

Supplementary material

An individual-based model to predict the spatial distribution of northern pike, European perch and pikeperch from habitat use in a reservoir subject to water level fluctuations

Un modèle individu-centré pour prédire la distribution spatiale du brochet, de la perche commune et du sandre, à partir de l'utilisation de l'habitat dans un réservoir soumis à des fluctuations de niveau d'eau

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Appendix A. Water level fluctuation

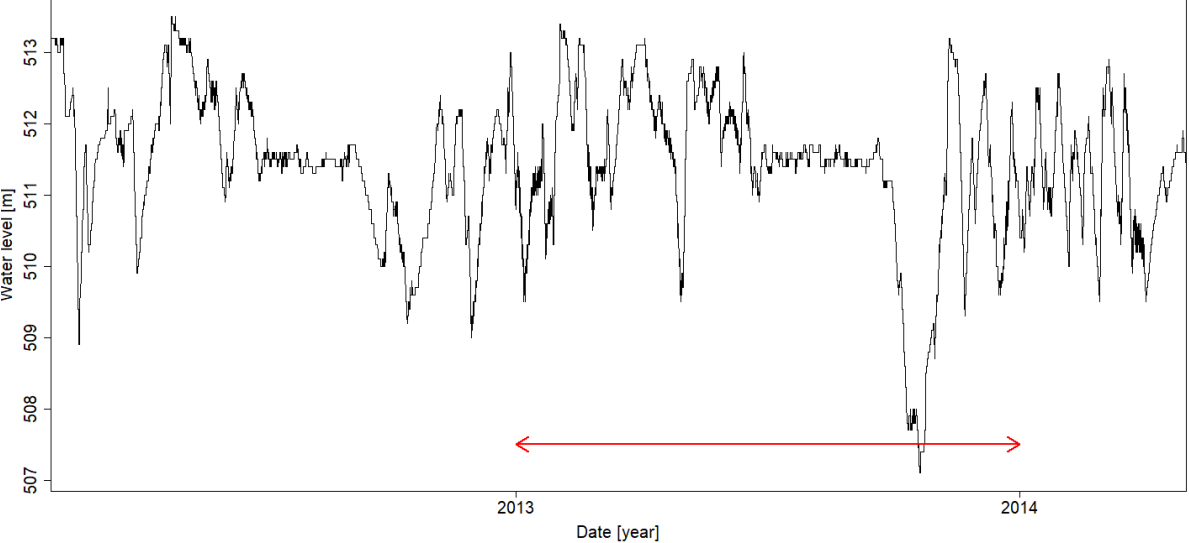


Figure A1. Water level time series over the tracking period (March 2012 - March 2014). Data are hourly and their vertical resolution is 0.1 m. The horizontal red arrow indicates the yearly time series used for the simulation: year 2013.

Appendix B. Characteristics of tracked individuals of pike, perch and pikeperch

Table B.1 Mean (range) of tracking days, number of positions, total length and weight are given over the pool of individuals by species.

Species	Number of individuals	Number of tracking days	Number of recorded positions per individual	Total length (mm)	Weight (g)
Pike	10	122 (8-420)	15759 (128-55394)	532 (425-629)	958 (398-1513)
Perch	22	182 (16-442)	38245 (2392-117621)	402 (320-486)	956 (383-1800)
Pikeperch	26	126 (5-442)	31102 (818-125551)	494 (360-695)	1136 (354-3000)

Appendix C. HSI calculation

For each of the three species, a selection ratio (SR) was calculated for five habitat variables, independently for each season, following the method of Westrelin *et al.* (2018) for perch. The first variable was water depth (divided in 7 depth classes for SR calculation: [0; 2.5[, [2.5; 5[, [5; 7.5[, [7.5; 10[, [10; 12.5[, [12.5;15[, [15; 22[m). It was available for the whole lake and was updated at each time step with the water level time series. The four other variables were main substrate (silt, sand, gravel, pebble, stone, boulder, rock and lawn which made a particular class as no other vegetation was observed except these flooded lawns), overhanging vegetation (yes, no), tree stumps (yes, no) and emerging trees (yes, no) in the littoral zone. These last ones were only available in the littoral zone.

The habitat suitability index (HSI) was calculated for each 10 m x 10 m cell and each time step as the sum of the local SR for each variable divided by the sum of the maximum SR for each variable. For the littoral area, the HSI was calculated with the five variables. For the center of the lake, the HSI was calculated with the water depth variable only.

In order to have a synthetic visual representation of HSI data, the HSI was averaged over the year (Figure C1) and in each season (Figure C2 for pike,

(a) (b) (c) (d)
Figure C3 for perch and

(a) (b) (c) (d)
Figure C4 for pikeperch) with the water level time series used for simulations.

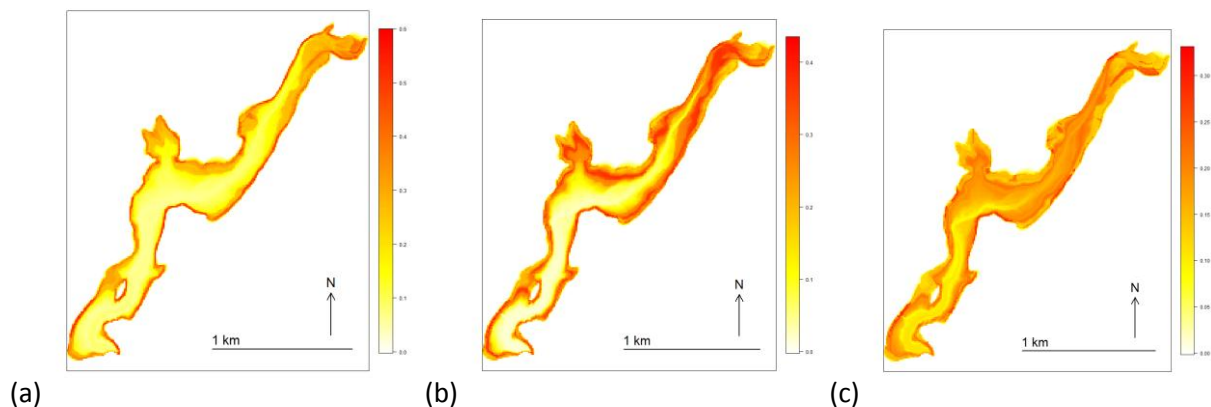


Figure C1. HSI map (averaged along the year with the water level time series used for simulations) for (a) pike; (b) perch; (c) pikeperch. Color legend: from white, low HSI, to red, high HSI

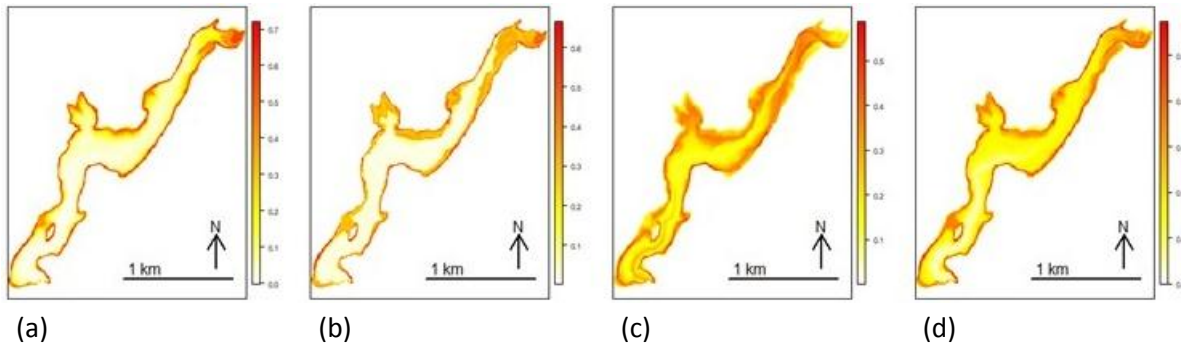


Figure C2. HSI map (averaged along the days of a season with the water level time series used for simulations) for pike during (a) spring, (b) summer, (c) autumn, (d) winter. Color legend: from white, low HSI, to red, high HSI.

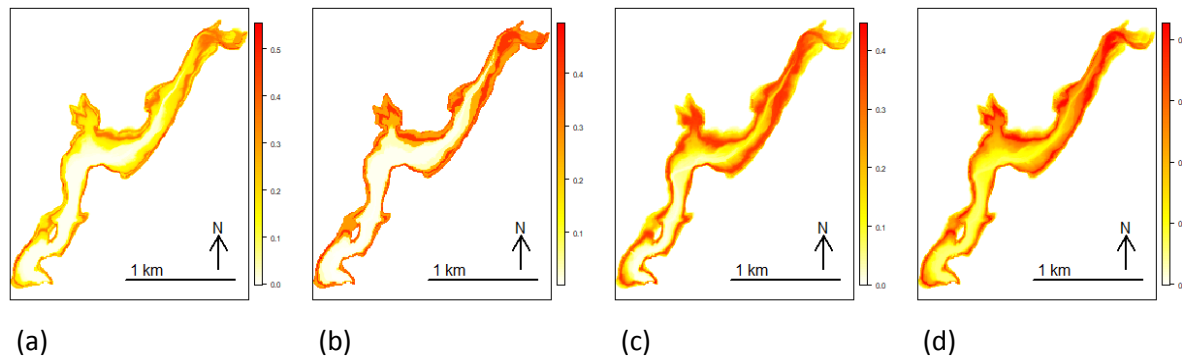


Figure C3. HSI map (averaged along the days of a season with the water level time series used for simulations) for perch during (a) spring, (b) summer, (c) autumn, (d) winter. Color legend: from white, low HSI, to red, high HSI.

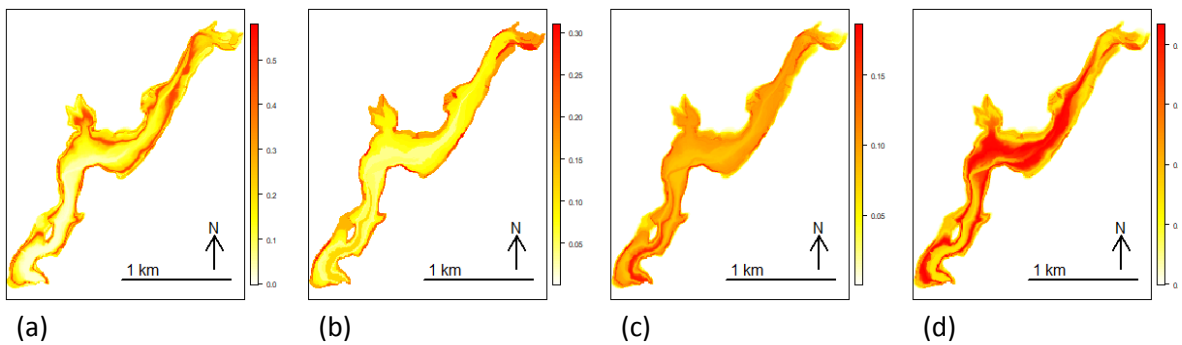


Figure C4. HSI map (averaged along the days of a season with the water level time series used for simulations) for pikeperch during (a) spring, (b) summer, (c) autumn, (d) winter. Color legend: from white, low HSI, to red, high HSI.

Reference

Westrelin, S., R. Roy, L. Tissot-Rey, L. Bergès and C. Argillier (2018). "Habitat use and preference of adult perch (*Perca fluviatilis* L.) in a deep reservoir: variations with seasons, water levels and individuals." *Hydrobiologia* **809**(1): 121-139.

Appendix D. Hourly distance range

Table D.1 Maximum hourly distance (R_a in m) for each species, season and phase of the day

Species	Season	Phase of the day			
		Dawn	Day	Dusk	Night
Pike	Spring	204	233	199	53
	Summer	153	201	94	31
	Autumn	151	131	117	29
	Winter	172	133	170	78
Perch	Spring	177	175	99	15
	Summer	235	308	156	27
	Autumn	170	248	117	15
	Winter	128	148	105	10
Pikeperch	Spring	60	36	58	53
	Summer	206	92	184	170
	Autumn	134	56	148	136
	Winter	126	44	94	77

Appendix E. Observed fish density map

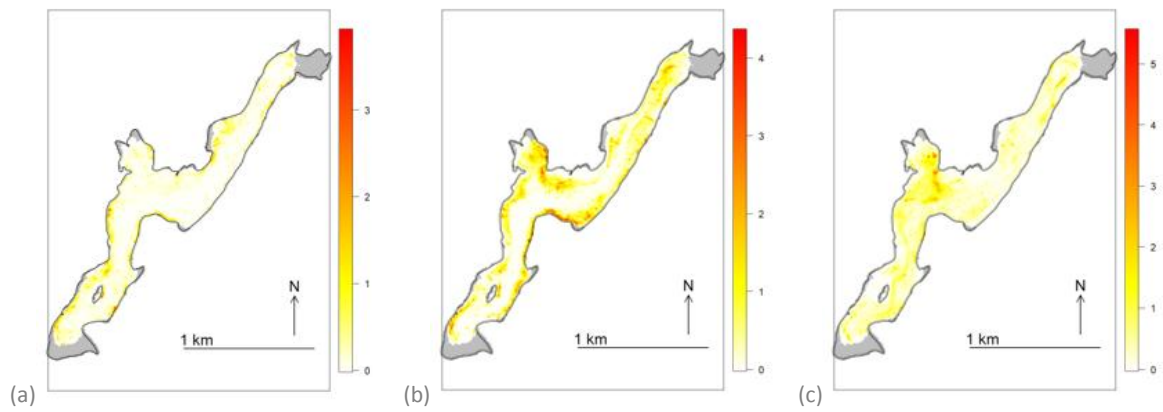
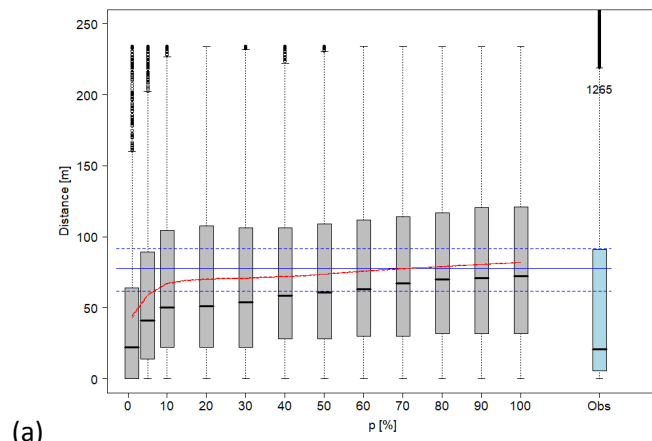
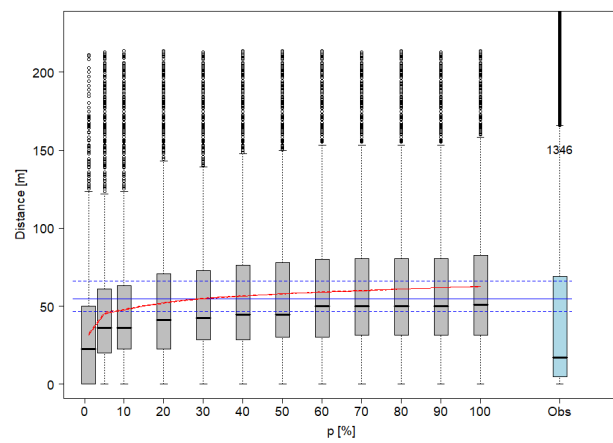


Figure E1. Observed density map for (a) pike, (b) perch and (c) pikeperch. Color legend: from white, low densities, to red, high densities. The log of the mean yearly density is represented. The grey areas are blind areas where no fish could be detected by the tracking system.

Appendix F. Supplementary figures

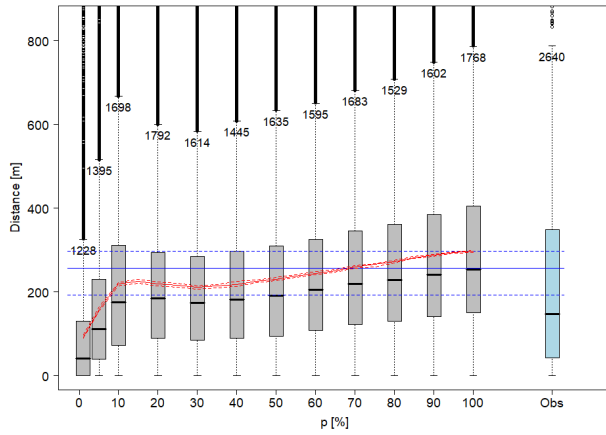


(a)

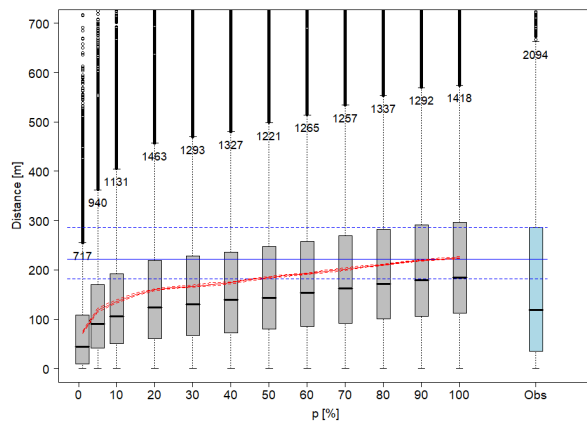


(b)

Figure F1. Mean simulated hourly distance for (a) pike and (b) pikeperch over a year as a function of p parameter varying from 1 to 100 %. The solid red line is the simulated mean (across all time steps, all individuals and all replicates) and the dashed ones are its range over the ten replicates (very close to the mean). The solid blue line is the mean observed hourly distance over all data and the dashed ones are its 95% confidence interval. Each grey boxplot represents the simulated distribution of the hourly distances for the 365x50x10x24 hours. The blue boxplot stands for observed values. The extreme values of the observed boxplot are truncated and the maximum value is displayed.

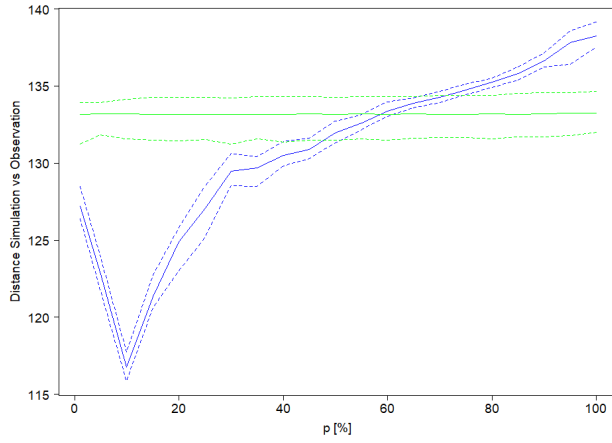


(a)

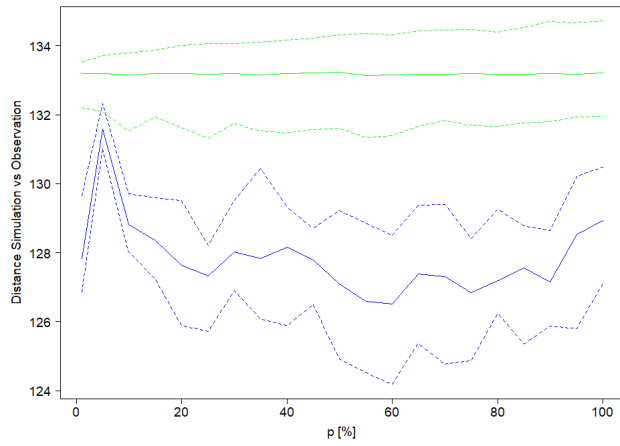


(b)

Figure F2. Mean simulated daily distance for (a) pike and (b) pikeperch as a function of the values of p varying from 1 to 100 %. The solid red line is the simulated mean (across all time steps, all individuals and all replicates) and the dashed ones its range over the ten replicates. The solid blue line is the mean observed daily distance over all data for each species, and the dashed ones its 95% confidence interval. Each grey boxplot represents the simulated distribution of the daily distances of the 365x50x10 days. The blue boxplot stands for observed values. The extreme values of the boxplots are truncated and the maximum value is displayed on each boxplot.



(a)



(b)

Figure F3. Distance between simulated and observed densities (mean and range) for (a) pike and (b) pikeperch as a function of p . The solid blue line is the average over the 10 replicates and the dashed blue lines are the range over the 10 replicates. The null model of this distance is also represented (mean and 95% confidence interval over 1,000 repetitions, respectively in green solid line and dashed green lines).