

**Table S1:** Backwards stepwise selection for the Scilly route (Tweedie distribution, log link). Each iteration removed a non-significant covariate. The basis here is a thin plate regression spline (bs="tp"). A bivariate spatial smooth (x,y) was added to the best-fit model and retained if significant. The selected model is identified in bold.

	Terms	AIC	REML	Deviance explained
1	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp) + s(slope)	2873	887	13.9%
2	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD)+ s(slope)	2871	886	13.9%
3	s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD)+ s(slope)	2870	885	14.0%
4	s(coast) + s(log(SST)) + s(MLD) + s(slope)	3339	1078	13.0%
5	s(coast) + s(log(SST)) + s(slope)	3438	1123	12.5%
<b>6</b>	<b>s(coast) +</b> <b>s(log(SST)) +</b> <b>slope</b>	<b>3438</b>	<b>1122</b>	<b>12.5%</b>

7	s(coast) + s(log(SST)) + s(slope) + te(x,y)	3443	1116	13.1%
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**Table S2:** Backwards stepwise selection for the English Channel (Tweedie distribution, log link). Each iteration removed a non-significant covariate. The basis here is a thin plate regression spline (bs="tp"). A bivariate spatial smooth (x,y) was added to the best-fit model and retained if significant. The selected model is identified in bold.

	Terms	AIC	REML	Deviance explained
1	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD)+ s(deltaTemp)+ s(slope)	7336	1274	10.8%
2	s(depth) + s(coast) + s(log(SST)) + s(MLD)+ s(deltaTemp)+ s(slope)	7330	1274	10.2%
3	s(depth) + s(coast) + s(log(SST)) + s(MLD)+ s(deltaTemp)	7327	1276	8.9%
4	s(coast) + s(log(SST)) + s(MLD)+ s(deltaTemp)	7326	1278	8.2%
5	s(log(SST)) + s(MLD) + s(deltaTemp)	7326	1278	7.6%
6	s(log(SST)) + s(deltaTemp)	7325	1281	5.27%

<b>7</b>	<b>s(log(SST)) + s(deltaTemp) + te(x,y)</b>	<b>7320</b>	<b>1254</b>	<b>14.1%</b>
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**Table S3:** Backwards stepwise selection for the North Sea (Tweedie distribution, log link). Each iteration removed a non-significant covariate. The basis here is a thin plate regression spline (bs="tp"). A bivariate spatial smooth (x,y) was added to the best-fit model and retained if significant. The selected model is identified in bold.

	Terms	AIC	REML	Deviance explained
1	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp) + s(slope)	11728	1032	15.1%
2	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp) +	11726	1035	14.7%
3	s(depth) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp)	11726	1035	14.8%
4	s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp)	11727	1037	14.5%
5	s(log(SST)) + s(log(ChL)) + s(deltaTemp)	11723	1042	11.5%
6	s(log(ChL)) + s(deltaTemp)	11730	1051	6.8%

<b>7</b>	<b>s(log(ChL)) + s(deltaTemp) + te(x,y)</b>	<b>11740</b>	<b>1033</b>	<b>14.4%</b>
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**Table S4:** Specifications and output for the Scilly route (Tweedie distribution, log link) using shrinkage (bs="ts"). The second iteration removed all covariates that were penalized to zero. A bivariate spatial smooth (x,y) was added to the best-fit model and retained if significant. The same covariates were retained as in the selected model for this region (Table S1).

	Terms	AIC	REML	Deviance explained
1	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp) + s(slope)	2873	886	13.9%
1	s(coast) + s(log(SST)) + slope	3438	1122	12.5%
2	s(coast) + s(log(SST)) + slope + te(x,y)	3437	1126	12.0%

**Table S5:** Specifications and output for the English Channel (Tweedie distribution, log link) using shrinkage (bs="ts"). The second iteration removed all covariates that were penalized to zero. A bivariate spatial smooth (x,y) was added to the best-fit model and retained if significant. The same covariates were retained as in the selected model for this region (Table S2).

	Terms	AIC	REML	Deviance explained
1	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp) + s(slope)	7336	1273	10.8%
2	s(log(SST)) + s(deltaTemp)	7325	1280	5.3%

3	s(log(SST)) + s(deltaTemp) + te(x,y)	7329	1262	15.2%
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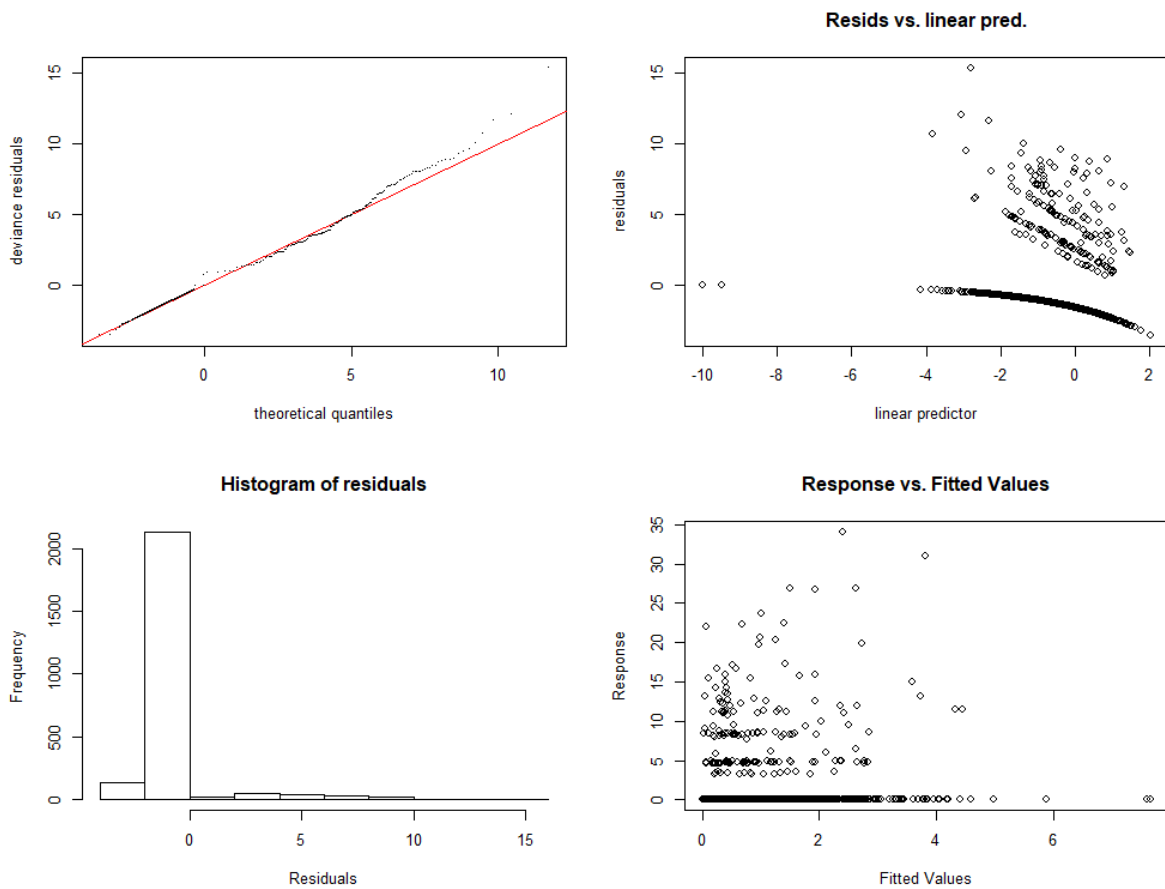


**Table S6:** Specifications and output for the North Sea (Tweedie distribution, log link) using shrinkage (bs="ts"). The second iteration removed all covariates that were penalized to zero. A bivariate spatial smooth (x,y) was added to the best-fit model and retained if significant. The same covariates were retained as in the selected model for this region (Table S3).

	Terms	AIC	REML	Deviance explained
1	s(depth) + s(coast) + s(log(ChL)) + s(log(SST)) + s(MLD) + s(deltaTemp) + s(slope)	14598	4009	8.7%
2	s(log(ChL)) + s(deltaTemp)	14619	4049	4.5%
3	s(log(ChL)) + s(deltaTemp) + te(x,y)	14553	3975	11.8%

**Table S7:** Approximate significance of smooth terms in selected Scilly route density surface model (DSM) (Table S1). Note that the p-value for the linear term, slope, is derived from a t-test.

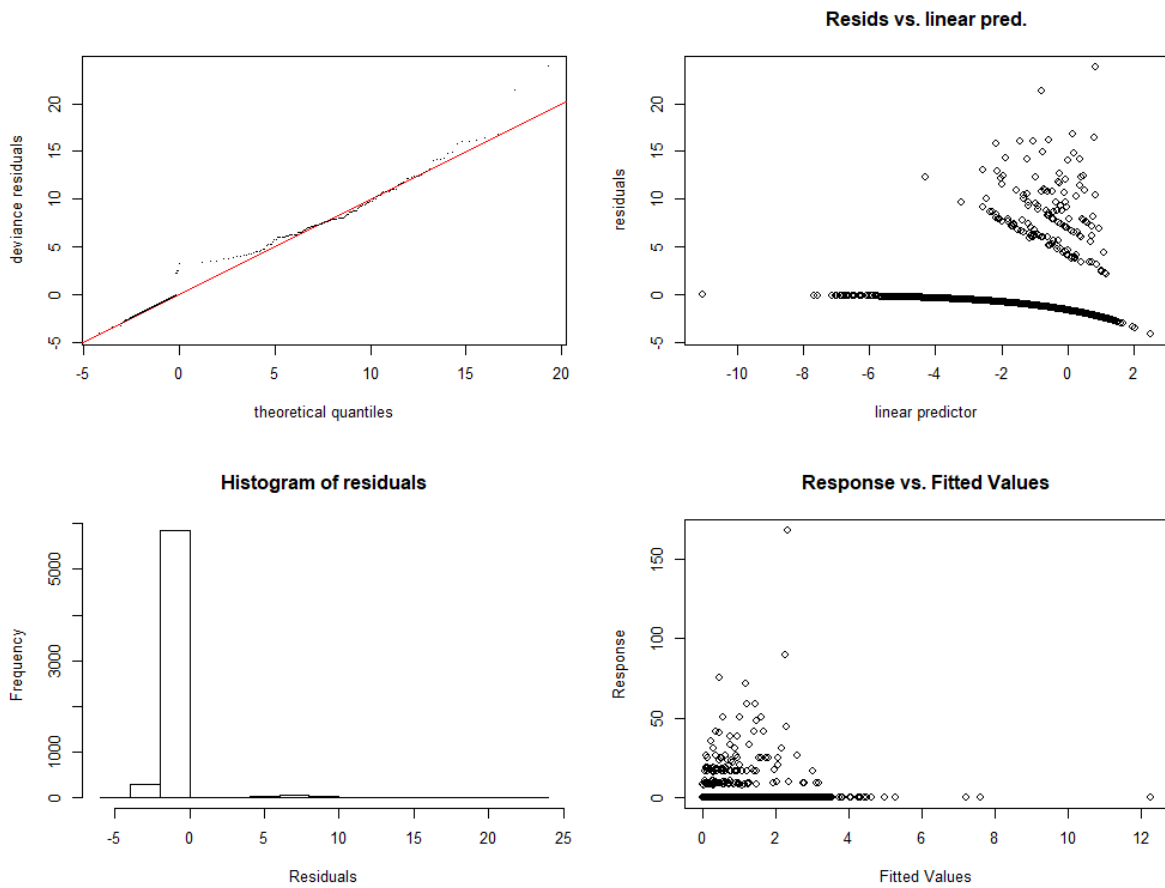
	edf	Ref.df	F	p-value
s(coast)	2.608	3.250	23.801	$p < 0.001$
s(log(SST))	2.281	2.897	3.723	0.0107
slope				0.0231



**Fig. S1:** Generalized additive model (GAM) residual plots for density model on the Scilly route.

**Table S8:** Approximate significance of smooth terms in selected English Channel density surface model (DSM) (Table S2).

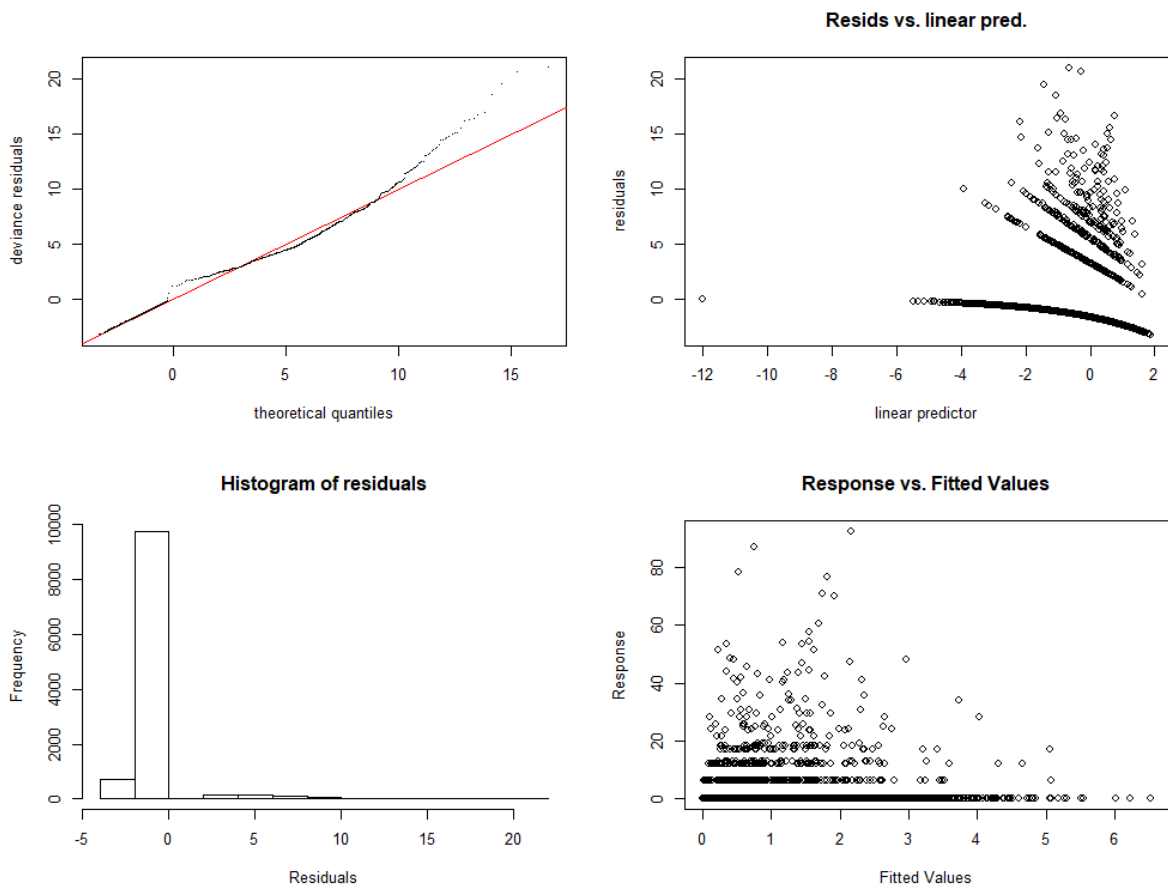
	edf	Ref.df	F	p-value
s(log(SST))	4.929	6.021	4.707	p < 0.001
s( $\Delta$ Temp)	1.203	1.378	7.957	p < 0.001
s(x,y)	14.085	18.166	3.297	p < 0.001



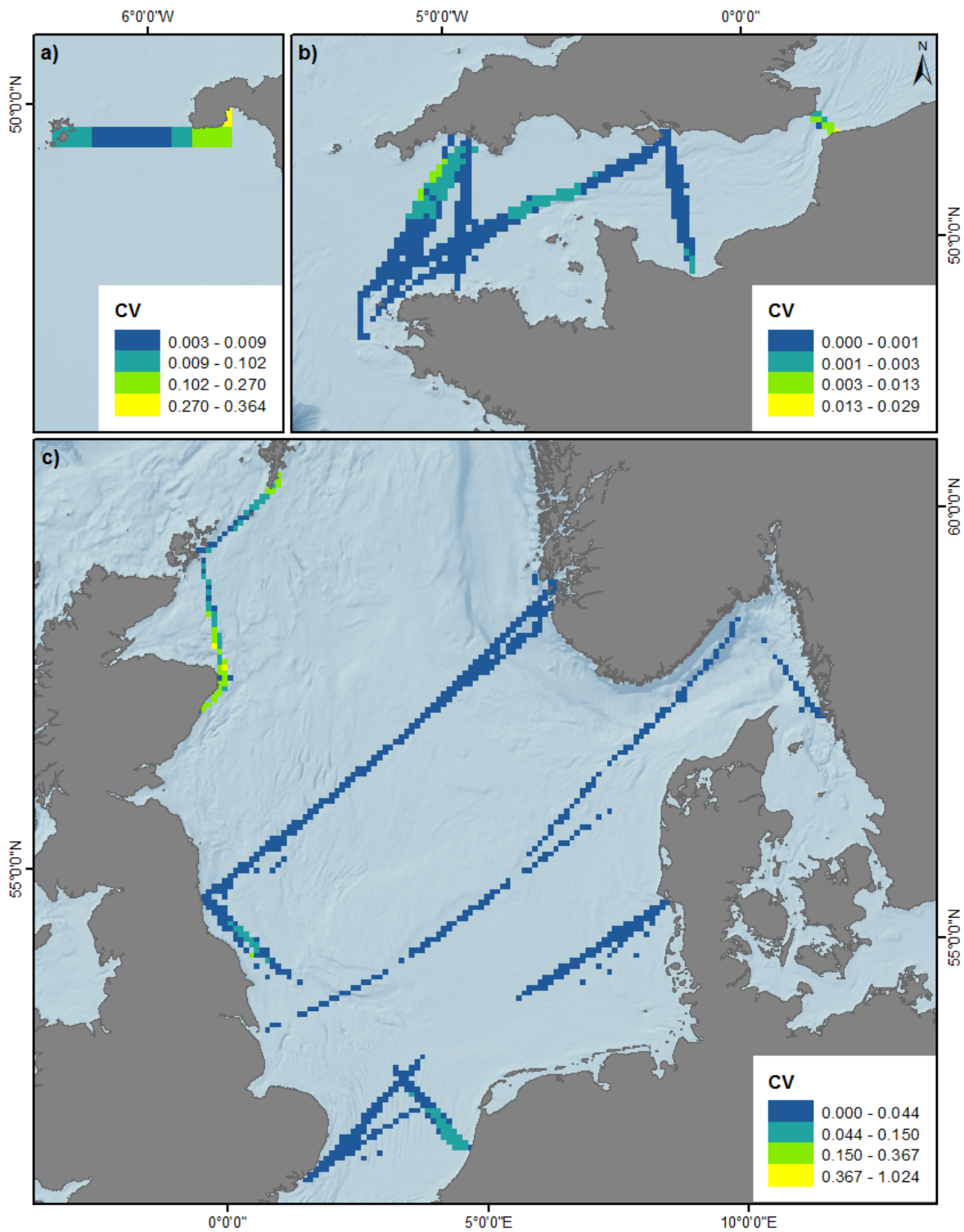
**Fig. S2:** Generalized additive model (GAM) residual plots for density model in the English Channel.

**Table S9:** Approximate significance of smooth terms in North Sea density surface model (DSM) (Table S3).

	edf	Ref.df	F	p-value
s(log(ChL))	3.001	3.864	4.681	0.00114
s( $\Delta$ Temp)	1.003	1.006	53.555	p < 0.001
s(x,y)	20.806	24.871	8.601	p < 0.001



**Fig. S3:** Generalized additive model (GAM) residual plots for density model in the North Sea.



**Fig. S4:** Plot of the coefficient of variation (CV) of harbour porpoise densities a) along the Scilly route, b) in the English Channel, and c) in the North Sea.