Regional variation in the impact of climate change: evidence that bottom-up regulation from plankton to seabirds is weak in parts of the Northeast Atlantic

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Supplement. Tables S1–S4 show the correlation matrix between covariates for the 3 regions considered in this study: Irish Sea, Celtic Sea and English Channel. Competing models (see Tables S5–S6) for the Irish and Celtic Sea are also shown

Table S1. Correlation matrix (Pearson's coefficient) between covariates for the Irish Sea. Significance (in **bold**) is indicated as follows: p value <0.001 ***, p value <0.01**, p value <0.05*. Kitt Bard: black-legged kittiwake productivity at Bardsey colony; Kitt Great: black-legged kittiwake productivity at Great Ormes Head colony; Cop: copepods; Diat: diatoms; WSST: Winter Sea Surface Temperature (mean December-March); SST annual: annual mean Sea Surface Temperature.

	Year	Kitt Bard	Kitt Great	Cop	Diat	Fish larvae	WSST	SSTannual
Year	1.00							
Kitt Bard	0.44	1.00						
Kitt Great	-0.38	0.35	1.00					
Cop	0.36	-0.07	-0.45	1.00				
Diat	0.13	-0.02	0.12	0.46	1.00			
Fish larvae	-0.10	0.41	0.36	0.21	0.37	1.00		
WSST	**0.75 *****	0.44	-0.05	0.11	0.24	-0.21	1.00	
SST annual	**0.81 *****	0.41	-0.15	0.24	0.32	-0.20	**0.89 *****	1.00

Table S2. Correlation matrix (Pearson's coefficient) between covariates for the Celtic Sea. Significance (in **bold**) is indicated as follows: p value <0.001 ***, p value <0.01**, p value <0.05*. KittEleg: black-legged kittiwake productivity at Elegug Stacks colony; KittSkom: black-legged kittiwake productivity at Skomer colony; KittDumn: black-legged kittiwake productivity at Dunmore East colony; KittRam: black-legged kittiwake productivity at Ram Head colony; Cop: copepods; Diat: diatoms; WSST: Winter Sea Surface Temperature (mean December-March); SST annual: annual mean Sea Surface Temperature.

	Year	Kitt Eleg	Kitt Skom	Kitt Dunm	Kitt Ram	Cop	Diat	Fish larvae	WSST	SST annual
Year	1.00									
Kitt Eleg	-0.36	1.00								
Kitt Skom	-0.16	0.44	1.00							
Kitt Dunm	**0.59***	0.26	0.23	1.00						
Kitt Ram	-0.28	0.26	0.14	-0.06	1.00					
Cop	0.25	-0.20	-0.35	0.33	-0.49	1.00				
Diat	0.41	0.23	0.01	0.44	0.10	-0.04	1.00			
Fish larvae	0.14	-0.24	-0.33	-0.11	-0.24	0.17	0.42	1.00		
WSST	**0.65****	-0.09	-0.04	0.52	-0.23	0.26	0.20	-0.01	1.00	
SST annual	**0.82*****	-0.18	-0.01	0.52	-0.17	0.34	0.35	-0.02	**0.68****	1.00

Table S3. Correlation matrix (Pearson's coefficient) between covariates for the English Channel. Significance (in **bold**)is indicated as follows: p value <0.001***, p value <0.01**, p value <0.05*. Kitt Durl: black-legged kittiwake productivity at Durlston Head colony; Cop: copepods; Diat: diatoms; WSST: Winter Sea Surface Temperature (mean December-March); SST annual: annual mean Sea Surface Temperature.

	Year	Kitt Durl	Cop	Diat	Fish larvae	WSST	SST annual
Year	1.00						
Kitt Durl	0.44	1.00					
Cop	0.20	-0.02	1.00				
Diat	0.30	0.19	0.34	1.00			
Fish larvae	-0.03	0.24	0.27	**0.55***	1.00		
WSST	**0.61***	0.40	0.04	-0.06	-0.19	1.00	
SST annual	**0.79*****	**0.64***	0.04	0.42	0.16	**0.58***	1.00

Table S4. Correlation matrix (Pearson's coefficient) between covariates in different regions. Significance is indicated as follows: p value <0.001 ***, p value <0.01**, p value <0.05*. Kitt Bard: black-legged kittiwake productivity at Bardsey colony; Kitt Great: black-legged kittiwake productivity at Great Ormes Head colony; Kitt Eleg: black-legged kittiwake productivity at Elegug Stacks colony; Kitt Skom: black-legged kittiwake productivity at Skomer colony; Kitt Dunm: black-legged kittiwake productivity at Dunmore East colony; Kitt Ram: black-legged kittiwake productivity at Ram Head colony; Kitt Durl: black-legged kittiwake productivity at Durlston Head colony; Cop: copepods; Diat: diatoms; WSST: Winter Sea Surface Temperature (mean December-March); SST annual: annual mean Sea Surface Temperature.

	Year	Kitt Bard	Kitt Great	Irish cop	Irish diat	Irish fish larvae	Irish WSST	Irish SSTa	Kitt Eleg	Kitt Skom	Kitt Dunm	Kitt Ram	Celtic cop	Celtic diat	Celtic fish larvae	Celtic WSST	Celtic SSTa	Kitt Dur	Channel cop	Channel diat	Channel fish larvae	Channel WSST	Channel SSTa
Year	1.00																						
Kitt Bard	0.44	1.00																					
Kitt Great	-0.38	0.35	1.00																				
Irish cop	0.36	-0.07	-0.45	1.00																			
Irish diat	0.13	-0.02	0.12	0.46	1.00																		
Irish fish larvae	-0.10	0.41	0.36	0.21	0.37	1.00																	
Irish WSST	**0.75***	0.44	-0.05	0.11	0.24	-0.21	1.00																
Irish SSTa	**0.81***	0.41	-0.15	0.24	0.32	-0.20	**0.89 ***	1.00															
Kitt Eleg	-0.36	0.10	0.55	-0.47	0.08	0.43	-0.04	-0.05	1.00														
Kitt Skom	-0.16	-0.36	0.16	-0.32	0.19	-0.04	-0.05	0.04	0.44	1.00													
Kitt Dunm	**0.59***	**0.56***	0.22	0.01	0.37	0.42	0.50	0.51	0.26	0.23	1.00												
Kitt Ram	-0.28	0.08	-0.02	-0.31	0.42	0.26	-0.11	-0.16	0.26	0.14	-0.06	1.00											
Celtic cop	0.25	0.35	0.34	0.49	0.32	0.42	0.13	0.13	-0.20	-0.35	0.33	-0.49	1.00										
Celtic diat	0.41	**0.61***	0.03	-0.15	-0.21	0.22	0.37	0.39	0.23	0.01	0.44	0.10	-0.04	1.00									
Celtic fish larvae	0.14	0.15	-0.03	0.16	-0.41	-0.12	0.06	-0.03	-0.24	-0.33	-0.11	-0.24	0.17	0.42	1.00								
Celtic WSST	**0.65***	**0.62***	0.19	0.01	0.15	-0.19	**0.85***	**0.76***	-0.09	-0.04	0.52	-0.23	0.26	0.20	-0.01	1.00							
Celtic SSTa	**0.82***	0.46	-0.11	0.41	0.46	-0.03	**0.72***	**0.86***	-0.18	-0.01	0.52	-0.17	0.34	0.35	-0.02	**0.68 ***	1.00						
Kitt Dur	0.44	0.29	-0.04	-0.09	0.09	-0.17	**0.57***	**0.70***	0.15	0.19	0.18	-0.08	-0.25	0.48	-0.27	0.43	**0.56***	1.00					
Channel cop	0.20	**0.59***	0.16	-0.32	-0.34	0.16	0.06	0.06	0.21	-0.15	0.32	0.02	-0.05	0.43	0.18	0.28	0.00	-0.02	1.00				
Channel diat	0.30	0.29	-0.25	0.22	0.12	**0.54***	0.11	0.25	0.41	-0.11	0.42	0.19	0.03	**0.65***	0.02	-0.22	0.21	0.19	0.34	1.00			
Channel fish larvae	-0.03	0.19	-0.03	0.07	0.04	0.35	-0.04	-0.02	0.32	-0.19	-0.06	0.27	-0.25	0.41	0.08	-0.22	0.10	0.24	0.27	**0.55***	1.00		
Channel WSST	**0.61***	0.46	0.37	-0.07	0.41	0.15	**0.83***	**0.61***	0.14	0.15	**0.75***	0.05	0.22	0.20	-0.23	**0.79***	0.51	0.40	0.04	-0.06	-0.19	1.00	
Channel SSTa	**0.79***	**0.61***	0.07	0.10	0.43	0.21	**0.78***	**0.84***	0.18	-0.02	**0.62***	0.17	0.22	0.51	-0.39	**0.61***	**0.88***	**0.64 ***	0.04	0.42	0.16	**0.58***	1.00

Table S5. Competing models for the Irish Sea. AICc weight: corrected Akaike's information criterion weights, values range from 0 to 1, high values indicating strong support for a given predictor; R^2: Adjusted coefficient. ASST-1: 1 year lagged annual Sea Surface Temperature. Significant relationships are highlighted in **bold**; not significant variables included in the model are also presented.

Model selected	AICc weight	N (years)	Deviance	R^2	p-value	Slope (±Standard Error)
PRIMARY PRODUCERS						
Diatom abundance						
Intercept only	0.47	17	1.04		<0.001	4.717 (±0.06)
PRIMARY CONSUMERS						
Copepod biomass						
diatom	0.31	17	8.14	0.16	0.062	0.121×10^{-6}
Intercept only	0.18	17	10.33		<0.001	0.879 (±0.195)
Fish larval abundance						
Intercept only	0.26	17	2.29		<0.001	0.626 (±0.091)
APEX PREDATORS						
Black-legged kittiwake productivity						
Bardsey						
fish larvae + year	0.28	16	1.39	0.38	**fish larvae 0.022**	0.604 (±0.233)
					year 0.018	0.048 (±0.0.17)
fish larvae lag + ASST-1	0.12	16	1.55	0.31	fish larvae lag 0.054	0.502 (±0.237)
					ASST-1 0.039	0.483 (±0.211)
Great Ormes Head						
Intercept only	0.20	17	1.00		<0.001	0.500 (±0.060)

Table S6. Competing models for the Celtic Sea. AICc weight: corrected Akaike's information criterion weights, values range from 0 to 1, high values indicating strong support for a given predictor; R^2: Adjusted coefficient. Significant relationships are highlighted in **bold**; not significant variables included in the model are also presented.

Model selected	AICc weight	N (years)	Deviance	R^2	p-value	Slope (±Standard Error)
PRIMARY PRODUCERS						
Diatom abundance						
year	0.42	17	2.45	0.12	0.098	0.035 (±0.020)
PRIMARY CONSUMERS						
Copepod biomass						
Intercept only	0.44	17	1.83		<0.001	1.115 (±0.082)
Fish larval abundance						
diatom	0.29	17	3.93	0.12	0.097	0.526 (±0.297)
Intercept only	0.26	17	4.76		<0.001	0.734 (±0.132)
APEX PREDATORS						
Black-legged kittiwake productivity						
Skomer						
Intercept only	0.24	17	0.88		<0.001	0.682 (±0.056)
Elegug Stacks						
Intercept only	0.20	17	0.096		<0.001	0.091 (±0.018)
Dunmore East						
fish larvae lag + year	0.38	17	0.434	0.41	fish larvae lag 0.07	-0.172 (±0.089)
					year 0.008	0.026 (±0.008)
year	0.29	17	0.550	0.30	**0.012**	0.026 (±0.009)
Ram Head						
Intercept only	0.35	13	0.860		<0.001	0.442 (±0.074)