Supplement

Non-native species spread in a complex network: The interaction of global transport and local population dynamics determines invasion success

Proceedings of the Royal Society B: Biological Sciences

http://dx.doi.org/10.1098/rspb.2019.0036

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Figures

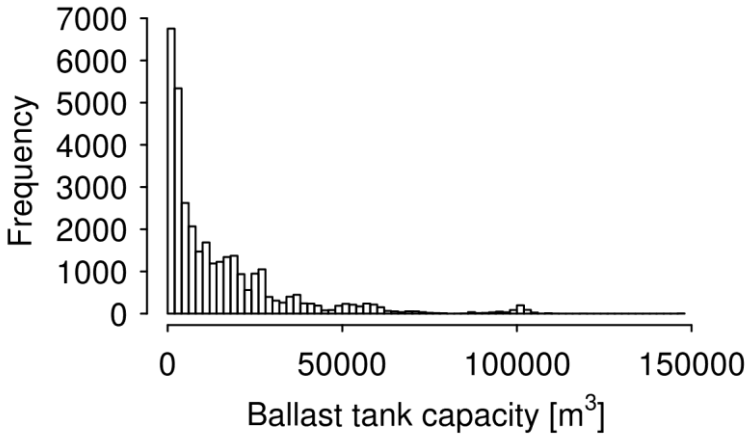

Fig. S1: Frequency distribution of the calculated ballast tank capacities for all ships considered in this study. The ballast tank capacity was assumed to be a fifth of the ship's carrying capacity measured in dead weight tonnes.

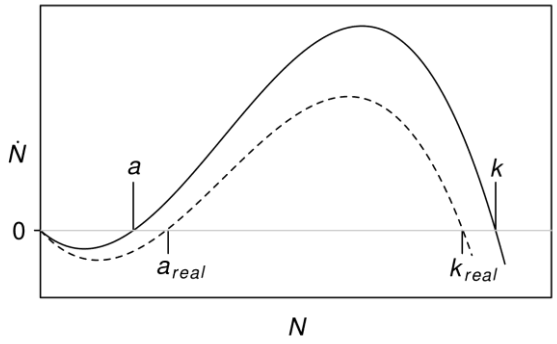

Fig. S2: Graphical representation of the simulated density-dependent population growth of *M. leidyi* in ports without exchanges (Eq. 1). Populations of *M. leidyi* experience positive growth above the Allee threshold *a* and below the carrying capacity *k* if environmental conditions perfectly match the optimal growth conditions of the species ($\mu_i = 0$, solid line). An increase in mortality rate ($\mu_i > 0$) due to an environmental mismatch (dashed line) increases the Allee threshold (now called the realised critical density a_{real}) and decreases the carrying capacity to the realised carrying capacity k_{real}.

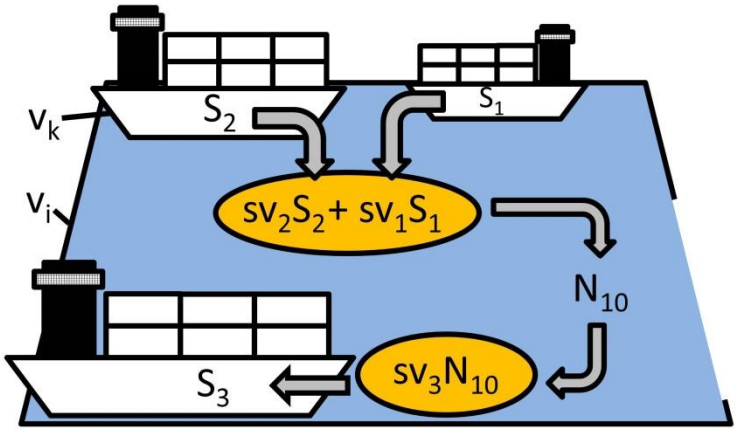

Fig. S3: Sketch of the dynamics considered in the model. Populations of *M. leidyi* are simulated in ships (*S*) and ports (*N*), respectively, as densities of individuals per cubic meter. Once a ship k (here $k = 1; 2$) enters a port i (here $i = 10$), a certain volume of ballast water sv_k is assumed to be released, with v_k denoting the ship-specific total capacity of ballast tanks and s being the released proportion of ballast water, which is constant for all ships. The number of released individuals constitutes sv_kS_k, which is added to the port population N_i. Ships leaving the port (here $k = 3$) upload the same volume of ballast water sv_k with port density N_i. Thus, sv_kN_i individuals enter the ballast tanks of the ship.

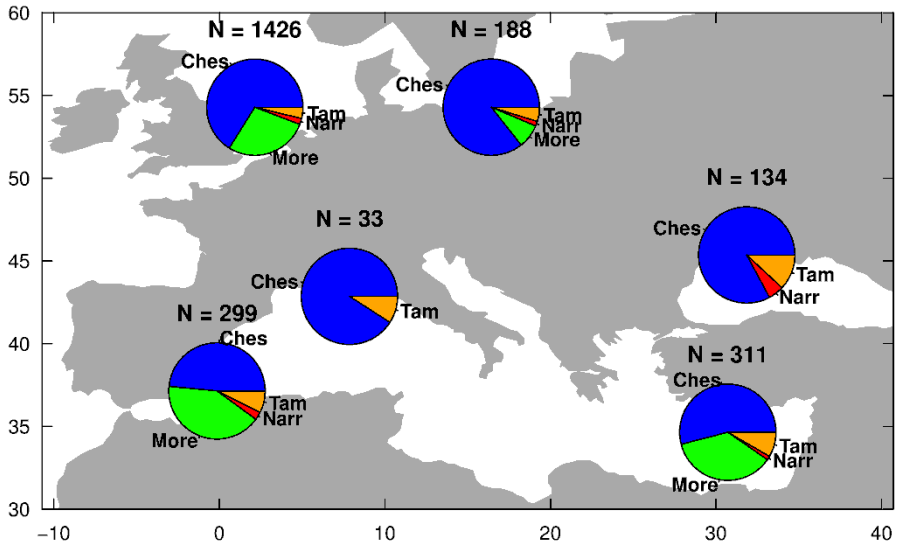

Fig. S4: Origins of ships' calling ports in different European Seas. The header of a pie chart indicates the total number of vessel movements from all native sample regions to the respective European location. A single vessel may be counted several times. (Ches: Chesapeake Bay; Tam: Tampa Bay; Narr: Narragansett Bay; More: Morehead City)

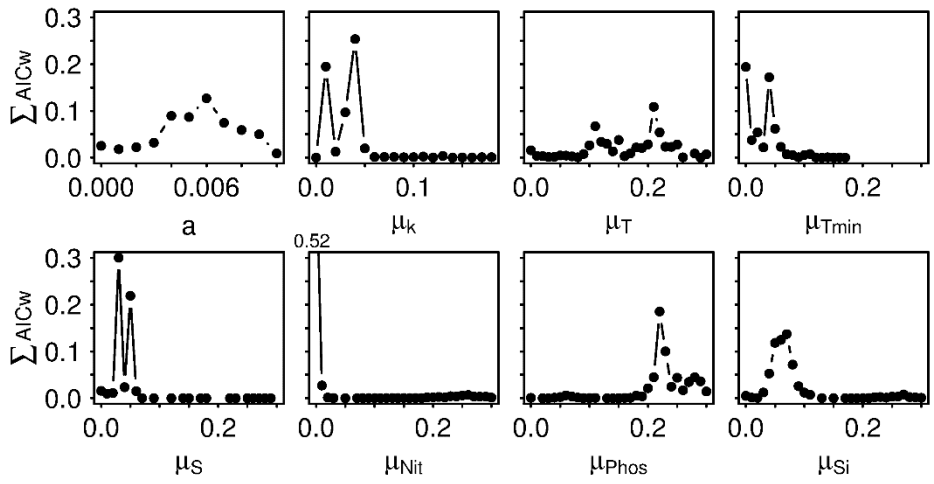

Fig. S5: Relevance of parameter settings based on the sum of AICw obtained by the four ecotype model. A high sum of AICw indicates that the respective parameterisation occurs in most of the relevant model runs. The variables describe the realised critical density *a*, in-ship mortality μ_k and in-port mortality μ_{Temp}, μ_{Tm}, μ_{Sal}, μ_{Nit}, μ_{Phos} and μ_{Sil} for each environmental factor.

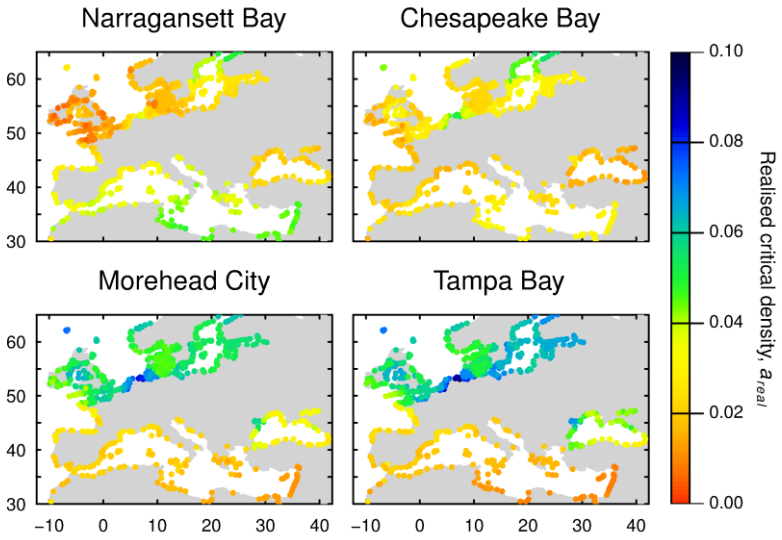

Fig. S6: Realised critical density, a_{real}, of *M. leidyi* for four American source sites, calculated from Eq. 2.1 in the main text using the parameters of the best-fitting model (Table S2). The realised critical density denotes the population density that must be exceeded to gain positive population growth, taking into account an Allee effect and mortality due to environmental conditions.

Table S1: Population structure (mean F_{st} values) of the four native (rows) and five non-native populations (columns). A low F_{st} denotes a low genetic differentiation and thus indicates high relatedness.

	Baltic Sea	Black Sea	East Med. Sea	France	Spain
Narragansett Bay	0	0.32	0.34	0.33	0.4
Chesapeake Bay	0.47	0.31	0.32	0.31	0.4
Morehead City	0.37	0.06	0	0	0
Tampa Bay	0.41	0	0	0.04	0.07

Table S2: Best-fitting simulations selected by AICc while ignoring environmental heterogeneity (NoEnv), considering a single ecotype (1Eco), or four ecotypes (4Eco). The best-fitting model is highlighted in bold.

Model version	AICc	R^2	μ_i	μ_k	a	μ_{Temp}	μ_{Tm}	μ_{Sal}	μ_{Nit}	μ_{Phos}	μ_{Sil}
NoEnv	-67.2	0.11	0.008	0.1	0.002	-	-	-	-	-	-
1Eco.	-83	0.6	-	0.048	0.008	0.052	0.038	-	0.088	0.207	-
4Eco.	**-86**	**0.65**	**-**	**0.01**	**0.006**	**0.206**	**-**	**0.048**	**-**	**0.296**	**0.073**

Table S3: Frequency of invaded ecoregions predicted by the set of best-fitting models in percent. The set of best-fitting models (n=197 models) represent those models with AICc differing by less than 5 from the single best–fitting model.

	Baltic Sea	Black Sea	East Med. Sea	France	Spain
Narragansett Bay	94	0	4	0	6
Chesapeake Bay	0	0	0	0	2
Morehead City	2	6	100	100	100
Tampa Bay	1	1	100	100	100