# Supplement 1

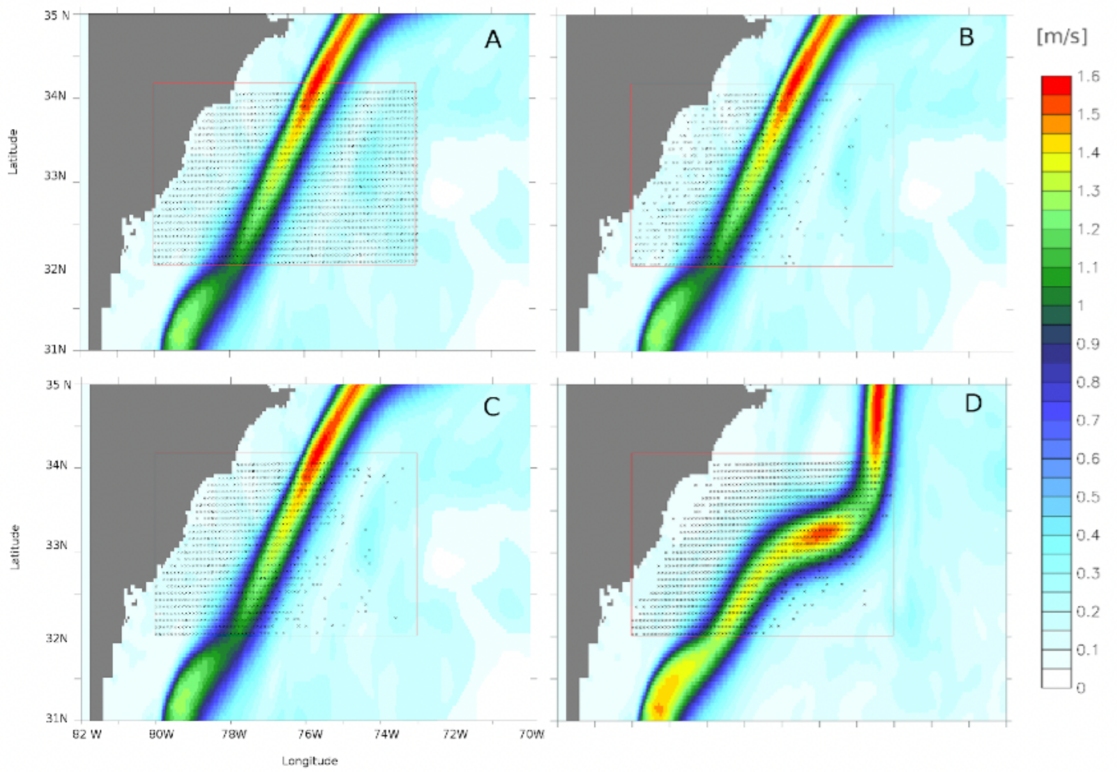


**Fig. S1 Gulf Stream core and release positions of virtual turtles.** Virtual turtles that were released east from the (mean) Gulf Stream have higher chances of staying in warm waters. We show the initial positions of virtual turtles in our release area (red box) plotted over mean current speed during the release time, which indicates the position of the Gulf Stream in meters per second. For a representative year (1996) we show the release position of: (**A**) virtual turtles that remained above 10 °C during first year, (**B**) cold virtual turtles (10°C or less during first year), (**C**) arrivals in the UK. (**D**) cold virtual turtles in a year with deviating Gulf Stream position.

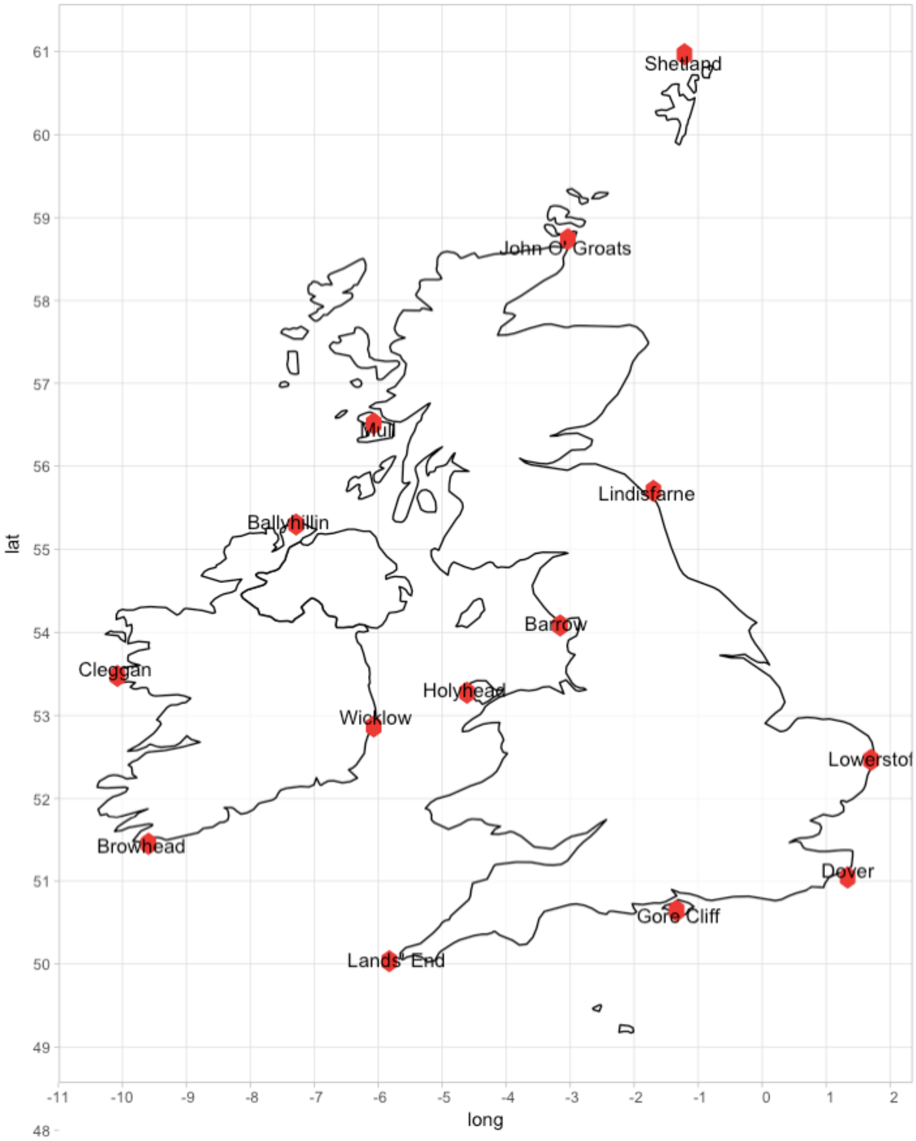


**Fig. S2** Map with the latitude and longitudes of 14 locations from around the UK and Ireland from which monthly sea surface temperatures (SST) for 1960 - 2015 were taken.

**Text S1 Environmental parameter processing**

To quantify northward current transport, we extracted a yearly value for the strength of northward flow of the Gulf Stream and North Atlantic current from our ocean model; based on measurements of the horizontal streamfunction (derived from 3D velocity fields of the VIKING20 model). The streamfunction $\psi$ is an integrated representation of the flow field assuming divergence free flow with zonal velocity ($u=\partial\psi/\partial y$) and meridional velocity ($v=-\partial\psi/\partial x$). This method allows representation of both direction and strength of the flow in one scalar field to assess maximum transport. Maximum yearly transport was calculated starting in July to coincide with the start of the hatchling/release season. We chose a representative area which included the maximum northward transport of the North Atlantic Current (40°-50°N) and Gulf Stream (32°N - 34°N) respectively in all years. To exclude effects of local recirculation we then averaged the streamfunction of that area across latitude and identified its maximum along the longitudinal range (NAC: 30°-45° W, GS: 73°W - 80°W this value was then used for further analysis. To check if currents in our release area (32°-34°N, 73°-80°W) are representative of Gulf Stream transport, we also compared the maximum of the streamfunction each year with that of a larger area (32°N-35°N, 70°-82°W) but detected no difference.

To characterize the climatic-oceanographic mode of the North Atlantic, we use the yearly North Atlantic Oscillation (NAO) station-based index developed by Hurrell (1995) (https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-station-based). The NAO is the dominant pattern of atmospheric circulation variability in this region. The index is calculated from the difference of normalized sea level pressure (SLP) between Lisbon, Portugal and Stykkisholmur /Reykjavik, Iceland in winter. Positive values are typically associated with stronger westerly winds across the North Atlantic over middle latitudes (Fig. S3).

To quantify storm events across the North Atlantic, we first calculated the mean of wind speed at 10 m above sea level between 50°-60°N and 350°-360°E from JRA55-do (Tsujino et al. 2018) at 6-hourly resolution. The resulting 'storm_index' indicates the number of time steps per year in which the measurement was higher than 2 standard deviations from the mean.

We checked whether excessive autocorrelation between the environmental covariates was a problem in the modeling process using the Durbin-Watson test (Table S2, Durbin & Watson 1950, Hartig 2018).

**Text S 2 Normalizing numbers of simulated arrivals**

We normalized counts for the visual representation, since the number of simulated strandings is magnitudes larger than reported strandings. To achieve this we divide each yearly count of simulated arrivals by the max simulated arrivals, and then multiply it by the max reported strandings.

**Table S1 GAM output with covariates for simulated arrivals at the UK coast, to validate the selection of environmental drivers.** The model was constrained from 1961-2009. s() are smooths of the explanatory variables. 'NAC_transport' is yearly northward transport of the North Atlantic Current, 'GS_transport' is yearly northward transport of the Gulf Stream, 'NAO_index' is the North Atlantic Oscillation which is the difference of normalized sea level pressure (SLP) between Stykkisholmur/Reykjavik, Iceland, and Lisbon, 'Storm_index' is yearly number of time steps >2 standard deviations above mean wind speed over the North Atlantic (10 m above sea level). s(Year) is the years that the model was constrained by. This table shows the estimated degrees of freedom (EDF) for each of the different variables that had a $p < 0.05$ (indicated by *) or $p < 0.01$ (indicated by **). The p-values show whether the smooth of that variable is significantly different from "no effect", i.e., if we estimated the smooth as a flat line at zero. Variables with a "-" had a non-significant p-value and an EDF below 1 and have not been reported here (see the supplemental for all results). The deviance explained is expressed in %.

| **Covariates in model** | Simulated arrivals UK coast **(EDFs)** |
|---|---|
| s(NAC_transport) | 8.56** |
| s(GS_transport) | 7.78** |
| s(NAO_index) | 6.88** |
| s(Storm_index) | 8.71** |
| s(Year) | 8.72** |
| Deviance explained (%) | 93.8** |

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**Table S2 Durbin-Watson results for autocorrelation between variables.** 'Storm_count' refers to the storm count per year, 'Storm_index' is the days of storms per year > sd than mean wind at 10 m above sea level in the North Atlantic, 'Mean_SST the yearly mean sea surface temperature around the UK (°C), 'NAO_index' the North Atlantic Oscillation which is the difference of normalized sea level pressure (SLP) between Stykkisholmur/Reykjavik, Iceland, and Lisbon, Portugal. Turtle stranding count are stranding records from the TURTLE database in the UK. * and ** indicate a significant p-value ($p < 0.01$, $p < 0.05$, respectively) which indicates autocorrelation is greater than zero (i.e., there is autocorrelation), this is common in time-series data. As a general rule, test statistic values in the range of 1.5 to 2.5 are relatively normal (Field 2009).

| | Storm_count | Storm_index | Mean_SST | NAO_index | Turtle stranding count |
|---|---|---|---|---|---|
| Storm_count | --- | 1.17** | 1.42* | 1.45* | 1.25** |
| Storm_index | 1.50* | --- | 1.62** | 1.99 | 1.57* |
| Mean_SST | 0.89** | 1.14** | --- | 0.83** | 1.41 |
| NAO_index | 2.17 | 2.39 | 2.09 | --- | 1.94 |
| Turtle stranding count | 0.75** | 1.73** | 1.44* | 1.72** | --- |

*p < 0.01 ** p < 0.05

**References Supplement 1**

Field, A.P. (2009). Discovering statistics using SPSS: and sex and drugs and rock 'n' roll (3rd edition). London: Sage.

Durbin, J. & Watson, G.S. (1950). Testing for Serial Correlation in Least Squares Regression I. Biometrika 37, 409–428.

Hartig, F. (2018). DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models. R package version 0.2.0. https://CRAN.R-project.org/package=DHARMa

Hurrell, J. W. (1995). Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. Science 269:676–679.

Tsujino H, Urakawa S, Nakano H, Small RJ, Kim WM, Yeager SG, Danabasoglu G, Suzuki T, Bamber JL, Bentsen M, Böning CW, Bozec A, Chassignet EP, Curchitser E, Boeira Dias F, Durack PJ, Griffies SM, Harada Y, Ilicak M, Josey SA, Kobayashi C, Kobayashi S, Komuro Y, Large WG, Le Sommer J, Marsland SJ, Masina S, Scheinert M, Tomita H, Valdivieso M, Yamazaki D (2018) JRA-55 based surface dataset for driving ocean–sea-ice models (JRA55-do). Ocean Model 130:79–139.

# Supplement 2

## Model checks and fitting

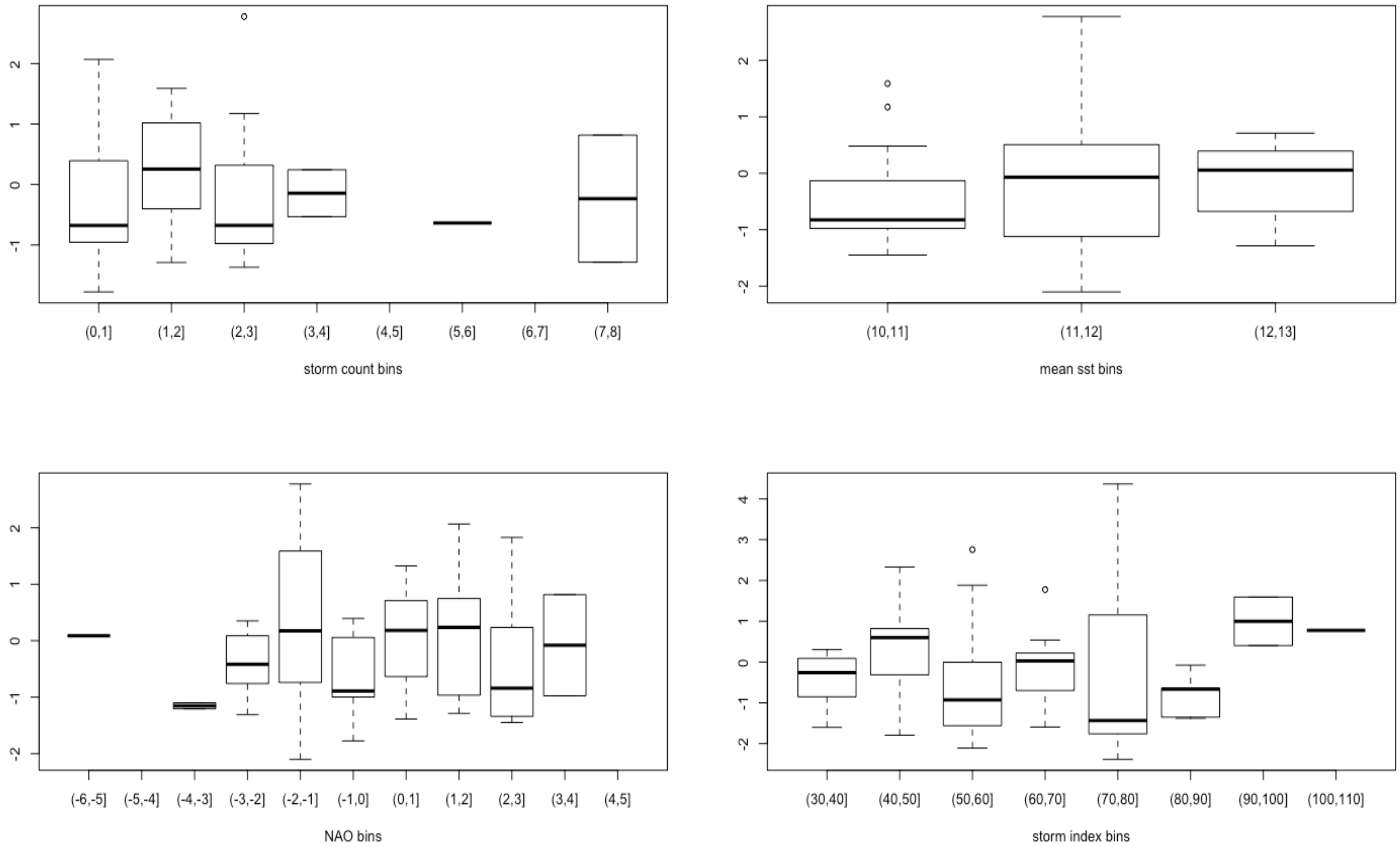



**Fig. S1 Residuals by covariate to confirm the goodness of our model fit for Model 1**. Model 1 was modelled using a Poisson response count distribution. From top left to bottom right; storm count residuals, mean sea surface temperature residuals, North Atlantic Oscillation (NAO) residuals, NA storm index residuals. Low variation in these covariate residuals suggest that the model is a good fit

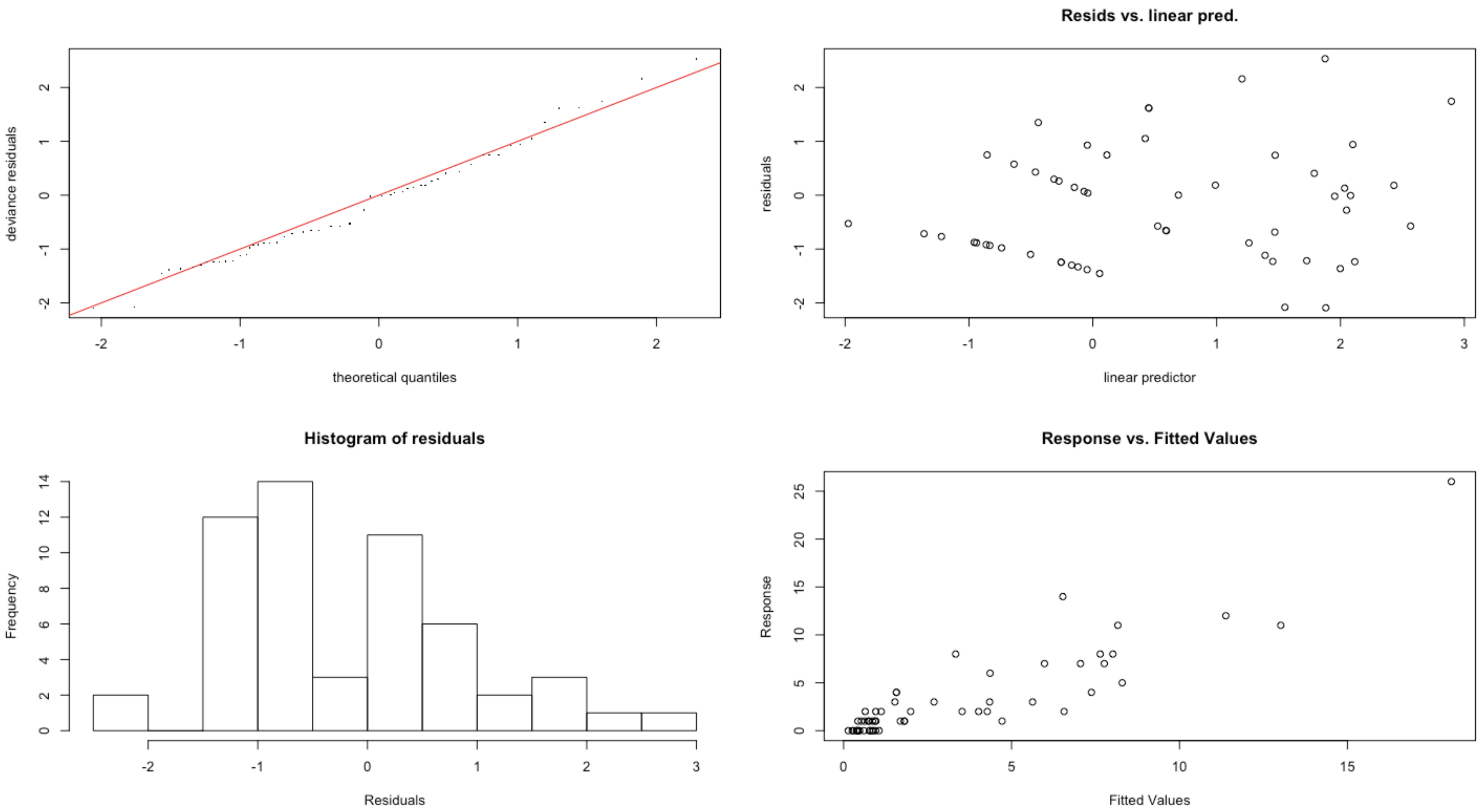



**Fig S2 Generalized additive model (GAM) check plots for observed strandings using the Poisson response count distribution – the best model fit for Model 1.** The Q-Q plot (top left) shows the closest fit to a y=x line, here this shows a good model fit. The histogram of residuals (bottom left) also shows a normal distribution, suggesting that most of the residuals fall around the mean. The residuals vs. linear predictors plot (top right) shows that there is some heteroscedasticity in the dataset *i.e.,* there is an increase in the residuals with increasing values of the linear predictor. The response vs. fitted values show a normal distribution (bottom right).

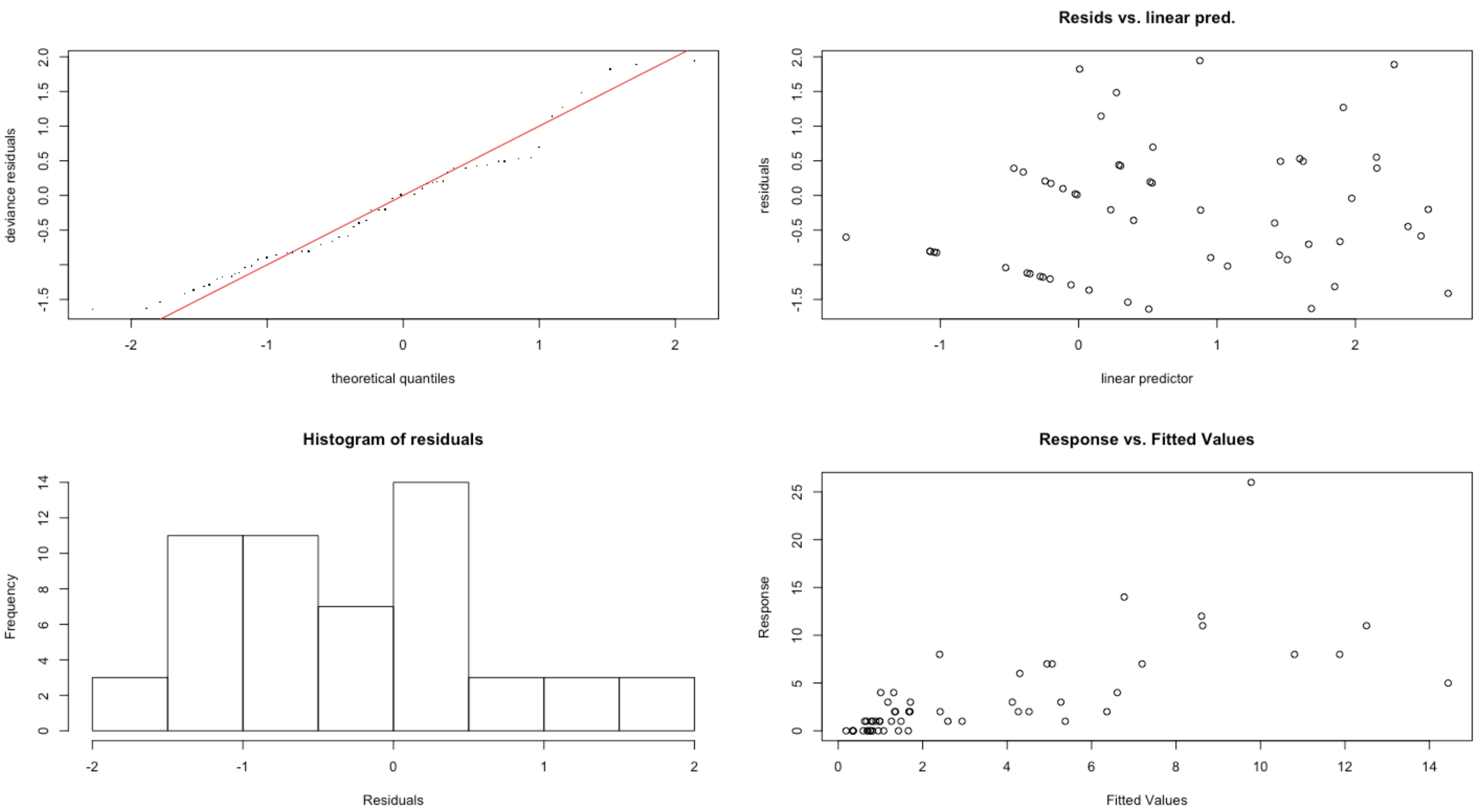



**Fig S3 As for Fig S2 except with negative binomial response count distribution for Model 1.** The Q-Q plot (top left) shows the closest fit to a y=x line, here this shows a poorer model fit when compared to the Poisson response distribution (Fig S2). The histogram of residuals (bottom left) shows a normal distribution, suggesting that most of the residuals fall around the mean. The residuals vs. linear predictors plot (top right) shows that there is some heteroscedasticity in the dataset. The response vs. fitted values show a normal distribution (bottom right). The poorer Q-Q plot meant that this response count was not used.

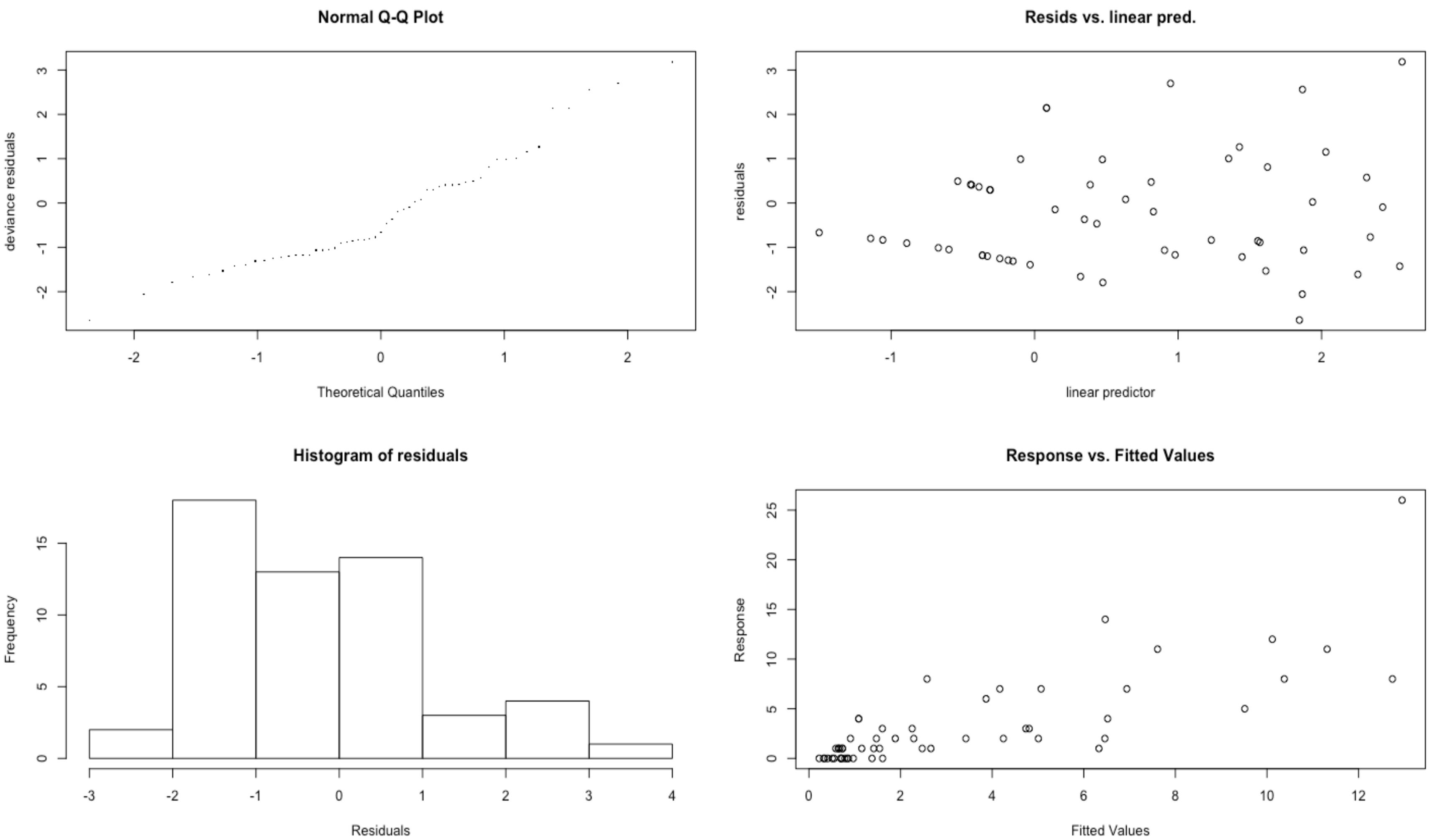



**Fig S4 As for Fig S2 except with a Quasipoisson response count distribution for Model 1.** The Q-Q plot (top left) shows the closest fit to a y=x line, here this shows a poorer model fit when compared to the Poisson response distribution (Fig S2). The histogram of residuals (bottom left) shows a normal distribution, suggesting that most of the residuals fall around the mean. The residuals vs. linear predictors plot (top right) shows that there is some heteroscedasticity in the dataset. The response vs. fitted values show a normal distribution (bottom right). The poorer Q-Q plot meant that this response count was not used.

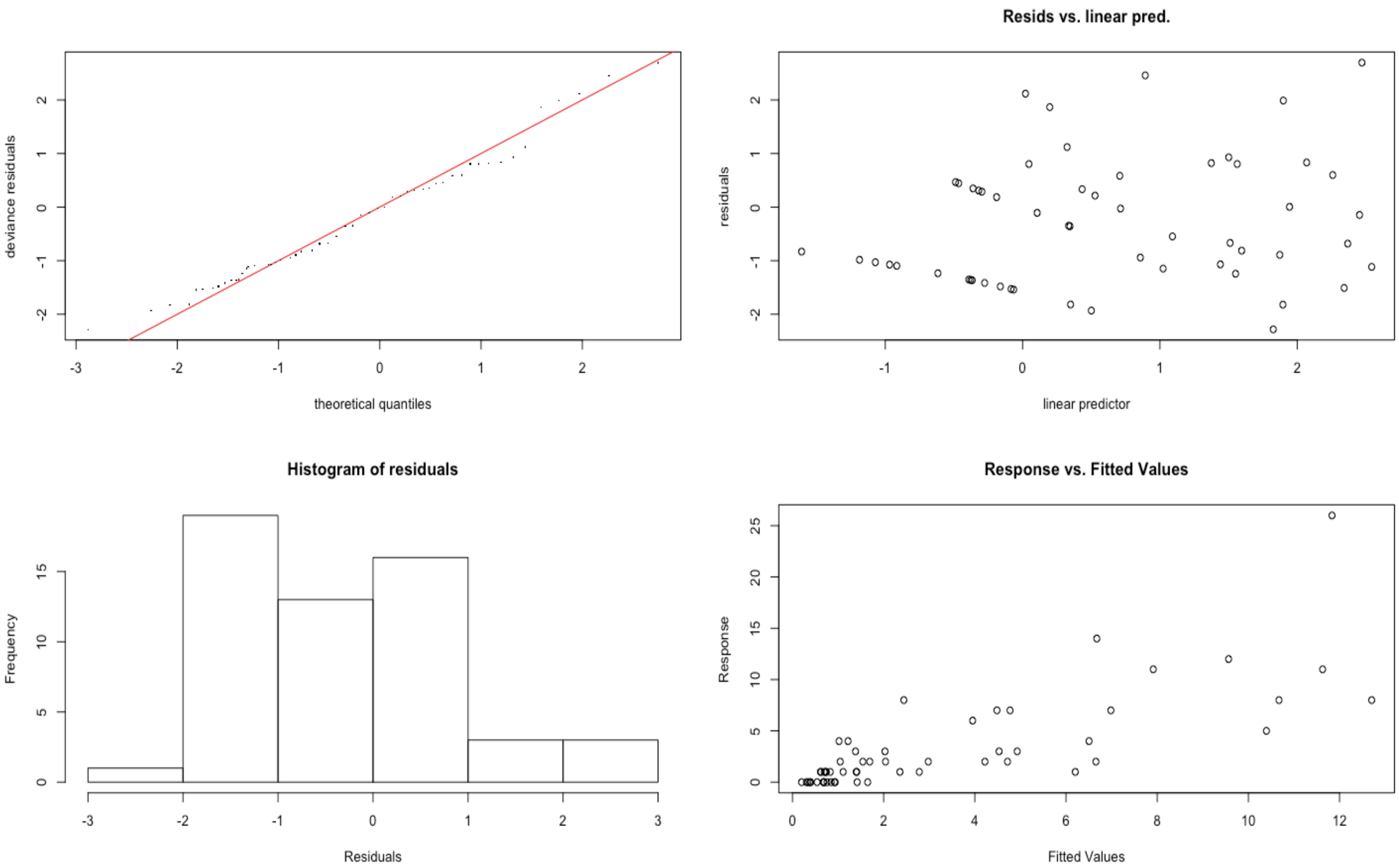



**Fig S5 As for Fig S2 except with a Tweedie response count distribution for Model 1.** The Q-Q plot (top left) shows the closest fit to a y=x line, here this shows a poorer model fit when compared to the Poisson response distribution (Fig S2). The histogram of residuals (bottom left) shows a normal distribution, suggesting that most of the residuals fall around the mean. The residuals vs. linear predictors plot (top right) shows that there is some heteroscedasticity in the dataset. The response vs. fitted values show a normal distribution (bottom right). The poorer Q-Q plot meant that this response count was not used.

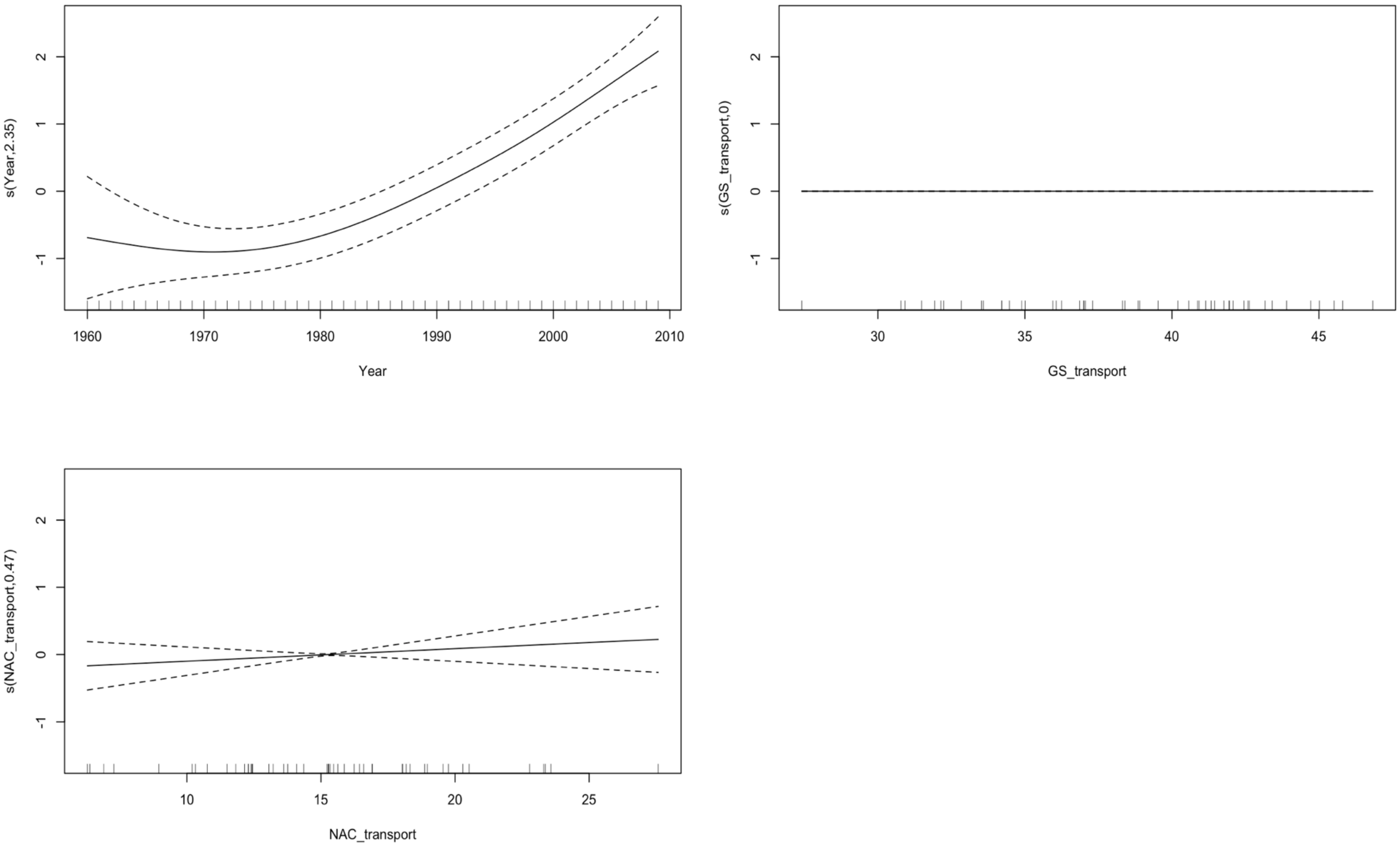



**Fig S6 Generalized additive model (GAM) summary plots for variables included for Model 2**. The model was constrained from 1960-2009. 'NAC_transport' (bottom left) is yearly northward transport of the North Atlantic Current, 'GS_transport' (top right) is yearly northward transport of the Gulf Stream. The y-axis shows the smooth and the estimated degrees of freedom (EDF). These EDF values are also reported in Table S1. Modelled using the Poisson response count distribution. The model has a deviance explained of 66.6%.

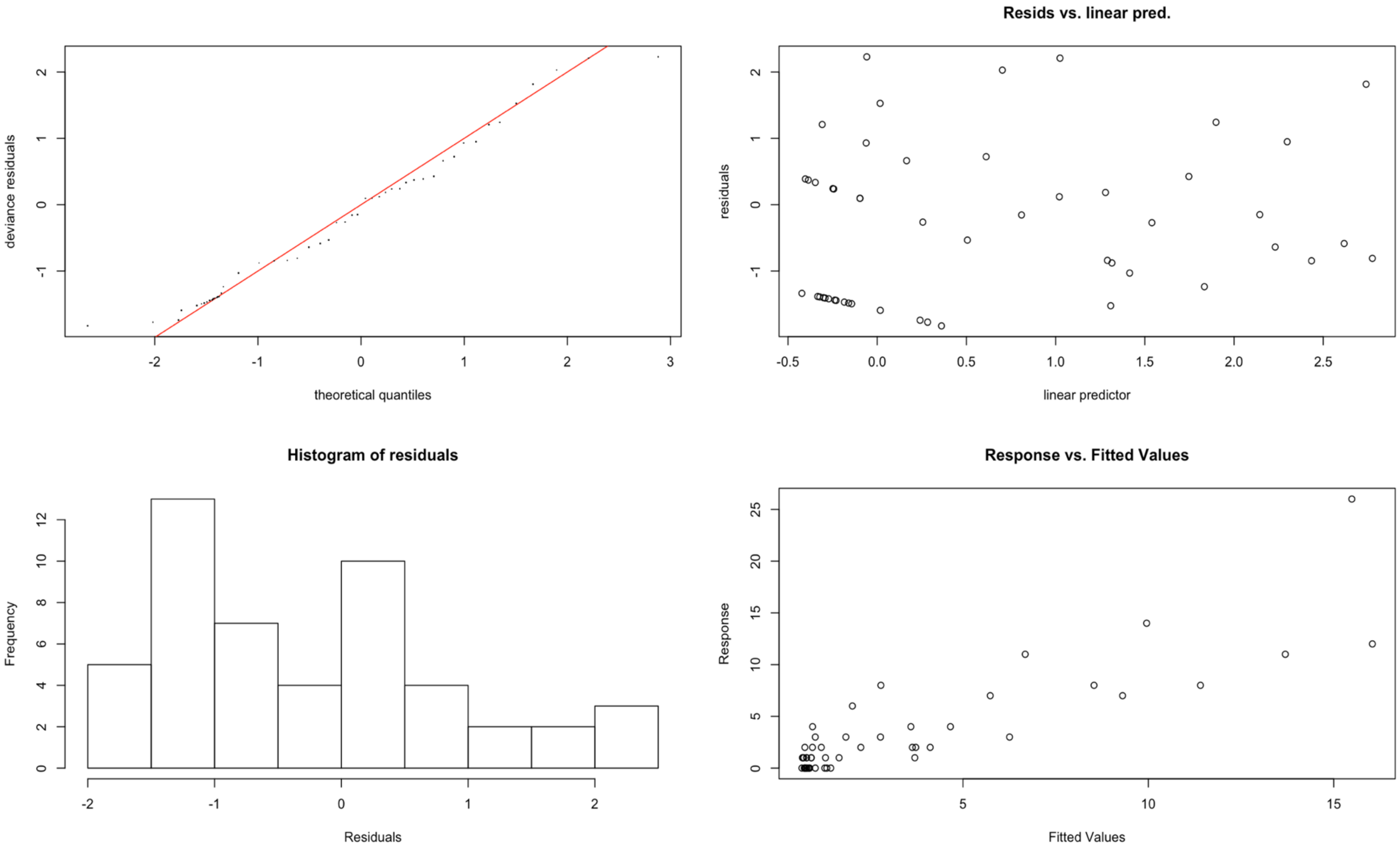
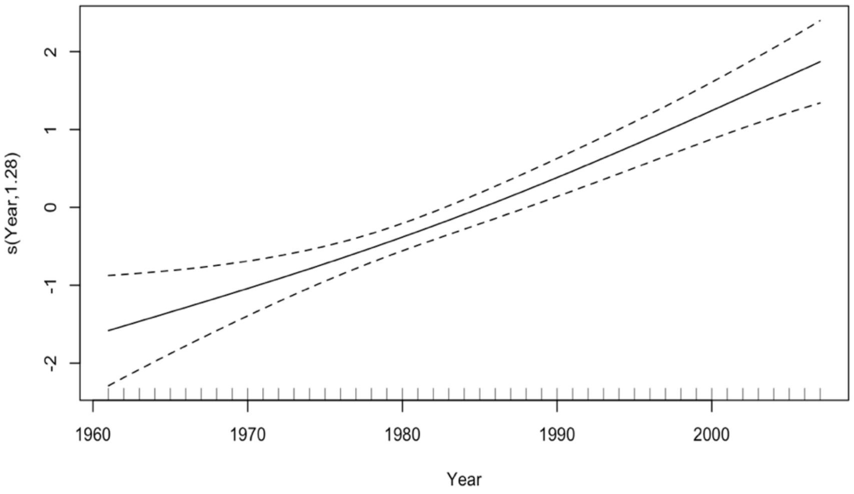
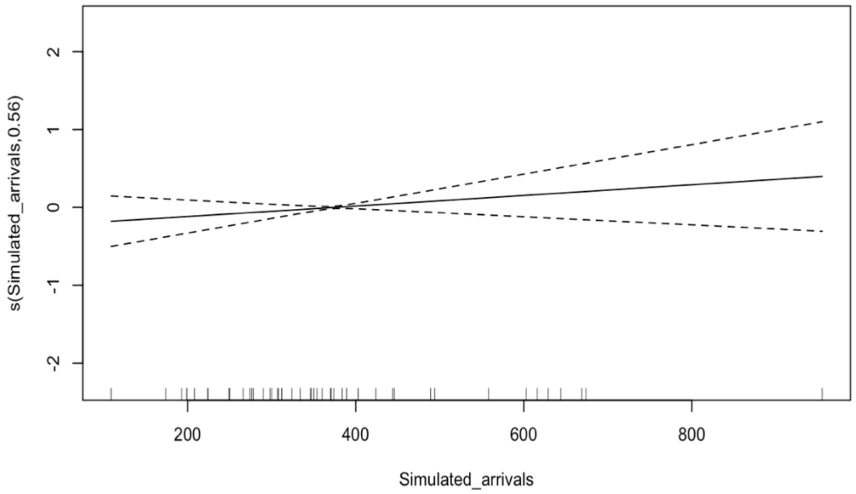



**Fig S7 Generalized additive model (GAM) check plots for all strandings using a Tweedie response count distribution (the best fit) for Model 2.** The Q-Q plot (top left) shows the closest fit to a y=x line. The histogram of residuals (bottom left) shows a normal distribution, suggesting that most of the residuals fall around the mean. The residuals vs. linear predictors plot (top right) shows that there is some heteroscedasticity in the dataset. The response vs. fitted values show a normal distribution (bottom right).



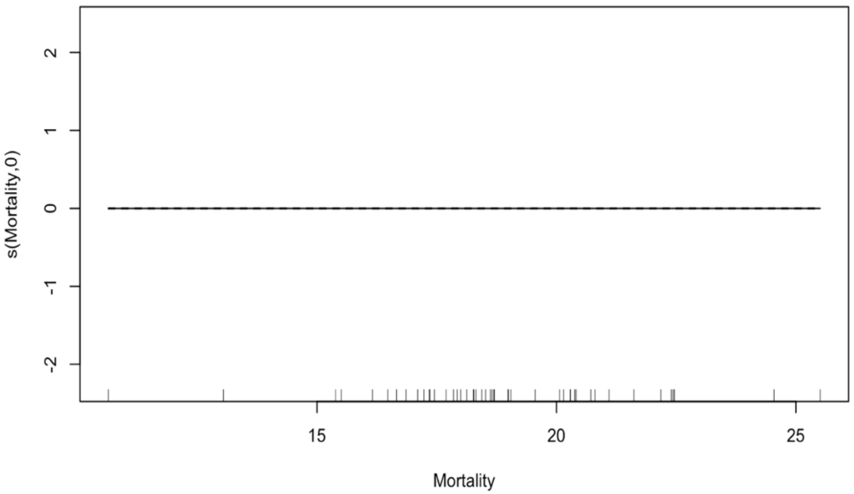




**Fig S8 Generalized additive model (GAM) summary plots for variables included for Model 3.** The model is constrained to 1961-2007. Simulated arrivals (top right) is the yearly number of modelled arrivals of virtual turtles to the UK coast., Mortality (bottom left) is the estimated mortality from exposure to ≤10 °C temperature during first year of drift. The y-axis shows the smooth and the estimated degrees of freedom (EDF). These EDF values are also reported in Table S1. Modelled using the Poisson response count distribution. The model has a deviance explained of 61.5%.

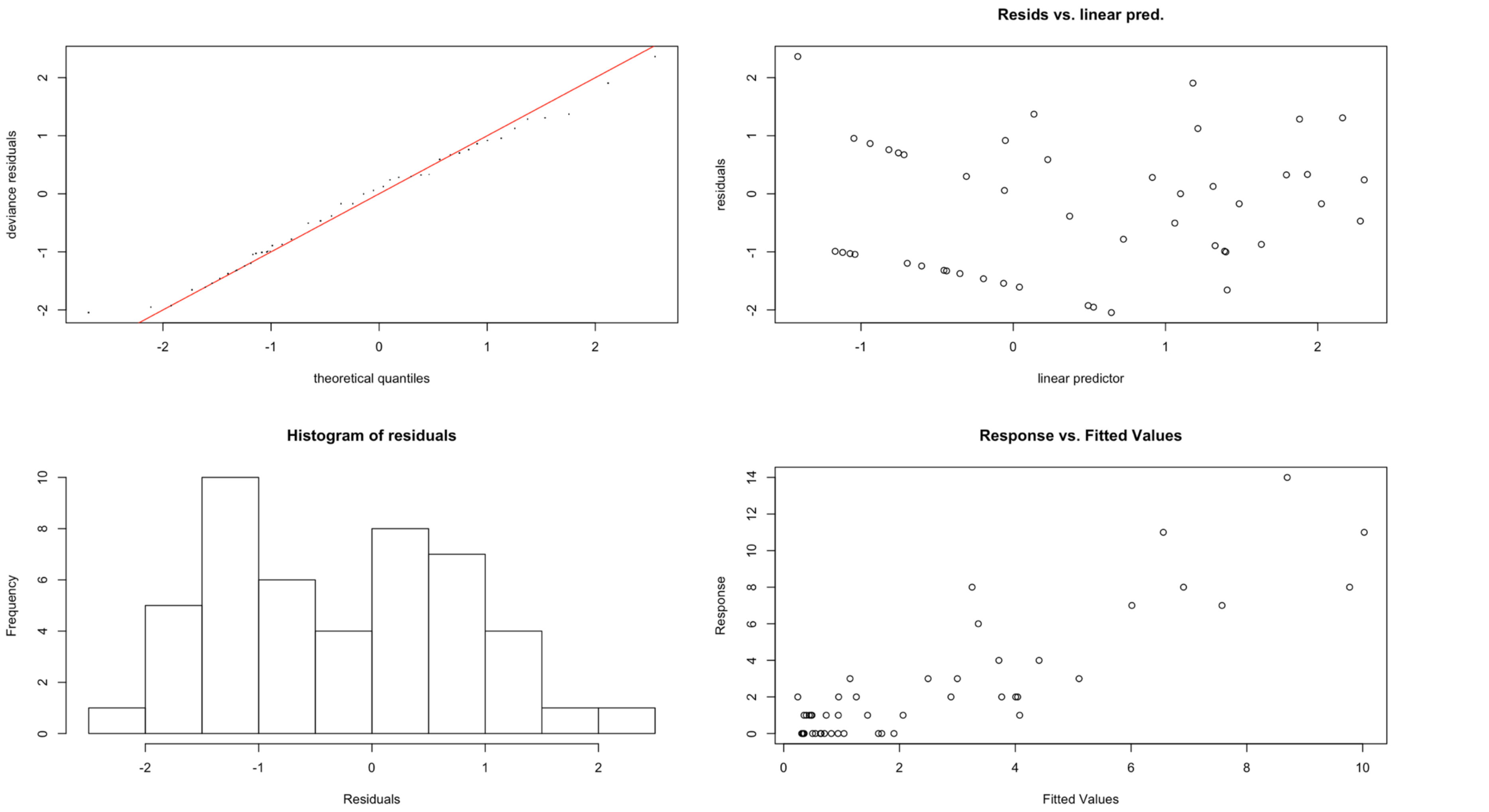



**Fig S9 Generalized additive model (GAM) check plots for all strandings using a Tweedie response count distribution (the best fit) for Model 3.** The Q-Q plot (top left) shows the closest fit to a y=x line. The histogram of residuals (bottom left) shows a normal distribution, suggesting that most of the residuals fall around the mean. The residuals vs. linear predictors plot (top right) shows that there is some heteroscedasticity in the dataset. The response vs. fitted values show a normal distribution (bottom right).

**Table S1. Approximate significance of smooth terms for Models 2 and 3.** The Tweedie distribution was the best model fit for these models.

| | Edf | Ref.df | F | p-value |
|---|---|---|---|---|
| **Model 2** | | | | |
| s(Year) | 2.349e+00 | 9 | 8.553 | 2.7e-13 ** |
| s(GS_transport) | 8.372e-06 | 9 | 0.000 | 0.338 |
| s(NAC_transport) | 4.697e-01 | 9 | 0.097 | 0.177 |
| | R-sq.(adj) = 0.732<br>Deviance explained = 66.6%<br>REML = 95.826<br>Scale est. = 1.5245<br>n = 50 | | | |
| **Model 3** | | | | |
| s(Year) | 1.278e+00 | 9 | 5.733 | 9.47e-10 ** |
| s(Simulated_arrivals) | 5.566e-01 | 9 | 0.142 | 0.125 |
| s(Mortality) | 2.663e-06 | 9 | 0.000 | 0.548 |
| | R-sq.(adj) = 0.74<br>Deviance explained = 61.5%<br>REML = 81.987<br>Scale est. = 1.4508<br>n = 47 | | | |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1