The following supplement accompanies the article

Population growth across heterogeneous environments: effects of harvesting and age structure

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Supplement. This supplement shows the model selection table, figures displaying the data used and the plots of the selected models.

Table S1. Model selection on generalized additive models on elasticity of the population growth to recruitment. After preliminary models (results not shown), GULF (annual mean values of the Gulf Stream) was retained as better global index than NAO (North Atlantic Oscillation) for Atlantic hake. A generalized additive mixed model (GAMM) conducted on logit transformed elasticity with years and stocks as random effect. In all models the dependent variable is the logit-transformed transient elasticity ($\boldsymbol{e}_t$) of population growth to recruitment (see 'Materials and methods'). p-values for each variable are indicated (***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1). GCV: generalized cross-validation criterion; NEA: Northeast Arctic; NS: North Sea; EBS: Eastern Bering Sea; GOA: Gulf of Alaska; NA: Northern Atlantic; SA: Southern Atlantic, BI: Balearic Islands; *s*: smoothing term; μ: mean age of the parents of the offspring produced by a cohort over its lifetime (generation time); *F*: fishing mortality for different age range (in yr) in subscripts ; wPDO: winter Pacific Decadal Oscillation; IDEA: hydro-climatic index based on the air-sea heat fluxes in the Gulf of Lions during winter; UI: upwelling index; wNAO: winter NAO index; SST: sea surface temperature (°C), sum1 for summer at Location 1 and wint2 for winter at Location 2. ST: sea temperature at 0–200 m. SST stands for sea temperature (SST and ST alike) in the GAMM model

Dependent variable	Model formulation	Adjusted R^2	GCV
SA hake	$s(\mu)^{**}+s(F_{2–5})+s(\mathrm{GULF})+s(\mathrm{UI})+s(\mathrm{SST}_{winter})$	0.59	0.052
	$s(\mu)^{**}+s(\mathrm{GULF})+s(\mathrm{UI})+s(\mathrm{SST}_{winter})$	0.60	0.046
	$s(\mu)^{**}+s(\mathrm{UI})+s(\mathrm{SST}_{winter})$	0.62	0.042
NA hake	$s(\mu)+s(F_{2–6})+s(\mathrm{GULF})+s(\mathrm{SST}_{winter})+s(\mathrm{SST}_{spring})^{*}$	0.39	0.026
	$s(\mu)+s(F_{2–6})+s(\mathrm{SST}_{winter})+s(\mathrm{SST}_{spring})^{*}$	0.42	0.023
	$s(\mu)+s(\mathrm{SST}_{winter})+s(\mathrm{SST}_{spring})^{*}$	0.44	0.021

BI hake	$s(\mu)^{*}+s(F_{2–4})+s(\mathrm{IDEA})+s(\mathrm{SST}_{\mathrm{winter}})$	0.24	0.124
	$s(\mu)^{*}+s(F_{2–4})+s(\mathrm{SST}_{\mathrm{winter}})$	0.28	0.111
	$s(\mu)^{**}+s(\mathrm{SST}_{\mathrm{winter}})$	0.29	0.105
NEA cod	$s(\mu)^{\dagger}+s(F_{5–10})^{\dagger}+s(\mathrm{wNAO})+s(\mathrm{ST})^{*}$	0.36	0.391
	$s(\mu)^{*}+s(F_{5–10})^{\dagger}+s(\mathrm{ST})^{**}$	0.37	0.379
NS cod	$s(\mu)+s(F_{2–4})+s(\mathrm{wNAO})+s(\mathrm{SST}_{spring})$	0.07	0.420
	$s(\mathrm{wNAO})+s(F_{2–4})^{\dagger}+s(\mathrm{SST}_{spring})$	0.09	0.399
EBS pollock	$s(\mathrm{MA}_{ss})+s(F_{6–10})^{\dagger}+s(\mathrm{wPDO})^{*}+s(\mathrm{SST})$	0.26	0.453
	$s(F_{6.10})+s(\mathrm{wPDO})^{*}+s(\mathrm{SST})$	0.27	0.425
GOA pollock	$s(\mu)+s(F_{5–8})+s(\mathrm{wPDO})+s(\mathrm{SST}_{\mathrm{wint2}})^{*}+s(\mathrm{SST}_{sum1})$	0.19	1.625
	$s(\mu)+s(\mathrm{wPDO})+s(\mathrm{SST}_{\mathrm{wint2}})^{*}+s(\mathrm{SST}_{\mathrm{sum1}})$	0.22	1.447
			AIC
All stocks (GAMM)	$s(\mu)^{***}+s(F)^{*}+s(\mathrm{SST})$	0.50	438
	$s(\mu)^{***}+s(F)^{*}$	0.51	430

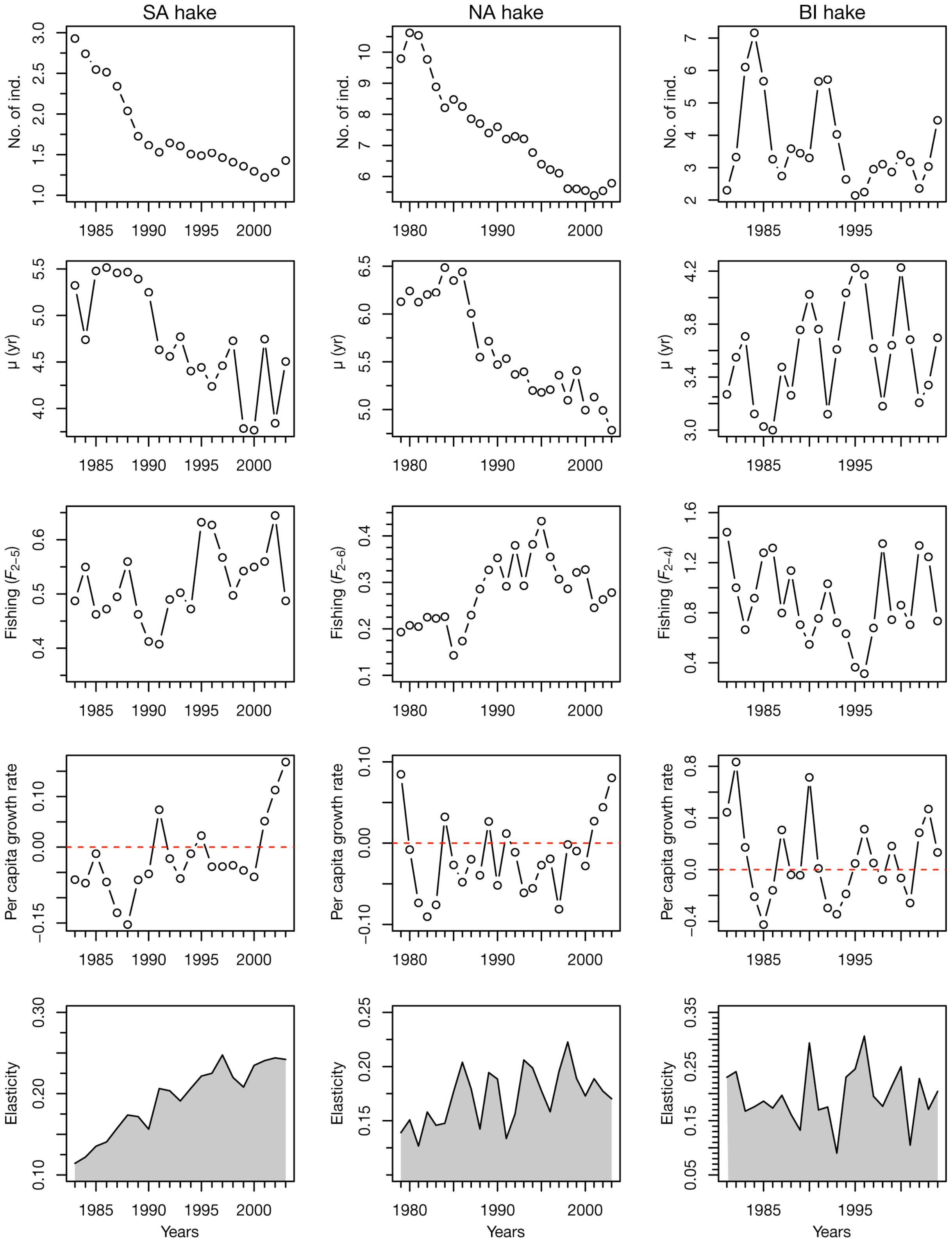

Fig. S1. Data for the 3 hake populations used in the study: South Atlantic (SA), North Atlantic (NA) and Balearic Islands (BI). The first row shows the change in the population abundance in numbers over time (output from virtual population analyses $\times 10^5$ for SA hake, 10^8 for NA hake, and $\times 10^6$ for BI hake). The second row shows the generation time, μ, the changes in mean age of the parents of the offspring produced by a cohort over its lifetime. The third row shows the changes in the fishing mortality (*F*) with age range (in yr) in subscripts. The fourth row shows the changes in the realized population growth rate with time (–1 to 1). The fifth row shows the changes in the relative importance of the transient elasticity (0–1) to recruitment of the population growth rate with time

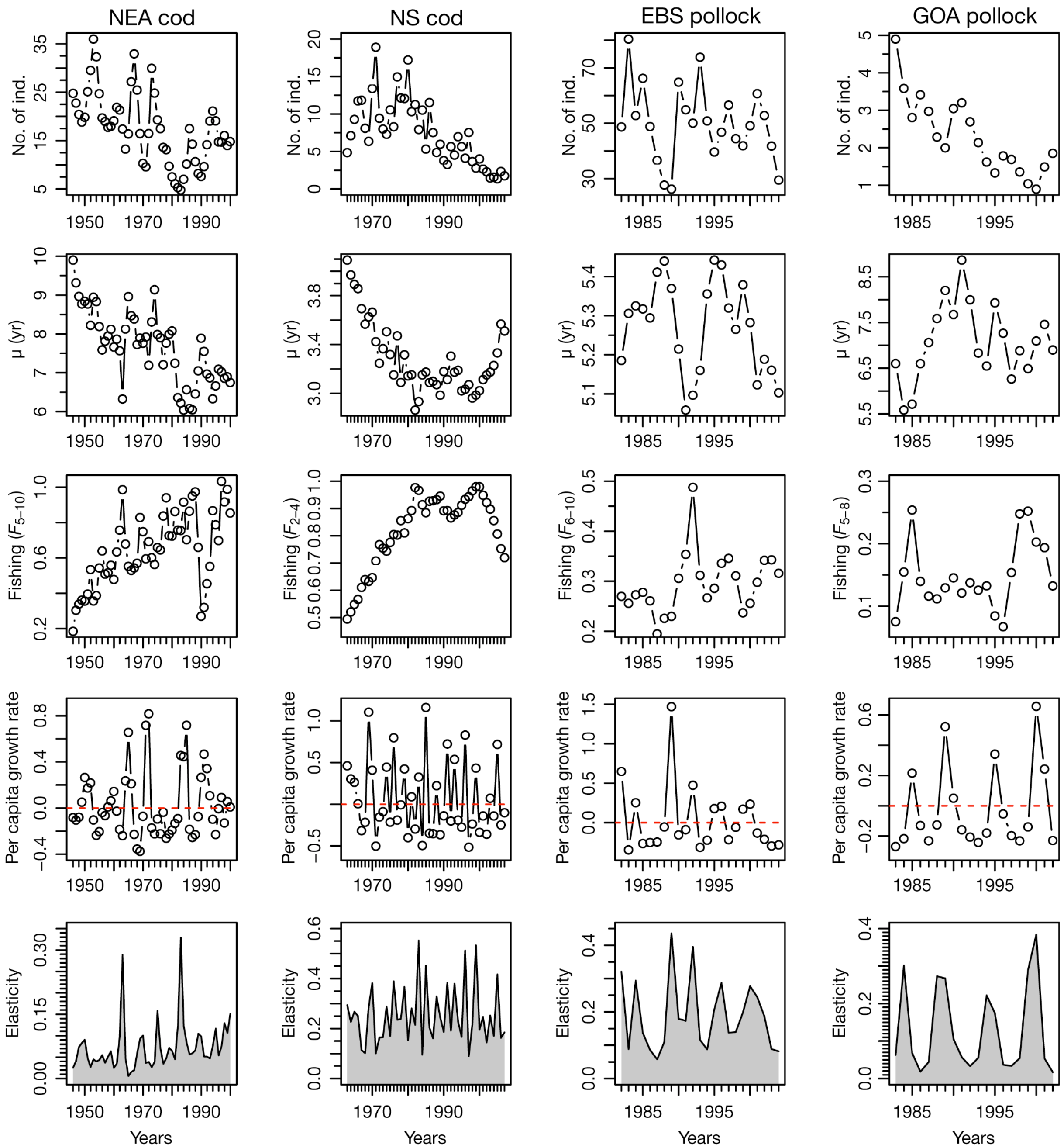

Fig. S2. Data for cod and pollock population used in the study: Northeast Arctic (NEA) cod, North Sea (NS) cod, Eastern Bering Sea (EBS) pollock and Gulf of Alaska (GOA) pollock. The first row shows the change with time in the population abundance in numbers (output from virtual population analysis $\times 10^8$ for NEA and NS cod and in $\times 10^9$ for EBS and GOA pollock). The second row shows the generation time, μ, the changes in the mean age of the parents of the offspring produced by a cohort over its lifetime. The third row shows the changes in the fishing mortality (*F*) with age range (in yr) in subscripts. The fourth row shows the changes in the realized population growth rate with time (–1 to 1). The fifth row shows the changes in the relative importance of the transient elasticity to recruitment (0 to 1) of the population growth rate with time

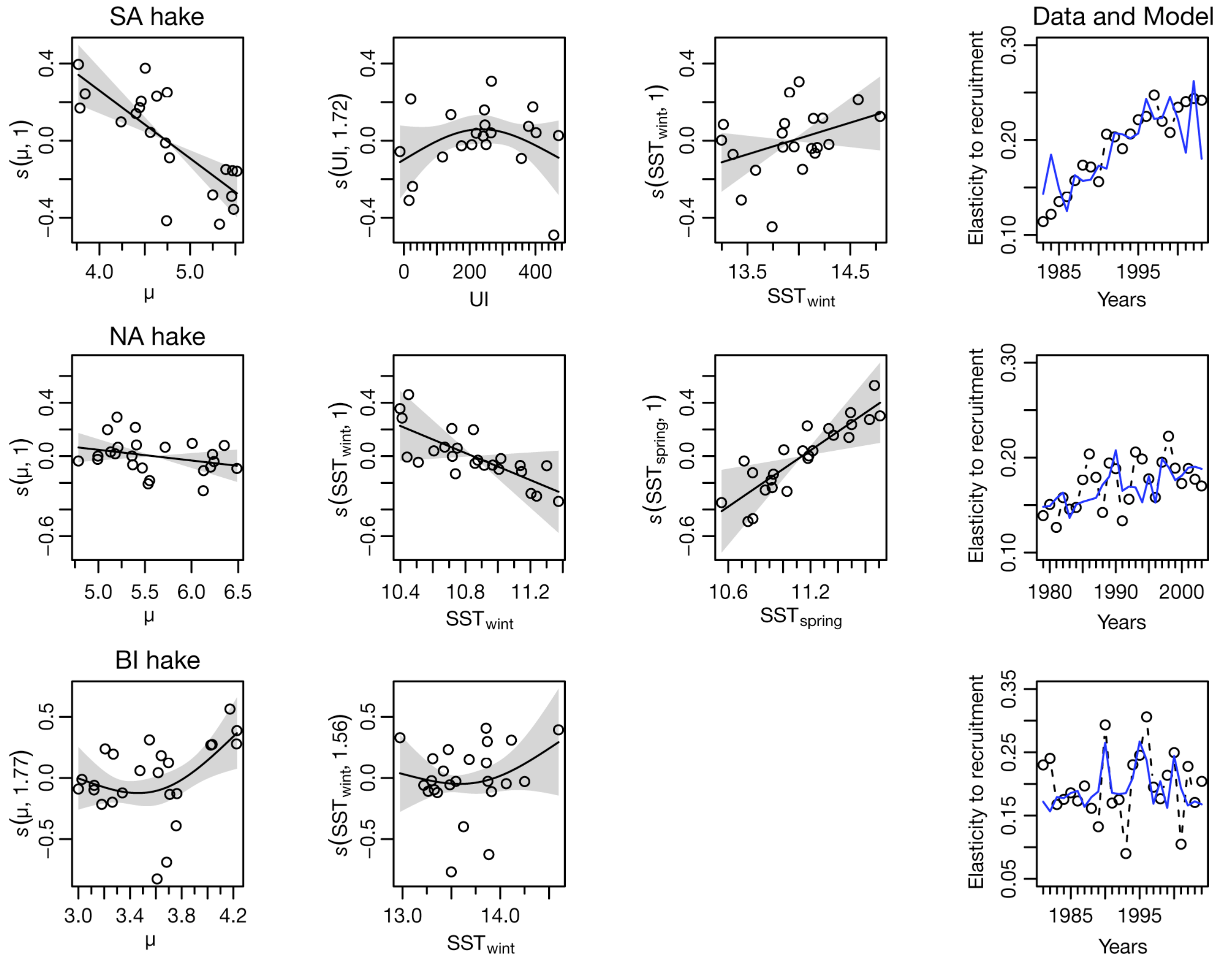

Fig. S3. Model of the elasticity to recruitment (logit transformed) for the 3 hake population used in the study: South Atlantic (SA), North Atlantic (NA) and Balearic Islands (BI). The generalized additive models (GAMs) are presented for each population. For each plot, the *x*-axes show the covariate and the *y*-axes the partial effect that each covariate has on the response variable. $s(X, y)$ is the smoothing term, where X represents the explanatory variable and y is the estimated degrees of freedom (edf) of the smoothing term. The line is the smooth term effect of the considered covariate on the elasticity with the pointwise 95% confidence interval around the mean prediction (grey-shaded area). The dots are the partial residuals calculated by adding to the effect of the concerned covariate to the residuals; the model prediction at any given point is given by the sum of all partial effects plus a constant. Superimposed on the data in the last column is the corresponding GAM prediction (blue line). UI: upwelling index; Generation time (μ) is expressed in years of age and sea surface temperature in °C

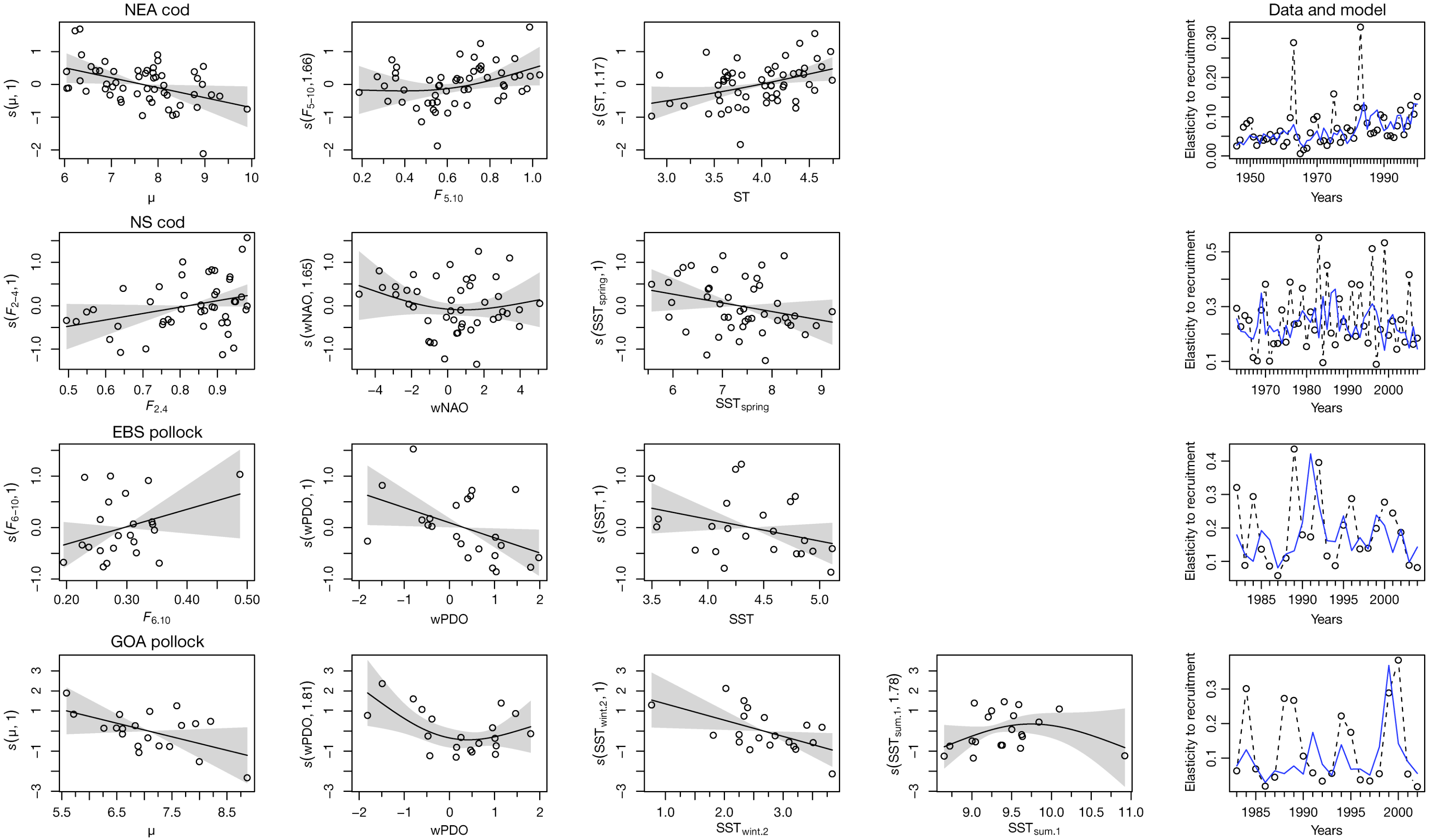

Fig. S4. Model of the elasticity to recruitment (logit transformed) for the cod and pollock populations used in the study: Northeast Arctic (NEA) cod, North Sea (NS) cod, Eastern Bering Sea (EBS) pollock and Gulf of Alaska (GOA) pollock. The generalized additive models (GAMs) are presented for each population. For each plot, the *x*-axes show the covariate and the *y*-axes the partial effect that each covariate has on the response variable. $s(X, y)$ is the smoothing term, where X represents the explanatory variable and y is the estimated degrees of freedom (edf) of the smoothing term. The line is the smooth term effect of the considered covariate on the elasticity with the pointwise 95% confidence interval around the mean prediction (grey-shaded area). The dots are the partial residuals calculated by adding to the effect of the concerned covariate to the residuals; the model prediction at any given point is given by the sum of all partial effects plus a constant. Superimposed on the data in the last column is the corresponding GAM prediction (blue line). μ: generation time; *F*: fishing mortality (with subscripts showing age in years); wNAO: winter North Atlantic Oscillation; wPDO: winter Pacific Decadal Oscillation; SST: sea surface temperature (°C) with 'wint.2' for winter at Location 2 and 'sum.1' for summer Location 1; ST: sea temperature at 0–200 m