Sensitivity Studies for SEAcross v1.0

Christine Hertler[1,2], Jan-Olaf Reschke[1,2,3], Ericson Hölzchen[4,5], Iwan Pramesti Anwar[6], Mika Puspaningrum[6], Nicolas Büscher[3], Emmanuel Kipruto Ngetich[1,2,3]

[1] ROCEEH Research Center, Senckenberg Research Institute, Frankfurt am Main, Germany

[2] ROCEEH Research Center, Heidelberg Academy of Sciences and Humanities, Heidelberg, Germany

[3] Paleobiology and Environment Group, Institute of Ecology, Evolution, and Diversity, Dept. of Biosciences, Goethe University, Frankfurt am Main, Germany

[4] Trier Lab for Social Simulation (TRILAB), Trier University, Trier, Germany

[5] German Center for Artificial Intelligence (DFKI), Cognitive Social Simulation, Trier University, Trier, Germany

[6] Bandung Institute of Technology, Faculty of Earth Sciences and Technology, Bandung, Indonesia

In order to characterize the features and the responsiveness of the SEAcross ABM we performed a series of sensitivity experiments by systematically varying one or more factors while monitoring model performance by the crossing success rate (CSR).

Experiments

Table 1 lists the experiments for agent factors, Table 2 the factors for features of the environment.

Test no.	Hydrophobia score	Body mass [kg]	Head body length [m]	Population size [n]
ANI-1	0.5	10	0.77	5
ANI-2	0.5	50	1.28	5
ANI-3	0.5	100	1.59	5
ANI-4	0.5	200	1.99	5
ANI-5	0.5	500	2.65	5
ANI-6	0.5	1000	3.30	5
ANI-7	0.5	5000	5.50	5
ANI-8	0	50	1.28	5
ANI-9	0	200	1.99	5
ANI-10	0	1000	3.30	5
ANI-11	0.25	50	1.28	5
ANI-12	0.25	200	1.99	5
ANI-13	0.25	1000	3.30	5
ANI-14	0.75	50	1.28	5
ANI-15	0.75	200	1.99	5
ANI-16	0.75	1000	3.30	5
ANI-17	0	10	0.77	5
ANI-18	0	100	1.59	5
ANI-19	0	500	2.65	5

ANI-20	0	5000	5.50	5
ANI-21	0.25	10	0.77	5
ANI-22	0.25	100	1.59	5
ANI-23	0.25	500	2.65	5
ANI-24	0.25	5000	5.50	5
ANI-25	0.75	10	0.77	5
ANI-26	0.75	100	1.59	5
ANI-27	0.75	500	2.65	5
ANI-28	0.75	5000	5.50	5

Tab. 1: Factor levels for the agents tested in the sensitivity experiments.

Test no	Barrier width [km]	current speed [ms^{-1}]	current direction [°]
BW-1	10	0.25	90
BW-2	530	0.25	90
BW-3	50	0.25	90
BW-4	70	0.25	90
BW-5	90	0.25	90
BW-6	110	0.25	90
BW-7	200	0.25	90
CS-1	50	0	90
CS-2	50	0.25	90
CS-3	50	0.5	90
CS-4	50	0.75	90
CS-5	50	1	90
CD-1	50	0.25	0
CD-2	50	0.25	45
CD-3	50	0.25	90
CD-4	50	0.25	135
CD-5	50	0.25	180

Tab. 2: Factor levels for the sea strait tested in the sensitivity experiments.

Agent factors

When varying agent factors, we kept the factor levels for the sea strait constant. The default levels for factors not varied are listed in Table 3.

Barrier features	Factor name	Default level
Width	"Water-barrier-size"	50 km
Current speed	"Current-speed"	0.25 ms^{-1}
Current direction	"Current-direction"	90°

Tab. 3: Default factor levels for the standard sea strait tested with the agents.

Body mass (ANI-1-9; Fig. 1)

The agents require a minimum size to cross a sea strait with a width of 50 km. An agent with a body mass of 10 kg swims with an optimum speed of 0.18 ms^{-1} over a maximum distance of 27 km. It is therefore unable to cross a sea strait with a standard width of 50 km (Tab. 3). Agents with body masses at or above 50 kg swim with higher speed (0.23 ms^{-1}) and are capable of swimming wider distances because of higher energy deposits. Beyond that critical body mass, an increasing number of agents manages to cross the standard sea strait. 50 % of all crossing attempts lead to the establishment of populations in the target area. Because the default agents possess a hydrophobia score of 0.5, 50 % of all crossing attempts were aborted.

Head body length was predicted from body mass using a regression established for ungulates (Damuth 1994). Thus, head body length depends linearly on body mass. It is therefore not required to test it separately.

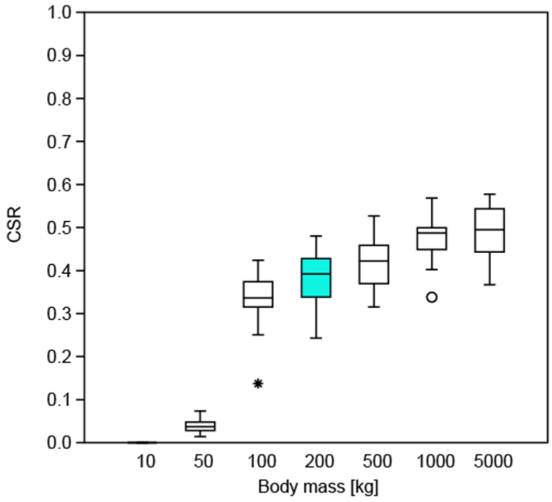


Fig. 1: Crossing success rates of mammals of various body masses for the default sea strait (Tab. 3).

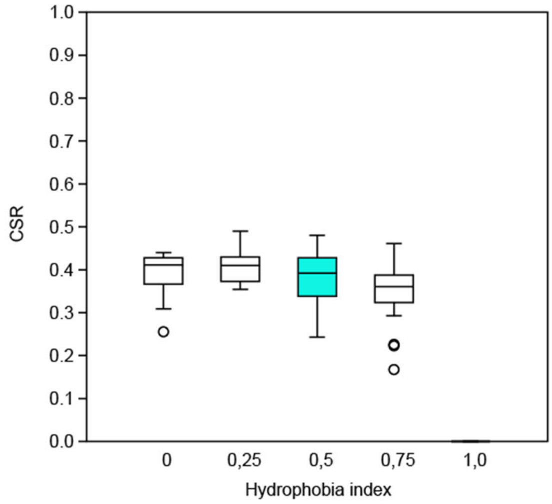


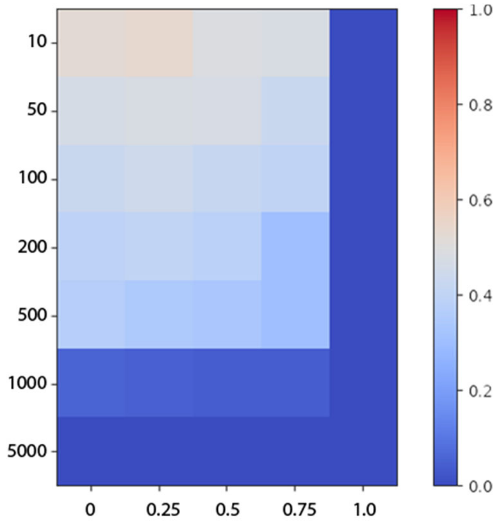
Fig. 2: Crossing success rates of agents with a variety of hydrophobia scores for the default sea strait (Tab. 3).

Hydrophobia score (ANI-4,-9,-12,-15; Fig. 2)

The hydrophobia coefficient determines the probability for an agent to enter a sea strait and start a crossing attempt. The agents tested here had a body mass of 200 kg, a head body length of 1.99 m and a minimum population size of 5 agents. These agents swim with an optimum speed of 0.29 ms^{-1} over a maximum distance of 75 km and are therefore generally capable to cross the standard sea strait successfully. The hydrophobia score does not have an impact on the swimming capabilities per se, but on the decision, whether an attempt is started or aborted. Increasing hydrophobia therefore leads to a higher number of abortions. The CSR, however, relates the number of successful attempts to the total number of started attempts. Varying the hydrophobia scores thus lowers the CSR only to a minor extent (Fig. 2). It increases variability, until a hydrophobia score of 1.0 is reached and agents abort all crossing attempts.

Bi-factorial analysis (ANI-1-28; Fig. 3)

In order to test the interaction of both of the factors, we performed an experiment in which we systematically varied both, body mass and hydrophobia score. Average CSRs are shown in figure 3. Crossing attempts generally fail, if the body mass is too low (A) or a hydrophobia score of 1 leads to



the abortion of all crossing attempts (V). Crossing success rises with increasing body mass leading to higher range and speed, and decreasing hydrophobia. The impact of body mass is higher than hydrophobia score.

Fig. 3: Average crossing success rates of agents with a variety of body masses and hydrophobia scores for the default sea strait (Tab. 3).

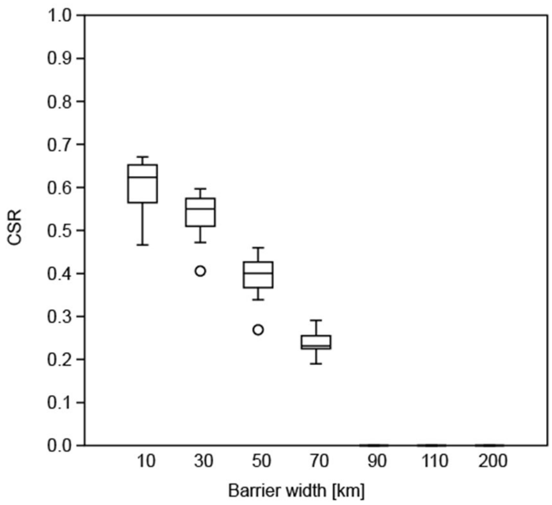
Environmental factors

When varying factors in the environment, we kept the factor levels for the agents constant. The default levels for factors not varied are listed in Table 4.

Agent features	Factor name	Default level
Body mass	applied to calculate	185 kg
Head Body Length	"optimum-swimming-speed"	2.0 m
Hydrophobia score	"hydrophobia-coefficient"	0.25
Number of founder agents per population	"number-founder-agents"	5

Tab. 4: Default factor levels for the standard agent.

Barrier width (BW1-7; Fig. 4)



The standard agent is capable of crossing maximum distances of 73 km and therefore crossing attempts should be successful up to that range. Beyond that critical distance, the agent suffers exhaustion or is washed off the map. Crossing attempts across sea straits with a width of 90, 110, and 200 km are therefore unsuccessful. Nevertheless, the number of successful crossings decreases with increasing width of the sea strait. Currents with a speed of 0.25 ms^{-1} coming at right angles to the swimming direction wash some agents off the map depending on the starting point of the crossing attempt.

Fig. 4: Crossing success rates of a standard agent (Tab. 4) across sea straits of variable width.

Current speed (CS-1-5; Fig. 5)

Current speed has a major impact on crossing success, because it determines whether the agent is capable of counteracting by its optimum swimming speed. The standard agent swims with an optimum speed of 0.29 ms^{-1}. A current speed of 0.25 ms^{-1} causes a considerable deflection, leading to an extension of the distance to be crossed and eventually washing the agent off the map. Current speeds of 0.5 ms^{-1} allow for successful crossing attempts in less than 10 % of all cases and current speeds above that are too strong to be countered by the default agent.

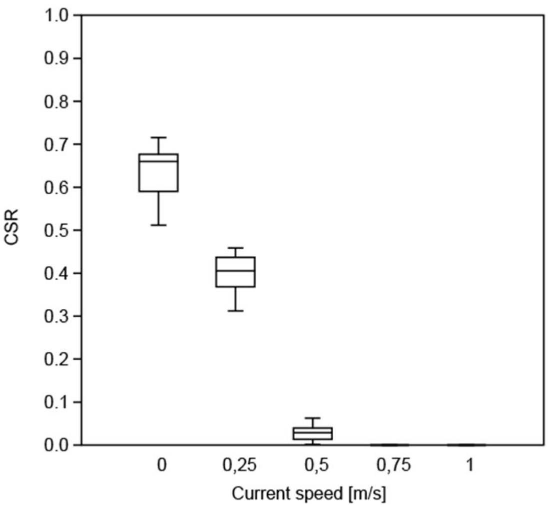


Fig. 5: Crossing success rates of standard agents (Tab. 4) facing a range of current speeds.

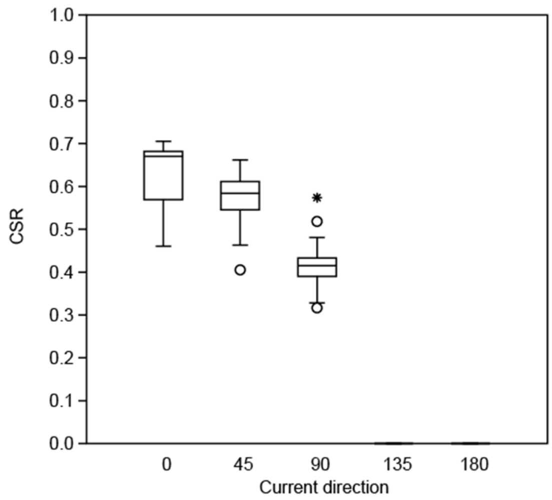


Fig. 6: Crossing success rates of standard agents (Tab. 4) facing a range of current directions.

Current direction (CD-1-5; Fig. 6)

The effect of current direction on crossing success rates is highest at an angle of 90°. Beyond that, when the agent has to face currents approaching him from front crossing attempts of the standard agent are no longer successful. The current speed is held constant at 0.25 ms^{-1} in this set of experiments. With angles of 45° and 0° respectively, the currents are favorable and support the agent in crossing sea straits.

References

Damuth J. 1990. Problems with using fossil teeth to estimate body sizes of extinct mammals. In: Damuth J & MacFadden B (eds). Body Size in Mammalian Paleobiology. Cambridge University Press. Cambridge. p207-228.