Biomathematics and Statistics Scotland

Additional Work Other Colonies – Seabird Tracking Data (Under Agreement C10-0206-0387)

CONTRACT No: C10-0206-0387

Report submitted to:

Joint Nature Conservation Committee

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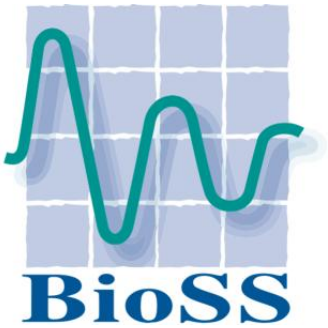

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In addition to this report, there are ancillary files associated with this project:

(i) Spreadsheet files of grid predictions for the Coquet Colony
(ii) Spreadsheets of correlations between covariates

1. Introduction

The Joint Nature Conservation Committee (JNCC) is working on the identification of important marine areas around the UK that are used by five species of tern during the breeding season. For the four larger tern species (Arctic, common, roseate and Sandwich terns), visual tracking data are available from boat surveys.

A Phase I project completed by BioSS in 2012 used these data to learn about important associations between terns usage/preference and environmental covariates, and to predict usage/preference. During subsequent Phase II work it became apparent that for some environmental covariates there were some issues with outliers and skewed distributions. BioSS was therefore asked to use the methodology developed from the Phase I project to re-run the models for after removing outliers and transforming variables where necessary. Models for the Coquet colony were covered in a separate report and this report covers the remaining colonies.

2. Methods

We followed the methodology described in the report for Phase I (Brewer et al., 2012a) with modifications (in terms of treatment of the environmental variables) described below.

The boxplots in the Phase II report (Brewer et al., 2012b) show a negatively skewed distribution for sea surface temperature, with low values occurring near the shore. The extent to which these data are reliable is uncertain. Removal of values considered unreliable would have resulted in considerable loss of data, resulting in a possible bias of the predictive model when applied to grid cells close to shore; for this reason, sea surface temperature (SST) was excluded from the Phase II analysis. For the current work we fitted models both excluding data points with extreme values of SST (for April this is interpreted as less than 6°C, for May as less than 8°C, and for June as less than 9.3°C) and models that excluded the SST variables entirely. These thresholds were chosen by visual inspection of Figure 1 from the Phase II report. The aim was to remove those data which appeared to be separated from the main part of the distribution.

The Phase II report did not include boxplots for eastness, northness or slope, as the decision had been taken to remove them because they had not been selected in the Phase 1 models. The variables sum_front_sd and spring_front_sd were also removed because it did not seem biologically realistic to suppose that the birds would respond to these variables while not responding to the probability of a frequent thermal front itself). For a subsequent piece of work for the Coquet colony (Potts et al., 2012) these variables were investigated for outliers, in case any subsequent appropriate treatment of the variables (e.g. transformation) might result in the variables that had not previously been selected now being selected. Chlorophyll concentrations and wave and current shear stresses had positively skewed distributions and were therefore log-transformed as in the Phase II report. The boxplots for the additional variables considered in this report show that only slope has a skewed distribution and hence this was also log-transformed prior to analysis. Where necessary, a small constant was added to variables prior to log transformation to avoid taking logs of zero values.

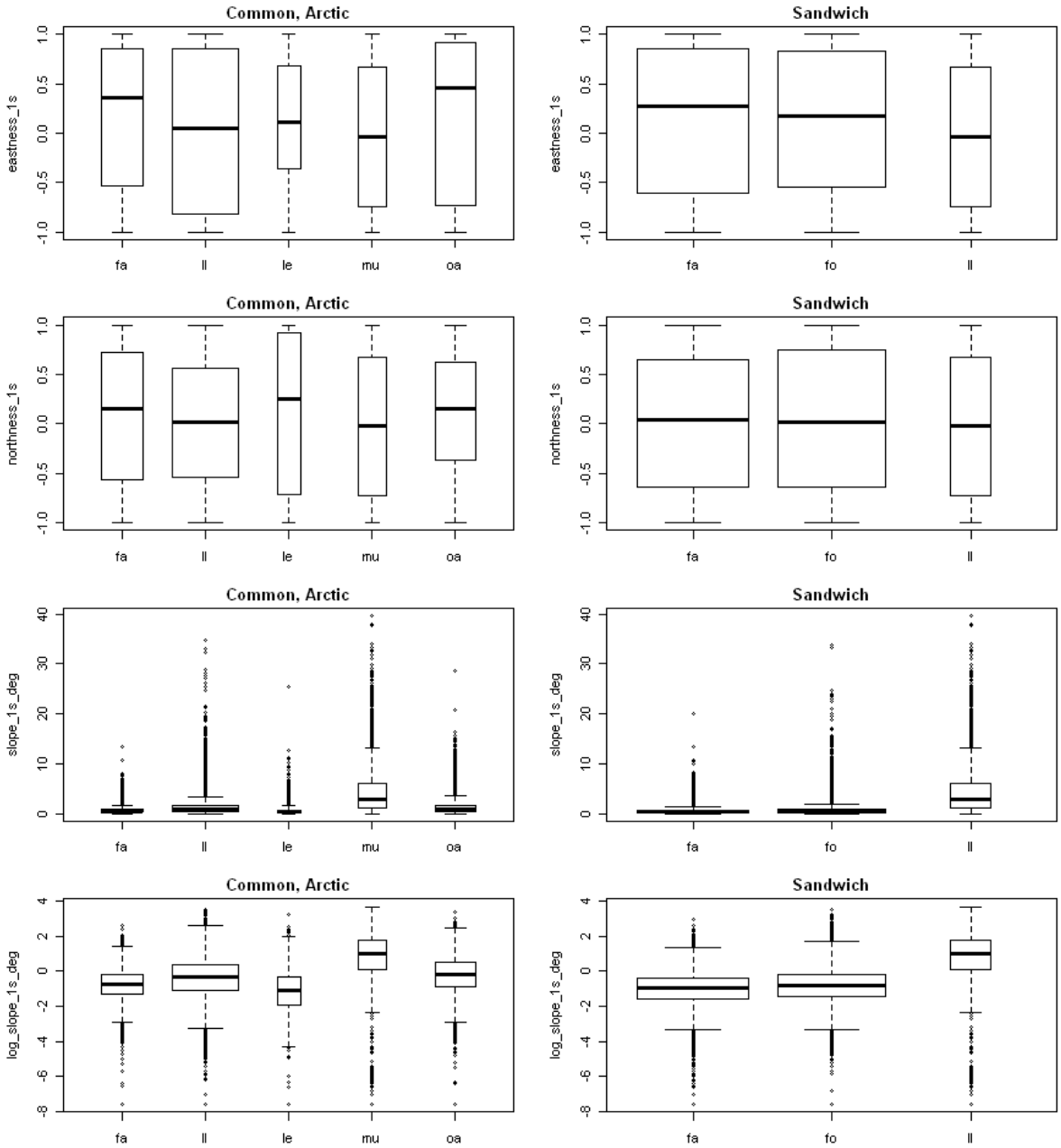
For the work in Potts et al. (2012) some additional code was written which starts with a model having the distance to colony variable as sole explanatory variable; the original code for performing stepwise selection started with all the potential covariates in the model. The new code could have started from a model with no covariates but we decided to start with a model that included distance to colony as this variable was selected in almost all models. Running a stepwise procedure from two different starting points increases the chances of finding the model that has minimum AIC. Where the models selected by running the stepwise procedure from the two starting points are the same, we can be reasonably confident that we have found a minimum AIC model. However, where they differ, the AIC statistics from the two models should be examined to see which one is lower and therefore corresponds to a better model. Code was also added for calculating correlations between variables in the selected model and for calculating variance inflation factors (VIFs). VIFs measure the impact of collinearity on the standard errors of the estimate. It is sometimes argued that a VIF score greater than 10 indicates that one or more of the collinear variables should be removed, but such rules of thumb should be treated with caution (O'Brein, 2007). In Potts et al. (2012) grid cells within 500m of the colony were removed, to avoid these cells 'consuming' a very high proportion of the available usage values (especially if the centre point of those grid cells was only metres from the colony).

This report extends the work for Coquet in Potts et al. (2012) to other colonies.

3. Results

Boxplots of eastness, northness and slope are shown in Figure 1. As in the previous work for the Coquet colony a decision was taken to log-transform slope.

Figure 1. Boxplots of eastness, northness, slope and log-transformed slope using grid data for common (C), Arctic (A) and Sandwich (S) terns. Colonies are indicated by fa Farnes; fo Forvie; ll Larne Lough;le Leith; mu Mull; oa Outer Ards.



The modelling results are presented in the Appendix and summarised in tables 1 to 10. In cases where no SST variables were selected for the models including SST with outliers removed we present only the results for the models excluding SST in the tables, as these allow the full data set to be used and were therefore used for making predictions. INLA was applied to the model chosen by the GAM model selection; so we do not show this separately in the tables.

After removal of outliers, the only case where one of the SST variables was selected in the GAM model was common terns at Leith. We therefore base the final predictions for this colony on the model including SST with outliers removed. In all other cases the GAM model excluding SST was used.

To help assess the effects of removing outliers from SST, and transforming the variables of chlorophyll, wave shear stress, current shear stresses and slope, it is useful to compare the models selected in this work which included SST as a candidate covariate, with the models selected under the Phase 1 work. It should be noted that the SST variables are selected less frequently than in the Phase I models. This suggests that it may have been selected previously because of the influence of points near the coast, where the outliers tend to occur.

There were no interaction with year that are significant at the 5% level.

Arctic Terns

Farnes

Table 1. Covariates selected in the Farnes Arctic tern model.

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col	*	*	*	*
summ_front_sd	*	*	*	*
spring_frt_sd	*		*	*

In the Phase I models, sst_april was selected.

Outer Ards

Table 2. Covariates selected in the Outer Ards Arctic tern model.

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col	*		*	*
chl_jun				*
ss_wave				*
ss_current	*	*	*	*

In the Phase I models sst_may was selected.

Common Terns

Larne Lough

Table 3. Covariates selected in the Larne Lough common tern model.

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col	*	*	*	*
dist_shore	*	*	*	*
chl_june	*		*	*
spring_front	*			
bathy_1sec	*	*	*	*

The Phase I models selected sst_april, but with the removal of the SST variables chl_june is now selected instead.

Leith

Table 4. Covariates selected in the Leith common tern model including SST.

	SST variables included with outliers removed			
	AIC	BIC	LRT	GAM
dist_col	*	*	*	*
chl_apr	*		*	*
sst_apr	*	*	*	*
spring_front	*		*	*
ss_wave	*		*	*
bathy_1sec	*		*	*

Table 5. Covariates selected in the Leith common tern model with SST excluded.

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col	*	*	*	*
dist_shore	*		*	*
chl_may	*		*	
chl_june	*		*	*
summ_front	*		*	*
spring_front	*		*	
sal_summ	*		*	
bathy_1sec	*		*	*
slope_1s_deg	*		*	*

Mull

After removal of SST outliers there was no case data remaining so we were only able to run models with SST excluded entirely. The GAM model shows a U-shaped relationship with bathymetry, which is difficult to justify. So in this case predictions were based on the LRT model.

Table 6. Covariates selected in the Mull common tern model.

	SST variables excluded			
	AIC	BIC	LRT	GAM
chl_apr	*		*	*
chl_may	*	*	*	*
ss_wave	*		*	*
bathy_1sec				*

Sandwich Terns

Farnes – SST excluded

Table 7. Covariates selected in the Farnes sandwich tern model.

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col	*			
dist_shore	*	*	*	*
summ_front	*		*	*
spring_front	*		*	*
bathy_1sec	*		*	*

Forvie – SST included with outliers removed

Table 8. Covariates selected in the Forvie sandwich tern model including SST.

	SST variables included			
	AIC	BIC	LRT	GAM
dist_col	*			
sst_june	*			
strat_temp		*		
ss_wave		*		
bathy_1sec	*		*	*

Forvie – SST excluded

Table 9. Covariates selected in the Forvie sandwich tern model excluding SST.

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col			*	
dist_shore	*	*		*
strat_temp	*	*	*	*
ss_wave			*	

Larne Lough

As noted in Brewer et al., 2012a it is not feasible to use many of the covariates for Sandwich terns at Larne Lough. All the values of SST for the case data were in fact negative and therefore excluded, so we were only able to run models with SST excluded entirely. These were run for a limited set of covariates (dist_col, dist_shore, bathy_1sec, slope_1s_deg, eastness, northness, sal_spring, strat_temp). It would also have been feasible to include sal_summ as well as sal_spring, but this was omitted due to the extremely high correlation between these two variables.

Table 10. Covariates selected in the Larne Lough sandwich tern model .

	SST variables excluded			
	AIC	BIC	LRT	GAM
dist_col	*	*	*	*
dist_shore	*	*	*	*
sal_spring	*	*	*	*

References

Brewer M.J., Potts J.M., Duff E.I. & Elston D.A. (2012a). To carry out tern modelling under the Framework Agreement C10-0206-0387. Report submitted to: Joint Nature Conservation Committee.

Brewer M.J., Potts J.M., Duff E.I. & Elston D.A. (2012b). Prediction of New Colonies – Seabird Tracking Data (Under Agreement C10-0206-0387). Report submitted to: Joint Nature Conservation Committee.

O'Brien R.M. (2007). A Caution Regarding Rules of Thumb for Variance Inflation Factors. *Quality & Quantity*, **41**: 673-690

Potts J.M., Brewer M.J., Duff E.I. & Elston D.A. (2012). Additional Work Coquet Colony - Seabird Tracking Data (Under Agreement C10-0206-0387). Report submitted to: Joint Nature Conservation Committee.

Appendix

Arctic Terns

Farnes – SST included with outliers removed

```
Running analysis for colony Farnes for species Arctic.

Using years 10 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + summ_front_sd, family =
"binomial",

    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.66329  -0.04827  -0.01970  -0.00675   2.53235


Coefficients:

             Estimate Std. Error z value Pr(>|z|)

(Intercept)   -1.64697    0.40322  -4.085 4.42e-05 ***

dist_col      -0.29467    0.06364  -4.630 3.66e-06 ***

summ_front_sd  0.04071    0.01243   3.274  0.00106 **

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)
```

```
    Null deviance: 202.62  on 17203  degrees of freedom
Residual deviance: 157.26  on 17201  degrees of freedom
AIC: 20.057

Number of Fisher Scoring iterations: 8

AIC Selected Model (backwards):

Call:
glm(formula = SEARCH_FORAGE ~ summ_front_sd + dist_col, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.66329  -0.04827  -0.01970  -0.00675   2.53235

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)   -1.64697    0.40322  -4.085 4.42e-05 ***
summ_front_sd  0.04071    0.01243   3.274  0.00106 **
dist_col      -0.29467    0.06364  -4.630 3.66e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 202.62  on 17203  degrees of freedom
```

```
Residual deviance: 157.26  on 17201  degrees of freedom
AIC: 20.057

Number of Fisher Scoring iterations: 8

              summ_front_sd  dist_col
summ_front_sd     1.0000000 0.4341275
dist_col          0.4341275 1.0000000
summ_front_sd      dist_col
     1.598853      1.598853
BIC Selected Model:

Call:
glm(formula = SEARCH_FORAGE ~ ss_current, family = "binomial",
    data = complete.data.to.analyse, weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-1.03224  -0.04713  -0.02771  -0.01628   2.14860

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.6548     0.3702  -9.871  < 2e-16 ***
ss_current    1.6667     0.3186   5.231 1.68e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)
```

```
    Null deviance: 202.62  on 17203  degrees of freedom
Residual deviance: 168.54  on 17202  degrees of freedom
AIC: 17.298

Number of Fisher Scoring iterations: 7

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.82920  -0.04679  -0.02144  -0.00514   2.47302

Coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)    6.423e+04  2.902e+04   2.213 0.026880 *
summ_front_sd  2.477e-02  1.401e-02   1.768 0.077037 .
sal_summ      -2.098e+03  9.086e+02  -2.309 0.020929 *
sal_spring     2.669e+02  1.180e+02   2.262 0.023687 *
ss_current     1.392e+00  3.678e-01   3.785 0.000153 ***
sand          -5.101e+00  5.257e+00  -0.970 0.331856
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)
```

```
    Null deviance: 202.62  on 17203  degrees of freedom
Residual deviance: 156.41  on 17198  degrees of freedom
AIC: 25.376

Number of Fisher Scoring iterations: 10

Single term deletions

Model:
SEARCH_FORAGE ~ summ_front_sd + sal_summ + sal_spring + ss_current +
    sand
             Df Deviance    AIC     LRT  Pr(>Chi)
<none>            156.41 25.376
summ_front_sd  1   159.62 26.583  3.2071  0.073319 .
sal_summ       1   163.31 30.271  6.8948  0.008645 **
sal_spring     1   162.53 29.495  6.1190  0.013374 *
ss_current     1   173.40 40.358 16.9820 3.774e-05 ***
sand           1   161.81 28.773  5.3970  0.020171 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit
```

```
Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(summ_front_sd, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.0339     0.5313  -7.593 3.13e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf Ref.df Chi.sq  p-value
s(dist_col)       1      1  21.44 3.66e-06 ***
s(summ_front_sd)  1      1  10.72  0.00106 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =   0.14   Deviance explained = 22.4%
ML score = 78.628  Scale est. = 1         n = 17204

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(summ_front_sd, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
```

```
(Intercept)  -4.0339     0.5313  -7.593 3.14e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                 edf Ref.df Chi.sq  p-value
s(dist_col)        1      1  21.44 3.66e-06 ***
s(summ_front_sd)   1      1  10.72  0.00106 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =   0.14   Deviance explained = 22.4%
REML score = 79.518  Scale est. = 1         n = 17204

Running INLA.

Call:
c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")

Time used:
 Pre-processing    Running inla Post-processing           Total
       2.527204       77.001735        9.625217       89.154156

Fixed effects:
                     mean         sd  0.025quant    0.5quant
0.975quant
(Intercept)   -1.63586827 0.40322405 -2.46786968 -1.62170138 -
0.88350346
```

```
dist_col      -0.29799692 0.06363899 -0.43352991 -0.29416841 -
0.18348286

summ_front_sd  0.04168103 0.01243355  0.01811838  0.04138349
0.06694406

                      kld

(Intercept)   0.0003817455

dist_col      0.0013690221

summ_front_sd 0.0030654656


Random effects:

Name                               Model      Max KLD

UserFunction0   NoModelName

UserFunction1   NoModelName

mesh.points   SPDE model


Model hyperparameters:

                           mean    sd     0.025quant 0.5quant
0.975quant

T.0 for mesh.points-basisT  7.343  3.162  1.152      7.335   13.578


Expected number of effective parameters(std dev): 3.00(1.076e-05)

Number of equivalent replicates : 5733.95


Marginal Likelihood:  -93.54

                 mean     sd 0.025quant 0.5quant 0.975quant    kld

(Intercept)   -1.6359 0.4032    -2.4679  -1.6217    -0.8835 0.0004

dist_col      -0.2980 0.0636    -0.4335  -0.2942    -0.1835 0.0014

summ_front_sd  0.0417 0.0124     0.0181   0.0414     0.0669 0.0031
```

Farnes – SST excluded

```
Running analysis for colony Farnes for species Arctic.

Using years 10 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + summ_front_sd +
spring_frt_sd,

    family = "binomial", data = complete.data.to.analyse, weights =
weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.65390  -0.04968  -0.01851  -0.00491   1.58395


Coefficients:

             Estimate Std. Error z value Pr(>|z|)

(Intercept)   -0.82532    0.49226  -1.677  0.09362 .

dist_col      -0.33065    0.07227  -4.575 4.75e-06 ***

summ_front_sd  0.05369    0.01639   3.275  0.00106 **

spring_frt_sd -0.05223    0.03152  -1.657  0.09747 .

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)
```

```
    Null deviance: 213.73  on 17470  degrees of freedom
Residual deviance: 163.60  on 17467  degrees of freedom
AIC: 15.4

Number of Fisher Scoring iterations: 8

AIC Selected Model(backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + summ_front_sd +
spring_frt_sd,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.65390  -0.04968  -0.01851  -0.00491   1.58395

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -0.82532    0.49226  -1.677  0.09362 .
dist_col      -0.33065    0.07227  -4.575 4.75e-06 ***
summ_front_sd  0.05369    0.01639   3.275  0.00106 **
spring_frt_sd -0.05223    0.03152  -1.657  0.09747 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)
```

```
    Null deviance: 213.73  on 17470  degrees of freedom
Residual deviance: 163.60  on 17467  degrees of freedom
AIC: 15.4

Number of Fisher Scoring iterations: 8

Correlations:
               dist_col summ_front_sd spring_frt_sd
dist_col      1.0000000     0.4376298     0.2905766
summ_front_sd 0.4376298     1.0000000     0.6134857
spring_frt_sd 0.2905766     0.6134857     1.0000000
VIF:
     dist_col summ_front_sd spring_frt_sd
     1.945559      3.329957      2.062823
BIC Selected Model:

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + summ_front_sd, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.67055  -0.04865  -0.02003  -0.00692   1.54020

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -1.41777    0.37156  -3.816 0.000136 ***
dist_col      -0.29305    0.06254  -4.685 2.79e-06 ***
```

```
summ_front_sd  0.03561    0.01171   3.040 0.002366 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 213.73  on 17470  degrees of freedom
Residual deviance: 166.41  on 17468  degrees of freedom
AIC: 13.721

Number of Fisher Scoring iterations: 8

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.65390  -0.04968  -0.01851  -0.00491   1.58395

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -0.82532    0.49226  -1.677  0.09362 .
dist_col      -0.33065    0.07227  -4.575 4.75e-06 ***
summ_front_sd  0.05369    0.01639   3.275  0.00106 **
spring_frt_sd -0.05223    0.03152  -1.657  0.09747 .
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 213.73  on 17470  degrees of freedom
Residual deviance: 163.60  on 17467  degrees of freedom
AIC: 15.4

Number of Fisher Scoring iterations: 8

Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + summ_front_sd + spring_frt_sd
              Df Deviance    AIC    LRT  Pr(>Chi)
<none>             163.60 15.400
dist_col       1   212.26 62.060 48.660 3.044e-12 ***
summ_front_sd  1   175.60 25.408 12.008 0.0005298 ***
spring_frt_sd  1   166.41 16.217  2.817 0.0932574 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit
```

```
Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(summ_front_sd, k = 3) +
    s(spring_frt_sd, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.2224     0.5907  -7.148  8.8e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf Ref.df Chi.sq  p-value
s(dist_col)       1      1 20.934 4.75e-06 ***
s(summ_front_sd)  1      1 10.726  0.00106 **
s(spring_frt_sd)  1      1  2.747  0.09747 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.155   Deviance explained = 23.5%
ML score = 81.798  Scale est. = 1         n = 17471

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(summ_front_sd, k = 3) +
```

```
    s(spring_frt_sd, k = 3)


Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.2224     0.5907  -7.148  8.8e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:
                edf Ref.df Chi.sq  p-value
s(dist_col)       1      1 20.933 4.76e-06 ***
s(summ_front_sd)  1      1 10.726  0.00106 **
s(spring_frt_sd)  1      1  2.747  0.09748 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.155   Deviance explained = 23.5%
REML score = 83.138  Scale est. = 1         n = 17471


Running INLA.


Call:
c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:
 Pre-processing    Running inla Post-processing           Total
       2.324404       82.477345        7.004413       91.806162
```

```
Fixed effects:
                     mean         sd  0.025quant    0.5quant
0.975quant
(Intercept)   -0.79899086 0.49226081 -1.80117646 -0.78652580
0.132902832
dist_col      -0.33490578 0.07226184 -0.48911153 -0.33042690 -
0.205246284
summ_front_sd  0.05517508 0.01639368  0.02414374  0.05476819
0.088528483
spring_frt_sd -0.05347846 0.03151744 -0.11634188 -0.05312385
0.007338389
                       kld
(Intercept)   0.0014358048
dist_col      0.0017384186
summ_front_sd 0.0040967666
spring_frt_sd 0.0007857928

Random effects:
Name                               Model      Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model

Model hyperparameters:
                            mean   sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.351  3.162  1.138      7.351   13.564

Expected number of effective parameters(std dev): 4.00(2.956e-05)
Number of equivalent replicates : 4367.33
```

```
Marginal Likelihood:  -103.70

                 mean     sd 0.025quant 0.5quant 0.975quant    kld
(Intercept)   -0.7990 0.4923    -1.8012  -0.7865     0.1329 0.0014
dist_col      -0.3349 0.0723    -0.4891  -0.3304    -0.2052 0.0017
summ_front_sd  0.0552 0.0164     0.0241   0.0548     0.0885 0.0041
spring_frt_sd -0.0535 0.0315    -0.1163  -0.0531     0.0073 0.0008
```

Outer Ards – SST included with outliers removed

```
Running analysis for colony OuterArds for species Arctic.
Using years 09,10,11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.
Employing model selection.


AIC Selected Model (forwards):


Call:
glm(formula = SEARCH_FORAGE ~ dist_col + chl_june, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.36762  -0.03192  -0.01978  -0.01220   0.49244


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  0.59062    1.70531   0.346   0.7291
```

```
dist_col    -0.10291    0.05365  -1.918   0.0551 .
chl_june    -2.68645    1.66233  -1.616   0.1061
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 94.978  on 23592  degrees of freedom
Residual deviance: 89.320  on 23590  degrees of freedom
AIC: 6

Number of Fisher Scoring iterations: 7

AIC Selected Model (backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + chl_apr +
    chl_june, family = "binomial", data = complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.36031  -0.02942  -0.01800  -0.01066   0.48715

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.27468    2.64969   1.613   0.1067
dist_col    -0.07966    0.05726  -1.391   0.1642
dist_shore  -0.25865    0.15587  -1.659   0.0970 .
```

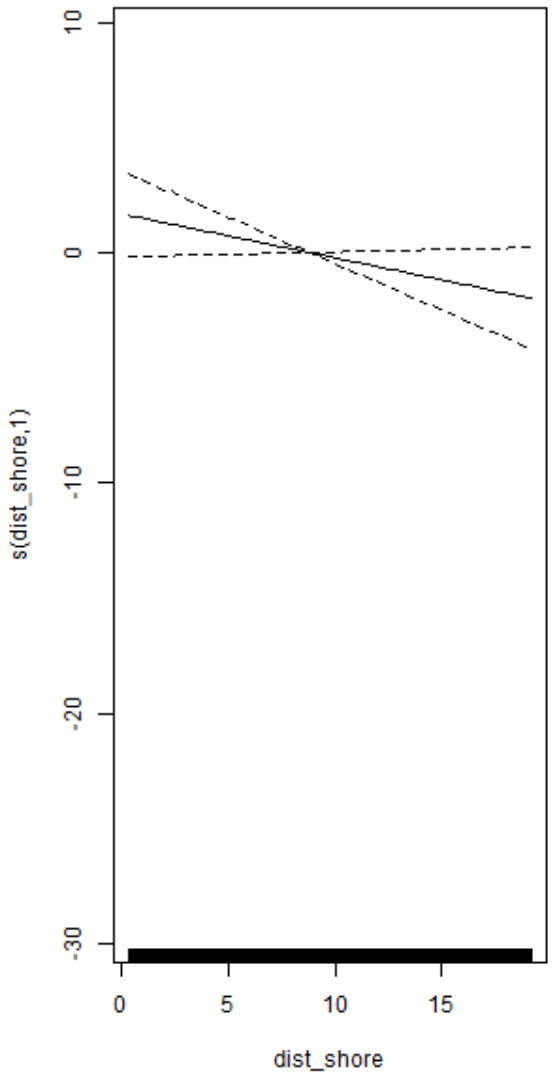
```
chl_apr     -3.04896    1.84960  -1.648   0.0993 .
chl_june    -2.73857    1.96852  -1.391   0.1642
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 94.978  on 23592  degrees of freedom
Residual deviance: 85.576  on 23588  degrees of freedom
AIC: 10

Number of Fisher Scoring iterations: 7

             dist_col dist_shore    chl_apr   chl_june
dist_col    1.0000000  0.4984307 -0.5066359 -0.1084967
dist_shore  0.4984307  1.0000000 -0.7920558 -0.5356392
chl_apr    -0.5066359 -0.7920558  1.0000000  0.5311532
chl_june   -0.1084967 -0.5356392  0.5311532  1.0000000
  dist_col dist_shore    chl_apr   chl_june
  1.749578   3.524344   2.871276   1.849351
BIC Selected Model:

Call:
glm(formula = SEARCH_FORAGE ~ 1, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
```

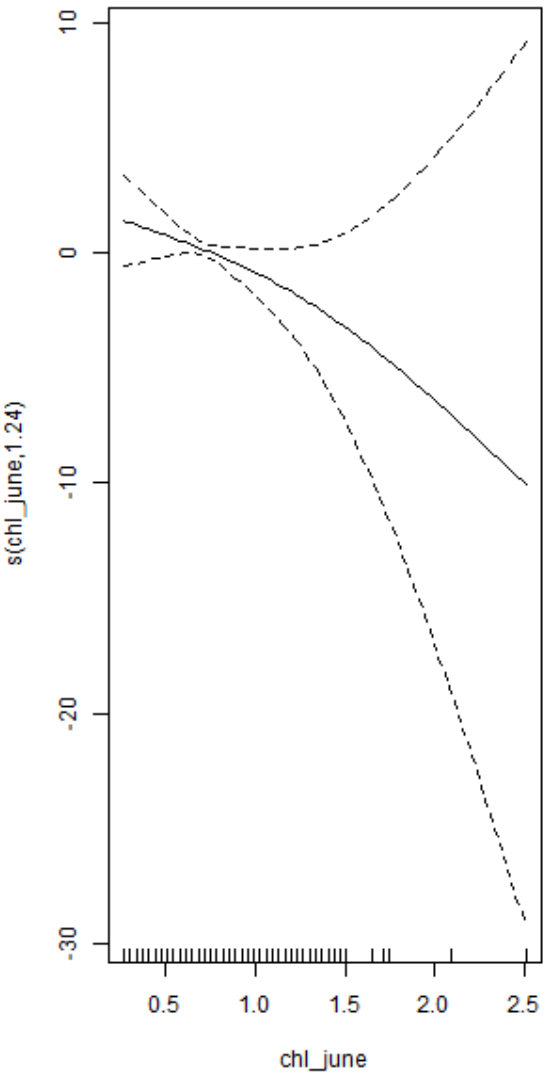
```
-0.22795  -0.02849  -0.02230  -0.01573   0.44596

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -2.9312     0.2963  -9.894   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 94.978  on 23592  degrees of freedom
Residual deviance: 94.978  on 23592  degrees of freedom
AIC: 2

Number of Fisher Scoring iterations: 6

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.36762  -0.03192  -0.01978  -0.01220   0.49244

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
```

```
(Intercept)  0.59062    1.70531   0.346   0.7291
dist_col    -0.10291    0.05365  -1.918   0.0551 .
chl_june    -2.68645    1.66233  -1.616   0.1061
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 94.978  on 23592  degrees of freedom
Residual deviance: 89.320  on 23590  degrees of freedom
AIC: 6

Number of Fisher Scoring iterations: 7

Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + chl_june
         Df Deviance    AIC    LRT Pr(>Chi)
<none>        89.320 6.0000
dist_col  1   94.210 8.8897 4.8897  0.02702 *
chl_june  1   92.344 7.0232 3.0232  0.08208 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Now checking for interactions with Year.
Single term deletions

Model:
```

```
SEARCH_FORAGE ~ Year * (dist_col + chl_june)
              Df Deviance    AIC     LRT Pr(>Chi)
<none>             83.395 18.000
Year:dist_col  2   85.732 16.337 2.33649   0.3109
Year:chl_june  2   84.211 14.816 0.81569   0.6651
No significant Year interactions.

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(chl_june, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.1303     0.3614  -8.661   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df Chi.sq p-value
s(dist_shore)   1      1  3.401  0.0651 .
s(chl_june)     1      1  3.322  0.0684 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
R-sq.(adj) =  0.0133   Deviance explained = 5.07%
ML score =  45.08  Scale est. = 1         n = 23593

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(chl_june, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.1302     0.3611   -8.67   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf Ref.df Chi.sq p-value
s(dist_shore) 1.000  1.000  3.245  0.0716 .
s(chl_june)   1.236  1.416  3.488  0.0997 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0149   Deviance explained = 5.46%
REML score = 45.475  Scale est. = 1         n = 23593
```

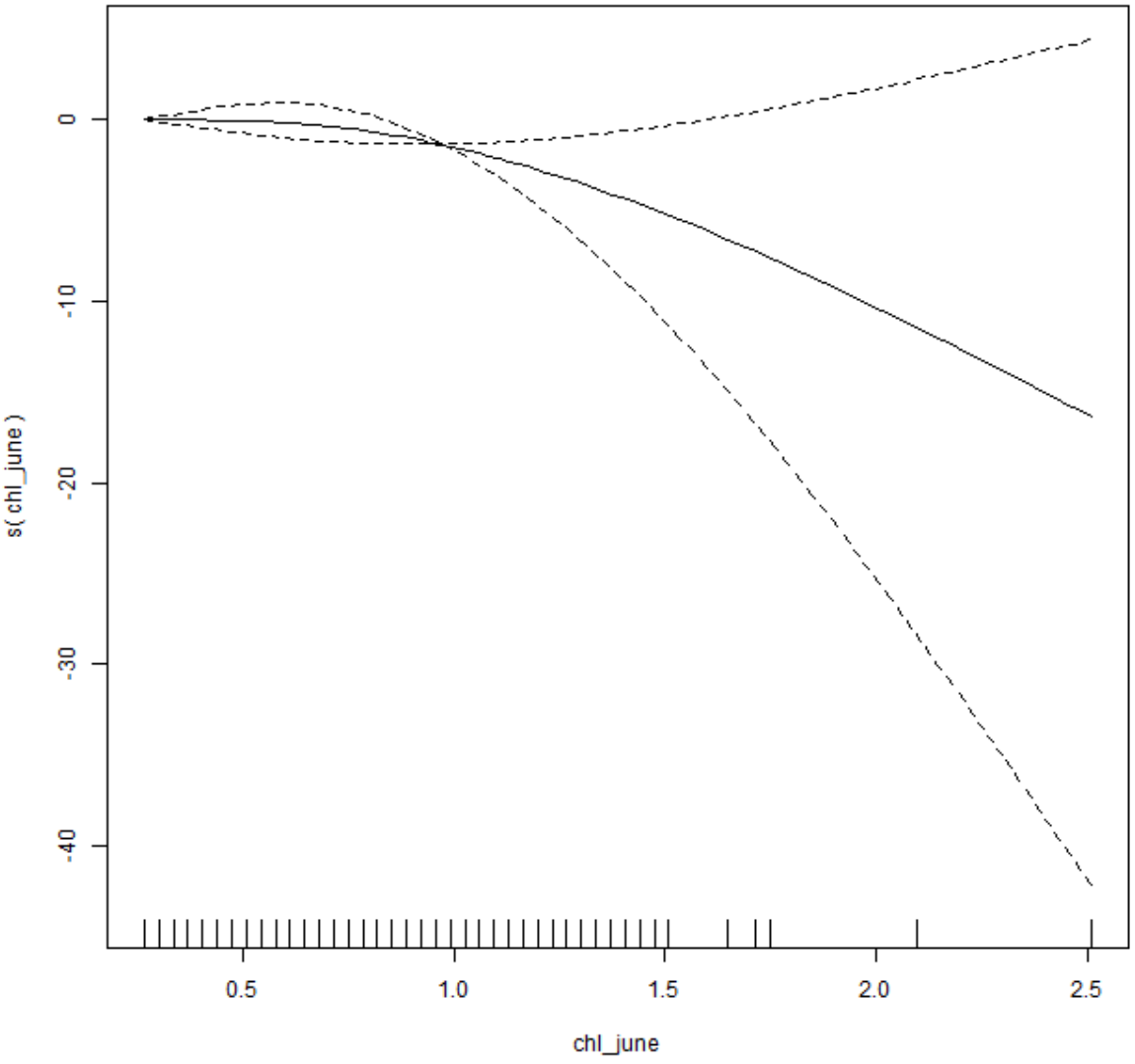





```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       3.946807      150.743065       12.667222      167.357094
```

```
Fixed effects:
                    mean         sd  0.025quant    0.5quant
0.975quant
(Intercept)  -1.0297077  1.9873222  -4.9817049  -1.0111513
2.814619023
dist_shore   -0.1787054  0.1037006  -0.3978004  -0.1731878
0.009867497
chl_june1    -8.9807630  4.7110765 -19.1585621  -8.6393179 -
0.663026104
chl_june2   -16.3789146 12.4575222 -43.4920458 -15.3887299
5.393664904
                     kld
(Intercept) 0.0028762892
dist_shore  0.0003086144
chl_june1   0.0092239031
chl_june2   0.0082883474

Random effects:
Name                               Model      Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model

Model hyperparameters:
                           mean   sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.226  3.153  1.019      7.225   13.420

Expected number of effective parameters(std dev): 3.822(8.132e-05)
Number of equivalent replicates : 6173.72
```

```
Marginal Likelihood:  -54.07

                mean      sd 0.025quant 0.5quant 0.975quant    kld
(Intercept)  -1.0297  1.9873    -4.9817  -1.0112     2.8146 0.0029
dist_shore   -0.1787  0.1037    -0.3978  -0.1732     0.0099 0.0003
chl_june1    -8.9808  4.7111   -19.1586  -8.6393    -0.6630 0.0092
chl_june2   -16.3789 12.4575   -43.4920 -15.3887     5.3937 0.0083
```



Outer Ards – SST excluded

```
Running analysis for colony OuterArds for species Arctic.

Using years 09,10,11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + ss_current, family =
"binomial",

    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.47927  -0.03069  -0.01727  -0.01060   1.18887


Coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept) -1.74151    0.53912  -3.230  0.00124 **

dist_col    -0.09268    0.04035  -2.297  0.02162 *

ss_current   0.95789    0.35498   2.698  0.00697 **

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 127.05  on 25376  degrees of freedom
```

```
Residual deviance: 108.53  on 25374  degrees of freedom

AIC: 7.4134


Number of Fisher Scoring iterations: 7


AIC Selected Model(backwards):


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + chl_june + ss_wave +

    ss_current, family = "binomial", data =
complete.data.to.analyse,

    weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.52159  -0.02933  -0.01739  -0.00969   0.95567


Coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept) -2.59669    1.05033  -2.472  0.01343 *

dist_col    -0.17080    0.08061  -2.119  0.03411 *

chl_june     1.18197    0.71055   1.663  0.09622 .

ss_wave     -0.37921    0.21735  -1.745  0.08104 .

ss_current   1.28606    0.42017   3.061  0.00221 **

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)
```

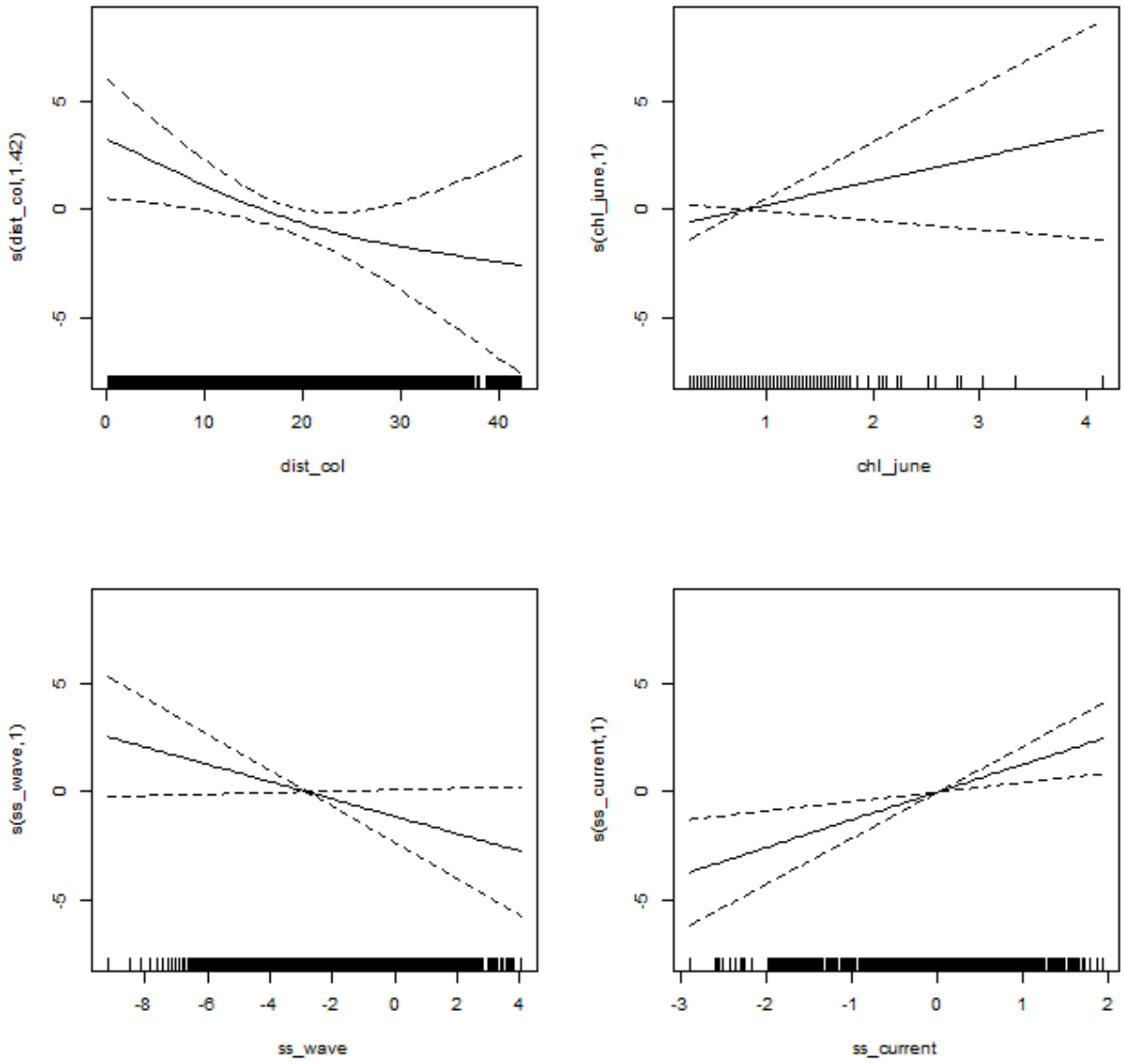
```
    Null deviance: 127.05  on 25376  degrees of freedom
Residual deviance: 104.84  on 25372  degrees of freedom
AIC: 10.913

Number of Fisher Scoring iterations: 7

Correlations:
               dist_col   chl_june     ss_wave   ss_current
dist_col    1.000000000 -0.2599825 -0.48920542  0.004078037
chl_june   -0.259982527  1.0000000  0.60721527 -0.315266288
ss_wave    -0.489205424  0.6072153  1.00000000  0.093928919
ss_current  0.004078037 -0.3152663  0.09392892  1.000000000
VIF:
  dist_col   chl_june    ss_wave ss_current
  3.932188   2.110211   6.279721   1.405949
BIC Selected Model:

Call:
glm(formula = SEARCH_FORAGE ~ ss_current, family = "binomial",
    data = complete.data.to.analyse, weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.48011  -0.03187  -0.02104  -0.01549   1.41138

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.0194     0.3168  -9.530  < 2e-16 ***
ss_current    1.2855     0.3845   3.343 0.000829 ***
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 127.05  on 25376  degrees of freedom
Residual deviance: 114.90  on 25375  degrees of freedom
AIC: 5.992

Number of Fisher Scoring iterations: 6

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.47927  -0.03069  -0.01727  -0.01060   1.18887

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.74151    0.53912  -3.230  0.00124 **
dist_col    -0.09268    0.04035  -2.297  0.02162 *
ss_current   0.95789    0.35498   2.698  0.00697 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 127.05  on 25376  degrees of freedom
Residual deviance: 108.53  on 25374  degrees of freedom
AIC: 7.4134

Number of Fisher Scoring iterations: 7

Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + ss_current
           Df Deviance     AIC    LRT Pr(>Chi)
<none>          108.53  7.4134
dist_col    1   114.90 11.7792 6.3658 0.011634 *
ss_current  1   117.41 14.2877 8.8743 0.002892 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Now checking for interactions with Year.
Single term deletions

Model:
SEARCH_FORAGE ~ Year * (dist_col + ss_current)
                Df Deviance    AIC    LRT Pr(>Chi)
<none>               98.649 18.662
Year:dist_col    2   99.937 15.950 1.2878   0.5252
Year:ss_current  2  102.921 18.934 4.2720   0.1181
```

```
No significant Year interactions.

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(chl_june, k = 3) + s(ss_wave,
    k = 3) + s(ss_current, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.5690     0.4723  -7.557 4.12e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df Chi.sq p-value
s(dist_col)     1      1  4.489 0.03412 *
s(chl_june)     1      1  2.767 0.09623 .
s(ss_wave)      1      1  3.044 0.08106 .
s(ss_current)   1      1  9.368 0.00221 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.184   Deviance explained = 17.5%
```

```
ML score = 52.422  Scale est. = 1         n = 25377

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(chl_june, k = 3) + s(ss_wave,
    k = 3) + s(ss_current, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.4586     0.4557   -7.59 3.19e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf Ref.df Chi.sq p-value
s(dist_col)   1.416  1.659  6.667 0.02577 *
s(chl_june)   1.000  1.000  2.085 0.14877
s(ss_wave)    1.000  1.000  3.396 0.06536 .
s(ss_current) 1.000  1.000  9.232 0.00238 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.189   Deviance explained = 18.5%
REML score = 53.601  Scale est. = 1         n = 25377
```




```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       3.712807      177.044710        9.235217      189.992734
```

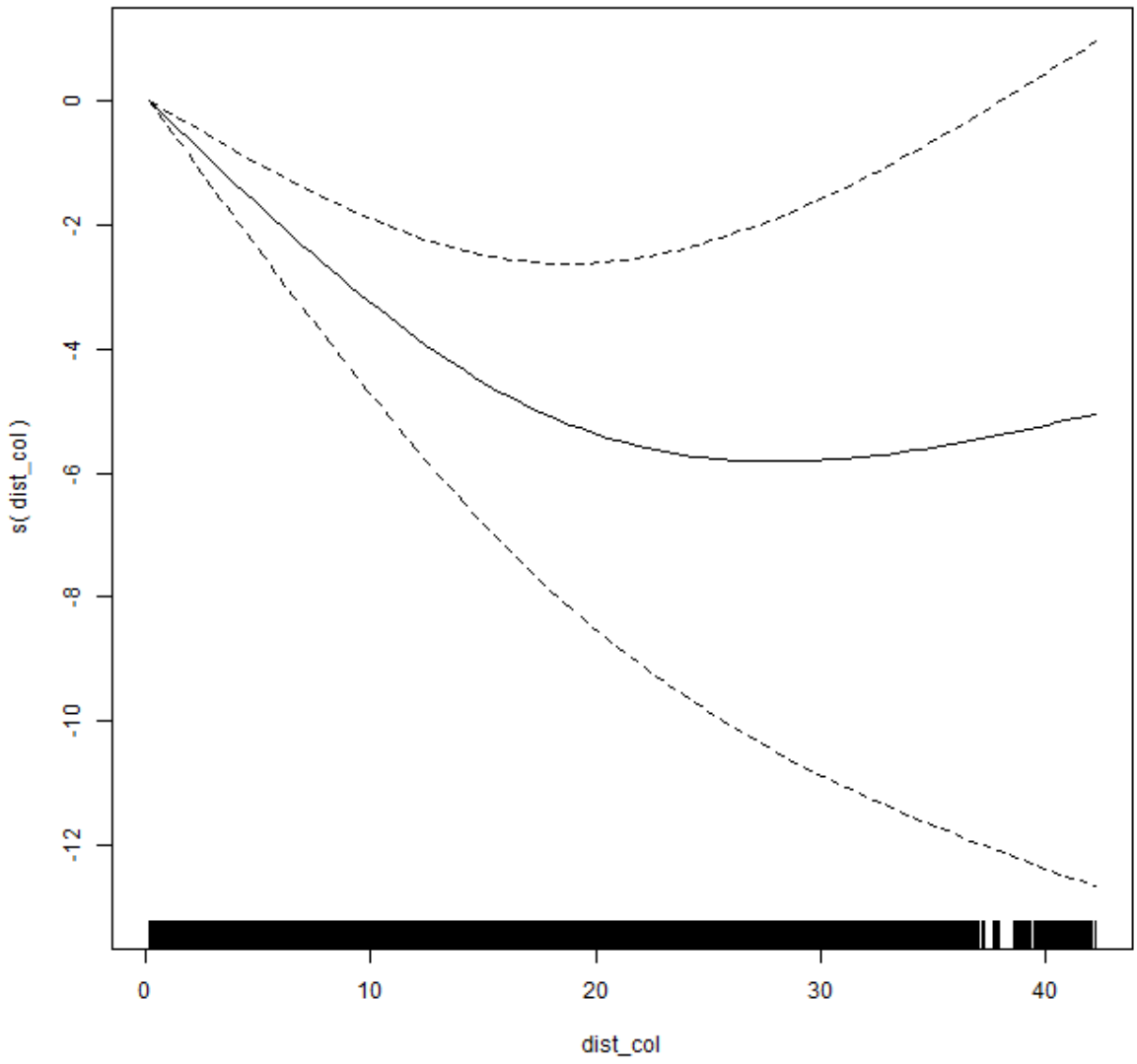
```
Fixed effects:
                    mean        sd  0.025quant   0.5quant 0.975quant
(Intercept)  -1.4165174 1.4073251  -4.0118743 -1.4777889  1.5199481
chl_june      0.9508272 0.8389256  -0.8538742  1.0084710  2.4398875
ss_wave      -0.4739561 0.2212573  -0.9318660 -0.4657144 -0.0624654
ss_current    1.3975379 0.4274679   0.6205868  1.3749009  2.3002748
dist_col1   -10.2101791 3.6239454 -17.9299954 -9.9913836 -3.6913179
dist_col2    -2.2472023 2.9016846  -8.6843344 -1.9563930  2.6608705
                     kld
(Intercept) 0.0005698673
chl_june    0.0010430648
ss_wave     0.0134930429
ss_current  0.0319425379
dist_col1   0.0371006258
dist_col2   0.0004460815

Random effects:
Name                               Model      Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model

Model hyperparameters:
                             mean    sd      0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.2119  3.1610  0.9912     7.2140
13.4105
```

Expected number of effective parameters(std dev): 5.978(3.701e-05)

Number of equivalent replicates : 4245.29

Marginal Likelihood: -70.46

	mean	sd	0.025quant	0.5quant	0.975quant	kld
(Intercept)	-1.4165	1.4073	-4.0119	-1.4778	1.5199	0.0006
chl_june	0.9508	0.8389	-0.8539	1.0085	2.4399	0.0010
ss_wave	-0.4740	0.2213	-0.9319	-0.4657	-0.0625	0.0135
ss_current	1.3975	0.4275	0.6206	1.3749	2.3003	0.0319
dist_col1	-10.2102	3.6239	-17.9300	-9.9914	-3.6913	0.0371
dist_col2	-2.2472	2.9017	-8.6843	-1.9564	2.6609	0.0004



Common Terns

Larne Lough – SST included with outliers removed

```
Running analysis for colony LarneLough for species Common.
Using years 09,10,11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.

Running GLM.
Employing model selection.
```

```
AIC Selected Model (forwards):


Call:
glm(formula = SEARCH_FORAGE ~ dist_col + bathy_1sec + dist_shore,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.83446  -0.01686  -0.00842  -0.00027   0.80976


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.90804    1.65501   2.966  0.00302 **
dist_col    -0.98482    0.38359  -2.567  0.01025 *
bathy_1sec   0.04067    0.00994   4.092 4.29e-05 ***
dist_shore   0.96677    0.41706   2.318  0.02045 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 107.651  on 16451  degrees of freedom
Residual deviance:  54.041  on 16448  degrees of freedom
AIC: 8.8838


Number of Fisher Scoring iterations: 10
```

```
AIC Selected Model (backwards):


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + bathy_1sec,

    family = "binomial", data = complete.data.to.analyse, weights =
weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.83446  -0.01686  -0.00842  -0.00027   0.80976


Coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)  4.90804    1.65501   2.966  0.00302 **

dist_col    -0.98482    0.38359  -2.567  0.01025 *

dist_shore   0.96677    0.41706   2.318  0.02045 *

bathy_1sec   0.04067    0.00994   4.092 4.29e-05 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 107.651  on 16451  degrees of freedom

Residual deviance:  54.041  on 16448  degrees of freedom

AIC: 8.8838


Number of Fisher Scoring iterations: 10


             dist_col dist_shore bathy_1sec
```

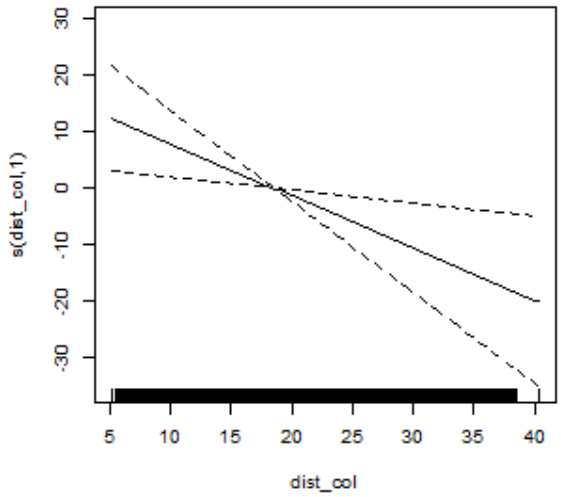
```
dist_col    1.0000000  0.6441675 -0.3947916
dist_shore  0.6441675  1.0000000 -0.5908240
bathy_1sec -0.3947916 -0.5908240  1.0000000
  dist_col dist_shore bathy_1sec
 17.991677  18.617921   1.204182
BIC Selected Model:


Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + bathy_1sec,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.83446  -0.01686  -0.00842  -0.00027   0.80976


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.90804    1.65501   2.966  0.00302 **
dist_col    -0.98482    0.38359  -2.567  0.01025 *
dist_shore   0.96677    0.41706   2.318  0.02045 *
bathy_1sec   0.04067    0.00994   4.092 4.29e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 107.651  on 16451  degrees of freedom
Residual deviance:  54.041  on 16448  degrees of freedom
```

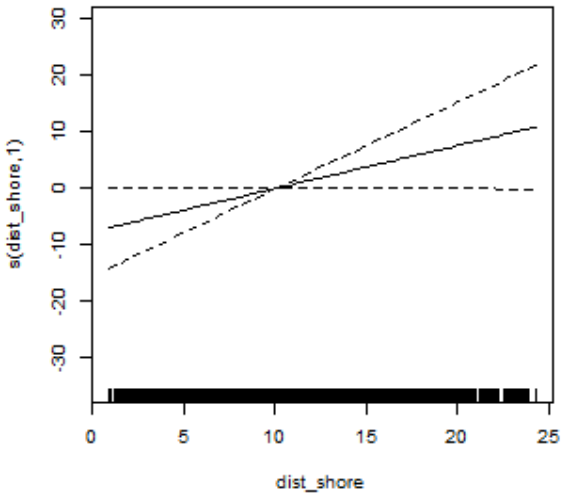
```
AIC: 8.8838

Number of Fisher Scoring iterations: 10

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.83446  -0.01686  -0.00842  -0.00027   0.80976

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.90804    1.65501   2.966  0.00302 **
dist_col    -0.98482    0.38359  -2.567  0.01025 *
dist_shore   0.96677    0.41706   2.318  0.02045 *
bathy_1sec   0.04067    0.00994   4.092 4.29e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 107.651  on 16451  degrees of freedom
Residual deviance:  54.041  on 16448  degrees of freedom
AIC: 8.8838
```

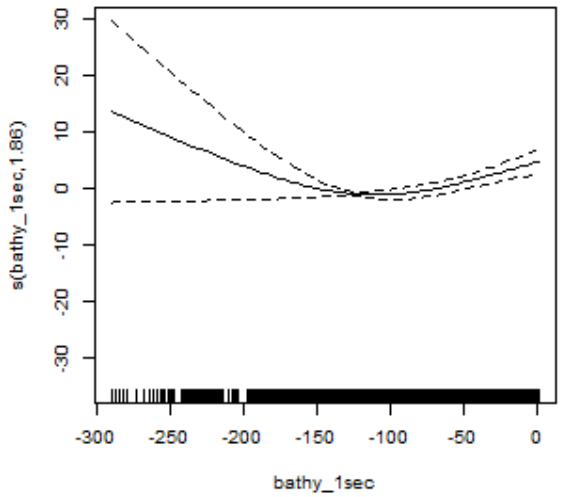
```
Number of Fisher Scoring iterations: 10


Single term deletions


Model:
SEARCH_FORAGE ~ dist_col + dist_shore + bathy_1sec
           Df Deviance    AIC    LRT  Pr(>Chi)
<none>          54.041  8.884
dist_col    1   85.052 37.895 31.011 2.566e-08 ***
dist_shore  1   67.016 19.859 12.975 0.0003156 ***
bathy_1sec  1   75.445 28.288 21.404 3.719e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Now checking for interactions with Year.
Single term deletions

Model:
SEARCH_FORAGE ~ Year * (dist_col + dist_shore + bathy_1sec)
                Df Deviance    AIC     LRT Pr(>Chi)
<none>               52.393 24.619
Year:dist_col    2   52.637 20.862 0.24329   0.8855
Year:dist_shore  2   52.722 20.947 0.32847   0.8485
Year:bathy_1sec  2   52.418 20.644 0.02507   0.9875
No significant Year interactions.

Running GAM.
```

```
GAM Model selected (ML output):


Family: binomial

Link function: logit


Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(bathy_1sec,

    k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)   -7.796      1.792  -4.352 1.35e-05 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

              edf Ref.df Chi.sq  p-value

s(dist_col)     1      1  6.591   0.0102 *

s(dist_shore)   1      1  5.373   0.0204 *

s(bathy_1sec)   1      1 16.741 4.29e-05 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.504   Deviance explained = 49.8%

ML score = 27.021  Scale est. = 1         n = 16452


GAM Model selected (REML output):
```

```
Family: binomial

Link function: logit


Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(bathy_1sec,

    k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)   -7.553      1.644  -4.595 4.33e-06 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

                edf Ref.df Chi.sq  p-value

s(dist_col)   1.000  1.000  7.118 0.007631 **

s(dist_shore) 1.000  1.000  3.885 0.048723 *

s(bathy_1sec) 1.864  1.982 18.160 0.000115 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.564   Deviance explained = 55.5%

REML score = 23.205  Scale est. = 1         n = 16452
```



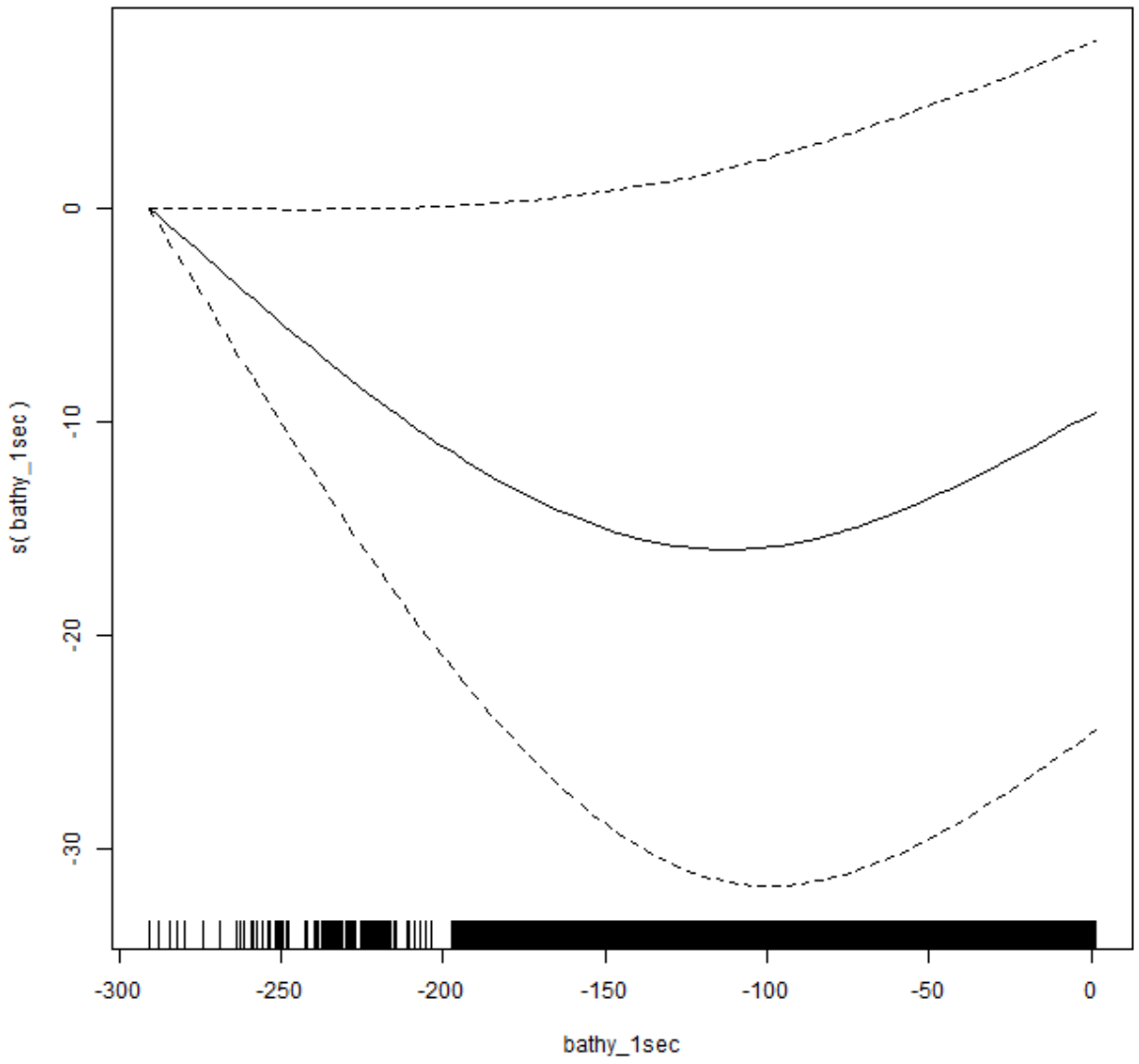





```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       2.683205       82.149744        6.942013       91.774962
```

```
Fixed effects:
                    mean         sd  0.025quant    0.5quant
0.975quant
(Intercept)  17.2504128  8.8737800  -1.2322228  17.6228640
33.6449470
dist_col     -0.9916954  0.3487971  -1.7766466  -0.9509396 -
0.4161388
dist_shore    0.8299499  0.3889190   0.1859347   0.7856156
1.7030087
bathy_1sec1 -27.5796745 15.5668502 -56.0545974 -28.3438293
5.1218605
bathy_1sec2   1.0326332  3.2383918  -4.7757220   0.8283660
7.9526907
                     kld
(Intercept) 0.0038949473
dist_col    0.0166284168
dist_shore  0.0085783798
bathy_1sec1 0.0001126305
bathy_1sec2 0.0074856183

Random effects:
Name    Model          Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model

Model hyperparameters:
                            mean   sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.366  3.156  1.157      7.372   13.565
```

```
Expected number of effective parameters(std dev): 4.749(0.0007987)
Number of equivalent replicates : 3464.03

Marginal Likelihood:  -38.09
                mean      sd 0.025quant 0.5quant 0.975quant    kld
(Intercept)  17.2504  8.8738    -1.2322  17.6229    33.6449 0.0039
dist_col     -0.9917  0.3488    -1.7766  -0.9509    -0.4161 0.0166
dist_shore    0.8299  0.3889     0.1859   0.7856     1.7030 0.0086
bathy_1sec1 -27.5797 15.5669   -56.0546 -28.3438     5.1219 0.0001
bathy_1sec2   1.0326  3.2384    -4.7757   0.8284     7.9527 0.0075
```



Larne Lough – SST excluded

```
Running analysis for colony LarneLough for species Common.

Using years 09,10,11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + slope_1s_deg + chl_apr +

    bathy_1sec + ss_wave, family = "binomial", data =
complete.data.to.analyse,

    weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.90281  -0.01698  -0.00550  -0.00091   0.77396


Coefficients:

             Estimate Std. Error z value Pr(>|z|)

(Intercept)   4.46968    2.23141   2.003  0.04517 *

dist_col     -0.37573    0.16619  -2.261  0.02377 *

slope_1s_deg  0.54725    0.39636   1.381  0.16737

chl_apr      -2.87711    1.60294  -1.795  0.07267 .

bathy_1sec    0.04350    0.01548   2.811  0.00494 **

ss_wave      -0.54149    0.33888  -1.598  0.11007

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 109.968  on 18063  degrees of freedom
Residual deviance:  60.163  on 18058  degrees of freedom
AIC: 13.765

Number of Fisher Scoring iterations: 9

AIC Selected Model(backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + chl_june +
    spring_front + bathy_1sec, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.73675  -0.01704  -0.00546  -0.00024   0.89690

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)   7.95501    2.68274   2.965  0.00302 **
dist_col     -1.00717    0.44057  -2.286  0.02225 *
dist_shore    0.84037    0.49081   1.712  0.08686 .
chl_june     -3.85631    1.72013  -2.242  0.02497 *
spring_front  0.07092    0.05001   1.418  0.15622
bathy_1sec    0.04666    0.01102   4.233 2.31e-05 ***
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 109.968  on 18063  degrees of freedom
Residual deviance:  58.619  on 18058  degrees of freedom
AIC: 13.406

Number of Fisher Scoring iterations: 10

Correlations:
               dist_col dist_shore   chl_june spring_front
bathy_1sec
dist_col      1.0000000  0.6749821 -0.2155376    0.6495723 -
0.4452322
dist_shore    0.6749821  1.0000000 -0.4369796    0.7757818 -
0.6604751
chl_june     -0.2155376 -0.4369796  1.0000000   -0.3743652
0.5365607
spring_front  0.6495723  0.7757818 -0.3743652    1.0000000 -
0.6923253
bathy_1sec   -0.4452322 -0.6604751  0.5365607   -0.6923253
1.0000000
VIF:
    dist_col   dist_shore     chl_june spring_front   bathy_1sec
   26.684847    26.241352     1.597567     3.480950     1.498391
BIC Selected Model:

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + bathy_1sec,
```

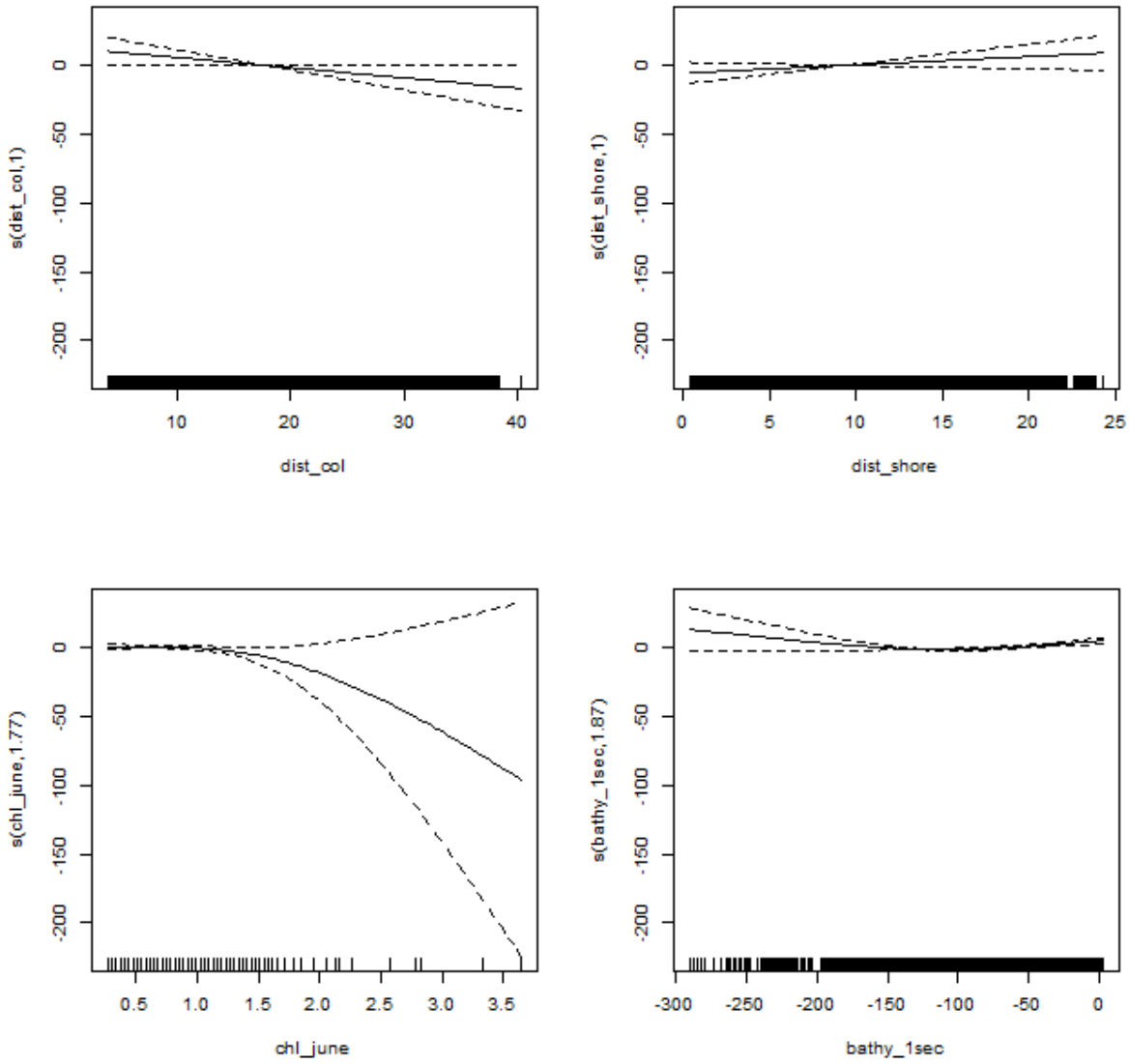
```
    family = "binomial", data = complete.data.to.analyse, weights =
weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-1.06182  -0.01759  -0.00960  -0.00083   0.83903


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  2.85914    1.39037   2.056  0.03974 *
dist_col    -0.81255    0.34628  -2.347  0.01895 *
dist_shore   0.91902    0.37412   2.457  0.01403 *
bathy_1sec   0.04069    0.01073   3.792  0.00015 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 109.968  on 18063  degrees of freedom
Residual deviance:  66.235  on 18060  degrees of freedom
AIC: 10.43


Number of Fisher Scoring iterations: 10


LRT Selected Model:


Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
```

```
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.77014  -0.01816  -0.00824  -0.00054   0.87300

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  6.63253    2.23062   2.973  0.00295 **
dist_col    -0.88546    0.36905  -2.399  0.01643 *
dist_shore   0.90380    0.40498   2.232  0.02563 *
chl_june    -3.31212    1.55363  -2.132  0.03302 *
bathy_1sec   0.04464    0.01088   4.103 4.08e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 109.968  on 18063  degrees of freedom
Residual deviance:  60.739  on 18059  degrees of freedom
AIC: 11.598

Number of Fisher Scoring iterations: 10

Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + dist_shore + chl_june + bathy_1sec
           Df Deviance    AIC     LRT  Pr(>Chi)
```

```
<none>          60.739 11.598
dist_col    1   84.070 32.928 23.3302 1.364e-06 ***
dist_shore  1   70.067 18.925  9.3273  0.002258 **
chl_june    1   66.235 15.094  5.4958  0.019062 *
bathy_1sec  1   82.612 31.470 21.8725 2.914e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Now checking for interactions with Year.
Single term deletions

Model:
SEARCH_FORAGE ~ Year * (dist_col + dist_shore + chl_june +
bathy_1sec)
               Df Deviance    AIC     LRT Pr(>Chi)
<none>              58.425 30.900
Year:dist_col    2   58.806 27.281 0.38099   0.8265
Year:dist_shore  2   58.826 27.301 0.40111   0.8183
Year:chl_june    2   58.870 27.345 0.44480   0.8006
Year:bathy_1sec  2   58.439 26.914 0.01420   0.9929
No significant Year interactions.

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit
```

```
Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(chl_june,

    k = 3) + s(bathy_1sec, k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)   -7.351      1.684  -4.366 1.26e-05 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

              edf Ref.df Chi.sq  p-value

s(dist_col)     1      1  5.757   0.0164 *

s(dist_shore)   1      1  4.980   0.0256 *

s(chl_june)     1      1  4.545   0.0330 *

s(bathy_1sec)   1      1 16.832 4.08e-05 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.443   Deviance explained = 44.8%

ML score =  30.37  Scale est. = 1         n = 18064


GAM Model selected (REML output):


Family: binomial

Link function: logit


Formula:
```

```
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(chl_june,
    k = 3) + s(bathy_1sec, k = 3)


Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -7.072      1.682  -4.204 2.62e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:
               edf Ref.df Chi.sq  p-value
s(dist_col)   1.000  1.000  4.154 0.041530 *
s(dist_shore) 1.000  1.000  2.035 0.153698
s(chl_june)   1.765  1.945  5.338 0.065822 .
s(bathy_1sec) 1.872  1.984 17.223 0.000184 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.546   Deviance explained = 53.6%
REML score = 25.161  Scale est. = 1         n = 18064
```




```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       2.979605      106.220587        8.221214      117.421406
```

```
Fixed effects:
                  mean         sd    0.025quant    0.5quant
0.975quant
(Intercept)  15.522522  8.8432214  -3.038452030  15.9479398
31.73242972
dist_col     -0.784144  0.3551386  -1.582101018  -0.7433432 -
0.19625218
dist_shore    0.682048  0.4081980  -0.001906146   0.6383014
1.59327969
chl_june1   -18.795567  6.9497447 -33.737127939 -18.3186096 -
6.44530268
chl_june2   -35.895313 19.5635324 -77.002380175 -34.9382615 -
0.07999735
bathy_1sec1 -26.276877 15.2301240 -53.819231558 -27.1439865
6.03754830
bathy_1sec2   2.208805  3.0547534  -3.247223090   2.0072557
8.75762830
                     kld
(Intercept) 0.0018338861
dist_col    0.0097437657
dist_shore  0.0098102559
chl_june1   0.0197787023
chl_june2   0.0172505457
bathy_1sec1 0.0001253783
bathy_1sec2 0.0157251679


Random effects:
Name    Model          Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model
```

Model hyperparameters:

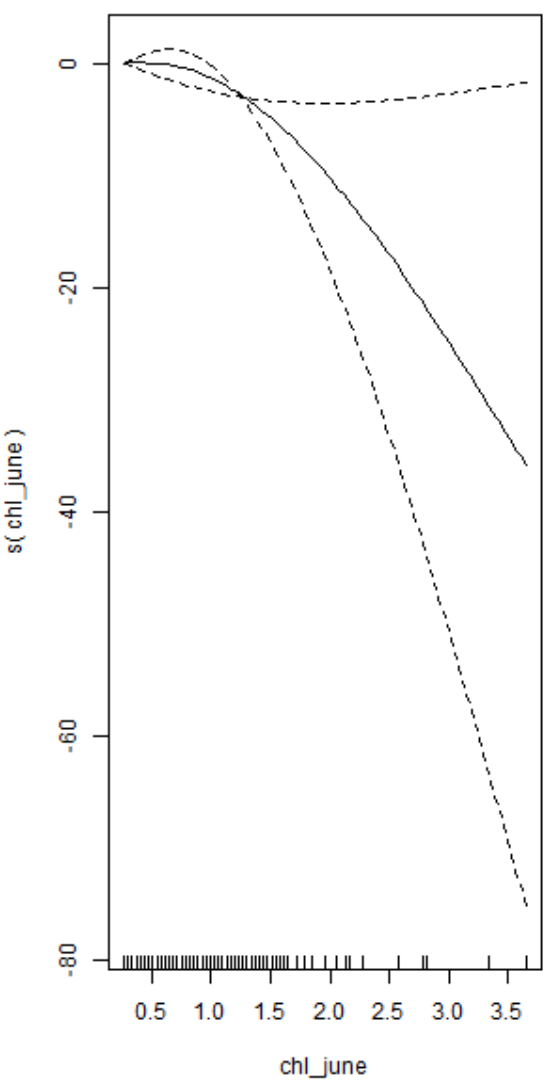
	mean	sd	0.025quant	0.5quant	0.975quant
T.0 for mesh.points-basisT	7.439	3.112	1.319	7.429	13.583

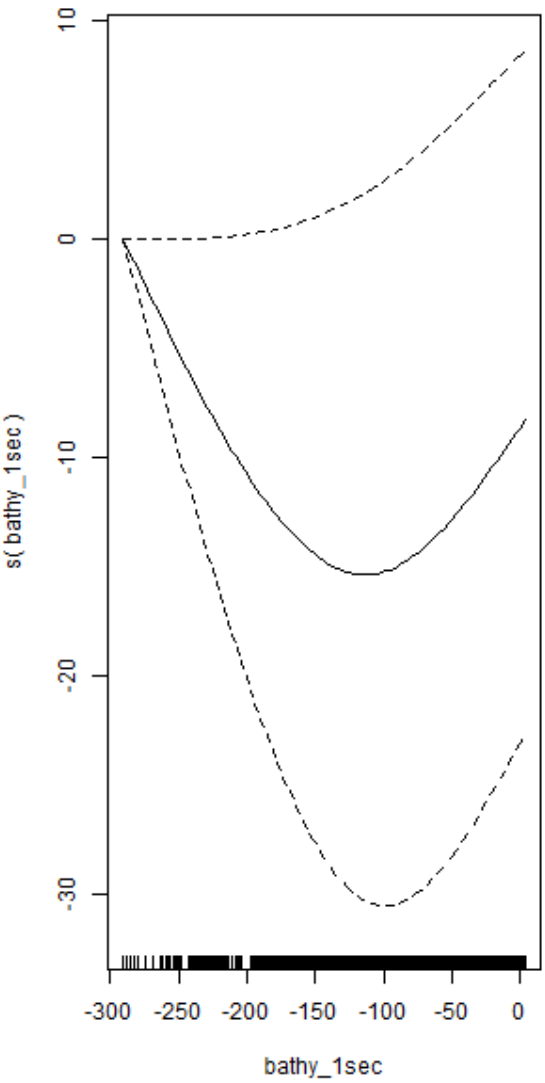
Expected number of effective parameters(std dev): 6.327(0.0005895)

Number of equivalent replicates : 2855.00

Marginal Likelihood: -43.16

	mean	sd	0.025quant	0.5quant	0.975quant	kld
(Intercept)	15.5225	8.8432	-3.0385	15.9479	31.7324	0.0018
dist_col	-0.7841	0.3551	-1.5821	-0.7433	-0.1963	0.0097
dist_shore	0.6820	0.4082	-0.0019	0.6383	1.5933	0.0098
chl_june1	-18.7956	6.9497	-33.7371	-18.3186	-6.4453	0.0198
chl_june2	-35.8953	19.5635	-77.0024	-34.9383	-0.0800	0.0173
bathy_1sec1	-26.2769	15.2301	-53.8192	-27.1440	6.0375	0.0001
bathy_1sec2	2.2088	3.0548	-3.2472	2.0073	8.7576	0.0157





Leith – SST included with outliers removed

```
Running analysis for colony Leith for species Common.

Using years 09,10 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):


Call:
```

```
glm(formula = SEARCH_FORAGE ~ dist_col + sst_april + spring_front,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.68576  -0.04077  -0.01575  -0.00450   2.47740

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  48.29029   13.30195   3.630 0.000283 ***
dist_col     -0.26289    0.05159  -5.096 3.47e-07 ***
sst_april    -6.92661    1.87907  -3.686 0.000228 ***
spring_front -0.13655    0.09478  -1.441 0.149698
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 495.85  on 43490  degrees of freedom
Residual deviance: 404.82  on 43487  degrees of freedom
AIC: 46.392

Number of Fisher Scoring iterations: 8

AIC Selected Model (backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + chl_apr + sst_april +
```

```
    spring_front + ss_wave + bathy_1sec, family = "binomial",
    data = complete.data.to.analyse, weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.74496  -0.03982  -0.01483  -0.00349   2.24037

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  65.38563   16.65295   3.926 8.62e-05 ***
dist_col     -0.23160    0.05605  -4.132 3.60e-05 ***
chl_apr      -1.21155    0.55035  -2.201   0.0277 *
sst_april    -8.93107    2.27308  -3.929 8.53e-05 ***
spring_front -0.18708    0.10220  -1.831   0.0672 .
ss_wave      -0.52122    0.22359  -2.331   0.0197 *
bathy_1sec    0.05426    0.02422   2.240   0.0251 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 495.85  on 43490  degrees of freedom
Residual deviance: 396.25  on 43484  degrees of freedom
AIC: 50.833

Number of Fisher Scoring iterations: 8

               dist_col     chl_apr   sst_april spring_front
ss_wave
```

```
dist_col      1.0000000 -0.38027817  0.13717845    0.5037562
0.11095610

chl_apr      -0.3802782  1.00000000 -0.24138118   -0.4860027 -
0.00614755

sst_april     0.1371784 -0.24138118  1.00000000    0.1735752
0.04378669

spring_front  0.5037562 -0.48600266  0.17357524    1.0000000 -
0.14649121

ss_wave       0.1109561 -0.00614755  0.04378669   -0.1464912
1.00000000

bathy_1sec   -0.6209133  0.39506377  0.04024528   -0.5669536
0.45869869

             bathy_1sec

dist_col     -0.62091332

chl_apr       0.39506377

sst_april     0.04024528

spring_front -0.56695357

ss_wave       0.45869869

bathy_1sec    1.00000000

    dist_col      chl_apr    sst_april spring_front      ss_wave
bathy_1sec

    1.369908     1.863609     1.642387     1.116939     1.947422
1.972823

BIC Selected Model:


Call:

glm(formula = SEARCH_FORAGE ~ dist_col + sst_april, family =
"binomial",

    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max
```

```
-0.67960  -0.04115  -0.01656  -0.00572   2.54797

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) 52.01066   13.29298   3.913 9.13e-05 ***
dist_col    -0.27514    0.05018  -5.483 4.17e-08 ***
sst_april   -7.47138    1.87738  -3.980 6.90e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 495.85  on 43490  degrees of freedom
Residual deviance: 407.18  on 43488  degrees of freedom
AIC: 45.1

Number of Fisher Scoring iterations: 8

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.74496  -0.03982  -0.01483  -0.00349   2.24037
```

```
Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  65.38563   16.65295   3.926 8.62e-05 ***
dist_col     -0.23160    0.05605  -4.132 3.60e-05 ***
chl_apr      -1.21155    0.55035  -2.201   0.0277 *
sst_april    -8.93107    2.27308  -3.929 8.53e-05 ***
spring_front -0.18708    0.10220  -1.831   0.0672 .
ss_wave      -0.52122    0.22359  -2.331   0.0197 *
bathy_1sec    0.05426    0.02422   2.240   0.0251 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 495.85  on 43490  degrees of freedom
Residual deviance: 396.25  on 43484  degrees of freedom
AIC: 50.833

Number of Fisher Scoring iterations: 8

Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + chl_apr + sst_april + spring_front +
    ss_wave + bathy_1sec
             Df Deviance    AIC     LRT  Pr(>Chi)
<none>            396.25 50.833
dist_col      1   424.44 77.018 28.1855 1.102e-07 ***
chl_apr       1   401.38 53.960  5.1270   0.02356 *
```

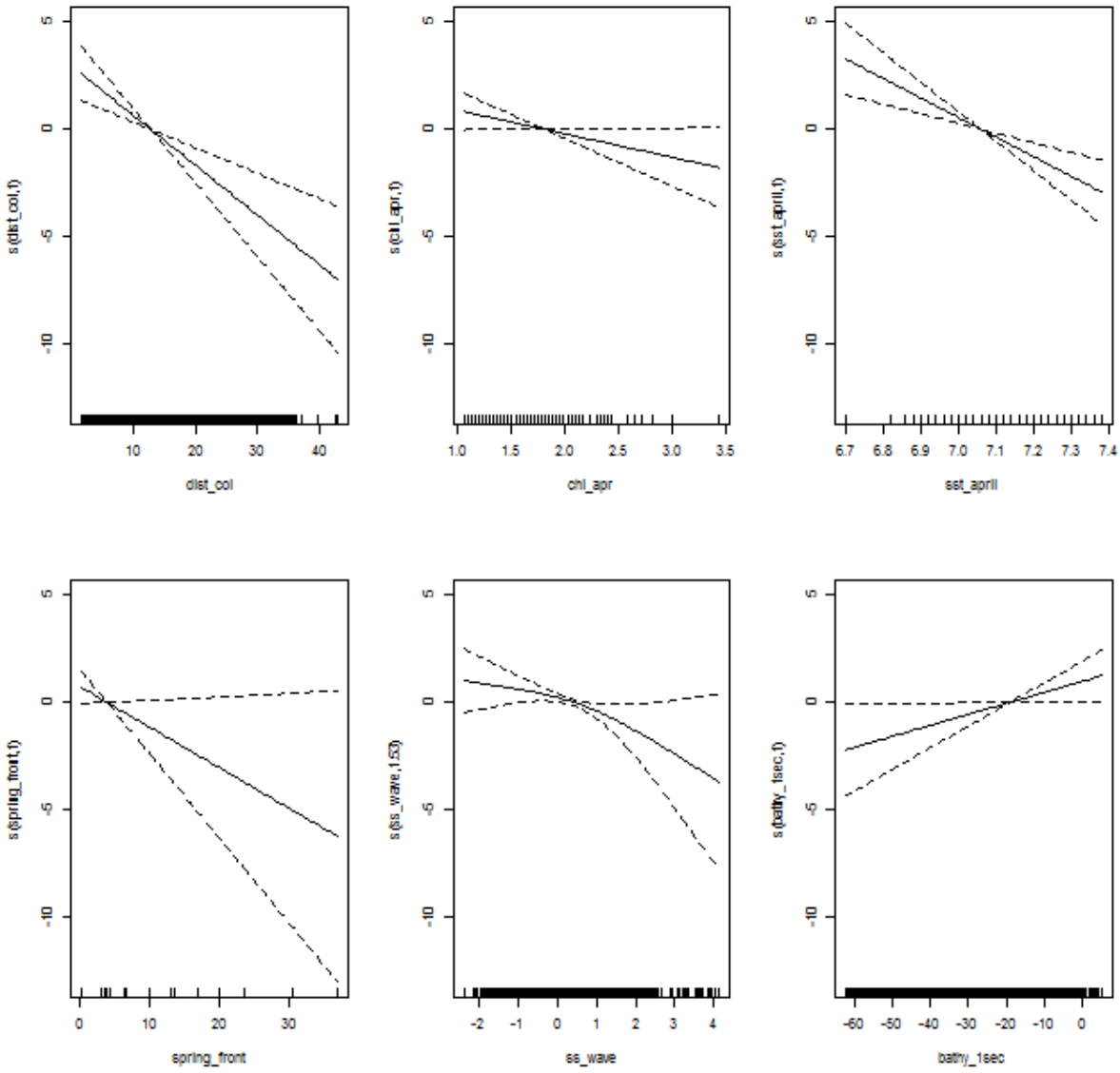
```
sst_april     1   413.75 66.335 17.5022 2.870e-05 ***
spring_front  1   400.12 52.696  3.8629   0.04937 *
ss_wave       1   401.92 54.501  5.6684   0.01727 *
bathy_1sec    1   401.91 54.486  5.6531   0.01742 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Now checking for interactions with Year.
Single term deletions


Model:
SEARCH_FORAGE ~ Year * (dist_col + chl_apr + sst_april +
spring_front +
    ss_wave + bathy_1sec)
                Df Deviance    AIC     LRT Pr(>Chi)
<none>               390.83 64.595
Year:dist_col    1   391.81 63.579 0.98386   0.3212
Year:chl_apr     1   391.23 63.002 0.40681   0.5236
Year:sst_april   1   390.83 62.601 0.00557   0.9405
Year:spring_front  1   390.95 62.717 0.12157   0.7273
Year:ss_wave     1   390.85 62.616 0.02120   0.8842
Year:bathy_1sec  1   391.86 63.633 1.03749   0.3084
No significant Year interactions.


Running GAM.


GAM Model selected (ML output):


Family: binomial
```

```
Link function: logit


Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(chl_apr, k = 3) +
s(sst_april,

    k = 3) + s(spring_front, k = 3) + s(ss_wave, k = 3) +
s(bathy_1sec,

    k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)  -4.7245     0.5111  -9.245   <2e-16 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

                edf Ref.df Chi.sq  p-value

s(dist_col)       1      1 17.063 3.62e-05 ***

s(chl_apr)        1      1  4.846   0.0277 *

s(sst_april)      1      1 15.434 8.54e-05 ***

s(spring_front)   1      1  3.350   0.0672 .

s(ss_wave)        1      1  5.434   0.0198 *

s(bathy_1sec)     1      1  5.018   0.0251 *

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.0935   Deviance explained = 20.1%

ML score = 198.13  Scale est. = 1         n = 43491
```

```
GAM Model selected (REML output):


Family: binomial

Link function: logit


Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(chl_apr, k = 3) +
s(sst_april,

    k = 3) + s(spring_front, k = 3) + s(ss_wave, k = 3) +
s(bathy_1sec,

    k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)  -4.7263     0.5094  -9.278   <2e-16 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

                  edf Ref.df Chi.sq  p-value

s(dist_col)     1.000  1.000 17.001 3.74e-05 ***

s(chl_apr)      1.000  1.000  3.720   0.0538 .

s(sst_april)    1.000  1.000 15.591 7.87e-05 ***

s(spring_front) 1.000  1.000  3.446   0.0634 .

s(ss_wave)      1.531  1.780  5.276   0.0578 .

s(bathy_1sec)   1.002  1.004  4.323   0.0378 *

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

R-sq.(adj) = 0.0954 Deviance explained = 20.4%

REML score = 202.09 Scale est. = 1 n = 43491



Running INLA.

Call:

c("inla(formula = formula.inla, family = \"binomial\", data = complete.data.to.analyse, ", " weights = weights, verbose = TRUE)")

Time used:

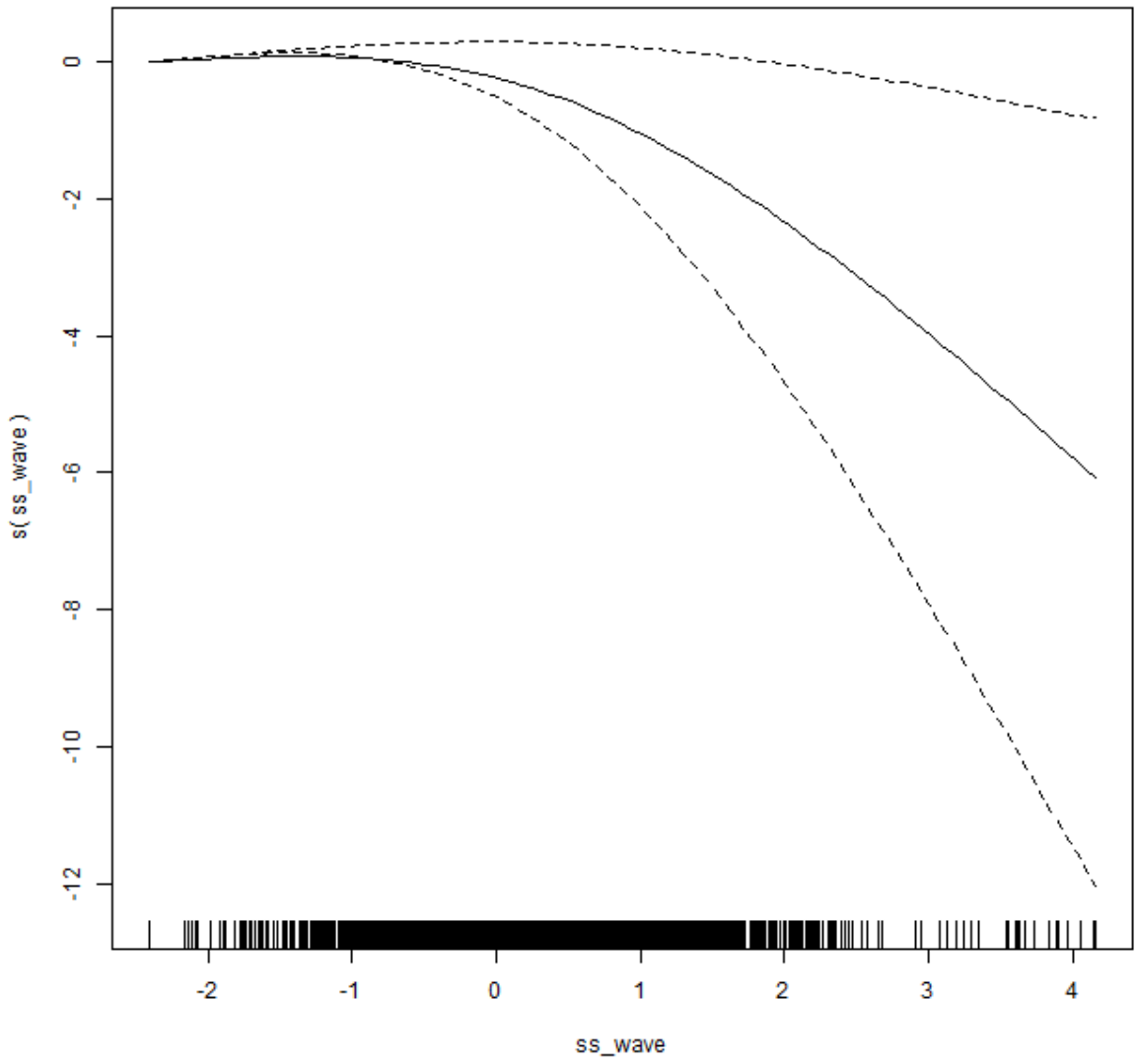
```
 Pre-processing    Running inla Post-processing           Total
       6.801612      991.241341       17.222430     1015.265383


Fixed effects:
                    mean          sd    0.025quant    0.5quant
0.975quant          kld
(Intercept)  70.99128566 17.37827930  38.052645942 70.57516837
106.298248207 4.917302e-03
dist_col     -0.23594269  0.05660182  -0.355271990 -0.23301914  -
0.132709146 3.124126e-03
chl_apr      -1.03616772  0.57629169  -2.186320433 -1.02942918
0.075193467 2.315715e-03
sst_april    -9.74066604  2.37604604 -14.565635969 -9.68472774  -
5.230393927 5.145633e-03
spring_front -0.18685424  0.10158269  -0.397294629 -0.18299827
0.001820772 5.282144e-06
bathy_1sec    0.05169055  0.02488200   0.004746635  0.05100898
0.102497810 2.110138e-03
ss_wave1     -3.45567523  1.78684278  -6.941667110 -3.46241691
0.069127328 4.434072e-03
ss_wave2     -6.22203707  2.86061426 -12.301082694 -6.05469004  -
1.059935611 5.361816e-03


Random effects:
Name    Model          Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model


Model hyperparameters:
                           mean   sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT 6.9226 0.2352 6.4612     6.9226   7.3845
```

Expected number of effective parameters(std dev): 8.019(0.001929)

Number of equivalent replicates : 5423.82

Marginal Likelihood: -232.53

	mean	sd	0.025quant	0.5quant	0.975quant	kld
(Intercept)	70.9913	17.3783	38.0526	70.5752	106.2982	0.0049
dist_col	-0.2359	0.0566	-0.3553	-0.2330	-0.1327	0.0031
chl_apr	-1.0362	0.5763	-2.1863	-1.0294	0.0752	0.0023
sst_april	-9.7407	2.3760	-14.5656	-9.6847	-5.2304	0.0051
spring_front	-0.1869	0.1016	-0.3973	-0.1830	0.0018	0.0000
bathy_1sec	0.0517	0.0249	0.0047	0.0510	0.1025	0.0021
ss_wave1	-3.4557	1.7868	-6.9417	-3.4624	0.0691	0.0044
ss_wave2	-6.2220	2.8606	-12.3011	-6.0547	-1.0599	0.0054



Leith – SST excluded

```
Running analysis for colony Leith for species Common.

Using years 09,10 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):
```

```
Call:
glm(formula = SEARCH_FORAGE ~ dist_col + sal_spring + dist_shore +
    chl_june + chl_may + spring_front + summ_front + bathy_1sec +
    slope_1s_deg, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.89517  -0.04534  -0.02105  -0.00614   2.08053


Coefficients:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)  -680.61817  195.12018  -3.488 0.000486 ***
dist_col       -0.19016    0.04322  -4.400 1.08e-05 ***
sal_spring     19.30933    5.56863   3.468 0.000525 ***
dist_shore     -0.29881    0.12699  -2.353 0.018617 *
chl_june        0.55134    0.26792   2.058 0.039608 *
chl_may         0.35527    0.21144   1.680 0.092909 .
spring_front   -0.13353    0.08516  -1.568 0.116873
summ_front      0.06150    0.03381   1.819 0.068898 .
bathy_1sec      0.03360    0.01783   1.885 0.059470 .
slope_1s_deg    0.14828    0.08332   1.780 0.075126 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 726.3  on 57616  degrees of freedom
```

```
Residual deviance: 595.4  on 57607  degrees of freedom
AIC: 74.568

Number of Fisher Scoring iterations: 8

AIC Selected Model(backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + chl_may +
    chl_june + summ_front + spring_front + sal_summ + bathy_1sec +
    slope_1s_deg, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.88556  -0.04485  -0.02107  -0.00612   2.09267

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  -616.63577  176.22877  -3.499 0.000467 ***
dist_col       -0.17758    0.04214  -4.214 2.51e-05 ***
dist_shore     -0.30443    0.12845  -2.370 0.017787 *
chl_may         0.36536    0.21232   1.721 0.085297 .
chl_june        0.53828    0.26739   2.013 0.044107 *
summ_front      0.05985    0.03395   1.763 0.077952 .
spring_front   -0.13645    0.08532  -1.599 0.109765
sal_summ       17.48150    5.02888   3.476 0.000509 ***
bathy_1sec      0.03231    0.01769   1.827 0.067734 .
```

```
slope_1s_deg    0.14606    0.08334   1.753 0.079670 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 726.3  on 57616  degrees of freedom
Residual deviance: 595.3  on 57607  degrees of freedom
AIC: 74.052

Number of Fisher Scoring iterations: 8

Correlations:
               dist_col dist_shore      chl_may   chl_june
summ_front
dist_col      1.00000000  0.4470569 -0.365681834 -0.6644283
0.46372264
dist_shore    0.44705685  1.0000000 -0.299264583 -0.6282554
0.61721414
chl_may      -0.36568183 -0.2992646  1.000000000  0.3296216 -
0.38411581
chl_june     -0.66442831 -0.6282554  0.329621618  1.0000000 -
0.55359784
summ_front    0.46372264  0.6172141 -0.384115809 -0.5535978
1.00000000
spring_front  0.53012817  0.6069712 -0.376684962 -0.5905272
0.63288943
sal_summ      0.21884525  0.2961548 -0.097446144 -0.1339962
0.16709685
bathy_1sec   -0.67422285 -0.4801686  0.411213612  0.5659270 -
0.53944307
slope_1s_deg -0.05766033 -0.1159514  0.002344929  0.1375453 -
0.08258089
```

```
             spring_front    sal_summ bathy_1sec slope_1s_deg
dist_col       0.53012817  0.21884525 -0.6742229 -0.057660332
dist_shore     0.60697120  0.29615479 -0.4801686 -0.115951376
chl_may       -0.37668496 -0.09744614  0.4112136  0.002344929
chl_june      -0.59052721 -0.13399623  0.5659270  0.137545317
summ_front     0.63288943  0.16709685 -0.5394431 -0.082580893
spring_front   1.00000000  0.13698367 -0.5874614 -0.075983271
sal_summ       0.13698367  1.00000000 -0.3463922  0.181036908
bathy_1sec    -0.58746141 -0.34639216  1.0000000 -0.201435613
slope_1s_deg  -0.07598327  0.18103691 -0.2014356  1.000000000
VIF:
    dist_col   dist_shore      chl_may     chl_june   summ_front
spring_front
    1.405544     1.633891     1.061113     1.220952     1.379727
1.096822
    sal_summ   bathy_1sec slope_1s_deg
    1.731197     1.663394     1.340734
BIC Selected Model:


Call:
glm(formula = SEARCH_FORAGE ~ dist_col, family = "binomial",
    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.76723  -0.04666  -0.02832  -0.01118   2.10430


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
```

```
(Intercept) -0.87617    0.18912  -4.633 3.61e-06 ***
dist_col    -0.22386    0.03131  -7.149 8.72e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 726.30  on 57616  degrees of freedom
Residual deviance: 629.43  on 57615  degrees of freedom
AIC: 61.737

Number of Fisher Scoring iterations: 7

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.88556  -0.04485  -0.02107  -0.00612   2.09267

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  -616.63577  176.22877  -3.499 0.000467 ***
dist_col       -0.17758    0.04214  -4.214 2.51e-05 ***
dist_shore     -0.30443    0.12845  -2.370 0.017787 *
```

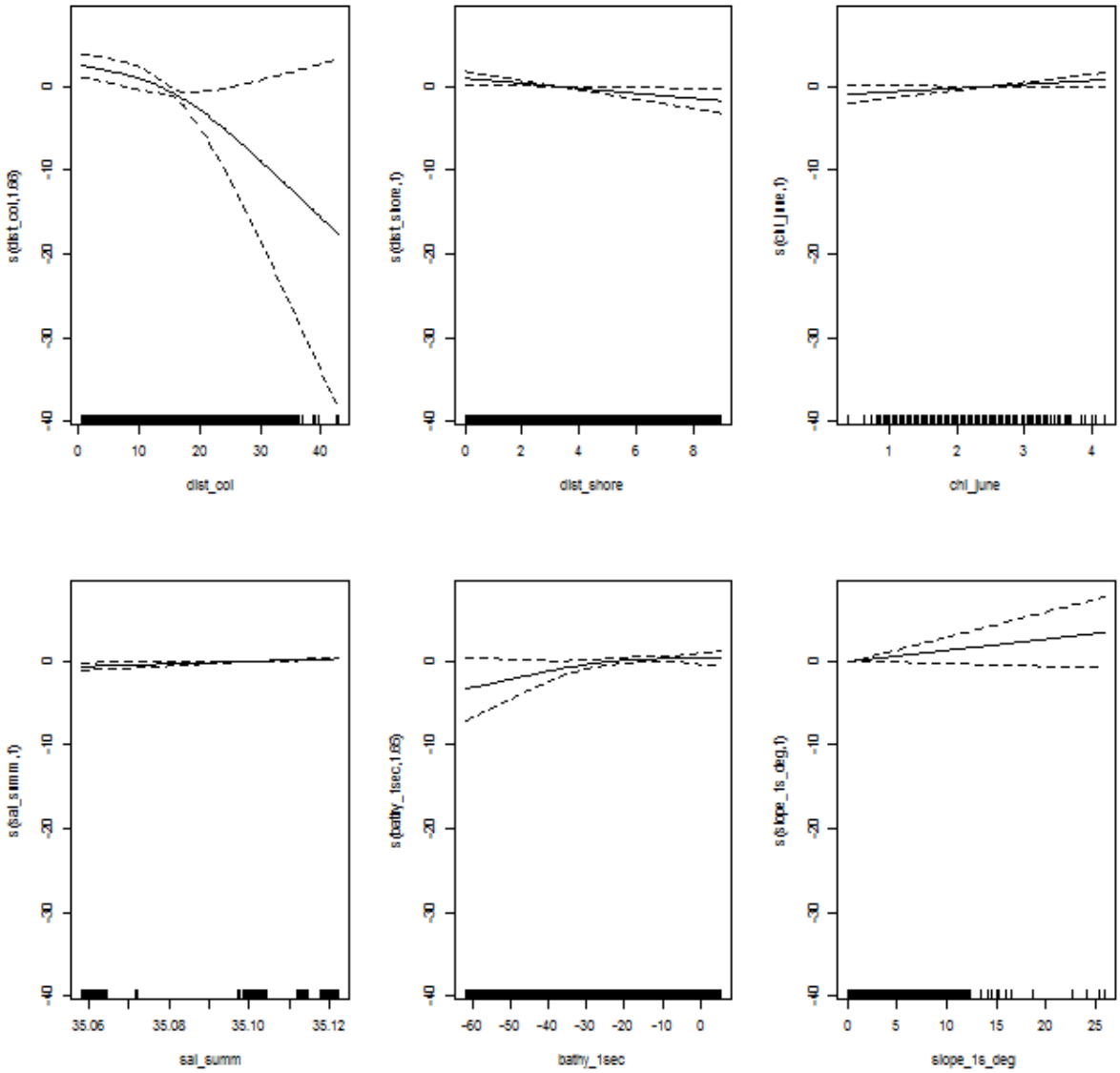
```
chl_may         0.36536    0.21232   1.721 0.085297 .
chl_june        0.53828    0.26739   2.013 0.044107 *
summ_front      0.05985    0.03395   1.763 0.077952 .
spring_front   -0.13645    0.08532  -1.599 0.109765
sal_summ       17.48150    5.02888   3.476 0.000509 ***
bathy_1sec      0.03231    0.01769   1.827 0.067734 .
slope_1s_deg    0.14606    0.08334   1.753 0.079670 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 726.3  on 57616  degrees of freedom
Residual deviance: 595.3  on 57607  degrees of freedom
AIC: 74.052

Number of Fisher Scoring iterations: 8

Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + dist_shore + chl_may + chl_june +
    summ_front + spring_front + sal_summ + bathy_1sec + slope_1s_deg
            Df Deviance     AIC     LRT  Pr(>Chi)
<none>           595.30  74.052
dist_col     1   623.31 100.063 28.0113 1.206e-07 ***
dist_shore   1   601.14  77.893  5.8418 0.0156494 *
chl_may      1   598.44  75.185  3.1338 0.0766868 .
chl_june     1   599.46  76.213  4.1611 0.0413626 *
```

```
summ_front    1   598.18  74.932  2.8805 0.0896571 .
spring_front  1   598.10  74.846  2.7948 0.0945711 .
sal_summ      1   608.14  84.887 12.8350 0.0003402 ***
bathy_1sec    1   599.00  75.753  3.7017 0.0543555 .
slope_1s_deg  1   598.20  74.946  2.8944 0.0888872 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Now checking for interactions with Year.
Single term deletions


Model:
SEARCH_FORAGE ~ Year * (dist_col + dist_shore + chl_may + chl_june +
    summ_front + spring_front + sal_summ + bathy_1sec +
slope_1s_deg)
                 Df Deviance    AIC    LRT Pr(>Chi)
<none>                579.01 93.124
Year:dist_col     1   579.30 91.414 0.2908  0.58973
Year:dist_shore   1   582.80 94.911 3.7877  0.05163 .
Year:chl_may      1   579.39 91.501 0.3777  0.53885
Year:chl_june     1   579.51 91.622 0.4988  0.48001
Year:summ_front   1   580.27 92.384 1.2599  0.26167
Year:spring_front 1   579.55 91.663 0.5395  0.46263
Year:sal_summ     1   579.09 91.199 0.0758  0.78307
Year:bathy_1sec   1   579.56 91.666 0.5419  0.46164
Year:slope_1s_deg 1   579.62 91.728 0.6043  0.43695
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Year effects not consistent - run one year at a time.
```

```
Running GAM.


GAM Model selected (ML output):


Family: binomial

Link function: logit


Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(chl_june,

    k = 3) + s(sal_summ, k = 3) + s(bathy_1sec, k = 3) +
s(slope_1s_deg,

    k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)   -3.763      0.283   -13.3   <2e-16 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

                edf Ref.df Chi.sq  p-value

s(dist_col)       1      1 21.313  3.9e-06 ***

s(dist_shore)     1      1  4.493 0.034026 *

s(chl_june)       1      1  3.515 0.060817 .

s(sal_summ)       1      1 11.260 0.000792 ***

s(bathy_1sec)     1      1  2.824 0.092894 .

s(slope_1s_deg)   1      1  3.172 0.074954 .
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0847   Deviance explained =   17%
ML score = 301.42  Scale est. = 1         n = 57617

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(chl_june,
    k = 3) + s(sal_summ, k = 3) + s(bathy_1sec, k = 3) +
s(slope_1s_deg,
    k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.4845     0.7079  -6.335 2.38e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                 edf Ref.df Chi.sq  p-value
s(dist_col)     1.660  1.885 18.346 0.000109 ***
s(dist_shore)   1.000  1.000  5.664 0.017318 *
s(chl_june)     1.000  1.000  3.287 0.069831 .
```

```
s(sal_summ)      1.000  1.000  8.040 0.004578 **
s(bathy_1sec)    1.652  1.879  4.022 0.119235
s(slope_1s_deg) 1.000  1.001  2.593 0.107426
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0874   Deviance explained = 17.6%
REML score = 307.43  Scale est. = 1         n = 57617
```

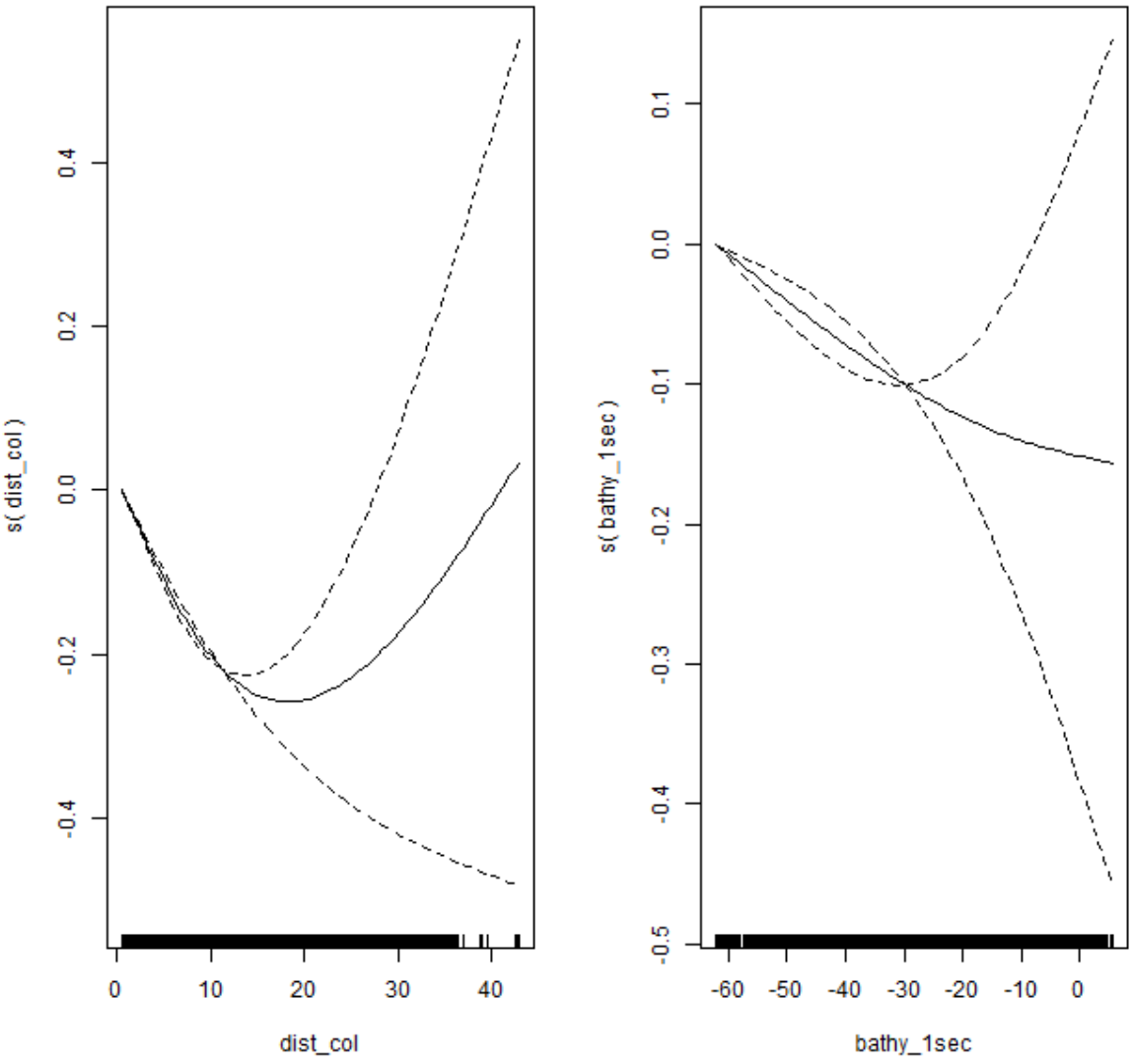



```
Running INLA.
```

```
Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       8.767216     2216.202292       49.982488     2274.951996


Fixed effects:

                     mean           sd   0.025quant     0.5quant
0.975quant

(Intercept)  -0.145518409 0.049034855 -0.241671859 -0.145518353 -
0.0493466108

dist_shore   -0.022642615 0.011627030 -0.045446151 -0.022641207
0.0001573495

chl_june     -0.040591578 0.018291410 -0.076460942 -0.040591062 -
0.0047181842

sal_summ     -0.004142597 0.001396915 -0.006881836 -0.004142595 -
0.0014028344

slope_1s_deg -0.013994012 0.028470633 -0.070080956 -0.013901342
0.0415788809

dist_col1    -0.427571385 0.119752278 -0.662425638 -0.427560547 -
0.1927331192

dist_col2     0.174198913 0.270329840 -0.356234255  0.174320901
0.7040424900

bathy_1sec1  -0.247235591 0.093794735 -0.431158718 -0.247235804 -
0.0632755368

bathy_1sec2  -0.080705416 0.170481072 -0.415098382 -0.080671581
0.2535602746

                      kld

(Intercept)  3.238399e-07

dist_shore   1.434211e-07

chl_june     1.403872e-07
```

```
sal_summ     3.231708e-07
slope_1s_deg 4.328417e-07
dist_col1    6.839882e-07
dist_col2    2.660700e-08
bathy_1sec1  1.433928e-07
bathy_1sec2  8.611060e-08

Random effects:
Name    Model          Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model

Model hyperparameters:
                            mean    sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.359  3.014  1.559      7.306   13.401

Expected number of effective parameters(std dev): 9.017(0.0003591)
Number of equivalent replicates : 6389.83

Marginal Likelihood:  -755.45
                mean     sd 0.025quant 0.5quant 0.975quant kld
(Intercept)  -0.1455 0.0490    -0.2417  -0.1455    -0.0493   0
dist_shore   -0.0226 0.0116    -0.0454  -0.0226     0.0002   0
chl_june     -0.0406 0.0183    -0.0765  -0.0406    -0.0047   0
sal_summ     -0.0041 0.0014    -0.0069  -0.0041    -0.0014   0
slope_1s_deg -0.0140 0.0285    -0.0701  -0.0139     0.0416   0
dist_col1    -0.4276 0.1198    -0.6624  -0.4276    -0.1927   0
```

```
dist_col2      0.1742 0.2703    -0.3562   0.1743     0.7040    0
bathy_1sec1   -0.2472 0.0938    -0.4312  -0.2472    -0.0633    0
bathy_1sec2   -0.0807 0.1705    -0.4151  -0.0807     0.2536    0
```



Mull – SST excluded

```
Running analysis for colony Mull for species Common.
Using years 11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.

Running GLM.
Employing model selection.
```

```
AIC Selected Model (forwards):


Call:
glm(formula = SEARCH_FORAGE ~ bathy_1sec + chl_may + chl_apr +
    ss_wave, family = "binomial", data = complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.84275  -0.03548  -0.01567  -0.00922   1.09645

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -6.898953   1.384020  -4.985 6.21e-07 ***
bathy_1sec  -0.007991   0.010663  -0.749   0.4536
chl_may      0.633697   0.252691   2.508   0.0121 *
chl_apr      0.633149   0.288845   2.192   0.0284 *
ss_wave     -0.339225   0.185967  -1.824   0.0681 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 99.601  on 8153  degrees of freedom
Residual deviance: 68.379  on 8149  degrees of freedom
AIC: 10.971

Number of Fisher Scoring iterations: 7
```

```
AIC Selected Model(backwards):


Call:
glm(formula = SEARCH_FORAGE ~ chl_apr + chl_may + ss_wave, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.82647  -0.03525  -0.01538  -0.00865   1.07797


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -6.3093     1.0728  -5.881 4.08e-09 ***
chl_apr       0.5476     0.2510   2.181   0.0292 *
chl_may       0.6402     0.2522   2.539   0.0111 *
ss_wave      -0.3996     0.1659  -2.409   0.0160 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 99.601  on 8153  degrees of freedom
Residual deviance: 68.904  on 8150  degrees of freedom
AIC: 9.0653


Number of Fisher Scoring iterations: 7


Correlations:
```

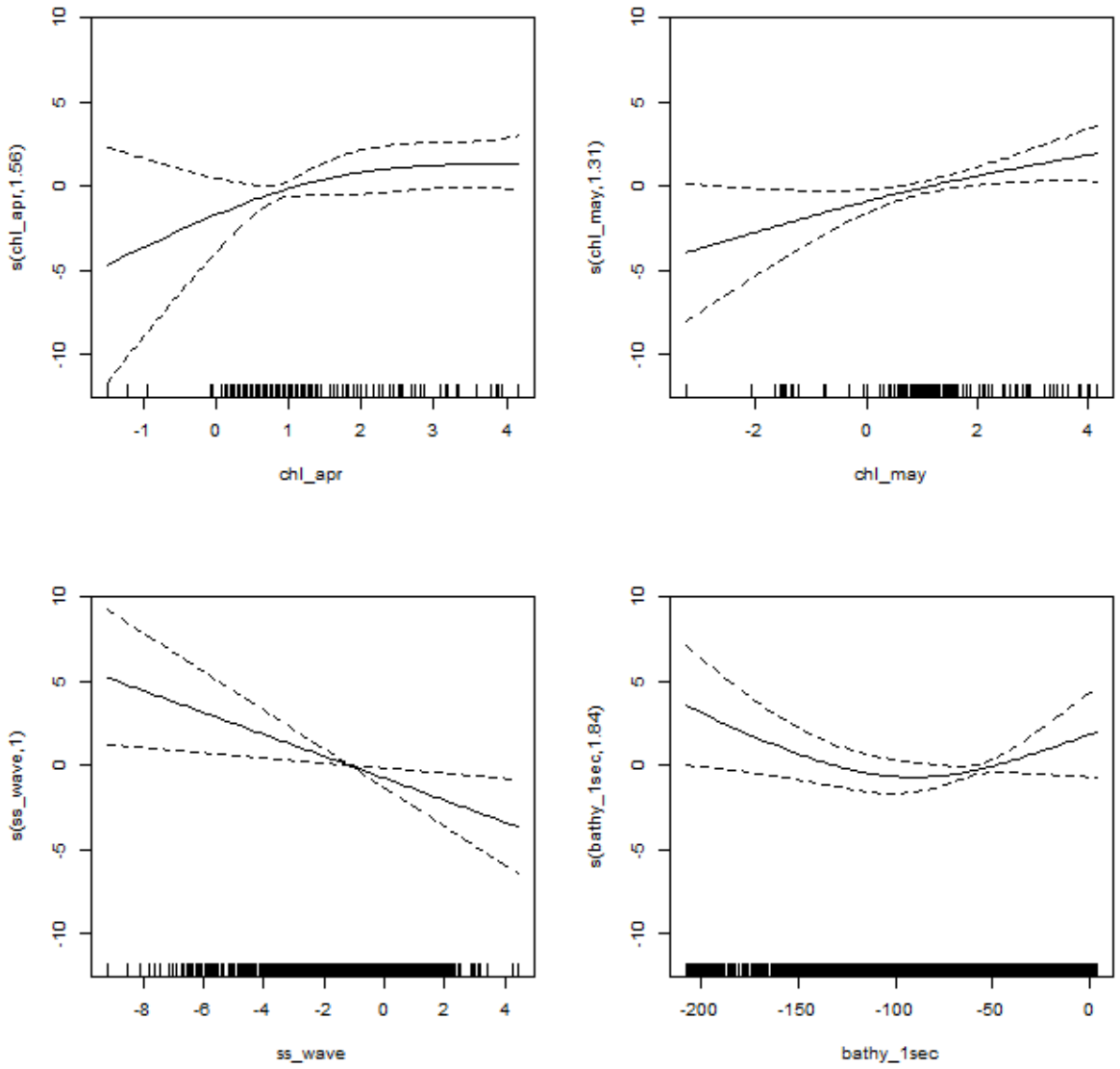
```
           chl_apr     chl_may     ss_wave
chl_apr  1.0000000  0.17500913 -0.21721862
chl_may  0.1750091  1.00000000 -0.05181873
ss_wave -0.2172186 -0.05181873  1.00000000
VIF:
 chl_apr  chl_may  ss_wave
1.056336 1.060107 1.003671
BIC Selected Model:


Call:
glm(formula = SEARCH_FORAGE ~ chl_may, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.77782  -0.04026  -0.02254  -0.01570   1.22621


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.8470     0.8052  -6.020 1.75e-09 ***
chl_may       0.9133     0.2567   3.558 0.000373 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 99.601  on 8153  degrees of freedom
Residual deviance: 82.396  on 8152  degrees of freedom
```

```
AIC: 8.0057

Number of Fisher Scoring iterations: 7

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.82647  -0.03525  -0.01538  -0.00865   1.07797

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -6.3093     1.0728  -5.881 4.08e-09 ***
chl_apr       0.5476     0.2510   2.181   0.0292 *
chl_may       0.6402     0.2522   2.539   0.0111 *
ss_wave      -0.3996     0.1659  -2.409   0.0160 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 99.601  on 8153  degrees of freedom
Residual deviance: 68.904  on 8150  degrees of freedom
AIC: 9.0653
```

```
Number of Fisher Scoring iterations: 7


Single term deletions


Model:
SEARCH_FORAGE ~ chl_apr + chl_may + ss_wave
        Df Deviance     AIC     LRT Pr(>Chi)
<none>       68.904  9.0653
chl_apr  1   74.105 12.2658  5.2004 0.022581 *
chl_may  1   79.103 17.2641 10.1988 0.001405 **
ss_wave  1   74.531 12.6918  5.6264 0.017692 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Running GAM.


GAM Model selected (ML output):


Family: binomial
Link function: logit


Formula:
SEARCH_FORAGE ~ s(chl_apr, k = 3) + s(chl_may, k = 3) + s(ss_wave,
    k = 3) + s(bathy_1sec, k = 3)


Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -4.602      0.765  -6.016 1.78e-09 ***
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf Ref.df Chi.sq p-value
s(chl_apr)    1.000  1.000  3.991 0.04573 *
s(chl_may)    1.000  1.000  6.779 0.00923 **
s(ss_wave)    1.000  1.000  6.020 0.01415 *
s(bathy_1sec) 1.795  1.958  5.829 0.05216 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.241   Deviance explained = 36.7%
ML score = 32.986  Scale est. = 1         n = 8154

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(chl_apr, k = 3) + s(chl_may, k = 3) + s(ss_wave,
    k = 3) + s(bathy_1sec, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.9115     0.8856  -5.546 2.92e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Approximate significance of smooth terms:
                edf Ref.df Chi.sq p-value
s(chl_apr)    1.564  1.804  4.517 0.08656 .
s(chl_may)    1.307  1.514  4.524 0.06427 .
s(ss_wave)    1.000  1.000  6.796 0.00914 **
s(bathy_1sec) 1.840  1.973  5.675 0.05716 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.259   Deviance explained = 38.5%
REML score = 33.216  Scale est. = 1         n = 8154
```




```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       1.544403       21.247237        3.510007       26.301647
```

Fixed effects:

	mean	sd	0.025quant	0.5quant	0.975quant
(Intercept)	-23.515627	10.2247918	-45.9566524	-22.6102884	-5.8806851
ss_wave	-0.839048	0.2835283	-1.4342362	-0.8254532	-0.3195511
chl_apr1	20.785202	13.3669132	-2.7158258	19.7758046	49.7450150
chl_apr2	5.904031	3.0070840	0.6790100	5.6554126	12.4674174
chl_may1	15.930953	8.4453297	2.1712963	14.8803117	35.0466411
chl_may2	5.520255	2.0458414	2.1826138	5.2673876	10.1478977
bathy_1sec1	-7.099380	3.6747131	-14.0613731	-7.1880881	0.3693901
bathy_1sec2	3.057644	2.1258369	-0.9874189	3.0124774	7.3595084

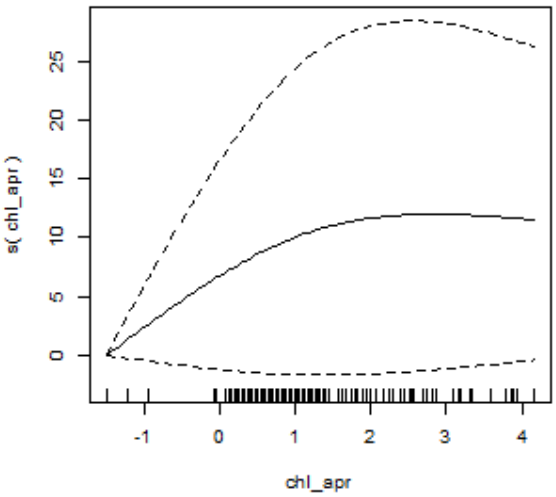
	kld
(Intercept)	0.147361821
ss_wave	0.035513412
chl_apr1	0.021372576
chl_apr2	0.025104686
chl_may1	0.070424916
chl_may2	0.099314311
bathy_1sec1	0.010054513
bathy_1sec2	0.004647138

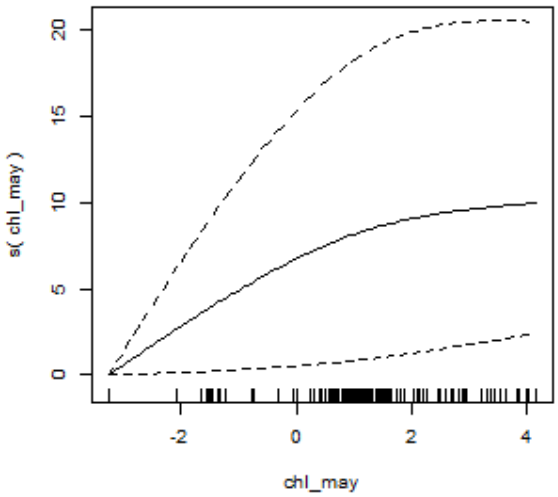
Random effects:

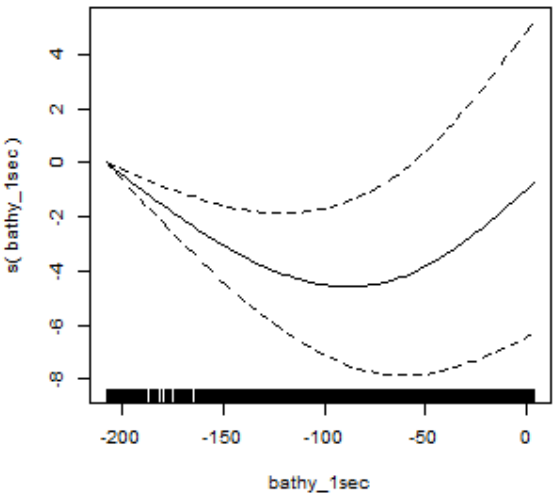
Name	Model	Max KLD
UserFunction0	NoModelName	
UserFunction1	NoModelName	
mesh.points	SPDE model	

Model hyperparameters:

```
                          mean    sd      0.025quant 0.5quant
0.975quant

T.0 for mesh.points-basisT  7.1422  3.1611  0.9236     7.1417
13.3449


Expected number of effective parameters(std dev): 7.719(0.0001802)

Number of equivalent replicates : 1056.39


Marginal Likelihood:  -49.84

                mean      sd 0.025quant 0.5quant 0.975quant    kld

(Intercept) -23.5156 10.2248   -45.9567 -22.6103    -5.8807 0.1474

ss_wave      -0.8390  0.2835    -1.4342  -0.8255    -0.3196 0.0355

chl_apr1     20.7852 13.3669    -2.7158  19.7758    49.7450 0.0214

chl_apr2      5.9040  3.0071     0.6790   5.6554    12.4674 0.0251

chl_may1     15.9310  8.4453     2.1713  14.8803    35.0466 0.0704

chl_may2      5.5203  2.0458     2.1826   5.2674    10.1479 0.0993

bathy_1sec1  -7.0994  3.6747   -14.0614  -7.1881     0.3694 0.0101

bathy_1sec2   3.0576  2.1258    -0.9874   3.0125     7.3595 0.0046
```







Sandwich Terns

Farnes – SST included with outliers removed

```
Running analysis for colony Farnes for species Sandwich.

Using years 10 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.

Employing model selection.


AIC Selected Model (forwards):
```

```
Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + ss_current,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.50266  -0.00001   0.00000   0.00000   1.52185

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   7.2118     3.0631   2.354  0.01855 *
dist_col     -0.2852     0.1706  -1.671  0.09470 .
dist_shore   -3.4601     1.1308  -3.060  0.00222 **
ss_current   -3.0175     1.3967  -2.160  0.03074 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 86.228  on 14570  degrees of freedom
Residual deviance: 29.917  on 14567  degrees of freedom
AIC: 8.255

Number of Fisher Scoring iterations: 14

AIC Selected Model (backwards):
```

```
Call:
glm(formula = SEARCH_FORAGE ~ dist_shore + chl_may + spring_front +
    sal_summ + ss_current, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.3774   0.0000   0.0000   0.0000   1.6991

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   2.336e+05  1.259e+05   1.855  0.06353 .
dist_shore   -4.904e+00  1.698e+00  -2.888  0.00387 **
chl_may      -1.689e+00  1.190e+00  -1.419  0.15587
spring_front -2.487e-01  1.098e-01  -2.266  0.02348 *
sal_summ     -6.660e+03  3.589e+03  -1.855  0.06354 .
ss_current   -4.483e+00  1.968e+00  -2.278  0.02272 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 86.228  on 14570  degrees of freedom
Residual deviance: 23.798  on 14565  degrees of freedom
AIC: 12.056

Number of Fisher Scoring iterations: 14
```

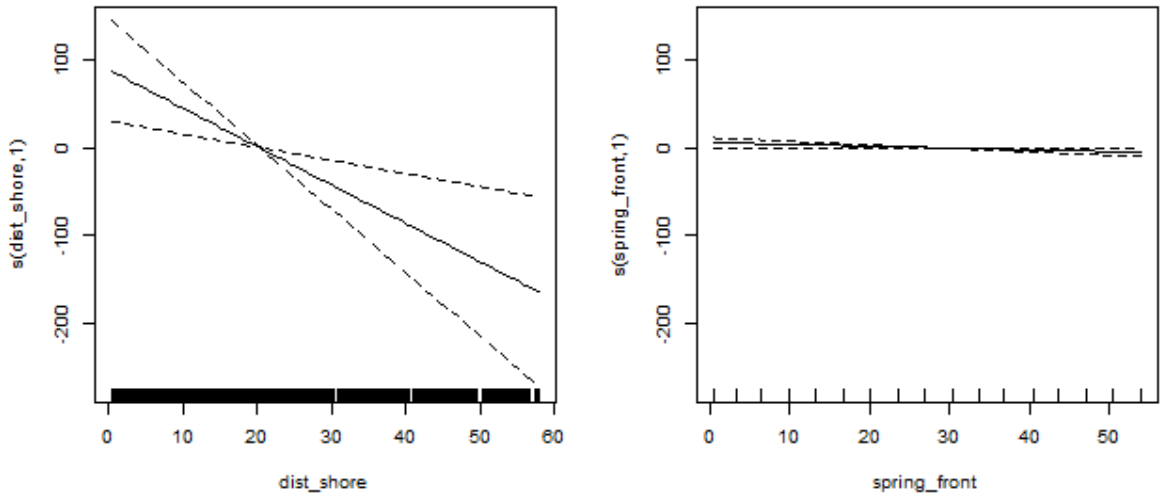
```
             dist_shore    chl_may spring_front    sal_summ
ss_current

dist_shore    1.0000000 -0.6782471   0.35551918 -0.10969184 -
0.5507364

chl_may      -0.6782471  1.0000000  -0.58768715 -0.14618575
0.4348045

spring_front  0.3555192 -0.5876871   1.00000000 -0.06986544 -
0.2844566

sal_summ     -0.1096918 -0.1461858  -0.06986544  1.00000000 -
0.2484865

ss_current   -0.5507364  0.4348045  -0.28445658 -0.24848651
1.0000000

  dist_shore      chl_may spring_front     sal_summ   ss_current

    5.019128     2.520441     3.384564     6.886959     8.810812

BIC Selected Model:


Call:

glm(formula = SEARCH_FORAGE ~ dist_shore, family = "binomial",

    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-0.55559  -0.00022   0.00000   0.00000   1.48947


Coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)   2.1113     1.0738   1.966 0.049284 *

dist_shore   -2.4735     0.7516  -3.291 0.000998 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

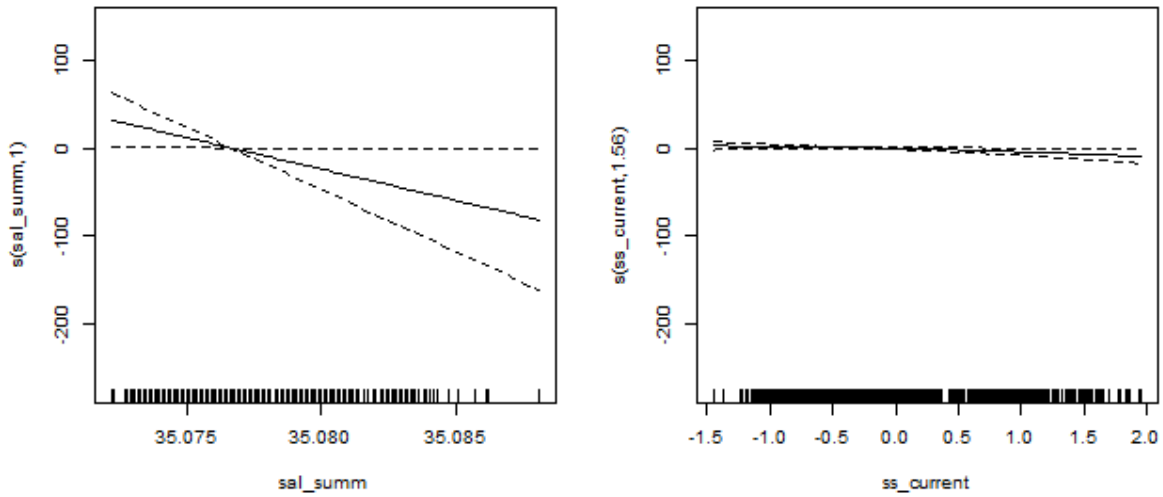
```
(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 86.228  on 14570  degrees of freedom
Residual deviance: 36.273  on 14569  degrees of freedom
AIC: 4.0281

Number of Fisher Scoring iterations: 13

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-0.424   0.000   0.000   0.000   1.570

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   2.298e+05  1.136e+05   2.023  0.04309 *
dist_shore   -4.116e+00  1.359e+00  -3.028  0.00247 **
spring_front -2.067e-01  9.897e-02  -2.089  0.03672 *
sal_summ     -6.552e+03  3.239e+03  -2.023  0.04309 *
ss_current   -3.291e+00  1.486e+00  -2.216  0.02672 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 86.228  on 14570  degrees of freedom
Residual deviance: 25.951  on 14566  degrees of freedom
AIC: 10.182

Number of Fisher Scoring iterations: 14

Single term deletions

Model:
SEARCH_FORAGE ~ dist_shore + spring_front + sal_summ + ss_current
             Df Deviance    AIC    LRT  Pr(>Chi)
<none>            25.951 10.182
dist_shore    1   59.449 41.680 33.498 7.133e-09 ***
spring_front  1   32.250 14.481  6.299   0.01208 *
sal_summ      1   32.517 14.748  6.566   0.01039 *
ss_current    1   32.217 14.448  6.266   0.01231 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit

Formula:
```

```
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(spring_front, k = 3) +
    s(sal_summ, k = 3) + s(ss_current, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -84.43      27.28  -3.095  0.00197 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                  edf Ref.df Chi.sq p-value
s(dist_shore)   1.000  1.000  9.268 0.00233 **
s(spring_front) 1.000  1.000  4.196 0.04051 *
s(sal_summ)     1.000  1.000  4.141 0.04186 *
s(ss_current)   1.228  1.404  5.788 0.02977 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.619   Deviance explained = 70.7%
ML score = 12.965  Scale est. = 1         n = 14571

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(spring_front, k = 3) +
    s(sal_summ, k = 3) + s(ss_current, k = 3)
```

```
Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -87.45      28.25  -3.096  0.00196 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                  edf Ref.df Chi.sq p-value
s(dist_shore)   1.000  1.000  9.302 0.00229 **
s(spring_front) 1.000  1.000  4.077 0.04347 *
s(sal_summ)     1.000  1.000  4.195 0.04054 *
s(ss_current)   1.557  1.804  6.027 0.04084 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.623   Deviance explained = 71.5%
REML score = 5.0908  Scale est. = 1         n = 14571
```

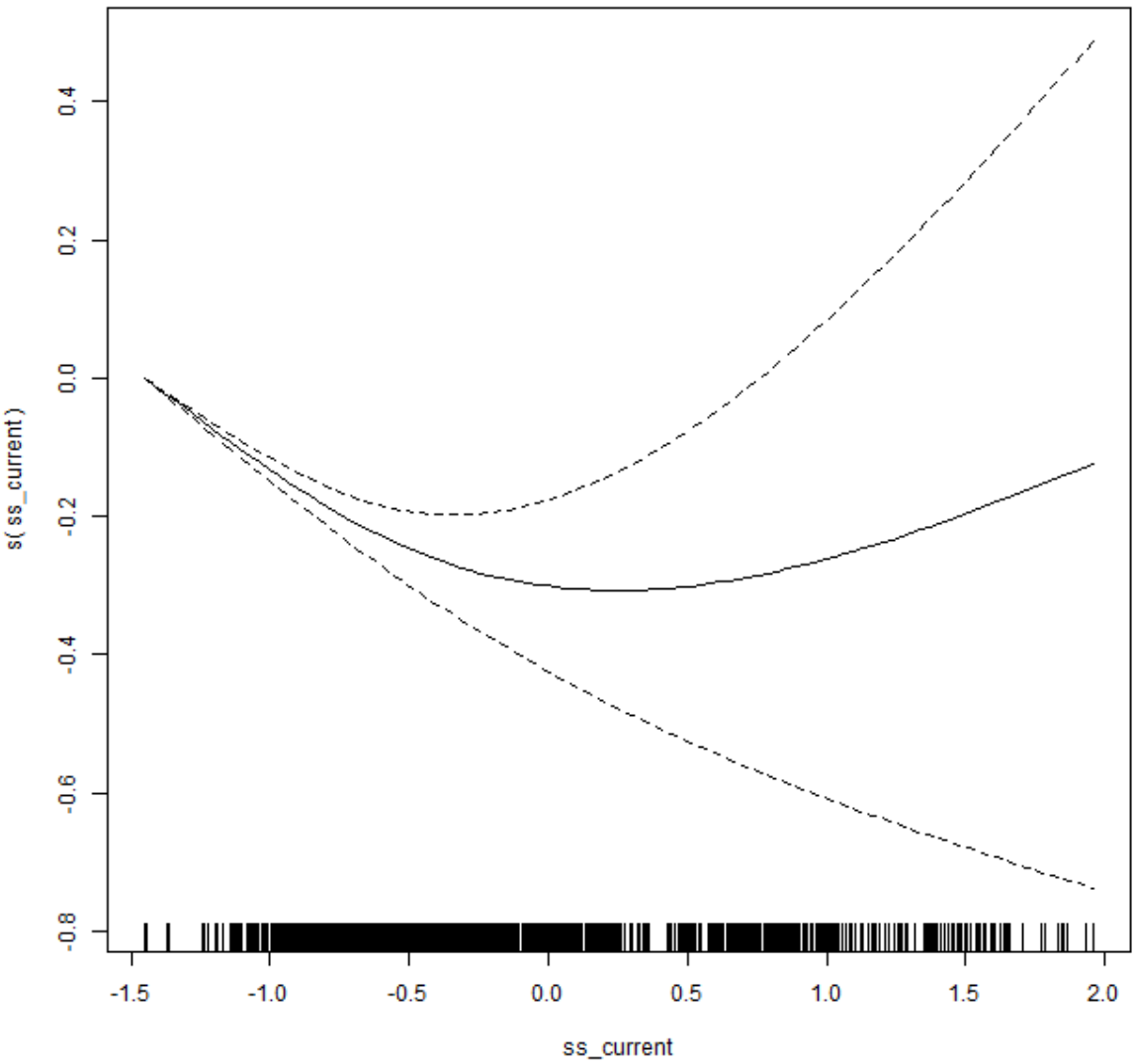





```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       2.355605      173.971505        7.191613      183.518723
```

```
Fixed effects:
                     mean          sd  0.025quant     0.5quant
0.975quant
(Intercept)  -0.242479338 0.093693930 -0.42621885 -0.242474458 -
5.873189e-02
dist_shore   -0.003937079 0.003221060 -0.01025956 -0.003934831
2.373875e-03
spring_front -0.005597920 0.002841647 -0.01117162 -0.005597389 -
2.614785e-05
sal_summ     -0.006912847 0.002671109 -0.01215106 -0.006912708 -
1.674412e-03
ss_current1  -0.531410507 0.204903371 -0.93329097 -0.531380899 -
1.296202e-01
ss_current2   0.033201813 0.303719462 -0.56414283  0.033838595
6.270529e-01
                      kld
(Intercept)  6.039853e-06
dist_shore   6.349477e-08
spring_front 1.088528e-06
sal_summ     6.039335e-06
ss_current1  4.007969e-06
ss_current2  7.469826e-09

Random effects:
Name                               Model      Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model

Model hyperparameters:
```

```
                          mean    sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.905  3.145  1.735      7.897   14.110

Expected number of effective parameters(std dev): 6.004(3.097e-05)
Number of equivalent replicates : 2426.73

Marginal Likelihood:  -228.82
               mean     sd 0.025quant 0.5quant 0.975quant kld
(Intercept)  -0.2425 0.0937    -0.4262  -0.2425    -0.0587   0
dist_shore   -0.0039 0.0032    -0.0103  -0.0039     0.0024   0
spring_front -0.0056 0.0028    -0.0112  -0.0056     0.0000   0
sal_summ     -0.0069 0.0027    -0.0122  -0.0069    -0.0017   0
ss_current1  -0.5314 0.2049    -0.9333  -0.5314    -0.1296   0
ss_current2   0.0332 0.3037    -0.5641   0.0338     0.6271   0
```



Farnes – SST excluded

```
Running analysis for colony Farnes for species Sandwich.
Using years 10 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.


Running GLM.
Employing model selection.


AIC Selected Model (forwards):


Call:
```

```
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + bathy_1sec +
    ss_current, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.59236  -0.00002   0.00000   0.00000   1.35662


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  5.28820    1.56462   3.380 0.000725 ***
dist_col    -0.16321    0.12278  -1.329 0.183755
dist_shore  -2.40153    0.81992  -2.929 0.003401 **
bathy_1sec   0.10205    0.06262   1.630 0.103180
ss_current  -1.28018    0.86591  -1.478 0.139298
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 160.421  on 15038  degrees of freedom
Residual deviance:  37.675  on 15034  degrees of freedom
AIC: 10.372


Number of Fisher Scoring iterations: 13


AIC Selected Model(backwards):
```

```
Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + summ_front +
    spring_front + bathy_1sec, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)


Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.7789   0.0000   0.0000   0.0000   1.2451


Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)   5.35776    1.45354   3.686 0.000228 ***
dist_col     -0.11668    0.09243  -1.262 0.206822
dist_shore   -3.20378    0.97439  -3.288 0.001009 **
summ_front    0.27039    0.10873   2.487 0.012885 *
spring_front -0.37414    0.17326  -2.159 0.030818 *
bathy_1sec    0.15665    0.08562   1.830 0.067309 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 160.421  on 15038  degrees of freedom
Residual deviance:  32.159  on 15033  degrees of freedom
AIC: 12.116


Number of Fisher Scoring iterations: 14
```

```
Correlations:
               dist_col dist_shore summ_front spring_front
bathy_1sec
dist_col      1.0000000  0.7464429  0.3053952    0.3134748 -
0.6290022
dist_shore    0.7464429  1.0000000  0.3794521    0.3978482 -
0.7125664
summ_front    0.3053952  0.3794521  1.0000000    0.6010157 -
0.5906358
spring_front  0.3134748  0.3978482  0.6010157    1.0000000 -
0.7203372
bathy_1sec   -0.6290022 -0.7125664 -0.5906358   -0.7203372
1.0000000
VIF:
    dist_col   dist_shore   summ_front spring_front   bathy_1sec
    1.227123     2.250775     6.271772     5.283603     2.122020
BIC Selected Model:


Call:
glm(formula = SEARCH_FORAGE ~ dist_shore, family = "binomial",
    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.64514  -0.00004   0.00000   0.00000   1.63006


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   3.1704     0.9034   3.509 0.000449 ***
dist_shore   -3.1710     0.7691  -4.123 3.74e-05 ***
---
```

```
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 160.421  on 15038  degrees of freedom
Residual deviance:  48.662  on 15037  degrees of freedom
AIC: 4.3857

Number of Fisher Scoring iterations: 13

LRT Selected Model:

Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.7437   0.0000   0.0000   0.0000   1.3221

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)   4.51683    1.17158   3.855 0.000116 ***
dist_shore   -3.11537    0.99365  -3.135 0.001717 **
summ_front    0.22447    0.10047   2.234 0.025462 *
spring_front -0.28879    0.15011  -1.924 0.054377 .
bathy_1sec    0.15035    0.08374   1.795 0.072591 .
---
```

```
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 160.421  on 15038  degrees of freedom
Residual deviance:  34.251  on 15034  degrees of freedom
AIC: 10.169

Number of Fisher Scoring iterations: 14

Single term deletions

Model:
SEARCH_FORAGE ~ dist_shore + summ_front + spring_front + bathy_1sec
             Df Deviance    AIC     LRT  Pr(>Chi)
<none>            34.251 10.169
dist_shore    1   57.649 31.568 23.3982 1.317e-06 ***
summ_front    1   40.730 14.649  6.4791   0.01091 *
spring_front  1   39.543 13.462  5.2927   0.02142 *
bathy_1sec    1   38.026 11.945  3.7759   0.05200 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit
```

```
Formula:
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(summ_front, k = 3) +
    s(spring_front, k = 3) + s(bathy_1sec, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -67.80      18.94  -3.579 0.000345 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf Ref.df Chi.sq p-value
s(dist_shore)     1      1  9.830 0.00172 **
s(summ_front)     1      1  4.992 0.02546 *
s(spring_front)   1      1  3.701 0.05438 .
s(bathy_1sec)     1      1  3.223 0.07259 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.754   Deviance explained = 78.6%
ML score = 17.125  Scale est. = 1         n = 15039

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
```

```
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(summ_front, k = 3) +
    s(spring_front, k = 3) + s(bathy_1sec, k = 3)


Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -64.57      20.89  -3.091    0.002 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:
                edf Ref.df Chi.sq p-value
s(dist_shore)   1.00  1.000  9.704 0.00184 **
s(summ_front)   1.00  1.000  4.971 0.02577 *
s(spring_front) 1.00  1.000  3.712 0.05402 .
s(bathy_1sec)   1.06  1.115  0.578 0.48417
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.755   Deviance explained = 78.8%
REML score = 10.323  Scale est. = 1         n = 15039


Running INLA.


Call:
c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:
```

```
 Pre-processing    Running inla Post-processing           Total
       2.106004      192.441938        8.236814      202.784756


Fixed effects:
                     mean          sd    0.025quant     0.5quant
0.975quant
(Intercept)  -0.283604164 0.084892923 -0.4501387073 -0.283580158 -
0.1171736177
dist_shore   -0.003325674 0.003267374 -0.0097384893 -0.003323600
0.0030766150
summ_front   -0.007937587 0.003400942 -0.0146078444 -0.007937120 -
0.0012686864
spring_front -0.006084669 0.002896175 -0.0117655704 -0.006084040 -
0.0004062372
bathy_1sec    0.003018302 0.001437407  0.0002000104  0.003018174
0.0058378660
                      kld
(Intercept)  5.979082e-07
dist_shore   5.454531e-07
summ_front   9.227759e-07
spring_front 1.034891e-06
bathy_1sec   1.366265e-06


Random effects:
Name                              Model      Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model


Model hyperparameters:
                            mean    sd     0.025quant 0.5quant
0.975quant
```

```
T.0 for mesh.points-basisT  7.897  3.150  1.731      7.892   14.106

Expected number of effective parameters(std dev): 5.005(3.219e-05)
Number of equivalent replicates : 3004.98

Marginal Likelihood:  -244.12
                mean     sd 0.025quant 0.5quant 0.975quant kld
(Intercept)  -0.2836 0.0849    -0.4501  -0.2836    -0.1172   0
dist_shore   -0.0033 0.0033    -0.0097  -0.0033     0.0031   0
summ_front   -0.0079 0.0034    -0.0146  -0.0079    -0.0013   0
spring_front -0.0061 0.0029    -0.0118  -0.0061    -0.0004   0
bathy_1sec    0.0030 0.0014     0.0002   0.0030     0.0058   0
```

Forvie – SST included with outliers removed

```
Running analysis for colony Forvie for species Sandwich.
Using years 11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.

Running GLM.
Employing model selection.

AIC Selected Model (forwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + bathy_1sec + sst_june,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
```

```
-1.3898   0.0000   0.0000   0.0000   0.7429

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -135.8407    92.5021  -1.469  0.14196
dist_col      -0.1139     0.1301  -0.875  0.38140
bathy_1sec     0.5964     0.2140   2.787  0.00531 **
sst_june      13.0641     8.6277   1.514  0.12998
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 89.82  on 26054  degrees of freedom
Residual deviance: 21.04  on 26051  degrees of freedom
AIC: 9.9339

Number of Fisher Scoring iterations: 13

AIC Selected Model (backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + chl_june + sst_june +
    strat_temp + ss_wave, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
```

```
-1.0040   0.0000   0.0000   0.0000   0.7699

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -168.3783   100.5467  -1.675   0.0940 .
dist_col       0.5117     0.3245   1.577   0.1149
chl_june       3.4655     2.7820   1.246   0.2129
sst_june      14.1608     8.7241   1.623   0.1046
strat_temp   -15.1263     7.9627  -1.900   0.0575 .
ss_wave        5.1755     2.1796   2.375   0.0176 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 89.820  on 26054  degrees of freedom
Residual deviance: 20.003  on 26049  degrees of freedom
AIC: 13.02

Number of Fisher Scoring iterations: 13

             dist_col   chl_june   sst_june strat_temp    ss_wave
dist_col    1.0000000 -0.5634766  0.4130406  0.8694789 -0.3719760
chl_june   -0.5634766  1.0000000 -0.2904897 -0.5985449  0.7193600
sst_june    0.4130406 -0.2904897  1.0000000  0.3148135 -0.4271376
strat_temp  0.8694789 -0.5985449  0.3148135  1.0000000 -0.3778379
ss_wave    -0.3719760  0.7193600 -0.4271376 -0.3778379  1.0000000
  dist_col   chl_june   sst_june strat_temp    ss_wave
 16.350420   3.531740   3.890198  16.418715   1.806789
```

```
BIC Selected Model:


Call:
glm(formula = SEARCH_FORAGE ~ strat_temp + ss_wave, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:
     Min        1Q    Median        3Q       Max
-1.48610  -0.00013  -0.00001   0.00000   0.82299


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -8.054      3.348  -2.406  0.01615 *
strat_temp    -3.530      1.689  -2.090  0.03660 *
ss_wave        4.525      1.533   2.952  0.00316 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 89.820  on 26054  degrees of freedom
Residual deviance: 26.568  on 26052  degrees of freedom
AIC: 8.2112


Number of Fisher Scoring iterations: 12
LRT Selected Model:


Call:
```

```
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-1.80175  -0.00001   0.00000   0.00000   0.82254

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   5.2048     1.9179   2.714  0.00665 **
bathy_1sec    0.4250     0.1346   3.157  0.00159 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 89.820  on 26054  degrees of freedom
Residual deviance: 24.126  on 26053  degrees of freedom
AIC: 7.2468

Number of Fisher Scoring iterations: 12

Single term deletions

Model:
SEARCH_FORAGE ~ bathy_1sec
           Df Deviance    AIC    LRT  Pr(>Chi)
<none>          24.126  7.247
```

```
bathy_1sec  1   89.820 70.941 65.694 5.267e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(bathy_1sec, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -24.021      7.429  -3.234  0.00122 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df Chi.sq p-value
s(bathy_1sec)   1      1  9.969 0.00159 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.559   Deviance explained = 73.1%
ML score = 12.063  Scale est. = 1         n = 26055
```

```
GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(bathy_1sec, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -24.021      7.429  -3.233  0.00122 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df Chi.sq p-value
s(bathy_1sec)   1      1  9.966 0.00159 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.559   Deviance explained = 73.1%
REML score = 9.7144  Scale est. = 1         n = 26055
```

Forvie – SST excluded

```
Running analysis for colony Forvie for species Sandwich.
Using years 11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.

Running GLM.
Employing model selection.
```

```
AIC Selected Model (forwards):


Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + strat_temp,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)


Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.3730   0.0000   0.0000   0.0000   0.9281


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  10.0398     4.0463   2.481  0.01309 *
dist_col      0.2363     0.1859   1.271  0.20385
dist_shore   -2.4304     0.9032  -2.691  0.00712 **
strat_temp   -9.7406     5.6905  -1.712  0.08695 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 97.836  on 26534  degrees of freedom
Residual deviance: 27.757  on 26531  degrees of freedom
AIC: 9.885


Number of Fisher Scoring iterations: 14


AIC Selected Model(backwards):
```

```
Call:
glm(formula = SEARCH_FORAGE ~ dist_shore + strat_temp, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.5505   0.0000   0.0000   0.0000   0.8509

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   7.1578     2.8420   2.519   0.0118 *
dist_shore   -2.8275     0.9526  -2.968   0.0030 **
strat_temp   -3.6398     2.0672  -1.761   0.0783 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 97.836  on 26534  degrees of freedom
Residual deviance: 29.274  on 26532  degrees of freedom
AIC: 8.4042

Number of Fisher Scoring iterations: 14

Correlations:
           dist_shore strat_temp
dist_shore  1.0000000  0.8693229
```

```
strat_temp  0.8693229  1.0000000
VIF:
dist_shore strat_temp
  1.144137   1.144137
BIC Selected Model:


Call:
glm(formula = SEARCH_FORAGE ~ dist_shore + strat_temp, family =
"binomial",
    data = complete.data.to.analyse, weights = weights)


Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.5505   0.0000   0.0000   0.0000   0.8509


Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   7.1578     2.8420   2.519   0.0118 *
dist_shore   -2.8275     0.9526  -2.968   0.0030 **
strat_temp   -3.6398     2.0672  -1.761   0.0783 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 97.836  on 26534  degrees of freedom
Residual deviance: 29.274  on 26532  degrees of freedom
AIC: 8.4042
```

```
Number of Fisher Scoring iterations: 14


LRT Selected Model:


Call:

glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,

    weights = weights)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-1.21714  -0.00016   0.00000   0.00000   0.91483


Coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)  -3.1304     4.6463  -0.674  0.50048

dist_col      0.2432     0.1585   1.534  0.12509

strat_temp   -9.1471     5.4575  -1.676  0.09373 .

ss_wave       3.6707     1.2179   3.014  0.00258 **

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 97.836  on 26534  degrees of freedom

Residual deviance: 29.155  on 26531  degrees of freedom

AIC: 9.4814


Number of Fisher Scoring iterations: 13
```

```
Single term deletions

Model:
SEARCH_FORAGE ~ dist_col + strat_temp + ss_wave
           Df Deviance     AIC     LRT  Pr(>Chi)
<none>          29.155  9.4814
dist_col    1   32.479 10.8053  3.3239  0.068280 .
strat_temp  1   40.068 18.3943 10.9129  0.000955 ***
ss_wave     1   47.496 25.8221 18.3406 1.847e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(strat_temp, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -58.28      18.87  -3.089  0.00201 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Approximate significance of smooth terms:
              edf Ref.df Chi.sq p-value
s(dist_shore)   1      1   8.81  0.0030 **
s(strat_temp)   1      1   3.10  0.0783 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.505   Deviance explained = 70.1%
ML score = 14.637  Scale est. = 1         n = 26535

GAM Model selected (REML output):

Family: binomial
Link function: logit

Formula:
SEARCH_FORAGE ~ s(dist_shore, k = 3) + s(strat_temp, k = 3)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -58.28      18.87  -3.089  0.00201 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df Chi.sq p-value
s(dist_shore)   1      1  8.807  0.0030 **
s(strat_temp)   1      1  3.093  0.0787 .
---
```

```
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.505   Deviance explained = 70.1%
REML score = 9.1939  Scale est. = 1         n = 26535

Running INLA.

Call:
c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")

Time used:
 Pre-processing    Running inla Post-processing           Total
       3.650407      446.753584       12.355222      462.759213

Fixed effects:
                mean        sd 0.025quant  0.5quant 0.975quant
kld
(Intercept)  7.838806 2.8221990   2.942585  7.599732 14.0087526
0.03242810
dist_shore  -3.025761 0.9486555  -5.099825 -2.946016 -1.3778902
0.02378760
strat_temp  -3.913432 2.0516161  -8.414270 -3.732624 -0.3757096
0.01066883

Random effects:
Name                            Model      Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model
```

```
Model hyperparameters:
                            mean     sd       0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT 8.475785 0.004367 8.467210   8.475785
8.484370

Expected number of effective parameters(std dev): 2.994(0.005714)
Number of equivalent replicates : 8862.85

Marginal Likelihood:  -289.63
               mean     sd 0.025quant 0.5quant 0.975quant    kld
(Intercept)  7.8388 2.8222     2.9426   7.5997    14.0088 0.0324
dist_shore  -3.0258 0.9487    -5.0998  -2.9460    -1.3779 0.0238
strat_temp  -3.9134 2.0516    -8.4143  -3.7326    -0.3757 0.0107
```

Larne Lough – SST excluded

```
Running analysis for colony LarneLough for species Sandwich.
Using years 09,10,11 and control sets 1,2,3,4,5,6,7,8,9,10,11,12.

Running GLM.
Employing model selection.

AIC Selected Model (forwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + sal_spring + dist_shore,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.6976   0.0000   0.0000   0.0000   0.6006

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -4677.4679  1896.8897  -2.466   0.0137 *
dist_col       -0.4314     0.1898  -2.273   0.0230 *
sal_spring    133.8926    54.2826   2.467   0.0136 *
dist_shore     -3.3519     1.3220  -2.535   0.0112 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 210.722  on 29785  degrees of freedom
Residual deviance:  53.631  on 29782  degrees of freedom
AIC: 8.4867

Number of Fisher Scoring iterations: 13

AIC Selected Model(backwards):

Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + sal_spring,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)

Deviance Residuals:
```

```
    Min       1Q   Median       3Q      Max
-0.6976   0.0000   0.0000   0.0000   0.6006

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -4677.4679  1896.8897  -2.466   0.0137 *
dist_col       -0.4314     0.1898  -2.273   0.0230 *
dist_shore     -3.3519     1.3220  -2.535   0.0112 *
sal_spring    133.8926    54.2826   2.467   0.0136 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 210.722  on 29785  degrees of freedom
Residual deviance:  53.631  on 29782  degrees of freedom
AIC: 8.4867

Number of Fisher Scoring iterations: 13

Correlations:
             dist_col  dist_shore  sal_spring
dist_col    1.00000000  0.21462847 -0.08386903
dist_shore  0.21462847  1.00000000 -0.05178246
sal_spring -0.08386903 -0.05178246  1.00000000
VIF:
  dist_col dist_shore sal_spring
  5.754416   1.015525   5.763089
BIC Selected Model:
```

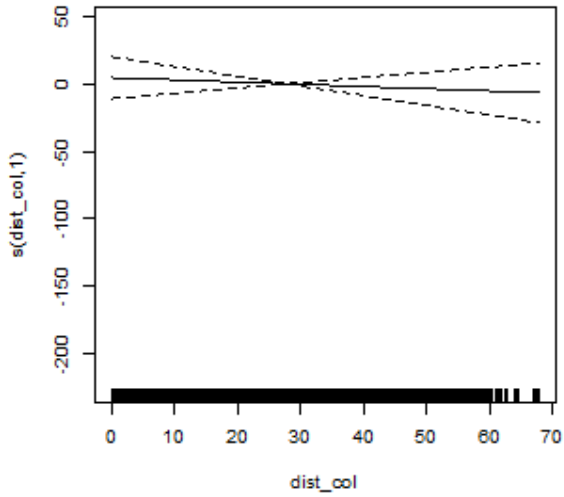
```
Call:
glm(formula = SEARCH_FORAGE ~ dist_col + dist_shore + sal_spring,
    family = "binomial", data = complete.data.to.analyse, weights =
weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.6976   0.0000   0.0000   0.0000   0.6006

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -4677.4679  1896.8897  -2.466   0.0137 *
dist_col       -0.4314     0.1898  -2.273   0.0230 *
dist_shore     -3.3519     1.3220  -2.535   0.0112 *
sal_spring    133.8926    54.2826   2.467   0.0136 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 210.722  on 29785  degrees of freedom
Residual deviance:  53.631  on 29782  degrees of freedom
AIC: 8.4867

Number of Fisher Scoring iterations: 13

LRT Selected Model:
```

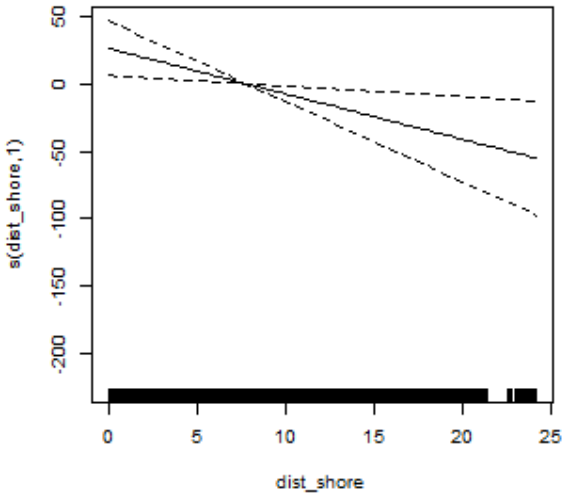
```
Call:
glm(formula = formula.glm, family = "binomial", data =
complete.data.to.analyse,
    weights = weights)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.6976   0.0000   0.0000   0.0000   0.6006

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -4677.4679  1896.8897  -2.466   0.0137 *
dist_col       -0.4314     0.1898  -2.273   0.0230 *
dist_shore     -3.3519     1.3220  -2.535   0.0112 *
sal_spring    133.8926    54.2826   2.467   0.0136 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 210.722  on 29785  degrees of freedom
Residual deviance:  53.631  on 29782  degrees of freedom
AIC: 8.4867

Number of Fisher Scoring iterations: 13

Single term deletions

Model:
```

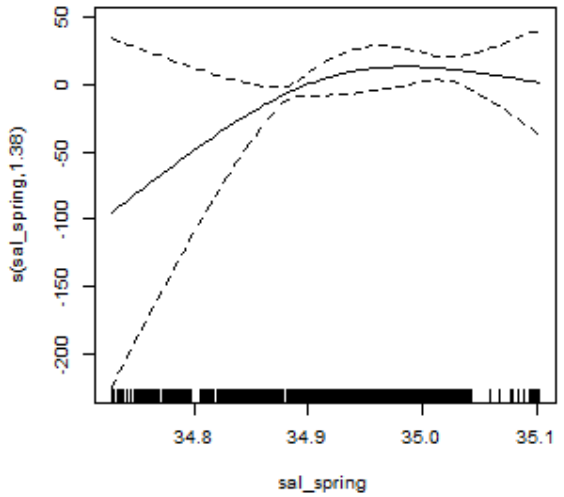
```
SEARCH_FORAGE ~ dist_col + dist_shore + sal_spring
           Df Deviance    AIC    LRT  Pr(>Chi)
<none>          53.631  8.487
dist_col    1   82.807 35.663 29.176 6.609e-08 ***
dist_shore  1   68.722 21.578 15.091 0.0001024 ***
sal_spring  1   69.594 22.450 15.964 6.457e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Now checking for interactions with Year.
Single term deletions

Model:
SEARCH_FORAGE ~ Year * (dist_col + dist_shore + sal_spring)
               Df Deviance    AIC    LRT Pr(>Chi)
<none>              46.504 25.091
Year:dist_col    2   50.429 25.017 3.9254  0.14048
Year:dist_shore  2   46.874 21.461 0.3697  0.83122
Year:sal_spring  2   51.858 26.445 5.3540  0.06877 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Year effects not consistent - run one year at a time.

Running GAM.

GAM Model selected (ML output):

Family: binomial
Link function: logit
```

```
Formula:

SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(sal_spring,

    k = 3)


Parametric coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept)   -38.34      11.51  -3.332 0.000864 ***

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:

              edf Ref.df Chi.sq p-value

s(dist_col)     1      1  5.168  0.0230 *

s(dist_shore)   1      1  6.429  0.0112 *

s(sal_spring)   1      1  6.084  0.0136 *

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.687   Deviance explained = 74.5%

ML score = 26.815  Scale est. = 1         n = 29786


GAM Model selected (REML output):


Family: binomial

Link function: logit


Formula:
```

```
SEARCH_FORAGE ~ s(dist_col, k = 3) + s(dist_shore, k = 3) +
s(sal_spring,
    k = 3)


Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -40.31      11.88  -3.392 0.000693 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Approximate significance of smooth terms:
               edf Ref.df Chi.sq p-value
s(dist_col)   1.000  1.000  0.352 0.55274
s(dist_shore) 1.000  1.000  6.763 0.00931 **
s(sal_spring) 1.383  1.619  7.849 0.01388 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


R-sq.(adj) =  0.702   Deviance explained = 75.5%
REML score = 19.844  Scale est. = 1         n = 29786
```








```
Running INLA.


Call:

c("inla(formula = formula.inla, family = \"binomial\", data =
complete.data.to.analyse, ",  "    weights = weights, verbose =
TRUE)")


Time used:

 Pre-processing    Running inla Post-processing           Total

       2.745605      217.027581       13.041623      232.814809
```

```
Fixed effects:
                    mean         sd  0.025quant    0.5quant
0.975quant
(Intercept) -12.5315840 15.0538925 -42.2660331 -12.4540966
16.77199817
dist_col     -0.3904357  0.2074987  -0.8479773  -0.3709956 -
0.03521415
dist_shore   -3.5021965  1.2969976  -6.2898831  -3.4136438 -
1.19640177
sal_spring1  34.2117201 25.4246795 -15.0215666  33.9766003
84.77176999
sal_spring2  26.4481641 12.1380327   5.8251902  25.2512939
53.34604183
                     kld
(Intercept) 0.0073618065
dist_col    0.0191964403
dist_shore  0.0079701858
sal_spring1 0.0197332233
sal_spring2 0.0002858282


Random effects:
Name    Model          Max KLD
UserFunction0   NoModelName
UserFunction1   NoModelName
mesh.points   SPDE model


Model hyperparameters:
                            mean   sd     0.025quant 0.5quant
0.975quant
T.0 for mesh.points-basisT  7.990  3.144  1.866      7.973   14.194
```

```
Expected number of effective parameters(std dev): 4.184(0.00339)
Number of equivalent replicates : 7118.41

Marginal Likelihood:  -40.06
                mean      sd 0.025quant 0.5quant 0.975quant    kld
(Intercept) -12.5316 15.0539   -42.2660 -12.4541    16.7720 0.0074
dist_col     -0.3904  0.2075    -0.8480  -0.3710    -0.0352 0.0192
dist_shore   -3.5022  1.2970    -6.2899  -3.4136    -1.1964 0.0080
sal_spring1  34.2117 25.4247   -15.0216  33.9766    84.7718 0.0197
sal_spring2  26.4482 12.1380     5.8252  25.2513    53.3460 0.0003
```