Ecography

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Hidalgo, M., Rouyer, T., Bartolino, V., Cerviño, S., Ciannelli, L., Massutí, E., Jadaud, A., Sabrino-Rey, F., Durant, J. M., Santurtún, M., Piñeiro, C. and Stenseth, N. C. 2011. Context-dependent interplays between truncated demographies and climate variation shape the population growth rate of a harvested species. – Ecography 34: xxx–xxx.

Supplementary material

Appendix 1

Table A1. Final formulations, adjusted R^2 (R$_{adj}^2$, i.e., proportion of the variance explained) and genuine cross validation (gCV) of the three best models of recruitment-independent growth rate estimates (*r*^{RI}) for each area after applying all the potential threshold effects for each covariate. Note that the best pure additive formulations are also shown for NA, SA and BI. Bold indicates the model with lowest gCV.

Area	Formula	Threshold variable/s	R$_{adj}^2$	gCV
NA	$r^{RI}{}_t = 0.09 + g(F_{2-6}) + f(NAO_t) + h(H_t^{SSB}) + \varepsilon_t$	-	53.5	0.00077
	$r^{RI}{}_t = f(NAO_t) + \varepsilon_t + \begin{cases} 0.13 + h_1(H_t^{SSB}) & if \quad F_{2-6} \le 0.28 \\ 0.06 + h_2(H_t^{SSB}) & if \quad F_{2-6} > 0.28 \end{cases}$	**F_{2-6}**	**89.8**	**0.00056**
	$r^{RI}{}_t = f(NAO_t) + \varepsilon_t + \begin{cases} 0.13 + h_1(H_t^{SSB}) & if \quad \{NAO_t, F_{2-6}\} \le r \\ 0.06 + + h_2(H_t^{SSB}) & if \quad \{NAO_t, F_{2-6}\} > r \end{cases}$	NAO, F_{2-6}	75.2	0.0009
	$r^{RI}{}_t = f(NAO_t) + \varepsilon_t + \begin{cases} 0.1 + h_1(L_t^{SSB}) & if \quad F_{2-6} \le 0.27 \\ 0.07 \quad if \quad F_{2-6} > 0.27 \end{cases}$	F_{2-6}	87.3	0.00048
SA	$r^{RI}{}_t = -0.1 + g(F_{2-5}) + f(NAO_t) + h(L_t^{SSB}) + \varepsilon_t$	-	60.3	0.0034
	$r^{RI}{}_t = -0.11 + g(F_{2-5}) + f(NAO_t) + \varepsilon_t + \begin{cases} h_1(H_t^{SSB}) & if \quad F_{2-5} \le 0.49 \\ h_2(H_t^{SSB}) & if \quad F_{2-5} > 0.49 \end{cases}$	F_{2-5}	82.4	0.0029
	$r^{RI}{}_t = -0.1 + g(F_{2-5}) + f(NAO_t) + \varepsilon_t + \begin{cases} h_1(L_t^{SSB}) & if \quad F_{2-5} \le 0.47 \\ h_2(L_t^{SSB}) & if \quad F_{2-5} > 0.47 \end{cases}$	**F_{2-5}**	**80.3**	**0.0027**
	$r^{RI}{}_t = -0.09 + g(F_{2-5}) + \varepsilon_t + \begin{cases} h_1(H_t^{SSB}) & if \quad NAO_t \le 0.47 \\ h_2(H_t^{SSB}) & if \quad NAO_t > 0.47 \end{cases}$	NAO	76.2	0.003
BI	$r^{RI}{}_t = -0.54 + f(IDEA_t) + h(H_t^{SSB}) + \varepsilon_t$	-	58.2	0.047
	$r^{RI}{}_t = -0.59 + f(IDEA_t) + \varepsilon_t + \begin{cases} h_1(H_t^{SSB}) & if \quad F_{2-4} \le 1.06 \\ h_2(H_t^{SSB}) & if \quad F_{2-4} > 1.06 \end{cases}$	**F_{1-2}**	**60.6**	**0.035**
	$r^{RI}{}_t = -0.57 + f(IDEA_t) + \varepsilon_t + \begin{cases} h_1(H_t^{SSB}) & if \quad IDEA \le 1.06 \\ h_2(H_t^{SSB}) & if \quad IDEA > 1.06 \end{cases}$	IDEA	64.3	0.038
	$r^{RI}{}_t = -0.57 + f(IDEA_t) + \varepsilon_t + \begin{cases} h_1(H_t^{SSB}) & if \quad \{IDEA_t, F_{2-4}\} \le r \\ h_2(H_t^{SSB}) & if \quad \{IDEA_t, F_{2-4}\} \le r \end{cases}$	F_{1-2}, IDEA	67.5	0.042
GL	$r^{RI}{}_t = -0.47 + f(SST_t^{Winter}) + h(L_t^{SSB}) + \varepsilon_t$	**-**	**83.4**	**0.0025**

	$r^{RI}{}_t = -0.48 + f(SST_t^{Winter}) + h(F_t^{2-6}) + \varepsilon_t$	-	80.2	0.003
	$r^{RI}{}_t = -0.47 + f(SST_t^{Winter}) + h(H_t^{SSB}) + \varepsilon_t$	-	83.1	0.0028
TS	$r^{RI}{}_t = -0.46 + f(SST_t^{Winter}) + h(F_t^{2-4}) + \varepsilon_t$	**-**	**53.6**	**0.033**
	$r^{RI}{}_t = -0.46 + f(SST_t^{Spring}) + h(L_t^{SSB}) + \varepsilon_t$	-	43.2	0.044
	$r^{RI}{}_t = -0.46 + f(SST_t^{Spring}) + h(H_t^{SSB}) + \varepsilon_t$	-	42.8	0.042

Notes: Abbreviations and variables are: *NAO*, North Atlantic Oscillation index; *IDEA*, mesoscale hydro-climatic index of the NW Mediterranean; SST^{Winter} and SST^{Spring}, sea surface temperature averaged for winter and spring; *SSB*, spawning stock biomass; H^{SSB}, age diversity index of *SSB*; L^{SSB}, mean length of *SSB*; $F^{2\text{-}6}$, $F^{2\text{-}5}$ and $F^{2\text{-}4}$ fishing mortality averaged from age classes 2 to 6, 2 to 5 and 2 to 4.

Table A2. Final formulations, adjusted R^2 (R_{adj}^2, i.e., proportion of the variance explained) and genuine cross validation (gCV) of the three best models of recruitment (R_t) for NA, SA and BI after applying all the potential threshold effects for each covariate. Note that the pure additive formulations are also shown. For NA and SA, the environmental covariate was not significant in the additive formulation. Bold indicates the model with lowest gCV.

Area	Formula	Threshold variable/s	R_{adj}^2	gCV
NA	$R_t = 12.2 + f(SSB_t) + \varepsilon_t$	-	46.1	0.054
	$R_t = f(SSB_t) + \varepsilon_t + \begin{cases} 12.24 + h_1(SST_t^{Winter}) & if \quad NAO_t \le r \\ 12.28 \quad if \quad NAO_t > r \end{cases}$	NAO	51.8	0.056
	$R_t = 12.23 + f(SSB_t) + \varepsilon_t + \begin{cases} h_1(SST_t^{Winter}) & if \quad \{H_{SSB}, r^{RI}{}_t\} \le r \\ h_2(SST_t^{Winter}) & if \quad \{H_{SSB}, r^{RI}{}_t\} > r \end{cases}$	**H_{ssb}, r^{RI}**	**60.3**	**0.045**
	$R_t = 12.27 + f(SSB_t) + \varepsilon_t + \begin{cases} h_1(SST_t^{Winter}) & if \quad \{NAO, r^{RI}{}_t\} \le r \\ h_2(SST_t^{Winter}) & if \quad \{NAO, r^{RI}{}_t\} > r \end{cases}$	NAO, r^{RI}	56.8	0.052
SA	$R_t = 4.7 + f(SSB_t) + \varepsilon_t$	-	26.8	0.015
	$R_t = f(SSB_t) + \varepsilon_t + \begin{cases} 4.79 + h_1(SST_t^{Spring}) & if \quad H_{SSB} \le 0.54 \\ 4.68 \quad if \quad H_{SSB} > 0.54 \end{cases}$	**H_{SSB}**	**59.4**	**0.0086**
	$R_t = f(SSB_t) + \varepsilon_t + \begin{cases} 4.97 + h_1(SST_t^{Spring}) & if \quad \{H_{SSB}, r^{RI}{}_t\} \le r \\ 4.71 \quad if \quad \{H_{SSB}, r^{RI}{}_t\} > r \end{cases}$	H_{ssb}, r^{RI}	64.3	0.013
	$R_t = f(SSB_t) + \varepsilon_t + \begin{cases} 4.97 + h_1(SST_t^{Spring}) & if \quad \{H_{SSB}, NAO\} \le r \\ 4.71 \quad if \quad \{H_{SSB}, NAO\} > r \end{cases}$	H_{ssb}, NAO	62.1	0.011
BI	$R_t = 7.58 + f(SSB_t) + f(IDEA_t) + \varepsilon_t$	-	53.3	0.111
	$R_t = 7.55 + f(IDEA_t) + \varepsilon_t + \begin{cases} h_1(SSB_t) & if \quad r^{RI}{}_t \le r \\ h_2(SSB_t) & if \quad r^{RI}{}_t > r \end{cases}$	r^{RI}	55.9	0.098
	$R_t = 7.58 + f(IDEA_t) + \varepsilon_t + \begin{cases} h_1(SSB_t) & if \quad \{IDEA, H_{SSB}\} \le r \\ h_2(SSB_t) & if \quad \{IDEA, H_{SSB}\} > r \end{cases}$	IDEA, H_{ssb}	56.7	0.105
	$R_t = 7.58 + f(IDEA_t) + \varepsilon_t + \begin{cases} h_1(SSB_t) & if \quad \{IDEA, r^{RI}{}_t\} \le r \\ h_2(SSB_t) & if \quad \{IDEA, r^{RI}{}_t\} > r \end{cases}$	**IDEA, r^{RI}**	**59.9**	**0.091**

Notes: Abbreviations and variables are: *NAO*, North Atlantic Oscillation index; *IDEA*, mesoscale hydro-climatic index of the NW Mediterranean; SST^{Winter} and SST^{Spring}, sea surface temperature averaged for winter and spring; *SSB*, spawning stock biomass; H^{SSB}, age diversity index of SSB; r^{RI}, recruitment-independent growth rate estimates.

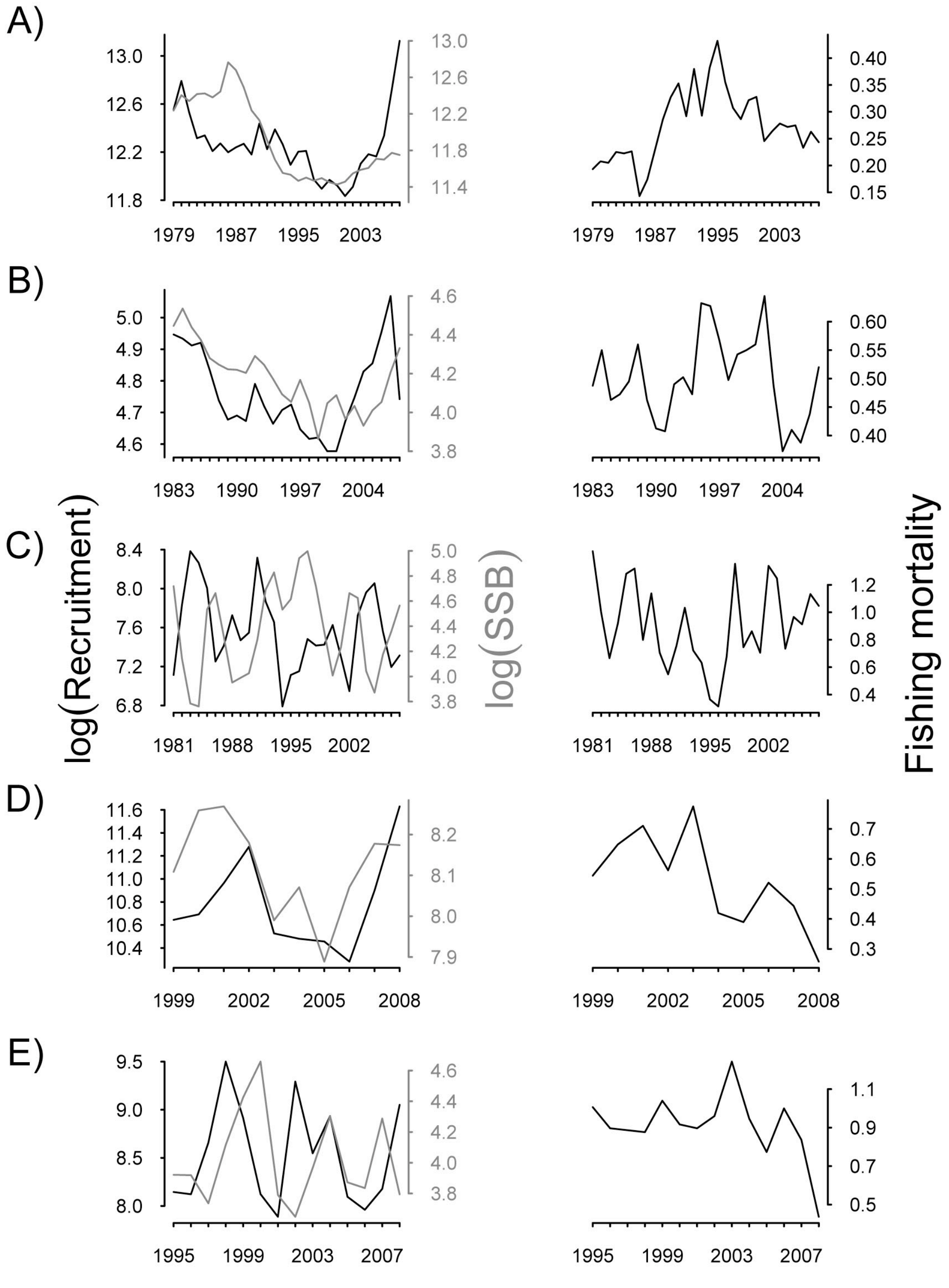

Figure A1. Log recruitment and log spawning stock biomass (SSB) (left column), and fishing mortality (right column) time series for all the stocks investigated: North Atlantic stock (A), South Atlantic stock (B), Balearic Islands (C), Gulf of Lions (D) and Tyrrhenian Sea (E). Note that fishing mortality time series are averaged over the more harvested age classes (see Methods section).

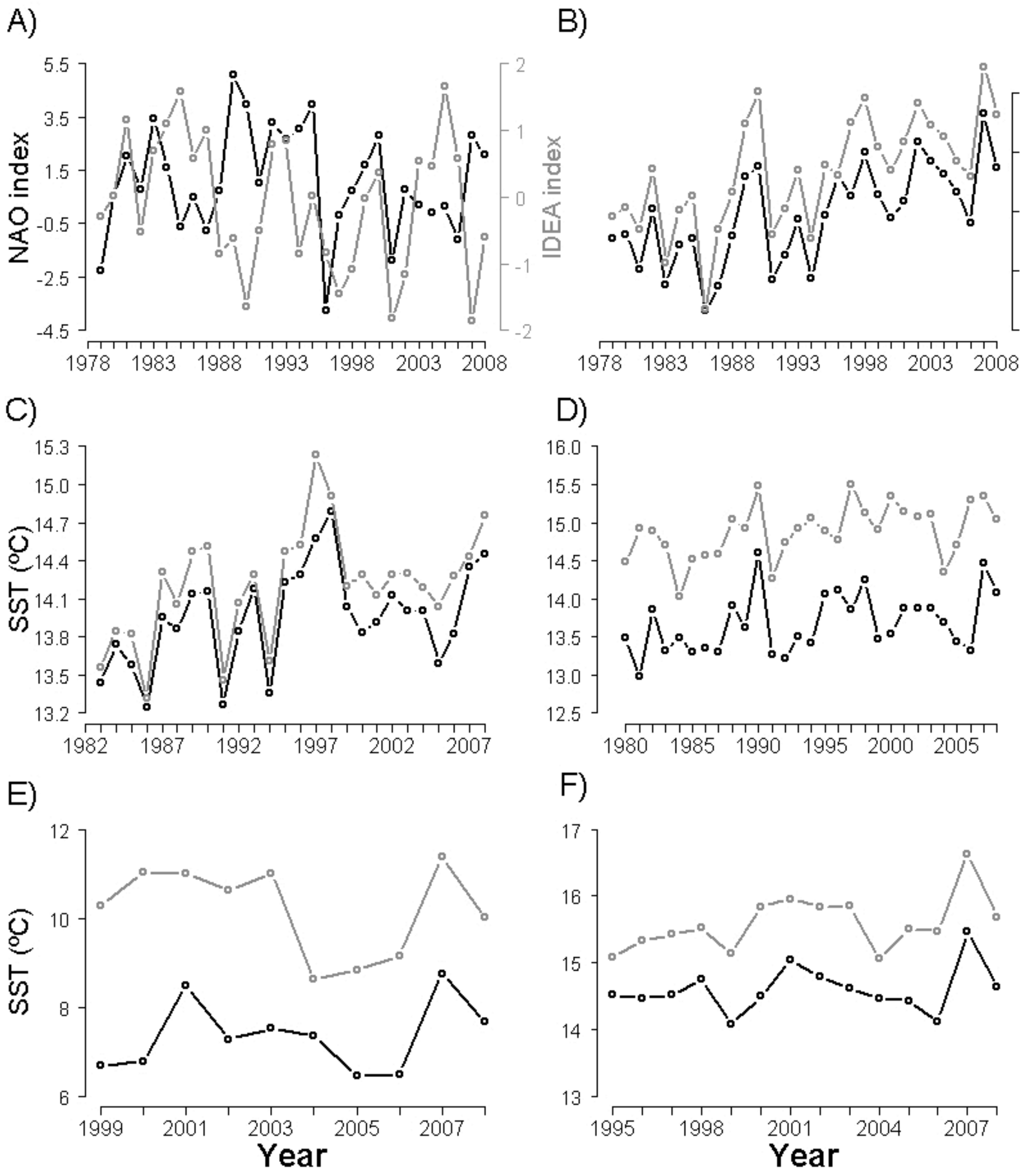

Figure A2. Environmental covariates used in the general additive modelling. North Atlantic Oscillation index (NAO) and the mesoscale hydro-climatic index for the NW Mediterranean (IDEA) (A). Sea Surface Temperature (SST) averaged for winter (black) and spring (grey) for the North Atlantic stock (B), South Atlantic stock (C), Balearic Islands (D), Gulf of Lions (E) and Tyrrhenian Sea (F).

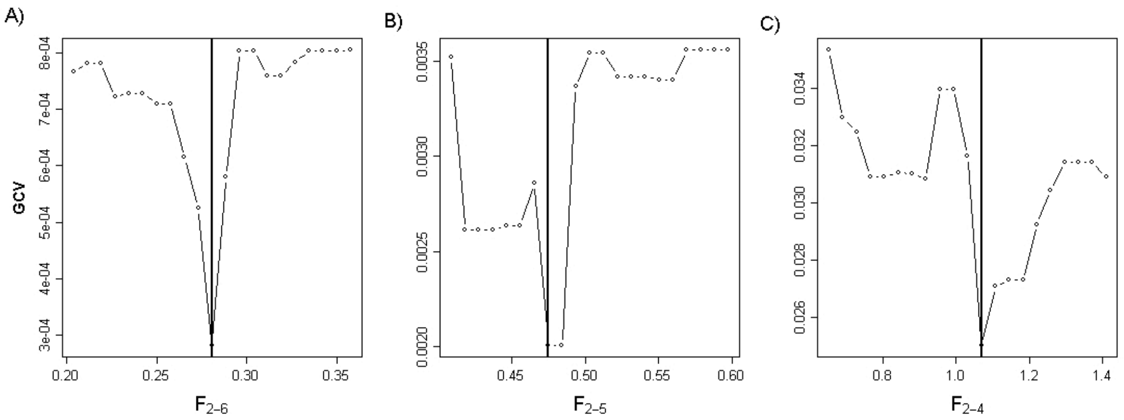

Figure A3. The Generalized Cross Validation (GCV) profile over the range of fishing mortality (F_i) applied for the North Atlantic Stock (A), South Atlantic Stock (B) and the Balearic Islands (C). Vertical lines indicate the F_i value at which the GCV reached the minimum value, corresponding with the predicted F_i value of change in the spawning characteristics effect on the recruitment-independent growth rate. Note that GCV differs from the genuine cross validation (gCV) valued used to select the best model performance (see Material and Methods and detailed methodological description in Ciannelli et al. 2004).