Mediterranean Marine Science

Vol 22, No 4 (2021)

Special Issue

Effects of sampling intensity and biomass levels on the precision of acoustic surveys in the Mediterranean Sea

MARCO BARRA, ANGELO BONANNO, TAREK HATTAB, CLAIRE SARAUX, MAGDALENA IGLESIAS5, IOLE LEONORI, VJEKOSLAV TIČINA, GUALTIERO BASILONE, ANDREA DE FELICE, ROSALIA FERRERI, ATHANASSIOS MACHIAS, ANA VENTERO, ILARIA COSTANTINI, TEA JURETIĆ, MARIA MYRTO PYROUNAKI, JEAN-HERVE BOURDEIX, DENIS GAŠPAREVIĆ, ZACHARIAS KAPELONIS, GIOVANNI CANDUCI, MARIANNA GIANNOULAKI

doi: [10.12681/mms.26100](https://doi.org/10.12681/mms.26100)

Mediterranean Marine Science
Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS
The journal is available on line at http://www.medit-mar-sc.net
www.hcmr.gr
DOI: http://doi.org/10.12681/mms26100

Contribution to the Special Issue: "MEDiterranean International Acoustic Surveys (MEDIAS)"

Effects of sampling intensity and biomass levels on the precision of acoustic surveys in the Mediterranean Sea

Marco BARRA, Angelo BONANNO, Tarek HATTAB, Claire SARAUX, Magdalena IGLESIAS, Iole LEONORI, Vjekoslav TIČINA, Gualtiero BASILONE, Andrea De FELICE, Rosalia FERRERI, Athanassios MACHIAS, Ana VENTERO, Ilaria COSTANTINI, Tea JURETIĆ, Maria Myrto PYROUNAKI, Jean-Herve BOURDEIX, Denis GAŠPAREVIĆ, Zacharias KAPELONIS, Giovanni CANDUCI and Marianna GIANNOULAKI

Mediterranean Marine Science, 2021, 22/4, Special Issue

Table S 1. Biomass estimated by multiplying the average fish density by the polygon surface in the GSAs where only a specific sector was considered (See polygons in Fig. 1). For sardine in the Thermaikos Gulf, the biomass found in the polygon in the low biomass year (related to the whole area as reported in Table 1) was higher than the one found in the medium abundance year.

	European anchovy			European sardine		
Area	**Year**	**Biomass level**	**Biomass** (metric tons)	**Biomas level**	**Year**	**Biomass** (metric tons)
GSA1	2013	L	77	L	2016	1108
	2017	M	1147	M	2017	2013
	2015	H	2813	H	2018	15925
GSA6	2010	L	21234	L	2014	5715
	2013	M	41770	M	2015	24603
	2018	H	126841	H	2013	37430
GSA9	2014	L	21799	L	2017	10099
	2018	M	27915	M	2018	21894
	2017	H	39283	H	2016	35383
GSA16	2014	L	2344	L	2013	8195
	2016	M	7739	M	2012	12803
	2012	H	10840	H	2015	25577
GSA17W	2016	L	59586	L	2016	43473
	2015	M	157515	M	2015	98418
	2018	H	191730	H	2011	234435
GSA17E	2014	L	8341	L	2016	44175
	2016	M	14045	M	2014	71380
	2018	H	25078	H	2018	119995
GSA22 Thermaikos gulf	2019	L	1568	L	2016	1254
	2014	M	6256	M	2019	1495
	2016	H	11366	H	2014	6127
GSA22 Thracian Sea	2014	L	4579	L	2014	3637
	2013	M	10655	M	2013	8170
	2016	H	27779	H	2016	12399

Table S 2. Variogram model parameters related to European anchovy. For each area and year, the nugget, the model type, the anisotropy coefficient, the sill and range are reported.

Area	year	Nugget	Mod	sill	Major range (nmi)	Minor range (nmi)	Mod. aniso. coeff.	% nugget
GSA1	2013	0.011	Spherical	0.011	2.0			50.0
	2017	0.037	Spherical	0.025	7.1			59.7
	2015	0.023	Exponential	0.07	18.3			24.7
GSA6	2010	0.082	Spherical	0.031	17.0	7.7	0.45	72.6
	2013	0.115	Spherical	0.042	17.4	3.2	0.18	73.2
	2018	0.114	Exponential	0.062	8.5	5.1	0.60	64.8
GSA7	2016	0.082	Exponential	0.146	10.2			36
	2018	0.066	Exponential	0.158	12.1			29.5
	2017	0.173	Spherical	0.302	15.1	4.6	0.30	36.4
GSA9	2014	0.11	Exponential	0.133	19.3	7.1	0.37	45.3
	2018	0.054	Spherical	0.121	13.6			30.9
	2017	0.089	Spherical	0.198	31.9	13.6	0.43	31.0
GSA16	2014	0.059	Exponential	0.063	27.1	10.8	0.40	48.4
	2016	0.046	Spherical	0.099	12.3			31.7
	2012	0.078	Spherical	0.054	10.2	4.6	0.45	59.1
GSA17W	2016	0.109	Exponential	0.092	45.1	16.9	0.38	54.2
	2015	0.11	Spherical	0.087	17.1			55.8
	2018	0.114	Spherical	0.064	14.5	5.7	0.39	64.0
GSA17E	2014	0.138	Spherical	0.107	15.0			56.3
	2016	0.183	Spherical	0.06	27.4			75.3
	2018	0.094	Spherical	0.159	34.8			37.2
GSA18	2016	0.108	Spherical	0.036	48.1	15.0	0.31	75.0
	2015	0.093	Spherical	0.044	16	4.9	0.31	67.9
	2018	0.045	Exponential	0.15	11.7	3.6	0.31	23.1
GSA22 Thermaikos gulf	2019	0.096	Spherical	0.032	12.9			75.0
	2014	0.156	Spherical	0.081	29.0			65.8
	2016	0.16	Spherical	0.064	19.9			71.4
GSA22 Thracian Sea	2014	0.18	Exponential	0.044	24.6			80.4
	2013	0.146	Spherical	0.051	6.5			74.1
	2016	0.129	Exponential	0.132	21.8			49.4

Table S 3. Variogram model parameters related to European sardine. For each area and year, the nugget, the model used, the anisotropy coefficient, the sill and range are reported.

Area	year	Nugget	Mod	Mod sill	Major range (nmi)	Minor range (nmi)	Mod aniso. coeff.	% nugget
GSA1	2016	0.11	Exponential	0.112	16.9	4.4	0.26	49.5
	2017	0.091	Exponential	0.039	7.2			70.0
	2018	0.052	Exponential	0.146	10.1	3.4	0.34	26.3
GSA6	2014	0.05	Exponential	0.022	17.8			69.4
	2015	0.08	Exponential	0.042	14.8			65.6
	2013	0.085	Exponential	0.083	30.4	25.1	0.83	50.6
GSA7	2017	0.082	Spherical	0.058	37.7			58.6
	2015	0.107	Spherical	0.077	36.0			58.2
	2012	0.105	Exponential	0.1	39.2			51.2
GSA9	2017	0.009	Exponential	0.175	21.8	6.8	0.31	4.9
	2018	0.09	Spherical	0.038	7.7			70.3
	2016	0.053	Exponential	0.172	20.0	8.9	0.45	23.6
GSA16	2013	0.022	Spherical	0.043	17	5.1	0.3	33.8
	2012	0.08	Spherical	0.055	18.3	3.5	0.19	59.3
	2015	0.074	Spherical	0.09	45			45.1
GSA17W	2016	0.045	Exponential	0.083	63.4	21.1	0.33	35.2
	2015	0.029	Exponential	0.059	32.9	16.3	0.50	33.0
	2011	0.055	Exponential	0.136	35.7	19.3	0.54	28.8
GSA17E	2016	0.112	Exponential	0.025	21.7			81.8
	2014	0.104	Exponential	0.022	21.5			82.5
	2018	0.085	Spherical	0.02	30.0			81.0
GSA18	2016	0.11	Spherical	0.045	37.6			71.0
	2015	0.093	Spherical	0.041	5.2			69.4
	2018	0.063	Spherical	0.082	25.0			43.4
GSA22 Thermaikos gulf	2019	0.031	Spherical	0.006	11.1			83.8
	2016	0.043	Spherical	0.015	24.9			74.1
	2014	0.112	Exponential	0.029	17.2			79.4
GSA22 Thracian Sea	2014	0.094	Spherical	0.011	4.3			89.5
	2013	0.085	Spherical	0.01	9.7			89.5
	2016	0.074	Spherical	0.022	27.8			77.1

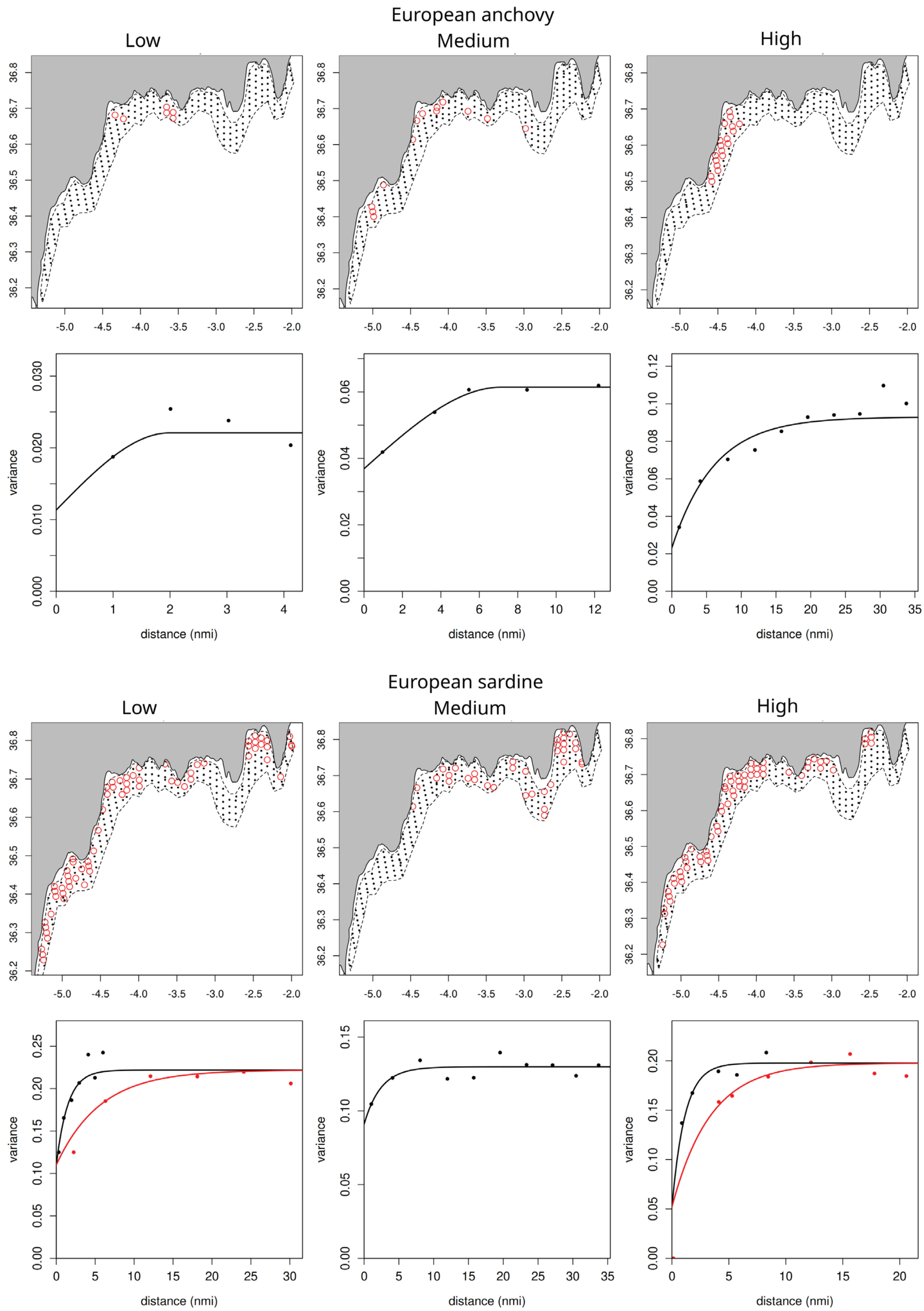

Fig. S 1: European anchovy and sardine maps, experimental variograms and fittings in GSA1. The red points in each map represent the EDSU accounting for the 99% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

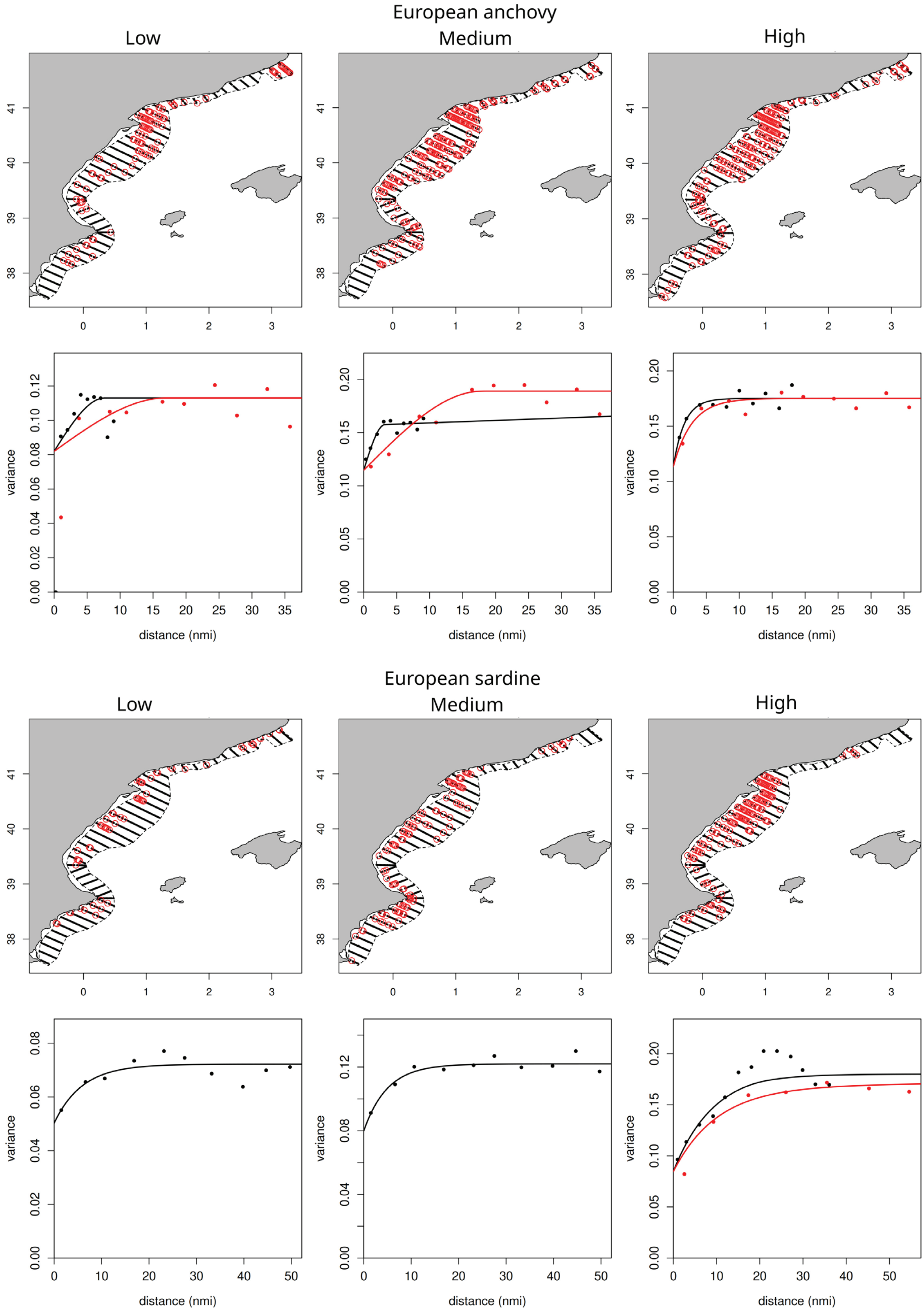

Fig. S 2: European anchovy and sardine maps, experimental variograms and fittings in GSA6. The red points in each map represent the EDSU accounting for the 90% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

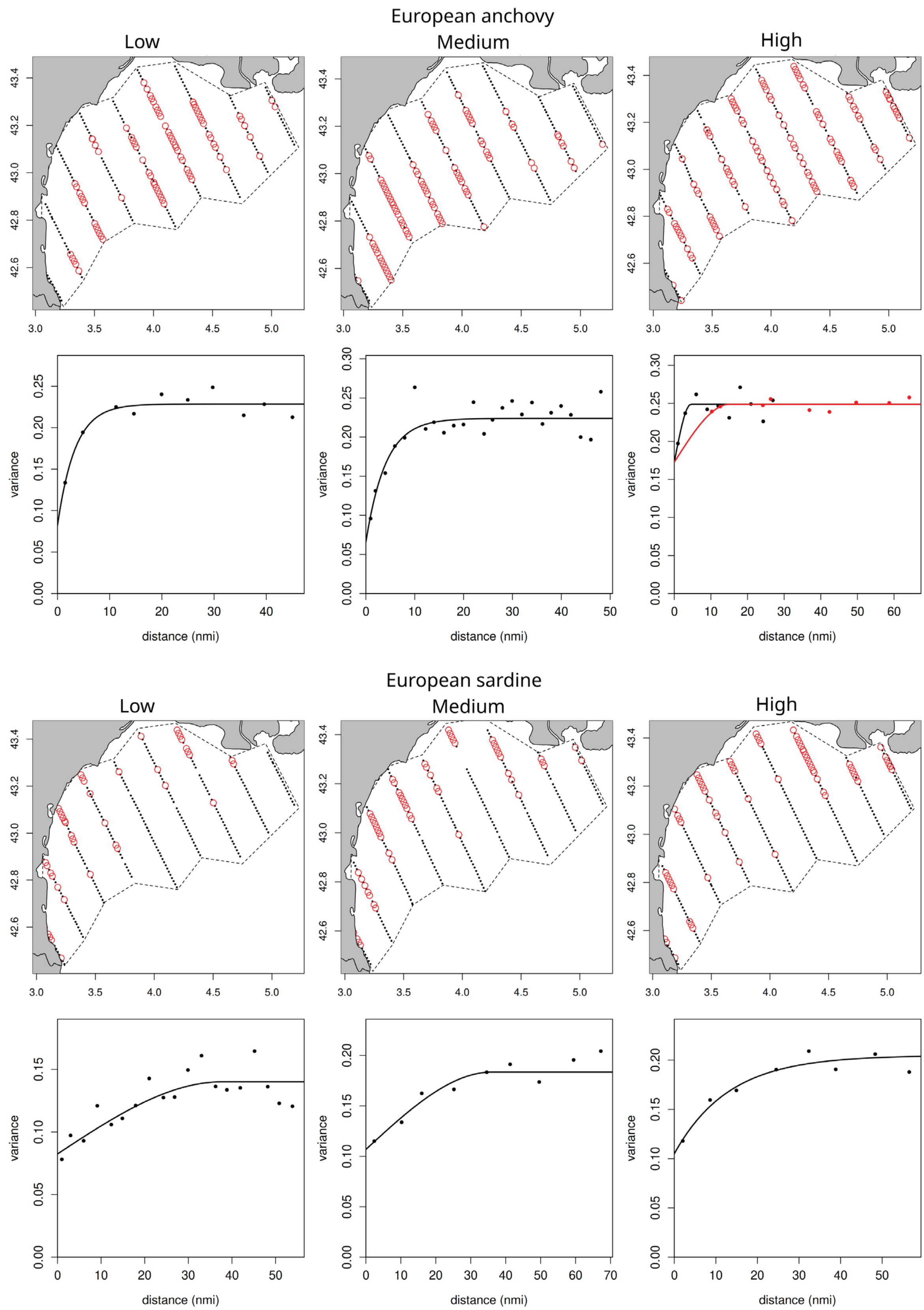

Fig. S 3: European anchovy and sardine maps, experimental variograms and fittings in GSA7. The red points in each map represent the EDSU accounting for the 90% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

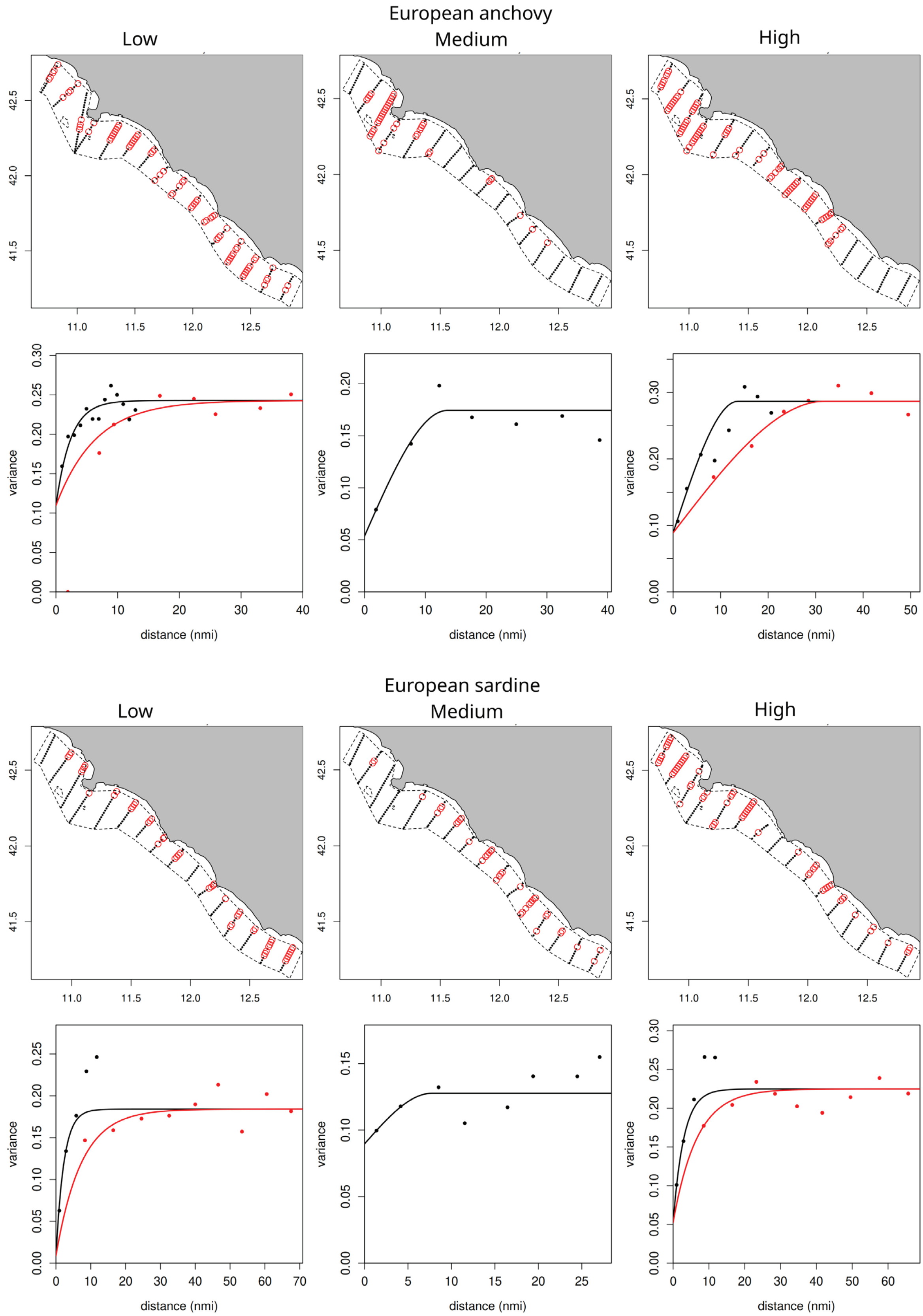

Fig. S 4: European anchovy and sardine maps, experimental variograms and fittings in GSA9. The red points in each map represent the EDSU accounting for the 90% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

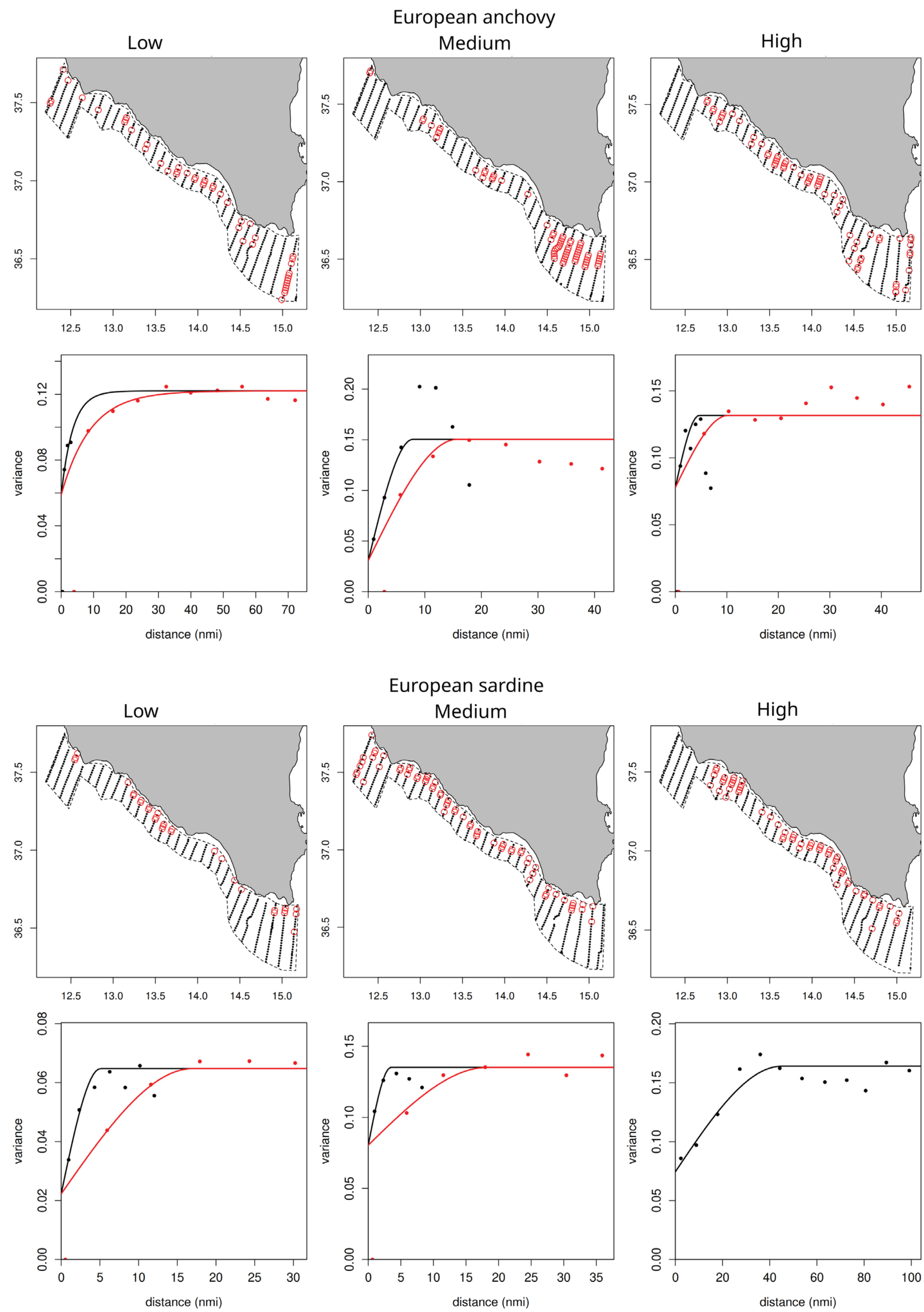

Fig. S 5: European anchovy and sardine maps, experimental variograms and fittings in GSA16. The red points in each map represent the EDSU accounting for the 90% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

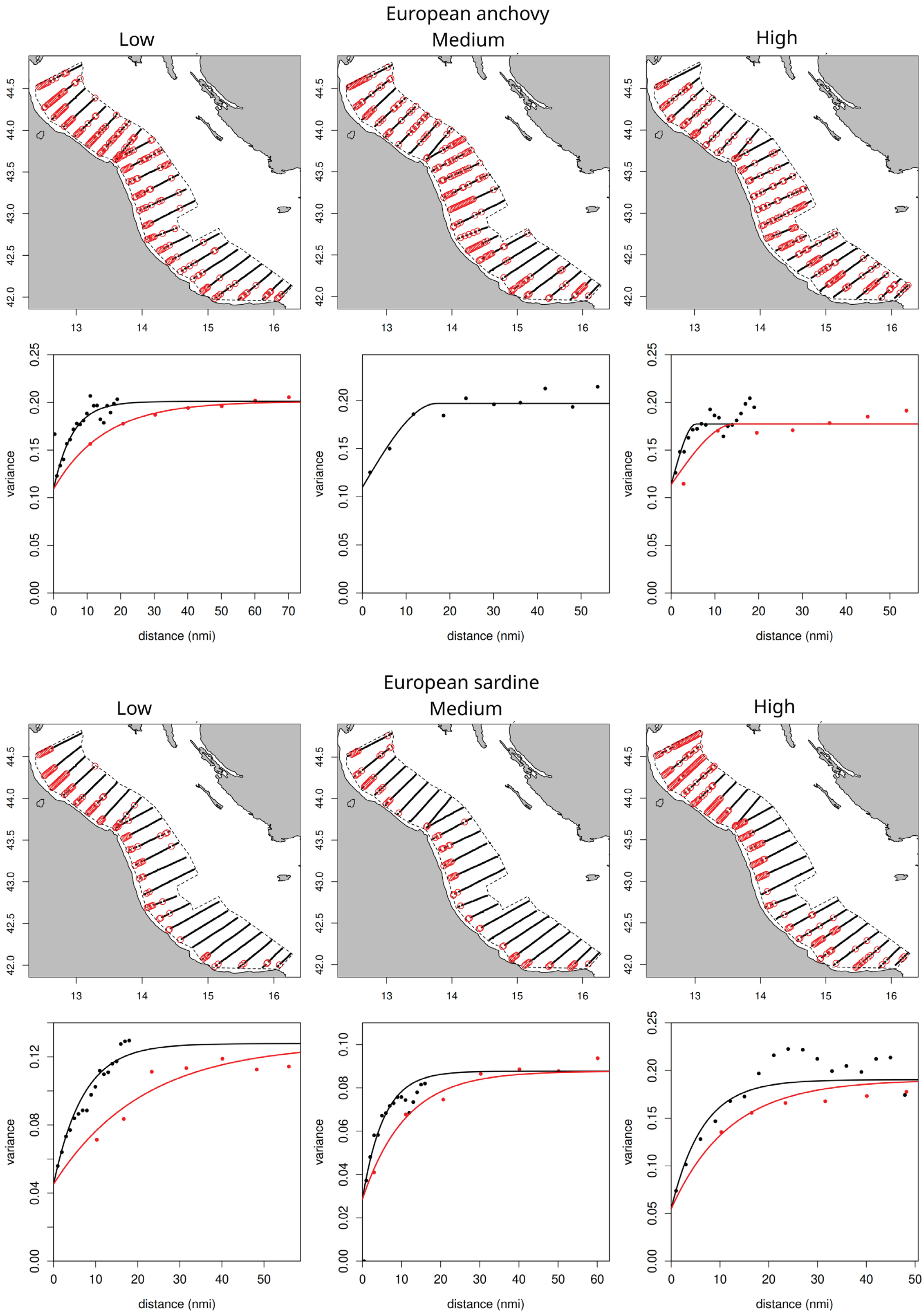

Fig. S 6: European anchovy and sardine maps, experimental variograms and fittings in GSA17W. The red points in each map represent the EDSU accounting for the 90% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

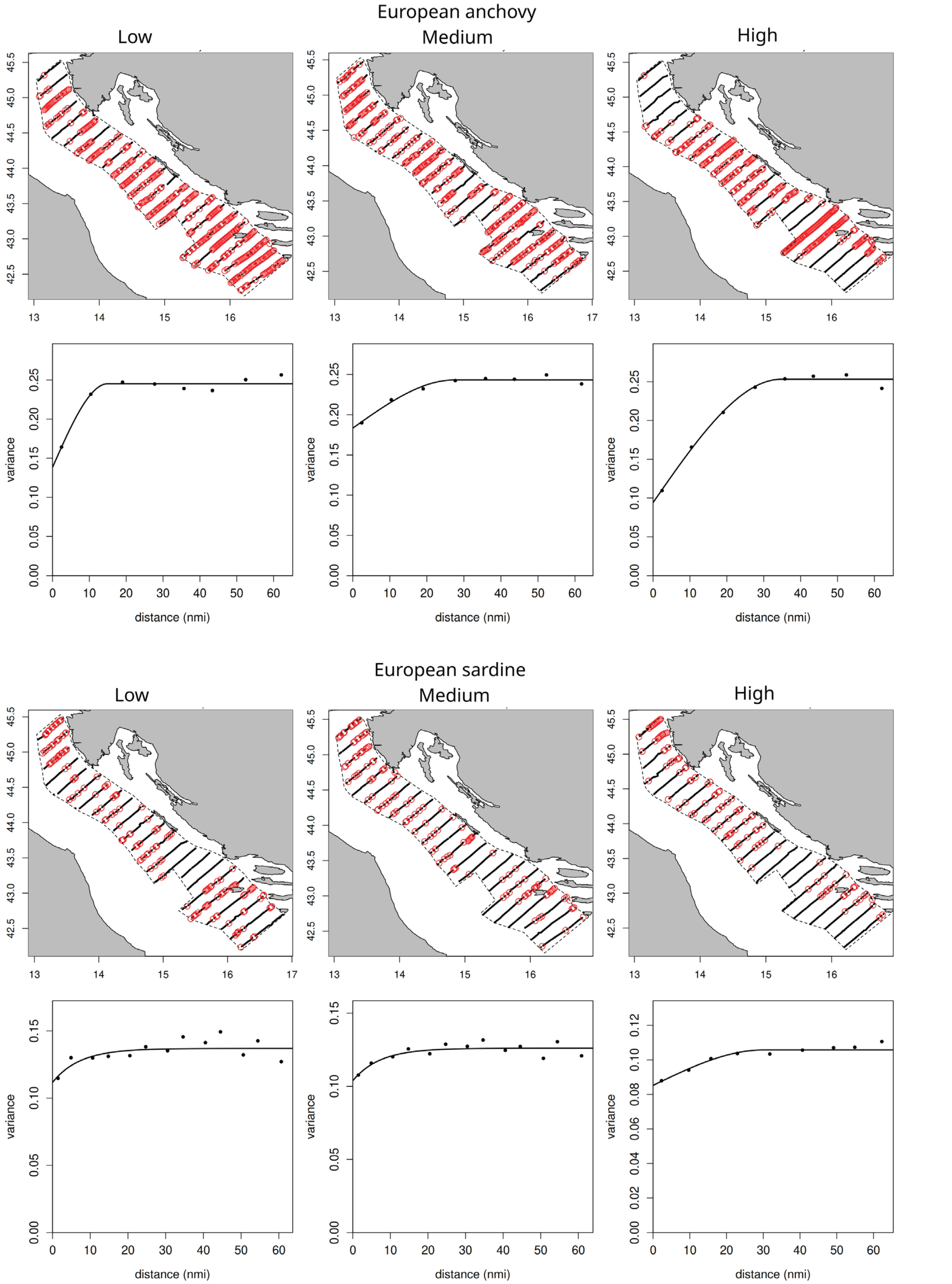

Fig. S 7: European anchovy and sardine maps, experimental variograms and fittings in GSA17E. The red points in each map represent the EDSU accounting for the 99% of the total biomass.All the variogram models were fitted by using a weighted automatic fitting procedure.

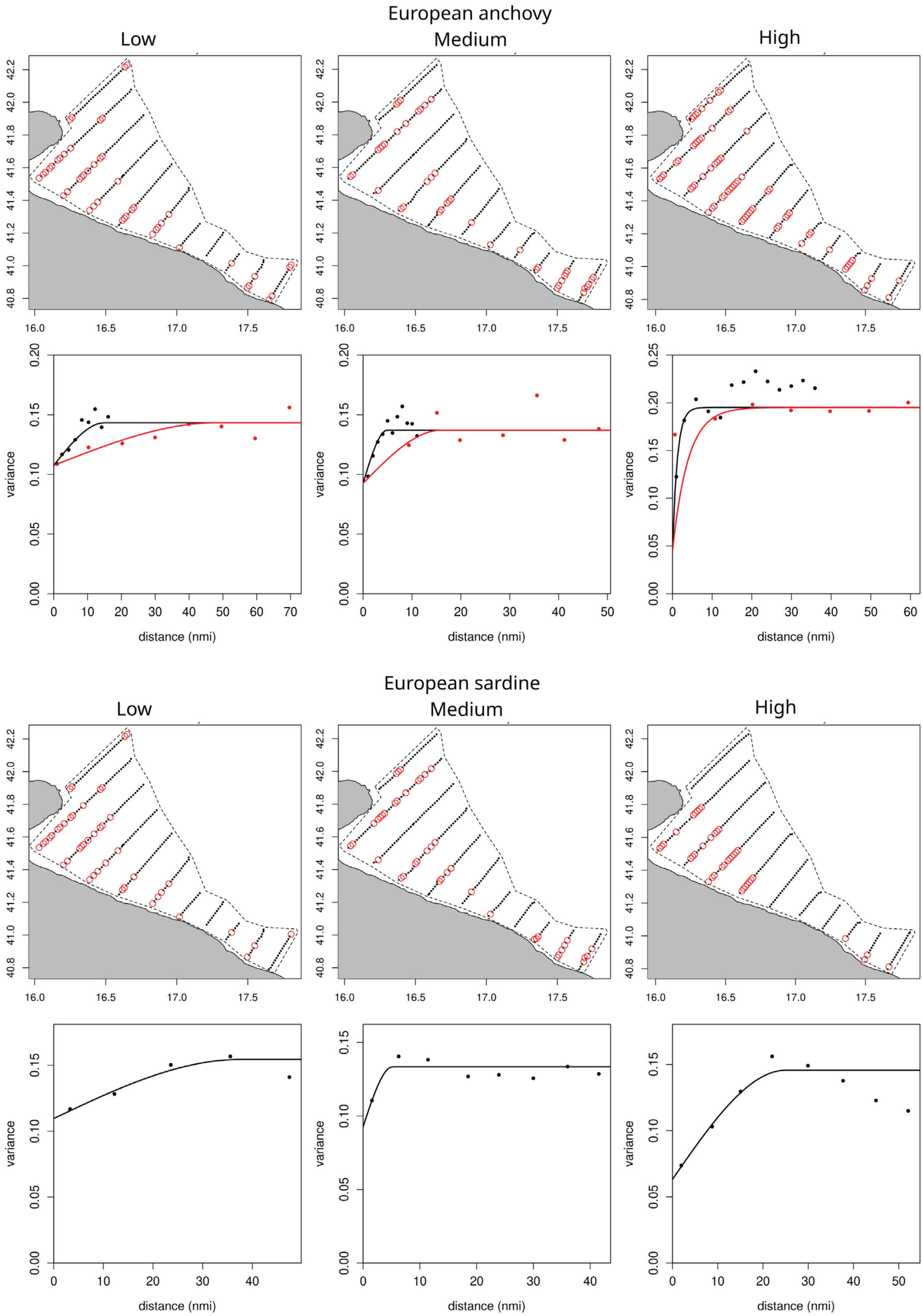

Fig. S 8: European anchovy and sardine maps, experimental variograms and fittings in GSA18. The red points in each map represent the EDSU accounting for the 90% of the total biomass. In the case of variograms accounting for spatial anisotropy, the red lines and dots represent the across-transect direction while the black ones the along-transect direction. All the variogram models were fitted by using a weighted automatic fitting procedure.

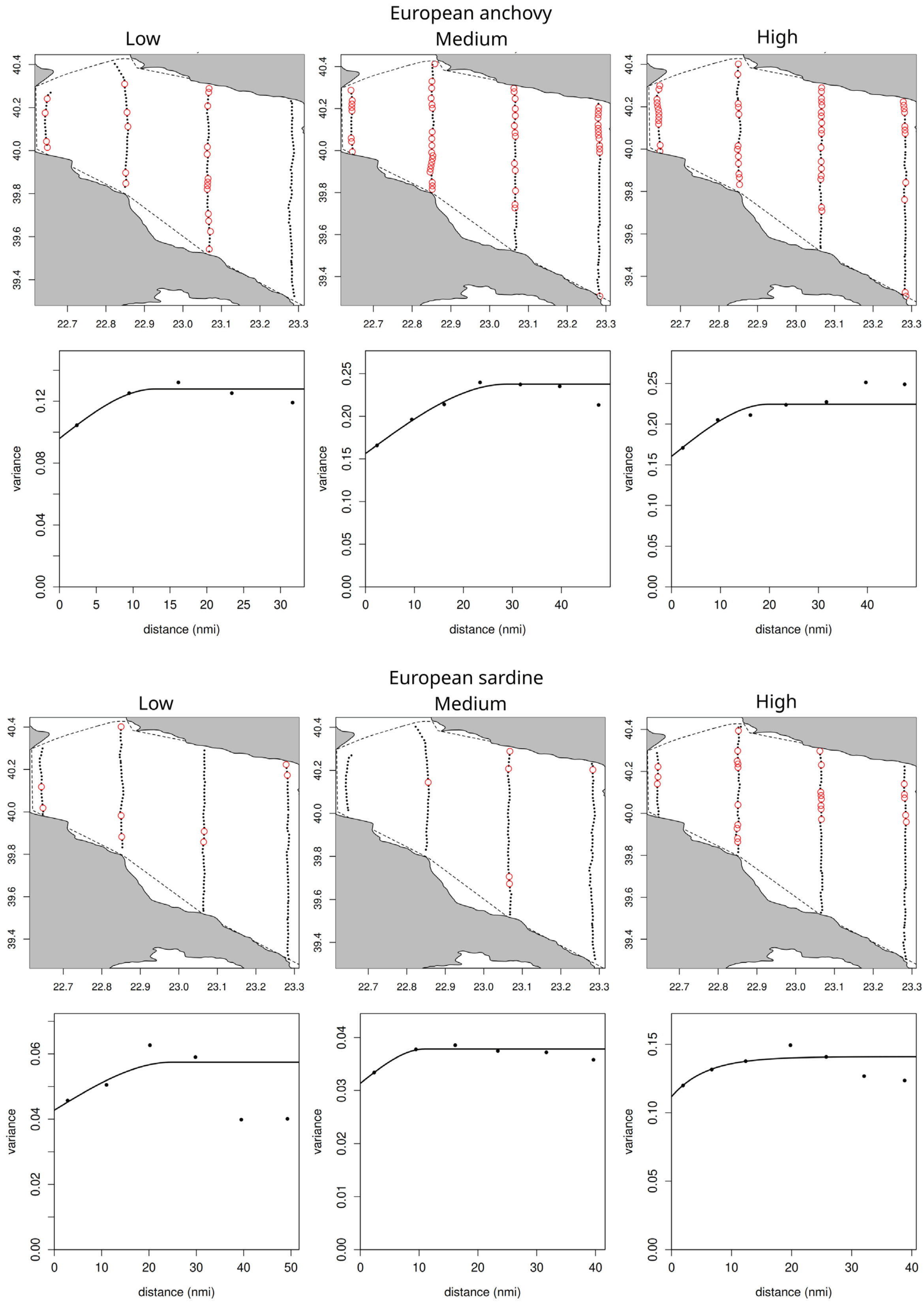

Fig. S 9: European anchovy and sardine maps, experimental variograms and fittings in GSA22 Thermaikos gulf. The red points in each map represent the EDSU accounting for the 99% of the total biomass. All the variogram models were fitted by using a weighted automatic fitting procedure.

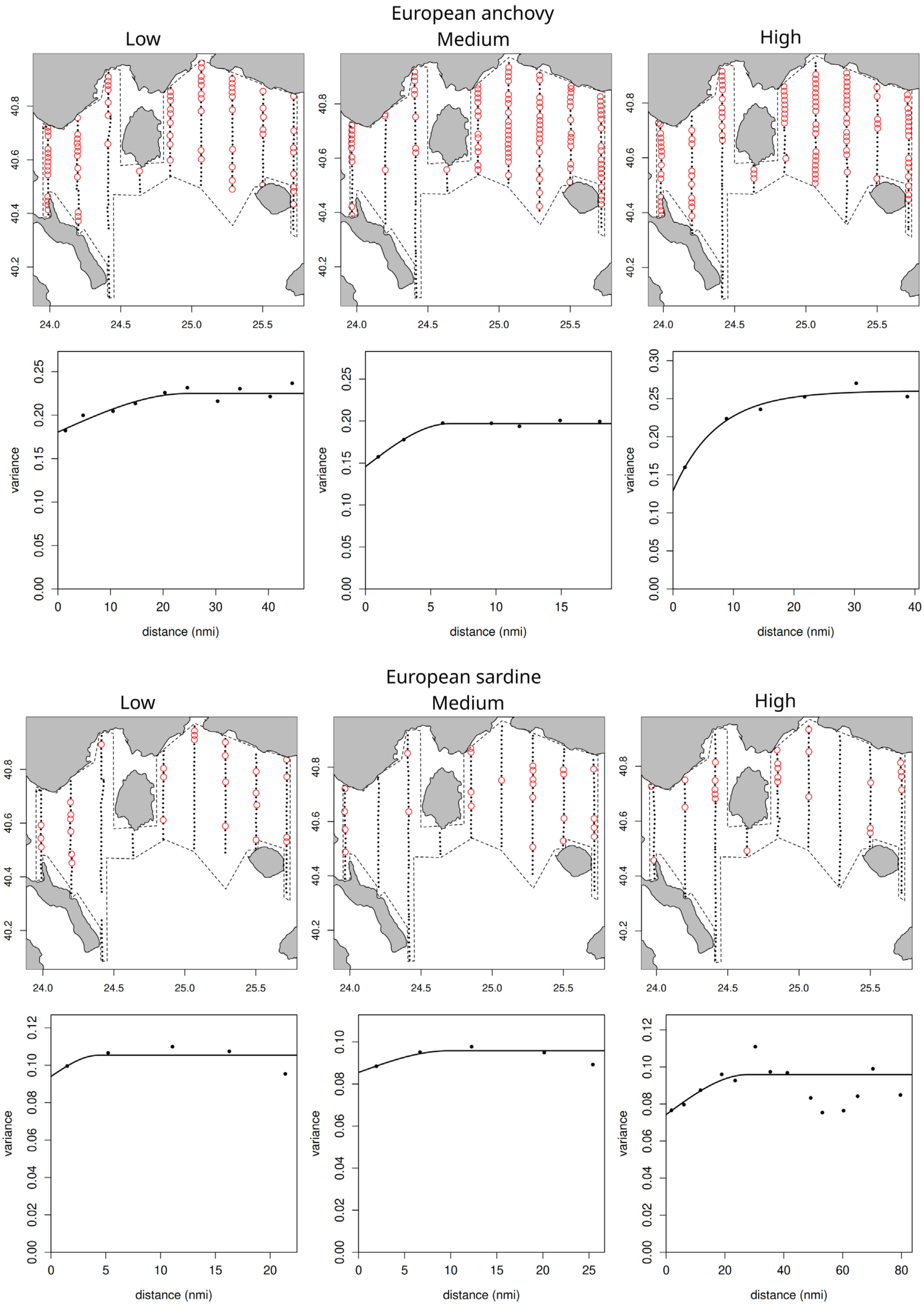

Fig. S 10: European anchovy and sardine maps, experimental variograms and fittings in GSA22 Thracian Sea. The red points in each map represent the EDSU accounting for the 99% of the total biomass. All the variogram models were fitted by using a weighted automatic fitting procedure.

Table S 4. Comparisons by area among CV_{geo} estimated marginal means considering an inter-transect distance of 10 nmi.

Contrast	Ratio	SE	df	t.ratio	p.value
GSA1/GSA6	2.926	0.130	199	24.196	0.00E+00
GSA1/GSA7	2.976	0.132	199	24.576	0.00E+00
GSA1/GSA9	2.516	0.112	199	20.792	0.00E+00
GSA1/GSA16	1.663	0.074	199	11.466	0.00E+00
GSA1/GSA17W	4.439	0.197	199	33.587	0.00E+00
GSA1/GSA17E	4.783	0.212	199	35.271	0.00E+00
GSA1/GSA18	2.094	0.093	199	16.651	0.00E+00
GSA1/GSA22 Therm. gulf	1.083	0.048	199	1.805	7.31E-01
GSA1/GSA22 Thr. Sea	1.919	0.085	199	14.692	0.00E+00
GSA6/GSA7	1.017	0.045	199	0.380	1.00E+00
GSA6/GSA9	0.860	0.038	199	-3.405	2.70E-02
GSA6/GSA16	0.568	0.025	199	-12.730	0.00E+00
GSA6/GSA17W	1.517	0.067	199	9.391	5.91E-14
GSA6/GSA17E	1.635	0.073	199	11.075	1.37E-14
GSA6/GSA18	0.715	0.032	199	-7.546	7.09E-11
GSA6/GSA22 Therm. gulf	0.370	0.016	199	-22.391	0.00E+00
GSA6/GSA22 Thr. Sea	0.656	0.029	199	-9.505	5.13E-14
GSA7/GSA9	0.845	0.038	199	-3.785	7.62E-03
GSA7/GSA16	0.559	0.025	199	-13.110	0.00E+00
GSA7/GSA17W	1.492	0.066	199	9.011	6.31E-14
GSA7/GSA17E	1.607	0.071	199	10.695	3.59E-14
GSA7/GSA18	0.703	0.031	199	-7.926	7.20E-12
GSA7/GSA22 Therm. gulf	0.364	0.016	199	-22.771	0.00E+00
GSA7/GSA22 Thr. Sea	0.645	0.029	199	-9.885	5.73E-14
GSA9/GSA16	0.661	0.029	199	-9.325	5.30E-14
GSA9/GSA17W	1.764	0.078	199	12.795	0.00E+00
GSA9/GSA17E	1.901	0.084	199	14.480	0.00E+00
GSA9/GSA18	0.832	0.037	199	-4.141	2.04E-03
GSA9/GSA22 Therm. gulf	0.431	0.019	199	-18.986	0.00E+00
GSA9/GSA22 Thr. Sea	0.763	0.034	199	-6.100	2.42E-07
GSA16/GSA17W	2.669	0.118	199	22.121	0.00E+00
GSA16/GSA17E	2.876	0.128	199	23.805	0.00E+00
GSA16/GSA18	1.259	0.056	199	5.184	2.32E-05
GSA16/GSA22 Therm. gulf	0.651	0.029	199	-9.661	5.61E-14
GSA16/GSA22 Thr. Sea	1.154	0.051	199	3.225	4.64E-02
GSA17W/GSA17E	1.078	0.048	199	1.684	8.03E-01
GSA17W/GSA18	0.472	0.021	199	-16.936	0.00E+00
GSA17W/GSA22 Therm. gulf	0.244	0.011	199	-31.782	0.00E+00
GSA17W/GSA22 Thr. Sea	0.432	0.019	199	-18.895	0.00E+00
GSA17E/GSA18	0.438	0.019	199	-18.621	0.00E+00
GSA17E/GSA22 Therm. gulf	0.226	0.010	199	-33.466	0.00E+00
GSA17E/GSA22 Thr. Sea	0.401	0.018	199	-20.580	0.00E+00
GSA18/GSA22 Therm. gulf	0.517	0.023	199	-14.845	0.00E+00
GSA18/GSA22 Thr. Sea	0.917	0.041	199	-1.959	6.29E-01
GSA22 Therm. gulf/GSA22 Thr. Sea	1.771	0.079	199	12.886	0.00E+00

Table S 5. Comparisons of the estimated CV_{geo} marginal means between species (ANE: anchovy; PIL: sardine) in each area considering an inter-transect distance of 10 nmi.

Contrast	Area	ratio	SE	df	t.ratio	p.value
ANE / PIL	GSA1	2.735	0.172	199	16.035	1.08E-37
ANE / PIL	GSA6	0.727	0.046	199	-5.073	8.93E-07
ANE / PIL	GSA7	0.763	0.048	199	-4.316	2.51E-05
ANE / PIL	GSA9	0.909	0.057	199	-1.515	0.131
ANE / PIL	GSA16	0.979	0.061	199	-0.333	0.740
ANE / PIL	GSA17W	0.836	0.052	199	-2.849	0.005
ANE / PIL	GSA17E	0.517	0.032	199	-10.521	7.23E-21
ANE / PIL	GSA18	0.737	0.046	199	-4.865	2.32E-06
ANE / PIL	GSA22 Therm. gulf	0.493	0.031	199	-11.281	3.89E-23
ANE / PIL	GSA22 Thr. Sea	0.438	0.027	199	-13.169	6.81E-29

Table S 6. p-values for the fixed and interaction terms in the ANCOVA models used to test for differences among high, medium, and low biomass levels for anchovy in each considered area. For each area was first evaluated the presence of interaction between the inter-transect distance (itr) and the biomass level factor.

	CV_{geo}~itr*abund			CV_{geo}~itr+abund	
Area	**p-value itr**	**p-value biomass level**	**p-value itr:biomass level**	**p-value itr**	**p-value biomass level**
GSA1	2.60E-07	1.94E-05	0.539	4.84E-09	1.16E-06
GSA6	1.92E-08	4.00E-06	0.017		
GSA7	5.69E-10	1.07E-07	0.000		
GSA9	2.25E-05	0.0001	0.002		
GSA16	2.11E-05	0.0504	0.542	1.64E-06	0.0305
GSA17W	2.11E-07	0.0063	0.019		
GSA17E	1.30E-06	0.0043	0.164	1.93E-07	0.0046
GSA18	9.00E-09	1.28E-06	0.141	3.25E-10	1.82E-07
GSA22 Therm. Gulf	2.75E-06	7.16E-05	0.006		
GSA22 Thr. Sea	7.97E-08	6.78E-05	0.009		

Table S 7. p-values for the fixed and interaction terms in the ANCOVA models used to test for differences among high, medium, and low biomass levels for sardine in each considered area. For each area was first evaluated the presence of interaction between inter-transect distance (itr) and biomass level factor.

	CVgeo~itr*abund			CVgeo~itr+abund	
Area	**p-value itr**	**p-value biomass level**	**p-value itr:biomass level**	**p-value itr**	**p-value biomass level**
GSA1	4.66E-07	1.84E-06	0.004		
GSA6	2.66E-08	9.80E-07	0.000		
GSA7	1.01E-09	3.41E-06	0.043		
GSA9	2.57E-08	5.95E-07	0.002		
GSA16	5.79E-05	0.0102	0.118	4.03E-05	0.0170
GSA17W	2.06E-07	5.88E-06	0.005		
GSA17E	1.89E-07	0.0967	0.334	5.93E-09	0.0917
GSA18	9.55E-07	0.0600	0.103	2.36E-07	0.1120
GSA22 Therm. gulf	5.85E-07	7.64E-06	0.002		
GSA22 Thr. Sea	1.27E-06	0.0071	0.046		