

1 **Supplementary material**

2 **Table S1.** Operating parameters and settings for the Agilent 7500cs inductively coupled

3 plasma mass spectrometer (ICP-MS) and New Wave Nd Yag 213 UV laser.

Laser

Wavelength	213 nm
Mode	Q-switch
Frequency	5 Hz
Laser diameter	30 μm
Transect scan rate	5 $\mu\text{m s}^{-1}$
Laser power	85%
Carrier	Ar (0.92 l min^{-1})

ICP-MS

Optional gas	He (58%)
Cone	Pt
Dwell times (ms)	^7Li (300), ^{23}Na (50), ^{24}Mg (300), ^{55}Mn (300), ^{59}Co (300), ^{60}Ni (300), ^{63}Cu (400), ^{66}Zn (400), ^{85}Rb (300), ^{88}Sr (200), ^{138}Ba (300), ^{203}Pb (300), ^{43}Ca (100), and ^{115}In (50)

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6 *Temporal analyses of the vertebral element composition*

7 Given that samples were collected across three sampling years (Table 1), the potential for
8 temporal variation in the elemental composition of *E. spinax* vertebrae confounding spatial
9 analyses was assessed. Elemental data of the vertebral samples collected from Langesund
10 in two sampling years (2012 and 2013) were analysed for temporal variation using single-
11 factor permutational ANOVA and MANOVA for individual and multi-elemental
12 signatures (respectively), with sampling year as the test factor (Table S2).

13 Among sampling years, neither the multi-element signature nor individual element:Ca
14 ratios differed significantly (Table S2). On this basis, samples collected from multiple
15 years were used in the subsequent spatial analyses.

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17 **Table S2.** Single-factor permutational ANOVA results comparing element:Ca
 18 concentrations in *E. spinax* vertebrae between sampling years (2012 and 2013) at
 19 Langesund. Multi = multi-element signature. Mean Element:Ca (\pm SD) is presented for
 20 each year in mmol mol⁻¹.

Element	Model	df	MS	F	P	Mean (\pm SD)	
						2012	2013
Multi	Year	1	0.267	0.541	0.506	N/A	N/A
	Residual	35	0.493				
Li:Ca	Year	1	<0.001	0.001	0.971	0.31 (\pm 0.01)	0.31 (\pm 0.01)
	Residual	35	<0.001				
Mg:Ca	Year	1	0.237	0.606	0.455	60.16 (\pm 27.3)	55.31 (\pm 51.2)
	Residual	35	0.392				
Co:Ca	Year	1	<0.001	0.679	0.517	0.0007 (\pm 0.0004)	0.0009 (\pm 0.001)
	Residual	35	<0.001				
Ni:Ca	Year	1	<0.001	0.216	0.752	0.003 (\pm 0.003)	0.004 (\pm 0.005)
	Residual	35	<0.001				
Zn:Ca	Year	1	<0.001	<0.001	0.983	0.266 (\pm 0.14)	0.319 (\pm 0.52)
	Residual	35	0.046				
Rb:Ca	Year	1	<0.001	15.232	0.711	0.003 (\pm 0.002)	0.004 (\pm 0.009)
	Residual	35	<0.001				
Sr:Ca	Year	1	0.002	0.718	0.400	2.22 (\pm 0.5)	2.07 (\pm 0.6)
	Residual	35	0.004				
Ba:Ca	Year	1	<0.001	0.025	0.878	0.011 (\pm 0.01)	0.01 (\pm 0.01)
	Residual	35	<0.001				
Pb:Ca	Year	1	<0.001	0.512	0.485	0.001 (\pm 0.001)	0.001 (\pm 0.001)
	Residual	35	<0.001				
Cu:Ca	Year	1	<0.001	0.041	0.971	0.06 (\pm 0.06)	0.08 (\pm 0.2)
	Residual	35	0.015				

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23 **Table S3.** Pairwise comparisons for element:Ca ratios that differed between one or more sites in the vertebrae of *E. spinax*. Multi = multi-
 24 element signature, t = t value, and P = probability. Significant differences ($P < 0.05$) are bolded. Refer to Table 1 for site codes.

Site	Multi		Mg:Ca		Zn:Ca		Sr:Ca		Ba:Ca		Cu:Ca	
	t	P	t	P	t	P	t	P	t	P	t	P
Berg – Flek	3.706	< 0.001	4.534	< 0.001	2.099	0.038	0.127	0.899	1.911	0.057	1.594	0.086
Berg – SkaW	1.160	0.233	0.975	0.324	1.807	0.071	0.006	0.949	0.898	0.376	0.150	0.891
Berg – SkaE	1.590	0.104	1.802	0.081	1.291	0.210	2.214	0.034	0.939	0.355	1.049	0.359
Berg – Lang	2.197	0.017	1.615	0.118	3.289	0.002	3.038	0.004	0.376	0.701	2.535	0.005
Berg – Brest	2.788	0.003	2.848	0.008	2.988	0.001	3.671	0.001	0.185	0.856	1.115	0.299
Berg – Bisc	1.723	0.068	1.566	0.122	2.054	0.043	3.727	0.002	3.126	< 0.001	0.659	0.532
Flek – SkaW	2.416	0.010	2.700	0.009	1.317	0.180	0.168	0.873	1.100	0.291	1.458	0.163
Flek – SkaE	3.438	0.001	3.986	< 0.001	2.007	0.043	1.516	0.137	1.088	0.289	1.474	0.114
Flek – Lang	4.039	< 0.001	4.439	< 0.001	0.708	0.492	2.111	0.037	1.698	0.101	0.654	0.471
Flek – Brest	3.877	< 0.001	4.156	< 0.001	1.098	0.282	2.623	0.013	2.058	0.048	2.110	0.038
Flek – Bisc	3.800	< 0.001	4.218	< 0.001	1.880	0.060	2.673	0.014	7.098	< 0.001	2.447	0.015
SkaW – SkaE	1.089	0.287	1.072	0.282	0.001	0.992	2.133	0.042	0.094	0.926	1.076	0.311
SkaW – Lang	1.157	0.243	0.489	0.633	1.983	0.049	0.782	0.439	0.690	0.488	1.323	0.195
SkaW – Brest	1.670	0.078	1.744	0.091	2.291	0.025	1.174	0.243	1.166	0.249	1.182	0.258
SkaW – Bisc	0.623	0.648	0.563	0.568	0.671	0.508	1.442	0.166	4.213	< 0.001	0.478	0.648
SkaE – Lang	1.221	0.207	0.889	0.368	1.403	0.147	2.888	0.007	0.703	0.484	2.499	0.006
SkaE – Brest	1.045	0.290	0.194	0.848	1.540	0.089	3.551	< 0.001	1.149	0.260	0.350	0.727
SkaE – Bisc	1.183	0.232	0.677	0.506	0.469	0.701	3.595	0.001	4.683	< 0.001	1.941	0.055
Lang – Brest	1.434	0.136	1.522	0.129	0.206	0.867	0.376	0.709	0.634	0.527	2.161	0.028
Lang – Bisc	1.307	0.187	0.171	0.875	1.258	0.229	0.717	0.469	3.779	< 0.001	4.038	< 0.001
Brest – Bisc	1.480	0.120	1.276	0.215	1.791	0.074	0.426	0.682	2.873	0.002	2.224	0.025