

Supplementary material

Decoupling carry-over effects from environment in fish nursery grounds

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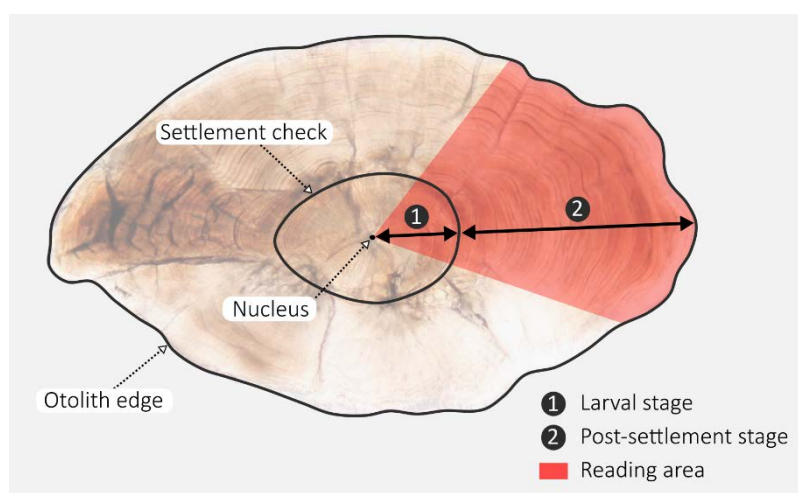


Figure S1: Thin section of sagittal otolith of European seabass, *Dicentrarchus labrax*. The settlement mark, identified by the initiation of the last accessory growth center, reflects the transition between the larval pelagic stage and the demersal juvenile stage in estuarine nursery. Otolith reading was conducted along the longest radius, from the nucleus to the outer margin.

Table S1: Details on the environmental conditions experienced by European seabass during their larval stage, 45-days and whole post-settlement periods in the six sampled estuarine nurseries. For each stage, the minimum and maximum values are provided: temperature (°C), salinity, microzooplankton ($\mu\text{gN}\cdot\text{L}^{-1}$), mesozooplankton ($\mu\text{gN}\cdot\text{L}^{-1}$), intertidal extent (%), catchment population (nb) and coastal artificialization (km^2).

ENVIRONMENTAL CONDITIONS DURING LARVAL STAGE

Years	Estuary	Temperature	Salinity	Micro-zooplankton	Meso-zooplankton
2020	Somme	10.92 - 14.88	33.42 - 33.51	3.18 - 4.73	2.56 - 4.50
	Orne	9.76 - 14.32	33.76 - 33.83	1.25 - 4.93	0.95 - 5.03
	Veys bay	10.54 - 14.34	34.98 - 35.02	1.96 - 4.41	1.42 - 3.71
	Mont St Michel bay	12.03 - 14.65	35.02 - 35.05	3.20 - 4.67	1.93 - 3.56
	Léguer	13.86 - 15.90	35.11 - 35.16	4.28 - 5.34	1.71 - 1.88
	Sèvre Niortaise	11.50 - 18.60	32.56 - 33.77	0.86 - 6.15	0.66 - 2.27
2021	Somme	10.49 - 15.31	33.23 - 33.27	3.64 - 5.05	2.82 - 4.34
	Orne	9.92 - 14.73	33.55 - 33.65	3.87 - 5.52	2.01 - 4.31
	Veys bay	9.65 - 13.38	34.89 - 34.93	2.37 - 4.70	1.21 - 2.97
	Mont St Michel bay	10.98 - 13.82	34.96 - 35.00	3.27 - 4.78	1.62 - 2.90
	Léguer	12.97 - 15.76	35.12 - 35.23	4.03 - 4.77	1.36 - 1.55
	Sèvre Niortaise	14.21 - 19.16	33.57 - 33.90	3.83 - 5.46	1.35 - 2.72

Table S1 (continued) ENVIRONMENTAL CONDITIONS DURING 45-DAY POST-SETTLEMENT PERIOD

Temperature	Salinity	Micro-zooplankton	Meso-zooplankton	Intertidal extent	Catchment population	Coastal artificialization
17.25 - 19.45	34.20 - 34.43	2.19 - 3.30	4.95 - 6.04	0.96	716117	6059
13.68 - 19.42	33.19 - 34.15	2.84 - 6.86	7.63 - 9.31	0.26	519921	20078
15.51 - 18.55	34.48 - 34.84	2.70 - 5.04	6.46 - 6.89	0.40	281957	4540
17.35 - 19.59	34.57 - 34.90	1.53 - 3.08	1.90 - 2.53	0.94	217854	4935
17.00 - 17.53	35.12 - 35.20	2.45 - 3.56	1.28 - 1.54	0.73	57119	4762
15.09 - 21.41	31.60 - 33.95	1.94 - 4.72	0.67 - 3.80	0.80	313009	4742
17.14 - 18.49	33.79 - 33.87	4.07 - 6.13	6.16 - 7.51	0.96	716117	6059
15.80 - 18.52	33.65 - 34.04	3.40 - 5.40	6.39 - 8.50	0.26	519921	20078
13.94 - 17.62	34.50 - 34.75	4.13 - 5.67	5.26 - 7.72	0.40	281957	4540
17.47 - 18.90	34.25 - 34.55	2.40 - 3.20	2.02 - 2.71	0.94	217854	4935
16.33 - 17.07	35.28 - 35.29	1.82 - 3.75	1.05 - 1.23	0.73	57119	4762
20.09 - 20.81	33.34 - 34.06	2.10 - 3.87	2.23 - 3.86	0.80	313009	4742

Table S1 (continued) ENVIRONMENTAL CONDITIONS DURING WHOLE POST-SETTLEMENT PERIOD

Temperature	Salinity	Micro-zooplankton	Meso-zooplankton	Intertidal extent	Catchment population	Coastal artificialization
18.23 - 19.11	34.24 - 34.34	8.24 - 8.81	5.71 - 6.29	0.96	716117	6059
17.10 - 19.02	33.86 - 34.22	11.11 - 12.39	8.22 - 8.78	0.26	519921	20078
17.15 - 18.55	34.68 - 34.85	9.46 - 10.59	6.64 - 6.82	0.40	281957	4540
18.48 - 19.34	34.74 - 34.88	3.59 - 4.48	2.00 - 2.23	0.94	217854	4935
16.84 - 16.96	35.18 - 35.23	3.07 - 3.88	1.09 - 1.28	0.73	57119	4762
18.65 - 20.55	33.05 - 34.03	5.00 - 5.90	2.04 - 3.42	0.80	313009	4742
17.84 - 18.52	33.82 - 33.88	11.35 - 12.23	6.77 - 7.73	0.96	716117	6059
17.43 - 18.54	33.81 - 33.92	11.73 - 12.34	7.79 - 8.76	0.26	519921	20078
15.96 - 17.67	34.61 - 34.69	11.47 - 12.08	6.60 - 7.93	0.40	281957	4540
18.08 - 18.62	34.45 - 34.56	4.81 - 4.96	2.41 - 2.69	0.94	217854	4935
16.56 - 16.76	35.29 - 35.30	2.55 - 3.53	0.96 - 1.04	0.73	57119	4762
18.10 - 19.06	33.76 - 34.00	3.74 - 4.83	2.12 - 2.58	0.80	313009	4742

Table S2: Summary table of the piecewise structural equation models built to investigate the direct (β_{DIR}), indirect (β_{IND}), and total effects (β_{TOT}) of traits that occurred earlier in the life cycle. For example, a trait A can directly impact a trait C (direct effect), but the trait A can also impact an intermediate trait such as B in a chain reaction where B finally impacts C (indirect effect). Standard errors and confidence intervals were calculated using 1,000 bootstrap replicates. Effects for which the confidence intervals do not contain zero were assumed significant.

Pathway	Earlier trait	Effect	Standard errors	Lower 95%CI	Upper 95%CI	Signif.
Larval duration						
DIRECT	Pelagic growth	-0.670	0.058	-0.762	-0.543	*
INDIRECT	-	-	-	-	-	
TOTAL	Pelagic growth	-0.670	0.058	-0.762	-0.543	*
Size at settlement						
DIRECT	Pelagic growth	0.798	0.017	0.764	0.830	*
	Larval duration	0.852	0.034	0.794	0.919	*
INDIRECT	Pelagic growth	-0.571	0.043	-0.639	-0.480	*
TOTAL	Pelagic growth	0.228	0.051	0.139	0.330	*
	Larval duration	0.852	0.034	0.794	0.919	*
Post-settlement growth						
DIRECT	Pelagic growth	-0.175	0.055	-0.225	-0.041	*
	Larval duration	-0.140	0.035	-0.171	-0.066	*
	Size-at-settlement	0.088	0.029	0.049	0.147	*
INDIRECT	Pelagic growth	0.114	0.030	0.056	0.147	*
	Larval duration	0.075	0.025	0.042	0.129	*
TOTAL	Pelagic growth	-0.062	0.033	-0.111	0.007	
	Larval duration	-0.065	0.027	-0.121	-0.016	*
	Size-at-settlement	0.088	0.029	0.049	0.147	*
Body condition						
DIRECT	Pelagic growth	0.133	0.053	-0.039	0.198	
	Larval duration	0.149	0.051	0.018	0.206	*
	Size-at-settlement	-0.106	0.047	-0.209	-0.029	*
	Post-settlement growth	0.076	0.040	-0.007	0.144	
INDIRECT	Pelagic growth	-0.129	0.043	-0.186	-0.022	*
	Larval duration	-0.095	0.039	-0.170	-0.029	*
	Size-at-settlement	0.007	0.004	0.000	0.014	
TOTAL	Pelagic growth	0.005	0.027	-0.057	0.045	
	Larval duration	0.053	0.055	-0.060	0.151	
	Size-at-settlement	-0.100	0.046	-0.206	-0.025	*
	Post-settlement growth	0.076	0.040	-0.007	0.144	

Table S3: Summary table of the LMMs built to examine the impact of environmental constraints on each life-history trait. Standard errors and confidence intervals of model coefficients were calculated using 1,000 bootstrap replicates. Coefficients for which the confidence intervals do not contain zero were assumed significant.

Parameter	Coefficient	Standard errors	Lower 95%CI	Upper 95%CI	Signif.
Pelagic growth					
Intercept	0.009	0.048	-0.080	0.105	
Temperature	0.573	0.067	0.402	0.667	*
Salinity	-0.048	0.063	-0.085	0.167	
Microzooplankton	-0.044	0.066	-0.163	0.097	
Mesozooplankton	0.225	0.062	0.111	0.348	*
Larval duration					
Intercept	-0.084	0.055	-0.149	0.063	
Temperature	-0.452	0.088	-0.614	-0.258	*
Salinity	0.645	0.231	-0.007	0.910	
Microzooplankton	-0.052	0.065	-0.213	0.036	
Mesozooplankton	-0.400	0.117	-0.577	-0.121	*
Size at settlement					
Intercept	0.009	0.053	-0.086	0.117	
Temperature	-0.074	0.073	-0.250	0.038	
Salinity	0.202	0.061	0.078	0.310	*
Microzooplankton	0.004	0.074	-0.122	0.168	
Mesozooplankton	-0.040	0.060	-0.145	0.087	
Post-settlement growth					
Intercept	0.017	0.050	-0.086	0.113	
Temperature	0.019	0.094	-0.136	0.235	
Salinity	-0.366	0.112	-0.585	-0.146	*
Microzooplankton	-0.251	0.109	-0.426	-0.006	*
Mesozooplankton	0.752	0.254	0.197	1.175	*
Intertidal extent	-0.658	0.213	-1.030	-0.208	*
Catchment population	-0.390	0.094	-0.580	-0.215	*
Coastal artificialization	0.466	0.208	0.017	0.814	*
Body condition					
Intercept	-0.054	0.048	-0.146	0.040	
Temperature	-0.293	0.128	-0.512	-0.024	*
Salinity	0.924	0.294	0.232	1.393	*
Microzooplankton	0.172	0.156	-0.161	0.441	
Mesozooplankton	-1.083	0.462	-2.017	-0.222	*
Intertidal extent	-0.710	0.383	-1.534	-0.042	*
Catchment population	2.044	0.387	1.272	2.757	*
Coastal artificialization	-0.069	0.177	-0.470	0.231	

Table S4: Partitioning of marginal R^2 coefficients (R^2_m) into independent (I) and conjoint (J) contributions of carry-over effect and environmental constraints for LMMs explaining variation in early life-history traits of European seabass juveniles. Asterisks denote significant contributions at a significance level of 0.05 assessed by randomized permutation tests, using 1,000 replicates.

Life-history traits	Carry-over contribution	Environment contribution	Conjoint contribution
Pelagic growth	-	0.279 *	-
Larval duration	0.077 *	0.019	0.404 *
Size at settlement	0.740 *	0.041 *	0.014 *
Post-settlement growth	0.031 *	0.242 *	0.010 *
Body condition	0.007 *	0.186 *	0.015 *