

## SUPPLEMENTARY ELECTRONIC MATERIAL

ARDEOLA 71(1)

### TEMPORAL CHANGES IN MIGRATORY SEABIRD ABUNDANCE ON THE PORTUGUESE COAST REVEALED BY A CITIZEN SCIENCE PROJECT

CAMBIOS TEMPORALES EN LA ABUNDANCIA DE AVES MARINAS  
MIGRATORIAS EN LA COSTA DE PORTUGAL REVELADOS POR UN  
PROYECTO DE CIENCIA CIUDADANA

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## APPENDIX 1

TABLE A1

Study years and total hours of observation for each study site.

*[Años de estudio y total de horas de observación para cada sitio de estudio.]*

Site	Study years	Total observation effort (hours)
Praia da Vagueira	2016 – 2018	80
Cabo Carvoeiro	2009 – 2014 2017 – 2018	175
Cabo Raso	2009 – 2018	238
Cabo Espichel	2009 – 2015 2017	165
Cabo de Sines	2009 – 2016	231
Cabo de São Vicente	2011 – 2018	209
Ilha do Farol	2013 – 2018	201

## APPENDIX 2

TABLE B1

The seven most common, migratory, locally non-breeding seabird species and total individuals recorded during the coastal census from 2009 to 2018. Maximum counts, in Birds Per Hour (BPH), also shown.

*[Las siete especies de aves marinas migratorias no reproductoras más comunes y el total de individuos registrados durante el censo costero de 2009 a 2018. También se muestra el conteo máximo en aves por hora (BPH).]*

<b>Species</b>	<b>Total individuals recorded</b>	<b>Max. count (BPH)</b>
<b>Northern Gannet</b> <i>Morus bassanus</i>	260,081	2,782
<b>Balearic Shearwater</b> <i>Puffinus mauretanicus</i>	24,242	650
<b>Common Scoter</b> <i>Melanitta nigra</i>	10,673	659
<b>Sandwich Tern</b> <i>Thalasseus sandvicensis</i>	6,051	164
<b>Mediterranean Gull</b> <i>Larus melanocephalus</i>	4,516	85
<b>Razorbill</b> <i>Alca torda</i>	4,004	174
<b>Great Skua</b> <i>Catharacta skua</i>	2,172	30

### APPENDIX 3

Generalised additive model (GAM) results

[Resultados del modelo aditivo generalizado (GAM).]

TABLE C1

Best fit model predicting the abundance of Northern Gannet *Morus bassanus* during the post-breeding migration.

[Modelo de mejor ajuste que predice la abundancia de alcatraz atlántico *Morus bassanus* durante la migración posterior a la reproducción.]

Model	AIC	Deviance explained
Counts ~ Year + s(eastw_rms) + s(northw_rms) + s(so_sst) + s(sst) + s(surf_down_east) + s(northw_wind) + s(uo_sst) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	595.8128	72%

TABLE C2

Best fit model predicting the abundance of Northern Gannet *Morus bassanus* during the pre-breeding migration.

[Modelo de mejor ajuste que predice la abundancia de alcatraz atlántico *Morus bassanus* durante la migración previa a la reproducción.]

Model	AIC	Deviance explained
Counts ~ Year + s(chla) + s(eastw_rms) + s(eastw_wind) + s(sst) + s(northw_wind) + s(uo_sst) + s(vo_sst) + s(wind_stress) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	1128.003	59%

TABLE C3

Best fit model predicting the abundance of Balearic Shearwater *Puffinus mauretanicus*.

[Modelo de mejor ajuste que predice la abundancia de pardela balear *Puffinus mauretanicus*.]

Model	AIC	Deviance explained
Counts ~ Year + s(shla) + s(so_sst) + s(sst) + s(surf_down_east) + s(surf_down_north) + s(uo_sst) + s(wind_stress) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	1325.816	49%

TABLE C4

Best fit model predicting the abundance of Common Scoter *Melanitta nigra* during the post-breeding migration.

[Modelo de mejor ajuste que predice la abundancia de negrón común *Melanitta nigra* durante la migración posterior a la reproducción.]

Model	AIC	Deviance explained
Counts ~ Year + s(shla) + s(eastw_rms) + s(northw_rms) + s(so_sst) + s(sst) + s(eastw_wind) + s(surf_down_north) + s(uo_sst) + s(vo_sst) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	826.6092	57%

TABLE C5

Best fit model predicting the abundance of Common Scoter *Melanitta nigra* during the pre-breeding migration.

[Modelo de mejor ajuste que predice la abundancia de negrón común *Melanitta nigra* durante la migración previa a la reproducción.]

<b>Model</b>	<b>AIC</b>	<b>Deviance explained</b>
Counts ~ Year + s(shla) + s(eastw_rms) + s(northw_rms) + s(so_sst) + s(sst) + s(eastw_wind) + s(uo_sst) + s(vo_sst) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	402.679	47%

TABLE C6

Best fit model predicting the abundance of Sandwich Tern *Thalasseus sandvicensis* during the post-breeding migration.

[Modelo de mejor ajuste que predice la abundancia de charrán patinegro *Thalasseus sandvicensis* durante la migración posterior a la reproducción.]

<b>Model</b>	<b>AIC</b>	<b>Deviance explained</b>
Counts ~ Year + s(so_sst) + s(eastw_wind) + s(northw_wind) + s(uo_sst) + s(vo_sst) + s(NAO_Monthly) + s(Location)	407.2859	27%

TABLE C7

Best fit model predicting the abundance of Sandwich Tern *Thalasseus sandvicensis* during the pre-breeding migration.

[Modelo de mejor ajuste que predice la abundancia de charrán patinegro *Thalasseus sandvicensis* durante la migración previa a la reproducción.]

<b>Model</b>	<b>AIC</b>	<b>Deviance explained</b>
Counts ~ Year + s(chla) + s(eastw_rms) + s(so_sst) + s(sst) + s(northw_wind) + s(uo_sst) + s(vo_sst) + s(wind_stress) + s(NAO_Monthly) + s(Location)	448.005	47%

TABLE C8

Best fit model predicting the abundance of the Mediterranean Gull *Larus melanocephalus*.

[Modelo de mejor ajuste que predice la abundancia de gaviota cabecinegra *Larus melanocephalus*.]

<b>Model</b>	<b>AIC</b>	<b>Deviance explained</b>
Counts ~ Year + s(chla) + s(sst) + s(eastw_wind) + s(northw_wind) + s(uo_sst) + s(vo_sst) + s(wind_stress) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	827.8863	46.8%

TABLE C9

Best fit model predicting the abundance of the Razorbill *Alca torda*.

[Modelo de mejor ajuste que predice la abundancia de alca común *Alca torda*.]

<b>Model</b>	<b>AIC</b>	<b>Deviance explained</b>
Counts ~ Year + s(so_sst) + s(uo_sst) + s(vo_sst) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	957.857	46.9%

TABLE C10

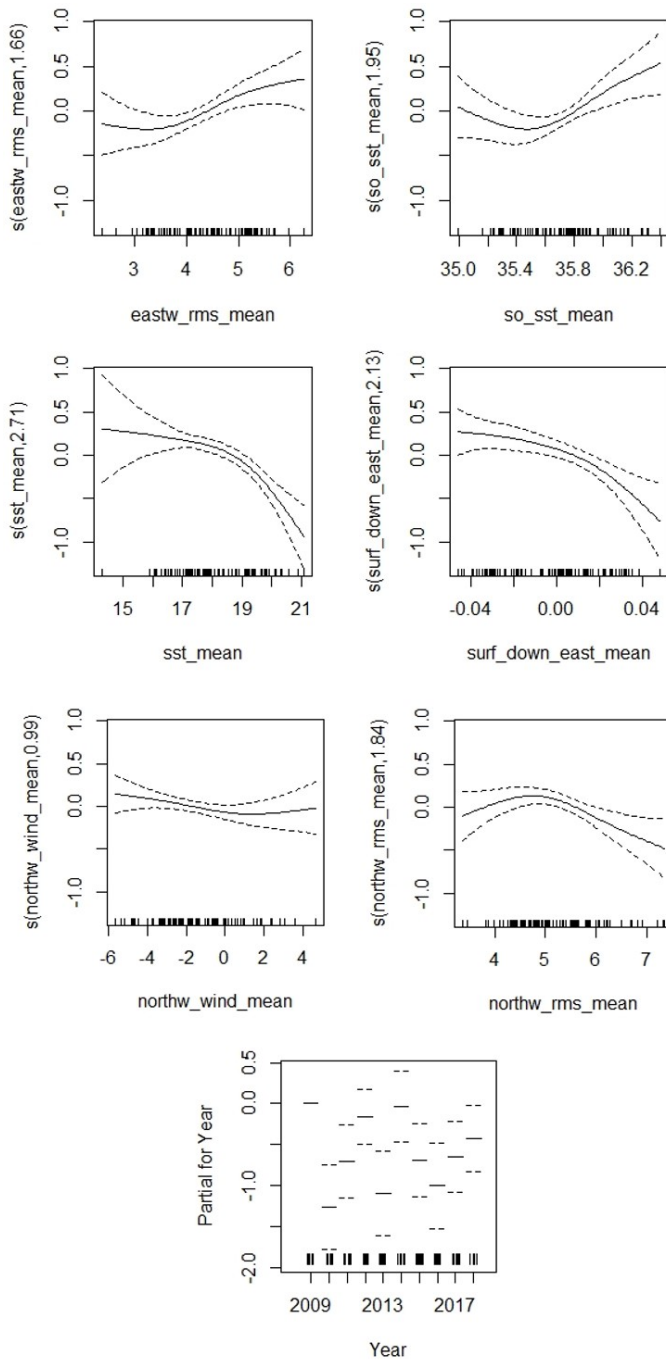
Best fit model predicting the abundance of the Great Skua *Catharacta skua*.

[Modelo de mejor ajuste que predice la abundancia de págallo grande *Catharacta skua*.]

<b>Model</b>	<b>AIC</b>	<b>Deviance explained</b>
Counts ~ Year + s(eastw_rms) + s(northw_rms) + s(so_sst) + s(sst) + s(eastw_wind) + s(northw_wind) + s(uo_sst) + s(vo_sst) + s(NAO_Monthly) + s(NAO_Annual) + s(Location)	675.5926	27.4%

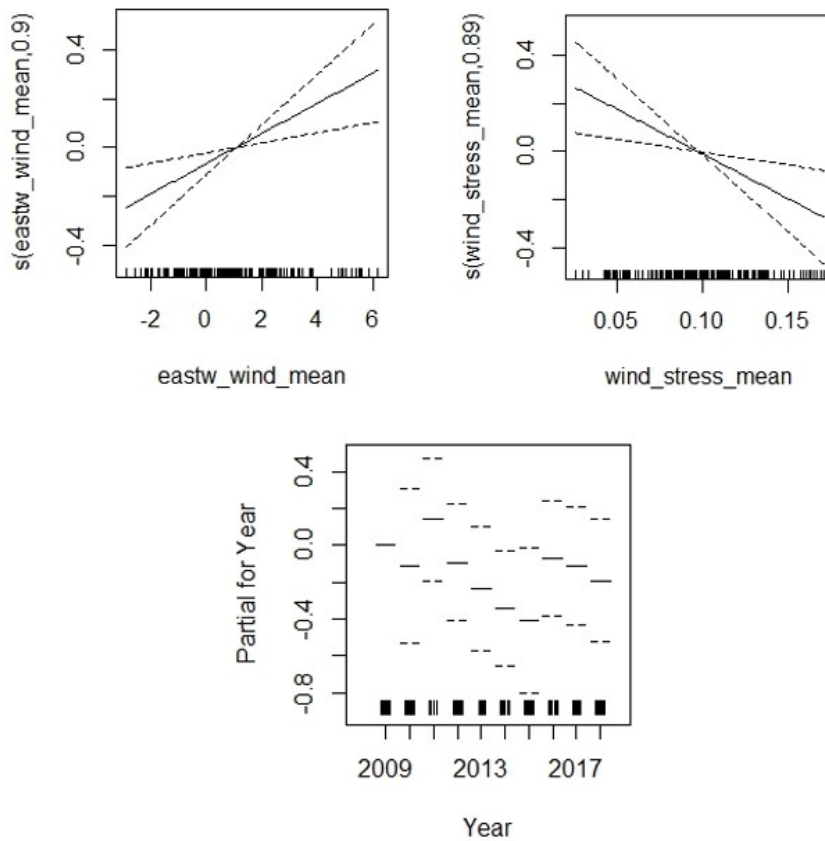
**Figure C1.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of Northern Gannet *Morus bassanus* during the post-breeding migration.

[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de alcatraz atlántico *Morus bassanus* durante la migración posterior a la reproducción.]



**Figure C2.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of Northern Gannet *Morus bassanus* during the pre-breeding migration.

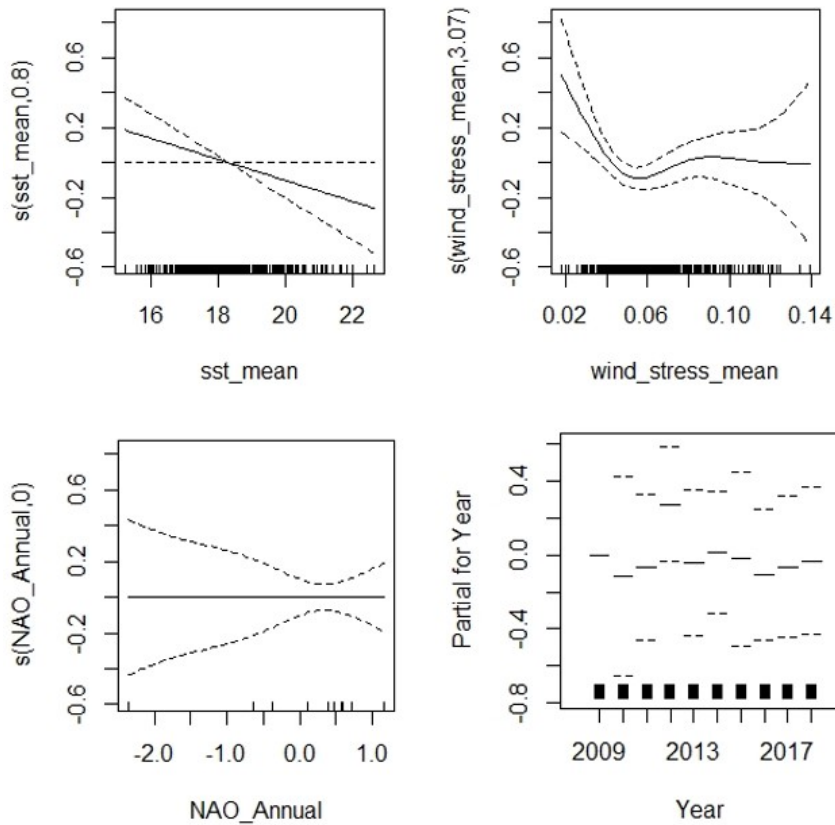
*[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de alcatraz atlántico *Morus bassanus* durante la migración previa a la reproducción.]*



Fagundes\_Portuguese coast use by migratory seabirds

**Figure C3.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Balearic Shearwater *Puffinus mauretanicus*.

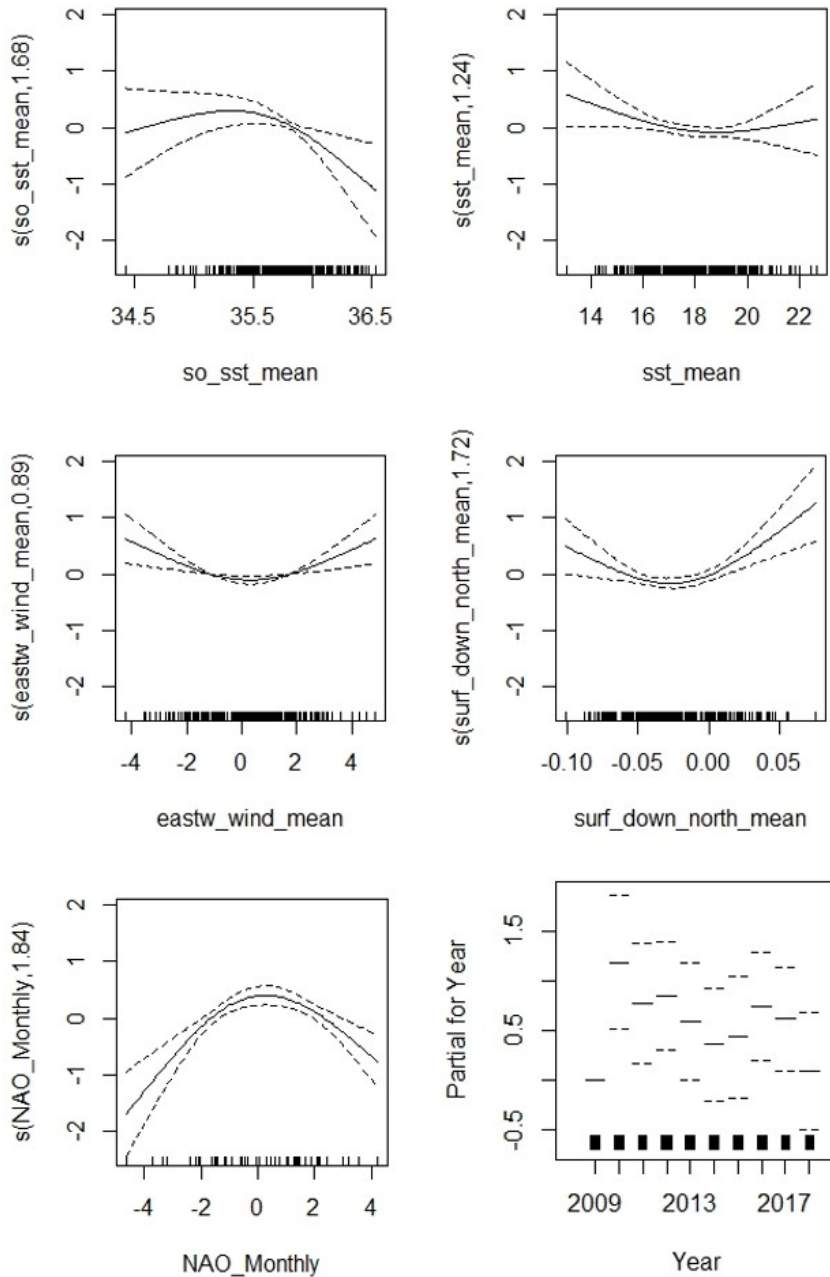
[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de pardela balear *Puffinus mauretanicus*.]



Fagundes\_Portuguese coast use by migratory seabirds

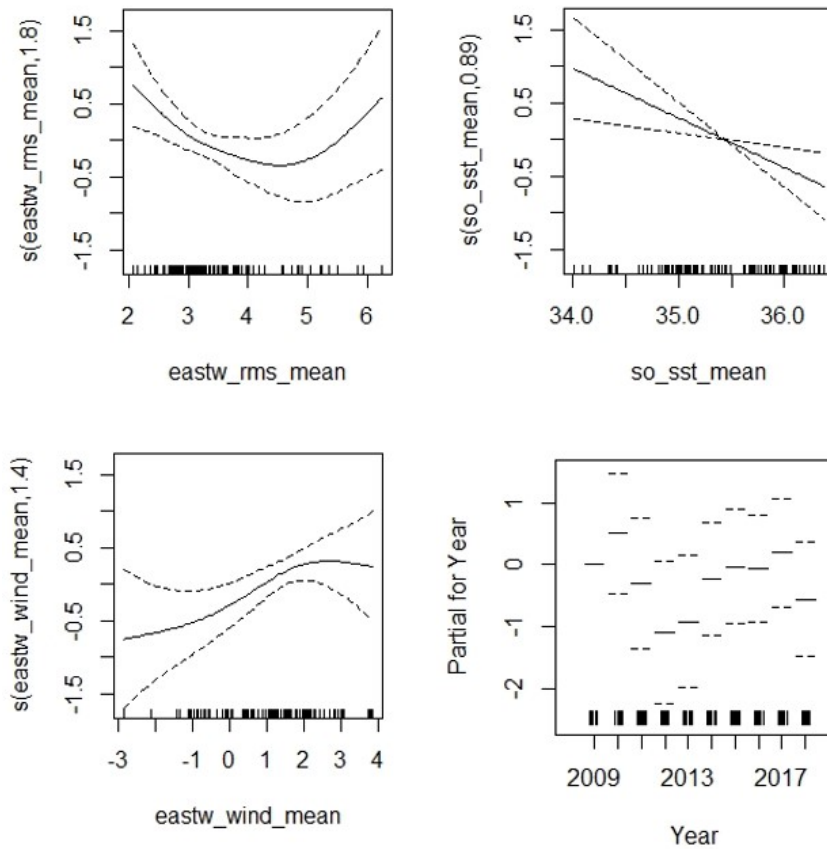
**Figure C4.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Common Scoter *Melanitta nigra* during the post-breeding migration.

[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de negrón común *Melanitta nigra* durante la migración posterior a la reproducción.]



**Figure C5.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Common Scoter *Melanitta nigra* during the pre-breeding migration.

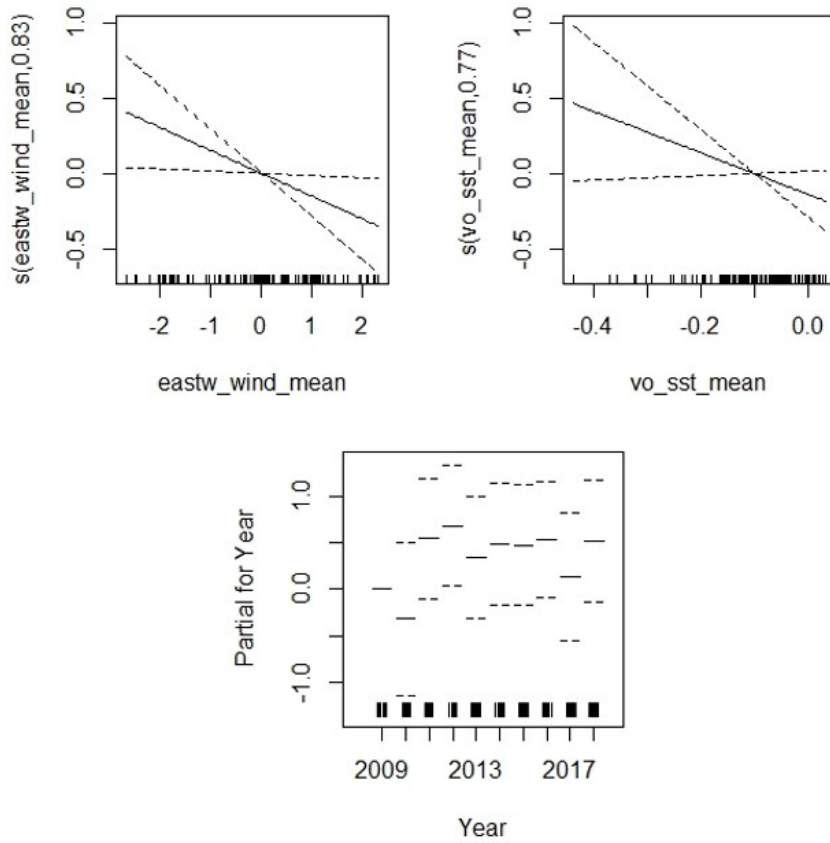
[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de negrón común *Melanitta nigra* durante la migración previa a la reproducción.]



Fagundes\_Portuguese coast use by migratory seabirds

**Figure C6.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Sandwich Tern *Thalasseus sandvicensis* during the post-breeding migration.

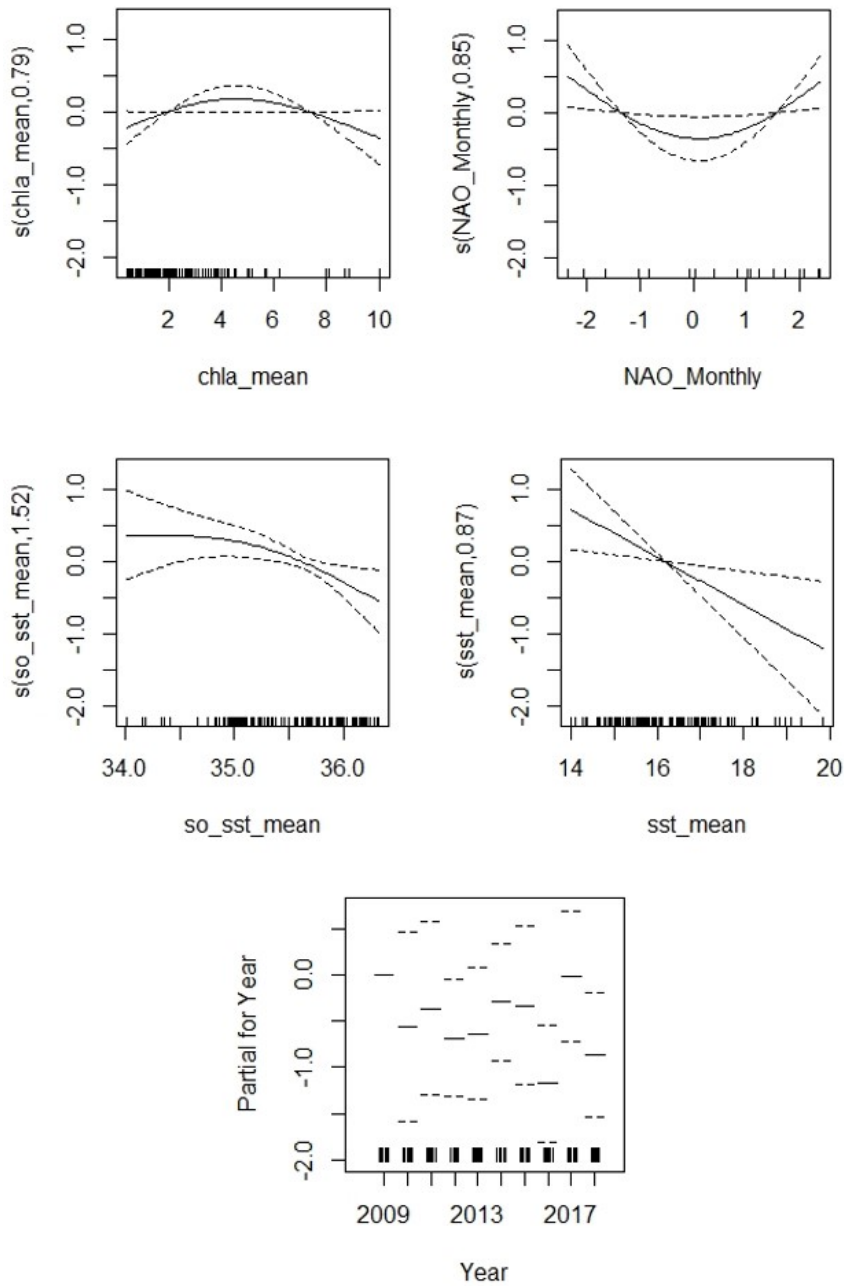
[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de charrán patinegro *Thalasseus sandvicensis* durante la migración posterior a la reproducción.]



Fagundes\_Portuguese coast use by migratory seabirds

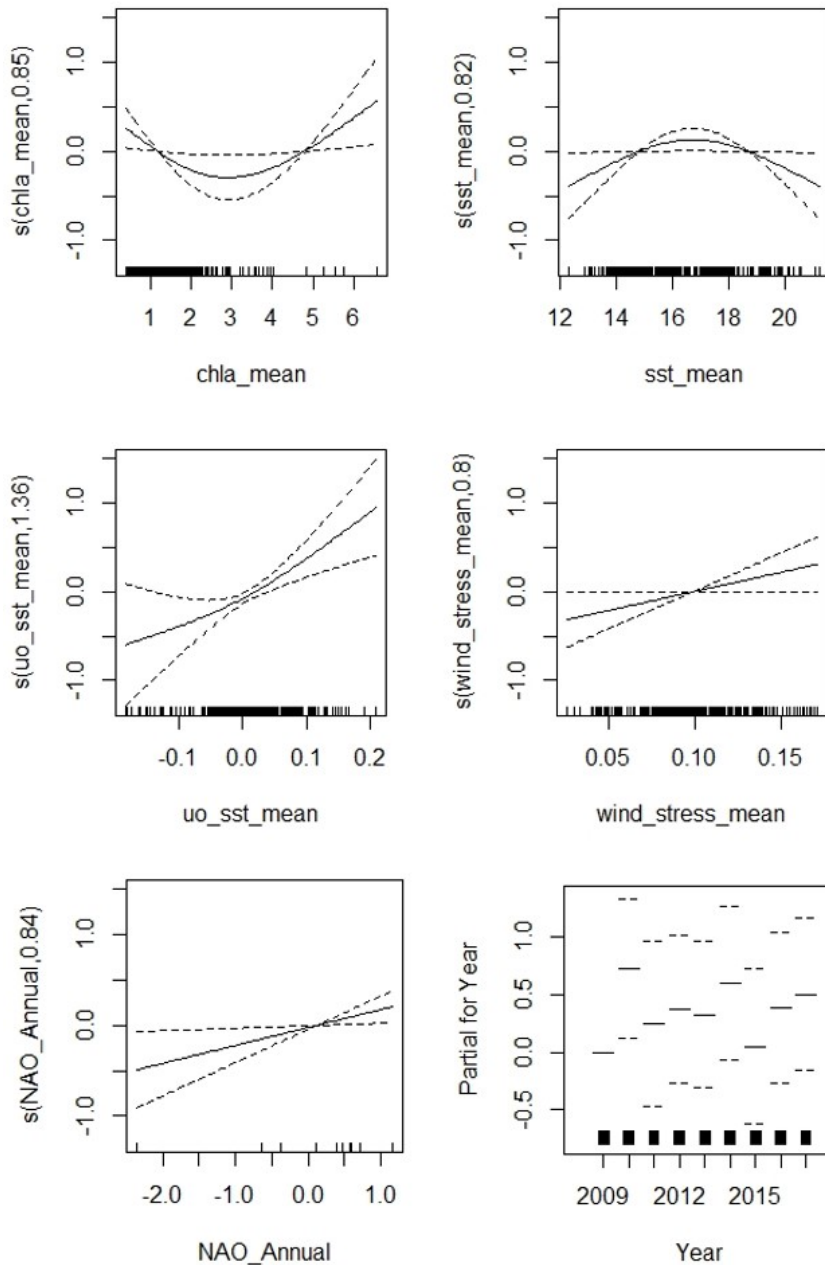
**Figure C7.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Sandwich Tern *Thalasseus sandvicensis* during the pre-breeding migration.

[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de charrán patinegro *Thalasseus sandvicensis* durante la migración previa a la reproducción.]



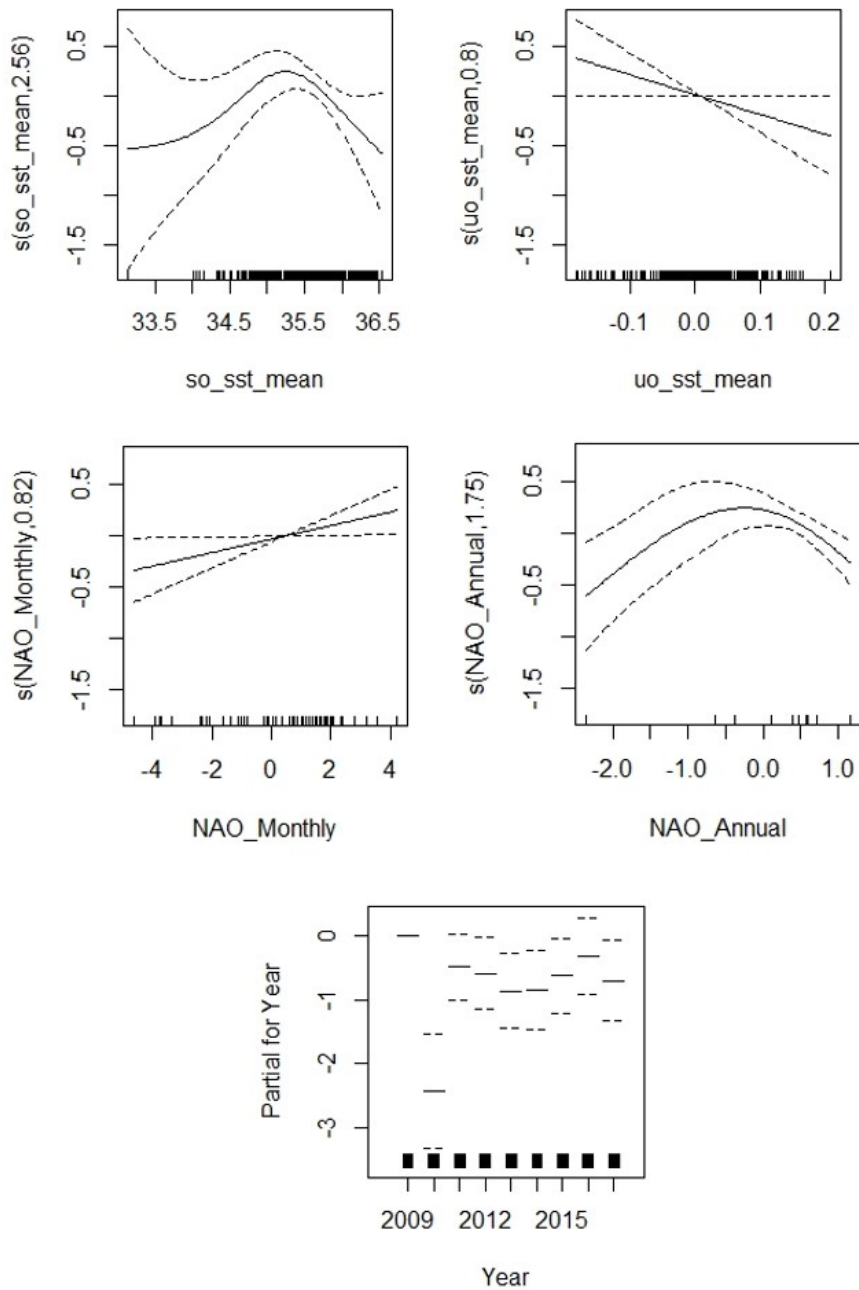
**Figure C8.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Mediterranean Gull *Larus melanocephalus*.

[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de gaviota cabecinegra *Larus melanocephalus*.]



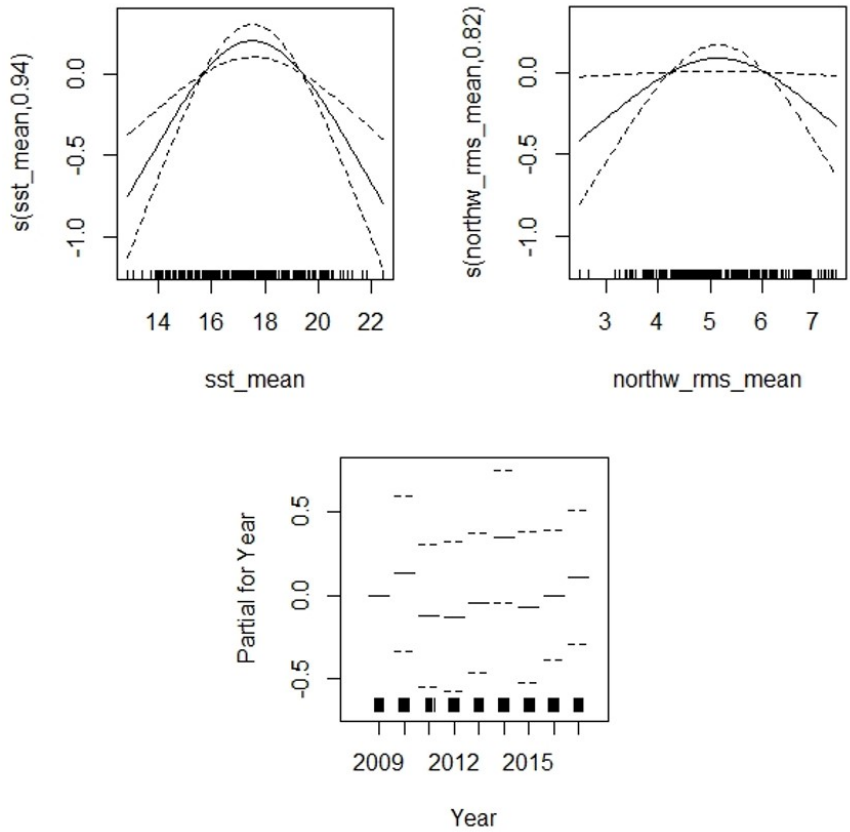
**Figure C9.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Razorbill *Alca torda*.

*[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de alca común Alca torda durante la migración previa a la reproducción.]*



**Figure C10.** Generalised additive model (GAM) smoothing curve fitted to partial effects of explanatory variables on abundance of the Great Skua *Catharacta skua*.

[Curva del modelo aditivo generalizado (GAM) ajustada a los efectos parciales de las variables explicativas sobre la abundancia de págalo grande *Catharacta skua*.]



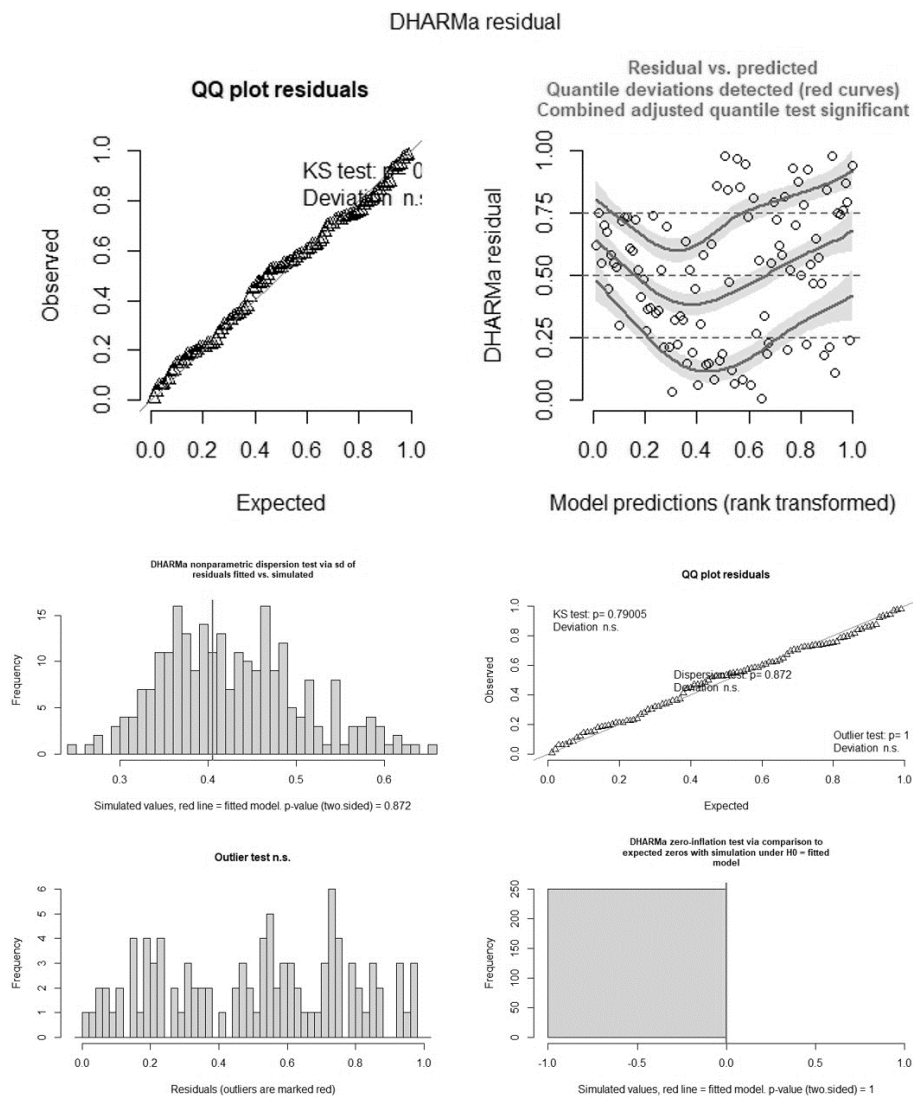
## APPENDIX 4

### Goodness of fit (GoF) results

[Resultados de la Bondad de ajuste (GoF).]

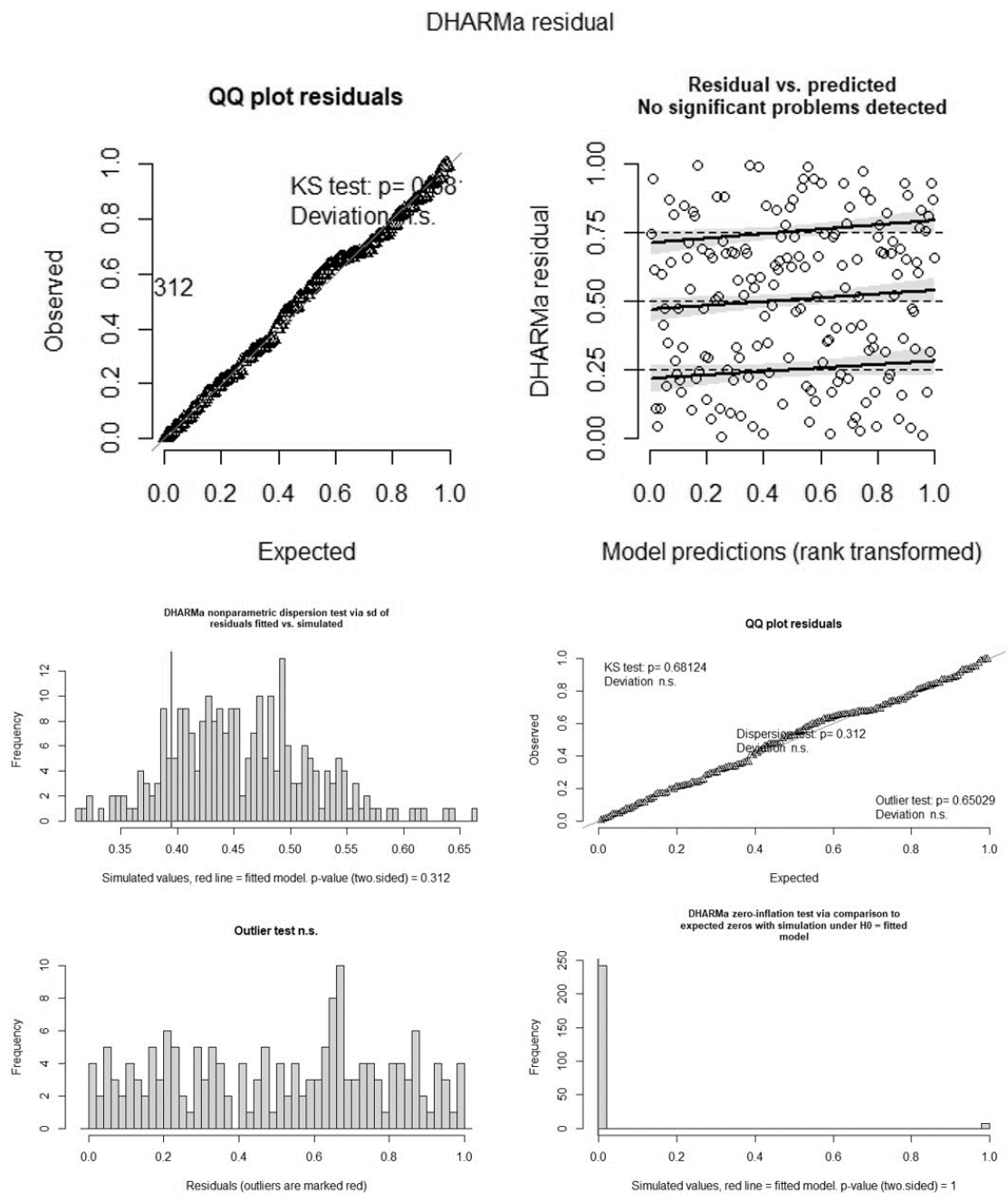
**Figure D1.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Northern Gannet *Morus bassanus* post-breeding GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM del alcatraz atlántico *Morus bassanus* durante la migración posterior a la reproducción.]



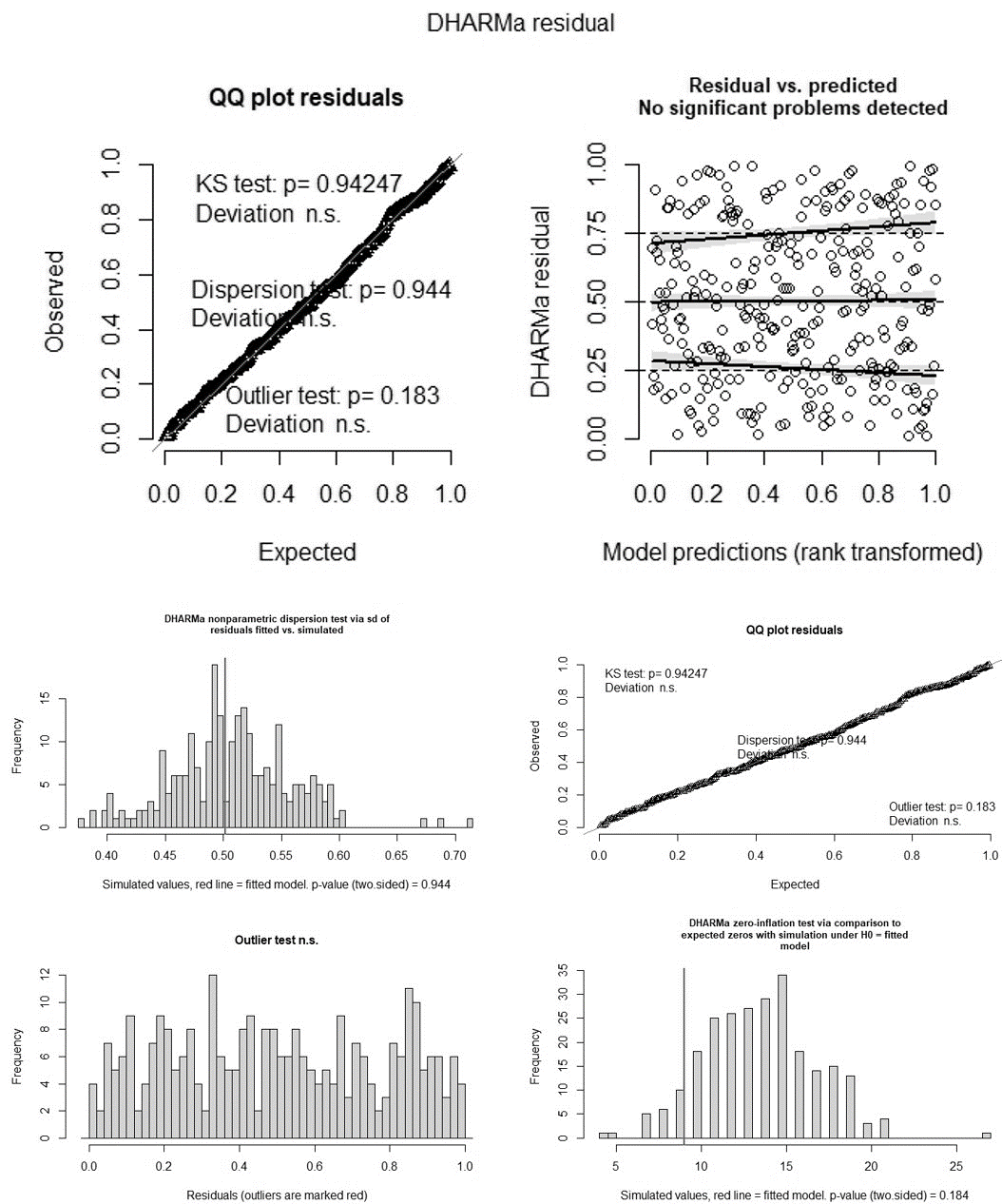
**Figure D2.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Northern Gannet *Morus bassanus* pre-breeding GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM del alcatraz atlántico *Morus bassanus* durante la migración previa a la reproducción.]



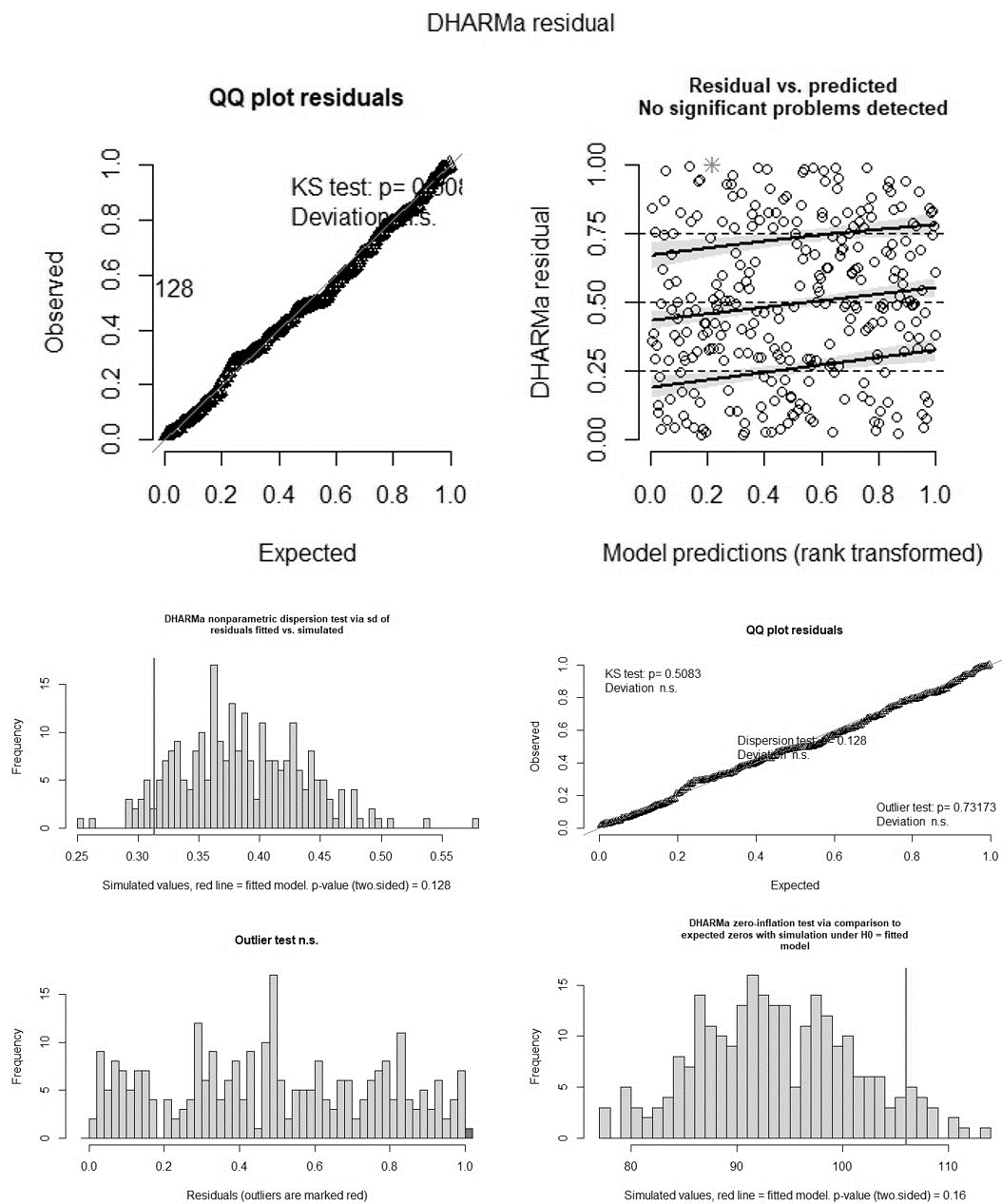
**Figure D3.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Balearic Shearwater *Puffinus mauretanicus* GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de pardela balear *Puffinus mauretanicus*.]



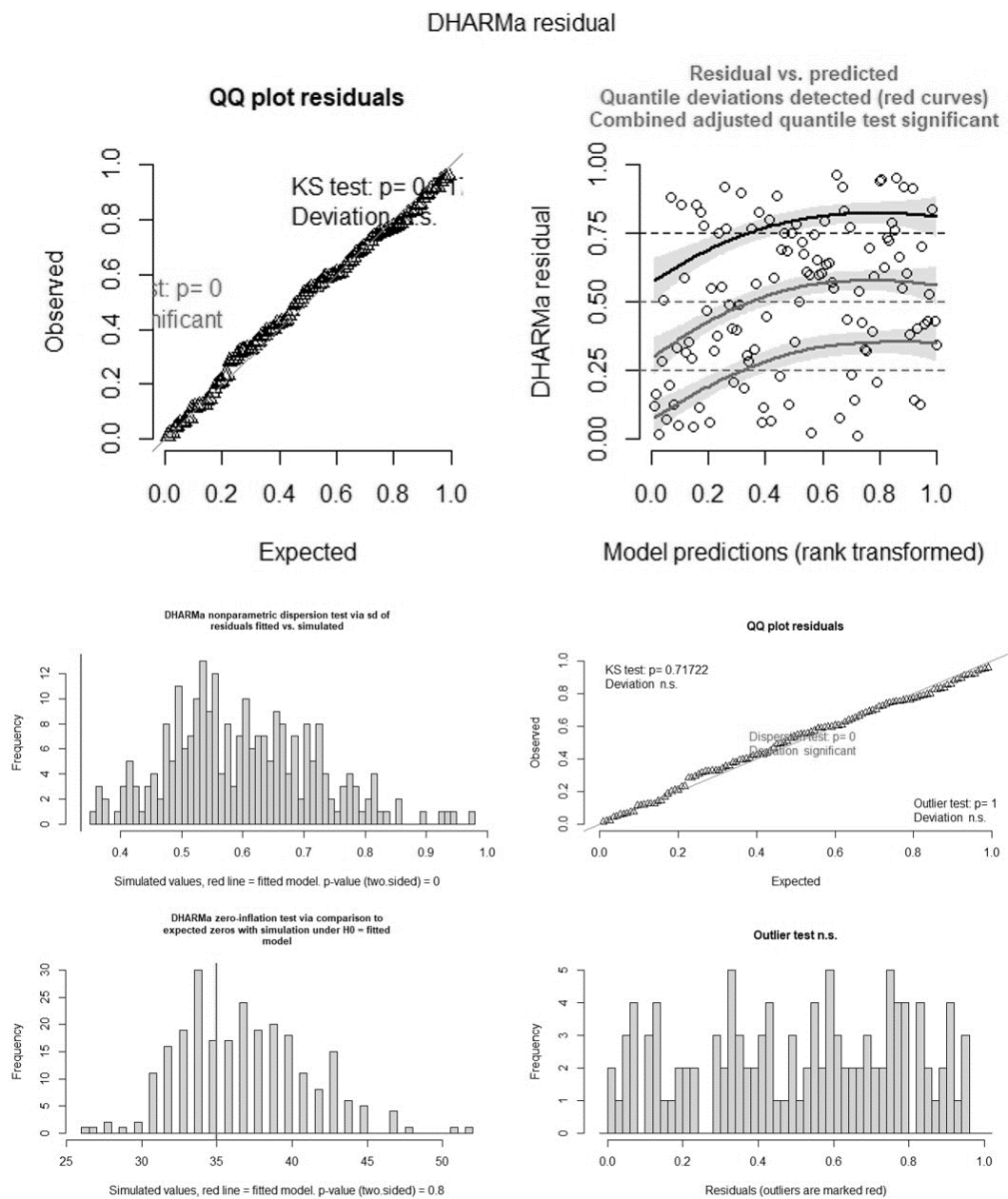
**Figure D4.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Common Scoter *Melanitta nigra* post-breeding GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de negrón común *Melanitta nigra* durante la migración posterior a la reproducción.]



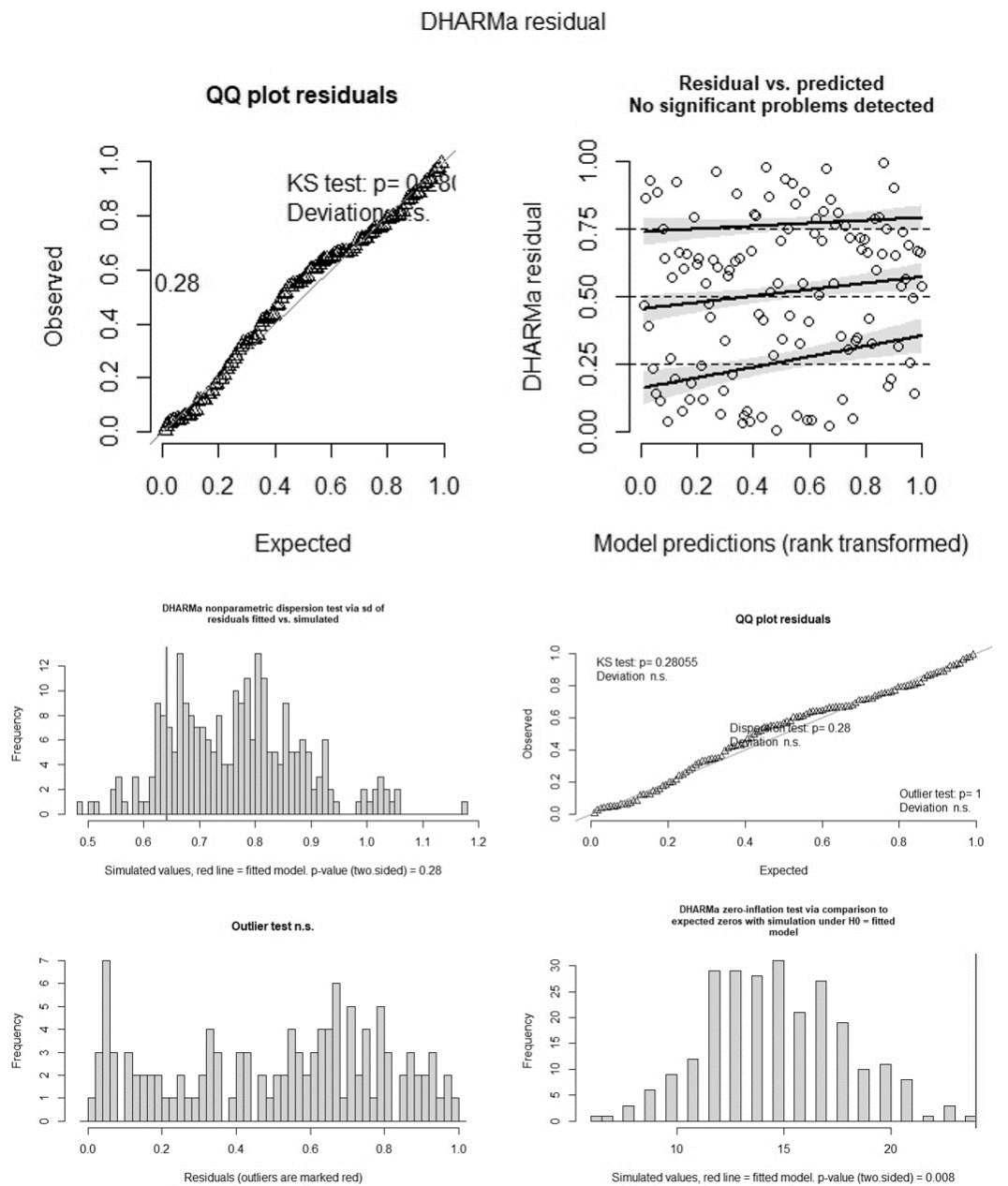
**Figure D5.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Common Scoter *Melanitta nigra* pre-breeding GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de negrón común *Melanitta nigra* durante la migración previa a la reproducción.]



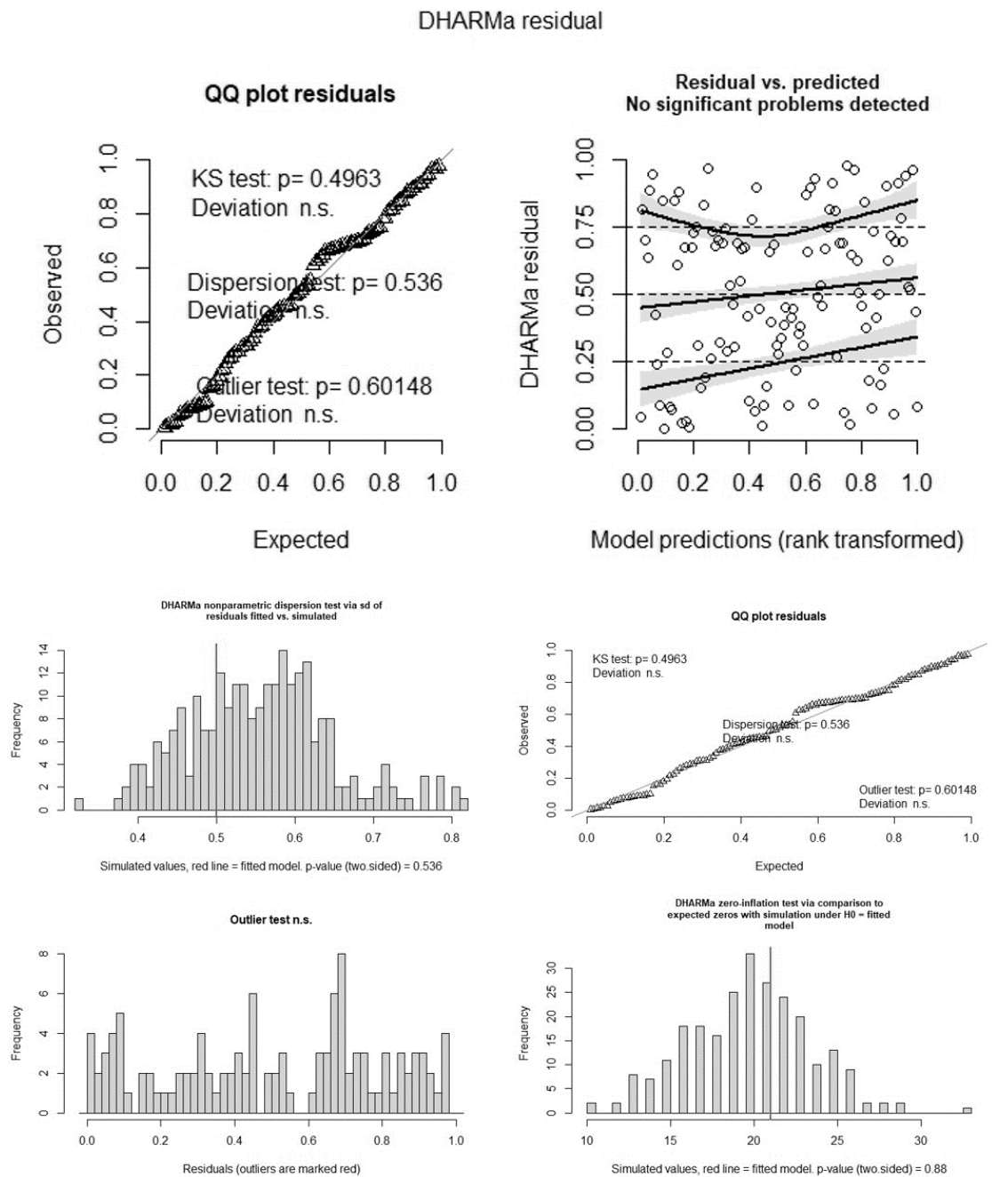
**Figure D6.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Sandwich Tern *Thalasseus sandvicensis* post-breeding GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de charrán patinegro *Thalasseus sandvicensis* durante la migración posterior a la reproducción.]



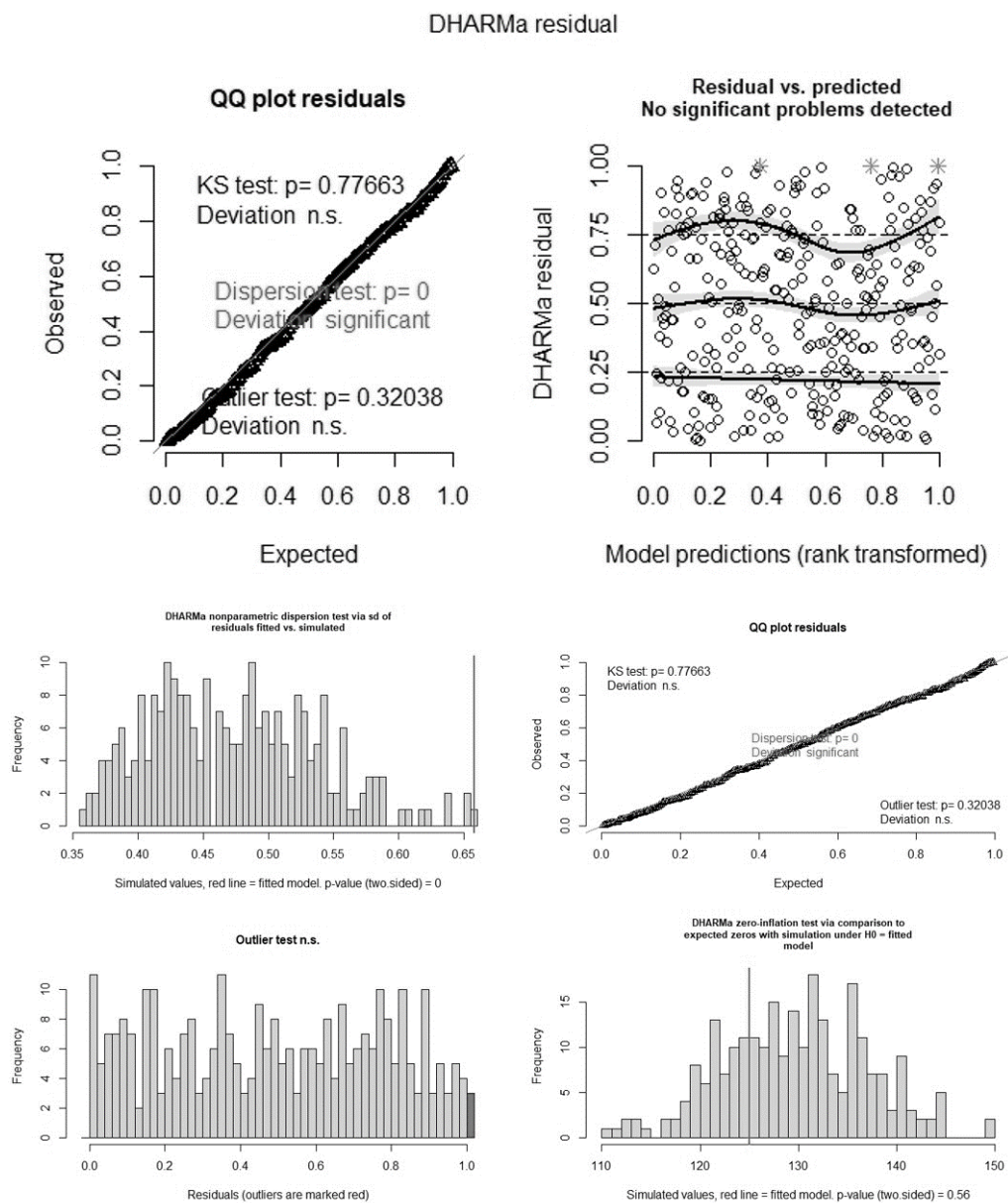
**Figure D7.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Sandwich Tern *Thalasseus sandvicensis* pre-breeding GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de charrán patinegro *Thalasseus sandvicensis* durante la migración previa a la reproducción.]



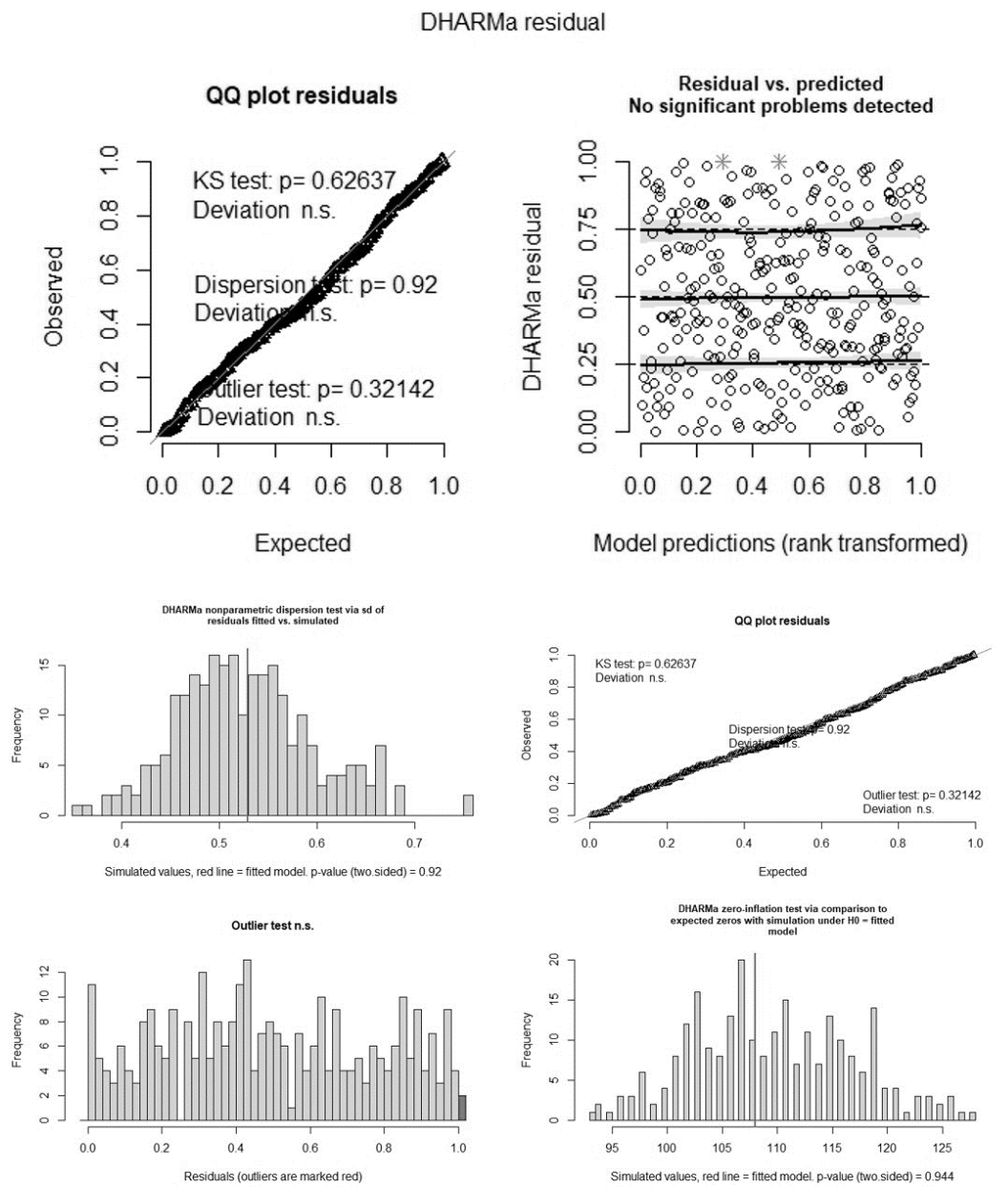
**Figure D8.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Mediterranean Gull *Larus melanocephalus* GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de gaviota cabecinegra *Larus melanocephalus*.]



**Figure D9.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Razorbill *Alca torda* GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de alca común *Alca torda*.]



**Figure D10.** DHARMA results (Residuals, testDispersion function, testUniformity function, testOutliers function and testZeroInflation function) of Great Skua *Catharacta skua* GAM model.

[Resultados del DHARMA (residuos, función testDispersion, función testUniformity, función testOutliers y función testZeroInflation) del modelo GAM de págallo grande *Catharacta skua*.]

