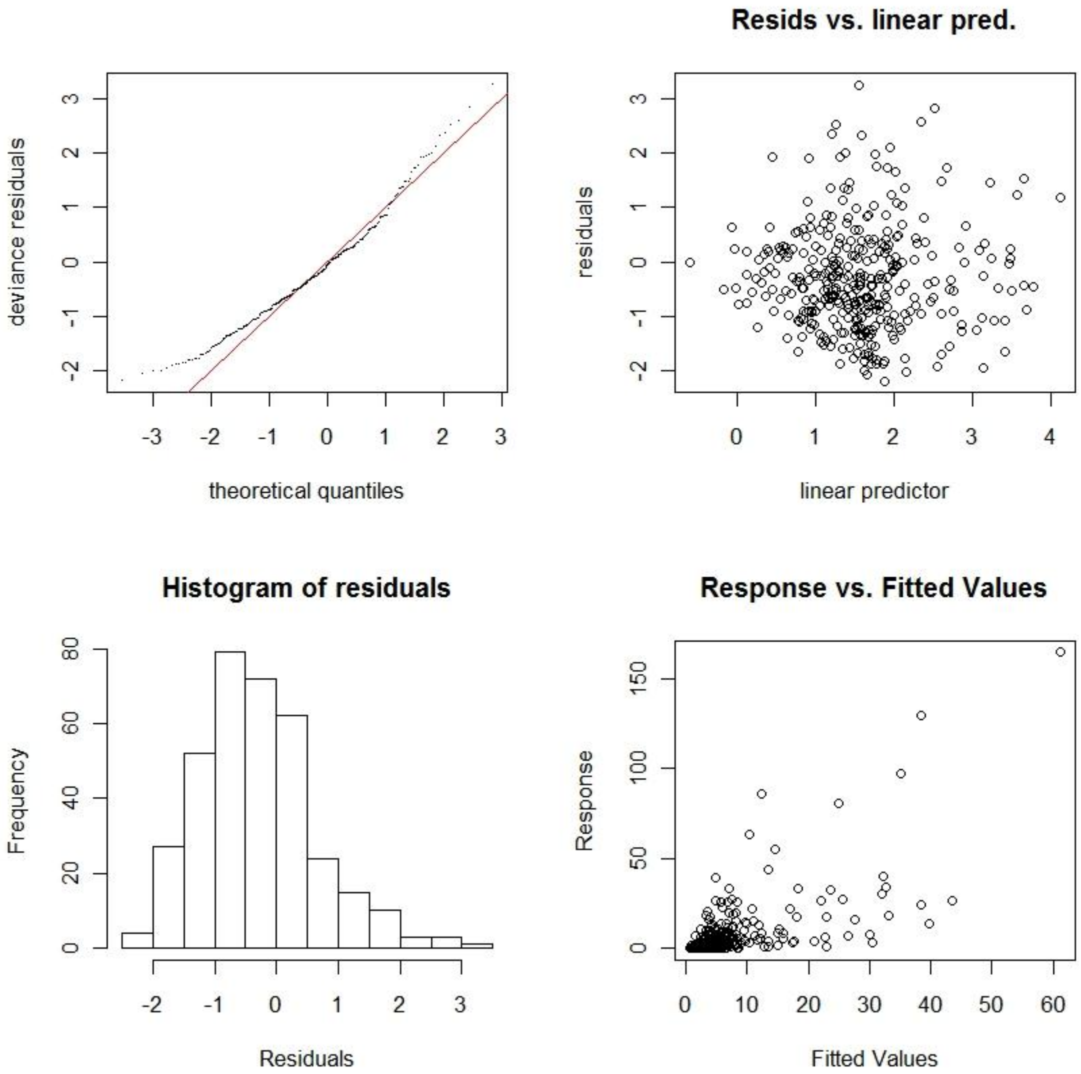
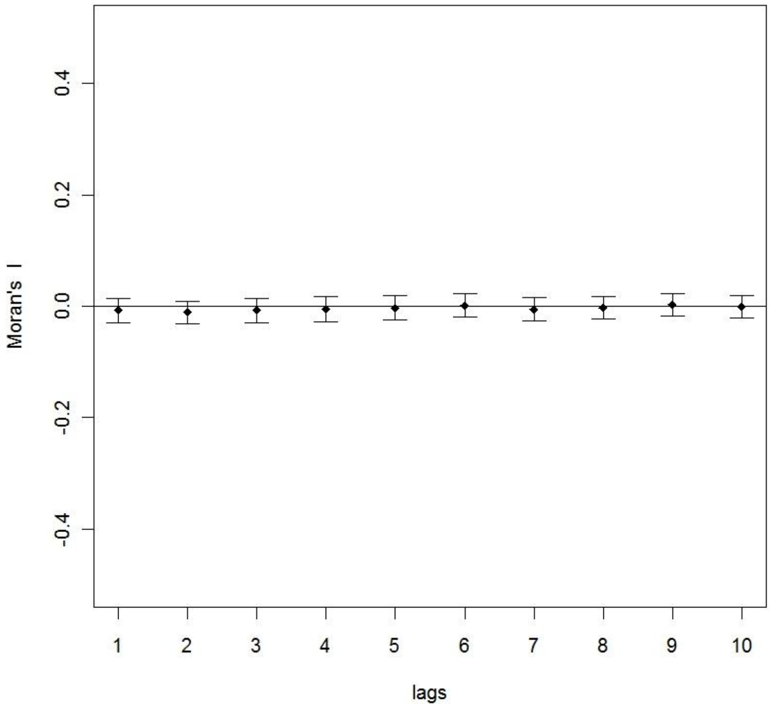
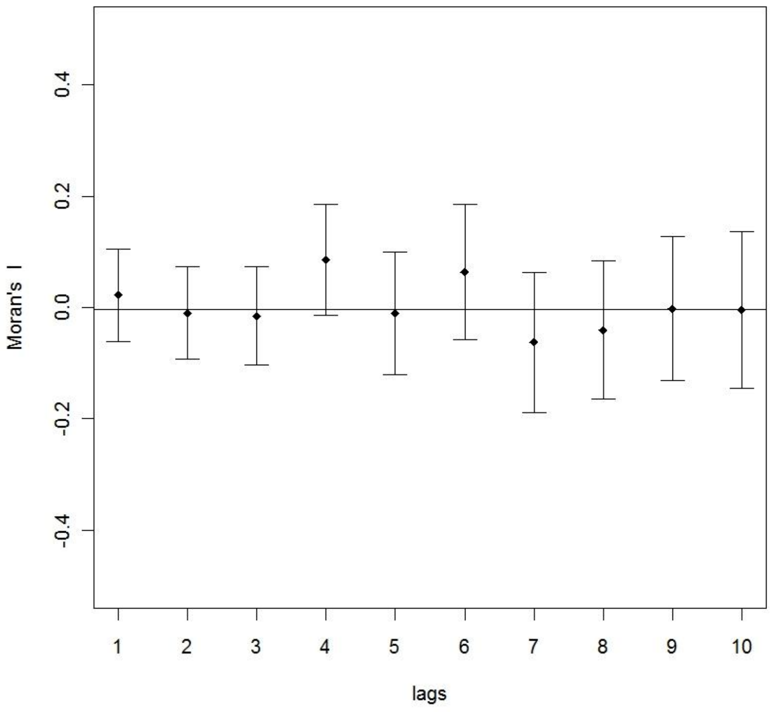


Figure 1.44 Diagnostic plots for the positive part of the two-part GAM for the Red-breasted Merganser in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.



A



B

Figure 1.45 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Red-breasted Merganser during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.

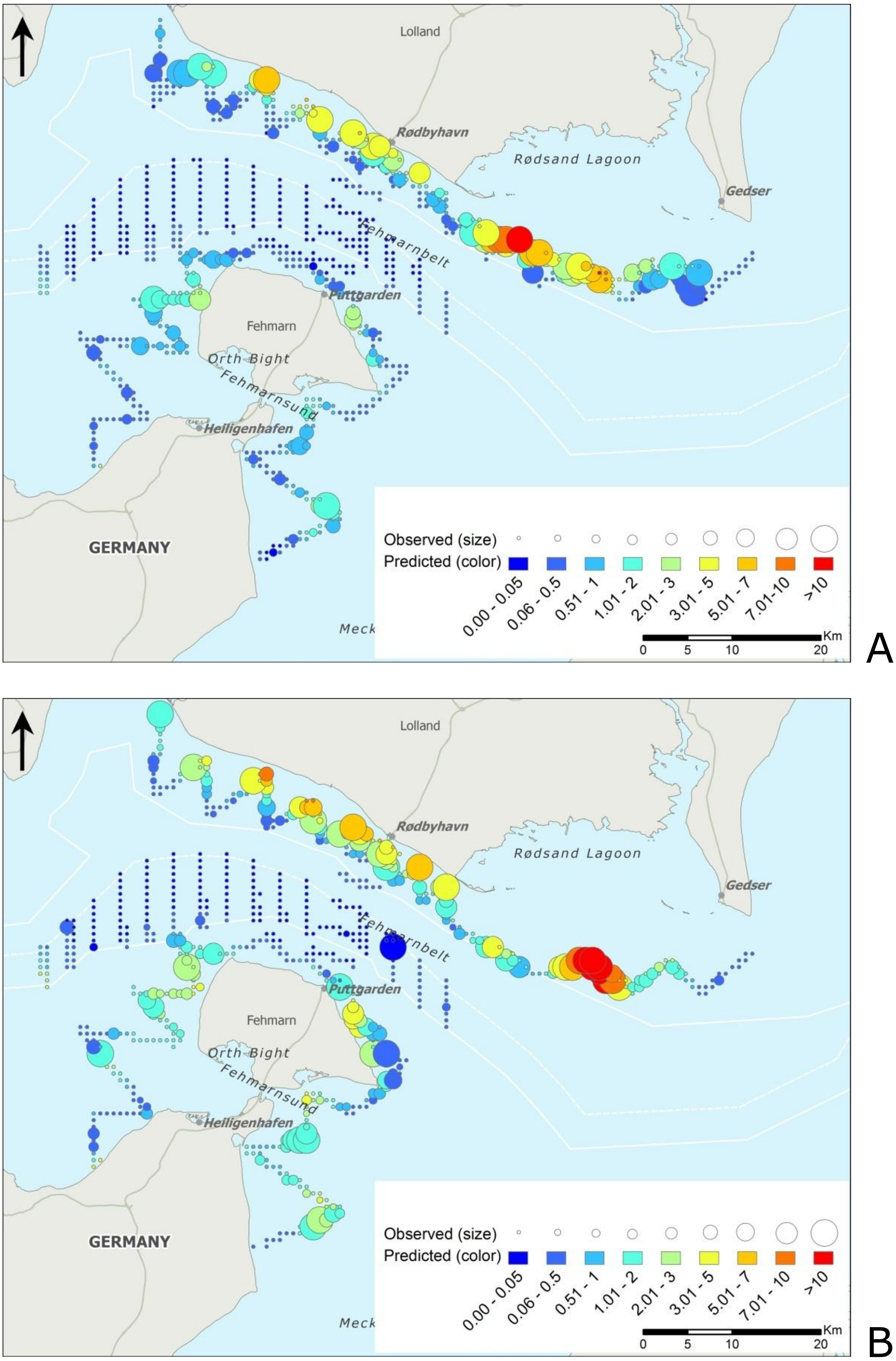


Figure 1.46 Observed and predicted values of Red-breasted Merganser densities (ind./km²) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

Table 1.7 Variability of Red-breasted Merganser density and abundance estimates for the season indicating the highest numbers (November 2009 – March 2010) according spatial modeling using ship-based survey data.

	Mean density		**Total numbers**	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	1.23	0.48	253	100
SPA Kiel Bight	1.04	0.59	451	255
SPA Baltic Sea east of Wagrien	1.16	0.55	363	173
SPA Hyllekrog-Rødsand	-	-	-	-
Residual area	1.96	1.11	2,971	1,681
Total	1.67	0.93	3,785	2,109

1.1.9 Razorbill – Alca torda

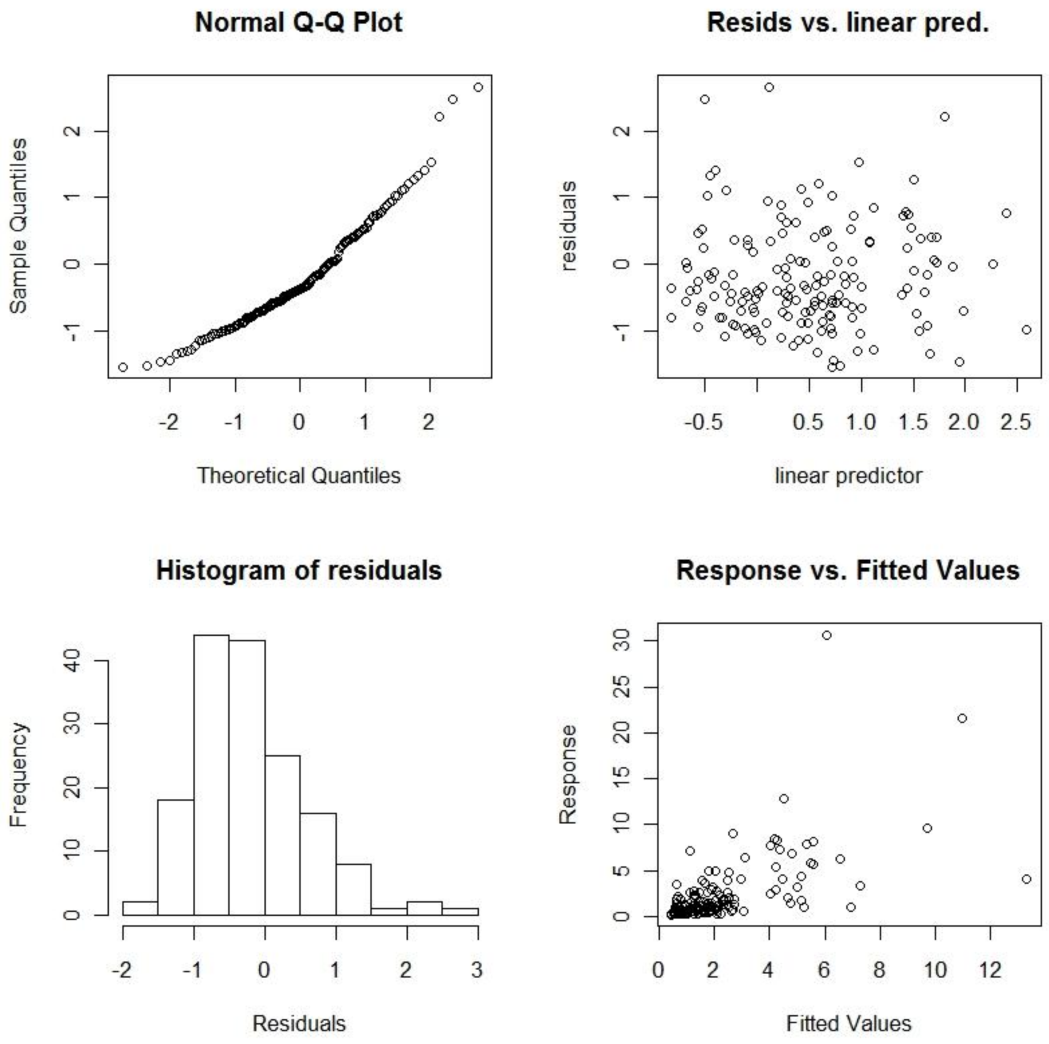
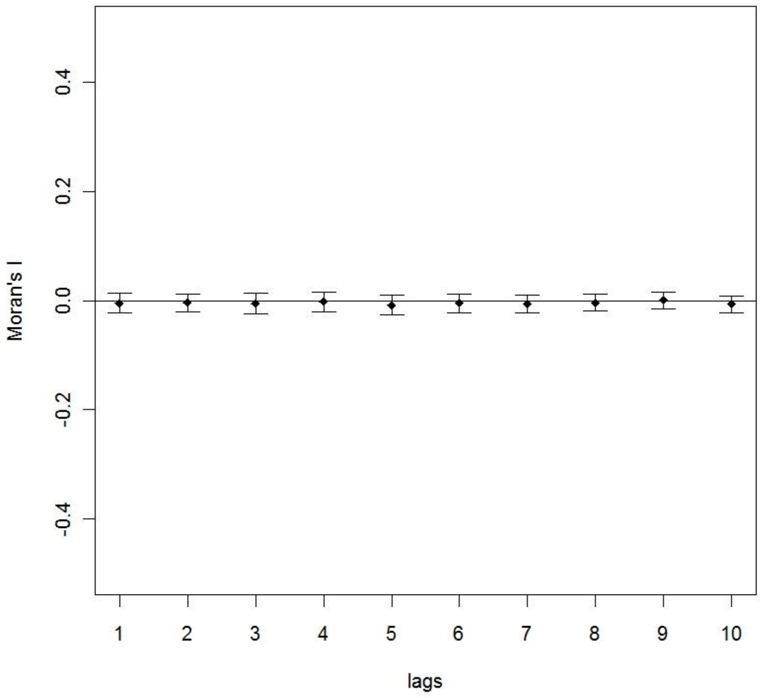
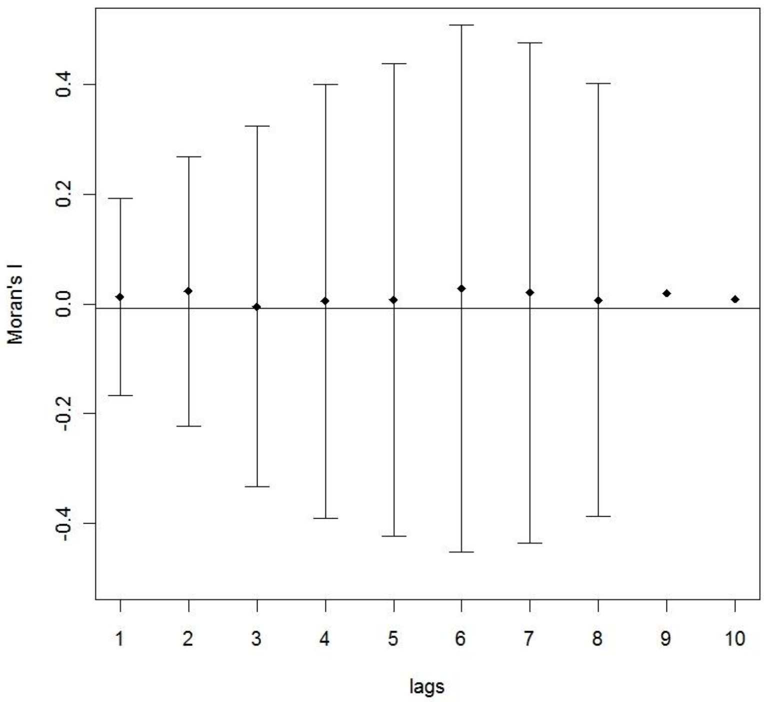


Figure 1.47 Diagnostic plots for the positive part of the two-part GAM for the Razorbill in Fehmarnbelt during the winter period. Normality of the residuals is displayed in a Q-Q plot (upper left) and in a histogram (lower left). The spread of the residuals is displayed in the upper right plot whereas the predicted against the observed values are plotted in the lower right plot.

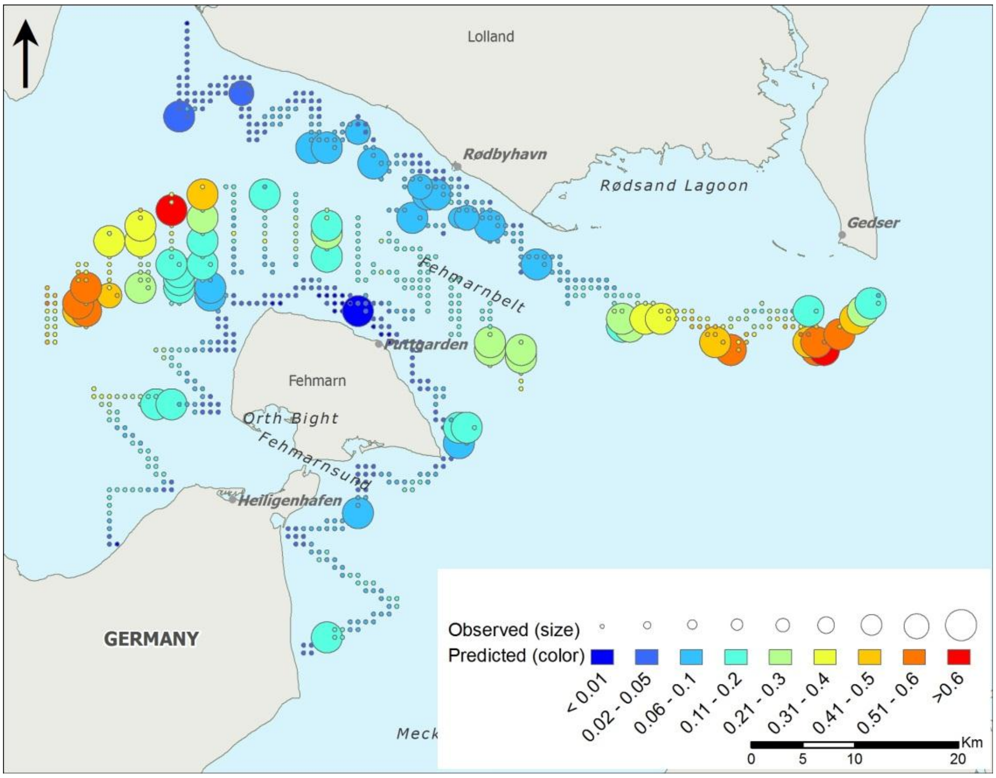


A

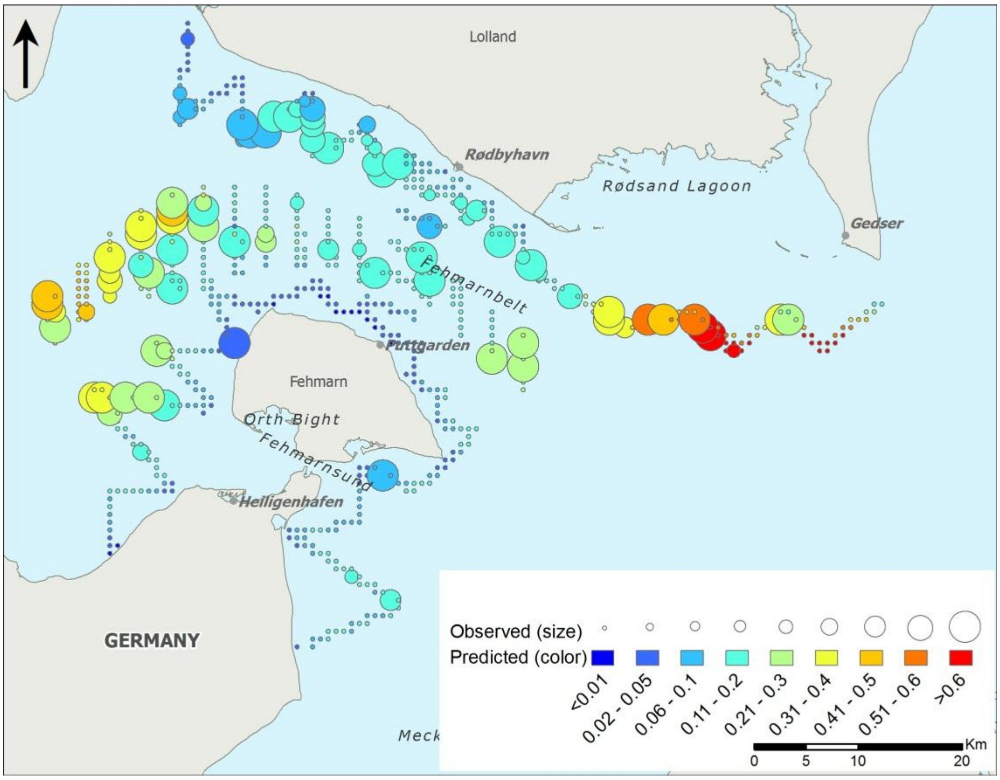


B

Figure 1.48 Spatial correlograms displaying the spatial autocorrelation over 10 lags in the residuals for the two-part GAM model for the Razorbill during the winter period in the Fehmarnbelt (A – binomial part, B – positive part). The dots indicate the estimated Moran's I value and the bars show twice the square root of the variance from the estimated Moran's I value. 1 lag equals the defined nearest neighborhood of 1,500 meters.



A



B

Figure 1.49 Observed and predicted values of Razorbill densities (ind./km^2) for season 1 (A) and season 2 (B) visualised together, the size of the symbols indicates observed values whereas the colour defines the predicted values. There is a good agreement between observed and predicted values when larger symbols have "warmer" colours or when smaller symbols have "colder" colours.

Table 1.8 Variability of Razorbill density and abundance estimates for the season indicating the highest numbers (November 2009 – March 2010) according spatial modeling using ship-based survey data.

	Mean density		Total numbers	
Area	**Density**	**SE**	**Total**	**SE**
Alignment area	0.09	0.03	19	6
SPA Kiel Bight	0.15	0.06	64	26
SPA Baltic Sea east of Wagrien	0.11	0.06	33	19
SPA Hyllekrog-Rødsand	-	-	-	-
Residual area	0.22	0.09	330	129
Total	0.19	0.08	427	174

Table of figures